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PREFACE

On-Farm Research Division (OFRD) of Bangladesh Agricultural Research Institute (BARI) is going to publish its Annual Research Report based on the research program implemented during 2020-21 through Farming System Research and Development (FSRD) and Multilocation Testing (MLT) sites across the country. The mandate of OFRD is to execute research for the improvement of existing farming systems, testing and validation of on-station technologies under a wide range of agroclimatic situation for the fine tuning of the technologies and development of location specific technologies based on the local problems and needs and transfer of appropriate mature technologies. As per the mandate, major thrust was given on the improvement of existing cropping systems through introduction of modern varieties, crop, and soil fertility management as well as pest and disease management.

Our commitment was given emphasis to address some challenges like improvement of existing cropping system practiced by the farmers with introduction of new crops and varieties and technologies in plainland, coastal, drought, charland, haor, floating and hill ecosystems. For sustainable crop production and soil fertility, it is needed to develop cropping pattern-based fertilizer recommendation and update the fertilizer recommendation guide. Our research thrust is to develop 2 to 4 crop-based cropping pattern for intensification and diversification in the environmental harsh areas, Integrated Plant Nutrient Systems (IPNS), bio-slurry management, bio-fertilizer, organic fertilizer, location specific soil test-based fertilizer recommendation and use of ash, biochar and lime for problematic soil, conservation agriculture base resource saving technologies, agriculture mechanization, subsistence agriculture to climate smart commercial agriculture etc. Adaptation to climate change, integrated farming, family nutrition, homestead production systems, soil fertility management, cropping systems, four crop-based cropping pattern, floating agriculture, agroforestry-based cropping systems, conservation agriculture, technology transfer of field and horticultural crops, socioeconomic studies and seaweeds production are also included in this report.

On-farm trials on cereals, tuber crops, pulses, oilseeds, spices, seaweed, horticultural crops, and community-based system approach pilot production program were conducted at different MLT and FSRD sites throughout the country in collaboration with NARS institutes, Department of Agricultural Extension (DAE) and development partners. Results of these activities also incorporated in this report. Through the technical support of this division, different activities (training, field days and others) were conducted and organized for farmers, DAE personnel, SSA/SA, and scientists with the financial support of MoA, KGF, NATP (Phase II), CIMMYT, IRRI, ACIAR and FtFBP during 2020-21.

We are expecting this report will be very useful to the researchers, GO, NGOs, extension personnel, grassroot level workers, development partners as well as policy makers.

I expressed my sincere thanks and gratitude to BARI, MoA, CIMMYT, IRRI, ACIAR, FtFBP, KGF, OCP Foundation, NATP (Phase-II), IDA, IFAD and BARC for providing financial assistance to conduct different research, training, and Research-Extension linkage activities. I sincerely admire and appreciate my colleagues and SSA/SA who look after the experiments at different locations. Special thanks to the cooperator farmers for their valuable cooperation and support. Last of all, I acknowledged those who worked hard to accomplish this voluminous report successfully.

Dr. Md. Shahiduzzaman
Chief Scientific Officer

ABBREVIATION

BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BCR	Benefit Cost Ratio
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugar Crops Research Institute
CP	Cropping Pattern
CV	Coefficient of Variance
DAE	Department of Agriculture Extension
DAS	Days After Sowing
DAT	Days After Transplanting
DMRT	Duncan's Multiple Range Test
FRG	Fertilizer Recommendation Guide
FSRD	Farming System Research and Development
GM	Gross Margin
GO	Government Organization
GR	Gross Return
ha	Hectare
IPNS	Integrated Plant Nutrient System
kg	Kilogram
LSD	Least Significant Difference
MBCR	Marginal Benefit Cost Ratio
MLT	Multilocation Testing
mm	Millimeter
NGO	Non-government Organization
OFRD	On-Farm Research Division
RCBD	Randomized Complete Block Design
REY	Rice Equivalent Yield
SRDI	Soil Resource Development Institute
t	Ton
T.	Transplanted
Tk.	Taka
TVC	Total Variable Cost

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EFFECT OF FERTILIZER APPLICATION METHODS ON MAIZE GROWN UNDER STRIP TILLAGE SYSTEM IN HIGH BARIND TRACT

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Abstract

A field experiment was conducted in the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2019-20 and 2020-21 to develop the best fertilizer application method in conservation agriculture for Maize cultivation in High Barind Tract. The experiment was laid out in randomized complete block design with three replications. There were four treatments namely, T_1 = fertilizer and seeds sown simultaneously on same row by strip machine, T_2 = fertilizer and seeds sown simultaneously on different row by strip machine, T_3 = fertilizer applied on strip manually and T_4 = fertilizer broadcasted on whole plot manually. The maximum germination rate (90%) and grain yield (7.34 and 7.22 t ha⁻¹ in Yr1 and Yr2, respectively) was recorded in T_2 when fertilizer and seed were sown different rows simultaneously with strip machine. Contrarily, treatment T_1 where fertilizer and seed sown on same row simultaneously showed poor performance regarding germination rate (65 and 63% in Yr1 and Yr2, respectively), grain yield (4.11 and 4.09 t ha⁻¹ in Yr1 and Yr2, respectively) and other parameters.

Introduction

In Bangladesh, food demand is increasing day by day due to high population growth. At this juncture, only rice and wheat could not fulfill the total cereal food demand of the country. To meet up this challenge Maize can be chosen to supplement food deficiency because of its higher yield potentiality as compared to rice and wheat. Being C₄ plant Maize can accumulate dry matter faster than rice, wheat or other cereals, contributing to more yields. It has multiple uses, such as human food, animal feed and fodder, and agro-based industrial raw materials. Maize is consumed as green cob both by boiling or roasting and as pop corn. Use of Maize flour mixed with that of wheat for making flat bread (chapati) is increasing. Maize area and production are increasing day by day due to multiple use, high yield potentiality, profitability etc. Again, labour shortage is becoming acute problem in agriculture sector. In the meanwhile, Bangladesh Govt. is enforcing mechanization as well as conservation agriculture. Conservation agriculture (CA) is said to result in sustainable farming systems as it saves time, economic inputs and natural resources. Strip tillage is a prominent technology for Maize cultivation in drought prone area. Seed germination or emergence, growth and development facilitated by reduced tillage system over the conventional cultivation practices. But fertilizer management system is a challenge for ensuring better crop growth as well as grain yield. Therefore, it is necessary to find out the sustainable or efficient fertilizer application methods for the betterment of the crop.

Materials and Methods

The field trial was conducted at Farming System Research and Development site, Basantapur, Godagari, Rajshahi during Rabi 2019-20 and 2020-21 to find out the best application methods for fertilizer application in resource conservation technology for Maize cultivation. Before conducting the experiment, the soil of the experimental field was chemically analyzed in the Soil Resource Development Institute (SRDI) laboratory, Shyampur, Rajshahi. The soil of the experimental plots belongs to Amnura series under AEZ-26. The levels of the fertilizers were calculated on the basis of high yield goal as per Fertilizer Recommendation Guide 2018. The chemical properties of soil are presented in Table 1. The STB fertilizer doses were 300-75-96-34-5-1.5 kg ha⁻¹ for N-P-K-S-Zn-B, respectively. The experiment was laid out in randomized complete block design with three replications. There were four methods of basal fertilizer application namely T_1 = fertilizer + seeds in same row by machine, T_2 = fertilizer + seeds in separate row by machine, T_3 = fertilizer in strip manually and T_4 = fertilizer broadcast. Only di-ammonium phosphate (DAP) was applied mechanically. Other fertilizers were applied with top dressing. The seeds were sown in 60 cm row to row distance and seed to seed 25 cm. Seeds were sown at proper soil moisture condition on 08 December, 2019 in 1st year (Yr1) and 12 December 2020 in 2nd year (Yr2). NK-40, a commercial Maize hybrid was used as test material. After establishment of seedling, the necessary management practice was done to support normal growth of

the Maize plant. The land was fertilized as per treatment. Pesticides were applied as per schedule. The crop was harvested on 7 May, 2020 and 5 May 2021 in Yr1 and Yr2, respectively. Data were recorded on phenological, agronomic, yield and yield components and analyzed statistically with open source software R (R Core Team, 2020).

Table 1. Chemical properties of initial soil (0-15 and 16-30 cm depth) of the experimental field at FSRD site, Basantapur, Godagari, Rajshahi

Depth (cm)	pH	Organic matter (%)	K	Total N (%)	P	S	B	Zn
			meq/100g soil					
0-15	7.4	1.0	0.23	0.06	15.3	6.3	0.18	0.16
16-30	7.8	0.87	0.21	0.05	7.8	10.6	0.17	0.29
Mean	7.60	0.94	0.22	0.06	11.55	8.45	0.16	0.23
	Slightly alkaline	Low	Medium	Very low	Low	Low	Low	Very low

Results and Discussions

Most of the parameters differed significantly among the treatments were presented in Table 2. Germination rate (%) was the highest in T₂ (90%) in both years when fertilizer and seed were planted simultaneously on different rows. The T₄ where fertilizer broadcasted on whole plot manually showed similar germination performance (86-88%) to T₂. The lowest germination rate (63-65.67%) was recorded in T₁ when fertilizer and seed sown on same row simultaneously indicating that Maize seed sensitive to fertilizer especially N which might damage seed viability. Similar to germination rate, plant population (m⁻²) was the highest in treatment T₂ (6.73-6.91). Treatments T₃ (5.40-5.77) and T₄ (5.44-5.83) gave similar no. of plant population which were statistically lower than T₂. The highest plant height, grains cob⁻¹, cob length, 100-grain weight were found in same treatment T₂. The lowest performance of aforesaid parameters was recorded in T₁. Grain yield is a complex character and it depends upon on many characters. The T₂ (7.34 and 7.22 t ha⁻¹ in Yr1 and Yr2, respectively) produced the highest grain yield among the treatments due to higher no. of plant per unit area and better performance of yield components. The T₃ and T₄ gave similar grain yield between themselves in both the years. The lowest grain yield was obtained from T₁ (4.11 and 4.09 t ha⁻¹ in Yr1 and Yr2, respectively).

Table 2. Effect of Fertilizer application method on yield and yield contributing characters of hybrid Maize at Godagari, Rajshahi

Treat	Germination (%)	Pl. Popn (m ⁻²)	Plant height (cm)	Ear height (cm)	Grains cob ⁻¹ (no)	Cob length (cm)	100-grain wt. (g)	Grain yield (t ha ⁻¹)
2019-20								
T ₁	65.67c	3.08c	175.33b	78.33	374.00a	16.5c	28.06b	4.11b
T ₂	90.00a	6.91a	197.00a	75.33	454.33a	21.2a	30.63a	7.34a
T ₃	82.33b	5.77b	182.67b	70.16	434.66a	20.1ab	28.13b	6.75b
T ₄	88.00ab	5.83b	184.33ab	75.00	425.66a	18.1bc	29.63a	6.36b
LSD _(0.05)	5.75	0.81	13.76	NS	90.32	2.93	1.35	0.57
CV (%)	3.54	7.55	3.73	6.07	10.70	7.74	2.32	8.73
2020-21								
T ₁	63.00c	3.46c	183.67ab	74.67	364.67d	15.63c	26.63c	4.09b
T ₂	90.33a	6.73a	192.33a	78.00	490.00a	20.72a	31.50a	7.22a
T ₃	78.00b	5.40b	180.33b	82.00	445.33b	17.53b	27.57bc	6.33b
T ₄	86.33a	5.44b	186.67ab	83.00	412.67c	16.88bc	29.40ab	6.33b
LSD _(0.05)	6.11	1.14	10.06	NS	27.72	1.60	2.43	0.59
CV (%)	5.85	10.86	6.71	7.54	5.24	5.52	5.23	9.77

T₁= fertilizer + seeds in same row by machine, T₂= fertilizer + seeds in separate row by machine, T₃= fertilizer in strip manually and T₄= fertilizer broadcast

Conclusion

From the result, it can be concluded that fertilizer and seed could be shown separate row simultaneously for cultivation of Maize in CA system.

DEVELOPMENT OF FERTILIZER PACKAGE FOR BITTER GOURD PRODUCTION IN CHARLAND

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Abstract

An experiment was conducted in the Charland of Begumganj, Ulipur, Kurigram during the rabi season of 2020-21 to find out the suitable fertilizer package for Bitter gourd production. The experiment comprised with six treatments T_1 : STB fertilizer dose, T_2 : Liquid PGR spray 4 times T_3 : STB fertilizer dose + Liquid PGR (Biofol Super) spray 3 times (5 ml/L water), T_4 : Compost + liquid PGR spray 3 times (compost will be placed at the bottom of pit before 1 week of seed planting), T_5 : Compost + STB fertilizer + liquid PGR spray 3 times, T_6 : Farmers practice (No fertilizer). Local Bitter gourd variety (ucche) was used for this experiment. Among the treatment higher Bitter gourd fruit yield (4.23 t ha^{-1}) and gross margin (Tk 170224 ha^{-1}) was obtained from T_4 treatment followed by T_2 treatment. Fruit yield was lower in both the treatment of T_1 (3.13 t ha^{-1}) and T_6 (3.16 t ha^{-1}) and also the gross margin was lower in these treatments.

Introduction

Bitter gourd (*Momordica charantia*) known as bitter melon, bitter squash or karela is one of the most popular vegetables in Bangladesh for its nutritive and medicinal values (Nadkarni, 1982). It is rich in vitamin C (88 mg/100g) (Akter *et al.*, 2009). Bitter gourdis widely cultivated in this country during kharif season but in the charland area of Kurigram district farmers used to produce during winter when the market price is very high. The yield of Bitter gourd is low which can be attributed to lack of improved varieties, imbalanced use of fertilizers, disease, insect infestation and inadequate irrigation. Of these factors proper fertilizer management and use of good varieties can improve the situation greatly (Tindall, 1983). There is a great possibility to improve its production and quality through proper nutrient management. Thus, the experiment was undertaken to find out the suitable fertilizer package for higher and sustainable yield of Bitter gourd in charland condition.

Materials and Methods

The experiment was conducted at sandy Charland of Begumganj, Ulipur, Kurigram during the rabi season of 2019-20 to find out the suitable fertilizer package for Bitter gourd production. The experiment comprised with six treatments T_1 : STB fertilizer dose (73-30-14-13-0-0.7 kg, N-P-K-S-Zn-B ha^{-1}), T_2 : Liquid PGR (Biofol Super) spray 4 times (5 mL $^{-1}$ water), T_3 : STB fertilizer dose + Liquid PGR spray 3 times (fertilizer was placed at the bottom of pit before 1 week of seed planting), T_4 : Compost (3 t ha^{-1}) + liquid PGR spray 3 times (compost was placed at the bottom of pit before 1 week of seed planting), T_5 : Compost + STB fertilizer + liquid PGR spray 3 times, T_6 : Farmers practice (No fertilizer). Initial soil was collected from the experimental plot and analyzed accordingly, which is shown in Table 1. Local Bitter gourd variety (Ucche) was used for this experiment. The experiment was laid out in RCB design with three replications. The unit plot size was 5m $\times$ 8m. The line to line spacing was 2m and row to row spacing was 2m. Two to three feet depth pit was made with round shape spade and compost and/fertilizer was placed at the bottom of pit and covered with the same sandy soil. Then the pit mouth soaked with soil water automatically and about 1 week after the pit making sprouted seeds were planted. The seeds were planted on 07 November 2020. All other intercultural operations were done as and when necessary. Fruit harvesting was started first in farmers practice plot at 12 February, 2021 but more and last harvesting was done in compost + liquid PGR applying plot at 27 May, 2021. Data related to yield attributes and yield were collected and analyzed statistically.

Table 1. Initial soil status of the experimental plot in charland at Begumganj, Kurigram

	pH	OM (%)	Total N (%)	P	S	Zn	B	K
				$\mu\text{g/g soil}$				meq/100g soil
Value	5.7	1.49	0.08	5.25	8.6	0.34	0.19	0.18
Interpretation	Slightly acidic	L	VL	L	L	VL	L	L

VL=very low, L=Low, M=Medium, VH=Very high, OM=Organic Matter

Results and Discussions

The yield and yield attributes varied significantly with the fertilizer treatments presented in Table 2. The highest fruit harvesting duration was found in T₄ treatment (101.33 d) followed by T₅ (98.33 d) and T₂ (96.67 d) treatment. Number of fruit per plant was counted more in T₄ treatment (250.33) followed by T₅ (248.33) and T₂ (247.67) treatment, where the lowest fruit per plant was produced in T₁ treatment. Maximum single fruit weight was measured in T₄ treatment (6.75 g) followed by T₂ (6.39 g) treatment and the lowest was found in T₆ treatment (5.37 g). Higher fruit yield was obtained from T₄ (4.23 t ha⁻¹) followed by T₂ (3.96 t ha⁻¹) and the lowest fruit yield was obtained from T₁ (3.13 t ha⁻¹). It was found that application of chemical fertilizer had slightly negative effect on Bitter gourd production in hot and dry charland condition. When too much fertilizer add to the soil, plants may not be taken up water. Plants rely on an osmotic pressure gradient in order to collect water. Fertilizer may act as a salt and can increase the concentration of limited water of sandy soil which may be more concentrate than plant root sap. In such case reverse osmosis may be happened in plant which can hamper plant growth. In the present study when fertilizers were applied in the sandy soil for Bitter gourd production, it caused plant weak and sometimes damage.

Cost and return analysis

Higher gross return (Tk 232449 ha⁻¹) and gross margin (Tk 170224 ha⁻¹) was obtained from T₄ treatment because of its higher fruit yield and moderate fertilizer cost compare to other treatments (Table 3).

Pest incidence

Infestation of aphid and leaf blight disease were observed partially and controlled successfully by chemical spray.

Farmers' opinion

Farmers opined that the plant and fruit was found better in T₄ treatment where compost and liquid PGR were applied and this system gave higher yield. But they expressed their interest more on production of Bitter gourd with only PGR spray because compost application is slightly bothering to them in char condition. However, they are happy with the result of the experiment and getting higher market price at early harvesting stage but expressed sorrows that mid to later stage, the market price had fallen severely.

Table 2. Yield and yield contributing characters of Bitter gourd as affected by different fertilizer packages at Charland of Begumganj, Ulipur, Kurigram during 2020-21

Treatment	Fruit harvesting duration (d)	Fruit plant ⁻¹ (no)	Single fruit wt (g)	Fruit yield (t ha ⁻¹)
T ₁ : STB fertilizer	78.67e	231.00e	5.41d	3.13f
T ₂ : Liquid PGR (Biofol Super) spray 4 times	96.67b	247.67b	6.39b	3.96b
T ₃ : STB fertilizer + Liquid PGR spray 3 times	90.00c	241.67c	5.42d	3.27d
T ₄ : Compost + Liquid PGR spray 3 times	101.33a	250.33a	6.75a	4.23a
T ₅ : Compost + STB fertilizer + Liquid PGR spray 3 times	98.33b	248.33b	6.19c	3.84c
T ₆ : Farmers practice (No fertilizer)	86.33d	235.33d	5.37d	3.16e
LSD (0.05)	1.81	1.36	0.05	0.02
CV (%)	7.45	7.57	6.41	6.15

Table 3. Cost and return analysis of Bitter gourd as affected by different fertilizer packages at Charland of Begumganj, Ulipur, Kurigram during 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ :STB fertilizer	171930	65445	106485
T ₂ :Liquid PGR (Biofol Super) spray 4 times	217715	59225	158490
T ₃ :STB fertilizer +Liquid PGR spray 3 times	180095	68500	111595
T ₄ :Compost+Liquid PGR spray 3 times	232449	62225	170224
T ₅ :Compost+STB fertilizer + Liquid PGR spray 3 times	211355	71500	139855
T ₆ : Farmers practice (No fertilizer)	173867	56625	117242

Price: (Tk kg⁻¹): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, ZnSO₄: 220, Boric acid: 440, Biofol super:315; Bitter gourd: 55 (100 to 10).

Conclusion

The application of liquid PGR (Biofol super) as well as compost has a positive effect on plant survival duration as well as fruit bearing capacity. Conversely, chemical fertilizer had a negative effect on Bitter melon in dry sandy Charland condition which need to investigate further in next year.

DEVELOPMENT OF FERTILIZER PACKAGE FOR GARLIC-MAIZE-T.AMAN RICE CROPPING PATTERN IN THE CHARLAND

Md. Samim Hossain Molla, Zannatul Ferdouse, Md. Al-Amin Hossain Talukder, M Akkas Ali, M Shahiduzzaman

Abstract

A study was undertaken at stable charland of Ulipur, Kurigram during 2019-20 to find out an optimum and economic fertilizer dose for Garlic-Maize-T.Aman rice cropping pattern. The soil of the experimental field was chemically analyzed, and levels of the fertilizers were calculated on the basis of target yields as per Fertilizer Recommendation Guide' 2018. The treatments were T₁: Soil test based fertilizer dose, T₂: IPNS with 5 t cow dung ha⁻¹ as of T₁, T₃: T₁+25% higher NPKS, T₄: IPNS with 5 t cow dung ha⁻¹ as of T₃, T₅: Farmers' practice employed for the trial. The yield of all crops performed better in T₄: 25% higher doses and IPNS approach nevertheless it gave the highest values of system productivity (25.48 t ha⁻¹), production efficiency (79.87 kg ha⁻¹ day⁻¹), gross return (Tk 662462 ha⁻¹) and gross margin (Tk 351862 ha⁻¹). But the MBCR was higher in T₁ (6.40) treatment. The IPNS including treatments showed more production cost due to relatively higher price of cow dung.

Introduction

The yield of major crops has been a gradually declining or stagnating in almost all over Bangladesh. This is mainly due to the degradation of soil fertility status of the soil. The low organic matter content, higher cropping intensity, improper cropping sequence and faulty management practices are the major causes of depletion of soil fertility. Intensive use of high yielding varieties of crop has led to a sharp increase in removal of plant nutrients. Imbalance use of fertilizers is a serious problem for the country. Moreover, farmers usually did not use any organic fertilizers in the most of areas of the country. A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter (BARC, 2005). Organic matter content of top soils under high land and medium high land situation has been declining over time. It was believed that the declining productivity of this country's soils is the result of depletion of organic matter due to increasing cropping intensity, higher rates of decomposition of organic matter under the prevailing hot and humid climate, use of lesser quantities of organic manure and little or no use of green manure practices. To maintain and improve soil fertility and organic matter content of the soil it felt necessary to use organic manures along with inorganic fertilizers as an integrated approach. Nutrients present in soil, added as inorganic and organic sources and the nutrient harvested by crops should be considered to develop a cropping pattern based fertilizer recommendation.

About 63805 hectares area of Kurigram district (AEZ-3) is under char land which covers about 19.4% of the total cultivated area in the district (BBS, 2012). The productivity of char land is very poor. The practice of Garlic-Maize-T.Aman rice cropping pattern is increasing in Ulipur, Kurigram. The present system of fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carry-over effect of the fertilizer applied to the preceding crop(s). Some nutrients (P, K) applied to the previous crop can benefit the succeeding crop to a good extent and the system productivity may become economic through cropping pattern based fertilizer application. On Farm Research Division, BARI, Rangpur has developed a location specific cropping pattern Garlic-Maize-T.Aman rice for stable charland of Ulipur, Kurigram. The cropping pattern is highly productive but very nutrient exhaustive. This cropping pattern can hamper soil fertility if nutrient management is not use in judiciary. For sustainable crop productivity and sustenance of soil fertility the experiment was undertaken to develop

the optimum fertilizer dose for higher productivity and profitability for Garlic-Maize-T.Aman rice cropping pattern in stable charland area.

Materials and Methods

A field experiment was conducted at stable charland of Char Goraipiar, Thetrai, Ulipur, Kurigram under On-Farm Research Division, Bangladesh Agricultural Research Institute, Rangpur during 2019-20 to develop cropping system-based an optimum and economic fertilizer dose for Garlic-Maize-T. Aman rice cropping pattern. Before conducting the experiment, the soil of the experimental field was chemically analyzed. The soil of the experimental plots belongs to AEZ-3. The levels of the fertilizers were calculated on the basis of Fertilizer Recommendation Guide' 2018. The chemical properties of soil are presented in Table 1. The experiment was designed with five treatments and laid out in a randomized complete block design with three replications. The treatments were T₁: Soil test based fertilizer dose (FRG' 2018), T₂: IPNS with 5 t ha⁻¹ cow dung as of T₁, T₃: T₁+25% higher NPKS, T₄: IPNS with 5 t ha⁻¹ cow dung as of T₃, T₅: Farmers' practice. The sources of nutrients were urea for N, TSP for P, MoP for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B. For STB treatment only chemical fertilizer was applied. The amount of mineralizable nutrients in CD were deducted and adjusted accordingly as per different IPNS treatments (BARC, 2018). The nutrient packages for different crops under Garlic-Maize-T.Aman rice cropping pattern are detailed in Table 2. Crop cycle was started with Garlic as the first crop on 1st week of December 2019. Cow dung was applied to the first crop (Garlic) only. The unit plot size was 8m × 5m. The details of the varieties used and cultural operations adopted in different crop sequences are given in Table 3. For Garlic, half of urea and MoP and all other inorganic and organic fertilizers were applied at the time of final land preparation as per treatment specification. Rest of the urea and MoP were applied in two splits at 25 and 50 days after planting. For Maize, one third of urea and all other the inorganic fertilizers were applied at final land preparation and mixed with soil and rest of urea were applied in two split at 30 and 50 days after planting. In case of T. Aman rice, all the fertilizers except urea were applied as basal. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting. Intercultural operations viz. weeding, thinning, irrigation, fungicide and insecticide spray were done in order to support normal plant growth. Fertilizer doses of Maize and T. Aman were calculated and rationalized considering residual effect of nutrient (except N) applied to previous crop (Garlic) (BARC, 2018). Data on yield and yield contributing characters of each crop were recorded from 10 randomly selected plants per plot. Yield of main and by-product of each crop under various treatments were measured in each plot (5 m²) at physiological maturity stage. Data on yield of various crops in sequences were recorded and converted into ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of different treatment under crop sequence was compared by calculating their economic rice equivalent yield using formula given by Ahlawat and Sharma (1993),

Where,

$$REY = \frac{\text{Yield of each crop (t ha}^{-1}\text{) x Economic value of respective crop (Tk. t}^{-1}\text{)}}{\text{Price of rice grain (Tk t}^{-1}\text{)}}$$

Note: Grain and straw yield of each crop which has economic value was considered here.

Production efficiency: Production efficiency (PE) was calculated by taking total economic yield of the sequence on rice equivalent basis divided duration of crops (Jamwal, 2001).

$$PE = \frac{REY}{\sum Dc}$$

Where, REY= Rice equivalent yield in a sequence and Dc= Duration of crops in that sequence.

Marginal benefit cost ratio (MBCR): The economic analysis was done following the method suggested by CIMMYT (1988). The MBCR can be computed as the marginal value product (MVP) over the marginal value cost (MVC). It can be computed as

$$\text{MBCR} = \frac{\text{MVP (over control)}}{\text{MVC (over control)}}$$

Table 1. Initial soil status of the experimental plot of stable charland at Ulipur, Kurigram

	pH	OM (%)	Total N (%)	P	S	Zn	B	K
				$\mu\text{g/g soil}$				meq/100g soil
Value	5.7	1.49	0.08	5.25	8.6	0.34	0.19	0.14
Interpretation	Slightly acidic	L	VL	L	L	VL	L	L

VL=very low, L=Low, M=Medium, VH=Very high, OM=Organic Matter

Table 2. Fertilizer packages used in different treatments under Garlic-Maize-T. Aman cropping pattern during 2019-20

Crop	Treatment	Nutrient dose (Kg ha ⁻¹)						
		Cowdung	N	P	K	S	Zn	B
Garlic	T ₁ = STB	-	119	49	74	43	3.32	2.77
	T ₂ = IPNS with 5 t ha ⁻¹ cowdung as of T ₁	5000	94	42	63	43	3.32	2.77
	T ₃ = T ₁ + 25% higher NPKS	-	149	61	93	54	3.32	2.77
	T ₄ = IPNS with 5 t ha ⁻¹ cow dung as of T ₃	5000	124	54	81	54	3.32	2.77
	T ₅ = Farmer's practice	6000	142	50	38	30	3.00	-
Maize	T ₁ = STB	-	265	53	69	50	4.56	-
	T ₂ = IPNS with 5 t ha ⁻¹ cowdung as of T ₁	-	265	53	69	50	4.56	-
	T ₃ = T ₁ + 25% higher NPKS	-	332	67	86	62	4.56	-
	T ₄ = IPNS with 5 t ha ⁻¹ cow dung as of T ₃	-	332	67	86	62	4.56	-
	T ₅ = Farmer's practice	-	280	30	50	15	3.00	-
T. Aman	T ₁ = STB	-	62	8	30	10	1.42	-
	T ₂ = IPNS with 5 t ha ⁻¹ cowdung as of T ₁	-	62	8	30	10	1.42	-
	T ₃ = T ₁ + 25% higher NPKS	-	78	9	38	13	1.42	-
	T ₄ = IPNS with 5 t ha ⁻¹ cow dung as of T ₃	-	78	9	38	13	1.42	-
	T ₅ = Farmer's practice	-	72	7	25	5	1.00	-

T₁: Soil test based fertilizer dose (FRG' 2018), T₂: IPNS with 5 t ha⁻¹ cow dung as of T₁, T₃: T₁+25% higher NPKS, T₄: IPNS with 5 t ha⁻¹ cow dung as of T₃, T₅: Farmers' practice

Table 3. Details of cultural practices adopted for different crops in field experiments

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of planting	Date of harvesting
Garlic	BARI Rasun-1	450	10 × 10	1 st week Dec.	1 st week April
Maize	BHM-9	30	60 × 20	2 nd week April	1 st week Aug.
T. Aman	BRRI dhan75	40	20 × 15	2 nd week Aug	1 st week Nov.

Results and Discussions

Effect of nutrient packages on Garlic: Bulb yield and single bulb weight of Garlic were responded significantly to different nutrient packages, but other plant characters were insignificant (Table 4). The highest bulb yield (5.54 t ha⁻¹) was obtained from treatment T₃ and was statistically identical with treatment T₄ (5.44 t ha⁻¹). The lowest yield (4.99 t ha⁻¹) was obtained from farmers' practice plot (T₅). Treatments T₂ (5.26 t ha⁻¹) produced slightly higher bulb yield than T₁ (5.22 t ha⁻¹) but statistically identical. The application of higher doses of fertilizer along with cow dung increased the bulb yield of Garlic. Better performance of yield components was contributed to higher yield in T₃ and T₄. The single bulb weight followed the similar order as was observed in bulb yield. The T₅ (16.08 g) produced the lowest bulb weight. The maximum rice equivalent yield (REY) was obtained from T₃ (12.78 t ha⁻¹) and minimum from T₅ (11.52 t ha⁻¹).

Effect of nutrient packages on Maize: Nutrient packages influenced yield and yield attributes of Maize (Table 5). The treatment T₄ produced the highest grain yield of Maize (10.73 t ha⁻¹), which was statistically identical with T₃ treatment (10.30 t ha⁻¹). Identically second highest yield was obtained from T₂ (9.40 t ha⁻¹) and T₁ treatment (9.13 t ha⁻¹) while the lowest grain yield (8.15 t ha⁻¹) was found in farmers' practice treatment (T₅). The highest seed yield in the treatment T₄ contributed by higher number of grain cob⁻¹ (410.67) and 1000-grain weight (291.33g). This might also be due to residual effect of

organic manure in the succeeding crop. However, Maize yield was relatively low, and it might be due to high temperature during *Kharif-2* season and short flash flood during harvesting stage. Stover yield of Maize resembled with the grain yield (Table 5). Consequently, stover yield was the highest in T₄ (11.02 t ha⁻¹) and the lowest in T₅ (8.27 t ha⁻¹). The REY was maximum in T₄ (7.03 t ha⁻¹) and minimum in T₅ (5.33 t ha⁻¹).

Yield of T. Aman rice: T. Aman rice is the common crop in the *Kharif-2* season in Bangladesh. Nutrient treatments had significant impact on grain yield of rice (Table 6). Identically higher 1000-grain weight was measured in T₁, T₂, T₃ and T₄ treatment but statistically different from T₅. The T₄ treatment gave the highest grain yield (4.86 t ha⁻¹). The T₃ treatment (4.80 t ha⁻¹) produced the second highest grain yield followed by T₂ (4.79 t ha⁻¹). The farmers package T₅ (4.46 t ha⁻¹) showed the lowest grain yield of T. Aman rice. Higher fertilizer doses as well as succeeding effect of organic amended treatments produced better yield components which eventually contributed to higher grain yield. The T₄ (5.41 t ha⁻¹) also recorded the highest straw yield among all other treatments. The T₃ (5.29 t ha⁻¹) and T₂ (5.25 t ha⁻¹) showed identical straw yield with the lowest in T₅ (4.91 t ha⁻¹). The T₁ recorded 5.23 t ha⁻¹ straw yield. The maximum rice equivalent yield (REY) was obtained from T₄ (5.90 t ha⁻¹) and minimum from T₅ (5.41 t ha⁻¹).

System productivity: System productivity is considered as system rice equivalent yield (REY). The system REY of the cropping pattern varied significantly by nutrient treatment (Table 7). The T₄ package (25.48 t ha⁻¹) recorded the greatest system REY among all other packages. The system REY in T₃ and T₂ were 25.34 and 24.08 t ha⁻¹. The lowest system REY was obtained from T₅ (22.26 t ha⁻¹). Total productivity increased by 14.47%, 13.84%, 8.18% and 6.69% in T₄, T₃, T₂ and T₁, respectively over T₅.

Production efficiency (PE): Production efficiency was influenced by nutrient treatment (Table 7). The T₄ (79.87 kg ha⁻¹ day⁻¹) gave the maximum PE followed by T₃ and T₂. The lowest PE was recorded in T₅ (69.79 kg ha⁻¹ day⁻¹).

Cost and return analysis

Nutrient packages attributed a remarkable impact on variable cost, gross return, gross margin and marginal benefit cost ratio (MBCR) (Table 7). The variable cost, annual gross return and gross margin were considered for choosing suitable technology. In general, higher fertilizer doses treatment markedly enhanced the variable cost. Consequently, the T₄ had higher variable cost (Tk. 310600 ha⁻¹) due to higher cost of fertilizer and manure followed by T₃ (Tk. 308600 ha⁻¹) and T₂ (Tk. 299000 ha⁻¹) while farmers fertilizer package (T₅) recorded the lowest cost (Tk. 290950 ha⁻¹). Again, the T₄ had higher gross return (Tk. 662462 ha⁻¹) and gross margin (Tk. 351862 ha⁻¹). Gross return and gross margin were also the lowest in farmers fertilizer package (T₅). MBCR was higher in mineral fertilizer packages T₁ (6.40) and T₃ (4.53) compared to their equivalent fertilizer doses treatment which are contained organic manure cow dung and it indicates that manure influenced the cultivation cost and eventually the MBCR.

Table 4. Yield and yield attributes of Garlic under Garlic-Maize-T. Aman cropping pattern as affected by different fertilizer packages during 2019-20

Treatment	Plant height (cm)	Plant population m ⁻² (no)	Leaves plant ⁻¹ (no)	Single bulb weight (g)	Bulb yield (t ha ⁻¹)	REY (t ha ⁻¹)
T ₁ = STB	50.97	39.00	5.57	17.05a	5.22c	12.05
T ₂ = IPNS with 5 t ha ⁻¹ CD	53.27	39.33	5.43	17.40a	5.26bc	12.13
T ₃ = T ₁ + 25% higher NPKS	56.07	38.67	6.17	17.89a	5.54a	12.78
T ₄ = IPNS based on T ₃ treatments	54.43	40.00	6.20	17.55a	5.44ab	12.55
T ₅ = Farmer's practice	52.07	39.33	5.33	16.08b	4.99d	11.52
LSD _{0.05}	NS	NS	NS	0.84	0.19	-
CV (%)	6.04	3.15	7.72	5.55	5.89	-

Table 5. Yield and yield attributes of Maize under Garlic-Maize-T. Aman cropping pattern as affected by different fertilizer packages during 2019-20

Treatment	Plant ht (cm)	Ear ht (cm)	Cob length (cm)	Grain cob ⁻¹ (no)	1000-grain wt (g)	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	REY (t ha ⁻¹)
T ₁ =STB	165.27	140.10	29.30	392.67b	281.00d	9.13b	9.27b	5.98
T ₂ =IPNS with 5 t ha ⁻¹ CD	182.77	139.13	28.70	392.33b	282.67c	9.40b	9.52b	6.15
T ₃ =T ₁ + 25% higher NPKS	180.37	134.27	28.17	396.67ab	288.67b	10.30a	10.66a	6.75
T ₄ =IPNS based on T ₃	177.50	136.90	28.43	410.67a	291.33a	10.73a	11.02a	7.03
T ₅ =Framer's practice	174.57	136.27	24.53	381.67b	271.67e	8.15c	8.27c	5.33
LSD _{0.05}	NS	NS	NS	17.46	1.35	0.44	0.41	-
CV (%)	5.34	7.23	7.40	6.51	5.25	5.28	6.37	-

Table 6. Yield and yield attributes of T. Aman under Garlic-Maize-T. Aman cropping pattern as affected by different fertilizer packages during 2019-20

Treatment	Plant height (cm)	Tiller hill ⁻¹ (no)	Panicle length (cm)	Grain panicle ⁻¹ (no)	1000-grain wt (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	REY (t ha ⁻¹)
T ₁ = STB	79.87	8.20	21.63	120.60	25.23a	4.72c	5.23b	5.73
T ₂ =IPNS with 5 t ha ⁻¹ CD	79.57	8.37	21.87	129.20	25.70a	4.79b	5.25b	5.80
T ₃ =T ₁ + 25% higher NPKS	78.20	7.53	21.57	128.07	25.80a	4.80b	5.29b	5.81
T ₄ =IPNS based on T ₃	78.47	8.17	21.67	129.40	25.53a	4.86a	5.41a	5.90
T ₅ =Framer's practice	79.30	7.80	21.47	118.87	24.43b	4.46d	4.91c	5.41
LSD _{0.05}	NS	NS	NS	NS	0.60	0.05	0.10	-
CV (%)	9.21	8.07	7.84	7.93	3.26	4.50	5.97	-

Table 7. Rice equivalent yield and cost and return analysis of Garlic-Maize-T.Aman cropping pattern as affected by different fertilizer packages during 2019-20

Treatment	System REY (t ha ⁻¹)	Production efficiency (kg ha ⁻¹ day ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	MBCR
T ₁ = STB	23.75	74.46	617546	297000	320546	6.40
T ₂ = IPNS with 5 t ha ⁻¹ CD	24.08	75.48	626014	299000	327014	5.86
T ₃ = T ₁ + 25% higher NPKS	25.34	79.43	658823	308600	350223	4.53
T ₄ = IPNS based on T ₃	25.48	79.87	662462	310600	351862	4.26
T ₅ = Framer's practice	22.26	69.79	578820	290950	287870	-

Price (Tk. kg⁻¹): Garlic= 60, Maize grain= 16, Maize stover= 1, Rice grain= 26, Rice straw= 5

Conclusion

Organic manure has positive subsequent effect on soil as well as crop production. Besides of it, charland soil is low fertile, so it needs relatively more fertilizer than general soil. From the results, it can be concluded that STB+25% NPKS fertilizer as IPNS basis was a promising technology for higher crop yields and system productivity though STB+25% NPKS fertilizer showed higher production cost.

VALIDATION OF BIOFERTILIZER ON GROUNDNUT AT JAMALPUR REGION

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Abstract

The experiment was conducted in the farmers' field at Naovanghar Char, Jamalpur during rabi season, 2020-21. The maximum yield of nut (2.42 t ha⁻¹) was found from the T₂ where Rhizobium inoculum was applied which was followed by T₃ treatment where nitrogen was added with PKSZn and the minimum (2.20 t ha⁻¹) from only PKSZn treated treatment (T₁). The higher gross return (Tk 242000 ha⁻¹) and gross margin (Tk 154680 ha⁻¹) were obtained from T₂ treatment due to its higher yield. The lowest gross return (Tk 220000 ha⁻¹) and gross margin (Tk 133986 ha⁻¹) were recorded from T₁ treatment due to its lower yield.

Introduction

Groundnut (*Arachis hypogaea*) is an important and leguminous oilseed crop. It is cultivated during rabi and kharif under rainfed condition. It contains high protein and fat. *Bradyrhizobium* bacteria forms nodules in the roots of Groundnut plant which fixes atmospheric nitrogen and used for its own and Groundnut plants are being benefited simultaneously. Farmers of different char land areas of Bangladesh grow Groundnut after receding of flood water. BARI has developed a good number of high yielding varieties of Groundnut. Therefore, the experiment was undertaken to popularize the rhizobium biofertilizer technology for producing Groundnut in the farmer's level.

Materials and Methods

The experiment was carried out at farmer's field of Naovanghar Char, Jamalpur during rabi season, 2020-21. The study was set up in RCB design with four replications. BARI Chinabadam-9 was used in the study. The unit plot size was 10.0 m × 15.0 m. Seeds were sown on 30 November 2020. The crop was fertilized with NPKSZn at the rate of 100-22-42-40-5 kg ha⁻¹ during final land preparation. In the rhizobium inoculant treatment, 1.5 kg inoculum ha⁻¹ was applied in the seed. The treatment combination was T₁=Without Rhizobium inoculant+PKSZn, T₂=With Rhizobium+PKSZn and T₃=Only NPKSZn. The intercultural operations such as weeding, irrigation, pest control etc were done as and when necessary. The crop was harvested on 12 May, 2021. Data on yield and yield contributing characters were taken statistically analyzed following MSTAT software package and mean separation was done as per LSD test.

Results and Discussions

Results obtained from the study have been presented in Table 1. The tallest plant (39.10 cm) was obtained from T₃ treatment and the shortest (34.85 cm) was T₁ treatment. The highest number of nut/plant (18.40) was found from T₂ treatment and the lowest (17.80) in T₁ treatment. The highest 1000 seed weight (341.1 g) was observed from T₂ treatment and the lowest (333.8 g) in T₁ treatment. The maximum yield of nut (2.42 t ha⁻¹) was found from T₂ which was followed by T₃ treatment and the minimum (2.20 t ha⁻¹) from T₁ treatment.

Cost and return analysis

The higher gross return (Tk 24200 ha⁻¹) and gross margin (Tk 154680 ha⁻¹) were observed from T₂ treatment due to its higher yield. The lowest gross return (Tk 220000 ha⁻¹) and gross margin (Tk 133986 ha⁻¹) were found from T₁ treatment due to its lower yield (Table 2).

Farmer's opinion

Farmers are interested to grow BARI Chinabadam-9 with applied rhizobium inoculant due to its higher yield as well as higher income.

Table1. Yield and yield attributes of Groundnut variety at Naovanghar Char, Jamalpur during rabi season 2020-21

Treatment	Plant height (cm)	Nut plant ⁻¹ (no)	Yield m ⁻² (g)	Yield (t ha ⁻¹)
T ₁ =Without Rhizobium inoculant+PKSZn	34.85	17.80	220	2.20
T ₂ =With Rhizobium+ PKSZn	34.95	18.40	242	2.42
T ₃ =Only NPKSZn	39.10	18.35	230	2.30
LSD (0.05)	2.20	0.82	NS	0.19
CV (%)	3.51	2.64	4.50	4.90

Table 2. Cost and return analysis of Groundnut varieties at Naovanghar Char, Jamalpur during rabi season, 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ = Without Rhizobium inoculant+PKSZn	220000	86014	133986
T ₂ =With Rhizobium+ PKSZn	242000	87320	154680
T ₃ =Only NPKSZn	230000	89500	140500

Price of Groundnut =Tk 100.0 kg⁻¹

Conclusion

Considering yield potentiality and economic point of view, it was found that Rhizobium inoculum with PKSZn treatment gave better performance.

DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR MAIZE-T.AUS-T. AMAN CROPPING PATTERN IN KARATOA BANGALI FLOODPLAIN

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Abstract

The trial was conducted in the farmers' field of Multi Location Testing Site, Sherpur, Bogura during Rabi season of 2020-21 FY to develop a suitable fertilizer recommendation for Maize-T.Aus-T.Aman rice cropping pattern. For the first crop (Maize) the treatments were T₁: Soil Test Based dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁@ 5 ton cow dung ha⁻¹ and T₅: IPNS based on T₃@ 5 t ha⁻¹ of cow dung. According to the treatment specifications the STB and other doses were estimated. Treatments were assigned randomly, and fertilizer doses were applied accordingly following randomized complete block design. Maximum grain yield (8.56 t ha⁻¹) was recorded from T₃ treatment that was statistically similar to T₂ and T₅ and the minimum (6.92 t ha⁻¹) from T₄ treatment. Similar trend was observed in stover yield also. The highest gross return (Tk 182750 ha⁻¹) was amounted from T₃ treatment against the cultivation cost of Tk 110454 ha⁻¹ that together led to the higher gross margin (Tk 72256 ha⁻¹). Lower gross return (Tk 147640 ha⁻¹) as well as gross margin (Tk 38768 ha⁻¹) was obtained from the T₄ treatment.

Introduction

Bangladesh is a densely populated (1008 per sq. km.) country of the world with an area of 1,47,570 sq. km and the present population is about 170 million, with an increase annually at the rate of about 1.42% per year (BBS, 2018). The major challenge for the agriculture sector of Bangladesh is to increase and sustain crop yield and production. This is possible through cropping intensification with high-yielding varieties of balanced fertilizer and proper soil fertility management. The present soil fertility status of Bangladesh is alarming. The use of organic manures to meet the nutrient requirements of the crop would be an inevitable practice in the years to come for sustainable agriculture since organic manures not only improve the soil physical, chemical, and biological properties (Heitkamp *et al.*, 2011) But also improves the moisture-holding capacity of the soil, thus resulting in enhanced crop productivity along with the better quality of crop produce (Premsekhar and Rajashree, 2009). Hence, fertilizers, manures, and other amendments either alone or in combinations could be used to develop a nutrient supplying capacity of the soil (Dutta and Sangam, 2014). The application of poultry manure increasing the pH, P, K, Ca, Mg, and Mn, in the soil, more effectively when compared to other animal manures (Wijejawardena 2000). In rice-based cropping system Maize-T.Aus-T.Aman is one of the major cropping patterns in Sherpur Upazila of Bogura which cover around 1330 hectare of land. The present cropping intensity of Sherpur is 251% by improving the present cropping pattern. Sustainable crop production in Bangladesh through the improvement of cropping patterns in rice-based cropping systems is regarded as increasingly important in national issues such as food security, poverty alleviation, and the creation of job opportunities. The cropping pattern can hamper soil fertility if nutrient management is not judicious use. However, there is still no recommended fertilizer dose for Maize-T.Aus-T.Aman cropping pattern, crop production, fertilizer management is the most logical way to raise total production. Thus, it is necessary to find out the optimum fertilizer dose for Maize-T.Aus-T.Aman cropping pattern in the Bogura region. Hence the program was undertaken to find out a suitable and economic fertilizer dose for sustainable crop productivity and soil fertility for Maize-T.Aus-T.Aman cropping pattern and increase the productivity and income of the farmers.

Materials and Methods

The trial was conducted in the farmers' field of Multi Location Testing site, Sherpur, Bogura during Rabi season of 2020-21 FY to develop a suitable fertilizer recommendation for Maize-T.Aus-T.Aman rice

cropping pattern. The experiment was laid out in a randomized complete block design with three replications. There were five treatments for each crop. Maize was the first crop in the sequence. The soils belong to the AEZ-4. Initially, the soil samples were collected from different points of the experimental field and analyzed to determine the nutrient status of the soils. Nutrient status of the soils presented in Table 1. Based on soil test values, fertilizer doses for respective treatment were estimated. For the subsequent crops i.e., T. Aus and T. Aman rice, fertilizer doses to be rationalized based on the doses applied for the first crop Maize.

Operations related to Maize cultivation

After selection of land and subsequent collection of soil samples and analysis, the land was well prepared through tillage followed by laddering. Then borders alongside the ages of the 15 plots were made leaving water channels in between the plots. Then fertilizer doses for each treatment were calculated based on the soil test report. For the first crop (Maize), the treatments were T₁: STB dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁ @ 5 ton cow dung ha⁻¹ of and T₅: IPNS based on T₃ @ 5 t cow dung ha⁻¹ of. According to the treatment specifications, the STB and other doses were estimated as T₁ = N-P-K-S-Zn-B @ 238.07-72.74-68.93-32.32-4.68-1.20 kg ha⁻¹; T₂ = N-P-K-S-Zn-B @ 297.59-72.74-86.17-32.32-4.68-1.20 kg ha⁻¹; T₃ = N-P-K-S-Zn-B @ 297.59-90.93-86.17-32.32-4.68-1.20 kg ha⁻¹; T₄ = CD-N-P-K-S-Zn-B @ 5000-213.07-65.24-57.43-32.32-4.68-1.20 kg ha⁻¹; T₅ = CD-N-P-K-S-Zn-B @ 5000-272.59-83.43-74.67-32.32-4.68-1.20 kg ha⁻¹ respectively. Before sowing of seed, all the fertilizers except urea were applied as basal thoroughly mixed with the soils. Treatments were assigned randomly, and fertilizer doses were applied accordingly following RCB design. The unit plot size was 40 m². Seeds of BARI Hybrid Maize-9 (BHM-9) @ 25 kg ha⁻¹ were sown on 26 November 2020 following a spacing of 60cm × 20cm. At the final stage of land preparation, one third of the approved urea and all other fertilizers was broadcast followed by tilling and leveling. The remaining urea was applied in equal to 2 installments. The first installment was applied at 35 days after seed germination (8-10 leaf stage) and the second installment at 60-65 days after seed germination (male flowering stage). Excess seedlings were removed from the land within 30 days of seedling emergence. The land was kept weed-free till the seedlings were one month old. Four irrigations were provided at 30, 45, 70, and 90 DAS respectively to facilitate necessary soil moisture essential for plant growth and development. Fertilizer Recommended Guide (BARC, 2018) along with the application methods followed for rationalizing the treatments in order to support the normal growth of the crops. Initially, Spodoptera pheromone @ 40 traps ha⁻¹ was set to control common cutworm. The crop was then sprayed with Proclaim 5 SG @ 1g/L at 7-10 days intervals to control Fall Armyworm. Beside this SNPV @ 0.2 g/L was applied as biocontrol measurement against fall armyworm. In some cases, leaf blight was observed and Rovral 50wp @ 2g/L was sprayed to control blight. The crop was harvested on 13 May 2021. The economic indices i.e., gross return, gross margin, and cultivation cost were also calculated based on the prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

Table 1. Average nutrient status of initial soil (0-15 & 15-30 cm depth) of the experimental fields at MLT site, Sherpur, Bogura

Matter	pH	OM (%)	Total N (%)	K (meq 100g ⁻¹ soil)	P	S	Zn	B
Value	5.95	1.55	0.085	0.172	8.254	17.145	0.321	0.263
Interpretation	N	L	L	M	L	L	VL	L

N= Neutral, M=Medium, L=Low, VL=Very low

Results and Discussions

Yield and yield contributing parameters are presented in Table 2. All the parameters were varied significantly among the treatments. Maize plants responded better with the higher amount of fertilizer applied to the field. Higher yield and yield contributing characters were associated with a higher amount of fertilizer. Higher plant height (175.36 cm) was recorded from T₃ treatment which was identical with T₂ and T₅ treatments and the lower (161.48 cm) from T₄ treatment. Extra N-P-K applied to the T₂, T₃, and T₅ treatments might be helpful for better plant growth and development. On the contrary, plants under T₁ and T₅ showed slightly stunting in nature as N-P-K were applied in lesser amount in the said treatments. Healthy plants produced longer cobs than those of stunted ones. Cob length was maximum (17.24 cm) in T₄ treatment which is statistically identical to T₂ and T₅ and the minimum (15.10 cm) was recorded in T₄

treatment which was like T₁. The maximum number of grain cob⁻¹ (460.23) was obtained from T₃ treatment followed by T₂ treatment (450.67) and the minimum (402.15) from T₄ treatment. A similar trend was observed for hundred-grain weight. Hundred-grain weight was almost identical in all the treatments. However, it was ranged from 22.21 g in T₄ to 26.65 g in T₃ treatment. It was observed that higher grain weight was associated with the boldness of the seeds. Higher yield contributing characters resulted in higher yield for the respective treatments. Maximum grain yield (8.56 t ha⁻¹) was recorded from T₃ treatment that was statistically similar to T₂ and T₅ and the minimum (6.92 t ha⁻¹) from T₄ treatment. A more or less similar trend was observed for the stover yield of the Maize. However, numerically stover yield was ranged from 6.16 t ha⁻¹ in T₄ to 7.70 t ha⁻¹ in T₃ treatment.

Cost and return analysis

Cost and return related information were presented in Table 3. From the presented data, it was observed that maximum yield provided maximum return and vice versa. The highest gross return (Tk 182750 ha⁻¹) was amounted to T₃ treatment against the cultivation cost of Tk 110454 ha⁻¹ that together led to the higher gross margin (Tk 72256 ha⁻¹). T₂ scored the second position regarding cost and return. Lower gross return (Tk 147640 ha⁻¹) as well as gross margin (Tk 38768 ha⁻¹) was obtained from the T₄ treatment. Though higher doses in T₁ and T₂ treatments coexisted with higher cultivation costs, the higher return from the higher yield resulted in a higher gross margin in said treatments.

Farmers' opinion: Higher doses of fertilizer resulted in higher yield and economic return.

Table 2. Yield parameter and yield of Maize as influenced by different nutrient treatment combinations in MLT site, Sherpur, Bogura during 2020-21 cropping season

Treatment	Plant height (cm)	Cob length (cm)	Grain cob ⁻¹ (no)	100 grain weight (g)	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁ : STB	165.72 b	15.12 b	408.82 b	22.67 b	7.15 b	6.31 b
T ₂ : T ₁ +25% NPK	172.57 a	16.78 a	450.67 a	24.59 ab	8.34 ab	7.52 a
T ₃ : T ₁ +50% NK	175.36 a	17.24 a	460.23 a	26.65 a	8.56 a	7.70 a
T ₄ : IPNS on T ₁ (5 t CD ha ⁻¹)	161.48 c	15.10 b	402.15 b	22.21 b	6.92 c	6.16 b
T ₅ : IPNS on T ₃	171.25 ab	16.95 a	438.54 ab	24.42 ab	7.85 ab	7.13 ab
CV%	8.34	5.61	4.68	4.72	6.17	7.38

NT₁: STB dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁ @ 5 ton cow dung ha⁻¹ of and T₅: IPNS based on T₃ @ 5 t cow dung ha⁻¹. T₁=N-P-K-S-Zn-B @ 238.07-72.74-68.93-32.32-4.68-1.20 kg ha⁻¹; T₂=N-P-K-S-Zn-B @ 297.59-72.74-86.17-32.32-4.68-1.20 kg ha⁻¹; T₃=N-P-K-S-Zn-B @ 297.59-90.93-86.17-32.32-4.68-1.20 kg ha⁻¹; T₄=CD-N-P-K-S-Zn-B @ 5000-213.07-65.24-57.43-32.32-4.68-1.20 kg ha⁻¹; T₅=CD-N-P-K-S-Zn-B @ 5000-272.59-83.43-74.67-32.32-4.68-1.20 kg ha⁻¹

Table 3. Cost and return of Maize as influenced by different nutrient treatment combinations in MLT site, Sherpur, Bogura during 2020-21 cropping season (Average data)

Treatment	Gross return (Tk ha ⁻¹)			Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
	Grain	Stover	Total		
T ₁ : STB	143000	9465	152465	105910	46555
T ₂ : T ₁ +25% NPK	166800	11280	178080	108493	69587
T ₃ : T ₁ +50% NK	171200	11550	182750	110494	72256
T ₄ : IPNS on T ₁ (5 t CD ha ⁻¹)	138400	9240	147640	108872	38768
T ₅ : IPNS on T ₃	157000	10695	167695	113456	54239

Input Price (Tk/kg): Urea: 16; TSP: 22; MoP: 15; Gypsum: 10; ZnSO₄: 150; Boric acid: 150; Cow dung: 1

Output price (Tk/kg): Maize grain: 20; Stover: 1.5

Conclusion

Considering the yield and economic return, T₂, T₃, and T₅ were found suitable for Maize cultivation. Extra application of N, P, and K essential nutrient elements was found suitable for better plant growth and development and consequently for higher grain yield of Maize. Despite having a slightly higher cultivation cost due to the use of a higher rate of fertilizers, treatments T₂, T₃, and T₅ were found profitable for higher grain yield. Therefore, it could be recommended that farmers may apply 25% NPK or 50% NK as extra with the STB dose for higher yield and return from Maize cultivation.

DEVELOPMENT OF FERTILIZER PACKAGE FOR MAIZE AT CHARLAND CONDITION

M. A. Islam, M. S. Alam, M. R. A. Mollah, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted in the farmers' field under the Multi Location Testing site, Dhunat for two consecutive years during the Rabi season of 2019-20 and 2020-21 to develop a suitable fertilizer recommendation for Maize cultivation at stable char land condition. The experiment was laid out in a randomized complete block design with three replications. There were five treatments i.e., T₁: STB dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁ @ 5 t ha⁻¹ of cow dung, and T₅: Farmers Practice. Maximum grain yield (11.16 t ha⁻¹ in 2019-20 and 11.65 t ha⁻¹ in 2020-21) was recorded from T₃ that was statistically similar to T₂ and T₁ and the minimum (8.43 t ha⁻¹ in 2019-20 and 8.62 t ha⁻¹ in 2020-21) from farmers practice (T₅) treatment. A similar trend was observed for stover yield. The highest gross return (Tk 241243 ha⁻¹) and gross margin (Tk 127508 ha⁻¹) were recorded from T₃ treatment where 50% N and K were added as extra dose with STB dose and the lowest gross return (Tk 180348 ha⁻¹), as well as gross margin (Tk 82028 ha⁻¹) was obtained from the farmer's practice (T₅).

Introduction

Recently a great part of the Charland is brought under crop cultivation. Soil fertility and productivity of the Charland are much lower than in other parts of the country. A higher proportion of sands, very low organic matter, low water holding capacity, and poor nutrient content of soils are the major causes for lower productivity. Maize is now a popular crop in Charland. Maize is a heavy feeder of nutrients; hence, it withdraws a high amount of nutrients from the soil. To produce one ton of grain and dry matter, Maize crop withdraws 20 kg of N, 3.5 kg of P₂O₅, 20 kg of K₂O, and 4 kg of S from the soil (BARC, 2005). The use of chemical fertilizers as a supplemental source of nutrients has been increasing steadily in Bangladesh but most of the farmers usually do not apply it in balanced proportions (BARC, 1997). Besides these, the common phenomena of char soil are low contained micronutrients especially B, Zn, Mg, etc. Recently, it is noticed in the Charland of Sariakandi and Dhunat area that a large area of Maize failed to cob formation which caused yield loss in Maize drastically. Considering the above facts, the experiment has been designed to find out an optimum fertilizer dose for a higher yield of Maize in Charland areas.

Materials and Methods

The trial was conducted in the farmers' field of Multilocation Testing Site, Dhunat during the *Rabi* season of 2019-20 and 2020-21 FY to develop a suitable fertilizer recommendation for Maize cultivation at stable Charland condition. The experiment was laid out in a randomized complete block design with three replications. There were five treatments i.e., T₁: STB dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁ @ 5 t ha⁻¹ of cow dung, and T₅: Farmers practice. STB dose as well as other corresponding treatments' fertilizer was amounted based on soil test values. STB dose was N-P-K-S-Zn-B @ 253.46-52.00-110.00-35.97-5.40-1.19 kg ha⁻¹ and the farmer's dose was estimated from the average surveyed data of 20 farmers who used to grow Maize. Farmers generally used NPKSZNB @ 152.07-56.00-57.50-17.99-0-1.0 kg ha⁻¹. The unit plot size was 40 m². Seeds of BARI Hybrid Maize-9 (BHM-9) @ 25 kg ha⁻¹ were sown on 26 November, 2019 and 18 November, 2020 following a spacing of 60cm × 20cm. At the final stage of land preparation, one-third of the approved urea and all other fertilizers were broadcast followed by tilling and leveling. The remaining urea was applied in equal 2 installments. The first installment was applied at 35 days after seed germination (8-10 leaf stage) and the second installment at 60-65 days after seed germination (male flowering stage). Excess seedlings were removed from the land within 30 days of seedling emergence. The land was kept weed free till the seedlings were one month old. Four irrigations were provided at 30, 45, 70, and 90 DAS respectively to facilitate necessary soil moisture essential for plant growth and development. Fertilizer Recommended Guide (BARC, 2018) along with the application methods were followed for rationalizing the treatments in order to support the normal growth of the crops. Initially, Spodoptera pheromone @ 40 traps ha⁻¹ was set to control common cutworm. The crop was then sprayed with Proclaim 5 SG @ 1g/L at 7-10 days intervals to control Fall Armyworm. Beside this SNPV @ 0.2 g/L was applied as biocontrol measurement against fall armyworm. In some cases, leaf blight was observed and Rovral 50wp @ 2g/L was sprayed to control blight. The crop was harvested on 25 May 2020 16 May 2021. The economic indices i.e., gross return, gross margin, and cultivation cost were

also calculated based on the prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

Table 1. Average nutrient status of initial soil (0-15 & 15-30 cm depth) of the experimental fields at Dhunat, Bogura

Matter	pH	OM (%)	Total N (%)	K (meq 100g ⁻¹ soil)	P	S	Zn	B
					$\mu\text{g g}^{-1}$ soil			
Value	6.56	1.07	0.053	0.163	5.79	16.24	0.39	0.09
Interpretation	N	L	VL	L	VL	M	VL	VL

N= Neutral, M=Medium, L=Low, VL=Very low

Results and Discussions

Yield and yield contributing parameters are presented in Tables 2 and Table 3. All the parameters were varied significantly except cob length. Higher plant height (222.43 cm in 2019-20 and 228.97 cm in 2020-21) was recorded from T₃ treatment which was identical with T₁, T₂, and T₄ treatments and the lower (195.43 cm in 2019-20 and 210.84 cm in 2020-21) from T₅ treatment (farmers practice). The maximum number of grain cob⁻¹ (523.73) was obtained from T₃ treatment followed by T₂ treatment (502.00) and the minimum (477.80) from T₅ treatment. A similar trend was observed for the number of grain cob⁻¹ in 2020-21. Hundred grain weight was almost identical in all the treatments in both years. However, it was ranged from 23.42 g in T₅ to 26.45 g in T₃ in 2019-20 and from 23.75 g in T₅ to 26.92 g in T₃ in 2020-21. Maximum grain yield (11.16 t ha⁻¹ in 2019-20 and 11.65 t ha⁻¹ in 2020-21) was recorded from T₃ that was statistically similar to T₂ and T₁ and the minimum (8.43 t ha⁻¹ 2019-20 and 8.92 t ha⁻¹) from T₅ treatment. A similar trend was observed for stover yield in both years.

Cost and return analysis

Cost and return related information from the two year observation were presented in Table 4. From the mean data, it was observed that maximum yield provided maximum return and vice versa. The highest gross return (Tk 241203 ha⁻¹) was amounted to T₃ treatment against the cultivation cost of Tk 113695 ha⁻¹ that together led to the higher gross margin (Tk 127508 ha⁻¹). The treatment T₂ scored the second position regarding cost and return. Lower gross return (Tk 180348 ha⁻¹) as well as gross margin (Tk. 82028 ha⁻¹) was obtained from the farmer's practice (T₅ treatment). Though the higher doses in T₁ and T₂ treatments incurred higher cultivation costs the higher return from the higher yield resulted in a higher gross margin in said treatment.

Farmers' opinion

Higher doses of fertilizer resulted in higher yield and economic return as the nutrient poor sandy soils responded better to the added nutrients.

Table 2. Yield parameter and yield of Maize as influenced by different nutrient treatment combinations in Charland of Dhunat, Bogura during the 2019-20 cropping season

Treatment	Plant height (cm)	Cob length (cm)	Grain cob ⁻¹ (no)	100 grain weight (g)	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁ : STB	221.46 a	17.13	492.60 bc	24.62 a	10.43 ab	8.56 a
T ₂ : T ₁ + 25% Nk	212.40 a	17.26	502.00 ab	25.30 a	10.6 ab	8.33 ab
T ₃ : T ₁ +50% Nk	222.43 a	17.73	523.73 a	26.45 a	11.16 a	8.51 a
T ₄ : IPNS on T ₁ (5 t CD ha ⁻¹)	215.73 a	16.93	500.33 b	25.21 a	9.64 bc	7.97 b
T ₅ : FP	195.43 b	16.26	477.80 c	23.42 b	8.43 c	6.63 c
CV%	11.78	3.42	4.29	5.6	3.73	4.78

Note: T₁: STB dose, T₂: T₁ + 25% extra NPK, T₃: T₁ + 50% extra NK, T₄: IPNS based on T₁ @ 5 t ha⁻¹ of cow dung, and T₅: Farmers practice. STB dose : N-P-K-S-Zn-B @ 253.46-52.00-110.00-35.97-5.40-1.19 kg ha⁻¹, FP: NPKSZNB @ 152.07-56.00-57.50-17.99-0-1.0 kg ha⁻¹

Table 3. Yield parameter and yield of Maize as influenced by different nutrient treatment combinations in Charland of Dhunat, Bogura during the 2020-21 cropping season

Treatment	Plant height (cm)	Cob length (cm)	Grain cob ⁻¹ (no)	100 grain weight (g)	Grain yield (tha ⁻¹)	Stover yield (tha ⁻¹)
T ₁ : STB	221.53 ab	16.81	495.46 c	24.25 ab	9.20 ab	7.41 c
T ₂ : T ₁ + 25% Nk	225.62 ab	17.48	507.6 b	26.54 a	10.71 ab	8.38 ab
T ₃ : T ₁ +50% Nk	228.97 a	17.75	514.34 a	26.92 a	11.65 a	8.96 a
T ₄ : IPNS on T ₁ (5 t CD ha ⁻¹)	219.47 b	16.75	502.63 bc	24.88 ab	8.74 bc	8.20 bc
T ₅ : FP	210.84 c	16.31	488.72 d	23.75b	8.62 c	6.50 d
CV%	6.42	4.55	5.67	3.79	5.47	6.78

T₁: STB dose, T₂: T₁+ 25% extra NPK, T₃: T₁+ 50% extra NK, T₄: IPNS based on T₁@ 5 t ha⁻¹ of cow dung, and T₅: Farmers practice. STB dose: N-P-K-S-Zn-B @ 253.46-52.00-110.00-35.97-5.40-1.19 kg ha⁻¹, FP: NPKSZNB @ 152.07-56.00-57.50-17.99-0-1.0 kg ha⁻¹

Table 4. Cost and return of Maize as influenced by different nutrient treatment combinations in Charland of Dhunat, Bogura during 2019-20 and 2020-21 cropping season (Average data)

Treatment	Gross return (Tk ha ⁻¹)			Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
	Grain	Stover	Total		
T ₁ : STB	196300	11978	208278	105910	102368
T ₂ : T ₁ + 25% Nk	213100	12533	225633	110615	115018
T ₃ : T ₁ +50% Nk	228100	13103	241203	113695	127508
T ₄ : IPNS on T ₁ (5 t CD ha ⁻¹)	183800	12128	195928	110910	85018
T ₅ : FP	170500	9848	180348	98320	82028

Input Price (Tk kg⁻¹): Urea: 16; TSP: 22; MoP: 15; Gypsum: 10; ZnSO₄: 150; Boric acid: 150; Cow dung: 1

Output price (Tk kg⁻¹): Maize grain: 20; Stover: 1.5

Conclusion

Considering the yield and economic return, T₂ and T₃ were found suitable for Maize cultivation in Charland areas. As the soils are light textured and poor in nutrient content especially nutrients like N, P, and K; extra application of those essential nutrient elements was found suitable for better plant growth and development and consequently for higher grain yield of Maize. Despite of incurring a slightly higher cultivation cost due to the use of a higher rate of fertilizers, treatments T₂ and T₃ were found profitable for higher grain yield. Therefore, it could be recommended that farmers may apply 25% NPK or 50% NK as extra with the STB dose for higher yield and return from Maize cultivation in char land areas.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF LENTIL

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Abstract

The study was conducted at Ramchandrapur area under Dewli union, Shibganj, Bogura during Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Lentil with the help of the OCPF-BARI-ICARDA collaborative project. BARI Moshur-8 was used as the test crop. The experiment was laid out in randomized complete block design with four replications. Three different fertilizers management was considered as the treatment for the trial viz. T₁: OCP compound fertilizer, T₂: Farmers' practice and T₃: Recommended fertilizer dose. The dose of OCP compound fertilizer was adjusted with the recommended fertilizer doses. Most of the parameters were statistically significant among the different fertilizer practices. The highest amount of seed yield (1.79 t ha⁻¹) was weighed from the OCP compound fertilizer application plot and the lower amount (1.52 t ha⁻¹) was weighed from the farmer practice which was identical to recommended fertilizer (1.73 t ha⁻¹). Application of both OCP compound fertilizer and recommended dose of fertilizer showed better performance over farmers' practice and significantly increased seed yield of Lentil. Upon cost and return analysis the highest BCR (2.95) was recorded from OCP compound fertilizer treat plots (T₁) followed by recommended fertilizer treated plots (T₃) and the lowest (2.76) from farmers practiced plots (T₂). This is the second-year trial and similar trends were obtained in the last year's observation.

Introduction

Among the major food crops in the Asia-Pacific region, particularly South, East, and Southeast Asia, pulses as nutritionally rich food, play an important role in improving the diet of the people. The countries in the region grow a dozen of summer and winter pulses to meet the dietary requirements, particularly for the poorer section of the society, to whom animal protein is less accessible. In Bangladesh, the production of major food crops – rice, wheat, pulses, and oilseeds – does not meet the present requirements of the country's population of about 135 million. The gap is widening both in quantity and quality. Agricultural scientists are faced with the complex and urgent task of bringing the “population – food supply” equation into rational balance. Rice and wheat have been the focus of concerted government efforts in research and development. Similar attention was long overdue for the pulse crops, commonly known as poor man's meat.

Pulses are vital components in the diversification of Bangladesh's predominantly rice-based cropping system. Lentil is the second most important pulse crop in terms of area (145,000 ha) and production (167,000 t) but ranks the highest in consumer preference and total consumption (BBS, 2015). Lentil seed is a rich source of protein and several essential micronutrients (Fe, Zn, β -carotene) (Bhatty, 1988). Only red cotyledon type is used as food in Bangladesh, where it is boiled into soup-like dhal and eaten with flatbread (roti) or rice. Khichuri is another popular dish, which is made from a mixture of split Lentil seed and pounded wheat or rice. Lentil straw is valued animal feed. Domestic pulse production satisfies less than half of the country's needs. Bangladeshis consume about 12.0 g of pulses per capita per day, far below the 45 g per day recommended by FAO/WHO (Islam and Ali, 2002). Meat production, including fish, has declined consistently in recent years, so animal sources of protein are also priced beyond the reach of the poor. To become self-sufficient in pulse production, and reduce the drain on foreign exchange, the government of Bangladesh, policymakers, scientists, and the extension department have launched pulse improvement and development programs in the country. The Office Chèrifien des Phosphates (OCP), a Moroccan state-owned phosphate rock miner, phosphoric acid manufacturer and phosphate fertilizer producer provided a compound fertilizer to trial on pulses and spices in Bangladesh. Whether the product do well in such of those crop and higher yield. The compound fertilizers are combination of Nitrogen, Phosphorus, Sulphur and Boron. Hence the trial was undertaken to evaluate the OCP compound fertilizer on the optimum management-based production over the farmer's one.

Materials and Methods

Description of the experimental site: The study was conducted at Kashipur under Dewli union, Shibganj, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Lentil funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents agro-ecological zone-25 (AEZ-25) recognized as “Level Barind Tract” and situated at 25°02'18.09" North latitude and 89°41'27.7" East longitude under Bangladesh (FAO, 1988). The initial physicochemical properties of the experimental field are given in Table 1. The experiment was conducted in randomized complete block design with 6 dispersed replication. However, the treatment combination and detailed are given below.

Table 1. Initial physicochemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.15	Neutral
Organic Matter (%)	1.53	Low
Total Organic Carbon (%)	0.8	Low
Total Nitrogen (%)	0.08	Very low
Phosphorous (ppm)	15.36	Medium
Potassium (meq/100g soil)	0.169	Medium
Calcium (meq/100g soil)	2.58	Low
Magnesium (meq/100g soil)	0.93	Medium
Sulphur (ppm)	20.45	Medium
Zinc (ppm)	0.86	Low
Boron (ppm)	0.164	Low

Treatments: Three different fertilizer management was considered as the treatment for the trial. The treatments are explained below:

a) OCP compound fertilizer: The OCP is a company in Morocco. The OCP Company is one of the largest phosphate and phosphate based products recommended a fertilizer compound to trial in Bangladesh. The OCP compound fertilizer is a combination of Nitrogen, Phosphorus, Sulphur and Boron. OCP produces three standard group fertilizers (mono-ammonium phosphate, di ammonium phosphate and triple super phathate) that can be used directly or mixed as needed in blanks. However, the dose used for this trial was

$$T_1 = \text{OCP } 91 \text{ kg ha}^{-1} + \text{TSP } 14 \text{ kg ha}^{-1} + \text{MoP } 38 \text{ kg ha}^{-1} + \text{Line sowing}$$

The total amount of OCP fertilizer, TSP, and half of the MoP was applied at final land preparation and the rest of MoP was top dressed at 30 days after sowing.

b) Farmer's practice: In general, the farmer of our country uses lower mount of fertilizer and minimum management practices for cultivating Lentils. The dose used for this treatment was

$$T_2 = \text{Urea } 38 \text{ kg ha}^{-1} + \text{TSP } 53 \text{ kg ha}^{-1} + \text{MoP } 30 \text{ kg ha}^{-1} + \text{Broadcast}$$

The total amount of TSP, $\frac{1}{2}$ MoP and $\frac{1}{2}$ Urea were applied at final land preparation. Rest Urea and MoP were top-dressed at 30 days after seeding.

c) Recommended fertilizer dose: Pulses Research Centre (SRC) developed nine Lentil varieties and also optimized the fertilizer dose for cultivating Lentil. The recommended fertilizers dose (FRG' 2018)

$$T_3 = \text{Urea } 38 \text{ kg ha}^{-1} + \text{TSP } 90 \text{ kg ha}^{-1} + \text{MoP } 38 \text{ kg ha}^{-1} + \text{Gypsum } 53 \text{ kg ha}^{-1} + \text{Boric acid } 8 \text{ kg ha}^{-1} + \text{Line sowing}$$

The total amount of TSP, Boric acid and Gypsum, half Urea and MoP were applied at final land preparation. Rest Urea and MoP were top dressed at 30 days after seeding.

Intercultural operation

Seed sowing of BARI Mosur-8 @ 30 kg ha⁻¹ was 11 December 2020. Single weeding along with thinning was done at 25 DAS. Two times spay with Tundra and Karate 55 EC@ 2ml/L was made for controlling insects like leaf feeder. Nativo 2g/L was sprayed two times at 10 days intervals to control fusarium wilt disease, collar rot diseases. Rovral 50WP @ 2g/L was applied to prevent Stemphylium blight disease. Harvest was done on 3 April 2021.

Results and Discussions

The effect of different fertilizer treatments on the morphological, yield, and yield contributing parameters of Lentils are shown in Table 2. The plant height was statistically significant among the different treatment combinations. The taller plant (48.27 cm) was measured from the OCP compound fertilizer application plot which was identical to PRC recommended fertilizer (46.35 cm). The shorter plant (41.68 cm) was measured from the farmer's practice. It was found that the total number of plants m⁻² was non significant. That means there was no variation in the total number of plants m⁻² among the treatments. However, a numerically higher plant population was observed in T₁ and T₃ treatments over the farmer's practice (T₂). It was found that the number of pods plant⁻¹ was statistically non-significant between OCP compound fertilizer and PRC recommended fertilizer application though they were significantly different from farmers' practice. Line sowing as well as optimum nutrient supplement ensured the higher number of pods plant⁻¹ in T₁ and T₃ treatments than that of T₂. Thousand seed weight (g) varied significantly among the different fertilizer applications. The higher 1000 seed (23.48 g) was weighed from the OCP compound fertilizer application plot and the lower was weighed from the farmer practice (21.67 g). The seed yield (t ha⁻¹) was statistically significant among the different fertilizer treatments. The higher amount of seed (1.79 t ha⁻¹) was weighed from the OCP compound fertilizer application plot which was identical to PRC recommended fertilizer (1.73 t ha⁻¹) and the lower amount of seed (1.52 t ha⁻¹) was weighed from the farmer's practice. The stover yield (t ha⁻¹) was statistically significant among the different fertilizer treatments. The higher stover yield (2.12 t ha⁻¹) was weighed from the OCP compound fertilizer application plot which was identical to PRC recommended fertilizer (2.10 t ha⁻¹) and the lower amount of stover (1.90 t ha⁻¹) was weighed from the farmer's practice.

Cost and return analysis

The economic performance of Lentil as influenced by different fertilizer practices are presented in Table 3. The highest gross return (Tk 131000 ha⁻¹) net return (Tk 86540 ha⁻¹) against the total cultivation cost (Tk 44460 ha⁻¹) was obtained from the application of OCP compound fertilizer and the lowest gross return (Tk 111340 ha⁻¹) net return (Tk 71060 ha⁻¹) against the total cultivation cost (Tk 40280 ha⁻¹) was obtained from farmer practice. Upon considering the return and production cost the highest BCR (2.95) was recorded from OCP compound fertilizer treat plots (T₁) followed by PRC recommended fertilizer treated plots (T₃) and the lowest (2.76) from farmers practiced plots (T₂).

Table 2. Effect of different doses of fertilizer on the morphological parameters of Lentil at Shibganj, Bogura during 2020-21

Treatment	Plant height (cm)	Plants m ⁻² (no)	Pods plant ⁻¹ (no)	1000 seed weight (g)	Seed yield (t ha ⁻¹)	Stover Yield (t ha ⁻¹)
T ₁	48.27 a	112.24 a	62.45 a	23.48 a	1.79 a	2.12 a
T ₂	41.68 b	95.62 b	52.47 b	21.67 b	1.52 b	1.90 b
T ₃	46.3547 a	108.32 a	59.98 a	22.96 a	1.73 a	2.10 a
CV (%)	3.6	6.34	4.59	2.48	4.38	5.36

Note: T₁= OCP 91 kg ha⁻¹ + TSP 14 kg ha⁻¹ + MoP 38 kg ha⁻¹ + Line sowing, T₂= Urea 38 kg ha⁻¹ + TSP 53 kg ha⁻¹ + MoP 30 kg ha⁻¹ + Broadcast, T₃=Urea 38 kg ha⁻¹ + TSP 90 kg ha⁻¹ + MoP 38 kg ha⁻¹ + Gypsum 53 kg ha⁻¹ + Boric acid 8 kg ha⁻¹ + Line sowing
In a column, means followed by the same letter did not differ significantly. * = 5% level of significance and ** = 1% level of significance, NS= Non-significant.

Table 3. Cost and return analysis of Lentil as influenced by different fertilizer treatments

Treatment	Return from grain (Tk ha ⁻¹)	Return from stover (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₁	128880	2120	131000	44460	86540	2.95
T ₂	109440	1900	111340	40280	71060	2.76
T ₃	124560	2100	126660	44460	82200	2.85

Urea-Tk.18/kg, TSP-Tk. 22/kg, MoP-Tk. 18/kg, Ploughing by tractor-6000 ha⁻¹, Labour-Tk. 400/man-day, Seed-Tk 100/kg. Sale price-Tk. 72/kg seed, stoverTk 1.5/kg.

Conclusion

Application of OCP compound fertilizer showed better performance than the improved as well as farmers' practice regarding seed yield of Lentil. Similar trends were obtained in the last year observation. Therefore, OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of Lentil. However, the trial will be repeated in the next year for confirmation of the result.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF ONION

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Abstract

The study was conducted at Laxmikhola area under Dewli union, Shibganj, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Onion with the help of the OCPF-BARI-ICARDA collaborative project. BARI Piuj-I was used as the test crop. The experiment was laid out in an RCB design with four replications. Three different fertilizer management were considered as the treatment for the trial viz. T₁: OCP compound fertilizer, T₂: Farmer's practice, and T₃: recommended fertilizer dose. The dose of OCP compound fertilizer was adjusted with the recommended fertilizer doses. Most of the bulb parameters and yield contributing characters were statistically significant among the different fertilizer practices. The numerically higher amount of bulb (12.82 t ha⁻¹) was weighted from the OCP compound fertilizer application plot which was identical to recommended fertilizer (12.22 t ha⁻¹) and the lower amount of bulb (10.16 t ha⁻¹) was weighted from the farmer practice. Upon cost and return analysis the highest BCR (2.24) was recorded from OCP compound fertilizer treat plots (T₁) followed by recommended fertilizer treated plots (T₃) and

the lowest (1.81) from farmers practiced plots (T_2). Application of OCP compound fertilizer exhibited better performance over the other practices regarding bulb yield and similar trends were obtained in the last year's observation. The highest gross return (Tk 448700 ha^{-1}) and BCR (2.24) was obtained from the application OCP compound fertilizer and the lowest gross return (Tk 355600 ha^{-1}) and BCR (1.81) from farmers practice. This is the second year trial and similar trends were obtained in the last year's observation.

Introduction

Onion is one of the daily necessities of the people of Bangladesh. The value of Garlic and ginger is almost equal. If there is no Onion in the curry or if it is less, it should not be left. Onions are an essential commodity during Ramadan and during sacrifices to make fun foods. Although there are no accurate statistics, it is estimated that there is a demand for 2.4 million tons of Onion in Bangladesh throughout the year. According to the latest statistics (BBS, 2016), the total production of Onions in the country is 16.36 million tons, which was 16.8 tons last year. The import is about 11 lakh tons.

Although it seems to be a bit inconsistent, it is very natural to try to keep the supply of Onions in the market a little higher considering it is a perishable product. Due to heavy rain in April last year, the Onions stored by the farmers in their way rot. This is the main reason for the shortage of domestic Onions in the market. The second reason is excessive import dependence. Most of the Onions are imported from neighboring India. Some Onions are also imported from Myanmar, Egypt, and Turkey. Due to the increase in the price of Onion in India in early September this year, its effect can be seen in the market of Bangladesh.

The soil and climate of Bangladesh are very good for Onion cultivation and seed production. Yield and total production can be increased by cultivating Onion in a modern way. And through this, it is possible to export by meeting the domestic demand. In our country, the demand for almost all spice crops is less than the production. The Office Chérifien des Phosphates (OCP), a Moroccan state-owned phosphate rock miner, phosphoric acid manufacturer and phosphate fertilizer producer provided a compound fertilizer to trial on pulses and spices in Bangladesh. Whether the product do well in such of those crop and higher yield. The compound fertilizers are combination of Nitrogen, Phosphorus, Sulphur and Boron. Therefore, good market value can be obtained by cultivating using improved varieties in an improved manner. Hence the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Materials and Methods

Description of the experimental site: The study was conducted at Laxmikhola area under Dewli union, Shibganj, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Onion funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents an agro-ecological zone (AEZ-25) recognized as “Level Barind Tract” and situated at 25°016585 North latitude and 89°399902 East longitude under Bangladesh (FAO, 1988). The experiment was conducted in randomized complete block design with 6 dispersed replication. The initial physicochemical properties of the experimental field are given in Table 1.

Table 1. Initial physicochemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	5.95	Neutral
Organic Matter (%)	1.51	Low
Total Organic Carbon (%)	0.72	Low
Total Nitrogen (%)	0.072	Very low
Phosphorous (ppm)	43	Very high
Potassium (meq/100g soil)	0.25	Medium
Calcium (meq/100g soil)	2.6	Low
Magnesium (meq/100g soil)	0.89	Medium
Sulphur (ppm)	15.2	Medium
Zinc (ppm)	1.21	Medium
Boron (ppm)	0.11	Very low

Treatments: Three different fertilizers management was considered as the treatment for the trial. The treatments are explained below:

d) OCP compound fertilizer: The OCP is a company in Morocco. The OCP Company is one of the largest phosphate and phosphate based products recommended a fertilizer compound to trial in Bangladesh. The OCP compound fertilizer is a combination of Nitrogen, Phosphorus, Sulphur and Boron. OCP produces three standard group fertilizers (mono-ammonium phosphate, di ammonium phosphate and triple super phathate) that can be used directly or mixed as needed in blanks. However, the dose used for this trial was

a) The OCP compound fertilizer is a combination of Nitrogen, Phosphorus, Sulphur, and Boron. The dose used for this trial was

$$T_1 = \text{OCP } 311 \text{ kg ha}^{-1} + \text{Urea } 59 \text{ kg ha}^{-1} + \text{MoP } 188 \text{ kg ha}^{-1} + \text{Gypsum } 1.64 \text{ kg ha}^{-1} + \text{CD } 5.25 \text{ t ha}^{-1}$$

The total amount of cow dung, OCP fertilizer, Gypsum, and one-third MoP were applied at final land preparation, and the rest of MoP and supplementary dose of N from Urea were top-dressed into two equal splits at 25 and 50 days after transplanting.

b) Farmer's practice: In general, the farmers of our country use a lower amount of fertilizer and minimum management practices for cultivating Onion. The dose used for this treatment was

$$T_2 = \text{Urea } 150 \text{ kg ha}^{-1} + \text{TSP } 188 \text{ kg ha}^{-1} + \text{MoP } 150 \text{ kg ha}^{-1} + \text{CD } 4.5 \text{ t ha}^{-1}$$

The total amount of cow dung, TSP, MoP, and ½ Urea was applied at the final land preparation. Rest Urea was top-dressed into two equal splits at 25 and 50 days after planting.

c) Recommended fertilizer dose: Spices Research Centre (SRC) developed six Onion varieties and also optimized the fertilizer dose for cultivating Onion. The recommended fertilizers dose (FRG' 2018) was

$$T_3 = \text{Urea } 188 \text{ kg ha}^{-1} + \text{TSP } 263 \text{ kg ha}^{-1} + \text{MoP } 188 \text{ kg ha}^{-1} + \text{Gypsum } 113 \text{ kg ha}^{-1} + \text{CD } 5.25 \text{ t ha}^{-1}$$

The total amount of cow dung, TSP & Gypsum, one-third Urea, and one-third MoP were applied at final land preparation. Rest Urea and MoP were top dressed into two equal splits at 25 and 50 days after transplanting.

Intercultural Operation

The trial of Onion with BARI-Piaz-4 following improved practices was conducted at Laxmikhola under Dewli union, Shibganj, Bogura during the 2020-21 cropping season to produce quality seeds at the farmer's level. Seeds of BARI Piaz-1 @ 7.5 kg ha⁻¹ were sown on 2 December 2020 for raising seedlings. Then 45 days aged seedlings were transplanted to the main field on 17 January 2021. Three times weedings were done at 10-15, 25-30, and 40-45 DAS. Five times spay with Tundra, Pegasus, Confidor @ 2ml/L was made at 7 days interval as precautionary measures for controlling insects like leaf feeder, thrips. Amistertob, Iprozim 26WP, Rovral 50WP 2g/L was sprayed 6 times at 7 days intervals to control fungal diseases like leaf blight and purple blotch. Harvest was done on 10 April 2021.

Results and Discussions

The effect of different fertilizer treatments on the morphological, yield and yield contributing parameters of Onion are shown in Table 2. The unit plot size was 20 m² and the plant spacing was 15 cm × 10 cm. So that 1200 seedlings were transplanted in each plot. Despite some seedlings were missing, it was observed that the total number of plants plot⁻¹ was non-significant. That means there was no variation in the total number of plants plot⁻¹ among the treatments. The plant height was statistically significant among the different treatment combinations. The taller plant (55.54 cm) was measured from the OCP compound fertilizer treated plot which was identical to SRC recommended

fertilizer (54.81 cm). The shortest plant (48.37 cm) was measured from the farmer's practice. It was found that the number of leaves plant⁻¹ was statistically non-significant among the different treatment combinations. Sumarni *et al.* (2012) claimed that the number of tillers or the number of bulbs was more determined by genetic factors than environmental factors such as fertilization. Single bulb weight (g) varied significantly among the different fertilizer applications. The heaviest bulb (32.52 g) was weighted from the OCP compound fertilizer application plot and the lightest bulb was weighted from the farmer practice (28.41 g). Bulb length was highly significant among the different fertilizer applications. The longest bulb (3.96 cm) was measured from the OCP compound fertilizer application plot and the shortest bulb was measured from the farmer practice (2.61 cm). Bulb diameter was statistically significant among the different fertilizer applications. The wider bulb (4.05 cm) was measured from the OCP compound fertilizer application plot and the narrowest bulb was measured from the farmer practice (3.30 cm). The bulb yield (t ha⁻¹) was statistically significant among the different fertilizer treatments. The highest amount of bulb (12.82 t ha⁻¹) was weighted from the OCP compound fertilizer application plot which was identical to SRC recommended fertilizer (12.22 t ha⁻¹) and the lower amount of bulb (10.16 t ha⁻¹) was weighted from the farmer's practice. These findings indicated that optimum nutrients flourished in the soil that helped the plants to grow better (Maisura *et al.*, 2019).

Cost and return analysis

The economic performance of Onion is influenced by different fertilizer practices presented in Table 3. The highest gross return (Tk 448700 ha⁻¹), with a net return (Tk 248475 ha⁻¹) was obtained from the application OCP compound fertilizer against a cultivation cost of (Tk 200225 ha⁻¹) and the lowest gross return (Tk 355600 ha⁻¹) net return (Tk 159275 ha⁻¹) from farmer practice against a cultivation cost (Tk 196325 ha⁻¹). Upon considering the return and production cost the highest BCR (2.24) was recorded from OCP compound fertilizer treat plots (T₁) followed by SRC recommended fertilizer treated plots (T₃) and the lowest (1.81) from farmers practiced plots (T₂).

Table 2. Effect of different doses of fertilizer on the morphological, yield, and yield contributing parameters of Onion at Shibganj, Bogura during 2020-21

Treatments	Plants plot ⁻¹ (no)	Plant height (cm)	Leaves plant ⁻¹ (no)	Single bulb wt (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb yield (tha ⁻¹)
T ₁	1110	55.54 a	10.72	32.52 a	3.96 a	4.05 a	12.82 a
T ₂	1102	48.37 b	10.58	28.41 c	2.61 c	3.30 b	10.16 b
T ₃	1095	54.81 a	10.65	30.85 b	3.32 a	3.48 a	12.22 a
CV (%)	6.12	5.98	5.61	4.23	3.91	5.12	5.48

Note: T₁= OCP 311 kg ha⁻¹ + Urea 59 kg ha⁻¹ + MoP 188 kg ha⁻¹ + Gypsum 1.64 kg ha⁻¹ + CD 5.25 t ha⁻¹, T₂= Urea 150 kg ha⁻¹ + TSP 188 kg ha⁻¹ + MoP 150 kg ha⁻¹ + CD 4.5 t ha⁻¹ and T₃=Urea 188 kg ha⁻¹ + TSP 263 kg ha⁻¹ + MoP 188 kg ha⁻¹ + Gypsum 113 kg ha⁻¹ + CD 5.25 t ha⁻¹

Table 3. Cost and return analysis of Onion as influenced by different fertilizer treatments at Shibganj, Bogura during 2020-21

Treatments	Bulb yield (t ha ⁻¹)	Gross return (Tkha ⁻¹)	Total variable cost (Tkha ⁻¹)	Gross margin (Tkha ⁻¹)	BCR
T ₁	12.82	448700	200225	248475	2.24
T ₂	10.16	355600	196325	159275	1.81
T ₃	12.22	427700	200225	227475	2.14

Input cost (Tk kg⁻¹): Urea-18, TSP-22, MoP-18, Ploughing by tractor-6000 ha⁻¹, Irrigation-2000 ha⁻¹/irrigation, Labour-Tk. 400/man-day, Seed-Tk 3000/kg. Sale price-Tk. 35 Tk/kg bulb

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased bulb yield of Onion. Similar trends were obtained in the last year's observation. Therefore, OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of Onion. However, the trial will be repeated in the next year for confirmation of the result.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF GARLIC

M. A. Islam, M. S. Alam, M. R. A. Mollah, M Akkas Ali, M Shahiduzzaman

Abstract

The study was conducted at Laxmikhola under Dewli union, Shibganj, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Garlic funded by the OCPF-BARI-ICARDA collaborative project. BARI Rashun-I was used as the test crop. The experiment was laid out in an RCB design with four replications. Three different fertilizers management was considered as the treatment for the trial viz. OCP compound fertilizer, recommended fertilizer dose (RFD) and farmer practice. The dose of OCP compound fertilizer was calculated from the SRC recommended dose. Most of the bulb parameters and yield contributing characters were statistically significant among the different fertilizer practices. The higher amount of bulb (8.78 t ha^{-1}) was weighed from the OCP compound fertilizer application plot which was identical to SRC recommended practice (8.22 t ha^{-1}). The lowest amount of bulb (6.32 t ha^{-1}) was weighted from the farmer's practice. Application of OCP compound fertilizer and optimum fertilizer management options showed better performance over the farmer's practice regarding bulb yield of Garlic. Upon cost and return analysis, the highest gross return (Tk 614600 ha^{-1}) and BCR (2.30) was obtained from the application OCP compound fertilizer-based treatment (T_1) followed by improved management practice and the lowest gross return (Tk 442400 ha^{-1}) and BCR (1.69) from the farmers practiced plots (T_2). This is the second year trial and similar trends were obtained in the last year's observation.

Introduction

Garlic (*Allium sativum* L.) has been used in world cuisines as well as in herbal medicine for thousands of years and at times, has been claimed to help prevent everything from high cholesterol to cancer (Rahman et al., 2012). Among the species grown in Bangladesh, Garlic is undoubtedly one of the important crops cultivated during the cool season. It has been in use for many centuries and was recognized for its therapeutic and medicinal value as far back as the era of ancient Egypt. It is a common ingredient in the preparation of meals in all parts of the world, used for its pungent flavour. The most common use of Garlic in the preparation of cooked dishes is in the form of fresh cloves. However, there are many preparations of Garlic available, particularly in health food stores, including powdered Garlic, tablets, and oil capsules. To elucidate the role of Garlic in the prevention of atherosclerosis, a large number of studies have investigated its effects on serum cholesterol, Low-Density Lipoprotein (LDL) cholesterol, High-Density Lipoprotein (HDL) cholesterol, and triglycerides (TG) (El-Sabban and Abouazra, 2008). Garlic juice reduced serum cholesterol and TG in human subjects (Bakhsh and Chughtai, 1984) and helped in preventing the rise of serum cholesterol, thus indicating a cholesterol-lowering property (Beier, 1990; Zink and Chaffin, 1998). A systematic review of randomized controlled trials in humans reported that the reduction of total cholesterol and TG with Garlic therapy was evident after 1 month and persisted for at least 6 months (Silagy and Neil, 1994). A meta-analysis of controlled trials on fresh Garlic showed that consuming half a clove per day decreased total serum cholesterol levels (Warshafsky et al., 1993).

A controlled trial and a meta-analysis of the use of Garlic powder in the treatment of moderate hyperlipidemia showed that it was less effective in reducing total cholesterol (Berthold and Sudhop, 1988). A meta-analysis of 13 trials showed that Garlic tablets significantly reduced total blood cholesterol levels (Stevinson et al., 2000).

Garlic has been considered a rich source of carbohydrates, proteins, and phosphorus (Bose and Som, 1990). Garlic also helps to eliminate waste materials and dangerous free radicals from the human body (Durak et al., 2004). Garlic is a profitable crop based on its return to investment. Among the competitive crops like mustard, Groundnut, and cabbage, the highest net return was obtained from Garlic cultivation, human labour, land preparation cost, manure, TSP, irrigation, and insecticide had a positive effect on the yield of Garlic. Non-availability of HYV seed at the proper time, lack of technical knowledge, the infestation of insects and diseases, and low market price were the major problems of Garlic cultivation (Haque et al., 2013). Garlic is generally cultivated with the traditional method. Though the production

of Garlic is increasing day by day, in a land of the hungry country like Bangladesh, it may not be possible to meet the domestic demand due to the increase in population. Moreover, the production of Garlic is insufficient in Bangladesh. Every year, Bangladesh imports big amounts of Garlic from neighboring countries and others to meet up the demand of its population. To meet the demand of domestic consumption of Garlic, it is too much essential to estimate the production of Garlic in Bangladesh which leads us to do this research. The Office Chérifien des Phosphates (OCP), a Moroccan state-owned phosphate rock miner, phosphoric acid manufacturer and phosphate fertilizer producer provided a compound fertilizer to trial on pulses and spices in Bangladesh. Whether the product do well in such of those crop and higher yield. The compound fertilizers are combination of Nitrogen, Phosphorus, Sulphur and Boron. The main purpose of this research is to identify the Auto-Regressive Integrated Moving Average (ARIMA) model that could be used to forecast the production of Garlic in Bangladesh. Hence the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Materials and Methods

Description of the experimental site: The study was conducted at Laxmikhola under Dewli union, Shibganj, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Garlic funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents the agro-ecological zone (AEZ-25) recognized as “Level Barind Tract” and situated at 25°00'59.9"N latitude and 89°24'01.1"E longitude. The experiment was conducted in randomized complete block design with 6 dispersed replication. The initial physiochemical properties of the experimental field are given in Table 1.

Table 1. Initial physicochemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.24	Neutral
Organic Matter (%)	1.48	Low
Total Organic Carbon (%)	0.69	Low
Total Nitrogen (%)	0.070	Very low
Phosphorous (ppm)	17.27	Medium
Potassium (meq/100g soil)	0.213	Medium
Calcium (meq/100g soil)	2.70	Low
Magnesium (meq/100g soil)	0.93	Low
Sulphur (ppm)	18.35	Medium
Zinc (ppm)	0.81	Low
Boron (ppm)	0.156	Low

Treatments: Three different fertilizer management were considered as the treatment for the trial. The treatments are explained below:

e) OCP compound fertilizer: The OCP is a company in Morocco. The OCP Company is one of the largest phosphate and phosphate based products recommended a fertilizer compound to trial in Bangladesh. The OCP compound fertilizer is a combination of Nitrogen, Phosphorus, Sulphur and Boron. OCP produces three standard group fertilizers (mono-ammonium phosphate, di ammonium phosphate and triple super phathate) that can be used directly or mixed as needed in blanks. However, the dose used for this trial was

a) The OCP compound fertilizer consists of Nitrogen, Phosphorus, Sulphur, and Boron in combination.
The dose used for this treatment was

$$T_1 = \text{OCP } 320 \text{ kg ha}^{-1} + \text{Urea } 18 \text{ kg ha}^{-1} + 338 \text{ kg ha}^{-1} + \text{CD } 5.25 \text{ t ha}^{-1}$$

The total amount of Cow dung (CD), OCP, and $\frac{1}{2}$ MoP were applied at final land preparation and the rest of MoP and supplementary dose of N from Urea were top-dressed into 3 equal splits at 25, 50, and 80 days after planting.

b) Farmers' practice: In general, farmers of our country use a lower amount of fertilizer and minimum management practices for cultivating Garlic. The dose used for this treatment was

$$T_2 = \text{Urea } 150 \text{ kg ha}^{-1} + \text{TSP } 188 \text{ kg ha}^{-1} + \text{MoP } 150 \text{ kg ha}^{-1} + \text{CD } 4.5 \text{ t ha}^{-1}$$

The total amount of cow dung, TSP, MoP, and ½ Urea will be applied at the final land preparation. Rest Urea will be top dressed into 3 equal splits at 25, 50, and 80 days after planting.

c) Recommended fertilizer dose: Spices Research Centre (SRC) developed four Garlic varieties and also optimized the fertilizer dose for cultivating Garlic. The recommended dose ((FRG' 2018) was

$$T_3 = \text{Urea } 150 \text{ kg ha}^{-1} + \text{TSP } 270 \text{ kg ha}^{-1} + \text{MoP } 338 \text{ kg ha}^{-1} + \text{Gypsum } 75 \text{ kg ha}^{-1} + \text{CD } 5.25 \text{ t ha}^{-1}$$

The total amount of cow dung, TSP, Gypsum, and ½ MoP were applied at the final land preparation. Rest MoP and Urea were top-dressed into 3 equal splits at 25, 50, and 80 days after planting.

Intercultural operation

The trials of Garlic with BARI Rosun-1 following improved practices were conducted at Gujia, Laxmikhola, Dewli under the MLT site Shibganj, Bogura. Clove sowing of Garlic @ 400 kg ha⁻¹ was done on 20 November 2020. Two times weeding was done at 25-20 and 30-40 days after sowing. Two times spay with Tundra and Pegasus @ 2ml/L was made for controlling insects like leaf feeder, thrips. Iprozim 26WP @ 2g/L was applied to prevent leaf blight disease. Harvest was done on 5 April 2021.

Results and Discussions

The effect of different fertilizer treatments on the morphological, yield, and yield contributing parameters of Garlic are shown in Table 2. It was found that the total number of plants plot⁻¹, plant height and the number of leaves plant⁻¹ were statistically non-significant. Probably the plant height and number of leaves plant⁻¹ are the genetic characteristics of BARI Rashun-1 and were not influenced by the different fertilizer applications. Sumarni *et al.* (2012) stated that the number of tillers or the number of bulbs was more determined by genetic factors than environmental factors such as fertilization. Single bulb weight varied significantly among the different fertilizer applications. The heaviest bulb (28.15 g) was weighted from the OCP compound fertilizer application plot and the lightest bulb was weighted from the farmer practice (24.22 g). Bulb length was statistically significant among the different fertilizer applications. The longest bulb (4.02 cm) was measured from the OCP compound fertilizer application plot which was identical to SRC recommended practice (3.78 cm) and the shortest bulb was measured from the farmer practice (3.63 cm). Bulb diameter was also highly significant among the different fertilizer applications. The widest bulb (3.17 cm) was measured from the OCP compound fertilizer application plot and the narrowest bulb was measured from the farmer practice (2.63 cm). The number of cloves bulb⁻¹ was statistically significant among the different fertilizer applications. The highest number of cloves bulb⁻¹ (22.34) was counted from the OCP compound fertilizer application plot and the lowest number of cloves bulb⁻¹ was counted from the farmer practice (16.78). The bulb yield (t ha⁻¹) was statistically significant among the different fertilizer treatments. The higher amount of bulb (8.78 t ha⁻¹) was weighed from the OCP compound fertilizer application plot which was identical to SRC recommended practice (8.43 t ha⁻¹). The lowest amount of bulb (6.32 t ha⁻¹) was weighed from the farmer's practice. These findings indicated that optimum management options in both treatment T₁ and T₃ provided sufficient nutrients to the soils that helped the plants to grow better (Maisura *et al.*, 2019).

Cost and return analysis

The economic performance of Garlic as influenced by different fertilizer practices is presented in Table 3. The highest gross return (Tk 614600 ha⁻¹) net return (Tk 346925 ha⁻¹) against the total cultivation cost (Tk 267675 ha⁻¹) was obtained from the application of OCP compound fertilizer followed by improved management practice and the lowest gross return (Tk 442400 ha⁻¹) net return (Tk. 180515 ha⁻¹) was obtained from farmer's practice. Upon considering the return and production cost, the highest BCR (2.30) was recorded from OCP compound fertilizer treat plots (T₁) followed by SRC recommended fertilizer treated plots (T₃) with a value of 2.20 and the lowest (1.69) from farmers practiced plots (T₂).

Table 2. Effect of different doses of fertilizer on the morphological parameters of Garlicat Shibganj, Bogura during the Rabi season of 2020-21

Treatments	Plants plot ⁻¹ (no)	Plant height (cm)	Leaves plant ⁻¹ (no)	Single bulb wt (g)	Bulb length (cm)	Bulb diameter (cm)	Cloves bulb ⁻¹ (no)	Bulb yield (t ha ⁻¹)
T ₁	1115	67.23	8.43	28.15 a	4.02 a	3.17 a	22.34 a	8.78 a
T ₂	1098	63.64	8.21	24.22 b	3.63 b	2.63 b	16.78 b	6.32 b
T ₃	1112	65.14	8.32	27.85 a	3.92 a	3.11 a	21.48 a	8.43 a
CV (%)	7.23	6.21	5.43	4.28	4.61	5.20	6.45	6.52

Note: T₁= OCP 320 kg ha⁻¹ + Urea 18 kg ha⁻¹ + 338 kg ha⁻¹ + CD 5.25 t ha⁻¹, T₂= Urea 150 kg ha⁻¹ + TSP 188 kg ha⁻¹ + MoP 150 kg ha⁻¹ + CD 4.5 t ha⁻¹ and T₃=Urea 150 kg ha⁻¹ + TSP 270 kg ha⁻¹ + MoP 338 kg ha⁻¹ + Gypsum 75 kg ha⁻¹ + CD 5.25 t ha⁻¹

Table 3. Economic performance of Garlic as influenced by different treatments at Shibganj, Bogura during the Rabi season of 2020-21

Treatments	Seed yield (tha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	8.78	614600	267675	346925	2.30
T ₂	6.32	442400	261885	180515	1.69
T ₃	8.43	590100	267675	322425	2.20

Urea-Tk.18/kg, TSP-Tk. 22/kg, MoP-Tk. 18/kg, Ploughing by tractor-6000 ha⁻¹, Irrigation-2000 ha⁻¹/irrigation, Labour-Tk. 400/man-day, Land Lease Value-Tk. 22500 ha⁻¹ for 4 months, Seed-Tk 150/kg bulb, Sale Price-Tk. 80/kg bulb

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased bulb yield of Garlic. Similar trends were obtained in the last year's observation. Therefore, OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of Garlic. However, the trial will be repeated in the next year for confirmation of the result.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF BLACKGRAM

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Abstract

The study was conducted at the on-station, of OFRD, BARI, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Blackgram funded by the OCPF-BARI-ICARDA collaborative project. BARI Mash-3 was used as the test crop. The experiment was laid out in an RCB design with four replications. Three different fertilizers management were considered as the treatment for the trial viz. OCP compound fertilizer, recommended fertilizer dose, and farmer practice. The dose of OCP compound fertilizer was calculated from the PRC recommended dose. Most of the yield and yield contributing characters were statistically significant among the different fertilizer practices. Application of OCP compound fertilizer and optimum fertilizer management options showed better performance over the farmer's practice regarding yield and economic return. The higher seed yield (1.46 t ha⁻¹) was weighted from the OCP compound fertilizer application plot which was identical to recommended practice (1.39 t ha⁻¹) and the lower (1.23 t ha⁻¹) from the farmer practice. Upon cost and return analysis, it was observed that the higher seed yield contributed to the higher economic return from OCP compound fertilizer treat plots (T₁) followed by recommended fertilizer treated plots (T₃) and the lower return from the farmers practiced plots (T₂). The highest gross return (Tk 89580 ha⁻¹) and BCR (2.48) was obtained from the application OCP compound fertilizer based treatment (T₁) followed by improved management practice and the lowest gross return (Tk 76050 ha⁻¹) and BCR (2.18) from the farmers practiced plots (T₂). This is the second-year trial and similar trends were obtained in the last year's observation.

Introduction

Blackgram (*Vigna mungo*) belongs to the family Leguminosae, is one of the important pulse crops in Bangladesh. It is used in various forms such as grain for human consumption and fodder for cattle, green manure, cover crop, and short-lived forage. It is a fast-growing, short-season, drought-tolerant, (Pillai and Arasuya, 1997) and low input promising crop for southeast Asia. The national average yield of Blackgram in Bangladesh is low. This low yield may be due to the cultivation of the low-yielding local varieties, the incidence of diseases and insects, lack of technical knowledge, and finally little or no use of balanced fertilizer. BARI already developed some high-yielding Blackgram varieties. These varieties have the potential to help generate farmers' income in a very short period. Great circulation of these varieties in different areas of Bangladesh is a prerequisite in respect of grain crop security in Bangladesh. The Office Chérifien des Phosphates (OCP), a Moroccan state-owned phosphate rock miner, phosphoric acid manufacturer and phosphate fertilizer producer provided a compound fertilizer to trial on pulses and spices in Bangladesh. Whether the product do well in such of those crop and higher yield. The compound fertilizers are combination of Nitrogen, Phosphorus, Sulphur and Boron. Hence, the present study was undertaken to evaluate the performance of the Blackgram variety under different fertilizer management practices at farmer's field condition and make popularized among the farmers to promote their adoption in different areas of Bogura. Hence the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Materials and Methods

Site description: The study was conducted at on-station, OFRD, Bogura during the Rabi season of 2020-21 to find out the effect of OCP compound fertilizer and improved practice on the yield of Blackgram funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents the agro-ecological zone (AEZ-4) recognized as "Karatoa Bangali Floodplain" and situated at 24°51'06.4"N latitude and 89°22'53.4"E longitude. The experiment was conducted in randomized complete block design with 6 dispersed replication. The initial physicochemical properties of the experimental field are given in Table 1.

Table 1. Initial physicochemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.45	Neutral
Organic Matter (%)	1.52	Low
Total Organic Carbon (%)	0.75	Low
Total Nitrogen (%)	0.075	Very low
Phosphorous (ppm)	16.89	Medium
Potassium (meq/100g soil)	0.215	Medium
Calcium (meq/100g soil)	2.91	Low
Magnesium (meq/100g soil)	0.73	Low
Sulphur (ppm)	15.19	Low
Zinc (ppm)	1.24	Medium
Boron (ppm)	0.182	Low

Treatments: Three different fertilizer management were considered as the treatment for the trial. The treatments are explained below:

f) OCP compound fertilizer: The OCP is a company in Morocco. The OCP Company is one of the largest phosphate and phosphate based products recommended a fertilizer compound to trial in Bangladesh. The OCP compound fertilizer is a combination of Nitrogen, Phosphorus, Sulphur and Boron. OCP produces three standard group fertilizers (mono-ammonium phosphate, di ammonium phosphate and triple super phathate) that can be used directly or mixed as needed in blanks. However, the dose used for this trial was

a) The OCP compound fertilizer consists of Nitrogen, Phosphorus, Sulphur, and Boron in combination. The dose used for this treatment was

$$T_1 = \text{OCP } 90 \text{ kg ha}^{-1} + \text{Urea } 0 \text{ kg ha}^{-1} + \text{TSP } 14 \text{ kg ha}^{-1} + \text{MoP } 38 \text{ kg ha}^{-1}$$

The total amount of OCP and other fertilizers except urea was applied at final land preparation. A supplementary dose of N from Urea was top-dressed at 20 days after sowing.

b) Farmers' practice: In general, farmers of our country use lesser amount of fertilizer and minimum management practices for cultivating Blackgram. The dose used for this treatment was

$$T_2 = \text{Urea } 38 \text{ kg ha}^{-1} + \text{TSP } 46 \text{ kg ha}^{-1} + \text{MoP } 36 \text{ kg ha}^{-1}$$

The total amount of all fertilizers except urea was applied at final land preparation. A supplementary dose of N from Urea was top-dressed at 20 days after sowing.

c) Recommended fertilizer dose: Pulses Research Centre (PRC) developed high yield potential Blackgram varieties and also optimized the fertilizer dose for cultivating Blackgram. The recommended dose (FRG' 2018) was

$$T_3 = \text{Urea } 38 \text{ kg ha}^{-1} + \text{TSP } 90 \text{ kg ha}^{-1} + \text{MoP } 38 \text{ kg ha}^{-1} + \text{Gypsum } 52 \text{ kg ha}^{-1} + \text{Boric } 7.5 \text{ kg ha}^{-1}$$

The total amount of all fertilizers except urea was applied at final land preparation. A supplementary dose of N from Urea was top-dressed at 20 days after sowing.

Intercultural operation

The trials of Blackgram with BARI Mash-3 following improved practices were conducted at on-station, OFRD, Bogura. Seeds of Blackgram @ 30 kg ha⁻¹ were sown on 17 September 2020. Two times weeding was done at 25-20 and 30-40 days after sowing. Two times spay with Tundra and Pegasus @ 2ml/L were made for controlling insects like leaf feeder, thrips. Acrobat MZ @ 2g/L was applied to prevent leaf spot disease. Harvest was done on 30 November 2020.

Results and Discussions

The effect of different fertilizer treatments on the different parameters of the Blackgram is shown in Table 2. It was found that the total number of plants population was found higher in T₂ treatment (42.5) as farmers were used to using a slightly higher seed rate (5-6 kg for 1320 m²) than the recommended one. Higher plant density led to plant height in T₂ treatment (44.37 cm). However, the number of branches/plant was statistically non-significant among the treatments. Probably the number of branch plant⁻¹ is one of the genetically characteristics of BARI Mash-3 and were not influenced by the different fertilizer applications. Sumarni *et al.* (2012) stated that the number of tillers was more determined by genetic factors than environmental factors such as fertilization while studying with spices crops. No pod/plant varied significantly among the different fertilizer applications. The higher number of pods/plant (44.56 g) was recorded from the OCP compound fertilizer which was statistically non-significant with PRC recommended based fertilizer application plot (42.95) and the lower number from the farmer practice (35.37 g). Pod length differed significantly among the fertilizer application-based treatments. The maximum pod length (4.81 cm) was recorded from the OCP compound fertilizer which was statistically non-significant with PRC recommended based fertilizer application plot (4.79 cm) and the lower number from the farmer practice (4.32 cm). The higher number of seeds/pod (7.56) was obtained from OCP-based treatment which is identical to PRC recommendation-based one and the lower (6.21) from farmers practice-based treatment. Higher and identical 1000 seeds weight was observed in T₁ and T₃ treatments and lower from T₂ treatment. Probably OCP compound fertilizer and PRC-based recommended fertilizer both provided balanced nutrients to the plants for better development of seeds. Higher yield contributing characters of Blackgram in T₁ and T₃ treatments provided higher yield than that of farmers' practice. However, numerically, maximum seed yield (1.46 t ha⁻¹) was recorded from T₁ treatment where OCP compound fertilizer was applied in combination with chemical fertilizers which was statistically like the yield (1.39 t ha⁻¹) recorded from PRC recommended fertilizer dose (T₃) and the lower (1.23 t ha⁻¹) from farmers' practice (T₂). Unlike seed yield, maximum plant population and higher plant height contributed to the highest stover yield (2.25 t ha⁻¹) in T₂ treatment as it was observed that less bearing was found in comparatively longer plants of Blackgram. Stover yield in T₁ and T₃ treatments was lower than T₂ treatment but identical to each other.

Cost and return analysis

The economic performance of Blackgram as influenced by different fertilizer practices is presented in Table 3. The highest gross return (Tk. 89580 ha⁻¹), net return (Tk 53530 ha⁻¹) against the total cultivation cost (Tk. 36050 ha⁻¹) was obtained from the application of OCP compound fertilizer followed by improved management practice and the lowest gross return (Tk 76050 ha⁻¹), net return (Tk 41230 ha⁻¹) was obtained from farmer's practice. Upon considering the return and production cost, the highest BCR (2.48) was recorded from OCP compound fertilizer treat plots (T₁) followed by PRC recommended fertilizer treated plots (T₃) with a value of 2.37 and the lowest (2.18) from farmers practiced plots (T₂).

Table 2. Effect of different doses of fertilizer on the yield contributing and yield parameters of Blackgram in Bogura during 2020-21

Treatment	Plant m ⁻² (no)	Plant height (cm)	Branch plant ⁻¹ (no)	Pod plant ⁻¹ (no)	Pod length (cm)	Seeds pod ⁻¹ (no)	1000 seed wt (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁	32.8 a	37.58 b	6.45	44.56 a	4.81 a	7.56 a	33.24 a	1.46 a	1.98 b
T ₂	42.5 b	44.37 a	4.67	35.37 b	4.32 b	6.21 b	31.45 b	1.23 b	2.25 a
T ₃	31.4 a	36.85 b	5.98	42.95 a	4.79 a	7.40 a	33.02 a	1.39 a	1.88 b
S _x	*	*	NS	*	*	*	*	*	*
CV (%)	5.56	4.32	7.87	4.12	3.95	3.89	4.25	5.24	6.46

Note: T₁= OCP 90 kg ha⁻¹ + Urea 0 kg ha⁻¹ + TSP 14 kg ha⁻¹ + MoP 38 kg ha⁻¹, T₂= Urea 38 kg ha⁻¹ + TSP 46 kg ha⁻¹ + MoP 36 kg ha⁻¹ and T₃=Urea 38 kg ha⁻¹ + TSP 90 kg ha⁻¹ + MoP 38 kg ha⁻¹ + Gypsum 52 kg ha⁻¹ + Boric 7.5 kg ha⁻¹

Table 3. Cost and return analysis of Blackgram as influenced by different treatments

Treatments	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	1.46	1.98	89580	36050	53530	2.48
T ₂	1.23	2.25	76050	34820	41230	2.18
T ₃	1.39	1.88	85280	36050	49230	2.37

Urea-Tk.18/kg, TSP-Tk. 22/kg, MoP-Tk. 18/kg, Ploughing by tractor-6000 ha⁻¹, Labour-Tk. 400/man-day, Land Lease value-Tk. 22500 ha⁻¹ for 4 months, Seed-Tk 100/kg, Sale price- Grain @Tk. 60/kg; Stover@ 1Tk/kg

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased seed yield of Blackgram. Therefore, OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of Blackgram. However, the trial will be repeated in the next year for confirmation of the result.

EFFECT OF DIFFERENT FERTILIZER MANAGEMENT PACKAGES ON YIELD OF SOYBEAN IN CHANDPUR

M.M. Bashir, M.H. Hossain, S.K. Bhowal, M Akkas Ali, M Shahiduzzaman

Abstract

The fertilizer trial was carried out in the Dakkhin Gobindia village of Chandpur Sadar upazilla of Chandpur district during the Rabi season of 2021 with a view to test the performance of different fertilizer packages on Soybean. There was no statistical difference in any parameter except plant height and plant population m⁻². Plant height (92.27cm) was the highest in farmers practice treatment, which produced numerically more yield, gross return and gross margin than BARI Recommended Dose and STB fertilizer treatment. STB gave numerically the lowest yield, gross return and gross margin, but it had highest plant population.

Introduction

Soybean, (*Glycine max*) is an annual legume of the pea family (Fabaceae). The Soybean is economically the most important bean in the world, providing richest and cheapest sources of vegetableprotein for millions of people and is a staple in the diets of people and animals in numerous parts of the world. It

is an ingredient for hundreds of chemical products. The Soybean seed contains 19-22% edible oil and 63 percent meal, 50 percent of which is protein. In Bangladesh Soybean have a bright future. It contains double protein than any other pulse crop. So, to get protein in a low price, we must increase the Soybean production. To increase productivity as well as production, proper fertilization is an important factor. For this reason, the fertilizer trial was taken in the Soybean growing area to test the different fertilizer doses with the farmers own practice.

Materials and Methods

The fertilizer trial was carried out in the farmer's field of Dakkhin Gobindia village of Chandpur Sadar upazilla of Chandpur district during the Rabi season of 2021. The soil of the experimental plot was sandy loam. Seeds were sown continuously in lines at 30 cm spacing. Seeds of BARI Soybean-6 were sown @ 60.0 kg ha⁻¹ on 14 January, 2021. The experiment was initiated in randomized complete block design with 3 replications. The area of the experimental field was 10.75 decimal. Fertilizers were applied as per treatment i.e T₁: STB (26-19.5-23.1-6.3-1.84-0.65 kg NPKSZnB ha⁻¹), T₂: Recommended fertilizer dose (23.6-30.8-51.3-14.92-1.40 kg NPKSB ha⁻¹) and T₃: Farmers practice (31.9-26.7-34.6 kg NPK ha⁻¹), respectively. All the fertilizers were applied during final land preparation. No irrigation was required in the cropping period. Weeding was done once at 20 DAS for maintaining hygienic condition. The crop was harvested 98 days after sowing dated on 22 April, 2021. Data on plant height, branch per plant, number of pods per plant, number of seeds per pod, hundred grain weight and seed yield and plant population m⁻² were taken. The seed yield was collected from 10 m² which was later converted into ton hectare. Moisture (%) of seeds was adjusted to 8% and yield data was minimized accordingly. For controlling pest and diseases, Virtako, Nitro and Autostin, were sprayed for controlling damping off, cut worm and leaf roller.

Results and Discussions

Yield and yield contributing characters are presented in Table 1. The result revealed that farmers practice gave the highest yield (2.47 t ha⁻¹) whereas STB dose performed the lowest (2.23 t ha⁻¹). From the Table, it was also found that, there was no statistical difference in any parameter except plant height and plant population m⁻². Plant height (92.27cm) was the highest in farmers practice treatment as well as pod per plant (51.93). Numerically, branch plant⁻¹, pods plant⁻¹ were also the highest in farmers practice treatment. Plant population was the highest in soil test based fertilizer treatment, but it gave numerically the lowest yield (2.23 t ha⁻¹).

Cost and return analysis

From the economic analysis, it has been observed that gross return and gross margin were also the highest in farmers practice (Tk 98882.9 ha⁻¹ and Tk 53882.9 ha⁻¹) followed by BARI Rec. dose treatment. STB gave lower gross return (Tk 89309.1 ha⁻¹) and gross margin (Tk 44309.1 ha⁻¹) (Table 2).

Table1. Average seed yield and yield contributing characters of Soybean as influenced by fertilizer at Chandpur district during late rabi 2021

Treatment	Plant population m ⁻² (no)	Plant height (cm)	Branch plant ⁻¹ (no)	Pods plant ⁻¹ (no)	Seeds pod ⁻¹ (no)	100 grain weight (g)	Seed yield (t ha ⁻¹)
STB	56.17	76.07	2.87	50.73	2.33	119.47	2.23
RFD	46.87	77.60	2.40	45.00	2.20	129.97	2.37
FP	47.23	92.27	3.07	51.93	2.20	126.97	2.47
LSD (0.05)	7.214	13.93	NS	NS	NS	NS	NS
CV (%)	6.35	7.49	13.68	11.02	9.03	5.51	5.59

Table 2. Cost and return analysis of Soybean as influenced by fertilizer at Chandpur district during late rabi 2021

Treatment	Grain yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
STB	2.23	89309.1	45000	44309.1
RFD	2.37	94825.7	45000	49825.7
FP	2.47	98882.9	45000	53882.9

Market price of Soybean @ Tk. 40 Kg⁻¹

Conclusion

From the trial it can be concluded that all the three treatment combinations are not superior to each other. However, the experiment should be repeated for next year for concrete confirmation.

NUTRIENT MANAGEMENT FOR BULB PRODUCTION OF BARI PIAJ-4 IN FARIDPUR

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

A trial was conducted at the Farming System Research and Development site, Sholakundu, Faridpur during the rab, 2020-21 to find out optimum fertilizer packages for higher sustainable productivity of BARI PIAJ-4 under farmers' field condition. Four treatments were considered as T_1 (STB following FRG, 2018) = $N_{144} P_{30} K_{47} S_9 Zn_{2.7} B_{0.7}$ kg ha⁻¹, T_2 (IPNS basis Recommended Fertilizer Dose with cow dung as per FRG, 2018) = $N_{115} P_{53} K_{49} S_{30} Zn_{3.5} B_{1.5}$ kg ha⁻¹ + cow dung (5 t ha⁻¹), T_3 (150% of chemical fertilizer) = $N_{210} P_{90} K_{90} S_{45} Zn_{4.5} B_{2.2}$ kg ha⁻¹ and T_4 (Farmer's practice) = $N_{205} P_{125} K_{100} S_{30} Zn_{3.5} B_{1.5}$ kg ha⁻¹. The experiment was laid out in randomized complete block design with five dispersed replications. BARI PIAJ-4 was used as planting material in the study. The highest bulb yield was obtained from farmers practice (T_4) (21.95 t ha⁻¹) followed by T_3 . The lowest bulb yield (19.90 t ha⁻¹) was recorded in soil test based treatment (T_1). Maximum gross return (Tk 549000 ha⁻¹) and gross margin (Tk 360065 ha⁻¹) obtained from farmer's practice. But, T_1 gave the highest benefit cost ratio (2.92).

Introduction

Onion likes sandy loam to clay loam soil rich in humus and fairly good content of potash. As it has a shallow root system, it needs friable soil enriched with enough plant nutrients and moisture in the upper 10 cm layer. Like tuber and root crops, Onion consumes a large amount of potash which is needed to use in the transportation of photosynthates and increasing the bulb size. Farmers use fertilizer irrationally that hamper soil health. Judicial use of fertilizer is necessary conserving soil health. Onion is one of the most important and popular spices crops in Bangladesh. Onion bulb is widely cultivated in this country during rabi season. In Faridpur and Rajbari, total about 52 thousand ha of land is cultivated with Onion seedling. BARI has released BARI PIAJ-4 in 2008. Farmers started to cultivate that variety as a high yielder (17-22 tha⁻¹) than BARI PIAJ-1 or Taherpuri (12-16 tha⁻¹). Experimental evidences revealed that the crop was highly responsive to different fertilizers along with organic manure and the yield could be increased remarkably through judicious fertilization. Thus, integrated nutrient management practices applied for Onion can contribute to sustainable growth of yield and quality, influences plant health and reduces environmental risks. Use of organic manures with optimum rate of inorganic fertilizers including major and minor elements especially Zinc and Magnesium under intensive farming system increased the turnover of nutrients in the soil plant system. Therefore, the present study was undertaken with the following objectives to determine suitable nutrient package for Onion and to increase sustainable yield of Onion bulb production.

Materials and Methods

The trial was conducted at the FSRD Site, Sholakundu, Faridpur during the rabi, 2020-21 to find out optimum fertilizer packages for higher sustainable productivity of BARI PIAJ-4 under farmers' field situation. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood

Plain soil under AEZ-12 was shown in Table 1. The soil is neutral in nature and medium high land. Total nitrogen content was very low, P, K and B was medium but S content was optimum.

Table 1. Chemical properties of Initial soil status of the experimental field of Onion at the FSRD Site, Sholakundu, Faridpur

Item	Texture	Land type	pH	OM (%)	Total N (%)	K (meq/100g soil)	Available P (ppm)	Zn	B	S (µg/g soil)
Average	Clay Loam	MHL with irrigated	6.8	1.9	0.09	0.20	18.0	0.70	0.45	35.0
Interpretation			Neutral	M	VL	M	M	L	M	Opt

MHL: Medium high land, VL: Very low, L: Low, M: Medium, Opt: Optimum

The experiment was laid out in randomized complete block design with five dispersed replications. Four treatments were considered as T_1 (STB following FRG' 2018) = $N_{144} P_{30} K_{47} S_9 Zn_2 B_{0.7} kg ha^{-1}$, T_2 (IPNS basis Recommended Fertilizer Dose with cow dung as per FRG' 2018) = $N_{115} P_{53} K_{49} S_{30} Zn_3 B_{1.5} kg ha^{-1}$ + cow dung (5 t ha^{-1}), T_3 (150% of recommended fertilizer dose) = $N_{210} P_{90} K_{90} S_{45} Zn_{4.5} B_{2.2} kg ha^{-1}$ and T_4 (Farmer's practice) = $N_{205} P_{125} K_{100} S_{30} Zn_3 B_1 Mg_{1.5} kg ha^{-1}$. Soil test based dose of fertilizers for Onion calculated following Fertilizer Recommendation Guide FRG' 2018. Farmers applied all nutrients with Magnesium @ 1.5 $kg ha^{-1}$. BARI Paj-4 was used as planting material in the study. The unit plot size was 5m × 3m. The land preparation was done with power tiller. Forty five to fifty days old seedlings were transplanted on 30 December 2020 to 10 January 2021 maintaining 15cm × 10cm spacing. All of organic fertilizer, P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 22-25 days after planting and 39-46 DAT under moist soil condition and mixed thoroughly with the soil. Recommended fertilizer for Onion was 140-60-60-30-3-1.5 $kg N-P-K-S-Zn-B ha^{-1}$. Weeding and mulching was done thrice at 16-20, 36 and 48-57 DAT and the crop land was irrigated four times at pre planting, immediate after planting, 22-25 and 39-46 DAT. Four times fungicides (Rovral at 10-11, 40-45 DAT, Amistar top at 22 DAT and Nativo at 54-64 DAT) and insecticide (Imitaf at 22, 40-45, 54-64 DAT and Enamektinbenzoet at 62-72 DAT) were applied. The crop was harvested on March 28-31, 2021 during the study period. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software and the means were separated by DMRT (Gomez and Gomez 1984).

Results and Discussions

Yield attributes and bulb yield of Onion as influenced by different fertilizer packages during 2020-21 was presented in Table 2. Fertilizer packages exerted significant influence on yield attributes except number of leaves plant⁻¹, % of bolted bulb and number of bulb per m² and bulb yield. The highest plant height (53.28 cm) was recorded in farmer's practice (T_4). The lowest plant height (49.16 cm) was recorded in Soil Test based treatment (T_1). Number of leaves per plant was ranged between 5.52 (T_1) to 5.92 (T_4). The highest (3.90 cm) base diameter was obtained from farmer's practice (T_4) followed by T_3 . The lowest base diameter 3.50 cm was found in T_1 treatment. The highest bolting bulb (0.63%) was calculated from T_3 and lowest from T_4 . Number of bulbs m² was ranged between 72.82 (T_3) to 74.63 (T_4). The highest weight of single bulb (28.48 g) was observed in T_4 which was at par with other treatments except T_2 . The lowest weight of single bulb was noted in T_2 (26.41 g). Extra application of chemical fertilizer especially P, K and Mg in farmer's practice exhibited relatively higher single bulb weight that may enhance optimum bulb growth and development as compared with other treatments. However, the highest bulb yield (21.95 t ha^{-1}) was obtained from T_4 followed by T_3 (20.50 t ha^{-1}). The lowest bulb yield (19.90 t ha^{-1}) was recorded in STB treatment (T_1). Relatively higher base diameter, number of bulb m² and single bulb weight may probable reason for increasing higher bulb yield in farmer's practice (T_4).

Cost and return analysis

Consequently, maximum gross return (Tk 549000 ha^{-1}) and gross margin (Tk 360065 ha^{-1}) were obtained from farmer's practice (Table 3). But the highest benefit cost ratio was calculated from T_1 (2.92) followed by T_4 (2.90).

Farmers' opinion

Farmers were quite convinced to observe the economic benefit from soil test-based fertilizer dose though bulb yield was lower.

Table 2. Yield attributes and yields of Onion as influenced by fertilizer management packages at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatment	Plant height (cm)	Leaves plant ⁻¹ (no)	Base diameter (cm)	Bolted bulb (%)	Bulbs m ⁻² (no)	Single bulb wt (g)	Bulb yield (t ha ⁻¹)
T ₁ (STB)	49.16 b	5.52	3.50 c	0.51	73.27	26.68 ab	19.90 b
T ₂ (IPNS basis RFD)	50.68 b	5.60	3.70 b	0.52	72.92	26.41 b	20.10 b
T ₃ (150% RFD)	52.84 a	5.84	3.76 b	0.63	72.82	27.23 ab	20.50 b
T ₄ (Farmer's practice)	53.28 a	5.92	3.90 a	0.50	74.63	28.48 a	21.95 a
CV (%)	2.49	5.24	2.33	78.05	4.56	5.18	4.51

Note: T₁ (STB following FRG' 2018) = N₁₄₄ P₃₀ K₄₇ S₉ Zn₂ B_{0.7} kg ha⁻¹, T₂ (IPNS basis Recommended Fertilizer Dose with cow dung as per FRG' 2018) = N₁₁₅ P₅₃ K₄₉ S₃₀ Zn₃ B_{1.5} kg ha⁻¹ + cow dung (5 t ha⁻¹), T₃ (150% of RFD) = N₂₁₀ P₉₀ K₉₀ S₄₅ Zn_{4.5} B_{2.2} kg ha⁻¹ and T₄ (Farmer's practice) = N₂₀₅ P₁₂₅ K₁₀₀ S₃₀ Zn₃ B₁ Mg_{1.5} kg ha⁻¹

Table 3. Cost and returns analysis of Onion as influenced by fertilizer management package at the FSRD site, Faridpur during the *rabi* season of 2020-21

Treatment	Bulb yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ (STB)	19.90	497250	170035	327215	2.92
T ₂ (IPNS basis RFD)	20.10	502750	184570	318180	2.72
T ₃ (150% RFD)	20.50	512750	186155	326595	2.75
T ₄ (Farmer's practice)	21.95	549000	188935	360065	2.90

Note: Price of average input (Tk kg⁻¹): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, Zinc: 200, Boron: 240, Seed: 3000
Output price (Tk kg⁻¹): Onion bulb: 25

Conclusion

After one year result, it may be concluded that, the highest bulb yield was obtained from farmers practice (T₄) where N₂₀₅ P₁₂₅ K₁₀₀ S₃₀ Zn₃ B₁ Mg_{1.5} kg ha⁻¹ was applied but the highest BCR was calculated from soil test based fertilizer dose (N₁₄₄ P₃₀ K₄₇ S₉ Zn₂ B_{0.7} kg ha⁻¹). It is the result of one year only. For concrete decision, the experiment may be repeated in next year.

INTEGRATED NUTRIENT MANAGEMENT FOR BITTER GOURD CULTIVATION IN CALCAREOUS SOIL IN FARIDPUR

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Abstract

A trial was conducted at the Farming System Research and Development site, Sholakundu, Faridpur during the kharif-I, 2020 to find out a suitable nutrient package and to increase sustainable yield of Bitter gourd under farmers' field situation. BARI Korola-2 was used as planting material in the study. The experiment was laid out in randomized complete block design with three dispersed replications. Seven (7) treatments were considered as T₁ (Soil Test Based following FRG' 2018) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} kg ha⁻¹, T₂ (120% of STB) = N₉₆ P₃₀ K₃₀ S₆ Zn_{1.2} B_{0.6} kg ha⁻¹, T₃ (IPNS basis T₁ with cow dung) = N₅₅ P₁₈ K₁₄ S₅ Zn₁ B_{0.5} kg ha⁻¹ + cow dung (5 t ha⁻¹), T₄ (IPNS basis T₁ with vermicompost) = N₅₅ P₄₀ K₄ S₁₃ Zn₁ B_{0.5} kg ha⁻¹ + vermicompost (2 t ha⁻¹), T₅ (T₁ + 8 kg ha⁻¹ Mg) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} Mg₈ kg ha⁻¹, T₆ (T₁ + 10 kg ha⁻¹ Mg) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} Mg₁₀ kg ha⁻¹, and T₇ (Farmer's practice) = N₁₁₅ P₅₀ K₅₀ S₄₅ Zn₄ B₂ kg ha⁻¹. The highest fruit yield was obtained from farmers practice treatment, T₇ (18.09 t ha⁻¹) for cumulative effect of the highest yield contributing parameters followed by STB dose with 8 kg ha⁻¹ Mg treatment, T₅ (17.84 t ha⁻¹). The maximum gross return (Tk 814050 ha⁻¹) and gross margin (Tk 615200 ha⁻¹) were obtained from farmer's practice followed by T₅. But, the highest benefit cost ratio was calculated from T₅ (4.23) followed by T₇ (4.09). The chemical fertilizer dose used in farmers

practice treatment (T_7) was many times higher than all treatments that was irrational and may harmful to environment. Whereas treatment, $T_3 (T_1 + 8 \text{ kg ha}^{-1} \text{ Mg}) = N_{80} P_{25} K_{25} S_5 Zn_1 B_{0.5} Mg_8 \text{ kg ha}^{-1}$ gave the statistically similar fruit yield in against of farmers treatment (T_7) with rational use of fertilizer and reducing production cost.

Introduction

Bitter gourd (*Momordica charantia* L) is one of the most important and popular vegetable crops in Bangladesh (Nasreen *et al.*, 2013). It is popular due to its nutritive and medicinal values (Nadkarni, 1982). It is rich in vitamin C (88 mg/100g) (Akter *et al.*, 2009). Bitter gourd is widely cultivated in this country during kharif season. The fruit is a good source of iron, calcium, phosphorus and vitamin B. The crop yield in Bangladesh is generally low. The lower productivity of this vegetable mainly due to lack of high yielding varieties, its cultivation with inadequate nutrients and also continuous and imbalance use of inorganic fertilizer deteriorates soil health. Experimental evidences revealed that the crop was highly responsive to different fertilizers along with organic manure and the yield could be increased remarkably through judicious fertilization. Thus, integrated nutrient management practices applied for Bitter gourd can contributes to sustainable growth of yield and quality, influences plant health and reduces environmental risks. Use of organic manures with optimum rate of inorganic fertilizers including major and minor elements especially zinc and magnesium under intensive farming system increased the turnover of nutrients in the soil plant system. Thus, the present study was undertaken to determine suitable nutrient package for Bitter gourd and to increase sustainable yield of Bitter gourd.

Materials and Methods

The trial was conducted at the Farming System Research and Development site, Sholakundu, Faridpur during the kharif-I, 2020 to determine suitable nutrient package for Bitter gourd and to increase sustainable yield of Bitter gourd. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood Plain soil under AEZ-12 and nutrient status of cow dung and vermicompost were shown in Table 1a and 1b. The soil is slightly alkaline in nature and medium high land. Total nitrogen content was very low, P and Zn were Low and K& Mg was medium. S & B content were optimum. Ca was shown very high value.

Table 1a. Chemical properties of initial soil status of the experimental field of Bitter gourd at the FSRD Site, Sholakundu, Faridpur

Item	Texture	Land type	pH	OM (%)	Total N (%)	S ($\mu\text{g/g}$ soil)	Available P (ppm)	Zn (ppm)	B (ppm)	K (meq/ 100g soil)	Ca (ppm)	Mg (ppm)
Average	Clay Loam	MHL with irrigated	8.3	1.9	0.081	23.10	15.0	0.78	0.60	0.22	14.4	0.76
Interpretation			Slightly alkaline	M	VL	Opt	L	L	Opt	M	VH	M

MHL: Medium high land, VL: Very low, L: Low, M: Medium, opt: Optimum, VH: Very High

Source: Soil science laboratory, BARI, Gazipur

Table 1b. Nutrient status of cowdung and vermicompost

Item	N	P	K	S
Vermicompost	1.24	2.00	1.06	0.87
Cowdung	1.00	0.30	0.50	0.40

Source: Soil science laboratory, BARI, Gazipur

The experiment was laid out in randomized complete block design with three dispersed replications. Seven treatments were considered as T_1 (Soil Test Based; following FRG' 2018) = $N_{80}P_{25}K_{25}S_5Zn_1B_{0.5} \text{ kg ha}^{-1}$, T_2 (120% of STB) = $N_{96}P_{30}K_{30}S_6Zn_{1.2}B_{0.6} \text{ kg ha}^{-1}$, T_3 (IPNS basis T_1 with cow dung) = $N_{55}P_{18}K_{14}S_5Zn_1B_{0.5} \text{ kg ha}^{-1}$ + cow dung (5 t ha^{-1}), T_4 (IPNS basis T_1 with vermicompost) = $N_{55}P_{40}K_4S_{13}Zn_1B_{0.5} \text{ kg ha}^{-1}$ + vermicompost (2 t ha^{-1}), T_5 ($T_1 + 8 \text{ kg ha}^{-1} \text{ Mg}$) = $N_{80}P_{25}K_{25}S_5Zn_1B_{0.5}Mg_8 \text{ kg ha}^{-1}$, T_6 ($T_1 + 10 \text{ kg ha}^{-1} \text{ Mg}$) = $N_{80}P_{25}K_{25}S_5Zn_1B_{0.5}Mg_{10} \text{ kg ha}^{-1}$, and T_7 (Farmer's practice) = $N_{115}P_{50}K_{50}S_{45}Zn_4B_2 \text{ kg ha}^{-1}$. Soil test based dose of fertilizers for Bitter gourd calculated following Fertilizer Recommendation Guide FRG' 2018. BARI Korola-2 was used as planting material in the study. The unit plot size was 3.75 m $\times$ 2 m and spacing was 1.25 m $\times$ 1.25m. The crop management practices used

for conducting research is shown in Table 2. Fertilizers were applied according to treatments. All of organic fertilizer P, K, S, Zn, B and Mg was applied in pit 5-7 days before planting and mixed thoroughly with the soil. N was applied around the plant as side dressing at 22, 44 and 65 days after sowing and mixed thoroughly with the soil as soon as possible for better utilization. For controlling insect and disease Pegasus @ 1ml L⁻¹ of water for two times at 51 and 72 DAS and Autostin @ 2.5 ml L⁻¹ of water four times at 26, 44, 58 and 78 DAS were sprayed. Other intercultural operations and plant protection measures were taken as and when required. Fruit was harvested ten times for two and half months (starts at 65 and ends at 142 DAS). Data on yield and yield contributing characters were recorded and analyzed statistically with R software and the means were separated by DMRT (Gomez and Gomez, 1984).

Table 2. Crop management practices of Bitter gourd used in Faridpur during kharif I, 2020

Date of seed sowing	Irrigation (DAS)	Weeding and mulching (DAS)	Harvesting time
19 May, 2020	26 and 44	21, 43 and 64 DAS	23 July 2020 (65 DAS) to 8 October 2020 (142 DAS)

Results and Discussions

Yield attributes and fruit yield of Bitter gourd as influenced by different fertilizer packages during kharif-I, 2020 was presented in Table 3. Fertilizer packages exerted significant influence on yield attributes of Bitter gourd. The number of final plant population m⁻² was ranged from 0.70 to 0.80. Different number of plant population observed under different treatments due to might be germination of seed. The statistically highest number of fruits plant⁻¹ (53.67) was observed from farmers practice (T₇) which was similar with other treatments except T₃ and T₄ where IPNS based fertilizer was used. The lowest number of fruits plant⁻¹ (37.33) was observed from T₃ and T₄. The statistically highest single fruit weight was obtained from T₇ (48.20 g) followed by T₅ (45.77 g) where soil test based fertilizer with 8 kg ha⁻¹ Mg was used. The lowest single fruit weight was counted from T₄ (40.07 g) where IPNS STB with 2 t vermicompost ha⁻¹ was applied. The highest fruit weight plant⁻¹ was counted from T₇ (2.57 kg) due to obtain the highest number fruit plant⁻¹, single fruit weight (g) from that treatment followed by T₅ (2.47 kg). The lowest fruit weight plant⁻¹ was counted from T₄ treatment (1.60 kg). The highest fruit yield was obtained from T₇ (18.09 t ha⁻¹) due to the effect of highest yield contributing parameters followed by T₅ (17.84 t ha⁻¹). The lowest fruit yield was obtained from T₄ (11.67 t ha⁻¹). Excess application of chemical fertilizer (about 44% of N, 100% of P and K, 180% of S, 250% of Zn and 300% of B) in farmer's practice (T₇) enhanced the fruit yield of Bitter gourd only 1.4% as compared to treatment T₅ where Mg was used along with STB dose.

Cost and return analysis: The maximum gross return (Tk 814050 ha⁻¹) and gross margin (Tk 615200 ha⁻¹) were obtained from farmer's practice, but the highest benefit cost ratio (BCR) was calculated from T₅ (4.23) followed by T₇ (4.09) (Table 4).

Table 3. Yield attributes and yield of Bitter gourd as influenced by fertilizer management packages at FSRD site, Faridpur during the *kharif-I* season of 2020

Treatments	Final plant population m ⁻² (no)	Fruits plant ⁻¹ (no)	Single fruit wt (g)	Fruit wt plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
T ₁ (STB)	0.77 ab	38.00 a	45.17 ab	1.69 c	12.76 bc
T ₂ (120% STB)	0.73 ab	46.33 ab	45.53 ab	2.11 b	15.15 ab
T ₃ (IPNS T ₁ with 5 t ha ⁻¹ cow dung)	0.77 ab	37.33 b	45.13 ab	1.68 c	12.85 bc
T ₄ (IPNS T ₁ with 2 t ha ⁻¹ vermicompost)	0.70 b	37.33 b	40.07 b	1.60 c	11.67 c
T ₅ (T ₁ + 8 kg ha ⁻¹ Mg)	0.80 a	47.67 a	45.77 ab	2.47 a	17.84 a
T ₆ (T ₁ + 10 kg ha ⁻¹ Mg)	0.70 b	52.00 a	44.20 ab	2.13 b	15.37 ab
T ₇ (Farmer's practice)	0.73 ab	53.67 a	48.20 a	2.57 a	18.09 a
CV (%)	5.99	12.17	9.10	8.89	13.14

Note: T₁ (STB following FRG, 2018) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} kg ha⁻¹, T₂ (120% of STB) = N₉₆ P₃₀ K₃₀ S₆ Zn_{1.2} B_{0.6} kg ha⁻¹, T₃ (IPNS basis T₁ with Cowdung) = N₅₅ P_{17.5} K_{13.5} S₅ Zn₁ B_{0.5} kg ha⁻¹ + cowdung (5 t ha⁻¹), T₄ (IPNS basis T₁ with vermicompost) = N₅₅ P₄₀ K₄ S_{12.5} Zn₁ B_{0.5} kg ha⁻¹ + vermicompost (2 t ha⁻¹), T₅ (T₁ + 8 kg ha⁻¹ Mg) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} Mg₈ kg ha⁻¹, T₆ (T₁ + 10 kg ha⁻¹ Mg) = N₈₀ P₂₅ K₂₅ S₅ Zn₁ B_{0.5} Mg₁₀ kg ha⁻¹, and T₇ (Farmer's practice) = N₁₁₅ P₅₀ K₅₀ S₄₅ Zn_{3.5} B₂ kg ha⁻¹

Table 4. Cost and returns analysis of Bitter gourd as influenced by fertilizer management packages at FSRD site, Faridpur during the *kharif*-I season of 2020

Treatment	Fruit yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ (STB)	12.76	574200	188524	385676	3.04
T ₂ (120% STB)	15.15	681750	190089	491661	3.58
T ₃ (IPNS T ₁ with 5 t ha ⁻¹ Cowdung)	12.85	578250	211485	366765	2.73
T ₄ (IPNS T ₁ with 2 t ha ⁻¹ vermicompost)	11.67	525150	203994	321156	2.57
T ₅ (T ₁ + 8 kg ha ⁻¹ Mg)	17.84	802800	189434	613366	4.23
T ₆ (T ₁ + 10 kg ha ⁻¹ Mg)	15.37	691650	189654	501996	3.64
T ₇ (Farmers practice)	18.09	814050	198850	615200	4.09

Note: Price of average input (Tk kg⁻¹): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, Zinc: 200, Boron: 240, seed: 1200

Output price (Tk kg⁻¹): Bitter gourd fruit: 45

Farmers' opinion

Farmers were happy to get higher yield using relatively lower fertilizer and quite convinced to follow STB dose with 8 kg ha⁻¹ Mg in next year. The fruit color was greener and more attractive where Mg was used and obtaining higher market price than others.

Conclusion

After one year result, it may reveals that, though the highest fruit yield (18.09 t ha⁻¹) was obtained from farmers treatment T₇ (N₁₁₅P₅₀K₅₀S₄₅Zn_{3.5}B₂ kg ha⁻¹) but it was more irrational whereas treatment T₅ (N₈₀P₂₅K₂₅S₅Zn₁B_{0.5}Mg₈ kg ha⁻¹) was more rational in terms of yield (17.84 t ha⁻¹) and benefit cost ratio (4.23). It was one year result so for final decision, the experiment may be repeated in the next year.

EFFECT OF VARIETY AND FERTILIZER OF ONION BULB PRODUCTION UNDER ZERO TILLAGE CONDITION IN SHARIATPUR

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Abstract

An experiment was carried out at farmers' field of Uttar Dubaldia under Jajira upazilla, Shariatpur during the rabi 2019-2020 to 2020-21 to find out the suitable variety and fertilizer dose for increasing bulb yield of Onion under zero tillage condition. Six treatments i.e. T₁: BARI Piuj-1 + Soil Test Based Fertilizer dose, T₂: BARI Piuj-1 + 150% STB, T₃: BARI Piuj-1 + Farmer's fertilizer dose (FFD), T₄: Local variety + STB, T₅: Local variety + 150% STB and T₆: Local variety + FFD were used. It was laid out in randomized complete block design with four dispersed replications. The average highest bulb yield (17.91 t ha⁻¹) was obtained from T₄ followed by T₅ (16.72 t ha⁻¹). The average lowest bulb yield was found in T₂ treatment (15.08 t ha⁻¹). The average highest gross return (Tk 1035100 ha⁻¹) and gross margin (Tk 735388 ha⁻¹) were accounted from T₄ due to obtain the highest yield.

Introduction

Zero tillage is a type of conservation tillage where minimal soil disturbance, surface cover through crop residue retention and diverse associations happened (Hobbs *et al.*, 2008; Kassam *et al.*, 2009). It also helps in reducing the costs of production, saving time, increasing yield through timely planting. In the district of Madaripur and Shariatpur, farmers normally practice dibbling of the Onion bulb in moist soil with maintaining spacing after harvesting of T.Aman rice when flood water recedes. They do not use Soil Test Based doses of chemical fertilizers resulting poor bulb yield. Hence, the present study was undertaken to find out suitable variety and fertilizer dose for increasing bulb yield of Onion.

Materials and Methods

The experiment was carried out at Zajira, Shariatpur during the *rabi* 2019-2020 and 2020-21 to find out suitable variety and fertilizer dose for increasing bulb yield of Onion under zero tillage condition. It

was laid out in randomized complete block design with four dispersed replications. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood Plain soil under AEZ-12 is shown in Table 1. The soil is slightly alkaline in nature. Nitrogen and Phosphorus content was very low and S, Zn and B was low, K was medium.

Table 1. Chemical properties of Initial soil of the experimental field of Onion in Shariatpur

Item	Texture	Land type	pH	OM (%)	Total N (%)	Available P (ppm)	K (meq/100g soil)	S (µg/g soil)	Zn (ppm)	B (ppm)
Average	Clay Loam	MLL with irrigated	7.7	1.9	0.10	5.80	0.17	14.0	0.90	0.20
Interpretation			Slightly alkaline	M	VL	VL	M	L	L	L

The plot was situated at 23° 21' 45.2" north latitude and 90° 17' 52.9" East longitude. Six treatments i.e. T₁: BARI Piaj-1 + Soil Test Based Fertilizer Dose, T₂: BARI Piaj-1 + 150% STB, T₃: BARI Piaj-1 + Farmer's fertilizer dose, T₄: Local variety + STB, T₅: Local variety + 150% STB and T₆: Local variety + FFD were used. The local variety used by farmer is a mixture of different varieties like Lal Teer, Taherpuri etc. The soil test based fertilized dose was N₁₂₀P₆₀K₈₀S₂₅Zn₃B_{1.5} kg ha⁻¹ whereas farmer's dose was N₂₅₀P₁₀₆K₁₆₃S₄Zn₀B₁₀ kg ha⁻¹ from the source of urea, DAP, MoP, gypsum, zinc sulphate (mono hydrate) and boric acid, respectively. All fertilizers were applied before bulb transplanting. The unit plot size was 5m × 4m with plant spacing 20 cm × 10 cm. The bulb was transplanted on 17 November, 2019 and 12 November, 2020. The crop was harvested on 17 February, 2020 (90 days after planting) and 23 February, 2021 (103 DAT). Data on yield and yield contributing parameters were recorded and analyzed statistically through R software and mean separation was done using DMRT value.

Results and Discussions

Plant height and bulb diameter showed significant result in 2019-20 but bulb diameter showed non-significant result in 2020-21 (Table 2 and Table 3). For both the years, the highest plant height was observed from the treatment where farmer's fertilizer dose (FFD) was used (56.37 cm during 2020-21 and 60.25 cm during 2019-20). The average highest plant height (58.01 cm) was calculated from T₆ where local Onion variety with FFD was applied (Table 4). The lowest average plant height (52.35 cm) was observed from T₁ treatment. The maximum number of bulbs per m² (48.50 in 2020-21 and 57.25 in 2019-20) was found from T₄ where farmer's variety with soil test based fertilizer dose was used. The lowest average number of bulb per m² was found from T₃ (48.37). The average highest base diameter (36.66 mm) was obtained from local variety and FFD dose (T₆) followed by T₄. The average lowest base diameter was 33.39 mm which was found from T₃ treatment. The range of bulb yield of 2020-21 (17.88 t ha⁻¹ to 23.09 t ha⁻¹) was found higher than that of 2019-20 (11.78 t ha⁻¹ to 12.74 t ha⁻¹). The average highest bulb yield (17.91 t ha⁻¹) was obtained from T₄ due to might be the highest number of bulb m⁻² and higher base diameter followed by T₅ (16.72 t ha⁻¹). The average lowest bulb yield was calculated from T₂ treatment (15.08 t ha⁻¹). For both the years, the bulb yield was obtained from the treatment where 150% STB dose was used (T₂ and T₅). Thus, in 2020-21, the lowest yield was obtained from T₂ (17.88 t ha⁻¹) and in 2019-20, T₅ gave the lowest bulb yield (11.78 t ha⁻¹).

Cost and return analysis

In cost and return analysis, Table 5 reveals that, total variable cost of all the treatment was varied due to variability of seed bulb price (70-105 Tk kg⁻¹ for BARI Piaj-1 and 90-105 Tk kg⁻¹ for local cultivar), fertilizer dose and harvesting cost. The average highest gross return (Tk 1035100 ha⁻¹) and gross margin (Tk 735388 ha⁻¹) were accounted from T₄ due to obtain the highest bulb yield. The average lowest gross margin (Tk 584275 ha⁻¹) was obtained from that treatment (T₂) where BARI Piaj-1 and 150% of STB was used. It may be due to the negative response of over use of chemical fertilizer whereas STB fertilizer dose T₄ gave the highest bulb yield as a suitable combination of chemical fertilizer with variety.

Farmers' opinion

Farmers were interested to produce bulb production through using local cultivar as a variety with Soil Test Based fertilizer dose. A new idea was realized that excess of anything is bad.

Table 2. Yield and yield components of Onion bulb production at Zajira, Shariatpur during 2020-21

Treatments	Plant height (cm)	Bulb m ⁻² (no)	Bulb diameter (mm)	Yield (t ha ⁻¹)
T ₁	50.30 b	46.50 ab	38.05	19.63 ab
T ₂	51.90 b	46.00 ab	41.06	17.88 b
T ₃	50.80 b	45.75 b	39.41	19.41 ab
T ₄	53.00 ab	48.50 a	39.35	23.09 a
T ₅	53.46 ab	45.50 b	39.88	21.66 ab
T ₆	56.37 a	47.25 ab	41.95	20.94 ab
CV (%)	4.35	3.63	13.30	13.26

Note: T₁: BARI Piaj-1 + Soil Test Based Fertilizer dose (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₂: BARI Piaj-1 + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₃: BARI Piaj-1 + Farmer's fertilizer dose (250-106-163-4 NPKZn kg ha⁻¹), T₄: Local variety + STB (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₅: Local variety + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₆: Local variety + FFD (250-106-163-4 NPKZn kg ha⁻¹)

Table 3. Yield and yield components of Onion bulb production at Zajira, Shariatpur during 2019-20

Treatments	Plant height (cm)	Bulb m ⁻² (no)	Bulb diameter (mm)	Yield (t ha ⁻¹)
T ₁	54.40 b	52.50	29.63 ab	12.61
T ₂	55.45 b	51.00	26.62 b	12.29
T ₃	60.25 a	51.00	27.38 b	12.71
T ₄	55.52 b	57.25	32.72 a	12.74
T ₅	56.91 ab	53.25	29.36 ab	11.78
T ₆	59.65 a	56.75	31.38 a	12.25
CV (%)	4.31	8.38	7.69	10.89

Note: T₁: BARI Piaj-1 + Soil Test Based Fertilizer dose (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₂: BARI Piaj-1 + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₃: BARI Piaj-1 + Farmer's fertilizer dose (250-106-163-4 NPKZn kg ha⁻¹), T₄: Local variety + STB (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₅: Local variety + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₆: Local variety + FFD (250-106-163-4 NPKZn kg ha⁻¹)

Table 4. Yield and yield components of Onion bulb production (av of 2 yrs) at Zajira, Shariatpur during 2019-20 and 2020-21

Treatment	Plant height (cm)	Bulb m ⁻² (no)	Bulb diameter (mm)	Yield (t ha ⁻¹)
T ₁	52.35	49.50	33.84	16.12
T ₂	53.67	48.50	33.84	15.08
T ₃	55.52	48.37	33.39	16.06
T ₄	54.26	52.87	36.03	17.91
T ₅	55.18	49.37	34.62	16.72
T ₆	58.01	52.00	36.66	16.59

Note: T₁: BARI Piaj-1 + Soil Test Based Fertilizer dose (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₂: BARI Piaj-1 + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₃: BARI Piaj-1 + Farmer's fertilizer dose (250-106-163-4 NPKZn kg ha⁻¹), T₄: Local variety + STB (120-60-80-25-3-1.5 NPKSZnB kg ha⁻¹), T₅: Local variety + 150% STB (180-90-120-38-4.5-2.25 NPKSZnB kg ha⁻¹), T₆: Local variety + FFD (250-106-163-4 NPKZn kg ha⁻¹)

Table 5. Cost and return analysis of Onion bulb production at Zajira, Shariatpur during 2019-20 and 2020-21 (av of 2 yrs)

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	16.12	960050	318017	642033
T ₂	15.08	910650	326375	584275
T ₃	16.06	960150	325646	634504
T ₄	17.91	1035100	299712	735388
T ₅	16.72	963300	308070	655230
T ₆	16.59	970050	307341	662709

Price of product (Tk kg⁻¹): Bulb: 90

Conclusion

After two years result, it may be concluded that excess fertilizer may not give good result but increasing production cost and hampering soil health. However, application of 120-60-80-25-3-1.5 N-P-K-S-Zn-B kg ha⁻¹ appeared as the best suitable combination of fertilizer for higher and economically profitable yield of bulb Onion production under zero tillage condition in Shariatpur region.

VALIDATION OF BIOFERTILIZER OF LENTIL

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Abstract

A field trial was conducted at the Farming Systems Research and Development site, Faridpur during the rabi of two consecutive year 2019-20 to 2020-21 to find out the effects of rhizobial biofertilizers on the performance of Lentil. The trial was laid out in randomized complete block design with four dispersed replications. The Lentil variety BARI Masur-8 and peat based rhizobium strain (BARI RLC-104) were used for the experiment. Unit plot size was 6 m × 5 m. Three treatment combinations viz., T_1 (without Rhizobium inoculant+ $P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹), T_2 (with Rhizobium inoculant+ $P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹) and T_3 ($N_{50}P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹) were tested in this regard. From the average of two years result, the higher seed yield was obtained (1.90 t ha⁻¹) where Rhizobium inoculant along with $P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹ was used (T_2). The highest gross return (Tk 133950 ha⁻¹) and gross margin (Tk 90589 ha⁻¹) was also accounted from the treatment T_2 .

Introduction

In Bangladesh, Lentil (*Lens culinaris* L.) occupies the top most position in terms of popularity. The cultivated area and production is 1.87 lac hectare and 2.60 lac m. ton, respectively. (AIS, DAE, 2021). The crop is cultivated during the rabi under rainfed (mostly) situation. About 80 percent of total Lentil produced in the country is grown in Faridpur, Kushtia, Jashore, Rajshahi and Pabna districts. The yield of Lentil is lower in Bangladesh. There is scope to increase yield of this crop by improving nodulation and thereby N₂-fixation through use of effective nitrogen fixing bacteria (Rhizobium) as seed inoculant. This can minimize use of nitrogenous fertilizer and might help to reduce adverse effects of chemical fertilizer in soil environment. Bangladesh Agricultural Research Institute (BARI) has developed a good number of Lentils varieties. Response of these varieties, especially the newly released ones to rhizobial inoculums in respect of nodulation, N₂-fixation and yield has yet to be studied. The response might be different under different agro ecological situation because of variation in native rhizobial population. The present investigation was, therefore, undertaken to observe the effect of rhizobial biofertilizers on the performance of Lentil under agro ecological situation-12.

Materials and Methods

The trial was conducted at the Farming Systems Research and Development site, Faridpur during the Rabi 2019-20 and 2020-21. The BARI Masur-8 and inoculum BARI RLC-104 were used as the trial materials. The trial was laid out in RCB design with four dispersed replications. Three treatments viz., T_1 (without Rhizobium inoculant+ $P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹), T_2 (with Rhizobium inoculant+ $P_{22}K_{42}S_{20}Zn_5$ kg ha⁻¹) and T_3 ($N_{50}P_{22}K_{42}S_{40}Zn_5$ kg ha⁻¹) were considered in this regard. The unit plot size was 6 m × 5 m. The seeds were sown in line maintaining 30 cm from line to line distance during 30 November to 2 December 2019 and 19 November to 2 December 2020. According to treatment, chemical fertilizers were applied at the time of final land preparation. In the rhizobium inoculant treatment, 1.5 kg ha⁻¹ was applied. Weeding was done twice at 23-26 and 42-45 Days after Sowing (DAS). For controlling foot and root rot (FRR), fungicide provax were applied twice at 24-27 and 38-41 DAS and during pod formation stage at 68-85 DAS, amister top was sprayed. The crop was harvested on 15-16 March 2020 and 9-13 March 2021. The data on yield and yield contributing characters were recorded and analyzed statistically using open source software R and the means were separated by DMRT (Gomez and Gomez 1984).

Results and Discussions

The data presented in Table 1 revealed that yield and yield contributing characters varied significantly due to treatments in both the years except number of plant population m⁻² and number of seeds pod⁻¹. All the parameters were found highest in both years for number of plant population m⁻² (98.47 during 2020-21 and 109.25 during 2019-20), number of pods plant⁻¹ (69 during 2020-21 and 57.80 during 2019-20) from the treatment T_2 where Rhizobium inoculum along with $P_{22}K_4S_{20}Zn_5$ kg ha⁻¹ was considered. During 2019-20, the highest plant height (38.72 cm) and number of seeds pod⁻¹ (1.67) were calculated from T_2 . The highest average number of plant population m⁻², number of pods plant⁻¹, number

of seeds pod^{-1} was 103.86, 63.40 and 1.71, respectively from T_2 treatment (Table 2). The highest average plant height (40.81 cm) and 1000 seed weight (22.45 g) were observed from T_3 and T_1 , respectively. The highest average seed yield (1.90 t ha^{-1}) was found in T_2 treatment, and it was due to the cumulative effect of all yield contributing characters. The plant grown without N and inoculant (T_1 treatment) showed the lowest performance in yield contributing characters especially number of plant population m^{-2} (98.44) and number of pods plant^{-1} (56.73), resulting the lowest average seed yield (1.61 t ha^{-1}). The yield obtained in plots under T_2 treatment was 9% higher over that of application of 50 kg N ha^{-1} in T_3 .

Cost and return analysis

The Table 3 showed that the highest gross return (Tk 133950 ha^{-1}) and gross margin (Tk 90589 ha^{-1}) was accounted from the treatment with Rhizobium inoculant+ $\text{P}_{22}\text{K}_{42}\text{S}_{20}\text{Zn}_5 \text{ kg ha}^{-1}$ (T_2) over those of other two treatments.

Farmers' opinion

Farmers were encouraged to observe the performance of BARI Masur-8 along with inorganic fertilizer and inoculum. They opined that the availability of inoculums should be ensured in sowing time.

Table 1. Yield and yield contributing characters of Lentil as influenced by bio-fertilizer at the FSRD site, Faridpur during 2019-20 and 2020-21

Treat	Plant height (cm)		Plant pop. m^{-2} (no.)		Pods plant^{-1} (no)		Seeds pod^{-1} (no)		1000-seed wt (g)		Seed yield (t ha^{-1})	
	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1
T_1	40.1 b	37.90	90.87	106.0	60.9	52.55b	1.77	1.65	24.50	20.40b	1.61 c	1.61c
T_2	41.2 b	38.72	98.47	109.25	69.0	57.80a	1.75	1.67	24.07	20.60a	1.92 a	1.88 a
T_3	43.1 a	38.52	89.79	108.25	64.5	54.15b	1.70	1.62	23.93	20.55ab	1.78 b	1.71 b
CV %	2.47	2.82	20.13	3.32	14.08	2.80	3.94	2.25	1.93	0.53	3.20	3.09

Note: $T_1 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$, $T_2 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1} + \text{Rhizobium inoculum}$, $T_3 = \text{N}_{50}\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$

Y2: 2020-21 and Y1: 2019-20

Table 2. Yield and yield contributing characters of Lentil as influenced by biofertilizer at the FSRD site, Faridpur (av of 2 years)

Treatment	Plant height (cm)	Plant pop ⁿ m^{-2} (no)	Pod plant^{-1} (no)	Seed pod^{-1} (no)	1000 seed wt (g)	Seed yield (t ha^{-1})
T_1	39.00	98.44	56.73	1.71	22.45	1.61
T_2	39.96	103.86	63.40	1.71	22.34	1.90
T_3	40.81	99.02	59.33	1.66	22.24	1.75

$T_1 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$, $T_2 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1} + \text{Rhizobium inoculum}$, $T_3 = \text{N}_{50}\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$

Table 3. Cost and return analysis of Lentil as influenced by biofertilizer (av of 2 years)

Treatment	Seed yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1	1.44	113505	42221	71284
T_2	1.63	133950	43361	90589
T_3	1.51	123375	44298	79077

$T_1 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$, $T_2 = \text{N}_0\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1} + \text{Rhizobium inoculum}$, $T_3 = \text{N}_{50}\text{P}_{22} \text{K}_{42} \text{S}_{20} \text{Zn}_5 \text{ kg ha}^{-1}$

Price (Tk kg^{-1}): Lentil seed (av of two years)= 68.50 and stover: 2

Conclusion

Two years' consecutive study revealed that, the highest seed yield obtained from BARI Masur-8 treated with $\text{P}_{22}\text{K}_{42}\text{S}_{20}\text{Zn}_5 \text{ kg ha}^{-1}$ chemical fertilizer along with Rhizobium inoculum (BARI RLc-104 @ 1.5 kg ha^{-1}) might be suitable and economically viable for Lentil cultivation in Faridpur region under Low Ganges River Floodplain (AEZ-12).

VALIDATION ON BIOFERTILIZER OF GROUNDNUT

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

A field trial was conducted at Dikrirchar, Faridpur during the kharif-I, 2020 to find out the effect of rhizobial biofertilizers on the performance of Groundnut. The BARI Chinabadam-8 and inoculum BARI RAh-801 were used as the trial materials. The trial was laid out in randomized complete block design with seven dispersed replications. Three treatments viz., T_1 (without *Rhizobium* inoculant+ $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹), T_2 (with *Rhizobium* inoculant+ $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹) and T_3 ($N_{50}P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹) were considered in this regard. It is observed that, the nut yield obtained (1.42 t ha⁻¹) was the highest in plots where *Rhizobium* inoculant along with $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ was used (T_2). Benefit cost ratio was also higher in T_2 treatment (1.27) over those of other two treatments.

Introduction

The yield of Groundnut is lower in Bangladesh. There is scope to increase yield of this crop by improving nodulation and thereby N₂-fixation through use of effective nitrogen fixing bacteria (*Rhizobium*) as seed inoculant. This can minimize use of nitrogenous fertilizer and might help to reduce adverse effects of chemical fertilizer in soil environment. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) has developed a good number of Groundnut varieties. Response of these varieties, especially the newly released ones to rhizobial inoculums in respect of nodulation, N₂-fixation and yield has yet to be studied. The response might be different under different agro ecological situation because of variation in native rhizobial population. The present investigation was, therefore, undertaken to observe the effect of rhizobial biofertilizers on the performance of Groundnut under agro ecological situation-12.

Materials and Methods

The trial was conducted at the Dikrirchar, Faridpur during the kharif-I 2020 to find out the effects of rhizobial biofertilizers on the performance of Groundnut. The BARI Chinabadam-8 and inoculum BARI RAh-801 were used as trial materials. The trial was laid out in randomized complete block design with seven dispersed replications. Three treatments viz., T_1 (without *Rhizobium* inoculant+ $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹), T_2 (with *Rhizobium* inoculant+ $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹) and T_3 ($N_{50}P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹) were considered in this regard. The unit plot size was 4 m × 3 m. The seeds were sown in line maintaining spacing of 40 cm × 10 cm on 2 February 2020. According to treatment, chemical fertilizers were applied at the time of final land preparation. In the rhizobium inoculant treatment, 1.5 kg ha⁻¹ was applied. The crop was harvested on 31 May 2020 (119 Days after sowing). The data on yield and yield contributing characters were recorded and analyzed statistically using open source software R and the means were separated by DMRT (Gomez and Gomez 1984).

Results and Discussions

The data presented in Table 1 revealed that yield and yield contributing characters varied non significantly due to treatments for all parameters except plant height and nut yield. The number of plant population per m² ranged from 18.85 (T_2) to 19.14 (T_3). The highest plant height (60.31 cm) was observed from T_3 ($N_{50}P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹) treatment followed by T_2 treatment. All the parameters were found highest for number of nuts plant⁻¹ (16.77) and 100 kernel weight (29.85 g) from the treatment T_2 where *Rhizobium* inoculum along with $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹ was considered. The highest nut yield (1.42 t ha⁻¹) was found in T_2 treatment and it was due to the cumulative effect of number of nut per plant and 100 kernel weight. But yield was lower than potential yield due to incoming of flood water into the field as a result harvest was earlier. The plant grown without N and inoculant (T_1 treatment) showed the lowest nut yield (1.32 t ha⁻¹). The yield obtained in plots under T_2 treatment was about 4.5% higher over that of application of 50 kg N ha⁻¹ in T_3 .

Cost and return analysis

The Table 2 shows that the highest gross return (Tk 92300 ha⁻¹), gross margin (Tk 20030 ha⁻¹) and BCR (1.27) were accounted from the treatment with *Rhizobium* inoculant+ $P_{50}K_{30}S_{35}Zn_2B_{1.5}$ kg ha⁻¹ (T_2) over

those of other two treatments.

Farmers' opinion

Farmers were encouraged to observe the performance of BARI Chinabadam-8 along with inorganic fertilizer and inoculum. They opined that the availability of inoculums should be ensured in sowing time and local market.

Table 1. Yield and yield contributing characters of Groundnut as influenced by biofertilizer at Dikrighar, Faridpur during Kharif-I, 2020

Treatment	Plant height (cm)	Plant pop ⁿ m ⁻² (no)	Nut plant ⁻¹ (no)	100 nut wt (g)	100 kernel wt (g)	Nut yield (t ha ⁻¹)
T ₁	57.08 c	19.00	15.87	64.57	29.00	1.32 c
T ₂	58.92 b	18.85	16.77	64.85	29.85	1.42 a
T ₃	60.31 a	19.14	15.54	65.00	29.28	1.36 b
CV %	1.93	4.39	7.24	1.66	2.77	1.65

T₁=without *Rhizobium* inoculant+ P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹, T₂ = *Rhizobium* inoculant+ P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹ T₃=N₅₀P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹

Table 2. Cost and return analysis of Groundnut as influenced by biofertilizer

Treatments	Nut yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	1.32	85800	72270	13530	1.20
T ₂	1.42	92300	72270	20030	1.27
T ₃	1.36	88400	74006	14394	1.19

Note: T₁ =without *Rhizobium* inoculant+ P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹, T₂ = *Rhizobium* inoculant+ P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹ T₃=N₅₀P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹, Output price (Tk kg⁻¹): Groundnut= 65

Conclusion

The highest nut yield obtained from plants treated with P₅₀K₃₀S₃₅Zn₂B_{1.5} kg ha⁻¹ chemical fertilizer along with *Rhizobium* inoculum (BARI Rah-801@ 1.5 kg ha⁻¹) might be suitable and economically viable for Groundnut cultivation in Faridpur region under Low Ganges River Floodplain (AEZ-12).

NUTRIENT MANAGEMENT OF ZERO TILLAGE POTATO IN SALINE AREAS

Mustafa Kamal Shahadat, Md. Harunor Rashid, Md. Kamrul Islam, Md. Mashfiqur Rahman, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment on nutrient management of zero tillage potato production was conducted at Dacopeupazila of Khulna district during 2020-21. Since, under zero tillage practice efficiency of conventional top dress nutrient application is poor, hence nutrient combination of foliar spray and top dress with soil were tested. Four nutrient combinations were tested on two potato varieties viz. BARI Alu-46 and BARI Alu-72. The treatments were T₁: 50% N and K + All P, S, Zn, Mg, B at basal + 25% N and K top dress with soil at 30 and 45 DAP (control); T₂: All Basal + only NPK top dress with spray at 30, 45, 60 DAP; T₃: 75% NPKS Basal+ 12.5%NPKS and 50% Mg, Zn, B top dress with soil at 30 and 45 DAP and T₄, All Basal NPKSMgZnB top dress with spray at 30, 45, 60 DAP. It was found that only foliar spray of NPK at 30, 45 and 60 DAP (T₂) produced highest tuber yield (20.0 t ha⁻¹) in BARI Alu-72. Between the varieties BARI Alu-72 gave highest yield (16.33 t ha⁻¹), where BARI Alu-46 was less responsive to spray treatments.

Introduction

In the south-western coastal region (viz. Khulna, Satkhira, Bagerhat) T. Aman rice is the main crop grown in kharif (mid March-mid November) season. But during the rabi season, most of the lands remain fallow mainly due to late T. Aman harvest, shorter winter period, increasing soil and water salinity, delay in attaining 'Jo' condition of the soil etc. Since, clay soil retains more moisture than

sandy loam soil. Under such situation for increasing cropping intensity, zero tillage cultivation with mulch could be an alternative way of crop production in that region. Zero tillage potato cultivation with rice straw mulch is gaining popularity in coastal saline area because it takes less labor and input than other rabi crops. However, appropriate cultivation techniques and suitable variety (ies) should be determined for higher yield and profit. In this regards, agronomic managements like spacing, suitable mulch materials, mulch thickness or amount, irrigation management, fertility management etc. should be optimized. Under zero tillage practice top dressing of nutrient is not straight forward, so therefore, the present experiment aimed at efficacy of nutrient spray on tuber yield of potato under zero tillage potato.

Materials and Methods

The experiment was conducted during 2020-21 in a randomized complete block design with three replications and had two factor factorial treatment combinations, where factor 'a' represents 'Variety', viz. V₁, BARI Alu-46 and V₂, BARI Alu-72, factor 'b' represents nutrient combinations, viz. T₁= 50% N and K + All P, S, Zn, Mg, B at basal + 25% N and K top dress with soil at 30 and 45 DAP (control); T₂= All Basal + only NPK top dress with spray at 30, 45, 60 DAP; T₃= 75% NPKS Basal+ 12.5%NPKS and 50% MgZn B top dress with soil at 30 and 45 DAP and T₄= All Basal NPKSMgZnB top dress with spray at 30, 45, 60 DAP. Detail treatment description has been presented in Table 1. Whole or cut tubers of 45-55 g in weight having at least two sprouting eyes were sown on 16 December 2020 just after T. Aman harvest. Planting was done by pressing the seed tuber into the wet muddy soil in a way that two-thirds of the tuber remains above the ground. Tubers were sown at a spacing of 20 cm with 40 cm between rows. Immediately after sowing all tubers were covered with compost @ 5 t ha⁻¹ and treatment specific basal fertilizer doses were applied. Over the compost, a layer of paddy straw (available in plenty in the coastal area) of 10-12 cm thick (8-10 t ha⁻¹) was spreaded to cover the plot.

Foliar and top dress of nutrients were applied to the respective treatments at 30, 45 and 60 days after planting (DAP). In all the foliar applications, spray volume of 300 L of water ha⁻¹ was used. Nutrients applied through foliar spray were also applied to soil in other treatments to keep the total amount of nutrients the same for all the treatments.

Three irrigations were applied at 30, 50 and 65 DAP. Harvesting of tubers was done manually by removing the top 10 cm paddy straw mulch on 13 March 2021.

Table 1. Detail description of treatment studied under the nutrient management of zero tillage potato cultivation in south western coastal region of Bangladesh during 2020-21

Treatment	Treatment description	Nutrient dose (kg ha ⁻¹)
T ₁	50% N and K + All P, S, Zn, Mg, B at basal + 25% N and K top dress with soil at 30 and 45 DAP (control)	N-P-K-S-Zn-Mg-B @ 67.5-30-45-6-4-2-1.6 kg ha ⁻¹ at basal. N-K @33.75-22.5 kg ha ⁻¹ at 30 and 45 DAP.
T ₂	74%N+96%P+96%K and 100% SZnMgB at Basal. 24% N top dress at 15 cm plant height. 1%N+2%P+2%K spray at 30 and 45 DAP. 0.2% N + 0.3% K spray at 60 DAP	N-P-K-S-Zn-Mg-B @100-28.8-86.7-6-4-2-1.6 kg ha ⁻¹ at basal. 32 kg ha ⁻¹ N at 15 cm plant height. N-P-K @1.38-0.6-1.5 kg ha ⁻¹ at 30 and 45 DAP. N-K @ 0.28-0.30 kg ha ⁻¹ at 60 DAP.
T ₃	75% NPKS Basal+ 12.5%NPKS and 50% MgZn B top dress with soil at 30 and 45 DAP	N-P-K-S @ 101.25-22.5-67.5-4.5 kg ha ⁻¹ at basal. N-P-K-S-Mg-Zn-B @ 16.88-3.75-11.25-0.75-1-2-0.8 kg ha ⁻¹ at 30 and 45 DAP.
T ₄	74%N+96%P+96%K+46%S+ 40.6% Zn + 68%Mg + 81.25% B at Basal. 24% N top dress at 15 cm plant height. 1%N+2%P+2%K+25%S+15%Mg+27%Zn +6.25% B spray at 30 and 45 DAP. 0.2% N + 0.3% K + 4% S + 5.4% Zn + 3% Mg + 6.25% spray at 60 DAP	N-P-K-S-Zn-Mg-B @100-28.8-86.7-2.8-1.4-1.6-1.3 kg ha ⁻¹ at basal. 32 kg ha ⁻¹ N top dress at 15 cm plant height. N-P-K-S-Mg-Zn-B @1.38-0.6-1.5-1.48-0.29-1.08-0.1 kg ha ⁻¹ at 30 and 45 DAP. N-K-S-Mg-Zn-B @ 0.28-0.30-0.25-0.06-0.22-0.1 kg ha ⁻¹ at 60 DAP.

Results and Discussions

Between the two varieties BARI Alu-72 is known to be moderately saline (up to 8 dS/m) tolerant variety, whereas BARI Alu-46 was used for comparison with same treatment. The yield of two varieties

significantly differed with each other, where yield of BARI Alu-72 was higher (16.33 t ha^{-1}) than BARI Alu-46 (10.24 t ha^{-1}) (Fig. 1).

Among the treatments, there were significant variations for tuber yield, where treatments receiving foliar spray being highest and conventional top dress remained lowest. There was no significant difference between both the spray treatments, T_2 and T_4 . Where tuber yield in T_2 and T_4 were 14.42 t ha^{-1} and 14.04 t ha^{-1} , respectively. On the other hand, tuber yield of treatment T_1 and T_3 , where nutrients were top dressed with soil, were 12.33 t ha^{-1} and 12.35 t ha^{-1} , respectively (Fig. 2).

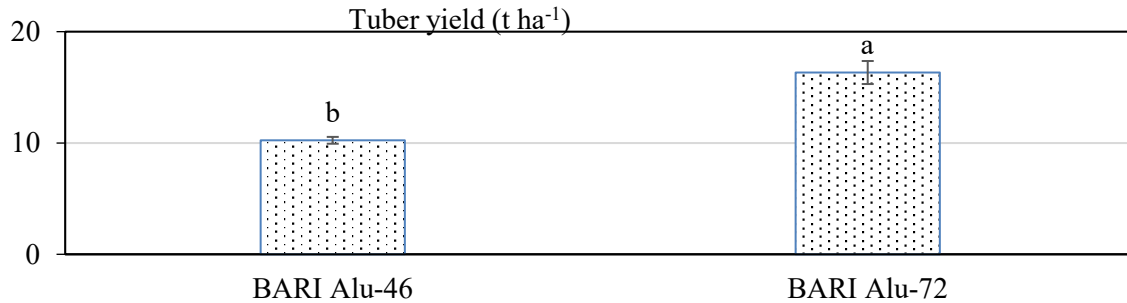


Fig 1. Tuber yield of BARI Alu-46 and BARI Alu-72 grown under zero tillage practice with different nutrient management practices at Dacope, Khulna during 2020-21

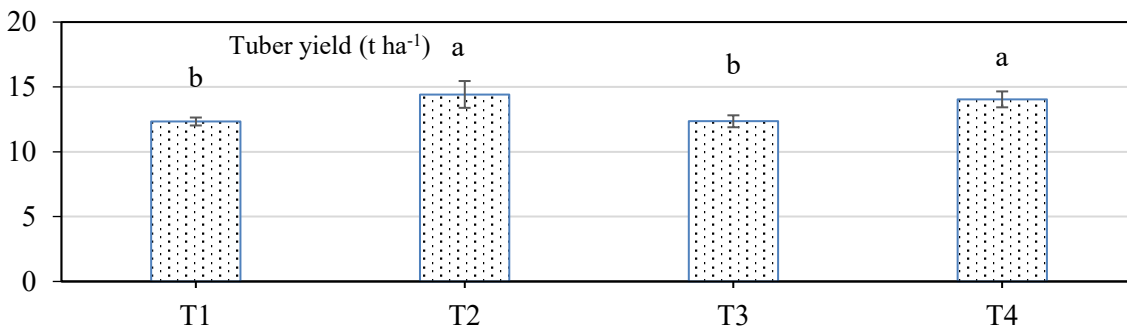


Fig 2. Tuber of yield of from different nutrient management treatments under zero tillage potato cultivation at Dacope, Khulna, 2020-21

Tuber yield of variety and treatment combinations also varied significantly. Overall, variety BARI Alu-72 performed better irrespective of treatments than BARI Alu-46. In BARI Alu-72, spray treatments produced higher tuber yield, where highest tuber yield was recorded from BARI Alu-72 + T_2 treatment (20.00 t ha^{-1}) followed by BARI Alu-72 + T_4 (17.04 t ha^{-1}). While, lower tuber yield was recorded from BARI Alu-46 + T_2 (8.83 t ha^{-1}) (Fig. 3). In case of BARI Alu-46 spray treatment did not perform well over soil application treatments, whereas spray treatments were more responsive in case of BARI Alu-72.

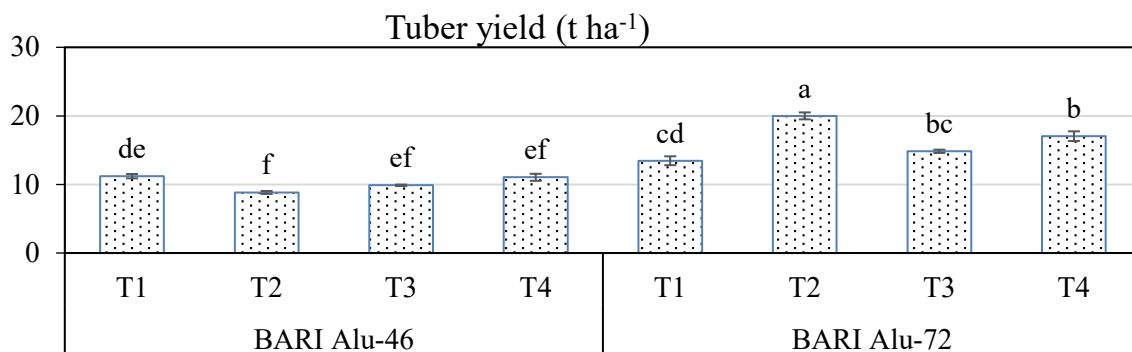


Fig 3. Tuber yield of variety X treatment combinations of zero tillage potato cultivation on nutrient management grown at Dacope, Khulna during 2020-21

Conclusion: There was difference in varietal response in terms of nutrient management, however, foliar spraying of only NPK at 30, 45 and 60 DAS (T_2) produced highest tuber yield than other treatments.

VALIDATION ON BIOFERTILIZER OF DIFFERENT LEGUME CROPS IN KUSHTIA

J A Mahmud, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at Kushtia sadar and Multi Location Testing site, Chuadanga during the rabi season of 2020-21 to observe the effect of rhizobial biofertilizers of Lentil, chickpea and mungbean. The effect of rhizobial biofertilizers of Lentil, chickpea and mungbean was found positive. The yield of Lentil (1.84 t ha^{-1}), chickpea (1.73 t ha^{-1}) and mungbean (1.25 t ha^{-1}) was higher in rhizobial applied field than other treatments.

Introduction

Pulses plays an important role in food crops of Bangladesh. It is called the meat of poor people. Because, there are high protein in pulses like meat. But the price of pulses is lower than meat. In rabi season it has to compete with other winter vegetable, wheat, oil seed etc. Rhizobial inoculum increases seed yield of different legumes at least by 20 percent over control. This technology generates information on the application of biofertilizer in different pulses as well as biomass for human health and also maintenance of soil fertility. With this view in mind, the experiment was undertaken to observe the effect of rhizobial biofertilizers to the performance of Lentil, chickpea and mungbean.

Materials and Methods

The experiment was conducted at Kushtia sadar for Lentil and mungbean and Multi Location Testing site, Chuadanga is for chickpea during rabi Season 2020-2021. The trial was laid out in randomized complete block design with four dispersed replications. The plot size was $10\text{m} \times 15\text{m}$ in each. The treatments were T_1 = Without *Rhizobium* inoculant + PKSZn, T_2 = With *Rhizobium* inoculant (1.5 t ha^{-1}) + PKSZn and T_3 = NPKSZn. BARI Masur-8, BARI Chola-5 and BARI Mung-6 were used as experimental varieties. Data on yield and yield contributing character were recorded for both the crops.

Table 1. Agronomic practices of legume crops

Agronomic practices	Lentil	Chickpea	Mung bean
Variety	BARI Masur-8	BARI Chola-5	BARI Mung-6
Date of sowing	18 th Nov, 2020	1 st Dec, 2020	14-18 March, 2021
Fertilizer dose (kg NPKSZn ha^{-1})	50-22-42-20-5	50-22-42-20-5	45-22-42-20-5
Fertilizer application	All chemical fertilizer except urea at final land preparation		
Plant protection	Provax-200WP and Rovral were applied to control diseases	Provax-200WP, and Carrate and Volium Flaxi were applied to control diseases and insects	Provax-200-WP, Virtako and Volium Flaxi were applied to control disease and insect
Date of harvesting	15 th March, 2021	05-07 April, 2021	16 th May to 10 th June, 2021

Results and Discussions

The effect of biofertilizers on yield and yield components of Lentil, chickpea and mungbean at farmer's field were presented in (Table 2 and Table 3).

Lentil: Plant height, number of pod per plant and thousand seed weight was also the highest in with rhizobium inoculant plot. The highest seed yield was obtained 1.84 t ha^{-1} in rhizobium inoculant plot and it followed by only NPKSZn plot (1.46 t ha^{-1}) and without rhizobium inoculant plot (1.23 t ha^{-1}). Gross return and gross margin was higher with rhizobium inoculant than that of without rhizobium inoculant and NPKSZn plot.

Chickpea: Plant height, number of pod per plant and thousand seed weight was also the highest in with rhizobium inoculant plot. The highest seed yield was obtained 1.73 t ha⁻¹ in with rhizobium inoculant plot and it followed by without rhizobium inoculant plot (1.53 t ha⁻¹) and only NPKSZn plot (1.42 t ha⁻¹). Gross return and gross margin was higher with rhizobium inoculant than that of without rhizobium inoculant and NPKSZn plot.

Mungbean: Plant height, number of pod per plant and thousand seed weight was the highest in with rhizobium inoculant plot. The highest seed yield was obtained (1.25t ha⁻¹) in with rhizobium inoculant plot and it followed by without rhizobium inoculant plot (1.15 t ha⁻¹) and only NPKSZn plot (1.23 t ha⁻¹). Gross return and gross margin was higher with rhizobium inoculant than that of without rhizobium inoculant and NPKSZn plot.

Farmer's opinion

Farmers' were impressed with the performance of rhizobium inoculant due to higher yield, bold size seed in Lentil, chickpea and mungbean. They were interested in using this rhizobium inoculant if it will be available in market.

Table 2. Effect of biofertilizers on yield and yield components of Lentil, chickpea and mungbean in farmer's field during 2020-21

Treatment	Days to maturity	Plant pop ⁿ m ⁻² (no)	Plant height (cm)	Pod plant ⁻¹ (no)	1000 seed wt (g)	Seed yield (tha ⁻¹)	Straw yield (tha ⁻¹)
Lentil							
T ₁	110	63.67	41.13	69	21.27	1.23	1.22
T ₂	111	63.00	45.00	88	22.53	1.84	1.38
T ₃	111	63.67	44.87	75	22.23	1.46	1.41
Chickpea							
T ₁	125	21.00	43.50	67	111.50	1.53	2.16
T ₂	127	21.50	46.50	74	113.50	1.73	2.34
T ₃	123	21.50	41.00	60	112.50	1.42	1.97
Mungbean							
T ₁	61	28.67	60.83	26	50.00	1.15	-
T ₂	61	30.00	63.66	31	50.90	1.25	-
T ₃	61	29.00	64.33	27	49.66	1.23	-

T₁= Without Rhizobium inoculant +PKSZn; T₂= With Rhizobium inoculant + PKSZn and T₃= NPKSZn

Table 3. Cost and return analysis of Lentil, chickpea and mungbean in farmer field during 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Lentil			
T ₁	88540	43854	44686
T ₂	131560	43854	87706
T ₃	105020	45590	59430
Chickpea			
T ₁	131040	56752	74288
T ₂	149340	56752	92588
T ₃	121498	57555	63943
Mungbean			
T ₁	63250	44956	18294
T ₂	68750	44956	23794
T ₃	67650	46692	20958

Selling price: Lentil @ 70 Tk/kg, Chickpea 80 @ Tk/kg, Mungbean @ 55 Tk/Kg

Conclusion

Based on findings, it may be concluded that seed yield was increased by applying rhizobium inoculant. It has positive impact on yield.

EFFECT OF NUTRIENT MANAGEMENT AND STORAGE METHODS ON THE YIELD AND STORABILITY OF SWEET POTATO IN KUSHTIA

J A Mahmud, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at Kumarkhali, Kushtia during 2020-2021 in farmer's field to observe the nutrient management of sweet potato. Three treatments viz. $T_1 = 126-15-115-8$ kg NPKS ha^{-1} + 3 ton poultry manure ha^{-1} (IPNS), $T_2 = 128-13-118-12$ kg NPKS ha^{-1} + 6 ton cow dung ha^{-1} (IPNS), $T_3 =$ Farmer's practice ($100-20-110$ kg NPK ha^{-1}) were applied in this experiment. BARI sweet potato variety BARI SP-8 was used in this trial. The highest tuber yield was obtained from T_1 (24.36 t ha^{-1}) and the lowest from T_3 (20.50 t ha^{-1}).

Introduction

Sweet potato is an important tuber crop in Bangladesh. It has potentiality to reduce pressure upon the staple food. The yield of sweet potato in Bangladesh is lower compared to that of other countries of the world. Yield and quality of variety is depends on nutrient management. Generally farmers applied fertilizer in imbalanced way resulting lower yield and quality as well as deteriorate soil fertility. The farmers will be able to achieve higher yield and quality by using the newly developed fertilizer package. So, it is necessary to disseminate this fertilizer package through adaptive trials.

Materials and Methods

The experiment was conducted at Kumarkhali, Kushtia during 2020-2021 in farmer's field. The unit plot size was $3.0\text{ m} \times 3.0\text{ m}$ for each treatment. BARI released sweet potato variety BARI SP-8 was used in the experiment. The treatments were three levels of nutrient management $T_1 = 126-15-115-8$ kg NPKS ha^{-1} + 3 ton poultry manure ha^{-1} (IPNS), $T_2 = 128-13-118-12$ kg NPKS ha^{-1} + 6 ton cow dung ha^{-1} (IPNS), $T_3 =$ Farmer's practice. The experiment was conducted in six dispersed replication in randomized complete block design. Necessary data were recorded and analyzed as per objectives. The crop was transplanted on 04 November, 2020. One irrigation was done 46 days after planting. One weeding and soil earthing up work was done. The tuber was harvested during 15-18 March, 2021. The experiment was done in farmers' field in Kushtia for yield and yield contributing characters. However, the storage methods and storability data were performed by the laboratory of Tuber Crops Research Center.

Results and Discussions

Days to maturity of BARI SP-8 was 131 days. The maximum number of tuber per plant was recorded (5.45) from T_1 (Table 1). The highest tuber yield was obtained (24.36 t ha^{-1}) from (T_1). The yield from T_2 and T_3 were (24.12 t ha^{-1}) and (20.50 t ha^{-1}) respectively.

The maximum gross return (Tk 440730 ha^{-1}) and gross margin (Tk 354548 ha^{-1}) were estimated from (T_1) (Table 2).

Farmers' opinion

Farmers were pleased to see the higher yield of sweet potato with the application of IPNS based fertilizer treatment of poultry manure and hoping to apply the fertilizer dose with PM.

Table 1. Yield and yield attributes of sweet potato as influenced by different fertilizer management at Kumarkhali, Kushtia during 2020-21

Treatment	Days to maturity	Vine length (cm)	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (kg)	Yield (t ha^{-1})
(126-15-115-8 kg NPKS ha^{-1} + 3 ton PM ha^{-1}) (IPNS)	131	158.00	5.45	3.60	24.36
(128-13-118-12 kg NPKS ha^{-1} + 6 ton CD ha^{-1}) (IPNS)	131	153.00	4.80	3.14	24.12
Farmer's practice (120-20-110 kg NPK ha^{-1})	125	145.50	4.50	3.03	20.50
F-test	NS	NS	NS	NS	*
CV (%)	11.33	13.21	6.33	9.61	8.67

Table 2. Cost and return analysis of sweet potato under different treatment at Kumerkhali, Kushtia during 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
(126-15-115-8 kg NPKS ha ⁻¹ +3 ton PM ha ⁻¹) (IPNS)	440730	86182	354548
(128-13-118-12 kg NPKS ha ⁻¹ + 6 ton CD ha ⁻¹) (IPNS)	436360	84495	351865
Farmer's practice (120-20-110 kg NPK ha ⁻¹)	371600	75000	296600

Selling price: Marketable (TK. 18 kg⁻¹); Nonmarketable (TK. 5 kg⁻¹)

Conclusion

Based on findings, it may be concluded that use of IPNS basis fertilizer dose (126-15-115-8 kg NPKS ha⁻¹ + 3 t poultry manure ha⁻¹) increased total yield and farmer's income. However, this is the first year trial for confirmation further trial should be needed.

EFFECT OF DIFFERENT FERTILIZER DOSES ON SESAME IN CHARLAND CONDITION IN KUSHTIA

J A Mahmud, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at Multi Location Testing site Bheramara in Kushtia during 2020-21 to observe the effect of different fertilizer doses on Sesame in charland condition. BARI Til-4 was used in this experiment. The treatments were: T_1 = Soil test based fertilizer dose, T_2 = 58-26-23-14-3-0.43 kg NPKSZnB ha⁻¹ + 5 ton cow dung ha⁻¹, T_3 = Farmer's practice were observed. The highest seed yield was obtained from T_2 (1.45 t ha⁻¹) and the lowest from T_3 (1.40 t ha⁻¹).

Introduction

Charland areas are estimated to be 1.82 million hectares. About 64 to 97% of the char areas are cultivable. Main constraint of charlands is deficient in soil nutrient, uncertain flood, duration of flood and flood depth. Sesame (*Sesame indicum* L.) is the second most important oil seed crops in Bangladesh. It is mainly grown in kharif-1 season. The potential yield of Sesame is more than 1.2 t ha⁻¹, but the national average yield is only 0.86 t ha⁻¹. Already the performance of different Sesame varieties developed by BARI has been done in the charland of Kushtia. BARI Til-4 performed better than other varieties. Farmers in the charland of this district are generally maintains poor fertilizer management practices which result in low yield. The experiment was undertaken to maintain judicious application of fertilizer along with organic manure which help to maintain soil fertility for better yield.

Materials and Methods

The experiment was conducted at Golapnagar char, Multi Location Testing site Bheramara in Kushtia district during kharif-1 season of 2020-21. Three farmers were involved in the experiment. Total land area was 3.00 acre. The trial was laid out in a randomized complete block design with six dispersed replications. The plot size was 5 m × 4 m for each treatment. The treatments were T_1 = Soil test based fertilizer dose, T_2 = 58-26-23-14-3-0.43 kg NPKSZnB ha⁻¹ + 5 ton cow dung ha⁻¹, T_3 = Farmer's practice. Half of urea and all other fertilizers were applied as basal during final land preparation. The rest half of urea was applied at 25-30 days after sowing. Necessary data were recorded and analyzed as per objectives are given in below. Seeds were sown during 14 March, 2021. One weeding and thinning was done at 25-30 DAS. Irrigation was applied two times at 05-30 DAS. Propiconazol (Tilt 250 EC) @ 0.5 ml L⁻¹ was applied for controlling stem rot disease of Sesame and cypermethrin (Ripcord 10 EC) @ 1 ml L⁻¹ was applied for controlling hairy caterpillar and thrips. The crop was harvested during 05 June, 2021.

Results and Discussions

The highest seed yield was obtained from T₂ (1.45 t ha⁻¹) followed by T₁ (1.41 t ha⁻¹) and farmer's practice T₃ (1.40 t ha⁻¹) respectively (Table 1). The highest gross return was also obtained from T₂ (Tk 87000 ha⁻¹) followed by T₃ (Tk 39472 ha⁻¹) and T₁ (Tk 37999 ha⁻¹).

Farmer's opinion

Farmers' were happy to see the performance of IPNS basis fertilizer management for HYG with cow dung (5 t ha⁻¹) which increased total production of farmers'.

Table 1. Yield and cost and return analysis of Sesame as influenced by fertilizer management at Kushtia during 2020-21

Treatment	Seed yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ : STB dose	1.41	84999	47000	37999
T ₂ : 58-26-23-14-3-0.43 kg NPKSZnB ha ⁻¹ + 5 ton CD ha ⁻¹	1.45	87000	45064	41936
T ₃ : FP	1.40	84000	44528	39472

Conclusion

Based on findings, it may be concluded that the fertilizer dose 58-26-23-14-3-0.43 kg NPKSZn and B ha⁻¹ along with 5 t cow dung ha⁻¹ increased total production and farmer's income. So, for confirmation further trial should be needed.

VALIDATION OF FERTILIZER MANAGEMENT ON FRUIT YIELD OF Bt BRINJAL

M R Amin, M Akkas Ali, M Shahiduzzaman

Abstract

The field experiment was conducted at Ramnagar village under Shibaloya upazila of Manikganj district during Rabi season of 2020-21 to observe the response of fertilizers on the yield performance of BARI Bt Begun-4 in the farmers' field. The experiment was conducted in randomized complete block design with three replications. Three fertilizer treatment combinations T₁=180-54-135-22-3-1.50 kg NPKSZnB ha⁻¹+5 ton cow dung ha⁻¹ (STB Recommended dose+50% NPK); T₂=150-45-112-18-2.5-1.25 kg NPKSZnB ha⁻¹+10 t cow dung ha⁻¹ (STB Recommended dose+25% NPK+5 t cow dung ha⁻¹); T₃= 150-45-112-18-2.5-1.25 kg N-P-K-S-Zn-B ha⁻¹ +5 t cow dung ha⁻¹ (STB Recommended dose+25% of NPKSZnB) were evaluated. Among the treatments T₂=150-45-112-18-2.5-1.25 kg NPKSZnB ha⁻¹+ 10 t cow dung ha⁻¹ (STB Recommended dose + 25% NPK+5 t cow dung ha⁻¹) gave the highest fruit yield (33.33 t ha⁻¹) followed by soil test based fertilizer dose T₃= 150-45-112-18-2.5-1.25 kg NPKSZnB ha⁻¹ of +5 t cow dung ha⁻¹ (STB Recommended dose+25% of NPKSZnB) produced 31.46 t ha⁻¹ and T₁= 180-54-135-22-3-1.50 kg NPKSZnB ha⁻¹+ 5 t cow dung ha⁻¹ (STB Recommended dose + 50% NPK) gave the lowest (30.00 t ha⁻¹) fruit yield. But, treatment T₃ (150-45-112-18-2.5-1.25 kg NPKSZnB ha⁻¹+ 5 t cow dung ha⁻¹ of) was the best in respect of economic return with higher BCR (3.49).

Introduction

Brinjal (*Solanum melongena*) is the third most important vegetables in terms of both yield and production area in Bangladesh. Recently Bangladesh developed four Bt brinjal varieties. It has potentiality to bump up the yield and brinjal production of the country. From two years demonstration in farmers' field, it was observed that Bt brinjal needed additional fertilizer than recommended one for proper growth and yield. The Bt brinjal has profuse bearing than non Bt brinjal. Hence, higher fertilizer dose may require for full exploitation of yield potentiality of Bt brinjal. Most of the flowering buds are active for fruiting. Probably Bt. gene is also resistance of fungal disease development on flowering buds of Bt brinjal. Consequently, more active flowering buds produce more fruits plant⁻¹ and higher yield of Bt brinjal. Now, there is a need to resort the fertilizer requirement for Bt brinjal. On the other hand, one of the major causes of low yield of brinjal might be due to low organic matter content as well as low

nutrient status of soils those has been declined over time. Optimum dose of fertilizer application provides better agronomic and economic benefits to vegetable growers. Soil analysis provide a better understanding of what and how much fertilizer inputs to be allocated considering the high cost of fertilizer and the limited financial resources of farmers. Therefore, the present investigation will be undertaken to validate the effect of fertilizer management on fruit yield of Bt brinjal in farmers' field.

Materials and Methods

The trial was conducted in the farmers' field at Ramnagar village under Shibaloya upazila of Manikganj district during Rabi season of 2020-21. The objective of the experiment was to validate the fertilizer management on fruit yield of Bt brinjal. The variety was BARI Bt Begun-4 and the Bt brinjal variety was grown against their non-Bt. counterparts in the border. The experiment was conducted in RCB design with three replications. The treatments were consisted of variable rates of fertilizer combinations viz. $T_1 = 180-54-135-22-3-1.50 \text{ kg ha}^{-1}$ of NPKSZnB + 5 t ha^{-1} of cow dung (STB Recommended dose + 50% NPK); $T_2 = 150-45-112-18-2.5-1.25 \text{ kg ha}^{-1}$ of NPKSZnB + 10 t cow dung ha^{-1} (STB Recommended dose + 25% NPK + 5 t ha^{-1} of cow dung); $T_3 = 150-45-112-18-2.5-1.25 \text{ kg ha}^{-1}$ of NPKSZnB + 5 t ha^{-1} cow dung (STB Recommended dose + 25% of NPKSZnB). Thirty days old seedlings were planted on 11 November, 2020. Unit plot size was $5.4\text{m} \times 4.8\text{m}$ with spacing of $100\text{cm} \times 80\text{cm}$. Stable bleaching powder was applied 15 days before transplanting @ 21 kg ha^{-1} as a preventive measure against bacterial wilt. Fertilizer treatments were assigned randomly in the plots. Half of organic manure was applied at the time of final land preparation. Remaining organic manure and full amount of phosphorus, sulphur, zinc and boron were applied in pit before one week of transplanting seedlings. Nitrogen and potassium were applied in four equal splits at 20, 40, 60 and 80 DAT as ring method around the plants and mixed thoroughly with the soil. Nitro @ 2 ml L^{-1} water was sprayed at seedling and fruit setting stage to control whitefly, jassid and aphid in some infested plot. Similarly, Autostin @ 2 gm L^{-1} was sprayed in 2-3 times to control fusarium wilt infested plots. Weeding, watering and removal of side branching and other intercultural operations were done as and when necessary. Initial soil samples were collected from each plot before fertilization and final samples after harvesting of fruits to determine uptake of nutrients from soil. Fruits were harvested from 10 March to 30 April 2021. The fruit yield was recorded from individual plots and yield was converted to express as ton per hectare.

Results and Discussions

The performance of BARI Bt Begun-4 as influenced by variable fertilizer treatments is shown in Table 1. BARI Bt brinjal varieties are presented in Table 2. Plant height did not differ significantly due to the variation in fertilizer treatments ranged from 60.33 cm to 64.66 cm although taller plants were observed in the treatment T_3 (64.66 cm) and lowest in T_1 (60.33 cm). The number of fruits plant^{-1} ranged from 12 to 15.00 among the treatments and the highest number of fruits were obtained from T_3 (15.00). Single fruit weight varied significantly among the variable rates of fertilizer treatments. The highest single fruit weight was produced in T_2 (177.33 g) treatment followed by T_3 (168.00g) and the lowest in T_1 (155.00g). The weight of fruit plant^{-1} differs statistically among the treatments ranged from 2.63 to 3.03 kg. The highest fruit yield (33.33 t ha^{-1}) was obtained from T_2 ($150-45-112-18-2.5-1.25 \text{ kg ha}^{-1}$ of NPKSZnB + 10 t ha^{-1} of cow dung) but the fruit yield between T_3 (31.46 t ha^{-1}) and T_1 (30.00 t ha^{-1}) were statistically at par. The application of higher amount of cow dung might contribute to produce higher yield in treatment T_2 . The highest benefit cost ratio (3.55) was obtained from T_3 treatment followed by T_1 (3.21) and T_2 (3.21) the least.

Cost and return analysis

Cost and return of BARI Bt brinjal as influenced by variable fertilizer treatments is shown in Table 2. Gross return (Tk 49500 ha^{-1}) was higher in T_2 ($180-54-135-22-3-1.50 \text{ kg NPKSZnB ha}^{-1}$ + 10 t cow dung ha^{-1} (STB Recommended dose + 50% NPK) than T_3 (Tk 471900 ha^{-1}) ($150-45-112-18-2.5-1.25 \text{ kg NPKSZnB ha}^{-1}$ + 5 t CD ha^{-1}) (STB Recommended dose + 25% NPK + 5 t CD ha^{-1}) and T_1 (Tk 450000 ha^{-1}) ($150-45-112-18-2.5-1.25 \text{ kg NPKSZnB ha}^{-1}$ + 5 t CD ha^{-1} (STB Recommended dose + 25% of NPKSZnB). Total variable cost in T_2 (Tk 157860 ha^{-1}) was higher than T_3 (Tk 132860 ha^{-1}) and was lower in T_1 treatment (Tk 139953 ha^{-1}) due to lower amount of chemical fertilizer. Therefore, treatment ($150-45-112-18-2.5-1.25 \text{ kg NPKSZnB ha}^{-1}$ + 5 t cow dung ha^{-1}) was the best in respect of yield and economics.

Non target Pest incidence: No brinjal fruit and shoot borer was observed in any fertilizer treatment except for not Bt brinjal plant. Different sucking pests like whitefly, jassid, aphid, mite etc. and diseases (Fusarium wilt) were observed in some plots. These pests were controlled by appropriate management approaches.

Farmers' opinion

Farmers opined that cow dung is available organic manure in the locality. They commented that they would grow BARI Bt Begun-4 following 150-45-112-18-2.5-1.25 kg NPKSZnBha⁻¹ + 5 t cow dung ha⁻¹ of in the next year for higher yield.

Table 1. Yield and yield characters of BARI Bt brinjal as influenced by variable fertilizer treatments at Shibaloya, Manikganj during Rabi season of 2020-21

Treatment	Plant height (cm)	Fruits plant ⁻¹ (no)	Single fruit wt (g)	Fruit wt plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
T ₁	60.33	11.67	155.00	2.63	30.00
T ₂	64.00	13.67	177.33	3.03	33.33
T ₃	64.66	15.00	168.00	2.77	31.46
LSD _(0.05)	4.207	2.72	18.27	0.0716	1.772
CV (%)	8.96	8.94	4.83	2.17	7.53

T₁= 180-54-135-22-3-1.50 kg ha⁻¹ of NPKSZnB + 5 t ha⁻¹ of cow dung (STB Recommended dose + 50% NPK); T₂=150-45-112-18-2.5-1.25 kg ha⁻¹ of NPKSZnB + 10 t cow dung ha⁻¹ (STB Recommended dose + 25% NPK + 5 t ha⁻¹ of cow dung); T₃= 150-45-112-18-2.5-1.25 kg ha⁻¹ of NPKSZnB + 5 t ha⁻¹ cow dung (STB Recommended dose + 25% of NPKSZnB)

Table 2. Cost and return of Bt brinjal as influenced by variable fertilizer treatments at Shibaloya, Manikganj during Rabi season of 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	450000	139953	310047	3.21
T ₂	495000	157860	337140	3.13
T ₃	471900	132860	339040	3.55

Market price of BARI Bt Brinjal-4 @Tk. 15.00 kg⁻¹, Cow dung @Tk. 4.00 kg⁻¹

Conclusion

The results indicated that 150-45-112-18-2.5-1.25 kg NPKSZnB ha⁻¹+ 5 t ha⁻¹ of cow dung (based on soil test basis) of fertilizer might be needed for optimum fruit yield and economic return of BARI Bt Begun-4 in the farmers field at Shibaloya, Manikganj. This is the 1st year trial and the experiment should be repeated in the next year for confirmation of the result.

EFFECT OF NUTRIENT MANAGEMENT ON THE PERFORMANCE OF ONION

M R Alom, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at Farming Systems Research and Development (FSRD) Site, Ganggarampur, Pabna during the rabi season of 2020-21 to find out the effect of nutrient management package on the performance of Onion. Different nutrient management packages viz. T₁= Recommended fertilizer (RF) (FRG' 2018), T₂= IPNS with 2 tonvermicompostha⁻¹, T₃= IPNS with 5 ton cow dung ha⁻¹, T₄= IPNS with 1.5 t rice husk ashha⁻¹ and T₅= Farmers practice (159-45-113-7 kg NPKS ha⁻¹) were tested on Onion (BARI Pij-1). The application of IPNS with 1.5 t ha⁻¹ rice husk ash exhibited better performance on bulb yield of Onion which was statistically similar with IPNS with 2 t vermicompostha⁻¹ and IPNS with 5 t cow dung ha⁻¹. Maximum gross return and gross margin was obtained from IPNS with 1.5 t rice husk ashha⁻¹ followed by IPNS with 2 t vermicompostha⁻¹ and IPNS with 5 t cow dung ha⁻¹.

Introduction

Onion is a high value crop in Bangladesh. Both high yield and quality are important economic considerations. Nutrient supply along with other management practices, pest and disease control, and climatic factors affect the quality and yield of Onion. Appropriate crop management gives significant contributions to increase crop yields. Many reports indicate that, in Bangladesh the low productivity of Onion is attributed to depleted soil fertility and poor agronomic practices such as unbalanced fertilizer application. Improper nutrient and pest management practices due to poor technical knowledge are considered a barrier for desired yield. The optimum nutrient management based on soil nutrient status can ensure better yield of Onion. Due to declining of soil fertility IPNS basis nutrient management is suggested by the scientists for sustainable production of Onion. In this connection assessment of IPNS basis nutrient management with different organic sources are deemed imperative. Therefore, the present study was undertaken with the following objectives.

- i) To assess the effect of nutrient management packages on yield of Onion
- ii) To find out the suitable nutrient management package for Onion

Materials and Methods

The experiment was carried out at Farming Systems Research and Development (FSRD) Site, Ganggarampur, Pabna during the *rabi* season of 2020-21. The experimental plot represents agro-ecological zone 12 (AEZ-12) having Gopalpur soil series. The nutrient status of the experimental plot indicate low to very low level of N, P, S and medium to low K content. The experiment consists of five nutrient management packages viz. T₁= Recommended fertilizer (RF) (FRG' 2018), T₂= IPNS with 2 tonvermicompostha⁻¹, T₃= IPNS with 5 ton cow dung ha⁻¹, T₄= IPNS with 1.5 t rice husk ashha⁻¹ and T₅= Farmers practice (159-45-113-7 kg NPKS ha⁻¹). The experiment was laid out in randomized complete block design with three replications. BARI Piaj-1 was used as planting material in the study. The size of unit plot was 8 m × 5 m. The land preparation was done with power tiller. Around 5/6 tillage operations were done for making the land suitable for planting of Onion seedling. Forty five day's old seedlings were transplanted on December 29, 2020 maintaining 15 cm × 10 cm spacing. Recommended fertilizer for Onion was 105-45-60-10-1.5-1.0 kg N-P-K-S-Zn and B ha⁻¹. Half of N and K and full dose of P, S, rice husk ash as per treatment specification were applied as basal during final land preparation. Remaining half of N and K was applied as top dress at 25 and 50 days after transplanting of seedlings. Two weeding were done on January 13 and February 17, 2021 to remove the weeds from the field. Two irrigations were applied on December 31, 2020 and February 10, 2021 for sustaining soil moisture and eventually better crop growth. Other intercultural operations were done when required. The crop was harvested on March 25, 2021. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software. Mean comparison were done using LSD value at 5% level of probability.

Results and Discussions

Yield attributes and bulb yield of Onion as influenced by different nutrient packages are presented in Table 1. Nutrient management package did not exert significant influence on yield attributes of Onion. The application of IPNS with 1.5 t rice husk ashha⁻¹ exhibited better performance on bulb yield of Onion which was statistically similar with IPNS with 2 t vermicompostha⁻¹ and IPNS with 5 t ha⁻¹ cow dung. The lowest bulb yield was recorded in recommended nutrient package. This result suggests that IPNS basis nutrient management with different organic sources like rice husk ash, vermicompost and cow dung probably make the soil more suitable for plant nutrient uptake and eventually better plant growth and yield. However, the non-significant response of yield traits does not make clear understanding for increasing yield in IPNS based nutrient management. In this regard more in depth study is needed for better understanding on yield process of Onion.

Cost and return analysis

Considering economic benefit, maximum gross return (Tk 359720 ha⁻¹) and gross margin (Tk 214280 ha⁻¹) was obtained from IPNS with 1.5 t rice husk ashha⁻¹ followed by IPNS with 2 t ha⁻¹ vermicompost and IPNS with 5 t ha⁻¹ cow dung (Table 2). The minimum gross return (Tk 314000 ha⁻¹) and gross margin (Tk 159962 ha⁻¹) was recorded in recommended nutrient package.

Farmers' opinion

Though the overall yield of onion was quite low, farmers were quite convinced to see the results of incremental bulb yield due to IPNS based nutrient management. The results encouraged them to apply IPNS based nutrient management with rice husk ash and vermicompost to their Onion field next year.

Table 1. Yield traits and yield of Onion as influenced by nutrient management packages at FSRD site, Ganggarampur, Pabna during 2020-21

Treatment	Plant height (cm)	Individual bulb wt (g)	Yield (t ha ⁻¹)
Recommended dose (RD)	24.97	16.00	7.52 c
IPNS with 2 ton vermicompost ha ⁻¹	25.73	16.93	8.64 ab
IPNS with 5 ton cow dung ha ⁻¹	25.30	16.77	8.56 ab
IPNS with 1.5 ton rice husk ash ha ⁻¹	25.20	16.97	8.99 a
Farmer's practice (159-45-113-7 kg NPKS ha ⁻¹)	25.03	16.45	7.91 bc
LSD (0.05)	NS	NS	0.816
CV (%)	3.82	12.16	5.21

Table 2. Cost and return analysis of Onion as influenced by nutrient management packages at FSRD site, Ganggarampur, Pabna during 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Recommended dose (RD)	314000	154038	159962
IPNS with 2 ton vermicompost ha ⁻¹	358800	162785	196015
IPNS with 5 ton cow dung ha ⁻¹	342400	149883	192517
IPNS with 1.5 ton rice husk ash ha ⁻¹	359720	145440	214280
Farmer's practice (159-45-113-7 kg NPKS ha ⁻¹)	321720	146519	175201

Local market price of Onion 40.00 Tk kg⁻¹

Conclusion

The application of IPNS with 1.5 ton rice husk ash ha⁻¹ exhibited better performance on bulb yield of Onion which was statistically similar with IPNS with 2 ton vermicompost ha⁻¹ and IPNS with 5 ton cow dung ha⁻¹. Maximum gross return (Tk 359720 ha⁻¹) and gross margin (Tk 214280 ha⁻¹) was also obtained from IPNS with 1.5 t rice husk ash ha⁻¹ followed by IPNS with 2 t vermicompost ha⁻¹ and IPNS with 5 t cow dung ha⁻¹. Therefore, IPNS based nutrient management with rice husk ash, vermicompost and cow dung can be a better option regarding yield and economic return of Onion. However, further experimentation is needed to validate the findings.

EFFECTS OF TILLAGE, RESIDUE RETENTION AND PHOSPHORUS MANAGEMENT ON THE PERFORMANCE OF MUSTARD IN RICE BASED SYSTEM OF NORTHWEST BANGLADESH

M R Alom, M Akkas Ali, M Shahiduzzaman

Abstract

Performance of mustard under three tillage treatments such as conventional tillage (CT), no tillage (NT) and strip planting (SP), two levels of residue retention—high residue (HR) and low residue retention (LR) and three levels of phosphorus (50% of recommended P, 100% of recommended P and 150% of recommended P) were evaluated in rice based system of Bangladesh. The field experiment was initiated in November 2015 and continuing for a longer term period at Pulses Research Centre Ishurdi, Pabna. The cropping sequence Mustard-Mungbean-T.Aman is practicing since November 2018 at Ishurdi, Pabna. In the present report, only the crop number 16 (mustard) grown in rabi season (cool dry season) of 2020-21 are presenting. The results showed that the application of SP resulted in higher number of plant population m⁻², siliqua plant⁻¹ while decreasing alternaria leaf spot diseases, which may lead to increase seed yield by 16% and straw yield of mustard by 24% over CT. The HR increased seed yield by 6% and straw yield by 11% over LR. In case of P levels, the increased dose of P (150% of

recommended P) increased plant height, siliquaplant⁻¹, seeds plant⁻¹ while decreasing alternaria leaf spot diseases and consequently, the seed and straw yield of mustard finally increased. However, this study will be continued for a long-term period to concrete conclusion.

Introduction

The detrimental effects of conventional systems such as soil degradation, organic matter depletion, erosion, falling biodiversity and increased production cost has stimulated the search for alternative food production strategies and to reverse the process of soil degradation. This led to promote conservation agriculture (CA) in many countries in the world. At this time, CA based on minimum soil disturbance, residue retention and pulse based crop rotations are being promoted and increasingly appreciated globally due to its more sustainable soil management outcomes (Islam *et al.*, 2016; Johansen *et al.*, 2012). Conventional crop production system in an agro-eco system is the most input intensive process and therefore more efficient alternative share urgently needed. During the last decades potential solutions include a shift from intensive to reduce or zero tillage and rice residue retention have been evaluated in cereal systems (Gathala *et al.*, 2011; Ladha *et al.*, 2009). However, the information of CA effects on the performance of pulse dominated rice based system is scanty. In addition, nutrient management for crop production in rice-based system is still largely based on blanket recommendation made similar to that for CT system in South Asia. This may lead to lower crop yields, low nutrient use efficiency, lower economic profitability and greater environmental footprints. Presently, limited information is available on the evaluation of nutrient management especially P management in CA system on soil health and crop productivity in rice based system of South Asia. Therefore, an attempt has been undertaken to evaluate CA practices (tillage, residue along pulse based rotation crop) and P management on crop performance and soil fertility of Mustard-Mung bean-Rice cropping pattern in northwest Bangladesh. The study has hypothesized that adopting the CA based management practices together with precise nutrient management especially P management would improve system productivity and soil fertility in northwest Bangladesh. Keeping these facts in mind, an experiment of Mustard-Mungbean-Rice has been undertaken to evaluate the effects of P management in CA on the performance of mustard in rice-based system of northern Bangladesh.

Materials and Methods

The field experiment was conducted at Pulses Research Centre, Ishurdi, Pabna, under the Agro-Ecological Zone of High Ganges River Floodplain (AEZ-11). The experimental field situated at 24° 7' 15.08" N latitude and 89° 4' 45.95" E longitude with an altitude 44 at the elevation of 26 m above the sea level. The soil belongs to the 'Sara' soil series sandy loam in texture having moderate organic matter content of soil with pH value 7.5. Field experiment for the present study was initiated with Lentil (BARI Masur-6 and BARI Masur-8 used in 2015-17 and 2017-18, respectively) in November (the cool dry season) in 2015, followed by Mungbean (BARI Mung-6) in the pre-monsoon season (March-June) then rice established in the monsoon season (July–October). This rotation was continuing for the first three years at Ishurdi. However, the rotation has been changed with mustard (BARI Sharisha-17)–Mungbean (BARI Mung-6)–T.Aman rice (BRRI dhan71) in November 2018. The current rotation of Mustard–Mungbean–T.Aman rice is practicing over the last three years. In this report, we are only presenting the data of Crop 16 i.e. mustard crop in the rotation for 2020-21. The mustard crop (variety: BARI Sharisha-17) was sown on 25 November, 2020 and harvested on 10 March, 2021 at Ishurdi. The experiment included four replicates for each treatment in a split-split plot design. The main plots consist of three types of tillage–strip planting (SP), no tillage (NT) and conventional tillage (CT); two levels of crop residue–high (HR) and low residue (LR) retention in the sub plots, and three levels of phosphorus levels such as 50% of recommended dose of P (13.5 kg ha⁻¹), 100% of recommended dose of P (27 kg ha⁻¹) and 150% of recommended dose of P (40.5 kg ha⁻¹) were assigned in a sub-sub-plots. However, in case of first crop mustard in 2018-19, three levels of phosphorus e.g. 75% of recommended P, 100% of recommended P (27 kg ha⁻¹) and 125% recommended P were used. The dimensions of the main-plots were 16 m × 16 m, the sub-plots were 16 m × 8 m and the sub-plots were 16 m × 2.2 m at Ishurdi. The experimental plots were fertilized at the rate of 90, 40, and 10, 1 kg N, K, S and B respectively (FRG'2018). Full doses of all fertilizers and half dose of N fertilizer were broadcasted before planting and the rest N fertilizer was top dressed at 20-25 days before irrigation. The procedure of all fertilizer

application (hand broadcast) was same in all tillage treatments except P fertilizer. The P fertilizer was drilled using VMP in SP and NT treatments while broadcasted in CT.

The seeds were sown maintaining line spacing of 30 cm for mustard. The seed rate of mustard were used 7.5 kg ha⁻¹. One hand weeding was done at 24-30 days after sowing (DAS) for controlling weed. Rovral-50 WP @ 2 g/L was sprayed two times at 55 DAS and 70 DAS for controlling alternaria leaf spot disease of mustard. Malathion 57 EC @ 2ml/L was applied at 60 and 72 DAS for controlling aphid. Data on yield contributing characters such as plant height, number of branches/plant, number of siliqua plant⁻¹, number of seeds siliqua⁻¹, length of siliqua and 1000 seeds weight were recorded from ten randomly selected plants of each plot. The crop was harvested at maturity stage i.e. when 80% of the pod turned chocolate brown to black in colour. The seed and straw yield was recorded from the pre-selected central area of two square meters (2 m × 1 m) of each plot and converted to tones per hectare (t ha⁻¹). The GenStat 17th Edition and R software packages were used for all statistical analyses. The mean differences between treatments were separated by the least significant difference (LSD) at P ≤ 0.05 for the measured variables.

Results and Discussions

Effect of tillage, residue retention and P management on yield and yield components of mustard in 2020-21 at Ishurdi

The plant population m⁻² was significantly affected by tillage (Table 1). The plant population m⁻² of SP (66.6) and NT (64.9) was higher as compared to CT. The plant height increased with increasing P dose, and the highest plant height was recorded at P3 treatment (94 cm) while the lowest plant height was in P1 treatment (91 cm), and the intermediate type (92 cm) plant found in P2 (Table 1). Although the plant height due to tillage were not significantly affected, the tallest plant recorded in combination with SP and P1 (98.3 cm) and the lowest found in NT and P2 (87.8 cm). The adoption of SP increased the silique number/plant (45.9) while the lowest silique number/plant was recorded from NT (41.1). With increasing P levels, the silique number plant⁻¹ increased (45.0) in P3 treatment and the decreased silique number plant⁻¹ recorded at P1 treatment (42.8) (Table 1). The highest number of seeds siliqua⁻¹ was recorded from P3 treatment (35.9) while the lowest number of seeds siliqua⁻¹ was recorded in P1 treatment (33.5) (Table 1). Branches plant⁻¹, pod length and 1000 seed weight are not significantly affected by tillage, residue retention and P levels (Table 1).

Seed yield of mustard: The plots under SP had significantly higher (1487 kg ha⁻¹) seed yield of mustard as compared to CT plots (1269 kg ha⁻¹) (farmers' practice) (Table 2). The plots under HR also had higher yield (1385 kg ha⁻¹) as compared to LR. Regarding P levels, the highest seed yield of mustard obtained from P3 (1494 kg ha⁻¹) and the second highest yield was recorded in P2 (1319 kg ha⁻¹) while the lowest was recorded from P1 (1227 kg ha⁻¹).

Straw yield of mustard: The combination of SP and HR increased the straw yield of mustard (2128 kg ha⁻¹) and the yield was lowest (1503 kg ha⁻¹) in CTLR (Table 2). The straw yield of P3 was higher (1768 kg ha⁻¹) and medium yield was recorded in P2 (1679 kg ha⁻¹) while the lowest straw yield (1586 kg ha⁻¹) obtained from P1. The result suggests that the straw yield increased with the increasing P fertilizer. The yield of mustard in 2020-21 was relatively low as compared to other experimental years. This might be due to absence of irrigation water just after sowing of mustard in the last year.

Flowering and Siliqua (%) at 93 days after sowing: Flowering and silique percentage at 90 DAS were not significantly affected neither by tillage nor by residue retention and P levels. Similarly, aphid infestation percentages at 90 DAS were not significantly affected due to different treatments (Table 3).

Correlation Matrix: Correlation coefficient among yield and yield contributing characters of mustard are given in Table 4. In correlation study, the significant positive relationship was recorded for plant population m⁻² with flowering (%) at 90 DAS (0.30) and straw yield (0.41) while significant negative relationship was recorded for plant population m⁻² with siliqua (%) at 90 DAS (-0.30) and alternaria leaf spots (-0.37). Plant height also positively correlated with pods plant⁻¹ (0.32), siliqua (%) at 90 DAS (0.31) and seed yield (0.37), but negatively correlated with flowering (%) at 90 DAS (-0.31). The pods plant⁻¹ had a strong positive correlation with seed yield (0.50) and straw yield (0.35). 1000 seed weight significantly and positively correlated with flowering (%) at 90 DAS (0.24), but negatively

correlated with podding (%) at 90 DAS (-0.24) and alternaria leafspot (-0.44). The relationship between flowering (%) at 90 DAS and alternaria leaf spot had strong and negative (-0.52). The relationship between siliquae (%) at 90 DAS and alternaria leaf spot had strong and positive (0.52). Finally, the relationship between seed yield and straw yield had a very strong and positive (0.75).

Table 1. Effects of tillage, residue and P management on yield attributes on mustard in rice-mustard-mungbean cropping system

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
Plants m ⁻² (no)												
SP	70.3	66.1	63.8	67.4	64.3	67.8	66.6	3.5**	ns	ns	ns	ns
NT	65.7	66.8	66.5	62.5	64.3	63.8	64.9					
CT	57.3	58.8	57.5	58.8	57.5	57.6	57.9					
Mean	63.6			62.7								
CV (%): Tillage (3.2), Tillage *Residue (4.5), Tillage *Residue* P levels (4.5)												
Plant height (cm)												
SP	90.7	95.6	99.3	89.5	91.2	97.4	93.9	ns	ns	2.2**	ns	4.7**
NT	92.3	88.5	92.0	91.9	87.1	91.4	90.5					
CT	89.9	94.5	93.5	92.7	92.3	91.9	92.4					
Mean	92.9			91.7								
CV (%): Tillage (2.5), Tillage *Residue (2.0), Tillage *Residue* P levels (4.2)												
Branches plant ⁻¹ (no)												
SP	1.5	1.3	2.0	2.0	2.0	2.2	1.8	ns	ns	ns	ns	ns
NT	1.9	1.7	1.8	2.0	2.0	1.7	1.8					
CT	1.7	1.8	1.9	1.9	1.8	1.8	1.8					
Mean	1.7			1.9								
CV (%): Tillage (6.8), Tillage *Residue (21.4), Tillage *Residue* P levels (24.1)												
Silique/plant												
SP	44.8	45.1	49.0	44.5	46.4	45.7	45.9	2.9**	ns	1.1**	ns	ns
NT	41.5	40.5	42.3	39.8	39.9	42.9	41.1					
CT	43.7	44.0	46.1	42.4	42.6	44.2	43.8					
Mean	44.1			43.1								
CV (%): Tillage (3.9), Tillage *Residue (3.8), Tillage *Residue* P levels (4.4)												
Seeds siliquae ⁻¹ (no)												
SP	35.5	35.4	35.5	33.1	33.7	34.8	34.6	ns	ns	1.5**	ns	ns
NT	34.0	34.6	36.6	30.9	35.9	36.9	34.8					
CT	32.8	34.8	36.1	34.9	35.2	35.5	34.8					
Mean	35.0			34.5								
CV (%): Tillage (4.6), Tillage*Residue (4), Tillage *Residue* P levels (7.5)												
Pod length (cm)												
SP	4.6	4.5	4.5	4.6	4.6	4.6	4.5	ns	ns	ns	ns	ns
NT	4.6	4.7	4.5	4.5	4.5	4.6	4.5					
CT	4.5	4.5	4.5	4.6	4.5	4.7	4.5					
Mean	4.5			4.6								
CV (%): Tillage (1.9), Tillage*Residue (1.9), Tillage *Residue* P levels (3.3)												
1000 seed weight (g)												
SP	2.9	2.9	2.9	2.8	2.9	3.0	2.9	ns	ns	ns	ns	ns
NT	2.8	2.9	2.9	3.0	2.9	3.1	2.9					
CT	2.8	2.8	2.7	2.8	2.8	2.8	2.8					
Mean	2.8			2.9								
CV (%): Tillage (2.7), Tillage*Residue (2.6), Tillage *Residue* P levels (4.4)												

¹HR - high residue; LR - low residue, SP - strip planting; NT - no-tillage; CT - conventional tillage; ²the least significant difference (LSD) at the P≤0.05, ns - not significant, * - significant at P≤0.05 and ** - significant at P≤0.01; T – tillage; R – residue ; CV - Coefficient of variation

Table 2. Effects of tillage, residue and P management on seed and straw yield on mustard in Rice-Mustard-Mung bean cropping system

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
Seed yield (kg ha ⁻¹)												
SP	1408	1434	1894	1262	1408	1517	1487	156*	69*	83**	ns	ns
NT	1169	1252	1429	1226	1203	1334	1269					
CT	1126	1331	1419	1170	1287	1375	1285					
Mean	1385			1309								
CV (%): Tillage (6.7), Tillage*Residue (5.5), Tillage *Residue* P levels (10.5)												
Straw yield (kg ha ⁻¹)												
SP	2131	1989	2265	1567	1708	1876	2131	122**	112**	117*	167**	ns
NT	1415	1653	1677	1481	1668	1526	1415					
CT	1472	1580	1676	1452	1472	1585	1472					
Mean	1762			1593								
CV (%): Tillage (4.2), Tillage*Residue (7.3), Tillage *Residue* P levels (11.9)												

Abbreviations as in Table 2

Table 3. Effects of tillage, residue and P management on flowering and Siliqua (%) of mustard at 93 days after sowing in Rice-Mustard-Mung bean cropping pattern

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
Flowering (%) at 93 DAS												
SP	21.3	21.3	15.0	17.5	30.0	17.5	20.4	ns	ns	ns	ns	ns
NT	33.8	28.8	31.3	17.5	25.0	23.8	26.7					
CT	10.0	5.0	2.5	12.5	13.8	13.8	9.6					
Mean	18.8			19.0								
CV (%): Tillage (63.0), Tillage *Residue (32.0), Tillage *Residue* P levels (43.6)												
Siliqua (%) at 93 DAS												
SP	78.8	78.8	85.0	82.5	70.0	82.5	79.6	ns	ns	ns	ns	ns
NT	66.3	71.3	68.8	82.5	75.0	76.3	73.3					
CT	90.0	95.0	97.5	87.5	86.3	86.3	90.4					
Mean	81.3			81.0								
CV (%): Tillage (14.6), Tillage *Residue (7.4), Tillage *Residue* P levels (10.2)												

Abbreviations as in Table 2

Table 4. Correlation matrix of different yield contributing characters and yield of mustard under different tillage, residue and P levels. Pearson's correlation coefficients (r) describing the relation of yield contributing characters and yield of mustard.

	PP	PH	BR	PD	SP	TSW	FL	SL	AP	ALS	SY	StY
PP	1											
PH	-0.10	1										
BR	-0.23	0.05	1									
PD	-0.15	0.32**	0.13	1								
SP	0.07	0.13	-0.15	0.06	1							
TSW	0.19	-0.04	-0.01	-0.21	0.14	1						
FL	0.30*	-0.31**	-0.17	-0.21	-0.02	0.24*	1					
SL	-0.30*	0.31**	0.17	0.21	0.02	-0.24*	-1.00	1				
AP	-0.02	-0.10	-0.12	0.08	-0.06	0.06	0.03	-0.03	1			
ALS	-0.37**	-0.01	0.01	0.08	-0.13	-0.44**	-0.52**	0.52**	0.08	1		
SY	0.15	0.37**	-0.05	0.50**	0.23	0.22	-0.12	0.12	-0.14	-0.22	1	
StY	0.41**	0.18	-0.07	0.35**	0.15	0.08	0.03	-0.03	-0.18	-0.21	0.75**	1

Legend: Plant/m² –PP, Plant height.– PH, Branches/plant–BR, Pods/plant–PD, Seeds/pod–SP, 1000-seed weight–TSW, Flowering (%)–FL, Siliquae (%)–SL, Aphid–AP, Alternaria leaf spots–ALS, Seed yield–SY, Straw yield–StY

**Significant at 0.01 level of probability *; Significant at 0.05 level of probability.

Conclusion

It can be concluded that practicing SP increased seed yield of mustard (16%) over farmer practices at Ishurdi in 2020-21. The results suggested that the higher number of plant population, siliquaplant⁻¹ and decreased alternaria leaf spot diseases might be attributed to increase yield of mustard in SP over CT. The higher load of residue also increased mustard yield. The increased level of recommended P fertilizer (150% of recommended P) increased the seed and straw yield of mustard, which might be due to increase plant height, siliquaplant⁻¹, seedsplant⁻¹ and decrease alternaria leaf spot diseases. However, this study will be continued for a longterm period to concrete conclusion.

DEVELOPMENT OF FERTILIZER MANAGEMENT PACKAGE FOR ONION

M R Alom, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at Multi Location Testing (MLT) Site, Sujanagar, Pabna during the rabi season of three consecutive years (2018-19 to 2020-21) to find out the optimum fertilizer package for Onion cultivation. Different fertilizer management packages viz. T₁= Recommended fertilizer (RF) (FRG' 2018), T₂= RF + Extra 25% NPKS, T₃= RF + 1.5 ton rice husk ashha⁻¹, T₄= RF+ 2 ton poultry manure ha⁻¹ and T₅= Farmers fertilizer package (159-45-113-7 kg NPKS ha⁻¹) were tested on popular variety of onion (BARI Piaj-1). The application of RF + 1.5 ton rice husk ash ha⁻¹ and RF+ 2 ton PM ha⁻¹ exhibited better performance on yield attributes and bulb yield of Onion. Maximum gross return (Tk 596150 ha⁻¹) and gross margin (Tk 447294 ha⁻¹) was obtained from RF + 1.5 ton rice husk ashha⁻¹ followed by RF + 2 ton PM.ha⁻¹ Therefore, application of RF + 1.5 ton rice husk ash ha⁻¹ and RF + 2 ton PMha⁻¹ is found viable fertilizer management package for Onion production regarding bulb yield and economic return.

Introduction

Onion is a high-value crop in Bangladesh. Both high yield and quality are important economic considerations. Nutrient supply along with other management practices, pest and disease control, and climatic factors affect the quality and yield of Onion. Appropriate crop management gives significant contributions to increase crop yields. Many reports indicate that, in Bangladesh the low productivity of Onion is attributed to depleted soil fertility and poor agronomic practices such as unbalanced fertilizer application. Improper nutrient and pest management practices due to poor technical knowledge are considered a barrier for desired yield. The optimum nutrient management based on soil nutrient status can ensure better yield of Onion. In this regard, a viable fertilizer management package deemed necessary to optimize Onion production in Pabna region. Therefore, the present study was undertaken with the following objectives

- i) To find out the optimum fertilizer package for Onion cultivation
- ii) To increase bulb yield and economic return

Materials and Methods

The experiment was carried out at Multi Location Testing (MLT) site, Sujanagar, Pabna during the *rabi* season of three consecutive years (2018-19 to 2020-21). The experimental plot represents agro-ecological zone 11 (AEZ-11) having Gopalpur soil series. The nutrient status of the experimental plot indicate low to very low level of N, P, S and medium to low K content. The experiment consists of five fertilizer management packages viz. T₁= Recommended fertilizer (FRG' 2018), T₂= RF + Extra 25% NPKS, T₃= RF + 1.5 ton rice husk ash ha⁻¹, T₄= RF+ 2 ton poultry manure ha⁻¹ and T₅= Farmers fertilizer package (159-45-113-7 kg NPKS ha⁻¹). The experiment was laid out in randomized complete block design with three replications. BARI Piaj-1 was used as planting material in the study. The unit plot size was 5m × 4m. The land preparation was done with power tiller. Around 5/6 tillage operations was done for making the land suitable for Onion planting. Forty five day's old seedlings were transplanted on December 25-28 maintaining 15cm × 10cm spacing. Recommended fertilizer for Onion was 105-

45-60-10-1.5-1.0 kg N-P-K-S-Zn-B ha⁻¹. Half of N and K and full dose of P, S, rice husk ash and poultry manure as per treatment specification were applied as basal during final land preparation. Remaining half of N and K was applied as top dress at 22 and 45 days after transplanting of seedlings. Two weeding's were done on January 14-20 and February 07-12 to remove the weeds from the experimental plot. Two irrigations were applied on December 27-30 and January 18-20 to sustain optimum soil moisture and eventually better plant growth. Pest and disease control measures were taken with recommended pesticides and fungicides as and when necessary. Other intercultural operations were done when required. The crop was harvested on March 25-30. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software. Mean comparison were done using LSD value at 5% level of probability.

Results and Discussions

Yield attributes and bulb yield of Onion as influenced by different fertilizer packages during three consecutive years (2018-19 to 2020-21) are presented in Table 1. The result showed that fertilizer packages exerted significant influence on yield attributes and bulb yield of Onion. Considering three years study, the highest plant height was recorded in RF + 1.5 ton rice husk ash ha⁻¹ (T₃) which was at par with RF + 2 ton PMha⁻¹ (T₄) and RF + Extra 25% NPKS (T₂). The lowest plant height was observed in farmers practice (T₅). The maximum weight of individual bulb was observed in T₃ which was at par with T₄ and T₂ during 2018-19 and 2020-21 whereas during 2019-20 the same treatment (T₃) exhibited maximum weight of individual bulb which was significantly higher than any other treatments. The lowest weight of individual bulb was noted in T₅. Extra application of rice husk ash, poultry manure and chemical fertilizer exhibited relatively higher individual bulb weight suggests that additional plant nutrients from organic or inorganic sources are needed for optimum bulb growth and development as compared with recommended fertilizer (T₁) and farmers' fertilizer management package (T₅). However, the highest bulb yield was obtained from RF + 1.5 ton rice husk ash ha⁻¹ (T₃) and RF + 2 ton PMha⁻¹ (T₄) followed by RF + Extra 25% NPKS (T₂). The lowest bulb yield was recorded in farmers practice (T₅). Relatively higher individual bulb weight is probably the reason for higher bulb yield in T₃ and T₄.

Cost and return analysis

Considering economic benefit, maximum gross return (Tk 596150 ha⁻¹) and gross margin (Tk 447294 ha⁻¹) was obtained from RF + 1.5 ton rice husk ash ha⁻¹ followed by RF + 2 ton PM ha⁻¹ (Table 2). The minimum economic return was noted in farmers practice.

Farmers' opinion

Farmers were quite convinced to see the results of incremental bulb yield due to extra application of ash and poultry manure coupled with recommended fertilizer. The results encourage them to apply RF + 1.5 ton rice husk ash ha⁻¹ and RF + 2 ton PM ha⁻¹ fertilizer package for growing Onion in next year.

Table 1. Yield attributes and yield of Onion as influenced by fertilizer management packages at MLT site, Sujanagar, Pabna during the *rabi* season of three consecutive years (2018-19 to 2020-21)

Treatment	Plant height (cm)			Individual bulb wt. (g)			Bulb yield (t ha ⁻¹)		
	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
T ₁ =RF (FRG' 2018)	51.00	51.00	51.32	36.33	35.50	36.67	18.17	17.63	17.93
T ₂ =RF+Extra 25% NPKS	53.00	51.33	51.35	37.17	35.67	38.33	18.60	17.83	18.90
T ₃ =RF+1.5 ton rice husk ash ha ⁻¹	53.30	53.67	53.33	39.33	39.24	40.00	20.00	19.67	19.33
T ₄ =RF+2 ton PM ha ⁻¹	52.30	52.65	52.30	37.28	37.17	38.67	18.75	18.33	19.13
T ₅ =Farmers practice(159-45-113-7 kg NPKS ha ⁻¹)	50.20	49.17	50.67	36.17	35.00	35.67	17.90	17.15	17.00
LSD (0.05)	1.700	2.410	1.140	2.54	1.925	2.318	1.274	0.889	0.445
CV (%)	5.70	5.48	3.17	7.62	4.80	3.25	5.62	6.41	4.28

Table 2. Average cost and returns analysis of onion as influenced by fertilizer management package at MLT site, Sujanagar during the *rabi* season of three consecutive years (2018-19 to 2020-21)

Treatment	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ =RF (FRG' 2018)	533506	148106	385400
T ₂ =RF+Extra 25% NPKS	551875	150029	401846
T ₃ =RF+1.5 ton rice husk ash ha ⁻¹	596150	148856	447294
T ₄ =RF+2 ton PM ha ⁻¹	578719	149106	429613
T ₅ =Farmers practice (159-45-113-7 kg NPKS ha ⁻¹)	562518	148106	414412

Conclusion

Application of recommended fertilizer (RF) + 1.5 ton rice husk ash ha⁻¹ and RF+ 2 ton poultry manure ha⁻¹ (PM) exhibits higher bulb yield of onion. Maximum gross return (Tk 596150 ha⁻¹) and gross margin (Tk 447294 ha⁻¹) was obtained from RF + 1.5 ton rice husk ash ha⁻¹ followed by RF + 2 ton PM ha⁻¹. Therefore, application of RF + 1.5 ton rice husk ash ha⁻¹ and RF + 2 ton PM ha⁻¹ in soil reveal better fertilizer management package for Onion production regarding bulb yield and economic return.

EFFECT OF ORGANIC FERTILIZER TO MITIGATE SOIL SALINITY AND MAXIMIZE YIELD OF POTATO IN COASTAL SALINE SOIL

K.N. Islam , M.M. Islam, P. Chakraborti, and M.S.I. Khan, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at Multi Location Testing site Kuakata, Patuakhali in the rabi season of 2020-21 to observe the effect of different organic matter of potato production under farmers field condition. Different types of organic matter along with soil test based inorganic fertilizers were used in the trial. The treatments of the trials were as T₁=STB+3 ton cow dung ha⁻¹, T₂= STB+5 t cow dung ha⁻¹, T₃= STB+1.5 ton Compostha⁻¹, T₄= STB+2 t Compost ha⁻¹, T₅= STB+ 2 ton Vermicompostha⁻¹, T₆= STB+2.5 t Vermicompost ha⁻¹ and T₇= Farmers practice. The significant effect was found in yield and yield contributing parameters in combination of various level of organic fertilizer with inorganic fertilizer for potato production in coastal region. Soil EC was found lower in organic fertilizer treated plots. Vermicompost reduced salinity more than compost and cow dung. The highest gross return (Tk415380 ha⁻¹), gross margin (Tk 249680 ha⁻¹) and BCR (2.51) was recorded from T₆ treatment, followed by T₅ and T₄. The lowest economic return was recorded from control plot (farmers practice) (Tk 307160 ha⁻¹) and BCR (2.00).

Introduction

Soil salinity is one of the major environmental hazards to global agriculture. The saline area in Bangladesh is about 0.83 million hectares and presently estimated that it has increased up to 1.2 m ha (Islam *et al.*, 2008). The coastal area of the country constitutes about 20% of the country of which about 53% are affected by different degrees of salinity (Haque, 2006). Soil salinity in Bangladesh is a seasonal problem that affects crop production severely in the saline belt during rabi season whereas in Kharif-II season soil salinity reaches about neutral and does not affect crop production. Soil salinity affects crop growth, yield and quality. As potato is cultivated in Rabi season, it provides very poor yields in saline coastal areas compared to its potential as soil salinity reaches to maximum during rabi season in coastal saline soil (Chaves, *et al.*, 2009). Organic fertilizer enhanced fertilizer activities and emission carbon-dioxide that's reducing soil salinity (Munns *et al.*, 2008). Cultivation of potato in Rabi season with improved management practices including organic fertilizer could increase tuber yield significantly compared to traditional method under saline ecosystem. Thus the experiment was undertaken to find out the effect of organic fertilizer to maximize yield of potato and to reduce soil salinity of the field.

Materials and Methods

An experiment was conducted at Multi Location Testing site Kuakata, Patuakhali during the rabi season of 2020-21 to find out the effect of organic fertilizers to produce potato under farmers field condition. Kuakata, Patuakhali is a coastal area and soils contain varying degrees of salinity. Potato is one of the major crop in coastal region which yield is affected by salinity of the soil. Three types of organic fertilizer i.e. cow dung, compost and vermicompost each of two varying amount along with Soil Test Based (STB) inorganic fertilizers were used in the trial. The treatment combinations were T_1 =STB+3 ton cow dung ha^{-1} , T_2 = STB+5 t cow dung ha^{-1} , T_3 = STB+1.5 ton compost ha^{-1} , T_4 = STB+2tcompost ha^{-1} , T_5 = STB+2 ton vermicompost ha^{-1} , T_6 = STB+2.5 tvermicompost ha^{-1} and T_7 = Farmers practice. The experiment was laid out in Randomized Complete Block design with three compact replications having unit plot size 5m $\times$ 4m. The organic fertilizers were applied during land preparation with inorganic fertilizers. Seeds of BARI Alu-7 (Diamant) were sown on 20 December, 2020 and harvested on 15 March, 2021. Recommended cultural practices from Tuber Crops Research Centre, BARI were done as and when necessary. Data were collected plot wise and analyzed statistically. Required inorganic fertilizers were calculated as per initial soil nutrient status. Required nutrient for potato as per soil test value was 177.5-46.5-50.5-25-7.34-6.5 kg ha^{-1} . Initial soil nutrient status, treatment combination and nutrient element of vermicompost, compost and cow dung has given in Table 1, Table 2 and Table 3.

Table 1. Initial soil nutrient status of experimental plot during 2020-21

Nutrient status								
pH	EC (dS/m)	OM (%)	K (meq/100g soil)	Total N (%)	P	S	Zn	B
5.8	1.61	0.79	0.26	0.095	2.68	14.75	0.53	0.46
Slightly acidic	Non saline	Very low	Medium	Very low	Very low	Low	Low	Low

Table 2. Treatment combinations of the trial

Nutrients (kg ha^{-1})						
Treatment	N	P	K	S	Zn	B
T_1	192	48	53	26	7.34	6.50
T_2	202	55	56	27	7.34	6.50
T_3	194	47	52	25	7.34	6.50
T_4	200	48	53	26	7.34	6.50
T_5	211	49	54	27	7.34	6.50
T_6	219	50	55	28	7.34	6.50
T_7	170	55	85	25	8	6

Table 3. Nutrient status of vermicompost, compost and cow dung used in the experimental field

Name of the Manure	PH	OC	Ca	Mg	K	Total N	P	S	B	Zn
		%								
Compost	7.1	16.3	1.50	2.10	1.17	1.23	0.79	0.50	0.013	0.14
Cowdung	7.5	15.4	2.23	0.44	0.69	1.15	0.57	0.36	0.011	0.15
Vermicompost	7.2	17.9	2.10	2.60	1.39	1.68	1.18	0.87	0.015	0.16

Moisture content of Compost = 12.15%, Cow dung = 12.46% and Vermicompost = 11.96%

Results and Discussions

Effect on yield and yield attributes

Among the treatments the highest plants height (52.35 cm), number of tuber per plant (7.92) with the highest weight of tuber per plant (696) was obtained with application of 219-50-55-28 kg NPKS ha^{-1} (T_6 treatments). Consequently this dose of fertilizers produced the highest tuber yield (29.67 t ha^{-1}). Lower yield attributes were recorded in absolute control farmers practice treatment (T_7). To analysis of benefit cost ratio higher benefit was obtained from soil test based fertilizer doses with 2.5 ton per hector vermicompost. Organic fertilizer contribute 35% more tuber yield (Table 4) over control. Salinity level were lower in organic fertilizer treated treatments that enhance productivity of potato yield coastal saline soil.

Cost and return analysis

From the economic point the highest gross return (Tk 415380 ha⁻¹), gross margin (Tk249680 ha⁻¹) and BCR (2.51) was recorded from T₆ treatment, followed by T₅ and T₄ (Table 5). The lowest economic return was recorded from control plot (Tk307160 ha⁻¹) and BCR (2.00).

Effect on salinity

Salinity level of the experimental plot was 1.21 during plantation then it increased with time up to 9.27 dS/m throughout the growing season (Fig. 1). It was observed that throughout the season the highest salinity was observed in farmers practice (FP) where no organic fertilizer was used. Among the organic fertilizer treated plots salinity reducing effect was observed as vermicompost>compost>cow dung.

Farmers' opinion

Farmers were very much interested to use organic fertilizer with inorganic doses as it gave more production. They also opined that vermicompost are not available in the market. They seek training on commercial vermicompost production locally.

Table 4. Plant populations, growth and yield contributing parameters of potato at Kuakata, Patuakhali during 2020-21

Treatment	Emergence at 30 DAP (%)	Plant height at 60 DAP	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)	Increased yield over FP (%)
T ₁ :STB+3 ton cow dung ha ⁻¹	91	44.65	6.67	535	23.69	7.98
T ₂ : STB+5 t CD ha ⁻¹	95	48.53	6.85	554	24.95	13.72
T ₃ : STB+1.5 ton compost ha ⁻¹	94	49.32	6.84	524	25.68	17.05
T ₄ : STB+2 t compost ha ⁻¹	95	49.92	6.97	589	26.02	18.60
T ₅ : STB+2 ton vermicompost ha ⁻¹	96	51.46	7.11	667	27.98	27.53
T ₆ : STB+2.5 t vermicompost ha ⁻¹	95	52.35	7.92	696	29.67	35.23
T ₇ : FP	87	46.78	5.37	487	21.94	0.00
LSD (0.05)	3.61	3.22	1.77	9.22	1.79	-
CV (%)	4.71	6.53	3.47	13.98	3.40	-

Table 5. Cost and return analysis of potato at Kuakata, Patuakhali during 2020-21

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
	23.69	331660	157700	173960	2.10
T ₁ :STB+3 ton cow dung ha ⁻¹	24.95	349300	159700	189600	2.19
T ₂ : STB+5 t CD ha ⁻¹	25.68	359520	160700	198820	2.24
T ₃ : STB+1.5 ton compost ha ⁻¹	26.02	364280	162700	201580	2.24
T ₄ : STB+2 t compost ha ⁻¹	27.98	391720	164700	227020	2.38
T ₅ : STB+2 ton vermicompost ha ⁻¹	29.67	415380	165700	249680	2.51
T ₆ : STB+2.5 t vermicompost ha ⁻¹	21.94	307160	153700	153460	2.00
T ₇ : FP					

Potato Price (Tk kg⁻¹) = 14

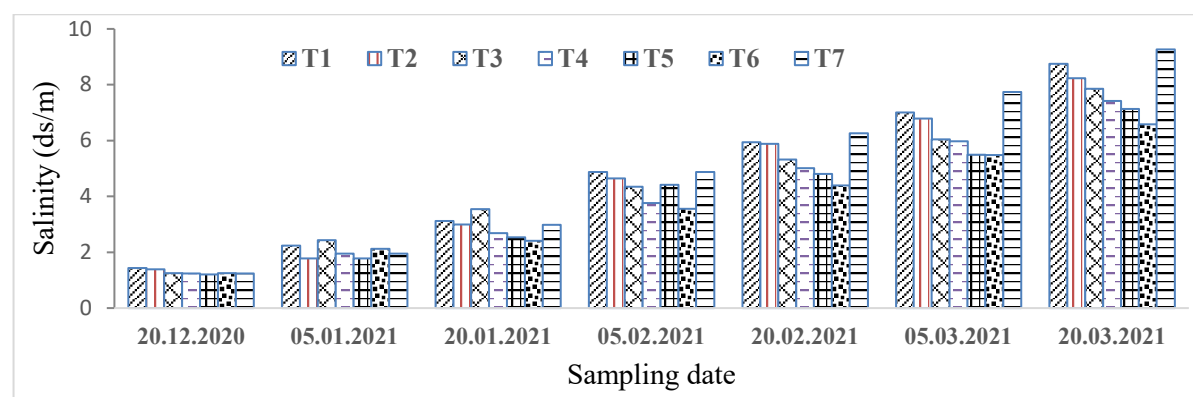


Fig1. Salinity level of different treatment

Conclusion

Organic fertilizer has a positive effect on reduction of soil salinity and to increase potato yield. Usually coastal farmers do not apply any organic fertilizer in their field. As per finding of the trial it may be recommended organic fertilizer specially vermicompost application to maximize potato yield in coastal saline soil.

EFFECT OF DIFFERENT FERTILIZER MANAGEMENT ON THE PERFORMANCE OF BARI Bt BRINJAL

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Abstract

The experiment was conducted in the farmers field of Shibpur, Puthia, Rajshahi during the robi season of 2017-18, 2018-19, 2019-20 and 2020-21 to evaluate the effect of nutrients management packages on Bt begun cultivation and to find out a suitable combination of different fertilizers for Bt Brinjal production. The experiment was laid out in Randomized Complete Block design with six fertilizer doses viz. T_1 = STB fertilizer splitting as per recommendation (FRG, 2018), T_2 = T_1 + 25% NPK (NK splitting 5 times), T_3 = T_1 + 50% NPK (NK splitting 5 times), T_4 = T_1 + 75% NK (NK splitting 5 times), T_5 = T_1 + 25% NPKS and T_6 = Farmers dose. Brinjal variety BARI Bt Begun-4 was used as test crop. Among the treatment, the highest yield 48.08 t ha^{-1} in 2017-18, 47.7 t ha^{-1} in 2018-19, 47.2 t ha^{-1} in 2019-20 and 40.5 t ha^{-1} in 2020-21 was obtained from T_4 followed by T_3 . Based on four year data maximum gross return (Tk 550440 ha^{-1}), gross margin (Tk 367471 ha^{-1}) and BCR (3.01) were recorded in T_4 . The fertilizer dose T_4 (187-26-135-8-1-1 kg ha^{-1} NPKSZn and B respectively) with 5 t cow dung ha^{-1} can be extensively used for BARI Bt Begun-4 production in AEZ-11.

Introduction

Bt brinjal is a transgenic brinjal variety created by inserting a crystal protein gene from the soil bacterium *Bacillus thuringiensis* into the genome of various brinjal cultivars. Recently many farmers in Bangladesh are cultivating Bt brinjal due to protect the infestation of brinjal fruit and shoot borer. BARI BtBrinjal4 is becoming popular in north-west part of the country for its size and colour. BARI is conducting trial on Bt brinjal at farmers' field across the country using recommended fertilizer dose of non-Bt brinjal. But Bt brinjal was not performing well with that fertilizer dose in the field trial. Probably it requires more fertilizer than that of non Bt brinjal. Hence, the present study is undertaken to find out optimum fertilizer packages for higher productivity of BARI Bt brinjal.

Materials and Methods

The experiment was conducted at Shibpur, MLT, Rajshahi during three consecutive year Rabi 2017-18 to 2020-21. The initial soil samples of the experimental field were collected and analyzed following standard laboratory procedures and are presented in Table 1. The experimental soil was slightly alkaline (7.45) having low organic matter (2.03%). The soil contained 0.12% total N (low), 14.08 ppm available P (low), 0.13 me% exchangeable K (low), 18.5 ppm available S (medium), 0.20 ppm available B (low) and 1.33 ppm available Zn (low). The rates of the fertilizers for different fertilizer management packages were calculated (Table 2) using soil test values based (STB) as per Fertilizer Recommendation Guide' 2012 (BARC, 2012). The experiment was laid out in Randomized Complete Block design with four dispersed replications (Three in farmers' field and one in on-station). There were six fertilizer treatment viz. T_1 = STB fertilizer splitting as per recommendation (FRG, 2018), T_2 = T_1 + 25% NPK (NK splitting 5 times), T_3 = T_1 + 50% NPK (NK splitting 5 times), T_4 = T_1 + 75% NK (NK splitting 5 times), T_5 = T_1 + 25% NPKS and T_6 = Farmers dose were presented in Table 2. Unit plot size 10m $\times$ 5m. The seed rate was 150 g ha^{-1} and seedling were transplanted at a spacing of 1m $\times$ 0.8m on 27 October, 29 October, 4 November and 26 December in the year of 2017, 2018, 2019 and 2020-21 respectively. One replication in on-station was unauthorized damaged in 2021. The BARI Bt Brinjal variety was BARI Bt Begun-4. The fertilizers were applied at the rate of respective packages in the form of Urea, Triple Super Phosphate, Muriate of Potash, Gypsum, Zinc Sulphate and Boric acid, respectively and Cow dung

@ 5 t ha⁻¹ were used. Furadan was used at the rate of 30 Kg ha⁻¹. Furadan and total quantity of all fertilizers except Urea and MoP were applied as basal at the time of final land preparation. Urea and MoP were applied by equal splits following management packages at vegetative, flowering and fruiting stage of Bt Brinjal. The intercultural operations such as weeding, earthing up, removed plant residues and irrigations were done as and when necessary. Insecticide (Admire 5 EC), Ektara, Vertimak, Pegasus-50 SC and Karata-2.5 EC were applied for controlling aphids, white fly and Mite. Fungicide, Tilt-250-EC was sprayed for controlling *Phomopsis* blight at fruiting and mature stage. The crop harvesting was started from 10 January, 15 January, 18 January and 02 March in the year of 2018, 2019, 2020 and 2021 respectively and continued up to 20, 24, 26 and 27 May in the year of 2018, 2019, 2020 and 2021 respectively. Data on plant height, individual weight of fruit, number of fruits per plant and yield were recorded and analyzed statistically following STAR program.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Shibpur, Puthia, Rajshahi

Sample	Soil pH	Organic matter (%)	Total N (%)	P (ppm)	K meq/100g soil	S (ppm)	Zn (ppm)	B (ppm)
1	7	2.24	0.13	13	0.12	18.4	1.2	0.2
2	7.2	1.7	0.1	16.6	0.14	17.3	1.33	0.2
3	7.9	1.96	0.11	14.4	0.11	21.4	1.13	0.2
4	7.7	2.22	0.13	12.3	0.16	16.9	1.47	0.2
Average	7.45	2.03	0.12	14.08	0.13	18.50	1.28	0.20
Critical level	-	-	0.12	10	0.12	08.00	0.20	0.20
Interpretation	Slightly alkaline	M	L	L	L	M	M	L

M=Medium, H=High, L=Low, Al=Alkaline and O=Optimum

Table 2. Different fertilizer treatment packages (kg ha⁻¹) for BARI Bt Begun-4 at MLT site, Shibpur, Puthia, Rajshahi

Treatment	N	P	K	S	Zn	B	CD
T ₁ = STB fertilizer dose (FRG, 2012)	107	26	77	8	1	1	5 ton
T ₂ = T ₁ + 25% NPK (NK splitting 5 times)	134	33	96	8	1	1	5 ton
T ₃ = T ₁ + 50% NPK (NK splitting 5 times)	161	39	116	8	1	1	5 ton
T ₄ = T ₁ + 75% NK (NK splitting 5 times)	187	26	135	8	1	1	5 ton
T ₅ = T ₁ + 25% NPKS	134	33	96	10	1	1	5 ton
T ₆ = Farmers practices	220	85	113	15	2	2	5 ton

Results and Discussions

The experiment was initiated in the year 2017 therefore, yield performance of BARI Bt Begun-4 under different fertilizer treatments during 2017-21 is presented in Table 3. The yield and yield attributes of BARI Bt Begun-4 was found significantly differed under different nutrient management packages. The tallest plant (117.3 cm) was obtained from treatment T₅= T₁ + 25% NPKS which were similar (113.3 cm) to T₄= T₁ + 75% NK (NK splitting 5 times). The highest individual fruit weight (246 g) was found in T₄= T₁ + 75% NK (NK splitting 5 times) followed by T₃ (239 g) = T₁ + 50% NPK (NK splitting 5 times). The highest number of fruits was produced in T₄. The highest yield was obtained from T₄ (48.08 t ha⁻¹) followed by T₃ (43.07 t ha⁻¹) and lowest was in T₁ (29.84 t ha⁻¹). In the year 2018-19, the yield performance of BARI Bt Begun-4 under different fertilizer treatments is presented in Table 4. The yield and yield attributes of BARI Bt brinjal was found significantly differed under different nutrient management packages. The tallest plant (115.8 cm) was obtained from treatment T₄= T₁ + 75% NK (NK splitting 5 times) which were similar to T₅= T₁ + 25% NPKS (115.1 cm), T₆= Farmers practices (114.8 cm) and T₃ (112.4 cm) = T₁ + 50% NPK (NK splitting 5 times). The highest individual fruit weight (236.3 g) was found in T₄= T₁ + 75% NK (NK splitting 5 times) which were similar to T₆= Farmers practices (232.2 g) and T₅= T₁ + 25% NPKS (225.6 g). The highest number of fruits was produced in T₄. The highest yield was obtained from T₄ (47.67 t ha⁻¹) followed by T₃ (39.59 t ha⁻¹) and lowest was in T₁ (28.16 t ha⁻¹). In the year 2019-20, the yield performance of BARI Bt Begun-4 under different fertilizer treatments is presented in Table 5. The yield and yield attributes of BARI Bt brinjal was found significantly differed under different nutrient management packages. The tallest plant (116 cm) was

obtained from treatment $T_4 = T_1 + 75\% \text{ NK}$ (NK splitting 5 times) which were similar to $T_5 = T_1 + 25\% \text{ NPKS}$ (114.4 cm) and $T_6 = \text{Farmers practices}$ (113.3 cm). The highest individual fruit weight (226.3 g) was found in $T_4 = T_1 + 75\% \text{ NK}$ (NK splitting 5 times) which were similar to $T_6 = \text{Farmers practices}$ (222.2 g) and $T_5 = T_1 + 25\% \text{ NPKS}$ (215.6 g). The highest number of fruits was produced in T_4 . The highest yield was obtained from T_4 (47.2 t ha⁻¹) followed by T_3 (38.0 t ha⁻¹) and lowest was in T_1 (26.6 t ha⁻¹). In the year 2020-21, the yield performance of BARI Bt Begun-4 under different fertilizer treatments is presented in Table 6. The yield and yield attributes of BARI Bt brinjal was found significantly differed under different nutrient management packages. The tallest plant (113.1 cm) was obtained from treatment $T_4 = T_1 + 75\% \text{ NK}$ (NK splitting 5 times) which were similar to $T_6 = \text{Farmers practices}$ (111.9 cm) and $T_5 = T_1 + 25\% \text{ NPKS}$ (111.3 cm). The highest individual fruit weight (225.1 g) was found in $T_4 = T_1 + 75\% \text{ NK}$ (NK splitting 5 times) which were similar to $T_6 = \text{Farmers practices}$ (220.1 g) and $T_5 = T_1 + 25\% \text{ NPKS}$ (212.5 g). The highest number of fruits was produced in T_4 . The highest yield was obtained from T_4 (40.5 t ha⁻¹) followed by T_3 (30.2 t ha⁻¹) and lowest was in T_1 (20.1 t ha⁻¹).

Cost and return analysis

Based on three years' observation, economic performance of the treatments was presented in the Table 7. Maximum gross return (Tk 550440 ha⁻¹) found in T_4 where maximum gross margin (Tk 367471 ha⁻¹) and BCR (3.01) were also recorded from the same treatment. The minimum gross margin and BCR were recorded from T_1 treatment.

Farmers' are interested to use optimum fertilizers to their BARI Bt begun-4 productions for higher yield and income.

Table 3. Yield of BARI Bt brinjal under different fertilizer Management packages in Shibpur, Puthia, Rajshahi during 2017-18

Treatment	Plant height (cm)	Fruit plant ⁻¹ (no)	Individual fruit wt (g)	Yield (t ha ⁻¹)
$T_1 = \text{STB fertilizer dose (FRG, 2012)}$	94.5 d	10.25 c	227.5d	29.84 e
$T_2 = T_1 + 25\% \text{ NPK (NK splitting 5 times)}$	102.3 c	12.0 bc	229.5cd	31.67 e
$T_3 = T_1 + 50\% \text{ NPK (NK splitting 5 times)}$	106.3bc	13.75ab	239.2 b	43.07b
$T_4 = T_1 + 75\% \text{ NK (NK splitting 5 times)}$	113.3a	16.0 a	246.1 a	48.08 a
$T_5 = T_1 + 25\% \text{ NPKS}$	117.3a	14.5 ab	234.5bc	38.17 c
$T_6 = \text{Farmers practices}$	107.3b	12.5 bc	233.5 bc	35.24 d
LSD (0.05)	4.7	2.74	6.0	2.63
CV (%)	2.92	13.8	1.7	4.64

Table 4. Yield of BARI Bt Brinjal under different fertilizer Management packages in Shibpur, Puthia, Rajshahi during 2018-19

Treatment	Plant height (cm)	Fruit plant ⁻¹ (no)	Individual fruit wt (g)	Yield (t ha ⁻¹)
$T_1 = \text{STB fertilizer dose (FRG, 2018)}$	96.2 c	11.0 d	207.5 d	28.2 c
$T_2 = T_1 + 25\% \text{ NPK (NK splitting 5 times)}$	104.7 b	12.4 cd	212.0 cd	31.9 d
$T_3 = T_1 + 50\% \text{ NPK (NK splitting 5 times)}$	112.4 a	13.1 bc	222.2 bc	39.6 b
$T_4 = T_1 + 75\% \text{ NK (NK splitting 5 times)}$	115.8 a	15.9 a	236.3 a	47.7 a
$T_5 = T_1 + 25\% \text{ NPKS}$	115.1 a	14.8 ab	225.6 ab	36.3 c
$T_6 = \text{Farmers practices}$	114.8 a	14.6 ab	232.2 ab	36.7 bc
LSD (0.05)	4.47	5.74	12.54	3.22
CV (%)	1.77	1.79	2.45	6.82

Table 5. Yield of BARI Bt brinjal under different fertilizer Management packages in Shibpur, Puthia, Rajshahi during 2019-20

Treatment	Plant height (cm)	Fruit plant ⁻¹ (no)	Individual fruit wt (g)	Yield (t ha ⁻¹)
T ₁ = STB fertilizer dose (FRG, 2018)	96.5 d	13.0 d	197.5 d	26.6 e
T ₂ = T ₁ + 25% NPK (NK splitting 5 times)	102.0 c	14.4 cd	202.0 cd	30.4 d
T ₃ = T ₁ + 50% NPK (NK splitting 5 times)	111.2 b	15.1 bc	212.2 bc	38.0 b
T ₄ = T ₁ + 75% NK (NK splitting 5 times)	116.0 a	20.7 a	226.3 a	47.2 a
T ₅ = T ₁ + 25% NPKS	114.3 ab	16.8 b	215.6 ab	34.8 c
T ₆ = Farmers practices	113.2 ab	16.6 b	222.2 ab	35.1 bc
LSD (0.05)	4.47	2.02	12.54	3.25
CV (%)	1.79	5.47	2.57	4.0

Table 6. Yield of BARI Bt brinjal under different fertilizer Management packages in Shibpur, Puthia, Rajshahi during 2020-21

Treatment	Plant height (cm)	Fruit plant ⁻¹ (no)	Individual fruit wt (g)	Yield (t ha ⁻¹)
T ₁ = STB fertilizer dose (FRG, 2018)	95.1 d	10.0 d	195.4 d	20.1 e
T ₂ = T ₁ + 25% NPK (NK splitting 5 times)	100.9 c	12.2 cd	201.0 cd	22.8 d
T ₃ = T ₁ + 50% NPK (NK splitting 5 times)	109.1 b	15.5bc	210.2 bc	30.2 b
T ₄ = T ₁ + 75% NK (NK splitting 5 times)	113.1 a	17.1 a	225.1 a	40.5 a
T ₅ = T ₁ + 25% NPKS	111.3 ab	13.1 b	212.5ab	26.7 c
T ₆ = Farmers practices	111.9ab	14.4 b	220.1ab	28.1 bc
LSD (0.05)	5.67	3.12	10.51	3.43
CV (%)	9.55	10.32	7.44	6.46

Table 7. Average four years cost and return analysis of BARI Bt Brinjal against different fertilizer packages

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ = STB fertilizer dose (FRG, 2018)	26.13	313620	178448	135172	1.75
T ₂ = T ₁ + 25% NPK (NK splitting 5 times)	29.19	350310	180729	169581	1.93
T ₃ = T ₁ +50% NPK (NK splitting 5 times)	37.72	452640	182927	269713	2.47
T ₄ = T ₁ + 75% NK (NK splitting 5 times)	45.87	550440	182969	367471	3.01
T ₅ = T ₁ + 25% NPKS	33.99	407910	180817	227093	2.25
T ₆ = Farmers practices	33.78	405420	190252	215168	2.13

Urea: 16 Tk kg⁻¹, TSP: 22 Tk kg⁻¹, MoP: 15 Tk kg⁻¹, gypsum: 7Tk kg⁻¹, zinc sulphate: 120 Tk kg⁻¹, boric acid: 150 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Brinjal seed: 20Tkkg⁻¹, Tillage cost :10000 Tk ha⁻¹, irrigation (1 time): 1875Tk ha⁻¹ and Labour: 300Tk day⁻¹ (6 hours)
Selling price: Brinjal 12 Tk kg⁻¹

Conclusion

Judicious application of fertilizer is essential for yield and maximization of income. The fertilizer dose T₄(187-26-135-8-1-1 kg ha⁻¹ N-P-K-S-Zn and B respectively) with 5 t cow dung ha⁻¹ can be extensively used for BARI Bt Begun-4 production in AEZ-11.

DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR MUKHIKACHU PRODUCTION IN AEZ-11

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Abstract

The experiment was conducted in the farmer's field of Mohanpur, Rajshahi during the kharif season of 2019-2021 to evaluate the effect of nutrients management packages on mukhikachu cultivation and to find out a suitable combination of different fertilizers for mukhikachu production. The experiment was laid out in Randomized Complete Block design with four fertilizer treatments viz. T₁= Soil test based dose (FRG, 2018), T₂= 25% higher NPK of soil test base dose, T₃= 50% higher NPK of soil test base

dose, and T_4 =Farmers dose. Local mukhikachu variety 'sonamukhi' was used as test crop. Among the treatment, the highest yield was obtained from T_3 (22.99 t ha⁻¹) followed by T_4 (20.84 t ha⁻¹) and T_2 (20.27 t ha⁻¹). Maximum gross return (Tk 574750 ha⁻¹) found in T_3 where maximum gross margin (413735 Tk ha⁻¹) and BCR (3.57) were recorded in 2019-20. On the other hand the highest yield was obtained from T_3 (33.23 t ha⁻¹) followed by T_4 (28.75 t ha⁻¹), T_3 (28.3 t ha⁻¹) and minimum obtained from T_1 (26.55 t ha⁻¹). Maximum gross return (Tk 764290 ha⁻¹), gross margin (Tk 592539 ha⁻¹) and BCR (4.44) found in T_3 treatment in 2020-21.

Introduction

Mukhikachu (*Colocasia esculenta* Schott) is an important tuber crop vegetable grown in kharif season in Bangladesh. It belongs to the family Araceae and is well known as taro. It is a carbohydrate, protein and iron and vitamin 'A' rich vegetable which is generally grown during February/March to September/October. It is considered as an important vegetable, particularly in the month of August-October when the supply of other vegetables is limited in the market. Mukhikachu is one of the most important summer vegetables in Bangladesh. It is a very popular vegetable crop usually cultivated as a sole crop can tolerate high temperature and drought. After winter, during lag period of vegetables Mukhikachu cultivation is a profitable practice for the farmer. To get the maximum return and crop production, fertilizer management is the most logical way to raise total production. It is necessary to find out an optimum dose of fertilizer for Mukhikachu production. Therefore, the trial has been undertaken to find out an optimum fertilizer dose for Mukhikachu production.

Materials and Methods

The experiment was carried out at MLT site Mohanpur, Rajshahi during 2019 in High Ganger River Flood Plain soil (AEZ-11). The initial soil samples of the experimental field were collected and analyzed following standard laboratory procedures and are presented in Table 1. The experimental soil was neutral (7.3) having low organic carbon (0.84 %). The soil contained 0.08% total N (very low), 102.1 ppm available P (very high), 0.29 meq % exchangeable K (optimum), 33.02 ppm available S (high), 0.86 ppm available B (very high) and 1.83 ppm available Zn (high). The rates of the fertilizers for different fertilizer management packages were calculated using soil test values based (STB) as per Fertilizer Recommendation Guide' 2018 (BARC, 2018). The experiment was laid out in Randomized Complete Block design with three replications. There were four fertilizer treatment viz. T_1 = Soil test based dose (FRG, 2018), T_2 = 25% higher NPK of soil test base dose, T_3 = 50% higher NPK of soil test base dose, and T_4 =Farmers dose were presented in Table 2. The unit plot size was 10 m × 8m with 60 cm (line-line) × 35 cm (plant to plant) spacing. The variety was local (Sonamukhi) and seed rate was 450 kg ha⁻¹. The land was prepared well with 5/6 ploughing followed by laddering and fertilized with different fertilizer packages. Five ton cow dung per hectare were also applied in the field. Entire cow dung and full of TSP, MOP and half of urea were applied at final land preparation. The rest urea was applied in two equal installments at 45 and 60 days after planting. The crop was sown on 12 April 2019 and harvested on 20 October 2019. On the other hand in 2020 crop was sown on 14 April and harvested on 23 October, 2020. Six irrigations were done and sprayed Emidachloprid (Tido) @ 0.5 ml/L of water and Ridomil @ 2g/L of water at 2 times to control insects and diseases during production. All necessary data were collected and analyzed through STAR program.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Mohanpur, Rajshahi

Item	pH	OM (%)	Total N (%)	P (ppm)	K meq/100g soil	S	Zn	B
						(ppm)		
Sample	7.7	0.84	0.08	17.5	0.29	24.50	1.83	0.63
Critical level	-	-	0.12	10	0.12	10.00	0.2	0.2
Interpretation	Slightly alkaline	VL	VL	M	O	O	H	H

N=Neutral, M=Medium, H=High, L=Low, VL=Very Low, VH=Very High, Al=Alkaline and O=Optimum

Table 2. Different fertilizer treatment packages (kg ha⁻¹) for Mukhikachu at MLT site, Mohanpur, Rajshahi

Treatment	N	P	K	S	CD
T ₁ = Soil test-based dose FRG, 2018)	132	10	25	8	5 ton
T ₂ = 25% higher NPK of soil test base dose	165	13	31	8	5 ton
T ₃ = 50% higher NPK of soil test base dose	198	15	38	8	5 ton
T ₄ = Farmers practices	138	25	75	-	5 ton

Results and Discussions

The experiment was initiated in the year 2019 therefore yield performance of mukhikachu under different fertilizer treatments during 2019-20 is presented in Table 3. The yield and yield attributes of mukhikachu was found significantly differed under different nutrient management packages. The tallest plant (77 cm) was obtained from treatment T₃= 50% higher NPK (of soil test base dose) and the highest cormel plant⁻¹ (24) was found in the same. The highest yield plant⁻¹ (588 g) was found in T₃ (50% higher NPK of STB). The T₂ (25% higher NPK of STB) produced the similar yield plant⁻¹ (453.7 g) with T₄ (Farmers practices) (475.7 g). The biggest cormel (24.85 g) was produced in T₃ than other fertilizer packages. The highest yield was obtained from T₃ (22.99 t ha⁻¹) and the T₄ (20.84 t ha⁻¹) and T₂ (20.27 t ha⁻¹) produced the similar yield. The lowest yield was produced in T₁ (18.44 t ha⁻¹). Yield performance of different treatments during 2020-21 is presented in Table 4. The tallest plant (76.25 cm) was obtained from treatment T₃ and the highest cormel plant⁻¹ (23.75) was found in the same. The highest yield plant⁻¹ (584.22 g) was found in T₃. The farmers practices (T₄) produced yield plant⁻¹ (497.5 g), T₂ (25% higher NPK of STB) produced yield plant⁻¹ (480.75 g) and lowest yield plant⁻¹ (454.75 g) obtained from T₁. The biggest cormel (25.58 g) was produced in T₃ than other fertilizer packages. The highest yield was obtained from T₃ (33.23 t ha⁻¹) followed by T₄ (28.75 t ha⁻¹), T₂ (28.3 t ha⁻¹) and lowest yield in T₁ (26.55 t ha⁻¹).

Cost and return analysis

Based on two years' observation, economic performance of the treatments was presented in the Table 5 and 6. In year 2019-2020, maximum gross return was obtained from T₃ treatment (Tk 574750 ha⁻¹) where maximum gross margin (Tk 413735 ha⁻¹) and BCR (3.57) were also recorded from the same treatment (Table 5). The minimum gross margin and BCR were recorded from T₁ treatment. In the next year 2020-2021 economic performance of the treatments was presented in the Table 6. Maximum gross return was obtained from T₃ treatment (Tk 764290 ha⁻¹) where maximum gross margin (Tk 592539 ha⁻¹) and BCR (4.44) were also recorded from the same treatment.

Framers' opinion

Farmers' are interested in using optimum fertilizers to mukhikachu production for higher yield and income.

Table 3. Yield of Mukhikachu under different fertilizer Management packages in Mohanpur, Rajshahi during 2019-20

Treatment	Plant height (cm)	Cormel Plant ⁻¹ (no)	Yield plant ⁻¹ (g)	Ind cormel wt (g)	Yield (t ha ⁻¹)
T ₁ = Soil test based dose (FRG, 2018)	65.0 c	18.3 b	425.3 c	22.8 b	18.44 c
T ₂ = 25% higher NPK of STB	67.0 bc	20.0 b	453.7 b	22.5 b	20.27 b
T ₃ = 50% higher NPK of STB	77.0 a	24.0 a	588.0 a	24.85 a	22.99 a
T ₄ = Farmers practices	68.8 b	20.0 b	475.7 b	23.6 b	20.84 b
LSD _(0.05)	2.64	2.0	23.35	1.22	0.96
CV (%)	1.91	4.86	2.41	2.60	2.32

Table 4. Yield of Mukhikachu under different fertilizer Management packages in Mohanpur, Rajshahi during 2020-21

Treatment	Plant height (cm)	Cormel Plant ⁻¹ (no)	Yield plant ⁻¹ (g)	Ind cormel wt (g)	Yield (t ha ⁻¹)
T ₁ = Soil test based dose (FRG, 2018)	66.75 b	20.50 b	454.75 c	22.21 b	26.55 c
T ₂ = 25% higher NPK of STB	68.5 b	21.25 b	480.75bc	22.69 b	28.3 b
T ₃ = 50% higher NPK of STB	76.25 a	23.75 a	584.22 a	25.58 a	33.23 a
T ₄ = Farmers practices	70 b	21.75 b	497.50 b	23.73 ab	28.75 b
LSD (0.05)	3.66	1.89	34.71	2.07	1.35
CV (%)	3.25	5.41	4.30	5.49	2.79

Table 5. Cost and return analysis of Mukhikachu under different fertilizer Management packages in Mohanpur, Rajshahi during 2019-20

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ =Soil test based dose (FRG, 2018)	18.44	461000	157783	303217	2.92
T ₂ = 25% higher NPK of STB	20.27	506750	159439	347311	3.18
T ₃ = 50% higher NPK of STB	22.99	574750	161051	413735	3.57
T ₄ = Farmers practices	20.84	521000	160791	360209	3.24

Input cost: Mukhikachu seed @ 70 Tk/kg, Mukhikachu @ 25Tk/kg, Urea @20 Tk/kg, TSP @ 22 Tk/kg, MOP @ 15 Tk/kg, Gypsum @ 7Tk/kg, Boric acid @ 120 Tk/kg, Labour wage @ 300Tk/day/person.(6 hours)

Table 6. Cost and return analysis of Mukhikachu under different fertilizer Management packages in Mohanpur, Rajshahi during 2020-21

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ = Soil test-based dose (FRG, 2018)	26.55	610650	159850	450800	3.82
T ₂ = 25% higher NPK of STB	28.30	650900	162875	488025	3.99
T ₃ = 50% higher NPK of STB	33.23	764290	171751	592539	4.44
T ₄ = Farmers practices	28.75	661250	164755	496495	4.01

Input cost: Mukhikachuseed @ 70 Tk/kg, Mukhikachu @ 23Tk/kg, Urea @16 Tk/kg, TSP @ 22 Tk/kg, MOP @ 15 Tk/kg, Gypsum @ 10 Tk/kg, Boric acid @480 Tk/kg, Labour wage @ 350 Tk/day/person.(6 hours)

Conclusion

Judicious application of fertilizer is essential for yield and income maximization of Mukhikachu. The fertilizer dose T₃ (198-15-38-8 kg NPK and S ha⁻¹ respectively) with 5 t cow dung ha⁻¹ can be recommended for Mukhikachu production in AEZ-11.

EFFECT OF RICE STRAW BURN ASH ON THE YIELD OF MUSTARD

M. I. Nazrul, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was conducted during 2020-21 in winter season at Madhobpur under MLT site, Habiganj. Four different cultivation practices T₁ = Rice straw burn + no tilth, T₂ = Rice straw burn + no tilth + water spray, T₃ = Rice straw burn + one tilth and T₄ = Rice straw burn + two tilths were used in this experiment. The experiment was setup in randomized complete block design with three replications. Among the cultivation practices the treatment Rice straw burn + two tilths contributed higher seed yield (1.64 t ha⁻¹) with maximum gross return (Tk 123000 ha⁻¹), gross margin (Tk82200 ha⁻¹) and also higher benefit cost ratio (3.02). Whereas the lowest benefit cost ratio (2.54) was obtained from cultivation practice Rice straw burn + one tilth.

Introduction

In some areas of Sylhet region especially medium low land of Hobiganj farmers following Broadcast Aman rice-Mustard-Fallow cropping pattern. Broadcast aman rice (viz. Gota, Lucky, Kasha) followed

by mustard BARI Sarisha-14/BARI Sarisha-15 are cultivated in various ways of techniques just shortly after harvest of B. Aman rice. Rice straw which remains in the field after harvest can be collected, burned, or left to decompose. Rice straw burning has environmental consequences, including emissions of carbon dioxide resulting in serious air pollution and organic plant decomposition. Preliminary survey revealed that farmers follow the custom of burning rice straw on the field shortly after harvesting and use ash as organic manure for soil treatment during cultivation. On the contrary some fields remain fallow due to lack of right cultivation practices and non-economic cultivation of mustard. A method to be standardized for productive cultivation of mustard. As a results, research work has been done to see the impact of rice straw ash on the soil's physiochemical properties and mustard yield.

Materials and Methods

The experiment was conducted at Madhobpur under MLT site, Habigonj during winter season in the year 2020-21. Four different treatments viz. T_1 = Rice straw burn + no till, T_2 = Rice straw burn + no till + water spray, T_3 = Rice straw burn + one till and T_4 = RSB + two tills were evaluated in the farmer's field. The experiment was setup in randomized complete block design with three replications. The seed was sown in broadcast method.

The crop was fertilized with 95-35-42-7-1 kg N-P-K-S-B ha^{-1} , respectively. The fertilizer nutrients were used in the form of Urea, TSP, MoP, Gypsum and Boric acid. Half of urea and all of TSP, MoP, Gypsum and Boric acid were applied at 10-15 days after sowing (DAS) of seeds. Remaining half of Urea was applied at 25-30 DAS in top dress at the time of flowering. The seeds were sown on 5-7 December 2020. No weeding and irrigation was provided.

But insecticide Fighter 2.5 EC @ 1 ml/L and fungicide Rovral 50 up @ 2g/L of water was sprayed once at pod setting stage for preventing pod borer and leaf blight of mustard. Other than that there was no remarkable disease and pest attack was observed. The crop was harvested on 05-07 March in 2021. Data on yield and yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analyzed statistically using "STAR" software package and means were separated by LSD.

Results and Discussions

The result showed that plant height, 1000 seed weight, seeds pod^{-1} and seed yield ($t\ ha^{-1}$) was significantly varied in different treatments (Table 1). Statistically highest plant height was recorded from the cultivation practice. "Rice straw burn + two tills" followed by "Rice straw burn + water spray". On the contrary, the shortest plant was found from, "Rice straw burn + no till". Similar trend was observed in case of plants m^{-2} and weight of 1000 seeds. Maximum number of plants m^{-2} was observed in, "Rice straw burn+ two tills" followed by "Rice straw burn + no till + water spray" practices. Statistically the height 1000 seed weight (3.36) was received from "Rice straw burn + two tills". The highest number of seed pod^{-1} and seed yield per plot was highest from "Rice straw burn + two tills", whereas lowest was recorded from the "Rice straw burn + no till" practice.

The highest seed yield ($1.64\ t\ ha^{-1}$) was also harvested from "Rice straw burn + two tills" followed by "Rice straw burn + water spray" shortly after showing of mustard seeds.

Cost and return analysis

The economic returns were varied in different cultivation practices of mustard (Table 2). The "Rice straw burn + two tills" showed higher monetary return than other practices. The highest gross return (Tk 123000 ha^{-1}), gross margin (Tk 82200 ha^{-1}) and benefit cost ratio (3.02) was given by "Rice straw burn + two tills", followed by "Rice straw burn + no till + water spray. Among the practices, the lowest benefit cost ratio (2.54) was obtained from "Rice straw burn + one till" practice.

Farmers' opinion

Farmers, showed interest to take part in on farm research activities for finding out the profitable system of mustard cultivation under Mustard-Broadcast aman rice-Fallow cropping pattern in Habigonj.

Table 1. Yield and yield attributes of mustard under different treatment in 2020-21

Treatment	Plant height (cm)	Plants m ⁻² (no)	Pods plant ⁻¹ (no)	1000 seed wt (g)	Seeds pod ⁻¹ (no)	Yield plot ⁻¹ (g)	Yield (tha ⁻¹)
T ₁	79.67	84.67	85.00	2.87	19.00	50.00	1.25
T ₂	87.67	87.33	83.67	3.07	21.33	59.33	1.51
T ₃	80.33	85.67	83.00	2.87	19.00	51.67	1.30
T ₄	90.67	90.00	85.67	3.36	23.33	68.33	1.64
LSD _(0.05)	2.45	2.45	NS	2.45	2.46	2.45	2.46
CV (%)	2.55	1.87	2.66	2.05	3.52	10.19	7.64

T₁ = Rice straw burn + no tilth, T₂ = Rice straw burn + no tilth + water spray, T₃ = Rice straw burn + one tilth and T₄ = Rice straw burn + two tilths

Table 2. Cost and return analysis of mustard under different treatment in 2020-21.

Treatment	Gross return (Tk ha ⁻¹)	Total cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	93750	36000	57750	2.60
T ₂	113250	39200	74050	2.89
T ₃	97500	30400	59100	2.54
T ₄	123000	40800	82200	3.02

T₁ = Rice straw burn + no tilth, T₂ = Rice straw burn + no tilth + water spray, T₃ = Rice straw burn + one tilth and T₄ = Rice straw burn + two tilths.

Conclusion

From the study, it can be concluded that rice straw burn + two tilths contributed the highest seed yield and economic return. However, the trial will be continued in next year for more confirmation of result.

EFFECT OF LIME AND FERTILIZER MANAGEMENT ON YIELD OF ONION IN SYLHET REGION

M. I. Nazrul, M Akkas Ali, M Shahiduzzaman

Abstract

Liming in acidic soil is a common practice in many countries, but not yet successfully in Bangladesh. Field experiments were carried out in 2020-21 at the farmer's field on an area with acidic clay loam soil at farming system research and development (FSRD) site, Kamalbazer, South Surma, Sylhet. Two factors experiment viz. A) Fertilizer management, M₁: Soil test based (STB) fertilizer recommendation, M₂: 80% of STB dose and M₃: Farmers practice (FP) and B) Level of limes viz. L₁: 0 t ha⁻¹, L₂: 1 t ha⁻¹ and L₃: 2 t ha⁻¹ were considered as treatments. These was tested on Onion variety BARI Paj-1. Trials were laid out in split plot design with three replications, where lime levels were allotted to main plot and level of fertilizers were distributed in the subplots. The bulb yield of onion from total of nine treatment combinations varied significantly with different lime doses and fertilizer management practices. The highest bulb yield of onion (13.78 t ha⁻¹) was obtained from treatment combination L₂M₁ (1.00 t lime ha⁻¹ and STB fertilizer dose) followed by L₃M₁. The highest gross margin (Tk 31878 ha⁻¹) was obtained from L₂M₁, but the maximum MBCR (6.60) was recorded in L₁M₁, where the lime was absent though it is essential for onion cultivation in acidic soil. Considering the overall benefit of lime in relation to soil acidity and nutrient availability for crop production the economic loss in term of MBCR might be over looked. So the application of lime (1.00 t ha⁻¹) along with STB fertilizer dose contributed higher bulb yield (13.78 t ha⁻¹) over all other treatment combinations.

Introduction

The optimal soil pH for onion crop is 6.2 to 6.8 with the sandy loam types of soil (Karim and Ibrahim, 2013). At the high end of this range, soil nutrients are most easily accessed. If soil isn't in the proper pH range for growing onions, it can be adjusted with organic substances, ammonium sulfate and dolomitic lime will also boost acidity. The soil of Sylhet region is mostly strongly acidic that adversely affects crop production. Presently, farmers in this region are using dolomite in different quantities to correct the soil acidity. Results of on-farm trial with lime indicated that it had good effect on bulb yield of

Onion. Soil pH management through liming is a basic practice for increasing crop yield. Liming optimizes nutrient availability in soil and its utilization by plants. Therefore, it is necessary to determine the optimum dose of lime and fertilizer for better growth and yield of Onion.

Materials and Methods

Experiments were carried out during 2020-2021 at the farmer's field on an area with acidic clay loam soil at farming system research and development (FSRD) site, Kamalbazar under South Surma in Sylhet. Two factors experiments viz. A) Fertilizer management, M₁: Soil test based (STB) fertilizer recommendation, M₂: 80% of STB fertilizer dose and M₃: Farmers practice (FP) and B) Level of limes viz. L₁: 0 t ha⁻¹, L₂: 1 t ha⁻¹ and L₃: 2 t ha⁻¹ were considered as treatments. Trials were laid out in split plot design with three replications. Where levels of lime were allotted to main plot and fertilizer management were distributed in the subplots. Top soil (0-15 cm depth) was sampled in the experimental plots before applying lime and after the cultivated Onion crop was harvested. The chemical properties of the collected soils are given in Table 1. The crop with variety, plot size with spacing, date of sowing or transplant and harvest date have been shown in Table 2. Intercultural operation and crop protection measures were taken as per requirement during the conduction of experiment. Irrigation, insect control and other intercultural operations were done as and when necessary. The fungicide mixture (Rovral @ 2% and Ridomil @ 0.2) was sprayed to control purple blotch disease. The amendments of different levels of lime were applied on 10-15 November and were incorporated into the soil by ploughing. Data on yield of Onion and farmers opinion were recorded. The collected data were analyzed statistically by using star package and means were separated by least significant difference (LSD) test at 5% level of significance. Cost benefit analysis were done based on the market price of the inputs and outputs.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field in Eastern Surma Kushiara Flood plain of Sylhet

pH	OM (%)	Total N (%)	K meq/100g soil	P	S	Zn	B
4.1-5.3	1.63	0.08	0.12	2.47	10.80	1.24	0.33
-		0.12	0.12	8.0	10	0.6	0.2
Strong acidity	Low	Very low	Low	Very low	Low	Medium	Medium

Table 2. Fertilizers doses, plot size, spacing, date of transplanting and date of harvest

Fertilizer (Kg ha ⁻¹) (N-P-K-S-Zn-B)		Plot size	Spacing (cm×cm)	Date of	
				Planting	Harvest
M ₁	100-67-79-23-3-1.4				
M ₂	80-54-63-78-2.5-1	20 m ²	15 × 7	17-20 Dec 2020	25-27 March 2021
M ₃	86-52-74-20-1.9-1				

Results and Discussions

Effect of Lime: The effect of lime on the yield and yield component of Onion has been shown in Table 3. The highest bulb yield (13.26 t ha⁻¹) was obtained from 2.0 t lime ha⁻¹, which was significantly higher over control and the moderate dose (1.0 t lime ha⁻¹). The second highest bulb yield (12.85 ha⁻¹) of onion was recorded with 1.0 t lime ha⁻¹, which was also significantly higher over the lime control treatment. The application of lime was contributed up to 15% higher bulb yield over control. This finding expressed that 2.0 t lime ha⁻¹ might be required for maximizing the bulb yield of Onion.

Effect of Fertilizer Management: The balance fertilizer dose played a significant role in the yield and yield attributes of onion (Table 3). The highest bulb yield of onion (13.14 t ha⁻¹) was found in soil test base fertilizer management (M₁), which was significantly higher over rest of the treatments. There was no significant difference between 80% of STB fertilizer dose (M₂) and farmer practice (M₃).

Interaction Effect of Lime and Fertilizer Management: The interaction between lime and fertilizer management practice was found statistically significant for bulb yield and yield components of Onion (Table 3). Combined application of both lime and fertilizer management augmented higher results than single effect. Significantly higher bulb weight (30.80g) and bulb diameter (3.73 cm) was found when 2.0 t lime ha⁻¹ and 80% of STB fertilizer was used integrately. The bulb yield of onion also increased significantly due to combined use of lime and fertilizer management practice. The highest bulb yield

(13.78 t ha⁻¹) was obtained from L₂M₁, followed by L₃M₁. On the contrary, the treatment combinations with zero lime (L₁M₁, L₁M₂ and L₁M₃) produces the lowest bulb yields of onion as compared to that of lime mixed treatment combinations.

Cost and return analysis : Cost and return analysis showed that the highest gross margin (Tk 318787 ha⁻¹) was obtained from L₂M₁ (Table 4). The second highest gross margin (Tk 306037 ha⁻¹) was recorded in L₃M₁, which was closely followed by L₃M₂. However the highest MBCR (6.60) was recorded in L₁M₁ where lime was absent but that was essential for Onion cultivation in acidic soil. On the contrary, incorporation of increased lime dose along with fertilizer provides higher cost involved due to lime and which gave lower MBCR. Anyway, the minimum amount of economic loss in terms of MBCR might be over looked, while overall benefits of lime in reclamation of soil acidity and nutrient availability to be considered for sustainable yield.

Table 3. Effect of fertilizer management and level of liming on the bulb yield of onion in acidic soil of Sylhet during 2020-21

Treatment	Plant height (cm)	Bulb weight (g)	Bulb diameter (cm)	Yield (t ha ⁻¹)
A. Level of liming				
L ₁ : 0 t ha ⁻¹	42.88	21.09	3.32	11.52
L ₂ : 1.0 t ha ⁻¹	46.87	27.89	3.78	12.85
L ₃ : 2.0 t ha ⁻¹	42.80	26.68	3.59	13.26
LSD (0.05)	0.45	3.57	0.21	0.84
CV (%)	0.78	8.51	4.35	5.08
B. Fertilizer management				
M ₁ : STB	46.05	25.62	3.52	13.14
M ₂ : 80% STB	44.10	26.71	3.81	12.34
M ₃ : FP	42.40	26.20	3.36	12.14
LSD (0.05)	0.01	3.57	0.17	0.43
CV (%)	09	7.97	4.77	7.13
Fertilizer management × Level of liming				
L ₁ M ₁	41.50	21.67	3.34	12.04
L ₁ M ₂	42.63	19.93	3.51	11.33
L ₁ M ₃	41.53	21.67	3.11	11.19
L ₂ M ₁	48.87	29.07	3.61	13.78
L ₂ M ₂	46.87	27.80	4.21	12.50
L ₂ M ₃	44.87	26.80	3.53	12.27
L ₃ M ₁	44.80	26.13	3.61	13.59
L ₃ M ₂	42.80	30.80	3.73	13.21
L ₃ M ₃	40.80	23.13	3.43	12.97
LSD (0.05)	0.52	5.03	0.51	1.35
CV (%)	4.40	8.11	4.67	6.71

M₁: Soil test based (STB) fertilizer recommendation, M₂: 80% of STB dose and M₃: Farmers practice (FP) and Level of limes L₁: 0 t ha⁻¹, L₂: 1 t ha⁻¹ and L₃: 2 t ha⁻¹

Table 4. Cost and return analysis of fertilizer management with levels of limes on the bulb yield of onion in Sylhet during 2020-21

Treatment	Bulb yield (t ha ⁻¹)	Gross return	Variable cost	Gross margin	Marginal gross margin	Marginal variable cost	MBCR
(Tk ha ⁻¹)							
L ₁ M ₁	12.04	301000	17713	283287	21250	3218	6.60
L ₁ M ₂	11.33	283250	14103	269147	3500	-392	-8.93
L ₁ M ₃	11.19	279750	14495	265255	0	0	0
L ₂ M ₁	13.78	344500	25713	318787	64750	11218	5.77
L ₂ M ₂	12.50	312500	22103	290397	32750	7608	4.30
L ₂ M ₃	12.27	306750	22495	284255	27000	8000	3.38
L ₃ M ₁	13.59	339750	33713	306037	60000	19218	3.12
L ₃ M ₂	13.21	330250	30103	300147	50500	15608	3.24
L ₃ M ₃	12.97	324250	30495	293755	44500	16000	2.78

Price of input and output (Tk. Kg⁻¹): Dolomite lime- CaMg (CO₃)₂-8.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Onion-25.00.

Conclusion

The application of lime (1.00 t ha^{-1}) along with STB fertilizer dose ($100-67-79-23-3-1.4 \text{ kg NPKSZn and B ha}^{-1}$) highly contributed to higher bulb yield (13.78 t ha^{-1}). However, the trial is from one year study, it will be repeated for next one or two years for final conclusion.

EFFECT OF LIME AND FERTILIZER MANAGEMENT ON YIELD OF MAIZE IN ACIDIC SOIL OF SYLHET REGION

M. I. Nazrul, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was carried out in 2020-21 at the farmer's field on an area with acidic clay loam soil at multi location testing (MLT) site, Moulvibazer. Two factors experiments viz. A) Fertilizer management, M_1 : Soil test based (STB) fertilizer recommendation M_2 : 80% of STB dose and M_3 : Farmers practice (FP) and B) Level of limes viz. L_1 : 0 t ha^{-1} , L_2 : 1 t ha^{-1} and L_3 : 2 t ha^{-1} were considered as treatments. These were tested on BARI Hybrid Maize-9. Trials were laid out in split plot design with three replications, where lime levels were allotted to main plot and level of fertilizers were distributed in the subplots. The grain yield of Maize in a total of nine treatment combinations varied significantly with different lime doses and fertilizer management practices. The highest grain yield of Maize (8.67 t ha^{-1}) was obtained from treatment combination L_3M_1 ($2.0 \text{ t lime ha}^{-1}$ and STB fertilizer dose) followed by L_3M_2 . The highest gross margin (Tk 273585 ha^{-1}) was obtained from L_2M_1 , but the maximum MBCR (20.93) was recorded in L_2M_2 , where the lime was 1.0 t ha^{-1} . Which is essential for Maize in acidic soil. Incorporation of higher lime dose and fertilizer levels increased higher cost and provided lower MBCR. So, moderate lime dose (1.0 t ha^{-1}) along with 80% of STB fertilizer might be useful for Maize cultivation in acidic soil.

Introduction

Maize (*Zea mays L.*) is an important cereal crop after rice and wheat in Bangladesh. The importance of Maize lies in its worldwide industrial applications besides serving as human food and animal feed. It is the most versatile crop with wider adaptability in varied agro-ecologies and has the highest genetic yield potential among the food grain crops. However, hybrid Maize has been introduced in our country due to its higher yield potentiality. The area and production of Maize is increasing gradually and becoming popular among farmers all over the country including Sylhet region. The Sylhet region is mostly under the AEZ-20 and the soils of this region are strongly acidic that adversely affects crop production in Sylhet. Presently, farmers in this region are using agricultural lime/dolomite in different quantities to correct the soil acidity. Results of on-farm trial with lime indicated that it had good effect on grain yield of Maize. Soil pH management through liming is a basic practice for increasing crop yield. Liming optimizes nutrient availability in soil and its utilization by plants. It also reduces availability of Al and Mn and improved microbial activity. Therefore, the experiment has been conducted to determine the optimum dose of lime and fertilizer management option for better growth and yield of Maize.

Materials and Methods

Field experiments were carried out during years of 2020-2021 at the farmer's field on an area with acidic clay loam soil at multi-location testing (MLT) site, Moulvibazer. Two factors experiments viz. A) Fertilizer management, M_1 : Soil test based (STB) fertilizer recommendation M_2 : 80% of STB dose and M_3 : Farmers practice (FP) and B) Level of limes viz. L_1 : 0 t ha^{-1} , L_2 : 1 t ha^{-1} and L_3 : 2 t ha^{-1} were considered as treatments. Trials were laid out in split plot design with three replications where lime levels were allotted to main plot and level of fertilizers were distributed in the subplots. Top soil (0-15 cm depth) was sampled in the experimental plots before applying lime and after the cultivated Maize crop was harvested. The chemical properties of the collected soils are given in Table 1. The crop with variety, plot size with spacing, date of sowing or transplant and harvest date have been shown in Table 2. Intercultural operation and crop protection measures were taken as per requirement during the

conduction of experiment. The insecticides (Darsbun 20 EC @ 2 ml/L) was sprayed on to soil to control common cutworm infestation. Irrigation, insect control and other intercultural operations were done as and when necessary. The amendments of different levels of lime were applied on 3-5 November and were incorporated into the soil by ploughing. Data on yield of Maize and farmers opinion were recorded. The collected data were analyzed statistically by using STAR package and means were separated by least significant difference (LSD) test at 5% level of significance. Cost benefit analysis were done based on the market price of the inputs and outputs.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field in MLT site, Moulvibazar

pH	OM (%)	Total N (%)	K	P	S	Zn	B
			meq/100g soil	Micro gram/g soil			
4.2-5.5	0.98	0.06	0.16	11.52	8.31	1.27	0.56
-	-	0.12	0.12	8.0	10	0.6	0.2
Strong acidity	Low	Very low	low	Low	Low	Medium	Optimum

Table 2. Fertilizers doses, plot size, spacing, date of sowing and date of harvest

Variety	Fertilizer (Kg ha ⁻¹) (N-P-K-S-Zn-B)		Plot size	Spacing (cm×cm)	Date of	
					Sowing	Harvest
BHM-9	M ₁	263-50-100-34-1.07-0.5	20 m ²	60 × 20	15-20 Nov. 2020	10-15 April, 2021
	M ₂	210-40-80-27-0.86-0.27				
	M ₃	302-58-115-39-0-0				

Results and Discussions

Effect of Lime: The effect of lime on the yield and yield component of Maize has been shown in Table 3. The highest grain yield (8.37 t ha⁻¹) was obtained with 2.0 t lime ha⁻¹, which was significantly higher over control and the moderate lime dose (1.0 t lime ha⁻¹). The second highest grain yield (7.66 ha⁻¹) of Maize was recorded with 1.0 t lime ha⁻¹, which was also significantly higher over the lime control treatment. The application of lime contributed up to 20% higher grain yield over control. This findings expressed that 2.0 t lime ha⁻¹ might be required for maximizing the grain yield of Maize.

Effect of Fertilizer Management: The balance fertilizer dose played a significant role in the yield and yield attributes of Maize (Table 3). The highest grain yield of Maize (7.92 t ha⁻¹) was found with soil test base (STB) fertilizer management (M₁), which was significantly higher over rest of the treatments. There was no significant difference between 80% of STB fertilizer dose (M₂) and farmer practice (M₃).

Interaction Effect of Lime and Fertilizer Management

The interaction between lime and fertilizer management practice was found statistically significant for grain yield and yield components of Maize (Table 3). From the interaction effect of lime and fertilizer management in revealed that yield and yield attributes gradually increased with the increasing of lime dose. The higher levels of lime produced maximum grain yield to that of non-lime treatment combinations. The treatment combination (L₃M₁) gave the highest grain yield (8.67 t ha⁻¹) which was statistically different to that of all other treatment combinations. The lowest grain yield (7.03 t ha⁻¹) was obtained from the combination of L₁M₂.

Cost and return analysis

Cost and return analysis showed that the highest gross margin (Tk 273585 ha⁻¹) was obtained from L₂M₁ (Table 4). The second highest gross margin (Tk 261405 ha⁻¹) was recorded in L₃M₁, which was closely followed by L₃M₂. However the highest MBCR (20.93) was recorded in L₂M₂ (1.0 t lime ha⁻¹ and 80% of STB fertilizer). On the contrary, incorporation of increased lime dose along with higher dose of fertilizer provide higher cost involved for lime and gives lower MBCR. Anyway the moderate and higher doses of lime along with the STB fertilizer and 80% of STB dose provided maximum MBCR (10.01 and 20.93) over control and any other treatment combinations.

Table 3. Effect of fertilizer management and levels of lime on the grain yield of Maize in acidic soil of Sylhet during 2020-21

Treatment	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	Seeds cob ⁻¹	1000 seed weight (g)	Grain yield (t ha ⁻¹)
A. Level of liming							
L ₁	174.09	18.83	14.06	164.67	342.11	328.89	6.96
L ₂	187.45	19.78	14.19	188.33	396.89	350.56	7.66
L ₃	208.08	20.28	15.54	213.89	406.11	421.11	8.37
LSD _(0.05)	1.72	0.83	0.13	9.24	40.19	2.07	0.21
CV (%)	0.55	3.21	0.62	3.74	8.07	5.35	2.08
B. Fertilizer management							
M ₁	194.77	20.28	14.88	196.56	412.78	371.67	7.92
M ₂	187.50	19.56	14.7	187.00	383.89	371.67	7.70
M ₃	180.67	19.06	14.21	183.33	345.44	357.22	7.36
LSD _(0.05)	1.70	0.55	0.12	7.49	33.96	NS	0.09
CV (%)	0.51	2.71	0.46	3.86	8.68	12.88	1.21
Fertilizer management × Level of liming							
L ₁ M ₁	173.07	19.17	14.13	168.00	375.67	338.33	7.23
L ₁ M ₂	168.39	19.00	14.03	159.33	371.00	326.67	7.03
L ₁ M ₃	160.82	18.33	14.00	166.67	279.67	321.67	6.60
L ₂ M ₁	194.90	20.50	14.50	201.67	421.67	348.33	7.87
L ₂ M ₂	186.85	19.67	14.07	186.67	386.00	356.67	7.67
L ₂ M ₃	180.59	19.17	14.00	176.67	374.00	346.67	7.43
L ₃ M ₁	216.35	21.17	16.00	220.00	441.00	428.33	8.67
L ₃ M ₂	207.28	20.00	16.00	215.00	394.67	431.67	8.40
L ₃ M ₃	200.61	19.67	14.63	206.67	382.67	403.33	8.03
LSD _(0.05)	2.84	1.62	0.21	21.01	94.37	58.26	0.33
CV (%)	0.52	2.84	0.50	3.83	8.53	5.47	1.47

M₁: Soil test based (STB) fertilizer recommendation, M₂: 80% of STB dose and M₃: Farmers practice (FP) and Level of limes L₁: 0 t ha⁻¹, L₂: 1 t ha⁻¹ and L₃: 2 t ha⁻¹

Table 4. Cost and return analysis of fertilizer management with levels of lime on the grain yield of Maize in Sylhet during 2020-21

Treatment	Grain yield (t ha ⁻¹)	Gross return	Variable cost	Gross margin	Marginal gross margin	Marginal variable cost	MBCR
		(Tk ha ⁻¹)					
L ₁ M ₁	12.04	264880	21575	243305	18700	-2308	-8.10
L ₁ M ₂	11.33	249260	17260	232000	3080	-6623	-0.47
L ₁ M ₃	11.19	246180	23883	222297	0	0	0
L ₂ M ₁	13.78	303160	29575	273585	56980	5692	10.01
L ₂ M ₂	12.50	275000	25260	249740	28820	1377	20.93
L ₂ M ₃	12.27	269940	31883	238057	23760	8000	2.97
L ₃ M ₁	13.59	298980	37575	261405	52800	13692	3.86
L ₃ M ₂	13.21	290620	33260	257360	44440	9377	4.74
L ₃ M ₃	12.97	285340	39883	245457	39160	16000	2.45

Price of input and output (Tk. Kg⁻¹): Dolomite lime-CaMg(CO₃)₂-8.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Maize-22.00.

Conclusion

Moderate lime dose (1.0 t ha⁻¹) along with 80% of STB fertilizer (210-40-80-27-0.86-0.27 kg NPKSZn and B ha⁻¹) might be recommended for maize cultivation in acidic soil. This is first year results. The trial will be repeated for next one or two years.

EFFECT OF ZINC AND BORON ON CHILLI PRODUCTION IN CHAR AREAS OF GAIBANDHA

Md. Jahangir Alam, Abdullah Al Mahmud, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted in the farmers' field at Chinirpotol char, Saghata, Gaibandha during the rabi season of 2019-20 and 2020-21 to find out the suitable fertilizer dose for chilli cultivation in char areas. The experiment comprised with five treatments T_1 : Soil Test Based (FRG' 2018), T_2 : $T_1 + Zn_1B_1$ kg ha⁻¹, T_3 : $T_1 + Zn_2B_{1.5}$ kg ha⁻¹, T_4 : $T_1 + Zn_3B_2$ kg ha⁻¹ and T_5 : Farmers practice (average of 10 farmers'). Among the treatment combinations the highest green chilli yield 12.47 t ha⁻¹ (12.43 t ha⁻¹ in 2019-20 and 12.50 t ha⁻¹ in 2020-21) and gross return (aver. Tk 373950 ha⁻¹), gross margin (av Tk 243847 ha⁻¹) was obtained from T_3 treatment with BARI Morich-3, similar to the T_4 treatment. The lowest green chilli yield 7.98 t ha⁻¹ in 2019-20 and 8.10 t ha⁻¹ in 2020-21 with an average of 8.04 t ha⁻¹, having the lowest gross return (av Tk 241200 ha⁻¹), gross margin (Tk 112208 ha⁻¹) was recorded from farmers' practices (T_5) treatment. The highest marginal benefit cost ratio (MBCR) was also recorded in the same T_3 treatment (119.5), more compared to the other treatment combinations.

Introduction

Chilli (*Capsicum frutescens*) is one of the major spices crop grown in char areas of Gaibandha. About 709 metric ton chilli is being produced from an area of 495 ha of land in Gaibandha, Bangladesh (BBS 2019). Chilli is an important cash crop in char areas of Gaibandha. It is also a good source of vitamin-C and other nutrients, used as a very important spice in our diet. Chilli is used both in fresh and in dry condition. Recently, it is widely using as dust form, marketed by different companies. Currently, In Gaibandha, about 1715 ha of land is cultivated under chill production in winter season and produces 2744 metric ton with an average yield of 1.60 t ha⁻¹ (Personal communication, DAE, Gaibandha). Farmers in char areas are growing chillies following indigenous methods (more seed, broadcasting, imbalanced fertilizer) with the poor yield rate. The reasons behind such low yield due to lack of proper fertilizer management. They also applied more fertilizers than its recommended dose for getting more yield which are not economically viable and reduce their benefit cost ratio. Spices Research Centre of BARI has developed some improved varieties of chilli which are supposed to be higher yielder and less susceptible to pest and diseases and also developed their recommended fertilizer dose. But in the Char areas of Gaibandha, there has no specific fertilizer recommendation for chill cultivation. Hence, the present study was undertaken to find out the suitable fertilizer dose for maximizing the yield and economic return of chilli in the charland farmers.

Materials and Methods

The experiment was conducted during 2019-20 and 2020-21 at farmers' field of Chinirpotol char in Saghata, Gaibandha under the AEZ-7 (Active Brahmaputra-Jamuna Floodplain) by the supervision of On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute, Gaibandha. The experiment was laid out in randomized complete block design with three dispersed replications. The unit plot size was 6m × 6m. The line to line spacing was 50 cm with plant to plant spacing 50 cm. The treatments comprised with five fertilizer doses viz., T_1 : Soil Test Based (FRG' 2018), T_2 : $T_1 + Zn_1B_1$ kg ha⁻¹, T_3 : $T_1 + Zn_2B_{1.5}$ kg ha⁻¹, T_4 : $T_1 + Zn_3B_2$ kg ha⁻¹ and T_5 : Farmers practice (110-30-45-10 kg NPKS ha⁻¹) (average of 10 farmers'). The tested chilli variety was BARI Morich-3. The calculated STB fertilizers dose for all treatments were 107-33-51-8 kg NPKS ha⁻¹. The fertilizers were calculated as per initial soil test basis (Table 1). Full dose of P, S, Zn, and 1/4th of K were applied during final land preparation. The remaining 3/4th K and full dose of N were divided into 3 equal split and applied 25, 50, and 75 days after transplanting (DAT). The seeds were sown on 20 to 25 November each of the year and transplanted after one month into the main field. Weeding and all other intercultural operations were done as and when necessary with four irrigations. Harvesting of green chilli commenced from 10 April and continued up to 30 May in every year. Data were analyzed by ANOVA (using CROPSTAT 7.2) to evaluate differences between treatments, and the means were separated using significant difference (LSD) at the 5% level of significance (p<0.05).

Table 1. Initial soil status of Chinirpotol char at Saghata, Gaibandha

Item	pH	OM (%)	Total N (%)	K	P	S	Zn	B
				meq/100 g				
Value	6.5	0.78	0.05	0.12	9.60	14.9	0.23	0.24
Critical level	-	-	0.12	0.12	7.0	10.0	0.6	0.2
Interpretation	Slightly acidic	VL	VL	L	L	M	VL	L

VL=Very low, L=Low, M=Medium

Results and Discussions

Effect of fertilizer on yield and yield attributes of chilli

Yield and yield attributes of chilli were found significantly influenced by the fertilizer treatments (Table 2 and Table 3). In 2019-20, the significant highest chilli plant⁻¹ (120), fruit weight plant⁻¹ (190 g), fruit length (9.40 cm), individual chilli weight (2.50 g) were observed in T₃ treatment which ultimately resulted the highest green chilli yield (12.43 t ha⁻¹) that was statistically similar to T₄ treatment (11.67 t ha⁻¹). On the contrary, the lowest chilli plant⁻¹ (78), fruit weight plant⁻¹ (132 g), fruit length (7.40 cm), individual chilli weight (1.53 g) was observed in farmers' practice (T₅), contributed the lowest crop yield (7.98 t ha⁻¹) (Table 2). Similarly, in 2020-21 the highest chilli plant⁻¹ (122), fruit weight plant⁻¹ (192 g), fruit length (9.50 cm), individual chilli weight (2.97g) were observed in T₃ treatment, resulted the highest green chilli yield (12.50 t ha⁻¹) which was statistically similar to T₄ treatment (11.90 t ha⁻¹). The lowest chilli plant⁻¹ (77), fruit weight plant⁻¹ (130 g), fruit length (7.47 cm), individual chilli weight (2.07 g) was observed in farmers' practice (T₅), contributed the lowest green chilli yield (8.10 t ha⁻¹) (Table 3). The reason of the highest green chilli yield in T₃ treatment (Zn₂B_{1.5}) mainly due to the application of proper zinc and boron fertilizer doses with others that contributed the more number of fruits plant⁻¹, fruit weight plant⁻¹ and individual fruit weight of chilli.

Disease incidence

Some anthracnose disease was occurred in the experimental field that could be easily controlled by the spraying of carbendazim (autostin 50 WDG) @ 1 g/L water at 10-12 days interval.

Cost and return analysis (average of 2 years)

The highest gross return (Tk 373950 ha⁻¹) and gross margin (Tk 243847 ha⁻¹) was observed from T₃ treatment (Zn₂B_{1.5} kg ha⁻¹) with STB doses of other fertilizers and the lowest gross return (Tk 241200 ha⁻¹) and gross margin (Tk 112208 ha⁻¹) in farmers' practice (T₅ treatment) (Table 4). The highest gross return as well as gross margin observed from the T₃ treatment due to the significant highest green chilli yield as well as good market price.

Farmers' opinion

Farmers are interested in cultivating BARI Morich-3 applying soil test based fertilizer dose with Zn₂B_{1.5} kg ha⁻¹ for higher yield and benefit.

Table 2. Effect of different fertilizer doses on the yield and yield attributes of chilli at Chinirpotol char, Saghata, Gaibandha during the rabi season of 2019-20

Treatments	Plant ht (cm)	Fruit plant ⁻¹ (no)	Fruit plant ⁻¹ (g)	Length (cm)	Individual fruit wt (g)	Green chilli yield (t ha ⁻¹)
T ₁ : STB (FRG' 2018)	73.13	102	178	8.60	2.03	8.97
T ₂ : T ₁ + Zn ₁ B ₁ kg ha ⁻¹	74.17	110	181	8.77	2.17	10.50
T ₃ : T ₁ + Zn ₂ B _{1.5} kg ha ⁻¹	80.07	120	190	9.40	2.50	12.43
T ₄ : T ₁ + Zn ₃ B ₂ kg ha ⁻¹	77.83	115	185	9.07	2.27	11.67
T ₅ : Farmers practice	65.27	78	132	7.40	1.53	7.98
LSD _(0.05)	5.37	21.6	17.8	0.77	0.41	0.81
CV (%)	2.70	7.35	5.9	5.70	3.73	4.90

STB dose for all treatments N-P-K-S @ 107-33-51-8 kg ha⁻¹, FP= N-P-K-S @ 110-30-45-10 kg ha⁻¹, FP= av of 10 farmers

Table 3. Effect of different fertilizer doses on the yield and yield attributes of chilli at Chinirpotol char, Saghata, Gaibandha during the rabi season of 2020-21

Treatment	Plant ht (cm)	Fruit plant ⁻¹ (no)	Fruit plant ⁻¹ (g)	Length (cm)	Ind fruit wt (g)	Green chilli yield (t ha ⁻¹)
T ₁ : STB (FRG' 2018)	71.83	103	180.3	8.83	2.55	9.00
T ₂ : T ₁ + Zn ₁ B ₁ kg ha ⁻¹	73.27	112	182.7	8.97	2.70	10.60
T ₃ : T ₁ + Zn ₂ B _{1.5} kg ha ⁻¹	79.63	122	192.0	9.50	2.97	12.50
T ₄ : T ₁ + Zn ₃ B ₂ kg ha ⁻¹	77.60	116	185.7	9.20	2.78	11.90
T ₅ : Farmers practice	65.10	77	130.0	7.47	2.07	8.10
LSD _(0.05)	4.16	15.69	17.98	0.88	0.30	0.77
CV (%)	3.50	8.12	4.83	4.95	2.81	6.82

STB dose for all treatments N-P-K-S @ 107-33-51-8 kg ha⁻¹, FP= N-P-K-S @ 110-30-45-10 kg ha⁻¹

Table 4. Cost and return analysis of chilli as influenced by different fertilizer dose (average of 2 years)

Item	Green chilli yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	MBCR
T ₁ : STB (FRG' 2018)	8.99	269550	129403	140147	69.0
T ₂ : T ₁ + Zn ₁ B ₁ kg ha ⁻¹	10.55	316500	129803	186697	92.8
T ₃ : T ₁ + Zn ₂ B _{1.5} kg ha ⁻¹	12.47	373950	130103	243847	119.5
T ₄ : T ₁ + Zn ₃ B ₂ kg ha ⁻¹	11.79	353550	130403	223147	79.6
T ₅ : Farmers practice	8.04	241200	128992	112208	-

Green chilli price (Tk. kg⁻¹): 30

Conclusion

From the two-year results, it may be recommended that the application of Zn₂B_{1.5} kg ha⁻¹ (T₃ treatment) with other fertilizers on STB based (107-33-51-8 kg ha⁻¹) gave the highest chilli yield as well as more profitable for chilli production in the char areas of Saghata, Gaibandha.

DETERMINATION OF SUITABLE ZINC FERTILIZER DOSE FOR MAIZE PRODUCTION IN CHAR AREAS OF GAIBANDHA

Md. Jahangir Alam, Abdullah Al Mahmud, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at Chinirpotol char of Saghata, Gaibandha under the supervision of OFRD, Gaibandha during the rabi season of 2019-20 and 2020-21 to determine the suitable dose of zinc fertilizer for better yield of Maize in char areas. The experiment was laid out in a randomized complete block design with six dispersed replications. Five zinc fertilizer doses i.e. T₁ = Zn₀ kg ha⁻¹, T₂ = Zn₂ kg ha⁻¹, T₃ = Zn₄ kg ha⁻¹, T₄ = Zn₆ kg ha⁻¹ and T₅ = Zn₈ kg ha⁻¹ were tested on hybrid Maize variety (BHM-9). Other fertilizers were used as soil test based (STB). The significant highest grain yield 10.30 t ha⁻¹ in 2019-20 and 10.50 t ha⁻¹ in 2020-21 with an average of 10.40 t ha⁻¹ was recorded in T₄ treatment where 6 kg Zn ha⁻¹ was applied, similar to T₅ (Zn₈ kg ha⁻¹) treatment and the lowest yield recorded in T₁ treatment with an average of 5.56 t ha⁻¹ (5.50 t ha⁻¹ in 2019-20 and 5.63 t ha⁻¹ in 2020-21). Similar trends were also observed in all the yield contributing characters. The highest gross return (Tk. 208000 ha⁻¹), gross margin (Tk 115036 ha⁻¹) was observed in the same T₄ treatment (Zn₆ kg ha⁻¹) due to highest Maize yield and the lowest gross return (Tk 111267 ha⁻¹) and gross margin (Tk 19143 ha⁻¹) in control (T₁) treatment. Although, the highest marginal benefit cost ratio (MBCR) was also recorded in the same T₃ treatment (121.2), more compared to the other treatment combinations.

Introduction

Char is usually developed by siltation in the river. After flooding, many chars developed in the river, are mostly sandy to sandy loam soil type. In char land, zinc status is extremely low among the seven micronutrients. Zinc is an element used by crops in small quantities (usually less than 0.5 pounds per acre) yet is essential to normal plant growth and development. Zinc has several important functions in

plants, including major roles in enzyme reactions, photosynthesis, DNA transcription and auxin activity. Zinc is enough in most soils to supply crop needs, but may be deficient in sandy soils, other low-organic soils (e.g., those with topsoil removed by erosion), or soils with high pH. Zinc is the one most often deficient in Maize production and most likely to elicit a yield response when applied as fertilizer. However, yield responses are only attainable when zinc is deficient and therefore limiting yield. Poor zinc status in soil hampers the proper plant growth which ultimately resulted low yield in Maize. Maize (*Zea mays*) is second most important cereal crops in our country depending on area and production after rice and it gains popularity for higher yield potentiality as well as diversified uses. Now a days, hybrid Maize becomes popular in some char areas as monoculture during *rabi* season (November to April) due to its diversified uses and higher productivity. The area of Maize has increased by double and production by three folds more in the last decades. Currently, about 101434 metric ton of winter Maize is being produced from an area of 12747 ha of land in Gaibandha (BBS, 2019), most of them produced from the char areas. As the soil zinc status is incredibly low and not appropriate the recommendation in this region. Keeping this view in mind the experiment was designed to find out the suitable zinc fertilizer dose for Maize in char areas of Gaibandha.

Materials and Methods

The field study was carried out at Chinirpotol char of Saghata, under OFRD, Gaibandha during the *rabi* season of 2019-20 and 2020-21. The experiment comprised of five treatments i.e. $T_1 = Zn_0 \text{ kg ha}^{-1}$, $T_2 = Zn_2 \text{ kg ha}^{-1}$, $T_3 = Zn_4 \text{ kg ha}^{-1}$, $T_4 = Zn_6 \text{ kg ha}^{-1}$ and $T_5 = Zn_8 \text{ kg ha}^{-1}$. The experiment was laid out in randomized complete block design with six dispersed replications. BARI Hybrid Maize-9 was used in the study. The unit plot size was 36 m^2 . The seeds of Maize were sown on 20-23 November in each of the growing years. Initial soil was collected and analyzed (Table 1). Soil test-based fertilizer dose was used @ 250-48-80-28-1 kg, N-P-K-S-B ha^{-1} , respectively. One third of N and all of P, K, S, Zn and B were applied during final land preparation. Remaining N was applied in two equal splits as top dressing in maize at 8-10 leaf stage (30-35 DAS) and at tasseling stage (60-65 DAS), and mixed thoroughly with the soil as soon as possible for better utilization. Irrigation was applied as and when necessary. One weeding was done at 30-35 DAS to keep the plot weed free. The crop was harvested between 20-25 April each year. Data were analyzed by ANOVA (using CROPSTAT 7.2) to evaluate differences between treatments, and the means were separated using significant difference (LSD) at the 5% level of significance ($p < 0.05$).

Table 1. Initial soil status of Chinirpotol char at Saghata, Gaibandha

Item	pH	OM (%)	Total N (%)	K	P	S	Zn	B
				meq/100 g	$\mu\text{g/g soil}$			
Value	6.5	0.78	0.05	0.12	9.60	14.9	0.23	0.24
Critical level	-	-	0.12	0.12	7.0	10.0	0.6	0.2
Interpretation	Slightly acidic	VL	VL	L	L	M	VL	L

*VL=Very low, L=Low, M=Medium

Results and Discussions

Yield and yield contributing characters of maize were differed significantly among the treatments (Table 2 and 3) in both the crop year. In 2019-20, the significant highest plant height (228.57 cm), cob length (19.37 cm) and breadth (8.75 cm), grain number per cob (558) and 100 grain weight (34.24 g) were observed when 6 kg Zn ha^{-1} applied (T_4). The highest grain yield (10.30 t ha^{-1}) was also obtained from the same (T_5) treatment mainly due to the proper zinc fertilization in soil which promote better seed formation as well as more filled grain per cob, similar to the treatment T_5 ($Zn_8 \text{ kg ha}^{-1}$) with a yield of 9.80 t ha^{-1} . The lowest yield was recorded in the T_1 treatment (5.50 t ha^{-1}) where no zinc fertilizer was applied. Similar trend was observed in the second year. In 2020-21, the significant highest plant height (230.03 cm), no. of cob plant⁻¹ (2.67), cob length (19.50 cm) and breadth (8.80 cm), grain cob⁻¹ (560) and 100 grain weight (34.40 g) and grain yield (10.50 t ha^{-1}) were observed in T_4 treatment (6 kg Zn ha^{-1}), statistically like the T_5 treatment ($Zn_8 \text{ kg ha}^{-1}$). The lowest yield (5.63 t ha^{-1}) was recorded in the T_1 ($Zn_0 \text{ kg ha}^{-1}$) treatment due to the lowest no. of cob plant⁻¹ (1.00), cob length (13.03 cm), cob breadth (7.45 cm) and 100-grain weight (30.70 g).

Cost and return analysis (average of 2 years)

The highest gross return (Tk. 208000 ha⁻¹) was obtained from T₄ treatment (6 kg Zn ha⁻¹), next to the T₅ (Zn8 kg ha⁻¹) treatment and the lowest gross return (Tk 111267 ha⁻¹) in the T₁ (Zn₀ kg ha⁻¹) treatment presented in table 4. Finally, the gross margin was also higher (Tk. 115036 ha⁻¹) in the same (T₄) treatment, where it was lower in T₁ treatment (Tk 19143 ha⁻¹). The highest gross return and gross margin in T₄ treatment mainly due to the highest grain yield of Maize (10.40 t ha⁻¹) and received more market price (20 Tk kg⁻¹) with negligible higher variable cost.

Pest incidence: Initially few seedlings were damaged by cutworm and was controlled by Dursban application @ 5 ml L⁻¹ of water. Some fall army worm infestation was observed in vegetative stage that could be controlled by fall army-lure (Ispahani Agro Ltd.) with two spray of spinosad (Success 2.5 S.C.) @ 1.3 ml/L of water.

Farmers' opinion

Farmers in the char areas are not well known about soil test based fertilizer management and judicious fertilizer use of fertilizer. Farmers are happy to get more maize yield and economic return. They influenced to practice the best fertilizer combination in future for Maize production.

Table 2. Yield and yield contributing characters of maize as influenced by different doses of zinc fertilizer at Chinirpotol char, Saghata, Gaibandha during 2019-20

Treatment	Plant ht (cm)	Cob plant ⁻¹ (no)	Cob length (cm)	Cob breadth (cm)	Grain cob ⁻¹ (no)	100-grain wt (g)	Grain yield (t ha ⁻¹)
Zn ₀ kg ha ⁻¹	192.53	1.33	13.13	7.48	380	30.93	5.50
Zn ₂ kg ha ⁻¹	206.33	1.67	16.73	7.90	408	31.48	7.22
Zn ₄ kg ha ⁻¹	216.07	2.00	17.63	8.15	450	32.45	8.38
Zn ₆ kg ha ⁻¹	228.57	2.67	19.37	8.75	558	34.24	10.30
Zn ₈ kg ha ⁻¹	221.17	2.33	19.23	8.50	552	33.38	9.80
LSD _{0.05}	12.1	NS	1.81	0.57	49.5	0.49	0.95
CV (%)	5.31	2.12	3.89	7.89	6.45	7.15	6.26

Table 3. Yield and yield contributing characters of maize as affected by different fertilizer management at Chinirpotol char, Saghata, Gaibandha during 2020-21

Treatment	Plant ht (cm)	Cob plant ⁻¹ (no)	Cob length (cm)	Cob breadth (cm)	Grain cob ⁻¹ (no)	100-grain wt (g)	Grain yield (t ha ⁻¹)
Zn ₀ kg ha ⁻¹	194.33	1.00	13.03	7.45	377	30.70	5.63
Zn ₂ kg ha ⁻¹	207.77	1.33	16.80	7.95	410	31.53	7.30
Zn ₄ kg ha ⁻¹	217.13	2.00	17.73	8.18	453	32.57	8.43
Zn ₆ kg ha ⁻¹	230.03	2.67	19.50	8.80	560	34.40	10.50
Zn ₈ kg ha ⁻¹	221.77	2.33	19.47	8.65	555	33.90	9.95
LSD _{0.05}	12.5	0.91	41.3	1.85	0.62	0.82	0.95
CV (%)	7.22	3.11	4.12	5.1	5.89	6.73	8.11

Table 4. Cost and return analysis of maize as influenced by different fertilizer dose (average of 2 years)

Treatment	Maize yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	MBCR
Zn ₀ kg ha ⁻¹	5.56	111267	92124	19143	-
Zn ₂ kg ha ⁻¹	7.26	145200	92404	52796	121.2
Zn ₄ kg ha ⁻¹	8.41	168133	92684	75449	101.5
Zn ₆ kg ha ⁻¹	10.40	208000	92964	115036	115.2
Zn ₈ kg ha ⁻¹	9.87	197467	93164	104303	82.9

Maize price (Tk. kg⁻¹): 20.0

Conclusion

From the two-year results, it may be recommended that the application of STB fertilizer (250-48-80-28-1 kg NPKS and B ha⁻¹) with Zn₆ kg ha⁻¹ in char areas of Gaibandha gave the highest yield and economic return.

PERFORMANCE OF WATER HYACINTH RESIDUE FOR CAULIFLOWER PRODUCTION AT AEZ-14

Abstract

The experiment was conducted at FSRD site, Gopalganj and Nazirpur, Pirojpur during rabi season 2020-21 to determine the amount of residue of water hyacinth as an organic source for production of cauliflower. There are four doses of different organic fertilizer viz. T_1 = 5 ton cow dung ha^{-1} (control) T_2 = 5 ton water hyacinth residue ha^{-1} , T_3 = 8 ton water hyacinth residue ha^{-1} , T_4 = 11 ton water hyacinth residue ha^{-1} as treatment. Result revealed that treatment T_1 gave the highest yield (44.30 t ha^{-1}) where 5 t cow dung ha^{-1} as organic fertilizer was used and its statistically similar yield (42.89 t ha^{-1}) was found by T_4 treatment where residue of water hyacinth was used @ 11 t ha^{-1} with recommended chemical fertilizer. The lowest yield (33.64 t ha^{-1}) was observed in T_2 treatment where 5 t ha^{-1} residue of water hyacinth was applied.

Introduction

Farmers use fertilizer irrationally that hamper soil health. Judicial use of fertilizer is necessary for conserving soil health but it is very difficult to maintain for deficit of organic manure like cow dung. But the residue of water hyacinth is more available in Gopalganj region which can be used as alternate source of cow dung. Water hyacinth residue is the decomposed of water hyacinth. Already, farmers of this region use this residue as alternate source of organic manure for vegetable production. But till to now they have no idea actually how much residue need for a unit land area for vegetable production. Thus, the present study was taken to determine suitable amount of water hyacinth residue for vegetable production.

Materials and Methods

The experiment was conducted at Farming System Research and Development site, Gopalganj and Nazirpur, Pirojpur during *rabi* season 2020-21 to determine the amount of residue of water hyacinth as an organic source for production of cauliflower. The experiment was laid out in randomized complete block design with four replications allocating three dose of water hyacinth residue with 5 ton cow dung (control) per hectare viz. T_1 = RFD (Recommended dose of chemical fertilizers) + 5 ton cow dung ha^{-1} (control), T_2 = RFD + 5 t water hyacinth residue ha^{-1} , T_3 = RFD + 8 t water hyacinth residue ha^{-1} , T_4 = RFD + 11 t water hyacinth residue ha^{-1} . The unit plot size was 4 m $\times$ 4 m. The land was fertilized with organic fertilizer (as per treatment) and 70-30-60-20-2.5-2 kg NPKSZnB ha^{-1} in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid. Seedling were transplanting at 03 and 04 November 2020 with 60cm $\times$ 40cm spacing. Half urea and all other fertilizer were applied as basal and remaining Urea was top dressed at 15, 30 and 45 days after transplanting. All the intercultural operations were done as and when necessary. The crop was harvested at 05-16 February, 2021. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Results and Discussions

A significant variation was found in different dose of organic fertilizer (Table 1). The highest plant height (49.43 cm) was found from this plot where use 5 t cow dung ha^{-1} (T_1) as organic fertilizer and its statistically similar height (48.20 cm) was recorded by T_4 treatment where residue of water hyacinth was used 11 t ha^{-1} as an organic fertilizer with recommended chemical fertilizer. The lowest plant height (40.03 cm) was from treatment T_2 where 5 t residue of water hyacinth ha^{-1} was applied. Curd length, curd diameter and single curd weight was found highest from the same treatment (T_1) which was 13.52cm, 19.5 cm and 1.49 kg, respectively and its statistically similar length, diameter and single curd weight were recorded from T_4 that were 12.98 cm, 18.04 cm and 1.44 kg, respectively. The lowest curd length, diameter and single curd weight were found from T_2 treatment which were 9.44 cm, 14.08 cm and 1.14 kg, respectively. Finally, the treatment T_1 gave the highest yield (44.30 t ha^{-1}) which gave highest plant height, curd length, curd diameter and single curd weight. Also, the yield of treatment T_4 (42.89 t ha^{-1}) was statistically similar of T_1 and the lowest yield (33.64 t ha^{-1}) was recorded from T_2 which showed lowest performance in case of others yield contributing characters.

Table 1. Effect of different doses of water hyacinth residue on yield and yield contribution characters of cauliflower at Gopalganj region during *rabi* season in 2020-21

Treatment	Plant height (cm)	Curd length (cm)	Curd diameter (cm)	Single curd wt (kg)	Yield (t ha ⁻¹)
RFD+ 5 t Cow dung ha ⁻¹	49.43	13.52	19.5	1.49	44.30
RFD+ 5 t water hyacinth residue ha ⁻¹	40.03	9.44	14.08	1.14	33.64
RFD+ 8 t water hyacinth residue ha ⁻¹	43.37	10.44	16.68	1.25	37.97
RFD+ 11 t water hyacinth residue ha ⁻¹	48.20	12.98	18.04	1.44	42.89
LSD _(0.05)	4.35	1.94	4.082	0.154	4.43
CV (%)	4.76	6.25	11.97	5.93	5.59

Conclusion

From the study it was revealed that 11 ton water hyacinth residue ha⁻¹ is the best for cauliflower production as an alternate source of 5 ton cow dung ha⁻¹. It was the first year results, for confirmation the result the trails will be repeated in next year.

A. Cropping Patterns

DEVELOPMENT OF FOUR CROP BASED CROPPING PATTERN MUSTARD-BORO/JUTE- T. AMAN AGAINST MUSTARD-BORO-T. AMAN

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Abstract

An on-farm trial has been conducted at MLT site, Satkhira under AEZ-13 to increase cropping intensity and productivity through a four crop-based cropping pattern against farmer's existing practice of Mustard-Boro-T. Aman. The four crop-based cropping pattern was Mustard- Boro/Jute-T. Aman and variety of each crop were BARI Sarisha-14, BRRI dhan28, NSC and GRO-524, and Binadhan-7, respectively. Jute was relayed into Boro rice for the accommodation of an extra crop in the pattern. It was observed that four crop patterns produced the highest rice equivalent yield (REY) (33.77, 37.74, and 42.78 t ha⁻¹) than farmer's practice (15.24, 18.00, and 20.31 t ha⁻¹) during 2019-20. Likewise, production efficiency was also higher in four crop patterns (95.12, 104.60, and 117.84 kg ha⁻¹day⁻¹) than farmer's practice (55.40, 74.70, 108.47 kg ha⁻¹day⁻¹). Cost-benefit analysis over three years showed that the four-crop pattern gave the highest gross return (Tk. 753243 ha⁻¹) and gross margin (Tk. 562180 ha⁻¹). The marginal benefit-cost ratio of the four crop patterns over the existing pattern was 4.08, which indicates four crops are a profitable one. However, there are challenges in the timely establishment of crops due to variability in the weather pattern, seed availability, sources of irrigation water, shortage of laborers, credit facilities, farm machinery etc.

Introduction

With the increasing population pressure, there is no other way to increase food production vertically. Hence, to fulfill Sustainable Development Goal (SDG)-2 Bangladesh Agricultural Research Institute (BARI) is committed to develop technologies for increasing cropping intensity. By keeping the goal in mind, BARI is trying to convert mono cropland into double-crop land, likewise, double-crop to triple crop and triple crop to four cropland. The major crop cropping patterns in Satkhira are Boro-Fallow-T. Aman (70,500 ha, 51.49%), Boro-Aus-T. Aman (6250 ha, 4.56%), Fallow-Fallow-T. Aman (20,500 ha, 14.97%), Mustard-Jute-T. Aman (4000 ha, 2.92%), Mustard-Boro-Jute (1900 ha, 1.39%), and Mustard-Boro-T. Aman (1500 ha, 1.10%) (DAE, Satkhira, 2021). Mustard is usually harvested in Satkhira at end of January to Mid February. So, if Boro is cultivated then there is limited scope for jute or Aus crop. In the present study, relayed jute with Boro as an extra crop can be incorporated into Mustard-Jute-T. Aman pattern. So, the trial was conducted to improve the existing cropping patterns and thereby increasing cropping intensity and economic return.

Materials and Methods

An On-farm trial of four-crop-based crop sequence was conducted at farmers' field of Multi-Location Testing Site (MLTs), Satkhira. The four-crop sequence- Mustard-Boro/Jute-T. Aman has been introduced against farmers' existing sequence of Mustard- Jute-T. Aman to increase cropping intensity and productivity. The trial started from mustard in 2017-'18 and continuing through 2019-'20, involving five co-operative farmers having a unit plot size of 33 decimal land per farmer. All agronomic activities including sowing/transplanting, harvesting, fertilizer, irrigation, weeding etc. were followed according to standard methods (Azad et al., 2017). Recommended fertilizer package (BARC, 2018) along with prescribed application methods were followed for all the crops. Pest management and other intercultural management practices were done as and when necessary. For economic comparison, the yield of all crops was converted into price equivalent yield of Boro rice based on the prevailing market price of individual crops (Ahlawat and Sharma, 1993).

Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of the individual (component) crop yield of each cropping cycle. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Results and Discussion

Agronomic management, field duration, and turnover time: Similar agronomic management practices were followed in both farmer's practices and four crop-based practices. However, the only difference in the four crop-based pattern is the inclusion of jute as a relay crop with Boro rice. Short duration and high yielding varieties were cultivated to accommodate in a cropping cycle, viz. mustard (var. BARI Sarisha-14), Boro rice (var. BRRI dhan28), Jute (NSC and GRO-524), and T. Aman (var. Binadhan-7).

In 2017-18, in existing pattern field duration of mustard-Boro-T. Aman was 84, 109, and 83 days respectively (276 days), and turn over period between mustard and Boro rice was 4 days and between Boro rice and Aman rice was 85 days. On the other hand, in the improved Mustard-Boro/Jute- T. Aman four-crop pattern, field durations were 87, 109, 119, and 80 days, respectively. Due to relay jute there were 40 days saved hence total field duration was 355 days. The turn-over period between Mustard-Boro, Boro-Jute (relay), Jute-T. Aman was 6, 40, and 18 days respectively (Table 2).

In 2018-19, in existing pattern field duration of Mustard-Boro-T. Aman was 82, 106, and 83 days, respectively (271 days), and turn over period between T. Aman and mustard was 4 days, between Mustard and Boro rice was 6 days and between Boro and T. Aman rice was 87 days. On the other hand, in the improved Mustard-Boro/Jute- T. Aman four-crop pattern, field duration was 85, 82, 121, and 83 days, respectively. Due to relay jute there were 11 days saved hence total field duration was 360 days. The turn-over period between T. Aman of 2017-18 and Mustard, between Mustard-Boro, Boro-Jute (relay), Jute-T. Aman was 8, 4, 11, and 4 days respectively (Table 3).

In 2019-'20, the field duration of Mustard, Boro, Jute, and T. Aman in four crop pattern were 81, 93, 122, and 90 days respectively. Jute was relayed inside Boro rice 23 days before harvest. In the existing pattern field duration of mustard, Boro and T. Aman were 71, 110, and 90 days, respectively. The turn-over period between T. Aman of 2019-20 and Mustard, between Mustard-Boro, Boro-Jute (relay), Jute-T. Aman was 3, 3, 23, and 2 days respectively (Table 4).

Grain and by-product yield, rice equivalent yield (REY), production efficiency (PE), and land-use efficiency (LUE): Both in existing and four-crop pattern rice equivalent yield of Mustard, Boro, Jute and T. Aman were calculated based on their respective grain/fiber and by-product yield. In 2017-18, in the existing pattern REY of Mustard, Boro and T. Aman were 3.56, 6.17, and 5.51 t ha⁻¹, respectively. The total REY, PE, and LUE in the existing cropping pattern was 15.24 t ha⁻¹, 55.40 kg ha⁻¹ day⁻¹ (276 days), and 75.62%, respectively. Then again, in the four-crop pattern REY of Mustard, Boro, Jute and T. Aman were 4.95, 6.11, 17.36, and 5.71 t ha⁻¹, respectively. Where the total REY of the whole pattern, PE, and LUE was 33.77 t ha⁻¹, 95.12 kg ha⁻¹ day⁻¹ (355 days), and 97.26%, respectively (Table 5).

In 2018-19, in the existing pattern REY of Mustard, Boro, and T. Aman were 5.67, 6.53, and 5.80 t ha⁻¹, respectively. The total REY, PE, and LUE in the existing cropping pattern were 18.00 t ha⁻¹, 74.70 kg ha⁻¹ day⁻¹ (241 days), and 74.25%, respectively. On the other hand, in the four-crop pattern, REY of Mustard, Boro, Jute and T. Aman were 5.24, 6.83, 20.11, and 5.56 t ha⁻¹, respectively. The total REY of the whole pattern, PE, and LUE were 37.74 t ha⁻¹, 104.6 kg ha⁻¹ day⁻¹ (361 days), and 98.85%, respectively (Table 6).

Again, in 2019-20, in the existing pattern REY of Mustard, Boro, and T. Aman were 6.84, 7.21, and 6.27 t ha⁻¹, respectively. The REY, PE, and LUE were 20.31 t ha⁻¹, 108.47 kg ha⁻¹ day⁻¹ (271 days), and 74.25%, respectively. Alternatively, in the four-crop pattern REY of Mustard, Boro, Jute and T. Aman were 5.91, 6.94, 23.74, and 6.19 t ha⁻¹, respectively. The total REY of the four crop pattern, PE, and LUE was 42.78 t ha⁻¹, 117.84 kg ha⁻¹ day⁻¹ (363 days), and 99.45%, respectively (Table 7).

Cost and return analysis

In four crop pattern, average gross return, total variable cost, and gross margin were Tk. 753,243, Tk. 333,730, Tk. 562,180 per hectare, respectively and in the existing cropping pattern gross return, total variable cost, and gross margin were Tk. 335,245, Tk. 242,331, Tk. 190,457 per hectare, respectively

(Table 8). The average MBCR was found 4.08, which indicates the profitability of four crop-based pattern over the farmers' existing patterns.

Farmers' opinion

After completion of three-year cycles cooperative four-crop farmers expressed a positive response to some extent towards four crop cropping pattern. Though they got higher production from four crop pattern but they are unconvinced about the sustainability of the pattern in their locality due to climate flexibility, timely allocation of inputs, high labor-intensive cultivation etc.

Table 1. Crop variety, crop geometry, plot size, fertilizer dose and application and cultural management practices of the crops for existing patterns and four crop-based pattern at the MLT site, Satkhira (2019-20).

Parameters	Existing cropping pattern			4 crop based cropping pattern			
Crop	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Variety	BARI Sarisha-14	BRRI dhan28	Binadhan-7	BARI Sarisha-14	BRRI dhan28	NSC	Binadhan-7
Spacing (cm x cm)	30 cm row	20 x15	20 x15	30 cm row	20 x15	Relay	20 x15
Unit plot size (dec)	33	33	33	33	33	33	33
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn-B)	90-27-60-15-5-2-0	138-20-83-21-4-0	77-12-42-10-3-0	90-27-60-15-5-2-0	138-20-83-21-4-0	92-10-45-8-4-0	77-12-42-10-3-0
Fertilizer application	Basal	Basal & top dress	Basal & top dress	Basal	Basal & top dress	Basal & top dress	Basal & top dress
Intercultural operation	2 sprays, 2 irrigations	2 weeding, 4 sprays, 11 irrigations	2 weeding, 2 sprays	2 sprays, 2 irrigations	2 weeding, 4 sprays, 11 irrigations	2weeding s, 2sprays	2 weeding, 2 sprays

Table 2. Agronomic management practices of the crops for existing patterns and four crop-based pattern at the MLT site, Satkhira during 2017-18.

Parameters	Existing cropping pattern			4 crop based cropping pattern			
Crop	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Variety	BARI Sarisha-14	BRRI dhan28	Binadhan-7	BARI Sarisha-14	BRRI dhan28	NSC	Binadhan-7
Date of sowing	2-Nov-17	12-Dec-17	16-Jul-18	25-Oct-17	15-Dec-17	5-Apr-18	27-Jul-18
Seedling age (days)	-	45	23	-	42	-	24
Date of transplanting	-	29-Jan-18	8-Aug-18	-	26-Jan-18	-	20-Aug-18
Date of harvesting	25-Jan-18	15-May-18	30-Oct-18	20-Jan-18	15 May 18	2 Aug 18	8-Nov-18
Field duration (days)	84	109	83	87	109	119	80
Turnaround time (days)	-	4	85	-	6	40	18

Table 3. Agronomic management practices of the crops for existing cropping patterns and four crop-based cropping pattern at the MLT site, Satkhira during 2018-19.

Parameters	Existing cropping pattern			4 crop based cropping pattern			
Crop	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Variety	BARI Sarisha-14	BRRI dhan28	Binadhan-7	BARI Sarisha-14	BRRI dhan28	NSC	Binadhan-7
Date of sowing	12-Nov-18	2-Jan-19	15-Jul-19	16-Nov-18	30-Dec-18	26-Apr-19	20-Jul-19
Seedling age (days)	-	37	36	-	46	-	40
Date of transplanting	-	8-Feb-19	20-Aug-19	-	13-Feb-19	-	28-Aug-19
Date of harvesting	2-Feb-19	25-May-19	11-Nov-19	9-Feb-19	7-May-19	25-Aug-19	20-Nov-19
Field duration (days)	82	106	83	85	82	121	83
Turnaround time (day)	4	6	87	8	4	11	4

Table 4: Agronomic management practices of the crops for existing cropping patterns and four crop-based cropping pattern at the MLT site, Satkhira during 2019-20.

Parameters	Existing cropping pattern			4 crop-based cropping pattern			
Crop	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Variety	BARI Sarisha-14	BRRI dhan28	Binadhan-7	BARI Sarisha-14	BRRI dhan28	GJO-524	Binadhan-7
Date of sowing	15-Nov-19	14-Dec-20	15 Jul 20	23-Nov-19	14-Jan-20	25-Apr-20	18-Jul-20
Seedling age (days)	-	45	38	-	32	-	40
Date of transplanting	-	28-Jan-20	25 Aug 20	-	15-Feb-20		27-Aug-20
Date of harvesting	25-Jan-20	17-May-20	23 Nov 20	12-Feb-20	18-May-20	25-Aug-20	25-Nov-20
Field duration (days)	71	110	90	81	93	122	90
Turnaround time (days)	4	3	100	3	3	23	2

Table 5: Average yield, REY, TREY, PE and LUE of the existing and improved four crops-based cropping patterns at the MLT site, Satkhira during 2017-18.

Parameters	Existing cropping pattern			Four crops-based cropping pattern			
	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Grain/seed/fibre yield (t ha ⁻¹)	1.66	5.63	4.86	1.63	5.58	3.57	5.08
By-product yield (t ha ⁻¹)	2.45	6.46	5.18	2.38	6.36	8.1	5.7
Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	3.56	6.17	5.51	4.59	6.11	17.36	5.71
Total Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	15.24			33.77			
Production efficiency (kg ha ⁻¹ day ⁻¹)	55.40			95.12			
Land use efficiency (%)	75.62			97.26			

Table 6: Average yield, REY, TREY, PE and LUE of the existing and improved four crops-based cropping patterns at the MLT site, Satkhira during 2018-'19

Parameters	Existing cropping pattern			Four crops-based cropping pattern			
	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Grain/seed/fibre yield (t ha ⁻¹)	1.62	5.78	5.11	1.49	6.09	3.54	5.08
By-product yield (t ha ⁻¹)	2.34	6.76	6.23	2.19	6.70	8.16	5.7
Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	5.67	6.53	5.80	5.24	6.83	20.11	5.56
Total Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	18.00			37.74			
Production efficiency (kg ha ⁻¹ day ⁻¹)	74.70			104.60			
Land use efficiency (%)	74.25			98.85			

Table 7: Average yield, REY, TREY, PE and LUE of the existing and improved four crops-based cropping pattern at the MLT site, Satkhira during 2019-'20

Parameters	Existing cropping pattern			Four crops-based cropping pattern			
	Mustard	Boro	T. Aman	Mustard	Boro	Jute	T. Aman
Grain/seed/fibre yield (t ha ⁻¹)	1.71	6.58	5.66	1.38	6.31	3.59	5.54
By-product yield (t ha ⁻¹)	2.56	6.91	6.11	2.47	6.92	8.20	5.83
Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	6.84	7.21	6.27	5.91	6.94	23.74	6.19
Total Rice Equivalent yield (t ha ⁻¹ yr ⁻¹)	20.31			42.78			
Production efficiency (kg ha ⁻¹ day ⁻¹)	108.47			117.84			
Land use efficiency (%)	74.25			99.45			

Table 8. Average rice equivalent yield and cost-benefit analysis of farmers and four crops-based cropping patterns at the MLT site, Satkhira during 2017-'18, 2018-'19, and 2019-'20

Pattern	Pattern	Rice equivalent yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
2017-'18	Existing	15.24	365760	245682	120078	-
	Four-crop	33.77	810435	334957	475478	3.98
2018-19	Existing	18.00	274320	229312	45008	-
	Four-crop	37.74	679302	323787	355515	3.29
2019-20	Existing	20.31	365655	252000	406284	-
	Four-crop	42.78	769993	342447	855547	4.97
Average	Existing	17.85	335245	242331	190457	-
	Four-crop	38.09	753243	333730	562180	4.08

Price (Tk. kg⁻¹):

2017-18: Boro rice- 24.00, straw-2.00, T. Aman rice -16.00, straw-2.00, Mustard seed- 50.00, Mustard straw-1, Jute fibre- 35.00, stick-3.00.

2018-19: Boro rice- 18.00, straw-2.00, T. Aman rice -18.00, straw-2.00, Mustard seed- 50.00, Mustard straw-1, Jute fibre- 40.00, stick-3.00.

2019-20: Boro rice- 18.00, straw-2.00, T. Aman rice -22.00, straw-2.00, Mustard seed- 55.00, Mustard straw-1, Jute fibre- 45.00, stick-4.00

Conclusion

At the end of the third-year cycle four crop-based cropping pattern Mustard- Boro/Jute-T. Aman gave the highest REY (38.09) and gross margin (Tk. 562180) over the existing pattern Mustard-Boro-T. Aman. Farmer's reaction was acceptable.

Recommendation and suggestion

In most cases, farmers are getting higher yield and income through cultivation alternate cropping pattern (ACP) composed of four crops as compared to that of farmers' existing cropping pattern (FCP). This technology may be recommended for a large scale area (about 80,150 ha) in the Satkhira region under AEZ-13 considering the following suggestions.

- Timely execution of all items
- Inputs should be collected before harvesting previous crops
- Clear conception about standard cultivation practices of the crops with soil health and pest management
- Mechanization should use from sowing/transplanting to harvesting of crops.
- Irrigation facilities should be ensured during the whole cycle.

Appendix I: Soil nutrient status at the beginning and end of 2017-18 cycle of four crop based cropping pattern of the study area during 2017-'18

	pH	EC (dS/m)	OM (%)	K (meq/100g soil)	Total N (%)	P (µg g ⁻¹)	S (µg g ⁻¹)	Zn (µg g ⁻¹)	B (µg g ⁻¹)
Before	7.3	2.46	2.79	0.90	0.162	51.11	207.70	2.33	1.50
	Neutral	Moderately saline	Medium	Very High	Low	Very High	Very high	High	Very High
After	7.2	2.55	2.71	0.87	0.155	48.41	201.87	2.17	1.39
	Neutral	Moderately saline	Medium	Very High	Low	Very High	Very High	High	Very High

DEVELOPMENT OF FOUR CROPS BASED FIELDPEA-BORO-T. AUS-T. AMAN CROPPING PATTERN AGAINST MUSTARD-BORO-T. AMAN CROPPING PATTERN

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Abstract

A field trial was conducted at the farmers' field of Jhikargacha MLT Site, Jashore during 2019-20 and 2020-21 to develop Field pea-Boro-T. Aus-T. Aman rice cropping pattern against Mustard-Boro-T. Aman rice cropping pattern. There were two treatments i.e. T₁: Existing cropping pattern; Mustard (var. Tori-7)-Boro (var. BRRI dhan28)-T. Aman (var. Binadhan-7) and T₂: Alternate cropping pattern: Field pea (var. BARI Motor-3)-Boro (var. BRRI dhan28)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan75). Higher Rice Equivalent yield and gross margin were obtained from alternate cropping pattern over existing cropping pattern due to inclusion of new crops and the marginal benefit-cost ratio was 2.05.

Introduction

Bangladesh with an area of 1, 47, 570 sq km is the most densely populated (about 1008 persons per km) country in the world. Its present population is about 149 million, which is increasing annually at the rate of about 1.42 percent (BBS 2011). By the year 2025 AD, the population will increase to about 198 million (en.wikipedia.org/wiki/world_population). The total cultivable land of the country is about 8.44 million hectares. Demographic pressures and increased urbanization have caused the cultivated areas to decline at a rate of 1 percent per year. The food requirement of the country is estimated to be doubled in the next 25 years (Islam and Haq 1999). The demand must be met from our limited and shrinking land resources. The present cropping intensity of the country is 192%. To produce more food within a limited area, it is very important to increase cropping intensity and for this reason more suitable crop(s) should be included in the existing cropping pattern. The present study was undertaken to develop four crops based Fieldpea (BARI Motor-3)-Boro (BRRI dhan28) -T. Aus (BRRI dhan48)-T. Aman (BRRI dhan75) cropping pattern against Mustard (Tori-7)-Boro (BRRI dhan28)-T. Aman (Binadhan-7) cropping pattern in AEZ-11.

Materials and Methods

The trial was conducted at the farmers' field of Multilocation testing (MLT) site, Jhikargacha, Jashore during 2019-20 and 2020-21 to develop Field pea (var. BARI Motor-3)-Boro (var. BRRI dhan28)-T. Aus (var. BRRI dhan48)-T. Aman (var. Binadhan-7) rice cropping pattern. There were two treatments i.e. T₁: Existing Cropping pattern: Mustard (var. Tori-7)-Boro (var. BRRI dhan28)-T. Aman (var. Binadhan-7) and T₂: Alternate Cropping pattern: Fieldpea (var. BARI Motor-3)-Boro (var. BRRI dhan28)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan75). Three farmers were selected for the experiment. Data for existing cropping patterns were collected from the adjacent farmer's field. The unit plot size was 0.135 hector. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management, etc. are presented in Table 1. Recommended fertilizer package (BARC, 2012) along with the application methods were done to support the normal growth of the crops. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield based on the prevailing market price of individual crops. The economic indices i.e. gross return, gross margin, and marginal benefit-cost ratio were also calculated based on the prevailing market price of the commodities. Relevant data were taken carefully and necessary table was prepared accordingly.

Results and Discussion

Crop management: Crop management practices, of existing and alternate cropping patterns, are shown in Table 1. Existing cropping pattern, Mustard-Boro-T. Aman rice required 263 days and alternate cropping pattern Fieldpea-Boro-T. Aus-T. Aman took 343 days (excluding seedling age of rice) to complete the cycle. Turnaround time in the existing cropping pattern was 102 days whereas it was only 22 days in four crops based on alternate cropping pattern.

Yield performance: Yield and economic return of existing and alternate cropping pattern are shown in Table 2. In alternate cropping patterns, the yield of Field pea, Boro, T. Aus, and T. Aman were 5.28,

5.44, 3.77, and 4.56 t ha⁻¹ while in the existing pattern yield of Mustard, Boro, and T. Aman were 0.95, 4.91, and 4.35 t ha⁻¹, respectively. Rice equivalent yield (REY) of alternate cropping pattern was 22.57 t ha⁻¹yr⁻¹, which was 87.46 % higher than the existing cropping sequence (12.04 t ha⁻¹yr⁻¹). Higher rice equivalent yield was obtained in alternate cropping patterns due to the introduction of new crops and varieties. Production efficiency of alternate cropping patterns was 55.05 kg ha⁻¹day⁻¹, which was about 49% higher compared to the existing cropping patterns (36.96 kg ha⁻¹day⁻¹). (Table 2).

Cost and return

Higher gross return (Tk.475690ha⁻¹) and gross margin (Tk. 175540ha⁻¹) were obtained in alternate pattern over existing pattern (gross return: Tk. 273640 ha⁻¹ and gross margin: Tk. 77090ha⁻¹). The gross margin of the alternate cropping pattern was 128% higher than that of the existing cropping pattern. The MBCR was calculated at 2.05 indicating that alternate cropping patterns could produce more returns than the existing farmer's pattern (Table 2).

Farmers' opinion: Farmers were happy to get higher income from four crops based on alternate cropping pattern over existing cropping pattern. Neighboring farmers were also interested to follow the pattern. But quality seed should be ensured in due time.

Table 1. Crop management practices of existing cropping pattern (Mustard-Boro-T. Aman) and alternate cropping pattern (Field pea-Boro-T. Aus-T. Aman cropping pattern) at Jhikargacha, Jashore during 2019-20 and 2020-21.

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern			
Crop	Mustard	Boro	T. Aman	Fieldpea	Boro	T. Aus	T. Aman
Variety	Tori-7	BRRI dhan28	Binadhan-7	BARI Motor-3	BRRI dhan28	BRRI dhan48	BRRI dhan75
Spacing	Broadcast	20x15 cm	20x15 cm	Broadcast	20x15 cm	20x15 cm	20x15 cm
Unit plot size	0.135 ha	0.135 ha	0.135 ha	0.135 ha	0.135 ha	0.135 ha	0.135 ha
Fertilizer dose (NPKSZnB Kg ha ⁻¹)	75-37.5-37-12-3-1.5	180-56-75-24-6-1.5	112-37.5-56-12-3-1	17-18-18-10-3.1-1.3	150-12-55-18-1.3-1.5	75-10-25-9-1-1	90-10-35-12-1-1.3
Fertilizer application	Basal	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress
Date of transplanting/sowing	06.11.19	30.01.20	01.08.19	04.11.19	25.01.20	06.05.19	04.08.19
Date of harvesting	24.01.20	04.05.20	27.10.19	20.01.20	29.04.20	28.07.19	28.10.19
Irrigation (no.)	1	40	12	1	35	15	10
Weeding (no.)	1	2	2	1	2	2	2
Field duration (days)	80	95	88	78	95	84	86
Turnaround time	T. Aman to Mustard: 09	Mustard to Boro: 05	Boro to T. Aman: 88	T. Aman to Field pea: 6	Field pea to Boro: 4	Boro to T. Aus: 6	T. Aus to T. Aman: 6

Table 2. Yield and economic return of existing cropping pattern (Mustard-Boro-T. Aman) and alternate cropping pattern (Fieldpea-Boro-T. Aus-T. Aman cropping pattern) at Jhikargacha, Jashore during 2019-20 and 2020-21 (Two years average).

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern			
Crop	Mustard	Boro	T. Aman	Fieldpea	Boro	T. Aus	T. Aman
Variety	Tori-7	BRRI dhan28	Binadhan-7	BARI Motor-3	BRRI dhan28	BRRI dhan48	BRRI dhan75
Seed/Grain yield (t ha ⁻¹)	0.95	4.91	4.35	5.28	5.44	3.77	4.56
Stover/straw yield (t ha ⁻¹)	1.27	5.45	4.15	-	5.82	4.82	4.94
Rice Equivalent yield (t ha ⁻¹)	12.04			22.57			
Production efficiency (kg ha ⁻¹ day ⁻¹)	36.86			55.05			
Gross margin (Tk.ha ⁻¹)	16290	22500	38300	79550	34580	24870	36540
Total variable cost (Tk. ha ⁻¹)	33750	97500	65300	78850	97500	58500	65300
Gross return (Tk. ha ⁻¹)	50040	120000	103600	158400	132080	83370	101840
Whole pattern Gross margin (Tk. ha ⁻¹)	77090			185540			
MBCR (Whole pattern)				2.05			

Market price (Tk. kg⁻¹): Fieldpea 30, Mustard 50, Boro rice 20, T. Aus rice 17, T. Aman rice 18, rice straw 4, Mustard stover 2.

Conclusion

From the experimentation, the cultivation of alternate cropping patterns is profitable than that of existing patterns. By practicing the improved cropping pattern, we can utilize 80 days' turnaround time and could increase cropping intensity, but its full efficiency depends on the successful cultivation of T. Aus rice. Thus, the cultivation of alternate cropping patterns would help to increase total production, enhance farmer's income, and reduce the nutritional imbalance of human beings.

Recommendation and suggestion

Farmers are getting higher yield and income through the cultivation of alternate cropping patterns composed of four crops as compared to that of farmers' existing cropping patterns. This technology may be recommended for small scale in the AEZ-11 and a similar area of the country considering the following suggestions.

- Timely execution of all items
- Inputs should be collected before harvesting previous crops
- Intensive soil health management to be considered
- Clear conception about standard cultivation practices of the crops with soil health and pest management
- Irrigation facilities should be ensured.

DEVELOPMENT OF CROPPING PATTERN BLACK GRAM/GRASS PEA-JUTE-T. AMAN RICE AGAINST EXISTING CROPPING PATTERN GRASS PEA-T. AMAN IN CHARLAND

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Abstract

The field experiment was conducted during 2019-20 and 2020-21 to increase the cropping intensity and productivity by developing four crop-based cropping patterns against the existing two or three crop-based cropping patterns. The four crops-based alternate cropping patterns (Jute-T. Aman-Black gram/Grass pea) were tested against the existing cropping pattern (T. Aman rice-Grass pea) in the farmer's field under stable Charland of Chilmari, Kurigram. Fiber or grain or seed yield of Jute, T. Aman, Blackgram, and Grass pea were recorded as 2.08, 4.89, 1.33, and 1.25 t ha⁻¹, respectively with rice equivalent yield (REY) 21.47 t ha⁻¹ in the improved cropping pattern whereas 3.23 and 1.28 t ha⁻¹ grain or seed yield of T. Aman and grass pea with REY 7.11 t ha⁻¹ were recorded in the existing cropping pattern during 2020-21. Production efficiency was 62.42 and 30.26 Kg ha⁻¹ day⁻¹, and land-use efficiency was 94.25 and 64.38% in alternate and existing cropping patterns, respectively. The whole pattern gross margin was higher in the alternate pattern (Tk. 317700 ha⁻¹) than the existing pattern (Tk. 90420 ha⁻¹). The MBCR was 3.56 in an alternate pattern over the existing pattern.

Introduction

Bangladesh is one of the most densely populated countries in the world with a population growth rate of 1.579%. The present cropping intensity of the country is 175.97%. Food requirement is estimated to be doubled in the next 25 years. On the other hand, the cultivable land is decreasing by 1% every year. So, Bangladesh has to produce additional food for millions of people every year. Under such a situation, it is very important to increase cropping intensity and for this more suitable crop(s) should be accommodated in the existing cropping pattern. Stable char lands of the northern region of Bangladesh are now a promising area for intensifying crop production where T. Aman rice is produced as a chance crop due to flash floods in some years. The practice of relay grass pea production with black gram is a promising technology in some areas which need validation under char land situations to incorporate in

cropping pattern. Although Bangladesh is nearly self-sufficient in rice production, other foods such as wheat, vegetables, pulses, oil crops, etc. are still deficit to a large extent. Even rice food security has not been achieved at the household level in many poor and extremely poor farm families. Crop diversification, increasing cropping intensity, raising the productivity of land and labor will eliminate food and nutritional insecurity and poverty of farming communities in the future. The present study was undertaken to evaluate the performance of the improved cropping pattern in the Rangpur region, to increase cropping intensity, productivity, and income of farmers.

Materials and Methods

The experiment was conducted at the farmers' field under stable Charland conditions during 2019-20 and 2020-21 to increase the cropping intensity and productivity by developing four crop-based cropping patterns against the existing two crop-based cropping patterns. The four crops-based alternate cropping pattern (Jute-T. Aman-Blackgram/Grass pea) were tested against the existing cropping pattern (T. Aman rice-Grass pea) in the farmer's field of Char Bongram, Chilmari, Kurigram. The alternate cropping pattern consists of 4 crops was compared with 2 crop-based farmers existing patterns. The experiment was designed with two cropping patterns as a treatment. Existing patterns data were collected from neighbor farmer's practiced land. Economic analysis was done based on the prevailing local market price of the commodities. The productivity of different cropping systems was compared in terms of rice equivalent yield (REY). The details of the used and cultural operations adopted in different crops under both alternate and farmers' cropping pattern are given in Table 1. The rates of the fertilizers for different crops were used per Fertilizer Recommendation Guide' 2018 (BARC, 2018). The sources of nutrients were urea for N, TSP for P, MOP for K, Gypsum for S, Zinc sulfate for Zn, and Boric acid for B.

Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of FP was recorded from adjacent farmers' plots. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Table 1. Details of the crop management of existing and improved cropping patterns at Char Bongram, Chilmari, Kurigram

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	T. Aman	Grass pea	Fallow	Jute	T. Aman	Blackgram	Grass pea
Variety	Local (Gainja)	Local	-	O-795	BRRI dhan52	BARI Mash-3	BARI Khesari-3
Spacing	20cm×15cm	Broadcast	-	Broadcast	20cm×15cm	Broadcast	Dibbling 30cm×30cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	70-15-38-0-0-0	0-0-0-0-0-0	-	75-4-40-5-0-0	90-6-33-4-0-0	12-10-15-0-2-1	0-0-0-0-0-0
Date of sowing/transplanting	20 July	15 Nov.	-	02 April	23 July	06 Nov.	23 Nov. as relay
Harvesting date	05 Nov.	22 Mar.	-	16 July	31 Oct.	12 Jan.	25 Mar.

Results and Discussion

Yield and economic performance of alternate and existing cropping patterns during 2020-21 are presented in Table 2.

The yield of jute fiber, T. Aman grain, black gram seed, and grass pea seed were recorded as 2.08, 4.89, 1.33, and 1.25 t ha⁻¹, respectively with rice equivalent yield (REY) 21.47 t ha⁻¹ in the improved cropping pattern whereas 3.23 and 1.28 t ha⁻¹ grain or seed yield of T. Aman and grass pea with REY 7.11 t ha⁻¹ were recorded in the existing cropping pattern during 2020-21.

Production efficiency (PE): Maximum production efficiency (62.42 kg ha⁻¹day⁻¹) was obtained from an alternate cropping pattern. The lower production efficiency of 30.26 kg ha⁻¹day⁻¹ was found in the farmer's existing pattern (Table 2).

Land use efficiency (LUE): Land use efficiency indicated that alternate cropping patterns used the land for 94.25% time of the year, whereas farmer's existing pattern used the land for 64.38% time of the year (Table 2).

Cost and return analysis: The whole pattern gross margin was higher in the alternate pattern (Tk. 317700 ha⁻¹) than the existing pattern (Tk. 90420 ha⁻¹). The MBCR was 3.56 in an alternate pattern over the existing pattern.

Farmers' opinion

Farmers opined that Jute-T. Aman-Blackgram/Grass pea cropping pattern was superior to existing cropping pattern.

Table 2. Crop performance of improved cropping pattern Jute-T. Aman-Black gram/Grass pea against the existing pattern T. Aman-Grass pea

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	T. Aman	Grass pea	Fallow	Jute	T. Aman	Black gram	Grass pea
Variety	Local (Gainja)	Local	-	O-795	BRRI dhan52	BARI Mash-3	BARI Khesari-3
Field duration (day)	108	127	-	105	100	67	72 (122d-50d relay)
Turnaround time (day)	10	120	-	7	6	0	8
Grain/fibre/tuber/fruit yield (t ha ⁻¹)	3.23	1.28	-	2.08	4.89	1.33	1.25
Straw/stover/stalk yield (t ha ⁻¹)	3.62	-	-	5.55	5.38	-	-
REY (t ha ⁻¹)	4.49	2.62	-	6.79	7.89	4.23	2.56
Whole pattern REY (t ha ⁻¹)	7.11			21.47			
Production efficiency (kg ha ⁻¹ day ⁻¹)	30.26			62.42			
Land use efficiency (%)	64.38			94.25			
Gross return (Tk. ha ⁻¹)	98850	57600	-	149425	173600	93100	56250
Total variable cost (Tk. ha ⁻¹)	44600	21430	-	63950	46795	22500	21430
Gross margin (Tk. ha ⁻¹)	54250	36170	-	85475	126805	70600	34820
Whole pattern GM (Tk. ha ⁻¹)	90420			317700			
MBCR (Whole pattern)				3.56			

Price (Tk. kg⁻¹): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-25, Rice straw-5, Jute fiber-62.5, Jute stick-3.5, Black gram-70 and Grass pea-45

REY: rice equivalent yield, MBCR: marginal benefit-cost ratio, GM: gross margin

Conclusion

From the experimentation, the cultivation of alternate cropping patterns is profitable than that of existing patterns. By practicing the improved cropping pattern, utilize 109 days' turnaround time and increase cropping intensity, but its full efficiency depends on the successful cultivation of T. Aman rice. Some years T. Aman was damaged by flood, and it is a chance crop. Thus, the cultivation of alternate cropping patterns would help to increase total production, enhance farmer's income, improve soil health, and reduce the nutritional imbalance of human beings.

Recommendation and suggestion

Farmers are getting higher yield and income through the cultivation of alternate cropping patterns composed of four crops as compared to that of farmers' existing cropping patterns. This technology may be recommended for small scale in the AEZ-3 and a similar area of the country considering the following suggestions.

- Timely execution
- Inputs should be collected before harvesting previous crops
- Clear conception about standard cultivation practices of the crops with soil health and pest management
- Irrigation facilities should be ensured.

DEVELOPMENT OF ALTERNATE FOUR CROPS BASED CROPPING PATTERN TO INCREASE CROPPING INTENSITY IN RANGPUR REGION

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Abstract

A set of four crop-based alternate cropping patterns (ACP) were tested against farmers existing three crop-based cropping patterns (FCP) at FSRD site, Ajoddhapur, Rangpur and MLT site, Gobindaganj, Gaibandha under On-Farm Research Division, BARI, Rangpur during the year of 2017-18 to 2019-20 to increase the cropping intensity and productivity and also to disseminate those ACPs among the farmers of respective locations. In all locations, ACP consist of 4 crops was compared with 3 crop-based farmers existing cropping pattern (FCP). In most cases, the results exposed that the ACP with four crops could be established successfully with short-duration crop varieties. In these studies, ACPs were more profitable and viable than those of FCPs in terms of the agronomic and economic points of view. Irrespective of locations, rice equivalent yield (REY), crop productivity, and profitability were higher in ACPs than FCPs. The inclusion of new crops in the existing cropping pattern and replacing old and traditional varieties with modern varieties enhanced productivity and profitability.

Introduction

Bangladesh is a densely populated (1237 person per sq. km) country of the world with an increasing rate of 1.05% per year (Source: Worldmeters, 2017). At present the total cultivable land is 7.95 million hectare (BBS, 2016) which is decreasing at the rate of about 0.44% per year. There is a very little scope of increasing cultivable land but there are some scopes of increasing cropping intensity from the present cropping intensity 194% to 400% by improving the present cropping pattern. Incorporating short duration or adjustable crops in the rice-based cropping pattern may be an option. In Rangpur region, potato is very popular, and some patterns are practiced by farmers which are mostly two to three crops based. Potato-Jute-T. Aman and Potato-Boro-T. Aman are some of them. Relay cropping system or short duration vegetables crops inclusion in these patterns may help to increase cropping intensity and productivity. Sustainable crop production in Bangladesh through improvement of cropping pattern in rice-based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation and creation of job opportunity. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing three or more crops over the same piece of land in a year and ii) to increase the production efficiency of the individual crop by using optimum management practices. The present study was undertaken to evaluate the feasibility of growing four crops in respect of productivity and in a year in a piece of land by incorporating new crops in the existing cropping pattern.

Materials and Methods

Experiments on alternate cropping pattern (ACP) were conducted at FSRD site, Ajoddhapur, Rangpur and MLT site, Gobindaganj, Gaibandha under On-Farm Research Division, BARI, Rangpur during the year of 2017-18 to 2019-20 to increase the cropping intensity and productivity by developing four crop-based patterns against the existing three crop-based cropping pattern and to disseminate among the farmers. Each experiment covered one hectare of land in each site. The land was selected based on the discussion with local farmers, DAE personnel, and available secondary information. The experiment was designed with two cropping patterns as a treatment. In both locations, an alternate cropping pattern consist of 4 crops was compared with 3 crop-based farmers existing patterns.

The details of the varieties used, and cultural operations adopted in different crops under both alternate and farmers' cropping pattern are given in Table 1. The fertilizers dose for different crops were used as per Fertilizer Recommendation Guide 2012 (BARC, 2012). The sources of nutrients were urea for N, TSP for P, MoP for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B.

For Rabi crops, all inorganic fertilizers except urea and MoP were applied to land and mixed with soil at the time of final land preparation and urea and MoP were used as top dressing in 2-3 splits. In the case of T. Aman rice, all the fertilizers except urea were applied as basal. Urea was applied as top

dressing in three equal splits at 10, 25 and 40 days after transplanting. All the crops were harvested at maturity from five spots with an area of 6.0 m² each. Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of FP was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of individual (component) crop yield of each cropping cycle. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was measured as per Appendix Table 1.

Table 1. The details of the varieties used and cultural operations adopted in different crops under both alternate and farmers' cropping patterns.

Location	Treat	Crop	Variety	Spacing (cm ²)	Date of Planting/Sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)							
							N	P	K	S	Zn	B	CD	
(i). FSRD site, Rangpur	ACP	Potato	BARI Alu-25	60× 25	20-24 Nov.	15-18 Feb.	135	30	110	22	2	1	5000	
		Sweet gourd(Relay)	BARI Hybrid Mistikumra-1	180×200	23-28 Nov.	1-6 April	0	0	0	0	0	0		
		Jute	O-795	Broadcast	10-15 April	19-24 July	90	6	50	16	0	0	0	
		T. Aman	Binadhan-17		06-10 Aug.	4-10 Nov.	90	6	33	4	1	0	0	
	FCP	Potato	BARI Alu-8	60 × 25	20 Nov.-05 Dec.	20 Feb.-6 Jan.	120	50	110	22	8	1	0	
		Jute	Indian Tosa	Broadcast	15-27 April	18-23 July	120	15	30	10	0	0	0	
		T. Aman	Swarna	20×15	26 July-7Aug.	07-12 Nov.	114	10	13	4	4	0	0	
(ii). MLT site, Gobindaganj, Gaibandha	ACP	Radish	BARI Mula-3	Broadcast	23-27 Oct.	25-27 Nov.	92	20	75	0	0	0	0	
		Potato	BARI Alu-25	60 × 25	01-02 Dec.	23-25 Feb.	135	20	90	10	0	1.5	3000	
		Maize	Mirakkel	60×20	02-05 Mar.	05-08 Jul.	135	16	31	18	2	0	0	
		T. Aman	Binadhan-17	20×15	13-17 Jul.	12-15 Oct.	90	6	33	4	1	0	0	
	FCP	Potato	BARI Alu-8	60 × 25	20 Nov.-05 Dec.	20 Feb.-6 Jan.	120	50	110	22	8	1	0	
		Boro	BRRI dhan28	20×15	20-25 Jan.	20-28 May	150	23	20	6	0	0	0	
		T. Aman	Swarna	20×15	26 July-7Aug.	05-10 Nov.	114	10	13	4	4	0	0	

ACP=Alternate cropping pattern i.e. 4-crop based cropping pattern, FCP= Farmers' cropping pattern i.e. farmers' existing cropping pattern consists of 3 crops.

Results and Discussion

i) FSRD site Ajodhpur, Rangpur

The average yield and economic performance of improved and existing cropping patterns during the year 2017-18 to 2019-20 are presented in Table 2.

Yield performance: Crop yield of potato, sweet gourd, jute, and T. Aman was recorded as 27.14, 33.12, 3.17, and 4.62 t ha⁻¹, respectively with whole pattern rice equivalent yield (REY) 39.37 t ha⁻¹ in the ACP whereas 23.12, 3.02 and 3.96 t ha⁻¹ crop yield of potato, jute and T. Aman with whole pattern REY 21.47 t ha⁻¹ were recorded in the FCP.

Production efficiency: Maximum production efficiency (121.52 kg ha⁻¹day⁻¹) was obtained from ACP and minimum (73.28 kg ha⁻¹day⁻¹) in FCP. The higher production efficiency in ACP might be due to the inclusion of high-yielding potato and T. Aman varieties and also the inclusion of sweet gourd as well as improved management practices.

Land Use Efficiency (LUE): Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The LUE indicated that ACP used the land for 88.77% period of the year, whereas FCP used the land for 80.27 % period of the year. The higher land uses efficiency in ACP because this pattern occupied the field for the longest duration (324 days), whereas the FCP occupied the field for 293 days of a year.

Cost and return analysis: Total gross return and gross margin of ACP were Tk. 866190 ha⁻¹ and Tk. 591179 ha⁻¹, respectively whereas in FCP these were Tk. 472370 ha⁻¹ and Tk. 249720 ha⁻¹, respectively. The whole pattern MBCR was 7.52.

Pest incidence: Aphid was observed in the Potato field, and it was sprayed with Asataf @ 2 g L⁻¹ water 30 days after planting. For controlling late blight disease of potato, Dithane M-45 @ 4 g L⁻¹ water was applied 5 times starting from 30 DAP and continued up to 70 DAPS at an interval of 10 days. In T. Aman rice, Vittaco was applied @ 80 gm ha⁻¹ to control stem borer and Folicure was sprayed @ 2 ml L⁻¹ at 65 DAT for controlling leaf blight.

Farmers' opinion: Farmers opined that Potato/Sweet Gourd-Jute-T. Aman rice cropping pattern could be profitable than the existing cropping pattern.

Table 2. The average crop performance of alternate cropping pattern (ACP) Vs, Farmers' cropping pattern (FCP) at FSRD site Ajodhpur, Rangpur during the year of 2017-18 to 2019-20

Parameter	Alternate cropping pattern (ACP)				Farmers' cropping pattern (FCP)		
	Potato	Sweet gourd	Jute	T. Aman	Potato	Jute	T. Aman
Crop	86	131 (83 days relay time included)	100	90	96	105	92
Field duration	86	131 (83 days relay time included)	100	90	96	105	92
Turnaround time	14	Relay	9	18	52	10	10
Crop yield (t ha ⁻¹)	27.14	33.12	3.17	4.62	23.12	3.02	3.96
Straw/stover yield (t ha ⁻¹)	-	-	5.12	5.08	-	5.32	4.35
REY (t ha ⁻¹)	12.34	15.05	6.21	5.77	10.51	6.01	4.95
Gross return (Tk. ha ⁻¹)	271400	331200	136550	127040	231200	132300	108870
Total variable cost (Tk. ha ⁻¹)	126560	42430	59226	46795	120630	57420	44600
Gross margin (Tk. ha ⁻¹)	144840	288770	77324	80245	110570	74880	64270
GM (Tk. ha ⁻¹)	591179				249720		
Production efficiency (kg ha ⁻¹ day ⁻¹)	121.52				73.28		
Land use efficiency (%)	88.77				80.27		
MBCR (Whole pattern)	7.52				-		

Price (Tk. kg⁻¹): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-22, Rice straw-05, Jute fiber-35, Jute stick-5, Potato-10 and sweet gourd-10 REY: rice equivalent yield, MBCR: marginal benefit-cost ratio, GM: gross margin

Conclusion: Alternate cropping pattern is found profitable than that of the existing pattern. By practicing the improved cropping pattern, utilize 31 days turnaround time and can increase cropping intensity. Thus, the cultivation of alternate cropping patterns would help to increase total production, farmer's income, improve soil health, and reduce the nutritional imbalance of human beings.

ii) MLT site Gobindaganj, Rangpur

The average yield and economic performance of 4-crop based alternative cropping pattern, ACP (Radish-Potato-Maize-T. Aman rice) and farmer's existing cropping pattern, FCP (Potato-Boro-T. Aman rice) during the year of 2017-18 to 2019-20 are presented in Table 3.

Crop performance: In ACP, the leafy vegetable yield of radish was 5.61 t ha⁻¹ whereas the tuber yield of potato was 28.5 t ha⁻¹. Grain and stover yield of Maize were 10.8 and 11 t ha⁻¹, respectively. Grain and straw yield of T. Aman rice were 5.5 and 6.05 t ha⁻¹, respectively in ACP. The tuber yield of BARI Alu-25 was 27.58 t ha⁻¹ in FCP. The yield of potato T. Aman rice in ACP increased than FCP due to improved production technologies and changing variety.

Field Duration: The field duration of a cropping pattern comprises the individual crop duration. FCP has needed 288 days field duration while ACP 333 days (excluding seedling age of rice) to complete the cycle. The result indicated that four crops could be fitted instead of FCP with 32 days turnaround time in a year.

Rice equivalent yield: Four crops based on ACP produced higher REY (35.05 t ha⁻¹) over FCP (23.92 t ha⁻¹). Inclusion of radish in rabi season and maize in Kharif-1 season in ACP increased REY by 47% compared to FCP.

Production efficiency: Maximum production efficiency (105.23 kg ha⁻¹ day⁻¹) was obtained from ACP and minimum (83.05 kg ha⁻¹ day⁻¹) in FCP. The higher production efficiency in ACP might be due to

the inclusion of high-yielding potato and T. Aman varieties and the inclusion of radish and maize crops as well as improved management practices.

Land Use Efficiency (LUE): Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The LUE indicated that ACP used the land for 91.23% period of the year, whereas FCP used the land for 78.90 % period of the year. The higher land uses efficiency in ACP because this pattern occupied the field for the longest duration (333 days), whereas the FCP occupied the field for 288 days of a year.

Economic analysis: From the economic point of view, ACP showed its superiority over FCP during the study period. The Gross return of ACP was Tk. 770900 ha⁻¹ which was more than 47% higher than FCP. The FCP gave the lowest gross return TK. 526190 ha⁻¹. The total variable cost was higher in ACP (Tk. 267470 ha⁻¹) might be due to the inclusion of two-component crops in the pattern. The gross margin was substantially higher in the ACP (Tk. 503430 ha⁻¹) than FCP (Tk. 296490 ha⁻¹). The higher gross margin of the improved pattern was achieved mainly higher yield advantages of the component crops. The marginal benefit-cost ratio (MBCR) was found at 6.48 which indicated the superiority of the ACP over the FCP. The marginal benefit-cost ratio (MBCR) analysis showed that the inclusion of new crops in the existing pattern might be profitable and acceptable to the farmers.

Table 3. The average crop performance of alternate cropping pattern (ACP) Vs, Farmers' cropping pattern (FCP) at MLT site Gobindaganj, Rangpur during the year of 2017-18 to 2019-20

Parameter	Alternate cropping pattern (ACP)				Farmers' cropping pattern (FCP)		
Crop	Radish	Potato	Maize	T. Aman	Potato	Boro	T. Aman
Field duration	35	87	123	88	91	105	92
Turnaround time	11	5	7	9	52	10	15
Crop yield (t ha ⁻¹)	5.61	28.5	10.8	5.5	27.58	5.27	4.11
Straw/stover yield (t ha ⁻¹)	-	-	11	6.05	-	5.87	4.58
REY (t ha ⁻¹)	6.38	12.95	9.34	6.38	12.54	6.60	4.78
Gross return (Tk. ha ⁻¹)	140250	285000	205400	140250	275800	145290	105100
Total variable cost (Tk. ha ⁻¹)	12500	137000	76470	41500	125950	61250	42500
Gross margin (Tk. ha ⁻¹)	127750	148000	128930	98750	149850	84040	62600
GM (Tk. ha ⁻¹)	503430				296490		
Production efficiency (kg ha ⁻¹ day ⁻¹)	105.23				83.05		
Land use efficiency (%)	91.23				78.90		
MBCR (Whole pattern)	6.48				-		

Price (Tk. kg⁻¹): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Leafy Radish-25, Rice grain (Boro)-22, Rice grain (Aman)-20, Rice straw-05, Potato-10 and Maize grain-18 REY: rice equivalent yield (22 Tk kg⁻¹), MBCR: marginal benefit-cost ratio, GM: gross margin

Recommendation and suggestion

In most cases, farmers are getting higher yield and income through cultivation alternate cropping pattern (ACP) composed of four crops as compared to that of farmers' existing cropping pattern (FCP). This technology may be recommended for a small scale in the Rangpur region under AEZ-3 considering the following suggestions.

- Timely execution of all items
- Inputs should be collected before harvesting previous crops
- Clear conception about standard cultivation practices of the crops with soil health and pest management
- Mechanization should use from sowing/transplanting to harvesting of crops.
- Irrigation facilities should be ensured during the whole cycle.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN POTATO - MAIZE + CORIANDER -T. AMAN RICE AGAINST POTATO-MAIZE-T. AMAN RICE CROPPING PATTERN

S. K. Bhowal, M. H. Hossain, M. M. Bashir, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was conducted at the farmers' field of Daudkandi under AEZ 19 of Cumilla during (2019-20) to fit Coriander in the existing cropping pattern and also to increase cropping intensity and productivity. Two treatments i.e., T₁: Existing cropping pattern (Potato-Maize-T. Aman) and T₂: Alternate cropping pattern (Potato-Maize+Coriander-T. Aman) were evaluated in the farmer's field. From the research findings, it was found that Rice equivalent yield (REY) in alternate cropping pattern (51.1 t ha⁻¹) was 63% higher over existing pattern (31.4 t ha⁻¹). Higher gross return (Tk. 1022000.00 ha⁻¹) and gross margin (Tk. 791620.00 ha⁻¹) as well as higher MBCR (4.43) were also obtained from alternate cropping pattern over existing cropping pattern due to additional yield of hybrid coriander leaves and higher yield of modern potato variety BARI Alu-40.

Introduction

Bangladesh is one of the most densely populated countries of the world with population growth rate of 1.579%. The present cropping intensity of the country is 176%. The urgent need is to produce more food to feed the teeming populations. Food requirement is estimated to be doubled in the next 25 years. Under such situations, it is very important to increase cropping intensity and for this reason, more suitable crop(s) should be accommodated in the existing cropping pattern. The main challenge of the new millennium is to increase per unit yield by at least 50% through manipulating the limited land resource. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing three or more crops over the same piece of land round the year and ii) to increase the productive efficiency of the individual crop. Considering the above issues, the present study was undertaken with the following objectives- (i) To utilize the gaps between the two rows of maize in the seedling stage and (ii) To increase production and economic return of the farmers by improving the cropping system.

Materials and Methods

The trial was conducted at the farmers' field of Daudkandi, Cumilla under AEZ 19 with the following rice-based cropping pattern during 2019-20 to fit Coriander as intercrop with maize in the Potato-Maize-T. Aman cropping pattern and increase cropping intensity. The experiment was laid out in a Randomized Complete Block Design with six dispersed replications. There were two treatments i.e., T₁: Existing cropping pattern (Potato-Maize-T. Aman) and T₂: Alternate cropping pattern (Potato-Maize+Coriander-T. Aman). The details of the crop management for the cropping patterns have been presented in the Table 2.

Potato was planted as a first crop during last week of November in the improved cropping pattern. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to Kabir and Haque (2012). BARI developed recent popular potato tuber (cv. BARI Alu-40) was planted with 60 cm x 25 cm spacing in the cropping system. Potato was harvested during third week of February. Tuber and foliage (over dry) weights were taken from whole plot and whole plant except tuber (1.35 t ha⁻¹) was incorporated with the soil.

Maize was planted as a second crop during first week of March in the improved cropping pattern. Fertilizer management and intercultural operations like weeding, thinning, irrigation and pest management were done according to Azad *et al.*, (2019). BARI developed recent popular hybrid maize variety (var. BARI Hybrid Bhutta-16) was planted with 60 cm x 25 cm spacing in the cropping system field. Maize cobs were harvested during last week of June. Foliage (over dry) weights were taken from whole plot and whole plant except cobs was incorporated with the soil.

Coriander as intercropped with Maize was the third crop of the crop sequence. Fertilizer management and other intercultural operations were done according to Azad *et al.*, (2019). Seeds of coriander variety

BARI Dhonia-2 were broadcasted in between the two rows of maize as intercropping system just after maize sowing in improved cropping pattern. Leaves of coriander was harvested at second week of April.

Transplanted Aman rice was grown during the Kharif-II season with fertilizer management and intercultural operations like weeding, irrigation and pest management were done according to Rahman *et al.* (2008). Seedlings were grown in adjacent plot and transplanting was done with 18-22 days old seedling of rice var. BRRI dhan49 at a spacing of 20cm x 15cm during third week of July in improved cropping pattern. T. Aman rice was harvested during third week of November. Rice plant was harvested at 12-15 cm height from soil surface and remaining parts of the plant was incorporated with soil.

Data on yield of the all crops were recorded carefully. The gross economic return was calculated on the basis of prevailing market price of the commodities.

REY = [Potato yield (kg) × Potato price (Tk. kg⁻¹)] / price of rice grain (Tk. kg⁻¹).

Results and Discussion

Yield and Productivity of Cropping Pattern

Soil properties from soil chemical analysis of initial soil sample of the cropping pattern are presented in (Table 1). There was no definite trend followed with respect to other elements but all the elements maintained above critical level except N. Organic matter added to soil through incorporation of non-economic plant parts in the improved cropping patterns and it helped to improve the quality of soil by increasing total organic matter in every succeeding year (Mondal *et al.*, 2015).

Yield and economic performance of alternate and existing cropping pattern during 2019-20 are presented in Table 2. The average tuber yield of Potato (BARI Alu-40), Maize (BARI Hybrid Bhutta-16), Coriander (Hybrid Coriander Morokko) and T. Aman (BRRI dhan49) were recorded as 47.1, 10.1, 1.7 and 4.3 t ha⁻¹, respectively, where in the existing cropping pattern of Potato (BARI Alu-7), Maize (NK-40) and T. Aman (BRRI dhan32) produces 29.6, 9.5 and 4.2 t ha⁻¹ tuber/grain yield, respectively. Higher tuber/grain yield of Potato, Maize and T. Aman were recorded in alternate cropping pattern compared to the existing cropping pattern.

Total productivity of different cropping sequences was determined by Rice Equivalent Yield (REY) which was calculated from yield of component crops. From the research findings it was revealed that higher REY (51.1 t ha⁻¹) was recorded from the alternate cropping sequence *i.e.* Potato-Maize+Coriander-T. Aman and the lower (31.4 t ha⁻¹) from the existing cropping sequence such as Potato-Maize-T. Aman. Rice equivalent yield in the improved cropping pattern was almost 63% higher than the existing cropping pattern due to the inclusion of one short duration culinary herb (Coriander) as inter crop with maize and use of modern high yielding varieties of potato such as BARI Alu-40 and technologies in the alternate cropping pattern. The result of the study similar with the Naheret.al (2016) and Hossain *et. al* (2014) who stated that short duration varieties and improved four crop-based cropping pattern increases total productivity and profitability over farmers existing pattern.

Economic Analysis

Economic analysis was done on the basis of prevailing market price of the commodities. Productivity of different cropping systems were compared in terms of Rice Equivalent Yield (REY). Economics of system productivity of alternate and existing cropping sequences showed in table 4. Higher gross return (Tk. 1022000.00 ha⁻¹) and gross margin (Tk. 791620.00 ha⁻¹) were obtained in improved cropping pattern and lower gross return (Tk. 628000.00 ha⁻¹) and gross margin (Tk. 432120.00 ha⁻¹) were found in existing cropping pattern. Higher total cost (Tk. 230380.00 ha⁻¹) was recorded from cropping sequence Potato-Maize+Coriander-T. Aman, due to the inclusion of hybrid Coriander as intercrop with maize and improved varieties and modern technologies in alternate cropping pattern whereas lower total cultivation cost (Tk. 195880.00 ha⁻¹) from the existing cropping sequence Potato-Maize-T. Aman rice. The highest (4.43) MBCR was calculated in improved cropping pattern T₂ compared to the farmers existing cropping pattern T₁ (3.2). Mondal *et al.*, 2014 also report same opinion that the four-crop based improved cropping pattern could play a vital role to meet the food security of increasing over population of our country in upcoming days.

Farmers' opinion

Farmers opined those four crops such as tuber, maize, coriander and rice can be grown successfully in the same field in a year but they are not more benefited from rice cultivation due to increased labour cost at pick period and lower market price of rice.

Table 1. Initial and final soil properties of improved cropping pattern field at Daudkandi, Cumilla during 2019-20 and 2020-21

Soil Properties	Land type	pH	Organic matter (%)	K	Total N (%)	P	Zn	B
				Meq100 ml ⁻¹		µgml ⁻¹		
Initial (2019-20)	MHL	5.5	1.85	0.26	0.11	86	15	0.20
Final (2020-21)	MHL	5.0	0.78	0.32	0.10	95	4.42	0.21
Critical Level	-	-	-	0.12	0.12	8.0	0.6	0.20

Source: Regional Laboratory, SRDI, Cumilla (2019) & FRG (2012)

Table 2. Crop management practices and yield of Potato-Maize+Coriander-T. Aman rice cropping pattern against Potato-Maize-T. Aman rice pattern at Daudkandi, Cumilla during 2020-21

Parameters	Existing CP (T ₁)			Improved CP (T ₂)			
Crop	Potato	Maize	T. Aman	Potato	Maize	Coriander	T. Aman
Variety	BARI Alu-7	NK-40	BRRI dhan32	BARI Alu-40	BARI Hybrid Bhutta-16	Hybrid Dhonia (Morokko)	BRRI dhan49
Unit plot size (Decimal)		10 Decimal		30 Decimal			
Planting date	03-05 Dec, 2019	15 March, 2020	Trans. 28-29 August, 2020	27-28 Nov, 2019	5-6 March, 2020	5-6 March, 2020	Seed bed, 1 July, 20 Transplanted 24-25 July, 2020
Harvesting date	07-08 March, 2020	12-15 July, 2020	27-28 Nov, 2020	1-2 March, 2020	1-3 July, 2020	18-20 April, 2020	22-23 Nov, 2020
Field duration	94-95	117-120	90-94	90-91	116-118		118-120
Turn around time	07-08	45-46	05-06	03-04	21-22		05-06
Grain/leaf Yield (t ha ⁻¹)	29.6	9.5	4.2	47.1	10.1	1.7	4.3
Bi-product Yield (t ha ⁻¹)	2.27	4.80	4.62	2.15	2.46	0.5	4.12

Table 3. Average yield of Potato, Maize, Coriander, T. Aman and REY in existing and improved cropping pattern at Daudkandi, Cumilla during 2019-20

Cropping Pattern	Yield (t ha ⁻¹)				Rice Equivalent Yield (REY)
	Potato	Maize	Coriander	T. Aman	
T ₁	29.6	9.5	-	4.2	31.4
T ₂	47.1	10.1	1.7	4.3	51.1

Market price of Potato @ 12 Tk kg⁻¹, Maize @ 20 Tk kg⁻¹, Coriander leaf @ Tk. 100 kg⁻¹, T. Aman rice @ Tk. 20 kg⁻¹, Urea @ 16, TSP @ 24, MP @ 15, Zypsum @ 10, Zinc Sulphate @ 120 and Boric acid @ 150 Tk kg⁻¹; Existing CP (T₁) = Potato-Maize-T. Aman and Improved CP (T₂) = Potato-Maize+Coriander-T. Aman rice

Table 4. REY and economic performances of existing and improved cropping pattern at Daudkandi, Cumilla during 2019-20

Cropping Pattern	REY (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
T ₁	31.4	628000.00	195880.00	432120.00	3.20
T ₂	51.1	1022000.00	230380.00	791620.00	4.43

Existing CP (T₁) = Potato-Maize-T. Aman and Improved CP (T₂) = Potato-Maize+Coriander-T. Aman rice

Conclusion

Based on the cropping pattern research, it may be concluded improved cropping pattern such as Potato (var. BARI Alu-40)-Maize (var. BARI Hybrid Bhutta-16)+Coriander (Hybrid Morokko)-T. Aman (var. BRRI dhan49) is agronomically feasible and economically profitable compared to the existing farmers cropping pattern Potato (BARI Alu-7)-Maize (NK-40)-T. Aman (BRRI dhan32). Due to growing of four crops in a year in the same piece of land cropping intensity and productivity have increased, more employment opportunity for male and female labors are generated and food and nutritional security is ensured for the farmers and the nation as a whole.

DEVELOPMENT OF BLACK GRAM-BORO RICE-FALLOW CROPPING PATTERN AGAINST FALLOW-BORO RICE-FALLOW CROPPING PATTERN IN UPPER CATENA OF HAOR AREA IN KISHOREGANJ

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Abstract

Changing single crop system to double crops pattern can play a potential role for achieving countries food security. With this view to increase crop productivity, production efficiency, land use efficiency and economic return through intensifying cropping intensity as well as crop diversity by transforming single cropping pattern to two crops, the experiment was conducted in Old Meghna Estuarine Floodplain Soils under the Agro-Ecological Zone (AEZ) 19 at Nunir haor, under the Multi-location Testing Site, Nikli, Kishoreganj, for two consecutive years 2019-20 and 2020-21. Two crops pattern black gram-Boro rice-fallow was tested at on-farm condition over the existing single crop pattern only Boro rice after flood water receded. Findings revealed that the mean crop duration of 185-189 days were required for one cycle in a year in improved cropping pattern which implied that two crops based cropping pattern was agronomically feasible to replace existing cropping pattern. Total grain yield in terms of REY of improved cropping pattern was 9.742 t ha⁻¹/year which was 29.38% higher than that of existing pattern (7.53 t ha⁻¹/year). Mean production efficiency of improved cropping pattern (52.09 kg ha⁻¹/day) which was 39% less than that of existing pattern due to more time involvement in improved pattern. Land use efficiency of improved cropping pattern was 51.23% i.e. 79.81% higher than that of existing cropping pattern. The gross return and gross margin were higher in the improved cropping pattern compared to existing cropping pattern due to additional yield of black gram and Boro rice with improved management practices. Therefore, farmers of haor region of Bangladesh could follow alternate cropping pattern in their medium high land to high land where lands remain fallow for 81-86 days after flood water receded for higher crop productivity and profitability.

Introduction

The average cropping intensity in Nikli upazilla of Kishoreganj is 112% whereas national average is 195% and the country is losing 0.49% cultivable land every year for high population pressure and other purposes (Hasan et al., 2013). Ensuring food security of increased population, the country needs to be increased food production by increasing cropping intensity. At last week of September to second week of October, 10-15% areas of this upazilla are suitable for crop cultivation. Farmers are waiting to produce Boro rice in this plot by irrigation with deep tub well. As a result, the vast area remains fallow for long time 80-90 days after flood water receded. So, there is a great scope of increasing cropping intensity as well as crop productivity here. If short duration BARI Mash-3 can be included, then farmers can easily cultivate Boro rice on those lands. Potential adoption of black gram in Fallow-Boro rice-Fallow cropping system would generate employment and additional income of the farmers by utilization fallow and underutilize lands in the haor areas. Considering the above facts, an adaptive trial on Black gram-Boro rice-fallow was conducted in the same piece of land in a year at Guroy in Kishoreganj with the following objectives.

1. To develop two crop-based cropping pattern for haor areas and
2. To increase cropping intensity, productivity and economic return

Materials and Methods

The study was carried out during two consecutive years 2019-20 and 2020-21 at farmer's field, at Nunir haor, Nikli, Kishoreganj (located in Agro Ecological Zone-19) under Old Meghna Estuarine Floodplain Soils. This trial was conducted to derive the economic consequences of two cropping patterns viz. IP: improved pattern (Black gram -Boro rice-Fallow) and FP: farmer's pattern (Fallow-Boro rice-Fallow) through incorporation of high yielding varieties with improved management practices.

In the improved pattern, Black gram var. BARI Mas-3 was introduced against fallow period. Boro rice var. BRRI dhan29 was used in both farmers pattern and improved pattern, respectively. The agronomic parameters and cultural operation for crop production under improved and farmer's practices are presented in Table 1. All field operation and management practices of both farmer's and improved pattern were closely monitored and the data were recorded for agro-economic performance. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Results and Discussions

Grain and By-product Yield: Results of improved cropping pattern black gram-Boro rice-fallow and the farmer's existing pattern fallow-Boro rice-fallow have been presented in Table 2. The result revealed that seed yield of BARI Mash-3 were 0.93 and 0.98 t ha⁻¹ and that of stover yield were 1.4 and 1.39 t ha⁻¹, respectively. The mean yield of black gram was observed 0.96 t ha⁻¹. Only 5.37% yield increase was observed in second year might be due to less infestation of *spodoptera litura* than previous growing season. Grain yield of Boro rice in improved pattern was 7.40 t ha⁻¹ in 1st year and it was 7.25 t ha⁻¹ in 2nd year with grain and straw yields of Boro rice were 7.33 and 3.68 t ha⁻¹. Lower yield of Boro rice in farmers practice were 7.2 and 7.1 t ha⁻¹, in 1st and 2nd year and mean grain and straw yield of Boro rice were 7.15 and 3.8 t ha⁻¹ from farmers practice. From the study it has been observed that in the improved pattern under black gram-Boro rice -fallow cropping pattern gave higher grain and by-product yield (Table 1) while the lower yield of Boro rice in farmers' practice might be due to imbalanced fertilizer and poor management practice. Similar results in higher productivity were also obtained by Nazrul et al. (2013), Khan et al. (2006), Khan et al. (2005) and Hossain and Wahhab (1992).

Rice equivalent yield: The mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield (9.742 t ha⁻¹/yr) over farmers' (7.53 t ha⁻¹/yr) pattern (Table 2). Inclusion of high yielding black gram variety and improve management practices increased by 29% compared to farmers' practice. Lower rice equivalent yield was obtained in the farmers' pattern due to traditional management practices.

Production efficiency: Maximum production efficiency (72.42) in terms of kg ha⁻¹/day was obtained from farmers existing cropping pattern (Table 2) because it takes less time. This result was found contradictory noted by Nazrul *et al.* (2013), Khan *et al.* (2006), and Khan *et al.* (2005).

Land utilization index (LUI): Land utilization index (LUI) is an effective way of using land in a cropping year which depends on individual crop duration. It indicated that improved pattern used the land for 51% period of the year, whereas farmers' pattern for 28% period of the year (Table 2). The higher land utilization index in improved pattern because this pattern occupied the field for longest duration (185-189 days), whereas farmers' pattern occupied the field for 102-106 days of the year.

Cost and return analysis

The benefit cost ratio of improved pattern and rice based farmers' existing pattern are presented in Table 3. From the economic point of view, the gross return of improved cropping pattern (194840 Tk ha⁻¹) showed its superiority by 29% over farmers' existing pattern (150600 Tk ha⁻¹). The production cost of the improved pattern (101775 Tk ha⁻¹) was higher than farmers' pattern (83740 Tk ha⁻¹) due to inclusion of black gram and improve management which takes extra cost of inputs of the production. The gross margin was substantially higher in the improved pattern (93065Tk ha⁻¹) than farmers' pattern (66860 Tk ha⁻¹). The higher gross margin of the improved pattern (39%) was achieved mainly higher yield advantages of the component crops. The mean marginal benefit cost ratio (MBCR) was found 2.5 which indicated the superiority of the improved cropping pattern over the farmers' pattern. The marginal

benefit cost ratio (MBCR) also showed that inclusion of black gram in the existing pattern might be profitable and acceptable to the farmers.

Disease and Pest infestations

Black gram crop was infested by *spodoptera litura*, leaf roller and flea beetle which was controlled by spraying of tracer twice @ 0.4 ml L⁻¹ water at 10-15 days interval, karate 2.5 Ec @ 1ml L⁻¹ water at 5-7 days interval. Boro rice was sporadically infested by rice stem borer, rice bug, rice brown plant hopper and rice hispa. Furadan 5G @ 10 kg ha⁻¹ was applied during final land preparation and Virtako 40WG @ 1.5 g per 10L water was sprayed twice at 10 days interval for controlling stem borer. Dursban @ 2mlL⁻¹ and Marshal 2 mL⁻¹ water were sprayed at 55 and 65 DAT for controlling other insects.

Farmers' opinion

All the farmers under the present study expressed their satisfaction and could be grown black gram after flood water receded with zero tillage and Boro rice. A good number of farmers are also willing to produce quality black gram seeds for their own and their areas.

Table 1. Agronomic practices of improved and farmers' existing pattern during 2019-20 and 2020-21

Parameter	Year	Improved Pattern (IP)		Farmers' Pattern (FP)
		Black gram	Boro rice	Boro rice
Variety	2019-20	BARI Mash-3	BRRI dhan29	BRRI dhan29
	2020-21	BARI Mash-3	BRRI dhan29	BRRI dhan29
Sowing/ transplanting	2019-20	16 Oct. 2019	26 Jan. 2020	05-10 Jan. 2020
	2020-21	27 Oct. 2020	23 Jan. 2021	10-12 Jan. 2021
Seedling age (days)	2019-20	-	35-40	40-45
	2020-21	-	35-40	35-40
Seed rate (kg ha ⁻¹)	2019-20	40	50	50
	2020-21	40	50	50
Planting method	2019-20	Broadcast	Line	Line
	2020-21	Broadcast	Line	Line
Spacing (Row×hill)	2019-20	Continuous	20cm × 15cm	20cm × 15cm
	2020-21	Continuous	20cm × 15cm	20cm × 15cm
Seedling/hill	2019-20	-	2-3	3-4
	2020-21	-	2-3	3-4
Fertilizer dose (NPKSZnB kg ha ⁻¹)	2019-20	20-18-20-10-0-02	140-18-53-08-03-02	115-40-63-14-0-0
	2020-21	20-18-20-10-0-02	140-18-53-08-03-02	115-40-63-14-0-0
Fertilizer application method	-	Entire N, P, K, S & B applied as basal after final land preparation.	Entire amount of P K S and Zn fertilizers were applied as basal. N fertilizer was applied in three equal splits, 1 st top dress was done after seedling establishment, 2 nd one at early tillering stage and 3 rd one at 5-7 days prior to panicle initiation (PI) stage	Entire amount of P K S and Zn fertilizers were applied as basal. N fertilizer was applied in three equal splits, 1 st top dress was done after seedling establishment, 2 nd one at early tillering stage and 3 rd one at 5-7 days prior to panicle initiation (PI) stage
Weeding (no.)	2019-20	Once	Twice at 15-20 and 35-40 DAT	Twice at 15-20 and 35-40 DAT
	2020-21	Once	Twice at 15-20 and 35-40 DAT	Twice at 15-20 and 35-40 DAT
Irrigation (no.)	2019-20	Once	Several times	Several times
	2020-21	Once	Several times	Several times
Insect/ pest control	2019-20	IPM	IPM	Chemical
	2020-21	IPM	IPM	Chemical
Harvesting time	2019-20	10 Jan, 2020	08 May, 2020	20-24 April, 2020
	2020-21	16 Jan, 21	07 May, 2021	22-24 April, 2021
Grain yield (t ha ⁻¹)	2019-20	0.93	7.40	7.20
	2020-21	0.98	7.25	7.10

Parameter	Year	Improved Pattern (IP)		Farmers' Pattern (FP)
		Black gram	Boro rice	Boro rice
Straw yield (t ha ⁻¹)	2019-20	1.4	4.0	4.10
	2020-21	1.39	3.35	3.50
TAT (days)	2019-20	161	16	259
	2020-21	173	07	263
Field duration(day)	2019-20	86	103	106
	2020-21	81	104	102

Table 2. Rice-equivalent yield, production efficiency and land utilization index of improved and farmers' cropping pattern at haor area of Kishoreganj during 2019-20 and 2020-21

Items	Improved pattern			Farmers' pattern		
	2019-20	2020-21	Average	2019-20	2020-21	Average
REY (tha ⁻¹ yr ⁻¹)	9.80	9.684	9.742	7.61	7.45	7.53
PE (kg ha ⁻¹ day ⁻¹)	51.85	52.35	52.10	71.79	73.04	72.42
LUI (%)	51.78	50.68	51.23	29.04	27.95	28.49

REY=Rice equivalent yield, PE=production efficiency and LUI= land utilization index

Table 3. Cost and return analysis of improved and farmers' cropping pattern in Kishoreganj during 2019-20 and 2020-21

Items	Improved pattern			Farmers' pattern		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean
Gross return (Tk ha ⁻¹)	196000	193680	194840	152200	149000	150600
Total variable cost (Tk ha ⁻¹)	100850	102700	101775	85500	81980	83740
Gross margin (Tk ha ⁻¹)	95150	90980	93065	66700	67020	66860
MBCR	2.85	2.16	2.50	-	-	-

Price of input (Tk kg⁻¹): Urea: 16, TSP: 22, MOP: 16, Gypsum: 10, Zinc sulphate: 130 and Boric acid: 300, Black gram seed: 85, rice seed: 40; Selling price (Tk/kg): Black gram: 40, Boro rice:20 and Straw: 2

Conclusion

The research findings indicated that *black gram-Boro rice-fallow* cropping pattern could be fitted in some haor areas of Bangladesh with higher benefit. Inclusion of black gram in the pattern will increase pulses production of the country as well as increase cropping intensity and productivity in haor areas.

DEVELOPMENT OF MAIZE-KENAF-FALLOW CROPPING PATTERN AGAINST EXISTING FALLOW-BORO- FALLOW CROPPING PATTERN IN UPPER CATENA OF HAOR AREA

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Abstract

An attempt was taken to transform Fallow-Boro rice-Fallow cropping pattern into Maize-Kenaf-Fallow to develop two crops-based cropping patterns in upper catena of haor areas and its agro-economic performance through modern variety and improved technology. With the inclusion of maize and kenaf against rice based pattern was compared in farmers' field at haor region of Kishoreganj during 2019-20 and 2020-21. The inclusion of maize and kenaf against Boro rice increased the rice equivalent yield (REY) 68% than the farmers' existing pattern. The gross return was increased by 67% in Maize-Kenaf-Fallow sequences compared to existing Fallow-Boro rice-Fallow cropping pattern. The marginal benefit cost ratio, land utilization index and production efficiency indicated the superiority of the improved pattern over the farmers' practices.

Introduction

The present cropping intensity of Nikli upazilla of Kishoreganj district is only about 112% which is very low then the country's cropping intensity 195%. After flood water receded 10-15% land in haor areas is suitable for crop cultivation in last week of October or first week of November. At that time,

farmers are waiting for cultivating Boro rice with irrigation by deep tube well up to December 2nd week to first week of January. If farmers cultivate maize in their fallow land it will harvest at March. After harvesting maize farmers can easily grow Kenaf which will not be affected by flash flood. Farmers will bear additional cost of Boro rice cultivation and other expenses from the income of maize. The present study was taken to achieve the following objectives.

- i) To develop two crops-based cropping patterns for haor areas.
- ii) To increase cropping intensity, total productivity and economic return

Materials and Methods

The experiment was conducted at the farmers' field of Nikli upazila under Kishoreganj district of Bangladesh during 2019-20 and 2020-21. The soil of experimental site was clay loam having pH 6.4 under the Agro-Ecological Zone-19 (AEZ-19). The improved cropping pattern (IP) Maize-Kenaf-Fallow was tested against the farmers' pattern (FP) Fallow-Boro rice-Fallow cropping pattern with three dispersed replications. Unit plot size was 35 decimal. All agronomic activities including sowing/transplanting and harvesting dates, seed rate, plant spacing, fertilizer management (FRG, 2018) etc. are mentioned in table 1. Irrigation, pest managements and other intercultural operations were done as and when necessary. Crop cut was done from an area of one square meter at three spots from each plot for yield samples in all cases. Agronomic performance like field duration, rice equivalent yield, gross return, gross margin, benefit cost ratio, production efficiency and land utilization index were calculated. For comparison between crop sequences, the yield of all crop were converted into rice equivalent on the basis of prevailing market prices of individual crop (Verma and Modgal, 1983). Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Results and Discussions

Grain and By-product Yield: Results of improved cropping pattern Maize-Kenaf-Fallow and the farmer's existing pattern Fallow-Boro rice-Fallow have been presented in Table 1. The result revealed that grain and by-product yield of BARI hybrid maize-9 was found to be 9.38 t ha^{-1} and 5.44 t ha^{-1} , respectively (Table 2). The fibre and stick yield of Kenaf were estimated at 2.103 t ha^{-1} and 4.52 t ha^{-1} , respectively whereas grain and straw yield of Boro rice was found to be 7.20 t ha^{-1} and 3.8 t ha^{-1} , respectively (Table 2).

Rice equivalent yield: The mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield ($12.69 \text{ t ha}^{-1}/\text{yr}$) over farmers' ($7.54 \text{ t ha}^{-1}/\text{yr}$) pattern (Table 3). Inclusion of high yielding maize and kenaf and modern production technology in the improved pattern influenced increased the rice equivalent yield and total productivity increased by 68% compared to farmers' practice. Lower rice equivalent yield was obtained in the farmers' pattern due to single crop and traditional management practices.

Production efficiency: Maximum production efficiency (69.64) in terms of $\text{kg ha}^{-1}\text{day}^{-1}$ was obtained from existing cropping pattern (Table 3). The higher production efficiency of existing cropping pattern might be due to lower time involvement in single crop (only Boro rice production) which is dissimilar to Nazrul *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005).

Land utilization index (LUI): Land utilization index (LUI) is an effective way of using land in a cropping year which depends on individual crop duration. The LUI indicated that improved pattern used the land for 62% period of the year, whereas farmers' pattern used the land for 30% period of the year (Table 3). The higher land utilization index in improved pattern because this pattern occupied the field for longest duration (226 days), whereas farmers' pattern occupied the field for 109 days of the year (Table 1).

Cost and return analysis

The benefit cost ratio of improved pattern and rice based farmers' existing pattern are presented in Table 4. From the economic point of view, the gross return of improved cropping pattern (Tk. 283206 ha^{-1}) showed its superiority by 67% over farmers' existing pattern (Tk. 169437 ha^{-1}). The production cost of

the improved pattern (Tk.138797 ha⁻¹) was higher than farmers' pattern (Tk.108037 ha⁻¹) due to inclusion of maize and kenaf which takes extra inputs for production. The gross margin was substantially higher in the improved pattern (Tk. 155996 ha⁻¹) than farmers' pattern (Tk. 72987 ha⁻¹). The mean marginal benefit cost ratio (MBCR) was found 3.70 which indicated the superiority of the improved cropping pattern over the farmers' pattern. The marginal benefit cost ratio (MBCR) also showed that inclusion of maize and kenaf in the existing pattern might be profitable and acceptable to the farmers.

Disease and Pest infestations

Maize was partially infested by cut worm and fall army worm which was controlled by sex pheromone of fall army worm and sprayed one time of carate @ 2 g L⁻¹ water and give one flash flood and sprayed also virtako @ 2 g L⁻¹ water at 7 days interval for 2 times. Boro rice was sporadically infested by rice stem borer, rice bug, rice brown plant hopper and rice hispa. Furadan 5G @ 10 kg ha⁻¹ was applied during final land preparation and virtako 40WG @ 1.5 g per 10L water was sprayed twice at 10 days interval for controlling stem borer. Dursban @ 2mL⁻¹ and Marshal 2 mL⁻¹ water were sprayed at 55 and 65 DAT for controlling other insects.

Farmers' opinion

All the farmers under the present study expressed their satisfaction and they showed their keen interest for growing kenaf after maize in future.

Table 1. Agronomic practices of improved and farmers' existing pattern during 2019-20 and 2020-21

Parameter	Year	Improved Pattern (IP)		Farmers' Pattern (FP)
		Maize	Kenaf	Boro rice
Variety	2019-20	BARI Hybrid maize-9	BJRI-2	BRRI dhan29
	2020-21	BARI Hybrid maize-9	BJRI-2	BRRI dhan29
Sowing/ transplanting	2019-20	28 Oct. 2019	05 April, 2020	15 Jan., 2020
	2020-21	09 Nov. 2020	15 April, 2021	10 Jan., 2021
Seedling age (days)	2019-20	-	-	40
	2020-21	-	-	45
Seed rate (kg ha ⁻¹)	2019-20	25	15	50
	2020-21	25	15	50
Planting method	2019-20	Line	Broadcast	Line
	2020-21	Line	Broadcast	Line
Spacing (Row×hill)	2019-20	60cm × 25cm	Continuous	20cm × 15cm
	2020-21	60cm × 25cm	Continuous	20cm × 15cm
Seedling/hill	2019-20	-	-	3-4
	2020-21	-	-	3-4
Fertilizer dose NPKSZnB kg ha ⁻¹)	2019-20	265-50-110-40-5-1.5	61-5-20-4-0-0	115-40-63-14-0-0
	2020-21	265-50-110-40-5-1.5	61-5-20-4-0-0	115-40-63-14-0-0
Fertilizer application method	-	All of P, K, S, Zn, B fertilizers and one third N were applied as basal after final land preparation. The remaining N was applied in two equal installments. The first installment was applied 30-35 days after seed germination (8-10 leaves stage) and second installment was applied 60-65 days after seed germination.	Entire amount of P, K, S and half of N fertilizers were applied as basal after final land preparation. The remaining N was applied 45 days after seed sowing	Entire amount of P K S and Zn fertilizers were applied as basal. N fertilizer was applied in three equal splits, 1 st top dress was done after seedling establishment, 2 nd one at early tillering stage and 3 rd one at 5-7 days prior to panicle initiation (PI) stage
Weeding (no.)	2019-20	Twice	-	Twice at 15-20 and 35-40 DAT
	2020-21	Twice	-	Twice at 15-20 and 35-40 DAT
Irrigation (no.)	2019-20	Three times as per BARI rec.	-	Several times
	2020-21	Three times as per BARI rec.	-	Several times
	2019-20	IPM	IPM	Chemical

Parameter	Year	Improved Pattern (IP)		Farmers' Pattern (FP)
		Maize	Kenaf	Boro rice
Insect/ pest control	2020-21	IPM	IPM	Chemical
Harvesting time	2019-20	25 March, 2020	22 June, 2020	09 May, 2020
	2020-21	08 April, 21	30 June, 2021	23 April, 2021
TAT (days)	2019-20	127	11	259
	2020-21	140	07	246
Field duration(day)	2019-20	148	78	114
	2020-21	150	76	103

Table 2. Yield performance of crops under improved and farmers existing pattern at haor area of Kishoreganj during 2019-20 and 2020-21

Parameter	Year	Improved Pattern (IP)		Farmers' Pattern (FP)
		Maize	Kenaf	Boro rice
Grain/fibre Yield (Kg ha ⁻¹)	2019-20	9285	2074	7240
	2020-21	8791	2132	7153
Straw/stick yield (kg ha ⁻¹)	2019-20	5486	4367	4108
	2020-21	5391	4671	3516

Table 3. Rice-equivalent yield, production efficiency and land utilization index of improved and farmers' cropping pattern at haor area of Kishoreganj during 2019-20 and 2020-21

Items	Improved pattern			Farmers' pattern		
	2019-20	2020-21	Average	2019-20	2020-21	Average
REY (tha ⁻¹ yr ⁻¹)	13.59	11.78	12.69	7.65	7.43	7.54
PE (kg ha ⁻¹ day ⁻¹)	60.14	50.19	55.17	67.11	72.18	69.64
LUI (%)	61.92	61.92	61.92	31.23	28.22	29.73

REY=Rice equivalent yield, PE=production efficiency and LUI= land utilization index

Table 4. Cost and return analysis of improved and farmers' cropping pattern in Kishoreganj during 2019-20 and 2020-21

Items	Improved pattern			Farmers' pattern		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean
Gross return (Tk ha ⁻¹)	271833	294580	283206	153016	185857	169437
Total variable cost (Tk ha ⁻¹)	125970	128450	127210	95424	97475	96450
Total cost (Tk ha ⁻¹)	137557	140037	138797	107011	109062	108037
Gross margin (Tk ha ⁻¹)	145863	166130	155996	57592	88382	72987
Net return (Tk ha ⁻¹)	134276	154543	144409	46005	76795	61400
MBCR	3.89	3.51	3.70	-	-	-

Price of input (Tk kg⁻¹): Urea: 18, TSP: 15, MoP: 22, Gypsum: 34, Zinc sulphate: 130 and Boric acid: 300, Kenaf seed: 450, rice seed: 80; Selling price (Tk kg⁻¹): Maize: 16.25 (2019-20) and 17.50 (2020-21), Boro:20 (2019-20) and 25(2020-21), Kenaf fibre: 42.50 (2019-20) and 50.00 (2020-21), Kenaf stick: 5.00 and rice straw: 2.00.

Conclusion

The research findings indicated that maize- kenaf- fallow cropping pattern is applicable in some haor areas of Bangladesh and can be easily fitted in the existing pattern with higher benefit. Inclusion of kenaf after maize in the pattern could increase fibre production and kenaf stick is very popular as fuel in the haor areas of the country as well as increase cropping intensity and productivity.

DEVELOPMENT OF RED AMARANTH-GARDEN PEA-OKRA-T. AMAN RICE CROPPING PATTERN AGAINST EXISTING RED AMARANTH-OKRA-T. AMAN IN MYMENSINGH REGION (AEZ 9)

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Abstract

The experiment was conducted at Multilocation Testing Site (MLT) Trishal under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2018-19 and 2019-2020 to study the comparative agro-economic performance of four crop based pattern and farmers' existing cropping pattern for increasing cropping intensity and productivity. Four crop based cropping pattern (Red amaranth-Garden pea-Okra-T. Aman) and farmers' existing cropping pattern (Red amaranth-Okra-T. Aman) with one rice crop as control were tested. Four crops can be grown successfully one after another in sequence of the tested pattern. The highest rice equivalent yield (43.69 t ha^{-1}) was obtained from 4-crop based cropping pattern. Gross return of the improved pattern was Tk.709962.5 ha^{-1} which was 98% higher over farmers' pattern. The marginal benefit cost ratio (MBCR) was found 3.74. The marginal benefit cost ratio (MBCR) analysis showed that inclusion of garden pea and improved production technology of other existing crop in the existing pattern might be profitable and acceptable to the farmers.

Introduction

In Mymensingh region one of the cropping pattern followed by the farmer in medium highland are vegetables-vegetables-rice. This pattern covered in some areas around less than 10% of cultivable land area (DAE, 2014). But farmers do not follow any specific pattern to fix up the pattern. Sometimes sporadic pattern are followed in three crops based with rice cultivation. But this pattern could be followed a four crops based cropping pattern. The average cropping intensity in Bangladesh is 191% and the country is losing 1% cultivable land every year for high population pressure and other purposes. Ensuring food security of increased population the country needs to be increased food production by increasing cropping intensity. So, there is a great scope of increasing cropping intensity as well as crop productivity here in Mymensingh. Bangladesh Agricultural Research Institute has developed some 4-crops based cropping patterns by inclusion of vegetable which needed to be disseminated at the farmers' field. Following the modern technologies, cropping intensity may increase up to 400% or more. For successful execution of the program, it requires selection of high yielding short duration crop varieties along with suitable land and farmers' awareness etc. Oilseed, tuber crops, pulses and vegetables are the vital group of crops which are mostly grown in rabi season but area of those crops decreased due to increased irrigated Boro rice. Development of short duration varieties of rice, mustard, potato, pulses and vegetables does have the opportunities been created to accommodate four crops in the same piece of land in a year. Potential adoption of mustard, mungbean, potato and vegetables in Boro-Fallow-T. Aman-Fallow cropping system would generate employment and additional income of the farmers by utilizing fallow and under-utilized lands in the country. Considering the above facts, a trial on Red amaranth-Garden pea-Okra-T. Aman was conducted in the same piece of land in a year at Mymensingh.

Materials and Methods

The trial was conducted to increase cropping intensity and productivity by incorporating high value garden pea in the existing cropping system (Red amaranth-Okra-T. Aman) during 2018-19 and 2019-2020. The experimental site belongs to tropical monsoon climate with high rainfall. Maximum rainfall was received during the months of April to September. The annual rainfall of the study period was 1854 mm. Mean annual minimum and maximum temperature was 21.18 and 29.58°C respectively. Monthly maximum, minimum and mean air temperature (°C), total rainfall (mm) and relative humidity (%) have been presented in Appendix Table 2. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Table 1. Agronomic parameters of four crop based cropping pattern and farmers' existing pattern at Mymensingh during 2018-2019 and 2019-2020

Parameters	Year	Four Crop Based Pattern (IP)				Farmers' Pattern (FP)		
		Red amaranth	Garden pea	Okra	T. Aman	Red amaranth	Okra	T. Aman
Variety		BARI Laalshak-1	BARI Motorshuti-3	BARI Dherosh-2	Binadhan-7/ BRRI dhan75	Local	Hybrid	BRRI dhan49
Sowing/transplanting	2018-2019	17 Nov, 2018	25 Dec, 2018	15-17 March 2019	02 August, 2019	25-27 Nov, 2018	25-30 Jan, 2019	05 Aug, 2019
	2019-2020	20 Nov, 2019	28-29 Dec, 2019	20-23 March, 2020	3-5 August, 2020	28-30 Nov, 2019	1-5 Feb, 2020	02-07 Aug, 2020
Spacing (Row×hill)		Broadcast	30cm×continuous sowing	50cm×40cm	10cm×15cm	Broadcast	Broadcast	20cm×20cm
Seedling age (days)		-	-	-	25-30		-	30-40
Fertilizer (kg NPKSZnBha ⁻¹)		92-20-75-0-0-0 along with 10 ton Cow dung ha ⁻¹	46-30-50-0-0-0 Along with 10-12 t ha ⁻¹ CD	69-20-75-0-0-0	92-25-50-11-3.5-0	100-0-0-0-0-0	100-50-100-0-0-0	95-23-15-6-0-0
Parameters	Year	Four Crop Based Pattern (IP)				Farmers' Pattern (FP)		
		Red amaranth	Garden pea	Okra	T. Aman	Red amaranth	Okra	T. Aman
Irrigation		-	-	-	5-7	-	-	5-7
Insect-pest/Rodent control		IPM	IPM	IPM	IPM	Chemical	Chemical/no control measure	Chemical
Harvesting time	2018-19	20 Dec, 2018	1-10 March, 2019	17 April-31 May, 2019	30 Oct, 2019	28 Dec, 2018	01 April- 15 May 2019	05-12 Nov, 2018
	2019-20	22 Dec, 2019	3-15 March, 2020	24 May to 28 June, 2020	28 Oct, 2020	30 Dec, 2019	7 April-22 May, 2020	07-13 Nov, 2019
TAT (days)	2018-19	17	5	7	62	19	28	80
	2019-20	22	7	8	38	20	33	74
	Av	19	6	7	50	19	30	77
Field duration (days)	2018-19	33	70	75	90	32	68	94
	2019-20	32	74	95	88	31	69	97
	Av	32	72	85	89	31	68	95

Results and Discussions

Grain yield and By-product yield: After two years in study 4-crop based cropping pattern (Red amaranth-Garden pea-Okra-T. Aman) and farmer's existing pattern (Red amaranth-Okra-T. Aman) have been presented in Table 3. The average yield of red amaranth was 13.0 tha⁻¹ while garden pea and okra gave 8.48 and 18.4 tha⁻¹. The grain and straw yield of T. Aman rice were 3.65 and 3.90 tha⁻¹, respectively. It was revealed that in all the 4-crop of Red amaranth-Garden pea-Okra-T. Aman cropping pattern gave higher grain yield except the T. Aman rice (Table 2). Yield of T. Aman rice in 4-crop pattern decreased a negligible amount might be due to varietal performance.

Field Duration: Field duration of cropping pattern comprises on the individual crop duration. The farmers' cropping pattern Red amaranth-Okra-T. Aman has needed 194 days field duration and improved cropping pattern Red amaranth-Garden pea-Okra-T. Aman has needed 278 days (excluding seedling age of rice) to complete the cycle (Table 1). Result indicated that garden pea could be easily fitted in existing cropping pattern with 82 days turnaround time in a year. Similar trend was also observed by Mondal *et al.* (2015).

Rice equivalent yield: Four crop based cropping pattern produced higher rice equivalent yield ($43.69 \text{ t ha}^{-1} \text{ yr}^{-1}$) over farmers' ($22.03 \text{ t ha}^{-1} \text{ yr}^{-1}$) existing cropping pattern (Table 3). Inclusion of high value garden pea crop in rabi season in existing cropping pattern increased REY by 49% compared to farmers' practice. These results are in agreement with Mondal *et al.* (2015).

Production efficiency: Maximum production efficiency ($156 \text{ kg ha}^{-1} \text{ day}^{-1}$) was obtained from four crop based pattern and minimum ($149 \text{ kg ha}^{-1} \text{ day}^{-1}$) in farmers' practice (Table 3). The higher production efficiency in 4-crop based cropping pattern might be due to inclusion of high value crop garden pea and improved management practices. Similar trend were also noted by Nazrul *et al.* (2013) and Khan *et al.* (2006).

Land Utilization Index (LUI): Land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. Land utilization index (LUI) indicated that 4-crop based cropping pattern used the land for 76% period of the year, whereas farmers' pattern used the land for 53% period of the year (Table 3). The higher land use efficiency in four crop based pattern because this pattern occupied the field for longest duration (278 days), whereas the farmers' pattern occupied the field for 194 days of a year.

Pest and disease incidence: Rice stem borer, rice bug, rice brown plant hopper, rice hispa and sheath blight were observed sporadically in some plots of T. Aman rice field. Furadan 5G @ 10 kg ha^{-1} was applied during final land preparation and Virtako 40WG @ $1.5 \text{ g } 10\text{L}^{-1}$ water was sprayed twice at 10 days interval for controlling stem borer. Dursban @ 2 mL^{-1} and Marshal 2 mL^{-1} water were sprayed at 55 and 65 DAT for controlling other insects. Folicur @ 0.5 mL^{-1} water was sprayed to control sheath blight disease.

Cost and return analysis

From the economic point of view, four crop based improved cropping pattern showed its superiority over farmers' pattern. Gross return of four crop based improved pattern was Tk. 1040060 ha^{-1} which was 85% higher over farmers' pattern (Tk. 560300 ha^{-1}). Total variable cost was higher in improved pattern (Tk. 400508 ha^{-1}) might be due to inclusion component crops and production technology in the pattern. The gross margin was substantially higher in the improved pattern (Tk. 639552 ha^{-1}) than in farmers' pattern (Tk. 333732 ha^{-1}). The higher gross margin of the improved pattern was achieved mainly higher yield advantages of the component crops. The marginal benefit cost ratio (MBCR) was found 2.75 which indicated the superiority of the improved pattern over the farmers' pattern. The marginal benefit cost ratio (MBCR) analysis showed that inclusion of cucumber and improved technology for potato production in the existing pattern might be profitable and acceptable to the farmers. These results are supported by Mondal *et al.*, (2015) who reported that inclusion of potato, in the existing pattern showed higher benefit.

Farmers' opinion

Farmers' opined that cultivation of 4-crop in a year increased crop productivity undoubtedly but it is very difficult to manage especially for establishing cucumber after harvesting of Boro rice due to rainfall.

Table 2. Yield of four crop based cropping pattern and farmers' cropping pattern at Mymensingh, during 2018-19 and 2019-2020

Cropping pattern	Year	Grain/Tuber yield (t ha^{-1})				By-product yield (t ha^{-1})			
		Red amaranth	Garden pea	Okra	T. Aman	Red amaranth	Garden pea	Okra	T. Aman
4-crop based pattern	2018-19	14.0	7.2	19.05	3.3	-	-	-	3.5
	2019-20	12.0	9.75	17.75	4.0	-	-	-	4.3
	Av	13.0	8.48	18.4	3.65	-	-	-	3.9
Cropping pattern	Year	Grain/Tuber yield (t ha^{-1})				By-product yield (t ha^{-1})			
		Red amaranth	Garden pea	Okra	T. Aman	Red amaranth	Garden pea	Okra	T. Aman
FP	2018-19	10.0	-	17.0	3.5	-	-	-	3.5
	2019-20	9.0	-	15.0	4.0	-	-	-	4.3
	Av	9.5	-	16.0	3.75	-	-	-	3.9

Table 3. Rice-equivalent yield, production efficiency and land utilization index of improved and farmers' cropping pattern at Mymensingh during 2018-19 and 2019-2020

Cropping pattern	Year	Rice-equivalent yield (t ha ⁻¹ yr ⁻¹)	Production efficiency (kg ha ⁻¹ day ⁻¹)	Land utilization index (%)
Red amaranth-Garden pea-Okra-T. Aman (IP)	2018-2019	41.56	162.50	73.42
	2019-2020	45.82	150.52	79.18
	Av	43.69	156.51	76.30
Red amaranth-Okra-T. Aman (FP)	2018-2019	22.88	157.22	53.15
	2019-2020	21.17	142.13	53.97
	Av	22.03	149.67	53.56

Table 4. Average cost and return analysis of four crop based improved and farmers' cropping pattern at Mymensingh during 2018-19 and 2019-2020

Cropping pattern	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	MBCR
Red amaranth-Garden pea-Okra-T. Aman (IP)	709962.5	220580	489382	3.74
Red amaranth-Okra-T. Aman (FP)	357987	126558	231419	-

Price (Tk kg⁻¹): Red amaranth=6, Garden pea=35, Okra=15 and T. Aman=16.25 and Straw=2

Conclusion

A high value garden pea could be grown in between farmer existing pattern Red amaranth-Okra-T. Aman rice crops. Cultivation of four crops could be created employment opportunity for male and female labors and increased crop productivity by increasing cropping intensity.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN VEGETABLE-BORO-T. AMAN RICE AGAINST VEGETABLE-FALLOW - T. AMAN

M. Asaduzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2018-19 and 2019-2020 to improve the existing cropping pattern by inclusion of vegetable and to increase crop yield and farmers income. The experiment was laid out in 4800 m² of land under 6 farmers. Alternate cropping pattern Cauliflower (Var. 770) - Boro (BRRI dhan50) - T. Aman (BRRI dhan57) gave higher whole pattern gross margin (Tk. 123890 ha⁻¹) against the existing pattern Vegetable (White snow)-Fallow-T. Aman (BRRI dhan39) (Tk. 101430 ha⁻¹).

Introduction

Farmers at Narsingdi followed different types of cropping pattern. Vegetable-Fallow – T. Aman is one of the important cropping patterns to them. Horticulture Research Centre, BARI has developed a number of short duration high yielding cauliflower varieties. It needs to popularize among the farmers by fitting cauliflower in the existing cropping pattern (Vegetable- Fallow – T. Aman). The alternate cropping pattern (Vegetable - Boro – T. Aman) was evaluated to find out its suitability in terms of productivity and profitability.

Materials and Methods

The trial was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2018-19 and 2019-2020 Unit plot size was 800m². The improved cropping pattern was Vegetable (Var. 770) – Boro (BRRI dhan50) –T. Aman (BRRI Dhan57) against existing cropping pattern Vegetable (White snow)-Fallow – T. Aman (BRRI dhan39). The year wise agronomic practices and fertilizer doses are given different following Tables. Necessary irrigation, intercultural operations and pest management practices were

done as and when necessary. Data on yield and yield contributing characters and economics were recorded and analyzed as per objectives.

Results and Discussion

Crop management and yield performance of the pattern: The details of crop management under improved cropping pattern and farmers existing pattern are shown in Table 1. Field duration of cropping pattern comprises on the individual crop duration. Farmers' cropping pattern (Vegetable-Fallow-T. Aman rice) have needed 210 days field duration. Total field duration of three crops pattern (Vegetable-Boro-T. Aman rice) have needed 280 days (excluding seedling age of rice) to complete the cycle (Table 1). Result indicated that Boro rice could be easily fitted in Vegetable -Fallow-T. Aman rice cropping pattern. Average grain yield of Boro rice in the alternate cropping pattern were 5.49 t ha⁻¹. The yield of cauliflower (var.770) and BRRI dhan57 was 40.5 and 4.56t ha⁻¹ from the alternate cropping pattern. The yield of cauliflower (white snow) and BRRI dhan39 were 42.8 and 4.27t ha⁻¹ in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (20.18t ha⁻¹ yr⁻¹) over farmers' existing cropping pattern (14.97t ha⁻¹ yr⁻¹). Inclusion of Boro rice in existing cropping pattern increased REY 34.80% compared to farmers' practice (Table 1)

Cost and return: Gross return of improved cropping pattern was Tk.398010 ha⁻¹ which was more than 32.93% higher over farmers' pattern (Tk.299400ha⁻¹). Total variable cost was higher in improved pattern (TK.283460 ha⁻¹) might be due to inclusion of Boro rice in the pattern. The gross margin was substantially higher in the alternate pattern Tk.123890 ha⁻¹ than farmers' pattern (TK.101430ha⁻¹). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of Boro rice as a component crop.

Farmers opinion

Farmers were highly satisfied to obtain higher returns from alternate cropping pattern Cauliflower (var. 770) - Boro (var. BRRI dhan50) - T. Aman (var. BRRI dhan57) against existing pattern Cauliflower (White snow)- Fallow-T. Aman (var. BRRI dhan-57) due to higher yield as well as return. They also opined that the practice would be expanded in this area.

Table 1: Agronomic management practices of the crops for the existing and alternate cropping patterns at Shibpur, Narsingdi during 2018-2019 and 2019-2020(Average two years)

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Vegetable	Fallow	T. Aman	Vegetable	Boro	T. Aman
Variety	White snow	-	BRRI dhan 39	Var. 770	BRRI dhan 50	BRRI dhan 57
Spacing(cm)	60×45	-	20×15	30×5	20×15	20×15
Seedling age (days)	25	-	30-35	25	40-45	20-25
Transplanting days	10-15 November,19	-	1-15 July, 20	5-10 November, 19	20-25 January, 20	18-22 July, 20
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn and B)	120-40-100-0-0	-	130-20-30-12-0-2.5	138-40-125-1.2-0.7-0	130-22-35-10-0-2.5	130-20-30-12-0-2.5
Fertilizer application	Basal & Top dress	-	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress
Intercultural operation	-	-	2 Weeding	2 Weeding	2 Weeding	2 Weeding
Harvesting date	8-23 February,20		20-30 Oct. 20	10-20 Jan. 20	10-15 May, 20	21-26 Oct. 20
Field duration (seedling to seed)	90-100		105-110	65-70	110-115	95-100
Turnaround time (days)	T. Aman to Vegetable 11	-	Vegetable to T. Aman 125-130	T. Aman to Vegetable 15	Vegetable to Boro 5	Boro to T. Aman 60-65
Curd/grain yield (t ha ⁻¹) 2018-19	43.4	-	4.12	40.00	5.45	4.64
Curd/grain yield (t ha ⁻¹) 2019-20	42.2	-	4.41	41.00	5.52	4.48

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Vegetable	Fallow	T. Aman	Vegetable	Boro	T. Aman
Average	42.8	-	4.27	40.5	5.49	4.56
Rice Equivalent Yield (t ha ⁻¹)	14.97			20.18		
Gross margin (Tk. ha ⁻¹)	84000	-	12430	72500	24060	17990
Total variable cost (Tk. ha ⁻¹)	130000	-	72970	130000	80250	73210
Gross return (Tk. ha ⁻¹)	214000	-	85400	202500	104310	91200
Whole pattern Gross margin (Tk. ha ⁻¹)	101430			123890		

Price (tk. kg-1) : Boro Rice sold-19, T. Aman Rice sold -20, Rice straw-1.00, Cauliflower- 5

Conclusion

From the above findings, it could be concluded that yield as well as returns from alternate cropping pattern, Cauliflower (White snow)-Boro (var. BRRIdhan50)-T. Aman (var. BRRIDhan57) showed higher than existing pattern in the study area.

STUDY ON VEGETABLE BASED CROPPING PATTERN IN NARSINGDI

M. Asaduzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2017-18, 2018-2019 and 2019-2020 to study an economically profitable vegetable based cropping pattern in Narsingdi region for increasing cropping intensity and productivity as well as to meet the vegetable demand for farm family as well as the country. The studied vegetable based cropping patterns were CP1: Radish-Cauliflower-Danta-Indian spinach-Red amaranth, CP2: Red amaranth – Cauliflower-Ladies finger-Brinjal and CP3: Bottle gourd-Snack gourd-Country bean-Cucumber respectively. The results showed that five vegetable crops could successfully be grown one after another in a sequence in the farmer's field instead of two or three crops in a pattern. Study revealed that on an average the highest Bottle gourd equivalent yield (BEY) 162.92 t ha⁻¹ yr⁻¹ was obtained from CP3 followed by CEY (129.63 t ha⁻¹ yr⁻¹) of CP1 where as the lowest CEY (124.4 t ha⁻¹ yr⁻¹) from CP2 during 2018-20. From the economic analysis, it was observed that the highest gross return Tk. 1629200 ha⁻¹ was obtained from vegetable crop based cropping pattern CP3: Bottle gourd-Snack gourd-Country bean-Cucumber which leads to the highest gross margin (Tk.1354200 ha⁻¹) as well as the highest MBCR (4.92)

Introduction

Bangladesh is one of the major horticultural country in South Asia (Ali.2000) which is the largest single sub-sector of the economy, accounting about 13 percent of the country's GDP (GoB, 2006). Several studies have pointed out that there is considerable potential for growing horticultural crops in Bangladesh (FAO, 1997; Ateng, 1998; Bouis, 2000; Shahabuddin and Dorosh, 2002; Alam, 2005). Farmers who are engaged in the production of vegetables often earn higher incomes than those of cereal crop alone (Weinberger and Lumpkin, 2005). Vegetables like eggplant, radish, cabbage, cauliflower. and pumpkin gave returns at least three times higher than rice (Ateng, 1998). Vegetables are very popular crops that grown all over Bangladesh and it supplies nutrient for us. Farmers of the Narsingdi, Specially Shibpur, Monohardi, Belabo and Raypura areas farmers grow 4-5 vegetables whole the year round haphazardly. Therefore, the present study have carried out to establish suitable vegetable based cropping pattern in Narsingdi region of Bangladesh.

Materials and Methods

The vegetable based cropping pattern study was conducted at the farmers field of Shibpur, Narsingdi under AEZ -09 to study an economically profitable vegetable based cropping pattern for increasing cropping intensity and productivity as well as to meet the vegetable demand for farm family round the year. The experiment was laid out in a randomized complete block design with three dispersed

replications . There were three vegetable based cropping patterns i.e, *CP1* : Radish-Cauliflower-Danta-Indian spinach, *CP2* : Red amaranth-Cauliflower-Ladies finger-Brinjal and *CP3* : Bottle gourd-Snack gourd-Country bean-Cucumber . The unit plot size was 1 decimal or 40 m² .The details of the crop management for the cropping patterns have been presented in Table 2. Plant protection measures were taken when required. Intercultural operations were done as and when necessary. Data on yield of the crops were recorded carefully. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Cauliflower Equivalent Yield (CEY)/BEY = [vegetable yield (kg) x Vegetable price (TK. kg⁻¹)] / Price of Cauliflower/brinjal (Tk . kg⁻¹) .

Table 1 . Initial soil properties of the farmer's field at Shibpur , Narsingdi during 2017-18

Soil Properties	Land type	pH	Organic matter (%)	K	Total N (%)	P	Zn	B
				Meq100 ml ⁻¹				
Initial	MHL	5.7	1.51	.081	0.08	4.9	0.934	0.30
Critical Level	-	-	-	0.12	-	7.0	0.6	0.2
Interpretation	-	-	-	-	-	-	-	-

Results and Discussion

Yield and economic performance of vegetable based cropping pattern during 2017-18, 2018-2019 and 2019-2020 are presented in table 3 and 4. From the research findings it was observed that the average vegetable yield of Radish-Cauliflower-Danta-Indian Spinach-Red amaranth cropping pattern were 22.88-34.00-18.2-28.00-9.8 t ha⁻¹ respectively. Red amaranth-Cauliflower-Ladies finger-Brinjal cropping pattern were 10-31.8-12.7-22.24 t ha⁻¹ where as cropping pattern Bottle gourd-Snack gourd-Country bean-Cucumber gave 47.2-18.82-15.2-12.44 t ha⁻¹ of yield respectively .

Total productivity of studied cropping patterns was calculated by Cauliflower (CEY) and Bottle gourd equivalent yield (BEY) and which was different under different cropping sequences. From the findings of vegetable based cropping pattern, it showed that the average highest BEY (162.92 t ha⁻¹ yr⁻¹) was recorded from the cropping sequence CP3: Bottle gourd-Snack gourd-Country bean-Cucumber and the lowest (124.4 t ha⁻¹yr⁻¹) from the cropping sequence of CP2: Red amaranth-Cauliflower-Ladies finger-Brinjal. Bottle gourd equivalent yield in *CP3* was almost 34 % higher than the cropping pattern *CP2* due to the inclusion of high value Cauliflower.

Cost and return analysis

Economic analysis was done on the basis of prevailing market price of the commodities. Economics of system productivity of vegetable based cropping sequences showed in Table 3. Higher gross return (Tk . 1629200 ha⁻¹) and gross margin (Tk. 1354200 ha⁻¹) were obtained in Bottle gourd-Snack gourd-Country bean-Cucumber cropping pattern compared to Red amaranth amaranth -Cauliflower-Ladies finger-Brinjal cropping pattern (gross return Tk . 995200 ha⁻¹ and gross margin (Tk . 765200 ha⁻¹) . The highest (Tk . 275000 ha⁻¹) total cultivation cost was recorded from cropping sequence *CP3* due to the inclusion of trellis vegetable crop along with improved varieties and modern technologies whereas the lowest (Tk . 204500 ha⁻¹) from the cropping sequence *CP1* . The highest (4.92) MBCR was calculated in improved *CP3* : Bottle gourd-Snack gourd-Country bean-Cucumber cropping pattern compared to the cropping pattern *CP2* : Red amaranth -Cauliflower-Ladies finger-Brinjal (3.32) .

Farmer's opinion

Farmers opined that five vegetable crops can be grown successfully in the same field in a year but sometimes they are not more benefited from vegetable due to increased labor cost at pick season and lower market price in a wholesale market.

Table 2: Crop Management practices of CP1, CP2 and CP3 cropping pattern at Narsingdi during 2017-18, 2018-2019 and 2019-20

Parameters	CP1				
	Radish	Cauliflower	Danta	Indian Spinach	Red amaranth
Variety	Bari Mula-3	White snow	BARI Danta-1	BARI Puishak-1	BARI Lalshak-1
Planting date	22-25 Oct. 19	03-05 Jan. 20	15-24 April, 20	18-24 June, 20	08-10 Sept. 20
Spacing (cm)	Broadcasting	60cm×40cm	Broadcasting	Broadcasting	Broadcasting
Fertilizer dose (N-P-K-S-Zn-B Kg ha)	138-50-107-0-0-0	115-30-100-0-0-0	115-20-75-0	129-16-37-15-0-0	101-14-30-15-0-0
Field duration	55-60	85-90	45-55	55-75	30-35
Turn around	Red amaranth to Radish 9	Radish to Cauliflower 15-20	Cauliflower to Danta 10	Danta to Indian spinach 8	Indian spinach to Red amaranth 9
Harvesting	15-20Dec,19	01-08 April,20	04-15 June,20	19-31 August, 20	10-15 Oct.20
parameters	CP2				
	Red amaranth	Cauliflower	Ladies finger	Brinjal	
Variety	BARI Lalshak-1	White snow	BARI Derosh-1	BARI begun-10	
Planting date	22-25 Oct. 19	18-20 Dec. 20	22-25 March, 20	25-27 June, 20	
Spacing (cm)	Broadcasting	60cm×40cm	50cm×40cm	80cm×60cm	
Fertilizer dose (N-P-K-S-Zn-B Kg ha)	101-14-30-15-0-0	115-30-100-0-0-0	65-24-55-15-0-0	170-30-125-18-0-0	
Field duration	30-35	80-90	80-90	100-115	
Turn around	Brinjal to Redamaranth 6	Redamaranth toCauliflower 16	Cauliflower to Ladies finger 6	Ladies finger to Brinjal 3	
Harvesting	25-30Nov.19	10-19March,20	13-23 June,20	04-19 Oct. 20	
parameters	CP3				
	Bottle gourd	Snack gourd	Country bean	Cucumber	
Variety	BARI Lau-4	BARI Chichinga-1	BARI Shim-3	Local	
Planting date	22-25 Oct. 19	3-5 Feb. 20	18-20 April, 20	13-15 August, 20	
Spacing (cm)	2m×2m	1.5m×1.5m	1.5m×1.5m	1m×1m	
Fertilizer dose (N-P-K-S-Zn-B Kg ha)	55-32-6014-1.4	80-35-75-18-4-1.7	23-18-30-0-0-0	45-30-50-0	
Field duration	90-100	60-70	95-110	55-65	
Turn around	Cucumber to Bottle gourd 5	Bottle gourd to Snack gourd 5	Snack gourd to Country bean 4	Country bean to Cucumber 6	
Harvesting	23-30 Jan.20	5-15April,20	23July-7 Aug. 20	9-19 Oct. 20	

Table 3. Average yield of crops under CP1, CP2 and CP3 cropping pattern at Narshingdi during 2017-18, 2018-2019 and 2019-20 (Average three years)

Parameters	CP1					Cauliflower Equivalent yield($t\ ha^{-1}\ yr^{-1}$)
	Radish	Cauliflower	Danta	Indian Spinach	Red amaranth	
Crop yield($t\ ha^{-1}$)(Average)	22.88	34.00	18.2	28.00	9.8	129.63
	CP2					Cauliflower Equivalent yield($t\ ha^{-1}\ yr^{-1}$)
	Red amaranth	Cauliflower	Ladies finger	Brinjal	-	
Crop yield($t\ ha^{-1}$)(Average)	10	31.8	12.7	22.24		124.4
	CP3					Bottle gourd Equivalent yield ($t\ ha^{-1}\ yr^{-1}$)
	Bottle gourd	Snack gourd	Country bean	Cucumber	-	
Crop yield($t\ ha^{-1}$)(Average)	47.2	18.82	15.2	12.44		162.92

Price (tk. kg-1) : Radish Tk.10, Cauliflower Tk. 8, Danta Tk. 6, Indian spinach Tk.10, Red amaranth Tk. 15, Ladies finger Tk. 15, Bottle gourd Tk. 10, Snack gourd Tk. 20, Country bean Tk. 35, Cucumber Tk. 20, Brinjal Tk. 18

Table 4. Equivalent yield and economic performances of vegetable-based cropping patterns at Narsingdi district during 2017-18, 2018-19 and 2019-2020(Average three years)

Cropping Pattern	CEY/BEY (t ha ⁻¹ yr ⁻¹)	Gross return (Tk.ha ⁻¹)	Total cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	MBCR
Radish-Cauliflower-Danta-Indian Spinach-Red amaranth	129.63	1037040	204500	832540	4.07
Red amaranth-Cauliflower-Ladies finger-Brinjal	124.4	995200	230000	765200	3.32
Bottle gourd-Snack gourd-Country bean-Cucumber	162.92	1629200	275000	1354200	4.92

Conclusion

Based on the results of vegetable based cropping pattern research , it could be concluded that five vegetable crop based cropping pattern such as Radish- Cauliflower- Danta- Indian Spinach- Red amaranth(*CP₁*), Red amaranth- Cauliflower- Ladies finger- Brinjal(*CP₂*) and Bottle gourd- Snack gourd- Country bean- Cucumber(*CP₃*) are agronomically feasible and economically profitable. Due to intensive growing of five vegetable crops in a year in the same piece of land cropping intensity and productivity were sharply increased, more employment opportunity for male and female labours is generated and at the same time increased production of seasonal and off season vegetable food and nutritional security is ensured for the farmers and the nation as a whole.

DEVELOPMENT OF FOUR CROPS BASED CROPPING PATTERN RICE- RICE VEGETABLE-VEGETABLE AGAINST RICE- RICE- VEGETABLE AT NARSINGDI

M. Asaduzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

A trial was conducted at the Shibpur, Narsingdi during 2018-19, 2019-2020 and 2020-2021 to increase cropping intensity and productivity through inclusion of crop in the rice based existing cropping system. The alternate cropping pattern T. Aus (BRRIDhan-48)-T. Aman (BINA-7)-Potato (BARI ALU-40)-Danta (BARI Danta-1) was tested against the existing cropping pattern, Boro Rice (BRRIDhan-29)-T. Aman (BRRIDhan-49)-Lalshak (BARI Lalshak-1). The average yield of different crops in alternative cropping pattern of T. Aus, T. Aman, Potato and danta was 4.3, 4.54, 39.39 and 26.4 t ha⁻¹ while that in the existing pattern of Boro, T. Aman and lalshak 5.61, 4.33 and 10 ha⁻¹ respectively. The higher gross return (Tk. 908370 ha⁻¹) and gross margin (Tk.642380 ha⁻¹) were obtained in alternative T. Aus, T. Aman, Potato and danta cropping pattern. The rice equivalent yield of alternate cropping pattern increased by 158 % and over existing cropping pattern, respectively. The MBCR was 2.42 over existing cropping pattern.

Introduction

Sustainable crop production in Bangladesh is regarded as increasingly important in national issue such as food security, poverty alleviation and creation of job opportunity. The main challenge of the new millennium is to increase per unit yield by at least 50 % through manipulating the limited land resource. Potato is a promising crop, which can be grown easily with minimum soil moisture. In order to increase the potato production, Potato- Danta- T. Aus-T. Aman based cropping pattern is needed to introduce against Boro-T. Aman- Vegetable cropping pattern in Narsingdi. Therefore, this study has been taken to improve a profitable cropping pattern against existing Boro- T. Aman-vegetable based cropping pattern which increase the income of the farmers in the concern areas.

Materials and Methods

On-farm trial was conducted at Shibpur, Narsingdi during 2018-19, 2019-20 and 2020-21 to increase cropping intensity and productivity through rice based cropping systems. The trial field belongs to the

agro-ecological zone of Old Brahmaputra Floodplain (AEZ 09). The alternate cropping pattern T. Aus-T. Aman Potato-Danta was tested against existing cropping pattern Boro-T. Aman-Lalshak. Crop varieties as used in the alternate cropping pattern were T. Aus (BRRI dhan48), T. Aman (var. Binadhan-7), Potato (var. BARI Alu-40), and Danta (var. BARI Danta 1) whereas, the crop variety used in the existing cropping pattern were Boro (BRRI dhan29), T. Aman (BRRI dhan49) and Lalshak (var. BARI lalshak 1) respectively. Seven farmers were selected as dispersed replications covering a total of 250 decimals of land. Recommended fertilizer package (BARC, 2012) along with the application methods were done to support the normal growth of the crops.

The collected data were averaged and presented in tabular form. Economic analysis was done on the basis of prevailing market price of the commodities. Agronomic performance like field duration, production efficiency and rice equivalent yield of cropping patterns were calculated.

Results and Discussion

Yield performance: Yield performance in alternate cropping pattern and existing cropping pattern were presented Table-1. The average yield of different four crops in alternate cropping pattern of T. Aus, T. Aman, Potato and Danta was 4.30, 4.54, 39.39 and 26.4 t ha⁻¹ while in existing cropping pattern of Boro, T. Aman and Lalshak 5.61, 4.33 and 10 t ha⁻¹ respectively (Table-1). Alternative cropping pattern gave higher rice equivalent yield (REY) (44.27 t ha⁻¹/yr) against existing cropping pattern (13.27 t ha⁻¹/yr). Higher rice equivalent yield was obtained in alternate cropping pattern due to introduction of short duration new crop and high yielding varieties. REY was found to increase 158% over existing cropping sequence. Alternative cropping pattern T. Aus-T. Aman-Potato-Danta required 312 days (excluding seedling age of rice) to complete the cycle. The production efficiency was increased near about 220% over existing cropping sequence. Result indicated that short duration potato (BARI Alu 40) and Danta (BARI Danta-1) could easily be fitted in the existing cropping pattern keeping 53 days turnaround time in a year.

Cost and return

The details of economic analysis of cropping pattern are presented in Table-3. Economics of system productivity of four crop sequences revealed that the gross return was different cropping patterns. The higher gross return (Tk. 908370 ha⁻¹) and gross margin (Tk. 642380 ha⁻¹) were obtained in alternative T. Aus-T. Aman-Potato-Danta cropping pattern and lower gross return (Tk. 347060 ha⁻¹) and gross margin (Tk. 196350 ha⁻¹) was found in existing cropping pattern. The MBCR was 2.42 over existing cropping pattern.

Farmers opinion

The concepts of four crops based cropping pattern was completely new to the cooperator farmers and also other farmers in the locality. Income and production efficiency was higher in improved cropping pattern than existing cropping pattern. Neighbouring farmers showed very much interest to adopt the alternate cropping pattern.

Table 1. Agronomic Parameters of four crops pattern and farmers existing pattern at Shibpur, Narsingdi during 2018-2019, 2019-2020 and 2020-2021

Parameters	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Boro Rice	T. Aman	Vegetable	T. Aus	T. Aman	Potato	Danta
Variety	BRRI dhan29	BRRI dhan49	BARI Lalshak-1	BRRI dhan48	BINA-7	BARI ALU-40	BARI danta-1
Spacing	20×15	20×15	Broadcast	25×15	25×15	60×25	Broadcast
Unit plot size	30 Decimal			30 Decimal			
Parameters	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Boro Rice	T. Aman	Vegetable	T. Aus	T. Aman	Potato	Danta
Seedling age (days)	40-45	30-32		25-30	28-30	-	-
Fertilizer dose(CD t h-1)	5, 135-20-25-8-2-0	0, 60-22-35-10-0-0	0, 40-20-30-0-0-0	5, 73-20-24-10-0-0	65-32-34-22-2.7-0	5, 161-44-132-22-5-2	86-50-42-16-0-0
Date of transplanting/sowing	8-14 Jan. 20	8-12 July,20	10-15 Nov.20	25-30 May,20	28-30 August, 20	2-5Dec. 20	10-15 March.21

Parameters	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Boro Rice	T. Aman	Vegetable	T. Aus	T. Aman	Potato	Danta
Date of harvesting	10-15 May,20	20-25 Oct, 20	18-22 Dec, 20	18-22 August,20	13-18 Nov. 20	5-8 March,21	5-10 May,21
Fertilizer application	Basal & Top dress	Basal & Top dress	Basal	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress
Intercultural Operation	2 Weeding	2 Weeding	-	2 Weeding	2 Weeding	2 Weeding	-
Field duration (days)	122	108	36	82	80	95	55
Turnaround (days)	Vegetable to Boro 19	Boro to T. Aman 58	T. Aman to Vegetable 22	Danta to T. Aus 22	T. Aus to T. Aman 10	T. Aman to Potato 12	Potato to Danta 9
Yield (t ha ⁻¹) 2018-19	5.58	4.1	10	4.23	4.3	35.07	25.0
Yield (t ha ⁻¹) 2019-20	5.86	4.3	9.8	4.18	4.42	40.6	27.4
Yield (t ha ⁻¹) 2020-21	5.38	4.6	10.2	4.48	4.9	42.5	26.8
Yield (t ha ⁻¹) (Average)	5.61	4.33	10	4.30	4.54	39.39	26.4

Table 2. Rice equivalent yield, Production efficiency and Land utilization index of four crops pattern and farmers existing pattern at Shibpur, Narsingdi during 2018-2019, 2019-2020 and 2020-2021

Parameters	REY (t ha ⁻¹ /yr)	PE (kg ha ⁻¹ /day)	LUI (%)
4-crops pattern	44.27	240	85
Farmers pattern	13.27	74.96	73

Note: REY-Rice equivalent yield, PE- Production efficiency and LUI-Land utilization index.

Table 3. Cost and return analysis of four crop-based cropping pattern and farmers cropping pattern at Shibpur, Narsingdi during 2018-2019 2019-2020 and 2020-21

Parameters	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	MBCR
4-crops pattern	9,08,370	2,65,990.00	6,42,380	2.42
Farmers pattern	3,28,920	1,32,570.00	1,96,350	1.48

Price (Tk. kg⁻¹) : Rice-18.00, Alu-15, Danta-6.0, Lalshak-15

Conclusion and Recommendation

A total of average about 312 days required to complete three cycle of alternative cropping pattern (T. Aus-T. Aman-Vegetable-Vegetable). It was only 53 days earlier than scheduled time to complete the whole cropping pattern of all co-operative farmers. The rice equivalent yield and production efficiency was increased remarkably. The MBCR (2.42) of alternative cropping pattern over existing cropping pattern was also promising. However, the technology could be recommended for large-scale community with similar type of land.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN SUNFLOWER– T. AUS RICE - T. AMAN RICE AGAINST FARMERS EXISTING PATTERN RELAY COWPEA – FALLOW - T. AMAN RICE

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Abstract

The experiment was conducted at MLT site Bauphal and MLT site Kalapara, Patuakhali during 2020-21 to determine the profitability of the alternate cropping pattern Sunflower (BARI Surjomukhi-2)- T. Aus (BRRI dhan-48) - T. Aman rice (BRRI dhan52) against the farmers' existing pattern Cowpea (BARI Felon-1) - Fallow - T. Aman rice (Sarnogota). The alternate cropping pattern was found agronomically and economically more profitable than the existing pattern. The highest gross return (Tk. 248520 ha⁻¹ and Tk. 278600 ha⁻¹), gross margin (Tk. 132560 ha⁻¹ and Tk. 124450 ha⁻¹) and MBCR (2.68 and 1.87) were obtained from alternate cropping pattern over existing pattern.

Introduction

Patuakhali one of the southern districts of Bangladesh, is a special area for agriculture with various problems, like salinity and charland. The area is characterized by heavy clay soil, heavy rainfall from March to November, cyclone, tidally flooded twice a day during wet season, high soil salinity and scarcity of sweet water for irrigation in the dry season, shorter winter that starts late, late harvesting of T. Aman rice etc. Relay cowpea and grasspea are major Robi crops in the coastal upazillas. But due to unusual rainfall at November and December sometimes cowpea/grasspea become damaged. In this situation it is needed to select an alternate crop of cowpea/grasspea. Sunflower is such a crop which can be grown instead of cowpea/grasspea and after that T. Aus rice could be transplant there in time. After grasspea/cowpea harvest land remain fallow in the coastal region but there is a scope to cultivate aus if the farmers are motivated with HYV Aus varieties and the cropping intensity of the region.

Materials and Methods

The experiment was conducted at Bauphal, Patuakhali and Kalapara, Patuakhali during the year of 2020-21. The alternate cropping pattern Sunflower (BARI Surjomukhi-2) - T. Aus Rice (BRRI dhan-48) - T. Aman rice (BRRI dhan 52) against the farmers' existing pattern Cowpea - Fallow - T. Aman rice (Gutisarna). The unit plot size was 10 decimal. Details of crop management including fertilizer application are presented in Table 1 and Table 2.

Table 1. Management practices of alternate cropping pattern and existing cropping pattern (MLT site, Bauphal)

Management factors	Improved pattern			Existing pattern		
Season	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
Variety	BRRI dhan 48	BRRI dhan 52	BARI Surjomukhi-2	Fallow	BRRI dhan 52	BARI Felon-1
Date of sowing	06.05.2020	30.07.20	04.01.2021	-	07.08.2020	16.12.2020
Date of Transplanting	04.06.2020	28.08.20	-	--	08.09.2020	-
Seedling age (days)	28	28	-	-	31	-
Fertilizer rate: (N-P-K-S-Zn-B kg ha ⁻¹)	70-18-36-10-10	90-20-45-10-10	90-30-75-30-5-5	-	110-40-60-25-0	13-8-15-0-0
Spacing	20cm*15cm	25cm*15cm	50cm*25cm	-	30cm*20cm	Continuous
Basal: (N-P-K-S-Zn kg ha ⁻¹)	0-18-36-10-10	0-20-45-10-10	45-30-75-30-5-5	-	0-40-60-25-0	13-8-15-0-0
N top dress (DAT/DAS)	20 & 40 DAT	20 & 40 DAT	-	-	20 & 40 DAT	-
Pest control	Curative	Curative	Curative	-	Curative	Curative
Irrigation (DAT/DAS)	35 & 60 DAS	-	-	-	-	-
Date of harvest	24.08.2020	02.12.20	25.04.21	-	26.12.20	15.04.21

Table 2. Management practices of alternate cropping pattern and existing cropping pattern (MLT site, Kuakata, Patuakhali)

Management factors	Improved pattern			Existing pattern		
Season	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
Variety	BRRI dhan48	BRRI dhan 52	BARI Surjomukhi-2	Fallow	Gutisarna	BARI Felon-1
Date of sowing	30.04.2020	25.07.20	26.12.2020	-	03.08.2020	05.12.2020
Date of Transplanting	25.05.2020	23.08.20	-	--	30.08.2020	-
Seedling age (days)	26	28	-	-	27	-
Fertilizer rate: (N-P-K-S-Zn-B kg ha ⁻¹)	70-18-36-10-10	90-20-45-10-10	90-30-75-30-5-5	-	110-40-60-25-0	13-8-15-0-0
Spacing	20cm*15cm	25cm*15cm	50cm*25cm	-	30cm*20cm	Continuous
Basal: (N-P-K-S-Zn kg ha ⁻¹)	0-18-36-10-10	0-20-45-10-10	45-30-75-30-5-5	-	0-40-60-25-0	13-8-15-0-0
N top dress (DAT)	20 & 40	20 & 40	-	-	20 & 40	-
Pest control	Curative	Curative	Curative	-	Curative	Curative
Irrigation (DAS)	35 & 60	-	-	-	-	-
Date of harvest	18.08.2020	10.12.20	04.04.21	-	18.12.20	12.04.21

Results and Discussions

Yield and economic performance of new cropping pattern and existing cropping pattern during 2020-21 were presented in Table 3 and Table 4. In the existing pattern, farmers used local T. Aman rice variety Gutisarna which produced yield only 3.15 t ha⁻¹ which was replaced by modern rice variety BRRI dhan52 that produced grain yield 4.37 t ha⁻¹ which 39% yield increased by varietal change in Aman rice. On the contrary, replacement of cowpea by new crop Sunflower gave 3.95 th⁻¹ more rice equivalent yield. New pattern gave 8.6 th⁻¹ additional REY that contributed to the highest gross return (Tk. 248520 ha⁻¹), gross margin (Tk. 132560 ha⁻¹) and MBCR (2.68) over existing pattern.

In the existing pattern, T. aman rice variety Gutisarna produced grain yield only 3.0 t ha⁻¹ which was replaced by modern rice variety BRRI dhan 52 that produced 4.5 t ha⁻¹ grain yield which showed 50% yield increased by varietal change in Aman rice. On the contrary, replacement of cowpea by new crop Sunflower gave 3.9 th⁻¹ more rice equivalent yield. Introduction of Aus rice in the existing pattern also increase productivity and income of the new pattern. New pattern gave 9.8 th⁻¹ additional REY that contributed to the highest gross return (Tk. 278600 ha⁻¹), gross margin (Tk. 124450 ha⁻¹) and MBCR (1.87) over existing pattern.

Farmers' opinion: Farmers realized that use of high yielding modern varieties instead of local varieties can increase production as well as their income. Yield of relay cowpea is reducing day by day so they showed their interest to grow sunflower instead of relay cowpea and relay grasspea. They also noticed some difficulties like laborious intercultural operations, more labor requirements and bird attack at harvesting stage which hampers sunflower cultivation.

Table 3. Yield and Economic analysis of alternate cropping pattern and existing cropping pattern (MLT site, Bauphal)

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Sunflower	T. Aus	T. Aman	Cowpea	Fallow	T. Aman
Seed/grain yield (t ha ⁻¹)	2.00	3.43	4.37	0.85	-	3.15
Straw yield (t ha ⁻¹)	-	-	4.06	-	-	4.2
Rice equivalent Yield (t ha ⁻¹)	7.50	3.43	4.37	3.55		3.15
Total REY (t ha ⁻¹)	15.3			6.7		
Gross return (Tk. ha ⁻¹)	100000	61740	86780	51000	-	64900
TVC (Tk. ha ⁻¹)	60300	45650	48200	18200	-	48200
Gross margin (Tk. ha ⁻¹)	39700	16090	38580	32800	-	16700
Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Sunflower	T. Aus	T. Aman	Cowpea	Fallow	T. Aman
Gross return (Tk. ha ⁻¹) (pattern)	248520			115900		
TVC (Tk. ha ⁻¹) (pattern)	153960			66400		
Gross margin (Tk. ha ⁻¹)	132560			49500		
MBCR (whole pattern)	2.68					

Unit price (Tk. kg⁻¹): T. Aman rice= 18/-, Aus rice=18/-, Rice straw = 2/-, Sunflower = 50/-, Cowpea = 60/-

Table 4. Yield and Economic analysis of alternate cropping pattern and existing cropping pattern (Kuakata, Patuakhali)

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Sunflower	T. Aus	T. Aman	Cowpea	Fallow	T. Aman
Seed/grain yield (t ha ⁻¹)	2.20	4.37	4.5	1.05	-	3.5
Straw yield (t ha ⁻¹)	-	-	4.06	-	-	4.0
Rice equivalent Yield (t ha ⁻¹)	8.3	4.37	4.5	4.4		3.0
REY (t ha ⁻¹)(Pattern)	17.2			7.4		
Gross return (Tk. ha ⁻¹)	110000	78600	90000	63000	-	620000
TVC (Tk. ha ⁻¹)	60300	45650	48200	18200	-	40350
Gross margin (Tk. ha ⁻¹)	49700	33010	41800	44800	-	21650
Gross return (Tk. ha ⁻¹)	278600			125000		
TVC (Tk. ha ⁻¹)	154150			58550		
Gross margin (Tk. ha ⁻¹)	124450			66450		
MBCR	1.87					

Unit price (Tk. kg⁻¹): T. Aman rice= 18/-, Aus rice=18/-, Rice straw = 2/-, Sunflower = 50/-, Cowpea = 60/-

Conclusion

Despite the fact of some difficulties which were noticed by the farmers to grow sunflower, mechanized cultivation could reduce those problems. The results obtained from the study indicated that alternate cropping pattern is more profitable than the farmer's pattern. So, Sunflower - T. Aus - T. Aman rice could be the one of the major pattern in coastal area.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN GROUNDNUT - T. AUS-T. AMAN RICE AGAINST FARMERS EXISTING PATTERN GROUNDNUT- FALLOW-T. AMAN RICE

K.N. Islam, M.M. Islam, P. Chakraborti, M.S.I. Khan, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at MLT site Bauphal and MLT site Kalapara, Patuakhali during 2020-21 to determine the profitability of the alternate cropping pattern Groundnut (BARI Chinabadam -8) - T. Aus (BRRI dhan-48) - T. Aman rice (BRRI dhan52) against the farmers' existing pattern Groundnut (Dhaka-01) - Fallow - T. Aman rice (Sarnogota). The alternate cropping pattern was found agronomically and economically more profitable than the existing pattern. The highest gross return (Tk. 354830 ha⁻¹ and Tk. 348290 ha⁻¹), gross margin (Tk. 139830 ha⁻¹ and Tk. 155290 ha⁻¹) and MBCR (2.63 and 2.79) were obtained from alternate cropping pattern over existing pattern.

Introduction

Ground nut is one of the major crops in coastal region especially in char ecosystem. More than three thousand hectares of lands of Patuakhali and Borguna districts are under groundnut cultivation. Farmers grow ground nut during Robi season after T. Aman rice harvest than the land remain fallow. So there is a scope to incorporate Aus Rice in the pattern. On the other hand farmers use local varieties in the pattern such as 'Dhaka-1' and in Aman 'Sarnogota' with low yielder. BARI Chinabadam-8, BRRI dhan-48 and BRRI dhan-76 are modern varieties have found promising in adaptive trial in coastal region by BARI and BRRI to introduce new modern varieties and to increase cropping intensity.

Materials and Methods

The experiment was conducted at Bauphal, Patuakhali and Kalapara, Patuakhali during the year of 2020-21. The alternate cropping pattern Groundnut (BARI Chinabadam-8) - T. Aus Rice (BRRI dhan-48) - T. Aman rice (BRRI dhan 52) against the farmers' existing pattern Chinabadam (Dhaka-1) - Fallow - T. Aman rice (Gutisarna). The unit plot size was 1 decimal. Details of crop management including fertilizer application are presented in Table 1 and Table 2.

00. Table 1. Management practices of alternate cropping pattern and existing cropping pattern (MLT site, Bauphal)

Management factors	Improved pattern			Existing pattern		
	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
Season						
Variety	BRRI dhan48	BRRI dhan 52	BARI Chinabadam-8	Fallow	Gutisarna	Dhaka 1
Date of sowing	06.05.2020	30.07.20	18.01.2021	-	07.08.2020	15.01.2021
Date of Transplanting	04.06.2020	28.08.20	-	--	08.09.2020	-
Seedling age (days)	28	28	-	-	31	-
Fertilizer rate: (N-P-K-S-Zn-B kg ha ⁻¹)	70-18-36-10-10	90-20-45-10-10	11.5-32-42.51	-	110-40-60-25-0	11.5-32-42.51
Spacing	20cm*15cm	25cm*15cm	30cm*15cm	-	30cm*20cm	30cm*15cm
Basal: (N-P-K-S-Zn kg ha ⁻¹)	0-18-36-10-10	0-20-45-10-10	45-30-75-30-5-5	-	0-40-60-25-0	13-8-15-0-0

Management factors	Improved pattern			Existing pattern		
Season	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
N top dress (DAT/DAS)	20 & 40 DAT	20 & 40 DAT		-	20 & 40 DAT	-
Pest control	Curative	Curative	Curative	-	Curative	Curative
Irrigation (DAT/DAS)	35 & 60 DAS	-	-	-	-	-
Date of harvest	24.08.2020	02.12.20	09.05.21		26.12.20	20.06.21

Table 2. Management practices of alternate cropping pattern and existing cropping pattern (MLT site, Kuakata, Patuakhali)

Management factors	Improved pattern			Existing pattern		
Season	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
Variety	BRRI dhan48	BRRI dhan 52	BARI Chinabadam-8	Fallow	Gutisarna	Dhaka-1
Date of sowing	30.04.2020	25.07.20	12.01.2021	-	03.08.2020	12.01.2021
Date of Transplanting	25.05.2020	23.08.20	-	--	30.08.2010	-
Seedling age (days)	26	28	-	-	27	-
Fertilizer rate: (N-P-K-S-Zn-B kg ha ⁻¹)	70-18-36-10-10	90-20-45-10-10	11.5-32-42-51	-	110-40-60-25-0	11.5-32-42-51
Spacing	20cm*15cm	25cm*15cm	30cm*15cm	-	30cm*20cm	30cm*15cm
Basal: (N-P-K-S-Zn kg ha ⁻¹)	0-18-36-10-10	0-20-45-10-10	11.5-32-42-51	-	0-40-60-25-0	11.5-32-42-51
N top dress (DAT/DAS)	20 & 40 DAT	20 & 40 DAT		-	20 & 40 DAT	-
Pest control	Curative	Curative	Curative	-	Curative	Curative
Irrigation (DAT/DAS)	35 & 60 DAS	-	-	-	-	-
Date of harvest	18.08.2020	10.12.20	15.05.21		18.12.20	22.05.21

Results and Discussions

Yield and economic performance of new cropping pattern and existing cropping pattern during 2020-21 are presented in Table 3 and Table 4. In the existing pattern, T. aman rice variety Gutisarna produced yield only 3.15 t ha⁻¹ which was replaced by modern rice variety BRRI dhan 52 that produced 4.37 t ha⁻¹ grain yield with 38.7% yield increased by varietal change in Aman rice. On the contrary, replacement of Groundnut by new variety BARI Chinabadam-8 gave 3.20 th⁻¹ rice equivalent yield. Introduction of Aus rice in the existing pattern also increase productivity and income of the new pattern. New pattern gave 18.00 th⁻¹ additional REY that contributed to the highest gross return (Tk. 354830 ha⁻¹), gross margin (Tk. 139830 ha⁻¹) and MBCR (2.63) over existing pattern.

In the existing pattern, farmers local T. *Aman* rice variety Gutisarna have produced yield only 3.0 t ha⁻¹ which was replaced by modern rice variety BRRI dhan 52 that produced 4.5 t ha⁻¹ grain yield with 50% yield increased by varietal change in *Aman* rice. On the contrary, replacement of groundnut by new variety BARI Chinabadam gave 8.8 th⁻¹ rice equivalent yield. Introduction of Aus rice in the existing pattern also increase productivity and income of the new pattern with 7.9 th⁻¹ additional REY that contributed to the highest gross return (Tk. 204000 ha⁻¹), gross margin (Tk. 49000 ha⁻¹) and MBCR (2.79) over existing pattern.

Farmers' opinion

Farmers realized that use of high yielding modern varieties instead of local varieties could increase production as well as their income. They are also happy with the yield of BARI Chinabadam-8.

Table 3. Yield and Economic analysis of alternate cropping pattern and existing cropping pattern (MLT site, Bauphal)

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Groundnut	T. Aus	T. Aman	Groundnut	Fallow	T. Aman
Seed/grain yield (t ha ⁻¹)	2.3	4.43	4.37	1.65	-	3.15
Straw yield (t ha ⁻¹)	-	-	4.06	-	-	4.2
Rice equivalent Yield (t ha ⁻¹)	9.20	4.43	4.37	6.6		3.15
Rice equivalent Yield (t ha ⁻¹)	18.00			9.75		
Gross return (Tk. ha ⁻¹)	184000	75310	95520	132000	-	65000
TVC (Tk. ha ⁻¹)	100000	55000	60000	100000	-	55000
Gross margin (Tk. ha ⁻¹)	84000	20310	35520	32000		10000
Gross return (Tk. ha ⁻¹) (pattern)	354830			197000		
TVC (Tk. ha ⁻¹) (pattern)	215000			155000		
Gross margin (Tk. ha ⁻¹) (pattern)	139830			42000		
MBCR (whole pattern)	2.63					

Unit price (Tk. kg⁻¹): T. Aman rice= 20/-, Aus rice=17/-, Rice straw = 2/, Groundnut= 80/-

Table 4. Yield and Economic analysis of alternate cropping pattern and existing cropping pattern (Kuakata, Patuakhali)

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Groundnut	T. Aus	T. Aman	Groundnut	Fallow	T. Aman
Seed/grain yield (t ha ⁻¹)	2.20	4.37	4.5	1.7	-	3.0
Straw yield (t ha ⁻¹)	-	-	4.06	-	-	4.0
Rice equivalent Yield (t ha ⁻¹)	8.8	4.37	4.5	6.8		3.0
Rice equivalent Yield (t ha ⁻¹)	17.7			9.8		
Gross return (Tk. ha ⁻¹)	176000	74290	98000	136000	-	68000
TVC (Tk. ha ⁻¹)	100000	55000	60000	100000	-	55000
Gross margin (Tk. ha ⁻¹)	76000	19290	38000	36000	-	13000
Gross return (Tk. ha ⁻¹)	348290			204000		
TVC (Tk. ha ⁻¹)	193000			155000		
Gross margin (Tk. ha ⁻¹)	155290			49000		
MBCR (whole pattern)	2.79					

Unit price (Tk. kg⁻¹): T. Aman rice= 20/-, Aus rice=17/-, Rice straw = 2/, Groundnut= 80/-

Conclusion

It should be needed to introduce modern varieties to replace local groundnut and rice varieties. Mechanization needed for sowing of groundnut seeds to minimize labour cost.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN THROUGH GARDENPEA-BORO- T. AMAN AGAINST FALLOW- BORO- T. AMAN

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Abstract

The experiment was conducted at the MLT site, Satkhira during 2017-'18, 2018-'19, 2019-'20 for improving the productivity and profitability of an existing cropping pattern Fallow - Boro- T. Aman by introducing garden pea variety after T. Aman harvest. Results revealed that improved cropping pattern Garden pea - Boro- T. Aman produced the highest total rice equivalent yield (28.71 t ha⁻¹) than farmers practice (12.78 t ha⁻¹). An improved cropping pattern brought the highest gross return (Tk. 5,63,417) and gross margin (Tk. 2,98,828) with MBCR of 1.76 over existing pattern meaning superiority of improved pattern over existing pattern.

Introduction

The existing major cropping pattern under rain fed condition of Satkhira is Fallow-Boro-T. Aman (62250 ha) which accounts about 33% of total cultivable land of Satkhira district. The existing cropping intensity of Satkhira is lower (204 %) compared to other regions of the country. Crop productivity can be increased by improving existing cropping patterns i.e. by introducing new crops and crop varieties suitable for the region. High yielding short duration crop variety along with modern cultivation technologies are the pre-requisite for developing improved cropping pattern. BARI Motorshuti-3 is a short duration high value crop which adds nutrients to the soil that improves soil health and soil fertility as well as brings high economic return. The crop could easily be cultivated in the region after harvest of T. Aman rice. Keeping the circumstances, the experiment has been undertaken to develop an alternate cropping pattern through Gardenpea-Boro-T. Aman in south-western coastal area of Bangladesh particularly in Satkhira.

Materials and Methods

The experiment was conducted at the MLT site, Satkhira during 2017-'18 and 2018-19 in the medium high land situation to study the suitability of proposed cropping pattern Gardenpea- Boro- T. Aman against the existing farmers' pattern Fallow-Boro- T. Aman for improving crop productivity as well as higher economic returns. The alternate cropping pattern was tested with 4 dispersed replications across the farmers' field under same land type. The unit plot size was 33 decimal. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1. Recommended fertilizer package (BARC, 2012) along with the application methods were used for all the crops. Pest management and other intercultural management practices were done as and when necessary. Relevant data were taken carefully. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield of rice on the basis of prevailing market price of individual crops (Ahlawat and Sharma, 1993). Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR) and Production efficiency (PE) was calculated as per Appendix Table 1.

Results and Discussion

Field duration: Field duration of cropping pattern mainly depends on individual duration of component crops in the field. The improved cropping pattern (IP) Garden pea-Boro- T. Aman had the longer field duration than farmers' existing pattern (FP) T. Aman -Fallow- Fallow (Table 1, 2 and 3). In 2017-18, 2018-19 and 2019-20, total field duration of improved pattern were 260, 292 and 225 days, respectively, while in farmers pattern it were 203, 167 and 188 days, respectively. During 2018-19, field duration is lower than previous year because of heavy rainfall damaged garden pea crop just after first harvest and in 2019-20, only one harvest of gardenpea was counted.

Grain yield: In 2017-18, yield of both improved practice (IP) and farmers' practice (FP) varied, which may be due differences in management practices. In farmers practice, grain yield of Boro rice was 5.84 t ha⁻¹, whereas in improved practices (IP) 6.24 t ha⁻¹ and grain yield of aman rice in farmers practice was 4.89 t ha⁻¹, while in improved practice it was 5.09 t ha⁻¹. Green pod yield of gardenpea in improved practice was 8.81 t ha⁻¹ (Table 1).

In 2018-19, grain yield of Boro and aman rice in farmers practice were 6.81 and 5.56 t ha⁻¹, respectively and in improved practice both were 6.80 and 5.26 t ha⁻¹, respectively. The green pod yield of garden pea in improved practice was 8.91 t ha⁻¹ (Table 2).

In 2019-20, Boro rice yield in farmers practice was 6.71 t ha⁻¹ and in improved practice it was 6.73 t ha⁻¹. T. Aman yield in improved practice was 5.36 t ha⁻¹, while in farmers practice it was little bit higher (5.46 t ha⁻¹). Garden pea pod yield in improved practice was 8.46 t ha⁻¹ (Table 3)

Rice equivalent yield and production efficiency

In 2017-'18, total rice equivalent yield in IP was 29.07 t ha⁻¹, whereas in FP it was 11.67 t ha⁻¹ (Table 1). Addition of new crops and high yielding varieties and improved management practices in the IP

increased the rice equivalent yield. Production efficiency of FP was 11.67 kg ha⁻¹day⁻¹ (203 days) whereas in IP it was 122.23 kg ha⁻¹day⁻¹ (260 days) (Table 1).

In 2018-'19, total rice equivalent yield in IP was 30.78 t ha⁻¹, whereas in FP it was 13.86 t ha⁻¹ (Table 2). While, production efficiency of FP was 66.33 kg ha⁻¹day⁻¹ (167 days) whereas in IP it was 105.42 kg ha⁻¹day⁻¹ (292 days) (Table 2).

In 2019-'20, total rice equivalent yield in IP was 26.29 t ha⁻¹, whereas in FP it was 12.8 t ha⁻¹ (Table 2). While, production efficiency of FP was 68.08 kg ha⁻¹day⁻¹ (188 days) whereas in IP it was 116.83 kg ha⁻¹day⁻¹ (225 days) (Table 3).

Cost benefit analysis

Average benefit cost analysis over three years shows that IP produced highest gross return (Tk. 563417) and gross margin (Tk. 298828) than FP (Tk. 250197 and Tk. 99358, respectively). MBCR of improved practice over farmers practice was found 1.76, which indicates improved pattern is profitable than farmers practice (Table 4).

Farmers' opinion

Garden pea cultivation is getting popularity but only drawback is lack of adequate and timely supply of seeds. Farmers are interested cultivating garden pea after T. Aman harvest for its higher yield, short duration and market price as well. They expressed their satisfaction for getting an extra crop after the harvest of T. Aman rice in the area, however, they opined that supply of seeds of BARI Motoshuti-3 should be ensured.

Table 1. Agronomic management practices and rice equivalent yield of the crops for the existing (Fallow-Boro-T. Aman) and alternate cropping pattern (Gardenpea- Boro- T. Aman) at the MLT site, Satkhira during 2017-'18

Parameters		Existing cropping pattern			Alternate cropping pattern		
Crop		Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
Variety		-	BRRI dhan-28	Binadhan-7	BARI Motorshuti-3	BRRI dhan-28	Binadhan-7
Spacing		-	20 cm x 15 cm	20 cm x 15 cm	30 cm row	20 cm x 15 cm	20 cm x 15 cm
Unit plot size (decimal)			33	33	33	33	33
Seedling age (days)		-	35-39	34	-	46-52	23
Date of sowing/transplanting		-	24-28 Jan 2018	12 July 18	3-11Nov' 17	7 Feb 18	2 Aug 18
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn-B)		-	138.25-19.60-82.5-20.55-4.32-0		46.08-30-50-9.09-0-0	138.25-19.60-82.5-20.55-4.32-0	-
Fertilizer application		-	Basal and top dress	Basal and top dress	Basal & top dress	Basal and top dress	Basal and top dress
Intercultural operation		-	weeding-2 irrigation-6	weeding 1	1 weeding, 1 thinning and 1 irrigation	weeding-2 irrigation-6	weeding 1
Date of harvesting		-	30 Apr- 02 May 2018	5 Nov 18	25 Jan '18 to 4 Feb'18	27 Apr 2018	1 Nov 18
Field duration (days)		-	94-96	107	79-88	80	92
Turnaround time (days)		-	-	107	-	3	97
2017-18	Grain Yield (t ha ⁻¹)	-	5.84	4.89	8.81	6.24	5.09
	Straw Yield (t ha ⁻¹)	-	7.32	5.66	-	6.93	5.73
	Rice Equivalent Yield (REY) (t ha ⁻¹)	-	6.21	5.52	16.52	6.82	5.73
	Total REY (t ha ⁻¹)		11.67		29.07		
	Production efficiency (kg ha ⁻¹ day ⁻¹)		87.78		112.23		

Price (Tk. kg⁻¹): Boro = 24.00, T. Aman=18.00, Straw = 2.00, Garden pea= 35.00.

Table 2. Agronomic management practices and rice equivalent yield of the crops for the existing (Fallow-Boro-T. Aman) and alternate cropping pattern (Gardenpea- Boro- T. Aman) at the MLT site, Satkhira during 2018-'19

Parameters		Existing cropping pattern			Alternate cropping pattern		
Crop		Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
Variety		-	BRRI dhan28	Binadhan-7	BARI Motorshuti-1	BRRI dhan28	Binadhan-7
Spacing		-	20 cm x 15 cm	20 cm x 15 cm	30 cm row	20 cm x 15 cm	20 cm x 15 cm
Unit plot size (decimal)		-	33	33	33	33	33
Seedling age (days)		-	41	34	-	47	24
Date of sowing/ transplanting		-	30 Jan 2019	25 July 19	5 Nov' 18	13 Feb 19	13 Aug 19
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn-B)		-	138.25-19.60-82.5-20.55-4.32-0		46.08-30-50-9.09-0-0	138.25-19.60-82.5-20.55-4.32-0	-
Fertilizer application		-	Basal and top dress	Basal and top dress	Basal & top dress	Basal and top dress	Basal and top dress
Intercultural operation		-	weeding-2 irrigation-6	weeding 1	1 weeding, 1 thinning and 1 irrigation	weeding-2 irrigation-6	weeding 1
Date of harvesting		-	5 May 2019	16 Nov 19	3 Feb '19 to 11 Feb'19	10 May 19	29 Nov 19
Field duration (days)		-	95	114	91-98	86	108
Turnaround time (days)		-	86	81	4	14	95
2018-19	Grain Yield (t ha ⁻¹)	-	6.81	5.56	8.91	6.80	5.26
	Straw Yield (t ha ⁻¹)	-	7.33	6.11	-	6.85	5.76
	REY (t ha ⁻¹)	-	7.62	6.24	17.32	7.56	5.90
	Total REY (t ha ⁻¹)		13.86		30.78		
	Production efficiency (kg ha ⁻¹ day ⁻¹)		66.33		105.42		

Price (Tk. kg⁻¹): Boro = 18.00, T. Aman=18.00, rice straw =2.00, Garden pea= 35.00.

Table 3. Agronomic management practices and rice equivalent yield of the crops for the existing (Fallow-Boro-T. Aman) and alternate cropping pattern (Gardenpea- Boro- T. Aman) at the MLT site, Satkhira during 2019-'20

Parameters		Existing cropping pattern			Alternate cropping pattern		
Crop		Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
Variety		-	BRRI dhan-28	Binadhan-7	BARI Motorshuti-3	BRRI dhan-28	Binadhan-7
Spacing		-	20 cm x 15 cm	20 cm X 15 cm	30 cm row	20 cm x 15 cm	20 cm X 15 cm
Unit plot size (decimal)		-	33	30	33	33	16.5
Seedling age (days)		-	42	30	-	49	31
Date of sowing/ transplanting		-	25-Jan-20	20-Aug-20	2-Dec-19	13-Feb-20	21-Aug-20
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn-B)		-	138.25-19.60-82.5-20.55-4.32-0	167-62-84-56-7.5-0	46.08-30-50-9.09-0-0	138.25-19.60-82.5-20.55-4.32-0	167-62-84-56-7.5-0
Fertilizer application		-	Basal and top dress	Basal & top dress	Basal & top dress	Basal and top dress	Basal & top dress
Intercultural operation		-	2 weeding, 6 irrigation	1 weeding	1 weeding, 1 thinning and 1 irrigation	2 weeding, 6 irrigation	1 weeding
Date of harvesting		-	2-May-20	20-Nov-20	2-Feb-20	25-Apr-20	20-Nov-20
Field duration (days)		-	98	90	62	72	91
Turnaround time (days)		-	70	110	3	11	118
2019-20	Grain yield (t ha ⁻¹)	-	6.03	5.46	8.46	6.16	5.36
	Straw yield (t ha ⁻¹)	-	6.78	5.68	-	6.73	5.61

Parameters		Existing cropping pattern			Alternate cropping pattern		
Crop		Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
	REY (t ha ⁻¹)	-	6.708	6.09	13.54	6.83	5.92
	Total REY (t ha ⁻¹)	12.80			26.29		
	Production efficiency (kg ha ⁻¹ day ⁻¹)	68.08			116.83		

Table 4. Rice equivalent yield and cost benefit analysis of farmers and improved cropping patterns (Gardenpea-Boro- T. Aman) at the MLT site, Satkhira during 2017-'18, 2018-19 and 2019-20

Pattern	Pattern	Rice equivalent yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
2017-'18	FP	11.67	245070	179751	65319	2.31
	IP	29.07	610424	290201	320223	
2018-'19	FP	13.86	249540	157366	92174	1.64
	IP	30.78	554103	272766	281337	
2019-'20	FP	12.80	255982	115400	140582	1.34
	IP	26.29	525725	230800	294925	
Average	FP	12.78	250197	150839	99358	1.76
	IP	28.71	563417	264589	298828	

Conclusion and Recommendation

Garden pea is a short duration vegetable crop which is profitable, so system productivity could be improved if adequate and timely seed supply is ensured.

DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD- T. AUS- T. AMAN RICE AGAINST FALLOW- BORO- T. AMAN CROPPING PATTERN IN RAJSHAHI REGION

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Abstract

A field trial was conducted at the farmers' field of Paba, Rajshahi during 2020-2021 to develop Mustard- T. Aus- T. Aman cropping pattern. There were two treatments i.e, T₁: Existing Cropping pattern: Fallow- Boro-(BRRI dhan-28)- T. Aman (Sharna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-18)- T. Aus (BRRI dhan 82). T. Aman (BRRI dhan 87). Higher Rice Equivalent yield (14.25 t ha⁻¹) and gross margin (Tk. 284394 ha⁻¹) were obtained from Alternate cropping pattern over existing cropping pattern (11.13 t ha⁻¹, Tk. 215640 ha⁻¹), due to introduction of new crops and varieties.

Introduction

Boro rice-T. Aman rice is one of the major existing cropping patterns at Paba upazila of Rajshahi district. Generally, farmers of the upazila cultivate T. Aman rice followed by Boro rice and a long period (around 90 days) remains fallow after T. Aman rice harvest which could be utilized by inclusion of a suitable Kharif crop like T. Aus rice. The area is comparatively high and there is scarcity of irrigation water to cultivate Boro rice after harvest of T. Aman rice. In this context, T. Aus rice might be a promising crop for cultivation in rainfed condition. Besides, BARI Sarisha 18 is a new variety which crop duration 100 days, yield 2-2.5 t ha⁻¹ and have low Uric acid. This cropping pattern requires minimum water with the increase cropping intensity as well as productivity and profitability. With this view in mind, the experiment was undertaken to increase productivity and income of farmers in AEZ-11.

Materials and Methods

The experiment was conducted at Paba, Rajshahi during 2020-21 in High Ganges River Floodplain (AEZ-11) to develop Mustard- T. Aus -T. Aman cropping pattern. The experiment was laid out in a randomized complete block design with six dispersed replications. There were two treatments i.e, T₁: Existing Cropping pattern: Fallow-Boro (BRRI dhan-28)-T. Aman (Sharna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-18)- T. Aus (BRRI dhan-82) - T. Aman (BRRI dhan-87). All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield on the basis of prevailing market price of individual crops. The economic indices i.e. gross return, gross margin, and benefit cost ratio were also calculated on the basis of prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

Table 1. Details of cultural practices adopted for different crops in field experiments

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantion	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Mustard	BARI Sarisha-18	7	Broadcast	1-15 Nov.2020	21 -25 February 2021	126	35	46	29	2.5	2
T. Aus	BRRI dhan 82	35	20 x 15	16-17 March 2020	14-16 June 2020	76	11	38	6.4	-	-
T. Aman rice	BRRI dhan 87	35	20 x 15	15-20 July 2020	25-30 October 2020	90	10	25	12	1	-

Results and Discussion

Yield, cost and return of improved pattern and existing pattern are presented in Table 2. In improved cropping pattern, yield of Mustard, T. Aus and T. Aman rice were 1.91, 4.75 and 5.2 t ha⁻¹ while in existing pattern, yield of Boro and T. aman rice were 5.68 and 5.02 t ha⁻¹, respectively. Improved cropping pattern gave higher rice equivalent yield (REY) (14.25 t ha⁻¹) against existing cropping pattern (11.33 t ha⁻¹). Total gross return and gross margin of improved cropping pattern were Tk. 443830 ha⁻¹ and Tk. 284394 ha⁻¹ whereas in existing cropping pattern those were Tk. 349840 ha⁻¹ and Tk. 215640 ha⁻¹, respectively and MBCR was 3.72. Higher gross return and gross margin were obtained in improved cropping pattern due to introduction of new crops and varieties.

Pest incidence

In mustard field Rovral@2 ml L⁻¹ was applied for controlling alternaria blight of mustard. In T. Aus and T. Aman, stem borer and sheath blight was observed in some plots. Follicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer.

Farmers reaction

Farmers' preferred Mustard - T. Aus - T. Aman cropping pattern compared to Boro-Fallow-T. Aman due to its higher rice equivalent yield as well as higher MBCR.

Table 2. Yield, cost and return analysis of existing and alternate cropping pattern (Mustard- T. Aus- T. Aman)

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.91	4.75	5.2	5.68	-	5.02
Straw yield (t ha ⁻¹)	3.5	5.10	5.34	5.81	-	5.31
Gross return (Tk ha ⁻¹)	133700	148650	161480	193640	-	156200
Total variable cost (Tk ha ⁻¹)	52976	57550	48910	85100	-	49100
Gross margin (Tk ha ⁻¹)	80724	91100	112570	108540	-	107100
Whole pattern REY (t ha ⁻¹)	14.25			11.33		
Whole pattern gross return (Tk ha ⁻¹)	443830			349840		
Whole pattern TVC (Tk ha ⁻¹)	159436			134200		

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Boro	Fallow	T. Aman
Whole pattern gross margin (Tk ha ⁻¹)	284394			215640		
MBCR				3.72		

Price of output: T. aman : Tk 29 kg⁻¹, straw 2 kg⁻¹, Mustard: Tk 70.00 kg⁻¹, T. Aus rice: Tk 27.00 kg⁻¹ and straw :Tk 4 kg⁻¹, Boro rice: Tk. 30 kg⁻¹ and straw : Tk 4 kg⁻¹

DEVELOPMENT OF ALTERNATE CROPPING PATTERN RELAYING OF SWEET GOURD WITH BUSHBEAN-FALLOW AGAINST FALLOW-FALLOW-BUSHBEAN CROPPING PATTERN IN HAOR AREA

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Abstract

An experiment was executed at Hakaluki haor under multilocation testing (MLT) site, Moulvibazer, during 2020-21 to see the performance of improved cropping pattern and to increase the productivity and income of farmers. The existing and improved cropping patterns was Bushbean-Fallow- Fallow (CP₁: Existing cropping pattern) and Bushbean-Sweet gourd-Fallow (CP₂: Improved cropping pattern). The higher pod yield (4.47 tha⁻¹) of bushbean was produced by improved pattern. In case of productivity, the bushbean equivalent yield was increased 27% in improved pattern. Land use efficiency (200%) and production efficiency (192%) was increased in Bushbean-Sweet gourd-Fallow cropping pattern than existing one.

Introduction

Geographically, most of the haor are situated under the districts of Sunamganj, Kishoreganj, Netrakona, Sylhet, Habiganj, Moulvibazar and Brahmanbaria. There are as many as 423 small or large haors in Bangladesh (Alam et al., 2010). The Hakaloki haor, Sumir haor, Dakhar haor, Tanguyar haor, Gungiajuri haor, Mukhar haor, Kaowadighir haor etc. are the prominent haors in Bangladesh. The cropping practices particularly Boro rice mainly cultivated low laying areas of haor but other vegetables and field crops grown in upper cratina of haor. The available statistics indicate that, the total cultivated area in those haor districts is about 1.26 million hectares of which 0.68 million ha (nearly 66%) is under haor. Almost 80% of this area (i.e. 0.68 million ha) is covered by Boro rice. Early flood, hailstorm and drought are the main constraints to grow modern Boro rice. So, farmers choice to cover more areas with high value vegetable and field crops instead of Boro rice. Farmers were growing bush bean and sweet gourd separately. But these can be relayed in the same field to save time, cost of cultivation and increased land productivity. The present study was therefore, executed with a view to find out the agro-economic feasibility to overcome existing farmer's practices in this area.

Materials and Methods

An experiment was executed at farmers field of Hakaluki haor under multilocation testing (MLT) site, Moulvibazer, initiated in the years of 2020-21 to see the performance of improved cropping pattern as well as productivity and income of farmers. The existing and improved cropping patterns were Bushbean-Fallow-Fallow (CP₁: Existing cropping patter) and Bushbean-Sweet gourd-Fallow (CP₂: Improvement cropping pattern), respectively. The variety BARI Hybrid Mistikumra-1 of sweet gourd and locally popular bushbean were used in this trial.

The area 1200 m² was covered by in each replication. The fertilizer nutrients @120-40-50-10-2-1 kg of NPKSZnB were used as Urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid. Seeds of both bush bean and sweet gourd were sown on 15-20 November 2021 maintaining the spacing of 30 cm x 15 cm and 2 m x 2 m respectively. Bushbean was harvested at maturity on 25-28 February 2020. Intercultural operations viz., weeding, irrigation and fungicide spray (Bavistine @ 0.2% for controlling damping of disease and sprayed 3 times) was maintained in order to support normal plant growth. After harvesting of bush bean on 30g of urea and 25 g of MoP were applied near the each pit. During experiment a total of 3 irrigations were provided for sweet gourd. The water suckers near the base of sweet gourd were

removed. Hand pollination was done for more fruit setting in sweet gourd. Seed yield of bushbean and fruit yield of sweet gourd was measured plot wise and converted in t ha^{-1} . All data were then analyzed following MS excel package.

Results and Discussions

Yield of Bush bean and Sweet gourd: The sole cultivation of bush bean under existing pattern (CP_1) was produced higher seed yield (4.47 t ha^{-1}) as compared to yield (4.31 t ha^{-1}) under improved cropping pattern (CP_2). On the contrary, 35 t ha^{-1} fruits of sweet gourd was produced by improved cropping pattern, whereas lands the remain follow in the existing cropping pattern.

Productivity: The total productivity of a pattern to be ascertained by the bushbean equivalent yield, which was calculated from the yields of component crop. Bushbean equivalent yield (BEY) was differed due to differences of yields and price of component crop. Between two different tested patterns, the highest average BEY (14.58 t ha^{-1}) was recorded from improved pattern (CP_2) as compared to existing pattern. Due to inclusion of sweet gourd increased of BEY, land use efficiency and production efficiency 27, 200 and 192%, respectively in improve cropping pattern.

Economics

The cost benefit of two tested cropping patterns revealed that the highest gross return (Tk. 874800 ha^{-1}) and gross margin (Tk. 659400 ha^{-1}) was obtained by improved pattern (CP_2).

Farmers' opinion

Farmers opined that bushbean as a short duration legume crop easily could be grown with sweet gourd in haor of Sylhet region.

Table 1. Yield performance of existing and improve cropping patterns in Sylhet, 2020-21

Pattern	Seed/Fruit yield (t ha^{-1})		
	Bushbean	Sweet gourd	Fallow
CP_1	4.47	-	-
CP_2	4.31	35	-

Table 2. Productivity of existing and improve cropping patterns in Sylhet, 2020-21

Pattern	BEY (t ha^{-1})	Land use efficiency (%)	Production efficiency ($\text{kg. ha}^{-1} \text{ day}^{-1}$)
CP_1	11.47	23.29	5.26
CP_2	14.58	69.86	15.41

BEY= Bushbean equivalent yield

Table 3. Cost benefit analysis of existing and improved cropping pattern.

Patterns	Gross Return (Tk. ha^{-1})	Cost of cultivation (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
CP_1	268200	125000	143200
CP_2	874800	215000	659400

Price of output (Tk. kg^{-1}): Poughing-Tk. 300 big^{-1} , Labour- Tk. 450 $\text{m}^{-1} \text{d}^{-1}$, bushbean- 60.00, sweet gourd -20.00

Conclusion

Bushbean as short duration legume crop could be grown with soyben in haor of Sylhet region.

DEVELOPMENT OF ALTERNATE CROPPING PATTERNS PROSO MILLET-FALLOW-T. AMAN AND SAFFLOWER-FALLOW-T. AMAN AGAINST EXISTING FALLOW-FALLOW-T. AMAN CROPPING PATTERN IN SALINE CHAR AREAS

A.H. Md. Amir Faisal, M. M. U. Chowdhury, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted to evaluate the agro-economic performance of alternate (Proso Millet-Fallow-T. Aman and Safflower-Fallow-T. Aman) cropping patterns against farmers existing cropping pattern (Fallow-Fallow-T. Aman) for increasing cropping intensity and productivity at farmers' field of FSRD site, Subarnachar upazilla under Noakhali district during 2019-2020 and 2020-2021. During Rabi season one crop can be grown successfully in the fallow land by using suitable salinity tolerance or escaping crops which was tested in the alternate cropping patterns (ACPs). The highest rice equivalent yield (7.81 t ha^{-1}) was obtained from Safflower-Fallow-T. Aman (ACP2) cropping pattern. Gross return of that pattern was TK..156230 ha^{-1} which was 6.30% higher over Proso millet-Fallow-T. Aman (ACP1) pattern. The higher gross margin (TK..72,444 ha^{-1}) from ACP2 pattern was achieved mainly higher price of the safflower (TK.. 45 Kg^{-1}). In case of mean production efficiency, 54.41 and 47.60 $\text{kg ha}^{-1} \text{ day}^{-1}$ were obtained from Proso millet-Fallow-T. Aman and Safflower-Fallow-T. Aman cropping patterns. Moreover, 2.95 (ACP1) and 2.17 (ACP2) marginal benefit cost ratio of the alternate cropping patterns indicate their superiority over farmers' existing patterns.

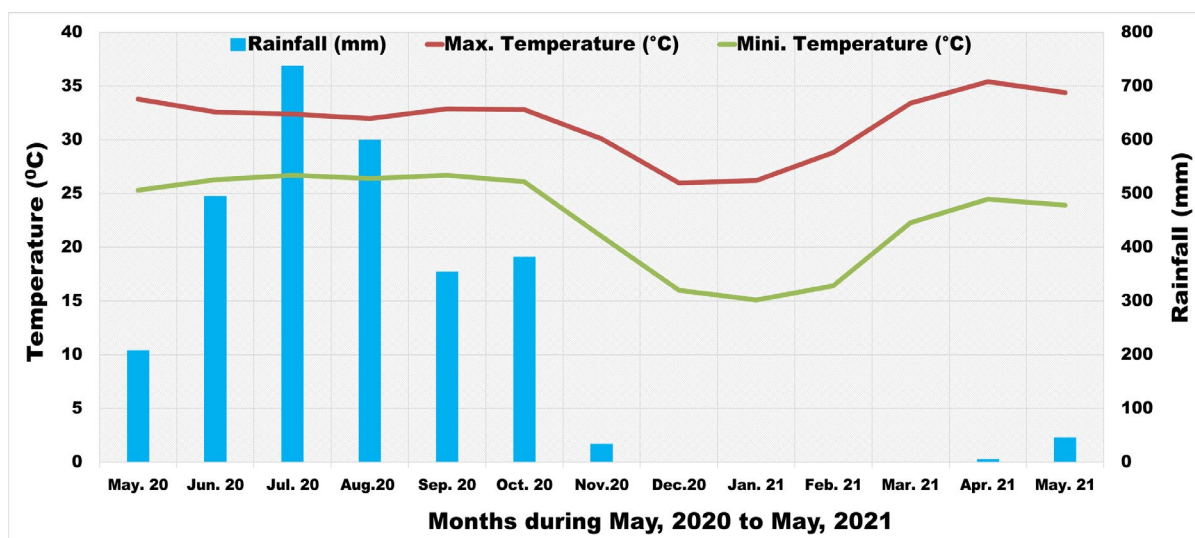
Introduction

In the char areas of Noakhali region, soil salinity increases progressively through capillary movement and reaches peak in around Mid-March to April, at the beginning of the pre-monsoon season (8.5 to 14.0 dS m^{-1}) which diminishes with the onset of monsoon (1.5 to 4.2 dS m^{-1}) and allow farmers to grow T. Aman (Sattar, 2002). Moreover, the salinity stress is most pronounced in the top 10 cm of soil where large spatial variations exist though, both in the top and sub soil layers, and even within the same plot of land (Amin *et al.*, 2011). However, dry season Aus rice can only be grown on plots of land that have the suitable land level and soil salinity. On the other hand, during Rabi season the land mostly remains fallow in the upazilla namely Subarnachar, Companiganj and Hatiya due to salinity, scarcity of quality irrigable water and irrigation facilities, poor knowledge about integration and inadequate salt tolerant varieties etc. The predominant cropping pattern is Fallow-Fallow-T. Aman (42%), although double cropping (Fallow-T. Aman -Rabi crops) is practiced in some areas, triple cropping (B. /D. Aus-T. Aman-Rabi crops) is rare. Additionally, during couple of years scientist of OFRD, BARI, Noakhali testing minor cereal crops performance in the saline areas and identified that Proso millet can escape the adverse effect of salinity due to its short duration (85-90 days) which may fit into the cropping pattern. Moreover, it can be grown in less fertile soil with minimum inputs. Despite Proso millet, Safflower is rated as moderately salt tolerant, and it can produce profitable crops on saline soils. It is slightly more tolerant of salinity than barley but is more tolerant than wheat. Bangladesh Agricultural Research Institute developed some high yielding varieties of Proso millet (BARI Cheena-1) and Safflower (BARI Saff-1) which are needed to validate and up-scaling as cropping pattern system along with improved management practices. With the aim of increased cropping intensity in changing climate the mentioned cropping patterns system was undertaken against Fallow-Fallow-T. Aman cropping pattern at farmer's field.

Materials and Method

The experiment was conducted to evaluate the agro-economic performance of alternate cropping patterns (ACP) against existing cropping pattern (ECP), with the objective to increase cropping intensity and productivity at six (three for each alternate cropping pattern) farmer's field of FSRD site, Subarnachar upazilla under Noakhali district during 2019-2020 and 2020-2021. The alternate cropping patterns (ACP) were Proso millet (BARI Cheena-1) - Fallow-T. Aman (BRRI Dhan52) and Safflower (BARI Saff-1) - Fallow-T. Aman (BRRI Dhan52) and the existing cropping pattern (ECP) is Fallow-Fallow-T. Aman (Rajashail/Kajalshail). The experimental fields belong to AEZ 18f (Young Meghna Estuarine Floodplains) where moderately to strong soil salinity level (4 to $\geq 12 \text{ dS m}^{-1}$) observed during dry season along with rainfed condition. Previously, only one rice crop was cultivated mainly T. Aman

when heavy rains temporarily decrease the salinity from the topsoil. Additionally, climatically the region represents a very wet region with annual rainfall ranging from 2500 mm to 3000 mm. The monthly highest temperature (35.4 °C) measured in the month of April 2021 and the lowest (15.1 °C) in the month of January 2021 (Graph 1).



Graph 1. Weather information of Noakhali (during May 2020 to May 2021).

Source: Bangladesh Meteorological Department, Noakhali

Soils are mostly silty clay loam, silty clay and clay loam with low organic matter content. Unit plot size was 10 decimals for all the alternate cropping patterns and existing cropping pattern. The agronomic practices for crop production under improved and farmers' practices were recorded for agro-economic performance analysis (Table 1 and Table 2).

Table 1. Agronomic parameters of Proso Millet-Fallow-T. Aman cropping pattern against farmers' existing pattern Fallow-Fallow-T. Aman rice at FSRD site, Subarnachar, Noakhali during 2019-20 and 2020-21

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Proso Millet	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Cheena-1	-	BRRI Dhan52	-	-	Mamun Swarna
Unit plot size (dec)	10	-	10	-	-	10
Transplanting/sowing Date	2019-20 13-15/12/19		12-14/8/19	-	-	16-18/8/19
	2020-21 16-18/12/20		19-21/8/20			19-22/8/20
Seed rate ((kg ha ⁻¹))	20		40	-	-	42
Planting method	Broadcasting	-	Line Sowing	-	-	Random
Spacing (row x hill)	-	-	25X15	-	-	Not specified
Seedling age (days)	-	-	30-32	-	-	33-35
Fertilizer dose (N-P-K-S-Zn kg ha ⁻¹)	54-24-32-10-1		52-18-33-4-2	-	-	76-10
Date of	2019-20 5-8/3/20		6-8/12/19	-	-	10-12/12/19
harvesting	2020-21 8-11/3/21		7-10/12/20	-		11-14/12/20
Field duration (days)	82 to 85		112 to 114	-	-	114 to 117

Table 2. Agronomic parameters of Safflower-Fallow-T. Aman cropping pattern against farmers' existing pattern Fallow-Fallow-T. Aman rice at FSRD site, Subarnachar, Noakhali during 2019-2020 and 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Safflower	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Saff-1	-	BRRRI Dhan52	-	-	Kajashail
Unit plot size (dec)	10	-	10	-	-	10
Transplanting/	19-22/12/19		14-16/8/19	-	-	15-18/8/19
sowing Date	2020-21	14-16/12/20	11-13/8/20			16-20/8/20
Seed rate ((kg ha ⁻¹))	20		40	-	-	45
Planting method	Line sowing	-	Line Sowing	-	-	Random
Spacing (row x hill)	30 cm X 5 cm	-	25 cm × 15 cm	-	-	Not specified
Seedling age (days)	-	-	30-32	-	-	34-36
Fertilizer dose (N-P-K-S-Zn kg ha ⁻¹)	38-20-11-0-0-0	-	52-18-33-4-2	-	-	82-12-8
Date of	2019-20	21-24/4/2020	-	6-9/12/19	-	14-16/12/19
harvesting	2020-21	15-18/4/21		5-8/12/20	-	13-1/12/20
Field duration (days)	120-125		114 to 117	-	-	118 to 120

Soil salinity data during growth stages of the mentioned entities were recorded. The salinity was measured by EZODO PCT-407 (GONDO Electronic Co. Ltd. Made by Taiwan). To get the actual reading, each time representative soil samples according to treatment from each replication were measured at the FSRD site office using 1:3 soil and distilled water extract method. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Results and Discussion

Soil salinity level in the fields of Proso millet- Fallow-T. Aman Cropping pattern (ACP1)

In 2019-2020, soil salinity was low in the experimental sites during crop establishment and at vegetative stage (after 20 DAS) about 2 dS m⁻¹. However, soil salinity was low in West Al-Amin site compared to Katabunia site throughout the growing season and peaks up near about 13 dS m⁻¹ during harvesting period of Proso millet (2020-21). In this site, shattering was observed which may be due to salinity or maturity start from lower side of the panicle to upper side.

Agro-economic performance of Proso millet- Fallow-T. Aman Cropping pattern (ACP1)

In the improved cropping pattern, grain yield of Proso millet were 1.58 and 1.37 t ha⁻¹ and straw yield were 1.89 and 1.81 t ha⁻¹ in two consecutive years, respectively. Proso millet grain yield decreased by 13.29 % in the second year probably due to late sown (3 to 5 days) than that in the first year or high salinity observed during reproductive and maturity stages. On the other hand, yield of T. Aman increased about 6% over farmers practices might be due to proper management practices and low lodging tendency of the variety during high rainfall in the maturity stage (Table 3).

Table 3. Performance of improved (Proso millet-Fallow- T. Aman) and existing (Fallow-Fallow- T. Aman) cropping pattern at FSRD site, Subarnachar, Noakhali during 2019-2020 and 2020-21.

Observation		Improved cropping pattern			Existing cropping pattern		
Crop	Year	Proso millet	Fallow	T. Aman	Fallow	Fallow	T. Aman
Grain Yield (t ha ⁻¹)	2019-20	1.58	-	4.18	-	-	3.92
	2020-21	1.37	-	4.12	-	-	3.87
Av. Seed/Grain Yield (t ha ⁻¹)		1.48	-	4.15	-	-	3.90
Straw yield (t ha ⁻¹)	2019-20	1.89	-	4.97	-	-	4.90
	2020-21	1.81	-	4.95	-	-	4.97
Av. Stover/ Straw Yield (t ha ⁻¹)		1.85	-	4.96	-	-	4.94
Rice equivalent yield (t ha ⁻¹)	2019-20	2.86	-	4.68	-	-	4.46
	2020-21	2.49	-	4.62	-	-	4.37
Av. REY (t ha ⁻¹)		2.68	-	4.65	-	-	4.42

Observation		Improved cropping pattern			Existing cropping pattern		
Crop	Year	Proso millet	Fallow	T. Aman	Fallow	Fallow	T. Aman
Whole pattern Rice equivalent yield (t ha ⁻¹)	2019-20	7.54			4.46		
	2020-21	7.11			4.37		
Av. WPREY yield (t ha ⁻¹)		7.33			4.42		
Av. GR (TK. ha ⁻¹)		53475	-	92920	-	-	87770
Av. TVC (TK. ha ⁻¹)		18650	-	59890	-	-	58570
Av. GM (TK. ha ⁻¹)		34825	-	33030			29200
Av. WPGM (TK. ha ⁻¹)		67855			29200		
Av. MBCR		2.95					
Production efficiency (kg ha ⁻¹ day ⁻¹)	2019-20	55.93			33.95		
	2020-21	52.79			33.52		
Average production efficiency (kg ha ⁻¹ day ⁻¹)		54.41			33.74		
Average Land Utilization Index (%)		54			31.50		

Input & output price per Kg: Proso millet selling price = 35/-, Paddy selling price = 20/-, Rice Straw=2/-, Millet Straw=1/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Labour = 500/- per day *Av. = Average, REY= Rice Equivalent Yield, WPREY= Whole Pattern Rice Equivalent Yield. GR= Gross Return, TVC=Total Variable Cost, GM= Gross Margin, WPGM=Whole Pattern Gross Margin, MBCR=Marginal Benefit Cost Ratio

Proso millet-Fallow-T. Aman cropping pattern produced average higher rice equivalent yield (7.33 t ha⁻¹ yr⁻¹) over existing farmers' cropping pattern (Table 3). Inclusion of Proso millet in *Rabi* season in alternate cropping pattern increased average REY at about 40% compared to farmers practiced cropping pattern.

Production efficiency was higher in Proso millet-Fallow- T. Aman cropping pattern compared to farmers' existing cropping pattern. Furthermore, two years average production efficiency (54.41) in terms of kg ha⁻¹ day⁻¹ was obtained from Proso millet-Fallow-T. Aman pattern (Table 3).

Land utilization index (LUI) indicated that the land was occupied by more than half period of the year whereas farmers' pattern used the land for 33.74% period of the year.

From the economic point of view, Proso millet-Fallow-T. Aman cropping pattern showed better gross margin than farmers' existing cropping pattern. It was TK.. 67,855 ha⁻¹ which was about 57% higher over farmers' pattern (Table 3). Furthermore, the average marginal benefit cost ratio was 2.95.

Soil salinity level in the fields of Safflower- Fallow-T. Aman Cropping pattern (ACP2)

In general, salinity tolerance was mainly estimated at plant germination and emergency stages. During 2019-2020 cropping season, soil salinity level was below 0.70 dS m⁻¹ at tow locations whereas it was just above 1.0 dS m⁻¹ at other locations. On the other hand, salinity level was above 1.70 dS m⁻¹ across all the locations during 2020-21. It is notable that Safflower crop is more sensitive to salinity at germination stage in comparison to late development stages. During harvesting time, soil salinity level was ranged from 8.96 to 10.61 dS m⁻¹ across all locations in 2019-2020 whereas the level ranged from 9.46 to 12.13 dS m⁻¹ in 2020-2021.

Agro-economic performance of Safflower- Fallow-T. Aman Cropping pattern (ACP2)

In the alternate cropping pattern (ACP2), two years average seed and stover yields of safflower were 1.40 and 1.99 t ha⁻¹. Safflower seed yield increased by 8.22 % in the second year probably due to early season (5 to 7 days) than that in the first year or low salinity level during germination stage. Moreover, safflower is a deep rooted plant and can uptake water from deeper layer which allow it to uptake water during reproductive and maturity stages though high temperature observed during reproductive stage (Graph 1). On the other hand, average yield of T. Aman increased about 30.10 % over farmers practices might be due to change of variety and proper management practices (Table 4).

Safflower-Fallow-T. Aman cropping pattern produced the highest rice equivalent yield (7.81 t ha⁻¹ yr⁻¹) over ACP1 as well as existing farmers' cropping pattern (Table 4). Inclusion of safflower in *Rabi* season in alternate cropping pattern increased average REY at about 57% compared to farmers practiced cropping pattern.

Moreover, 12.52 kg ha⁻¹ day⁻¹ lower production efficiency was obtained from safflower-Fallow-T. Aman pattern compared to Proso millet-Fallow-T. Aman pattern (54.41 kg ha⁻¹ day⁻¹) but 49.16% higher than the farmers' existing pattern (Table 4). Production efficiency in ACP2 increased might be due to inclusion of an additional safflower crop with modern varieties (both safflower and T. Aman) and improved management practices (Table 2).

Land utilization index (LUI) indicated that ACP2 pattern used the land for 65 % period of the year, whereas farmers' pattern for 33 % (Table 4). Land use efficiency was 49.23 % higher in ACP2 pattern than farmers' practice, mostly because the improved pattern occupied the field for longer duration (234 to 238 days), than the farmers' pattern (118 to 120 days) in a year (Table 2).

From the economic point of view, Proso millet-Fallow-T. Aman cropping pattern showed better gross margin than farmers' existing cropping pattern. It was TK.. 67,855 ha⁻¹ which was about 57% higher over farmers' pattern (Table 3). Furthermore, the average marginal benefit cost ratio was 2.95.

The economic analysis as shown in Table 4 indicated the higher return of the alternate cropping pattern (Safflower-Fallow-T. Aman) than the farmers' pattern (Fallow-Fallow-T. Aman). Average gross return of the alternate pattern was TK..1,56,230 ha⁻¹ which was 57 % higher over farmers' pattern. Average gross margin was substantially higher in the ACP2 pattern (Tk.72,444 ha⁻¹) than farmers' pattern (TK.. 24,601 ha⁻¹). Additional gross margin (66.04%) was achieved by adding 48.86 % extra cost in the alternate pattern (Table 4). Mean marginal benefit cost ratio (MBCR) was found 2.17 which further indicated the superiority of the improved pattern over the farmers' one.

Farmers' Opinion

Farmers' expressed their satisfaction for getting higher yield and economic return from both alternate patterns. In general, they preferred Proso millet-Fallow-T. Aman cropping pattern due to less investment and labour requirements during sowing time. Furthermore, there was no insect infestation in Proso millet whereas disease and insect infestation were noticed in Safflower.

Table 4. Performance of improved Safflower-Fallow- T. Aman) and existing (Fallow-Fallow- T. Aman) cropping pattern at FSRD site, Subarnachar, Noakhali during 2019-2020 and 2020-21

Observation		Improved cropping pattern			Existing cropping pattern		
Crop	Year	Safflower	Fallow	T. Aman	Fallow	Fallow	T. Aman
Grain Yield (t ha ⁻¹)	2019-20	1.34	-	4.09	-	-	2.81
	2020-21	1.46	-	4.15	-	-	2.95
Av. Seed/Grain Yield (t ha ⁻¹)		1.40	-	4.12	-	-	2.88
Straw/stover yield (t ha ⁻¹)	2019-20	2.09	-	5.02	-	-	4.87
	2020-21	1.89	-	4.81	-	-	4.98
Av. Stover/ Straw Yield (t ha ⁻¹)		1.99	-	4.92	-	-	4.93
Rice equivalent yield (t ha ⁻¹)	2019-20	3.07	-	4.59	-	-	3.30
	2020-21	3.33	-	4.63	-	-	3.45
Av. REY (t ha ⁻¹)		3.20	-	4.61	-	-	3.38
Whole pattern Rice equivalent yield (t ha ⁻¹)	2019-20	7.66			3.30		
	2020-21	7.96			3.45		
Av. WPREY yield (t ha ⁻¹)		7.81			3.38		
Av. GR (TK. ha ⁻¹)		64000	-	92230	-	-	67450
Av. TVC (TK. ha ⁻¹)		23896	-	59890	-	-	42849
Av. GM (TK. ha ⁻¹)		40104	-	32340			24601
Av. WPGM (TK. ha ⁻¹)		72444			24601		
Av. MBCR		2.17					
Production efficiency (kg ha ⁻¹ day ⁻¹)	2019-20	47.33			23.61		
	2020-21	47.86			24.79		
Average production efficiency (kg ha ⁻¹ day ⁻¹)		47.60			24.20		
Average Land Utilization Index (%)		65			33		

Input & output price per Kg: Safflower selling price = 45/-, Paddy selling price = 20/-, Rice Straw=2/-, Safflower stover=0.50/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Labour = 500/- per day *Av. = Average, REY= Rice Equivalent Yield, WPREY= Whole Pattern Rice Equivalent Yield. GR= Gross Return, TVC=Total Variable Cost, GM= Gross Margin, WPGM=Whole Pattern Gross Margin, MBCR=Marginal Benefit Cost Ratio

Conclusion

The cropping pattern Proso millet-Fallow-T. Aman and Safflower-Fallow-T. Aman are found agronomical and economically viable for moderate to high saline prone area as Proso millet can escape adverse effect soil salinity with less growth duration and safflower can uptake moisture from differ layer of soil. A final Conclusion could be drawn after completion of three cycle of the whole pattern.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN SWEET SORGHUM-FALLOW-T. AMAN AGAINST EXISTING FALLOW-FALLOW-T. AMAN CROPPING PATTERN IN SALINE CHAR AREAS

A.H. Md. Amir Faisal and M. M. U. Chowdhury, M Akkas Ali, M Shahiduzzaman

Abstract

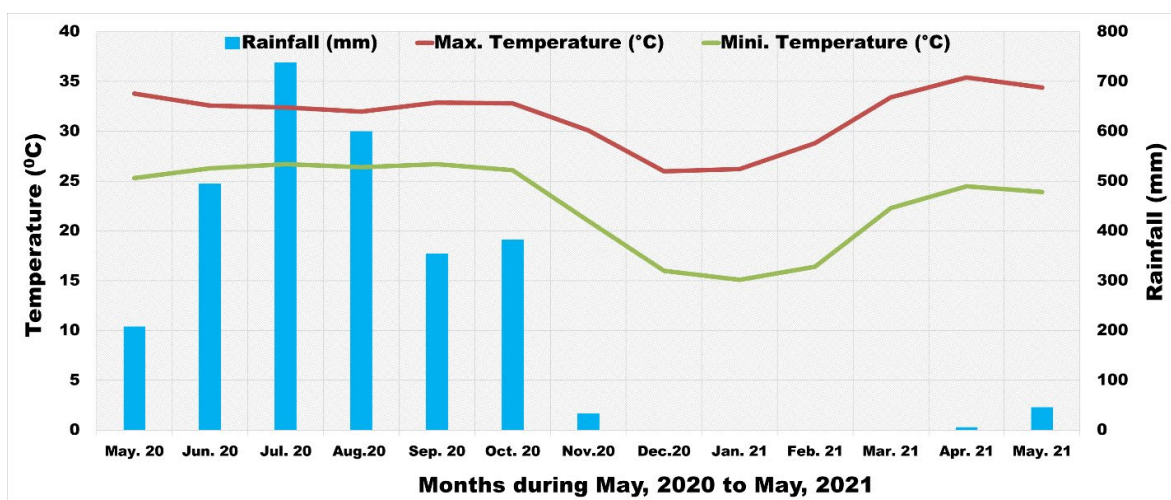
The experiment was conducted to evaluate the agro-economic performance of alternate (Sweet Sorghum-Fallow-T. Aman) cropping pattern against farmers' existing cropping pattern (Fallow-Fallow-T. Aman) for increasing cropping intensity and productivity at farmers' field of Kellar Char, Companiganj upazilla under Noakhali district during 2019-2020 and 2020-2021. During Rabi season one crop can be grown successfully in the fallow saline land by using suitable salinity tolerance crop which was tested in the alternate cropping pattern (ACP). The highest rice equivalent yield (6.86 t ha^{-1}) was obtained from Sorghum-Fallow-T. Aman alternate cropping pattern whereas it was 3.34 t ha^{-1} in existing cropping pattern. Average gross margin of alternate pattern was Tk. 55,470 ha^{-1} which was above 57% higher over farmers' existing cropping pattern.

Introduction

Fallow-Fallow-T. Aman is the most dominant cropping pattern, alone occupied 45% land of net cropped area in Noakhali district where a sharp variation was observed in cropping patterns among the different upazilla. However, crop lands of Subarnachar, Sadar, Companiganj and Hatiya upazilla are affected with varying degrees of soil salinity which is a constraint for the cultivation of Boro rice and other Rabi crops. The cropping intensity is much lower than those of non-saline areas of the country. The yields of cereal crops are tending to stagnation, especially in favourable environments and cultivable land area is decreasing day by day in the country. To increase the system productivity of the total environment it needs to bring diversity in cropping pattern for better utilization of limited resources. OFRD, BARI, Noakhali testing performance of sorghum crop advanced lines and local (Munshiganj) variety in the saline areas and identified that sorghum can tolerate salinity due to its salt tolerance properties which may fit into the cropping pattern. Moreover, it is slightly more tolerant of salinity than barley but is more tolerant than wheat. Above mentioned crop are needed to further testing, validation and up-scaling in cropping pattern system along with improved management practices. -

Materials and Method

The experiment was conducted to evaluate the agro-economic performance of alternate cropping patterns (ACP) against existing cropping pattern (ECP) at farmer's field in Companiganj upazilla under Noakhali district during 2019-2020 and 2020-21. The alternate cropping patterns (ACP) was Sorghum (BARI Sorghum-1)-Fallow-T. Aman (BR23) and the existing cropping pattern (ECP) Fallow-Fallow-T. Aman (Kajalshail). The experimental fields belong to AEZ 18f (Young Meghna Estuarine Floodplains) where moderately to strong soil salinity level ($4 \text{ to } \geq 12 \text{ dS m}^{-1}$) observed during dry season along with rainfed condition. Additionally, climatically the region represents a very wet region with annual rainfall ranging from 2500 mm to 3000 mm. The monthly highest temperature (35.4°C) measured in the month of April 2021 and the lowest (15.1°C) in the month of January 2021 (Graph 1).



Graph 1. Weather information of Noakhali (during May 2020 to May 2021).

Source: Bangladesh Meteorological Department, Noakhali

The agronomic practices for crop production under improved and farmers' practices were recorded for agro-economic performance analysis (Table 1).

Table 1. Agronomic parameters of Sorghum-Fallow-T. Aman cropping pattern against existing pattern Fallow-Fallow-T. Aman rice at FSRD site, Subarnachar, Noakhali during 2019-2020 and 2020-2021

Observation		Improved cropping pattern			Existing cropping pattern		
Crop		Sorghum	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety		BARI Sorghum-1	-	BR23	-	-	Kajashail
Unit plot size (dec)		10	-	10	-	-	10
Transplanting/ sowing Date	2019-20	17-19/12/2019		20-22/8/2019	-	-	19-21/8/19
	2020-21	14-16/12/2020		17-19/8/2020			19-22/8/20
Seed rate ((kg ha ⁻¹))		10		40	-	-	45
Planting method		Line Sowing	-	Line Sowing	-	-	Random
Spacing (row x hill)		50X15	-	25X15	-	-	Not specified
Seedling age (days)		-	-	34-36	-	-	34-36
Fertilizer dose (N-P-K-S-Zn kg ha ⁻¹)		120-60-40-30-10-2	-	80-19-33-9-4-0	-	-	76-10-0-0-0-0
Date of harvesting	2019-20	20-22/4/2020	-	9-12/12/2019	-	-	10-14/12/2019
	2020-21	16-19/4/2021		8-10/12/2020	-		11-14/12/20
Field duration (days)		123 to 125		112 to 115 (without seedling age)	-	-	113 to 117

Soils are mostly silty clay loam, silty clay and clay loam with low organic matter content. Unit plot size was 5 decimals for all the alternate cropping patterns and existing cropping pattern. The agronomic practices for crop production under improved and farmers' practices were recorded for agro-economic performance analysis (Table 1 and Table 2). Soil salinity data during growth stages of the mentioned entities were recorded. The salinity was measured by EZODO PCT-407 (GOnDO Electronic Co. Ltd. Made by Taiwan). To get the actual reading, each time representative soil samples according to treatment from each replication were measured at the FSRD site office using 1:3 soil and distilled water

extract method. Different parameters such as rice equivalent yield (REY), Marginal benefit-cost ratio (MBCR), Production efficiency (PE), Land use efficiency (LUE) was calculated as per Appendix Table 1.

Results and Discussion

Soil salinity level in the fields of Proso millet- Fallow-T. Aman Cropping pattern (ACP1)

Salinity levels were ranged from 0.92 to 1.69 dS m⁻¹ at emergence stage during 2019-2020 whereas it was 1.30 to 2.09 dS m⁻¹ during 2020-2021. Soil salinity was higher in the second year might be due to less rainfall compared to previous year. Furthermore, soil salinity remained below 4.15 dS m⁻¹ in the first year experimental plots whereas it was more than 4.5 dS m⁻¹ during last phase of vegetative stage in the year of 2020-2021. In the first year, soil salinity level was low during vegetative stage because of rainfall occurred in early January 2020. In case of second year, high temperature with no rainfall observed throughout the vegetative to maturity stage which provoked salinity progression and ranged from 11.15 to 13.34 dS m⁻¹.

Grain and byproduct yield: Results of alternate cropping pattern and farmer's existing pattern have been presented in Table 2. In the alternate cropping pattern, BARI Sorghum-1 average grain yield and the byproduct yield was 1.62 and 4.30 t ha⁻¹ (Leaf with stalk), respectively (Table 2). In case of field duration, it required 123 to 125 days for physiological maturity.

Rice equivalent yield (REY): Sorghum-Fallow-T. Aman cropping pattern produced higher mean rice equivalent yield (6.86 t ha⁻¹yr⁻¹) over existing farmers' cropping pattern (Table 2) which increased at about 51.31 % compared to farmers practice.

Production efficiency: Production efficiency was higher in alternate cropping pattern compared to farmers' existing cropping pattern. Furthermore, maximum production efficiency (47.39) in terms of kg ha⁻¹day⁻¹ was obtained from Sweet Sorghum-Fallow-T. Aman pattern (Table 2).

Land utilization Index (LUI): In case of Sweet Sorghum-Fallow-T. Aman cropping pattern, Land utilization index (LUI) indicated that the land was occupied by 65% period of the year whereas farmers' pattern used the land for 32% period of the year. The higher land use efficiency in ACP pattern because this pattern occupied the field for longest duration (235 to 240 days), whereas the farmers' pattern occupied the field for 113 to 117 days of the year.

Cost and return analysis

Average gross return of the alternate pattern was TK..1,41,765 ha⁻¹ which was 53 % higher over farmers' pattern. Average gross margin was substantially higher in the alternate pattern (TK.. 55,470 ha⁻¹) than farmers' pattern (TK.. 23,851 ha⁻¹). Additional gross margin (57%) was achieved by adding 50 % extra cost in the alternate pattern (Table 2). Mean marginal benefit cost ratio (MBCR) was found 1.73 which further indicated the superiority of the improved pattern over the farmers' one. Thus, inclusion of sorghum in the existing pattern might be agronomically suitable and economically profitable.

Farmers' Opinion

It was observed that at the time of sorghum harvesting a serious fodder crisis was prevailed across the sites. So, sorghum might be a good option for forage production in the saline areas. Moreover, farmers' expressed their satisfaction for getting higher yield and economic return from alternate pattern.

Table 2. Performance of improved (Proso millet-Fallow- T. Aman) and existing (Fallow-Fallow- T. Aman) cropping pattern at FSRD site, Subarnachar, Noakhali during 2019-2020 and 2020-21.

Observation		Improved cropping pattern			Existing cropping pattern		
Crop	Year	Sorghum	Fallow	T. Aman	Fallow	Fallow	T. Aman
Grain Yield (t ha ⁻¹)	2019-20	1.72	-	3.91	-	-	2.87
	2020-21	1.51	-	3.89	-	-	2.84
Av. Seed/Grain Yield (t ha ⁻¹)		1.62	-	3.90	-	-	2.86
Byproduct yield (t ha ⁻¹)	2019-20	4.58	-	4.76	-	-	4.72
	2020-21	4.01	-	4.63	-	-	4.90

Observation		Improved cropping pattern			Existing cropping pattern		
Crop	Year	Sorghum	Fallow	T. Aman	Fallow	Fallow	T. Aman
Average byproduct Yield (t ha ⁻¹)		4.30	-	4.70	-	-	4.81
Rice equivalent yield (t ha ⁻¹)	2019-20	2.69	-	4.39	-	-	3.34
	2020-21	2.28	-	4.35	-	-	3.33
Av. REY (t ha ⁻¹)		2.49	-	4.37	-	-	3.34
Whole pattern Rice equivalent yield (t ha ⁻¹)	2019-20	7.08			3.34		
	2020-21	6.63			3.33		
Av. WPREY yield (t ha ⁻¹)		6.86			3.34		
Av. GR (TK. ha ⁻¹)		54375	-	87390	-	-	66700
Av. TVC (TK. ha ⁻¹)		28410	-	57885	-	-	42849
Av. GM (TK. ha ⁻¹)		25965	-	29505			23851
Av. WPGM (TK. ha ⁻¹)		55470			23851		
Av. MBCR		1.73					
Production efficiency (kg ha ⁻¹ day ⁻¹)	2019-20	48.33			24.96		
	2020-21	46.45			24.70		
Average production efficiency (kg ha ⁻¹ day ⁻¹)		47.39			24.83		
Average Land Utilization Index (%)		65			32		

Input & output price per Kg: Sorghum selling price = 32/-, Paddy selling price = 20/-, Rice Straw=2/-, Sorghum byproduct=1/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Labour = 500/- per day *Av. = Average, REY= Rice Equivalent Yield, WPREY= Whole Pattern Rice Equivalent Yield. GR= Gross Return, TVC=Total Variable Cost, GM= Gross Margin, WPGM=Whole Pattern Gross Margin, MBCR=Marginal Benefit Cost Ratio

Conclusion

The improved cropping pattern Sweet Sorghum-Fallow-T. Aman was found agronomical and economically viable for moderate to high saline prone area as sorghum can tolerate adverse effect soil salinity with more byproduct, could be used as fodder.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN MAIZE-T. AUS-T. AMAN AGAINST BORO-FALLOW-T. AMAN

K U Ahammad, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted in the farmers' field of Multilocation Testing (MLT) site, Kaliganj, Jhenidah during 2019-20 and 2020-21 to develop a alternate cropping pattern Maize (BHM-9)-T. Aus(BRRI dhan-48)-T. Aman (BRRI dhan-75) against Boro (BRRI dhan28)-Fallow-T. Aman (Binadhan-7). There were two treatments i.e, T₁: Existing cropping pattern: Boro (BRRI dhan28)-Fallow-T. Aman (Binadhan-7) and T₂: Alternate cropping pattern: Maize (BHM-9)-T. Aus(BRRI dhan-48)-T. Aman (BRRI dhan-75). Higher Rice Equivalent yield (19.25 t ha⁻¹) and gross margin (Tk. 208560 ha⁻¹) were obtained from alternate cropping pattern over existing cropping pattern due to inclusion of new crops and marginal benefit cost ratio was 3.46.

Introduction

The present cropping intensity of the country is 192%. In order to produce more food within a limited area, it is very important to increase cropping intensity and for this reason more suitable crop(s) should be included in the existing cropping pattern. The present study was undertaken to develop a alternate cropping pattern Maize (BHM-9)-T. Aus (BRRI dhan-48)-T. Aman (BRRI dhan-75) against Boro (BRRI dhan28)-Fallow-T. Aman (Binadhan-7) cropping pattern in AEZ-11.

Materials and Methods

The trial was conducted in the farmers' field of Multilocation Testing (MLT) site, Kaliganj, Jhenidah during 2019-20 and 2020-21 to develop an alternate cropping pattern Maize (BHM-9)-T. aus (BRRI dhan-48)-T. Aman (BRRI dhan-75) against Boro (BRRI dhan28)-Fallow-T. Aman (Binadhan-7). There were two treatments i.e., T₁: Existing Cropping pattern: Boro (BRRI dhan28)-Fallow-T. Aman (Binadhan-7) and T₂: Alternate Cropping pattern: Maize (BHM-9)-T. Aus (BRRI dhan-48)-T. Aman (BRRI dhan-75). Four farmers were selected for conducting the experiment. Data for existing cropping pattern were collected from the adjacent farmer's field. The unit plot size was 0.135 hectare. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield on the basis of prevailing market price of individual crops. The economic indices i.e. gross return, gross margin, and marginal benefit cost ratio were also calculated on the basis of prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

Results and Discussion

Crop management: Crop management practices of existing and alternate cropping pattern are shown in Table 1. Existing cropping pattern, Boro-Fallow-T. Aman rice required 192 days and alternate cropping pattern Maize-T. Aus-T. Aman took 329 days (excluding seedling age of rice) to complete the cycle. Turn around time in existing cropping pattern was 173 days whereas it was only 36 days in three crops based alternate cropping pattern.

Yield performance: Yield and economic return of existing and alternate cropping pattern are shown in Table 2. In alternate cropping pattern, yield of Maize, T. Aus and T. Aman were 8.17, 3.87 and 4.61 t ha⁻¹ while in the existing pattern yield of Boro and T. Aman were 4.89 and 4.35 t ha⁻¹, respectively. Rice equivalent yield (REY) of alternate cropping pattern was 19.25 t ha⁻¹/yr, which was 108 % higher over existing cropping sequence (9.24 t ha⁻¹/yr). Higher rice equivalent yield was obtained in alternate cropping pattern due to introduction of new crops and varieties.

Cost and return

Higher gross return (Tk.381110 ha⁻¹) and gross margin (Tk. 208560 ha⁻¹) were obtained in alternate pattern over existing pattern (gross return: Tk. 214500 ha⁻¹ and gross margin: Tk. 60300 ha⁻¹). Gross margin of alternate cropping pattern was 246 % higher than that of existing cropping pattern. The MBCR was calculated 3.46 indicating that alternate cropping pattern will produce more returns than the existing farmer's pattern (Table 1).

Farmers' opinion

Farmers were happy to obtain higher income from alternate cropping pattern over existing cropping pattern. Neighboring farmers were also interested to follow the pattern. But quality seed should be ensured in due time.

Table 1. Crop management practices of existing cropping pattern (Boro-Fallow-T. Aman) and alternate cropping pattern (Maize-T. Aus-T. Aman cropping pattern) at Kaliganj, Jhenaidah during 2019-21 and 2020-21.

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Boro	Fallow	T. Aman	Maize	T. Aus	T. Aman
Variety	BRRI dhan28		Binadhan-7	BHM-9	BRRI dhan48	BRRI dhan75
Spacing	20x15 cm		20x15 cm	60x20 cm	20x15 cm	20x15 cm
Unit plot size	0.135 ha		0.135 ha	0.135 ha	0.135 ha	0.135 ha
Fertilizer dose (NPKSZnBkgha ⁻¹)	180-56-75-24-6-1.5		112-37.5-56-12-3-1	90-27-32-15-1-1	75-10-25-9-1-1	90-10-35-12-1-1.3
Fertilizer application	Basal & Top dress		Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Boro	Fallow	T. Aman	Maize	T. Aus	T. Aman
Date of transplanting/ sowing	06.02.19		28.07.18	02.11.18	01.05.19	01.08.19
Date of harvesting	10.05.19		02.11.18	02.04.19	28.07.19	27.10.19
Irrigation (no.)	40		12	2	15	10
Weeding (no.)	2		2	2	2	2
Field duration (days)	94		98	152	89	88
Turnaround time	T. Aman to Boro:95		Boro to T. aman:78	T. Aman to Maize: 05	Maize to T. aus : 28	T. aus to T. Aman : 03

Table 2. Yield and economic return of existing cropping pattern (Boro-Fallow-T. Aman) and alternate cropping pattern (Maize-T. Aus-T. Aman cropping pattern) at Kaliganj, Jhenidah during 2019-20 and 2020-1 (Pooled)

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Boro	Fallow	T. Aman	Maize	T. Aus	T. Aman
Variety	BRRI dhan28	-	Binadhan-7	BHM-9	BRRI dhan48	BRRI dhan75
Seed/Grain yield (t ha ⁻¹)	4.89	-	4.35	8.17	3.87	4.61
Stover/straw yield (t ha ⁻¹)	5.45	-	4.15	6.68	4.89	4.92
Rice Equivalent yield (t ha ⁻¹)	9.24			19.25		
Gross margin (Tk.ha ⁻¹)	22700	-	37600	125600	37600	45360
Total variable cost (Tk. ha ⁻¹)	96900	-	57300	67500	47750	57300
Gross return (Tk. ha ⁻¹)	119600	-	94900	193100	85350	102660
Whole pattern Gross margin (Tk. ha ⁻¹)	60300			208560		
MBCR (Whole pattern)				3.46		

Market price: Maize @ 22 Tk. kg⁻¹ Rice: Boro @ 20 Tk. kg⁻¹, T. Aus @ 17 Tk. kg⁻¹, T. Aman @ 18 Tk. kg⁻¹
Straw: Rice @ 4 Tk. kg⁻¹, Maize @ 2 Tk. kg⁻¹

B. Intercropping

INTERCROPPING OF VEGETABLES, SPICES AND RED AMARANTH WITH CHEWING TYPE SUGARCANE

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Abstract

A trial was carried out at the FSRD site, Sholakundu, Faridpur during the Rabi 2020-21 to find out profitable intercrop combinations with chewing type sugarcane and to intensify use of land for growing vegetables and spices crops in AEZ-12. Four treatments viz T₁: red amaranth (Lalshak) in between four rows of onion bulb, T₂: red amaranth in between three rows of coriander (leaf purpose), T₃: red amaranth in between three rows of radish, and T₄: red amaranth and radish in between four rows of onion bulb (farmer's practice). It was laid out in RCB design with six compact replications. BARI Piaz-1, BARI Lalshak-1, BARI Mula-1, BARI Dhonia-2 and Gendari (local) were used as planting materials of onion, red amaranth, radish, coriander and sugarcane, respectively. The highest onion equivalent yield (OEY) was calculated from T₁ (8.66 t ha⁻¹) followed by T₄ (6.77 t ha⁻¹). The lowest OEY was found in T₃ (4.23 t ha⁻¹). The highest gross return (GR) was calculated from T₁ (Tk 259800 ha⁻¹) and the lowest from T₃ due to lowest OEY. The highest Gross margin (GM) was found from T₁ (Tk 134353 ha⁻¹) followed by T₂ where red amaranth was cultivated in between two rows of coriander (Tk 109165 ha⁻¹). The lowest GM was observed in T₄ (Tk 44742 ha⁻¹).

Introduction

Sugarcane (*Saccharum officinarum* L.) is a long duration crop for cultivation which needs about 12-13 months from transplanting to harvest. It is a wide spacing crop usually planted at 80 to 120 cm row to row spacing depending on varietal purpose. There is a little scope of increasing area under sugarcane due to heavy competition for food, fiber, oilseed, pulses etc. Therefore, the only alternative left is to increase the vertical production of sugarcane and sugar by finding out the efficient agronomic management practices. Intercropping of different vegetables and spices is possible in sugarcane field because the wide space of inter-row 90 cm available between 2 rows. Sugarcane have efficient root system helps to tap plant nutrients and moisture from the soil deep layers allowing the intercrops to feed at the top layer of soil. In Faridpur, about 2500-3000 ha of land is used for sugarcane production where farmers can cultivate different crops (onion bulb, black cumin, coriander leaf), vegetables (tomato, radish, lalshak) using ridge up-to 2-3 months after sugarcane planting. Farmers plant sugarcane in furrow and grow intercrops in ridge for 3-4 months, then, farmers breakdown the ridge and its soil is used to fill the furrow for mechanical support of the sugarcane. Farmers normally use different combination of intercrops but yet studied that which one is more productive and economically viable. Hence, the trial was conducted to find out suitable intercropping combination of different vegetables and spices with sugarcane for increasing farmers income as well as production.

Materials and Method

The experiment was carried out at the FSRD site, Faridpur of AEZ-12 during the *Rabi* 2020-21 to find out profitable intercrop combinations with chewing type sugarcane and to intensify use of land for growing vegetables and spices crops. Four treatments *viz* T₁: red amaranth (Lalshak) in between four rows of onion bulb, T₂: red amaranth in between three rows of coriander (leaf purpose), T₃: red amaranth in between three rows of radish, and T₄: red amaranth and radish in between four rows of onion bulb. It was laid out in RCB design with six compact replications. BARI Piaz-1, BARI Lalshak-1, BARI Mula-1, BARI Dhonia-2 and Gendari (local) were used as planting materials of onion, red amaranth, radish, coriander and sugarcane, respectively. The unit plot size was 10.5 m² (7m × 1.5m). Planting system of sugarcane, red amaranth, both radish & coriander and onion bulb was 1 m x 0.15 m, broadcast, 30 cm x continuous seed sowing and 25 cm x 15 cm, respectively. Seed of intercrops was sown for red amaranth @ 3 kg ha⁻¹ (75% for all treatment except T₄; 50%), coriander @ 18 kg ha⁻¹, radish @ 5 kg ha⁻¹ (100% for T₃ and 75% for T₄) and onion bulb @ 750 kg ha⁻¹. The sugarcane (100% of recommended dose; RD), red amaranth (50% of RD), radish, coriander and onion bulb (75% of RD each) were fertilized with 230-100-750-45-4-2 kg ha⁻¹, 50-12-10-5-0-0 kg ha⁻¹, 135-45-60-14-2-0 kg ha⁻¹, 75-30-22-11-1.5-0 kg ha⁻¹ and 105-45-45-22-2-1 kg ha⁻¹ N-P-K-S-Zn-B, respectively in the form of urea, DAP, MOP, gypsum, zinc sulphate and boric acid, respectively. For sugarcane cultivation, half of N & K and all of P, S, Zn, B was applied in trench and mixed thoroughly with the soil before planting of sugarcane. Remaining N and K was applied as top dress at tillering stage (120-150 DAP) under moist soil condition. For onion, all of P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 20 DAT and 48 DAT under moist soil condition and mixed thoroughly with the soil. For intercrops, all fertilizers except N were applied during final land preparation and N was applied as top dress at 20 DAS. Sugarcane seedlings were transplanted in trenches with 15 cm plant to plant spacing during 28 October, 2020. Intercrops of vegetables and spices were sown on 4 November, 2020. Irrigation was applied to intercrops at immediately after sowing, 20 DAS/DAT and 48 DAT (onion intercrop). Two times weeding of intercrop was done at 20 DAS/DAT and 46 DAT. Different fungicides (Rovral at 29 DAT and Amistar top at 56 DAT for controlling onion disease) were sprayed. Coriander, radish, red amaranth and onion bulb were harvested at 38 DAS, 44 DAS, 28 DAS and 90 DAT. Chewing type sugarcane is not yet harvested. The yield of intercrop was calculated in ton per hectare considering from 5 m² sample plot. Collected data of onion equivalent yield were analysed statistically. Cost benefit analysis was performed considering the prevailing price of onion at the harvesting period in the local market.

Results and Discussion

Red amaranth was common intercrop in all the treatments (Table 1). The highest leaf yield (2.28 t ha⁻¹) of red amaranth was calculated from T₁ treatment followed by T₂ (1.94 t ha⁻¹). The lowest red amaranth

leaf yield (1.02 t ha^{-1}) was obtained from T_4 treatment. The higher yield of onion was found with red amaranth based treatment T_1 (7.14 t ha^{-1}) and the lower yield (3.42 t ha^{-1}) from T_4 due to higher intercrop competition. In case of radish cultivation as intercrop, higher radish yield was obtained from T_3 treatment (19.88 t ha^{-1}) but in T_4 treatment showed lower yield (14.96 t ha^{-1}).

The highest OEY (8.66 t ha^{-1}) was calculated from T_1 and the lowest OEY from T_3 (4.23 t ha^{-1}) where red amaranth was sown in between two rows of radish.

Considering cost and return analysis from Table 2, it is revealed that the higher variable cost (VC) was calculated from those treatments where onion bulb was planted (T_1 and T_4). The highest gross return (GR) was calculated from T_1 (Tk 259800 ha^{-1}) and the lowest from T_3 due to lowest OEY. The highest gross margin (GM) was found from T_1 (Tk 134353 ha^{-1}) followed by T_2 where red amaranth was cultivated in between two rows of coriander (Tk 109165 ha^{-1}). The lowest GM was observed in T_4 (Tk 44742 ha^{-1}).

Farmers' opinion

Farmers were interested to cultivate intercrop of red amaranth (Lalshak) in between four rows of onion bulb and in between two rows of coriander (leaf purpose).

Table 1. Intercrop yield (t ha^{-1}) at the FSRD site, Faridpur during 2020-21

Treatment	Red amaranth (t ha^{-1})	Onion bulb (t ha^{-1})	Coriander (t ha^{-1})	Radish (t ha^{-1})
T_1 (Red amaranth+Onion bulb)	2.28	7.14	--	--
T_2 (Red amaranth+Coriander leaf)	1.94	--	2.82	--
T_3 (Red amaranth+Radish)	1.38	--	--	19.88
T_4 (Red amaranth+Radish+Onion bulb)	1.02	3.42	--	14.96

T_1 : Red amaranth (Lalshak) in between four rows of onion bulb, T_2 : red amaranth in between three rows of coriander (leaf purpose), T_3 : red amaranth in between three rows of radish, and T_4 : red amaranth and radish in between four rows of onion bulb.

Input price: Seed (Tk kg^{-1}): Red amaranth: 800.00, coriander: 100.00, Radish: 500.00 and onion bulb: 100.00, Fertilizer (Tk kg^{-1}): Urea-16, DAP-16, MoP- 15, Gypsum-10, Zn SO_4 - 200, Boric acid- 240, Out price (Tk kg^{-1}): Red amaranth: 20.00, Onion bulb: 30.00, coriander: 45.00, radish: 5.00

Table 2. Onion Equivalent Yield (t ha^{-1}) and cost & return at the FSRD site, Faridpur

Treatment	Onion Equivalent Yield (t ha^{-1})	GR (Tk ha^{-1})	VC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1 (Red amaranth+Onion bulb)	8.66 a	259800	125447	134353
T_2 (Red amaranth+Coriander leaf)	5.52 c	165300	56135	109165
T_3 (Red amaranth+Radish)	4.23 d	126900	59148	67752
T_4 (Red amaranth+Radish+Onion bulb)	6.77 b	176400	131658	44742
CV(%)	12.57	--	--	--

Out price (Tk kg^{-1}): Red amaranth: 20.00, Onion bulb: 30.00, coriander: 45.00, radish: 5.00

Conclusion

Cultivation of red amaranth (Lalshak) in between four rows of onion bulb and in between three rows of coriander (leaf purpose) was profitable as intercrop combination with chewing type sugarcane. It was the result of one year only. So, the experiment may be repeated in next year.

PERFORMANCE OF MUNGBEAN AND SESAME INTERCROPPING IN SOUTHERN DISTRICT OF BANGLADESH

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Abstract

The experiment was conducted at MLT site Kuakata, Patuakhali and MLT site Amtoli, Borguna during Rabi season of 2020-21 to find out suitable intercrop combination in southern district and to increase the total crop productivity of the farmers. Four treatments namely: T_1 = 100% mungbean in rows (30cm $\times$ 5 cm) + 50% sesame as broadcast, T_2 = 100% mungbean in rows (30cm $\times$ 5 cm) + 25% sesame as broadcast, T_3 = Sole crop of mungbean in row (30 cm $\times$ 5 cm) (100% mungbean) and T_4 = Sole crop of sesame in row (30 cm $\times$ 5 cm) (100% sesame) were evaluated at each location. Sole mungbean and sesame gave higher yields than intercrop treatments in all the locations. Among the intercrop treatment the highest seed yield (1680 kg ha⁻¹) of mungbean was obtained from T_2 treatment in all the locations while the lowest from T_1 . Among intercrop treatment, sesame gave higher seed yield in T_1 treatment. Intercropping increased mungbean equivalent yield (MEY) compared to sole cropping. Over the locations, the highest MEY (2656 kg ha⁻¹) was found in T_1 treatment and similarly the highest BCR was also (2.15) found from same treatment.

Introduction

Intercropping is the means of producing more food from limited area of land by cultivating multiple crops simultaneously. It ensures improved use of land, labor and resources. Since multiple crops are involved in this system it reduces the risk of total crop failure in adverse conditions. The southern districts of Bangladesh have problems in crop production such as hailstorm, cyclones, floods and soil salinity. The adoption of intercropping technology can increase the total crop productivity of the region by reducing the risk of crop failure. Therefore, the experiment was undertaken to find out suitable intercrop combination and to increase the total crop productivity by reducing the risk of crop failure.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali and MLT site, Amtoli, Borguna during late Rabi season of 2020-21. Four treatments namely: T_1 = 100% mungbean in rows (30cm $\times$ 5 cm) + 50% sesame as broadcast, T_2 = 100% mungbean in rows (30cm $\times$ 5 cm) + 25% sesame as broadcast, T_3 = Sole crop of mungbean in row (30 cm $\times$ 5 cm) (100% mungbean) and T_4 = Sole crop of sesame in row (30 cm $\times$ 5 cm) (100% sesame) were evaluated at each location. BARI Mungbean-6 and BARI Til-4 were used as test crop. The experiment was laid out in RCB design with three replications. The unit plot size was 8m $\times$ 5m at Kuakata and Amtoli. Seeds were sown according to treatments on 29 January and 25 January at Kuakata and Amtoli, respectively. In sole mungbean and intercrop plots, the land was fertilized with 50-85-35 kg N-P-K ha⁻¹ in the form of Urea, TSP, MoP, respectively. In sole sesame, fertilizers were applied at the rate of 125-150-50-110-5-10 kg N-P-K-S-Zn-B ha⁻¹ in the form of Urea, TSP, MoP, Gypsum, Zinc Sulphate, Boric acid, respectively. All intercultural operations were done in proper time for better growth of the crop. The data were statistically analyzed and means were separated by critical difference (CD) values at 5% level of significance.

Results and Discussion

Mungbean and sesame yields were greatly influenced by intercropping (Table 1). At Kuakata, sole mungbean gave the highest seed yield (1780 kg ha⁻¹). In intercropping, T_2 gave higher yield of mungbean. Sole sesame gave the highest seed yield (1210 kg ha⁻¹). In intercropping, T_1 gave higher yield of sesame than that of T_2 . Similar trend was found in Amtoli. Intercropping increased mungbean equivalent yield (MEY) compared to sole cropping (Table 2). At Amtoli, the highest MEY (2666 kg ha⁻¹) was found in T_1 treatment followed by T_2 . Similar trend was found in Kuakata. Considering economic analysis, the highest gross margin and BCR were obtained Tk. 92530 and 2.15, respectively from 100% mungbean in rows (30cm $\times$ 5 cm) + 50% sesame as broadcast combination over other combination (Table 3).

Farmers' opinion

Farmers showed their interest in crop production through intercropping because maximum use of land is possible, increasing total crop productivity and reducing the risk of crop failure.

Table 1. Seed yield of mungbean and sesame as influenced by intercropping at different locations during Rabi season of 2020-21

Treatments	Seed yield (kg ha ⁻¹)			
	Kuakata		Amtoli	
	Mungbean	Sesame	Mungbean	Sesame
T ₁ = 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast	1660 c	856 b	1640 b	890 b
T ₂ = 100% mungbean in rows (30cm × 5 cm) + 25% sesame as broadcast	1680 b	693 c	1650 b	670 c
T ₃ = Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean)	1780 a	-	1760 a	--
T ₄ = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame)	-	1210 a	-	1327 a
CV (%)	15.54	9.52	20.69	11.81
LSD(0.05)	0.41	0.45	0.54	0.54

Table 2. Mungbean equivalent yield (MEY) as influenced by intercropping over locations during rabi season of 2020-21

Treatments	MEY (kg ha ⁻¹)		Mean MEY (kg ha ⁻¹)
	Kuakata	Amtali	
T ₁ = 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast	2647	2666	2656
T ₂ = 100% mungbean in rows (30cm × 5 cm) + 25% sesame as broadcast	2479	2423	2451
T ₃ = Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean)	1780	1760	1770
T ₄ = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame)	1210	1327	1268

Table 3. Cost and return analysis of mungbean equivalent yield (MEY) as influenced by intercropping during rabi season of 2020-21

Treatments	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	172725	80195	92530	2.15
T ₂	159337	80035	79302	1.99
T ₃	115050	79875	35175	1.44
T ₄	95100	62940	32160	1.51

Selling Price: Mungbean= Tk. 65/ kg, Sesame= Tk. 75/kg; T₁= 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast; T₂ = 100% mungbean in rows (30cm × 5 cm) + 25% sesame as broadcast; T₃= Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean); T₄ = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame)

Conclusion

The results revealed that intercropping combination of 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast would be suitable for higher total productivity and economic return over sole mungbean.

INTERCROPPING OF VEGETABLE WITH CHILLI IN SOUTHERN REGION OF BANGLADESH

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Abstract

A field experiment on intercropping of vegetables with chilli was executed at saline area of Kuakata in Patuakhali district during Rabi season of 2020-21 to find out an appropriate crop to cultivation with chilli for higher productivity and maximum economic return. The trial was consisted of three crop combinations viz., T₁: Sole chilli, T₂: chilli + Kangkong, T₃: chilli + Indian Spinach. Significantly the highest yield (dry chilli) was obtained from sole chilli (1.92 t ha⁻¹). Among the intercropping treatments, the highest chilli equivalent yield (2.84 t ha⁻¹) was obtained from chilli + Indian Spinach and the lowest chilli equivalent yield (1.92 t ha⁻¹) was found from sole chilli.

Introduction

Intercropping is a crop management system involving the growing of two or more dissimilar crops in distinct row combinations simultaneously on the same land area. Intercropping involves crop intensification in respect to both time and space dimensions (Ahlawat and Sharma, 2002). Therefore, it is one of the techniques of vertical expansion of crop production that increase cropping intensity in developing countries like Bangladesh. It increases total productivity through efficient utilization of land, labour and resources such as increasing utilization of solar radiation and different inputs including fertilizer and water (Gosh et al., 2006). Intercropping not only reduces the risk associated with input costs but also increases profit potential (Rathi and Verma, 1979). Moreover, it provides several major advantages namely; diversification reduces risk associated with crop failure, offers greater yield stability and utilizes the available growth resources more efficiently and sustainably (Islam et al., 2006). Chilli is one of the major spices crops usually grown as sole crop. Intercropping of chilli with different vegetables offer greater scope to utilize the land and other resources to the maximum extent. Productivity of the system can be enhanced by judicious selection of vegetables differing in duration and growth. The review of research work done so far indicated that growth of chilli as intercrop is more beneficial than growing chili alone in many situations (Aravazhiet al., 1997; Natarajan, 1992, Sadashiv, 2004). Therefore, the present study has been undertaken to find out a suitable vegetable crop for intercropping with chili for higher productivity and economic return.

Materials and Methods

An experiment was conducted at MLT site, Kuakata, Patuakhali in the *Rabi* season of 2020-21 to verify the performance of different vegetables intercrop with chill in the coastal area under farmer's field condition. The trial consisted with three treatments as follows: T₁: Sole chilli, T₂: chilli + Kangkong, T₃: chilli + Indian Spinach. The experiment was laid out in RCB design with dispersed replications having unit plot size 8 m x 5 m. Fertilizers were applied in each plot at the rate of 120-86-130-10 kg ha⁻¹ NPKS, respectively in the form of urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum and boric acid as per recommendation. Cowdung @ 10 t ha⁻¹ was applied during final land preparation. The full amount of cow dung, TSP, gypsum, boric acid and one third MoP were applied as basal at final land preparation. The rest amount of MoP and full dose of urea were applied in three equal splits at 25, 50 and 70 days after planting (DAP). Thirty days old seedlings of chilli (var. BARI morich 1) were planted in the field on 01 January 2021. One row of Kangkong, Coriander and Indian spinach seeds were sown in between two rows of chilli. Weeding, irrigation and crop protection measures were taken as and when necessary. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically.

Results and Discussion

Yield of chili varied from 1.62 to 1.92 t ha⁻¹ due to influence exerted by different treatments. Sole chilli produced significantly the highest fruit yield of 1.92 t ha⁻¹ and the lowest yield in chilli + Indian spinach (1.62) intercropping system. Among the treatments chilli+ Indian spinach (T₃) produced the highest chilli equivalent yield (CEY) (2.84 ton ha⁻¹). From economic analysis the highest gross margin (

247100tk) and BCR (2.83) was obtained from Chilli+ Indian Spinach (T_3) combination over other combination.

Table 1. Yield and yield contributing characters of chilli under different intercropping system

Treatments	Plant height (cm)	Branches / plants (No.)	No. of fruits/ Plant	Dry wt. of fruits/plant (gm)	Dry yield of chilli ($t\ ha^{-1}$)	Yield of vegetables ($t\ ha^{-1}$)	CEY ($t\ ha^{-1}$)
T_1 : Sole Chilli	31.85	6	77.99	58.91	1.92	-	1.92
T_2 : Chilli + Kangkong	30.47	5	73.54	54.78	1.63	10.43	2.25
T_3 : Chilli + Indian spinach	30.63	5	72.96	52.71	1.62	16.39	2.84
CV (%)	4.13	6.39	7.32	4.38	5.08	-	-
LSD (0.05)	1.64	3.05	7.76	6.19	1.12	-	-

Table 2. Cost and return analysis of different intercropping system at MLT site, Kuakata, Patuakhali during Rabi, 2021

Treatments	Gross return ($Tk\ ha^{-1}$)	TVC ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	BCR
T_1 : Sole Chilli	259200	123920	235280	2.11
T_2 : Chilli + Kangkong	303490	138500	164990	2.20
T_3 : Chilli + Indian spinach	382600	135500	247100	2.83

Note: Chilli dry 135/kg; Kangkong 08/kg; Indian spinach 10/kg

Conclusion

Considering the findings, it may be concluded that cultivation of Indian spinach with chilli may be the best option for higher productivity and maximum economic return for the coastal area. It is also found that all intercrops are more profitable than the sole cropping and risk of cultivation of one crop can be reduced by intercropping. The trial should be continued next year for more confirmation.

INTERCROPPING OF FOXTAIL MILLET WITH GROUNDNUT IN THE CHARLAND

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Abstract

The experiment was conducted in the farmers' field at Char Thetrai, Ulipur, Kurigram under AEZ-2 during the Kharif season of 2021 to verify the performance of foxtail millet and groundnut intercropping system in charland areas and to increase yield and economic return. The treatment combinations used for the experiment were T_1 : Sole Foxtail millet (100%), T_2 : Sole Groundnut (100%), T_3 : Groundnut (100%) + Foxtail millet (25%) and T_4 : Groundnut (100%) + Foxtail millet (50%). The maximum LER (1.36) was found in Groundnut (100%) + foxtail millet (25%) treatment followed by Groundnut (100%) + foxtail millet (50%) treatment. The highest groundnut equivalent yield ($2.23\ t\ ha^{-1}$) was obtained in the treatment combination of Groundnut (100%) + foxtail millet (25%) and it gave the highest gross return ($Tk. 155933\ ha^{-1}$) and gross margin ($Tk. 85183\ ha^{-1}$). The sole foxtail millet (100%) and sole groundnut (100%) gave the lower gross return ($Tk. 77867$ and $131833\ ha^{-1}$) and gross margin ($Tk. 46517$ and $62583\ ha^{-1}$), respectively.

Introduction

Foxtail millet or Kaon (*Setaria italica*) is one of the most important drought tolerant crops which can be cultivated in unfertile land even without any chemical fertilizer and care. It is called the cereal of the poor in the crisis period. Groundnut (*Arachis hypogaea*) is a cash earning and excellent edible oil seed crop, which is generally produced in charland area using local cultivar. Farmers of these areas cultivate kaon as a mixed crop with groundnut without determining benefit, cost and return and land use efficiency. Successful intercropping system gives higher cash return and total production per unit area

and diversifies crop production than that of growing sole crop (Mondal *et al.*, 1998). Intercropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. However, information on intercropping of groundnut with Kaon under varying plant population in charland areas is inadequate. Therefore, the present study was conducted to investigate the impact of intercropping of foxtail millet and groundnut on productivity, monetary advantages and land use efficiency against sole cropping in the charland condition.

Materials and Method

The experiment was carried out at Char Thetrai, Ulipur, Kurigram under AEZ-2 during the Kharif season of 2021 to verify the performance of groundnut and foxtail millet intercropping system in charland areas and to increase production and farmers' income. The experiment was laid out in Randomized Complete Block Design (RCB) with three dispersed replications (Ferdous *et al.* 2018). It consists of four treatments as T₁: Sole Foxtail millet (100%), T₂: Sole Groundnut (100%), T₃: Groundnut (100%) + Foxtail millet (25%) and T₄: Groundnut (100%) + Foxtail millet (50%). According to the treatments, seeds of groundnut (BARI Chinabadam-8) were sown in line sowing method having with 30 cm x 15 cm spacing and foxtail millet (BARI Kaon-2) were broadcasted in groundnut plot. Both groundnut and foxtail millet seeds were sown on 18 March, 2021. The unit plot size was 40 m² (8 m x 5 m). The plots were fertilized with 12-32-43-54-1.7 kg ha⁻¹ NPKSB, respectively. Half of nitrogen and full quantity of P K S B were applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. Remaining N was top dressed at flowering stage and covered with soil for proper establishment of crop. Plant protection measure and all other management practices were done as and when necessary. Foxtail millet was harvested on 18 May 2021 whereas groundnut on 12 June 2021. Data on different crop parameters were collected from the 10 sample plants and then average was taken which was further analyzed statistically. Different parameters such as Groundnut equivalent yield (GEY) and land equivalent ratio (LER) was calculated as per Appendix Table 1.

Result and Discussion

Groundnut: The results indicated 100-seed weight and yield were significantly influenced by treatments (Table 1). However, number of pod per plant was slightly higher in sole ground nut plot. The maximum 100-seed weight (48.00g) was measured in sole ground nut, which was statistically identical with Groundnut (100%) + Foxtail millet (25%) treatment and the lowest in Groundnut (100%) + Foxtail millet (50%). The highest groundnut pod yield (1.88 t ha⁻¹) was recorded in sole groundnut treatment and the lowest pod yield (1.57 t ha⁻¹) from Groundnut (100%) + Foxtail millet (50%) treatment combination (Table 1). The results showed that the pod yield of groundnut decreased with the increasing of foxtail millet population in the intercropping situation. It might be due to competition for nutrients and less light interception between the sole and the intercrops.

Foxtail millet: Tiller number per plant and yield of foxtail millet were influenced significantly (Table 2). Sole foxtail millet gave higher yield (1.95 t ha⁻¹), which was statistically different from other treatments T₃ and T₄. Lower yield of foxtail millet was obtained from T₃ treatment (0.85 t ha⁻¹). The lower bulb yield in T₃ might be due to lower plant population possessed to the treatment. Higher yield production in monoculture compared to intercrop culture might be due to no intercrop competition for light, nutrients, moisture, and space. This corroborates with the findings of Uddin *et al.* (2003).

Land equivalent ratio (LER)

The land equivalent ratio (LER) was used to assess the performance of an intercrop relative to the corresponding sole crop (Mead and Willey, 1980). It was found that the highest LER value (1.36) was found from T₃ treatment (Groundnut 100% + Foxtail millet 25%) which might be due to maximum complementary use of different growth resources in intercropping system.

Groundnut equivalent yield (GEY)

The result showed that the highest groundnut equivalent yield (2.23 t ha⁻¹) was obtained from the treatment T₃ (Groundnut 100% + Foxtail millet 25%) which was followed by T₄ treatment (Groundnut

100% + Foxtail millet 50%). The lowest groundnut equivalent yield (1.11 t ha^{-1}) was obtained from sole foxtail millet (Table 3). The results revealed that intercropping showed higher groundnut equivalent yield (GEY) than sole crop. The obtained results indicated that all the intercropping treatments produced better groundnut equivalent yield than their respective sole crop cultivation.

Cost and return analysis

Cost and return data are presented in the Table 3. Gross return as well as gross margin was found higher in intercropping cultivation in comparison to sole cropping. From cost and return analysis, it was observed that T_3 treatment made the highest gross margin (Tk. 85183 ha^{-1}) followed by T_4 (Tk. 78817 ha^{-1}). The lowest gross margin (Tk. 46517 ha^{-1}) was obtained from sole foxtail millet and sole groundnut with gross margin Tk. 62583 ha^{-1} .

Farmers' opinion

The farmers obtained more yield from groundnut and foxtail millet as intercropping which was more profitable than the sole cropping. They opined that 50% densely populated foxtail millet created problem sometimes for ground nut during foxtail millet harvesting. They showed positive attitude towards 25% foxtail millet intercropping with 100% ground nut.

Table 1. Yield and yield attributes of groundnut as intercropping with foxtail millet at Char Thetrai, Ulipur, Kurigram during the Kharif season of 2021

Treatments	Plant height (cm)	Branch plant ⁻¹ (no.)	Pod plant ⁻¹ (no.)	Wt. of pod plant ⁻¹ (g)	100 seed wt.(g)	Yield (t ha ⁻¹)
T_2 = Sole groundnut (100%)	66.13	8.73	27.80	32.40	48.00a	1.88a
T_3 = Groundnut 100% + Foxtail millet 25%	66.23	8.63	25.87	31.77	47.83a	1.74b
T_4 = Groundnut 100% + Foxtail millet 50%	67.53	8.17	25.63	31.67	47.63b	1.57c
LSD (0.05)	NS	NS	NS	NS	0.19	0.14
CV (%)	7.36	7.92	8.59	6.80	4.48	5.50

Table 2. Yield and yield attributes of foxtail millet as intercropping with groundnut at Char Thetrai, Ulipur, Kurigram during the Kharif season of 2021

Treatments	Plant height (cm)	Tiller plant ⁻¹ (no.)	Panicle length (cm)	1000 grain wt. (g)	Yield (t ha ⁻¹)
T_1 = Sole foxtail millet (100%)	145.70	3.20b	24.80	2.38	1.95a
T_3 = Groundnut 100% + Foxtail millet 25%	153.33	3.87a	25.63	2.35	0.85c
T_4 = Groundnut 100% + Foxtail millet 50%	153.57	3.43b	25.27	2.34	0.99b
LSD (0.05)	NS	0.35	NS	NS	0.11
CV (%)	5.37	4.36	5.82	4.84	6.55

Table 3. Groundnut equivalent yield (GEY), land equivalent ratio (LER), cost and benefit analysis of groundnut as a intercropping with foxtail millet at Char Thetrai, Ulipur, Kurigram during the Kharif season of 2021

Treatment	Yield (t ha ⁻¹)		LER	GEY (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	Ground nut	Foxtail millet					
T_1 = Sole foxtail millet (100%)	-	1.95	1	1.11	77867	31350	46517
T_2 = Sole groundnut (100%)	1.88	-	1	1.88	131833	69250	62583
T_3 = Groundnut 100% + Foxtail millet 25%	1.74	0.85	1.36	2.23	155933	70750	85183
T_4 = Groundnut 100% + Foxtail millet 50%	1.57	0.99	1.35	2.14	149867	71050	78817

Price (Tk./Kg): Groundnut pod= 70.00 and Foxtail millet = 40.00

Conclusion

Considering the yield and return, it can be concluded that 100% groundnut with 25% foxtail millet is the most profitable as intercropping and risk of cultivation of single crop can be reduced. The experiment needs to be repeated another year.

INTERCROPPING OF ONION WITH GROUNDNUT AT THE CHARLAND OF TANGAIL

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Abstract

An experiment was conducted at MLT site, Bhuapur during the Rabi season of 2020-21 to find out a suitable intercrop combination of groundnut and onion to increase the productivity and income of farmers. Four treatments viz., T_1 = Sole groundnut (100%), T_2 = Sole onion (100%), T_3 = One row of onion between two rows of groundnut, T_4 = Two rows of onion between two rows of groundnut were considered. In intercropping groundnut with onion, groundnut yield was not significantly affected; however, onion yield was significantly reduced (38.05 to 55.71%). Groundnut equivalent yields were recorded higher from all intercrop treatments as compared to sole groundnut and sole onion. Analysis of intercropping treatments revealed that two rows of onion in between two rows of groundnut gave the highest groundnut equivalent yield (6.86 t ha^{-1}) as well as gross margin (Tk. 193955 ha^{-1}) followed by two rows of onion in between two rows of groundnut and the lowest groundnut equivalent yield (2.00 t ha^{-1}) as well as gross margin (Tk. 52955 ha^{-1}) was obtained from sole groundnut treatment.

Introduction

Intercropping has been identified as a promising system that makes effective use of land and other resources (Remison, 1982) like water and soil nutrients and results in reduced cost of production (Bijay et al., 1978). It has also gained wide acceptability among farmers of tropical and sub-tropical countries because of its economic advantages resulting from the symbiotic association of groundnut intercropped with onion (Qasimet al., 2013). Intercropping involving legumes has been found to be most useful as it improves soil fertility and gives better yields and economic returns (Lithourgidiset al., 2011). Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Onion is a main spices crop of Bangladesh. Groundnut (*Arachis hypogaea* L.) was selected as an intercrop because of its high nitrogen fixing activity. It is a popular oil seed crop containing protein (25-28%) and oil (43-55%) grown as a sole crop culture in Bangladesh. A wider spacing (40 cm x 15 cm) is maintained to growing groundnut. This spacing could be used as inclusion of an additional crop as intercrop in existing groundnut cultivation. Hence, two crops can be grown using single dose of nitrogenous fertilizer by reducing the cost of nitrogenous fertilizer up to 50%. Keeping this view in mind, the present study was undertaken to find out a suitable crop combination as intercrop with groundnut for maximum land use efficiency and economic return.

Materials and methods

The experiment was conducted at the MLT site Bhuapur, Tangail under AEZ # 8 during the rabi season 2020-21. The experiment was laid out following RCB design with six dispersed replications (Ferdous et al. 2018). The unit plot size was 8 m x 5 m. There were four treatments viz., T_1 = Sole groundnut (100%), T_2 = Sole onion (100%), T_3 = One row of onion in between two rows of groundnut, T_4 = Two rows of onion in between two rows of groundnut. Spacing of groundnut was maintained 40 cm x 15 cm and onion 15 cm x 10 cm. The plot was fertilized with 12-32-43-54-2 N-P-K-S-B ha^{-1} for sole and intercropping treatments. All fertilizers and $2/3^{\text{rd}}$ of urea was applied during final land preparation and rest urea was top dressed at two equal installments in between two rows of onion. The variety of groundnut was BARI Chinabadam-9 and onion (Taherpuri). Seeds of groundnut and onion were planted on 10 November, 2020. Intercultural operations were done properly for normal growth and development of the crops. The onion was harvested 22 February, 2021 and groundnut on 26 April, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous et al., 2020, Ferdous et al. 2021). Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package.

Results and Discussion

Effect of intercropping on groundnut: There were no significant differences between intercropping treatments. The maximum plant height (42.40 cm), number of effective pods per plant (20.33), 1000-kernel weight (588.57 g) and pod yield (2.00 t ha⁻¹) of groundnut were recorded when it was grown alone (Table 2). A slight decrease in all the parameters was observed when groundnut was intercropped with onion. Both groundnut and onion are shallow rooted but groundnut has ability to exploit available resources more efficiently so vegetative growth of groundnut decreased at a small level. The maximum number of pods per plant (20.33) was recorded when groundnut was grown alone. As the height of groundnut was reduced, it caused a decrease in number of leaves or green area for photosynthesis resulting in reduced number of pods per plant. Similarly, number of seeds per pod, 1000- kernel weight and average pod yield were maximum when groundnut was grown alone because of good vegetative growth which directly influences the yield. The maximum pod yield was recorded where groundnut was grown alone. This increase in yield was directly related with increase in plant height, number of pods per plant, number of seeds per pod, 1000-kernel weight. The maximum number of effective pod plant⁻¹ was recorded in T₁ treatment (20.33) followed by T₃ (19.60) and T₄ (19.60). The highest nut yield (2.00 t ha⁻¹) was produced in T₁ treatment which might be due to higher number of effective pods plant⁻¹ and higher thousand kernel weight (588.57 g). Due to intercropping, the yield of groundnut was decreased in T₃ and T₄ treatment (Table 2). The higher groundnut equivalent yields were recorded from all intercrop treatments as compared to sole crop of groundnut. The higher groundnut equivalent yield (6.86 t ha⁻¹) was obtained from T₄ treatment (Table 3). The highest gross returns (Tk. 343000 ha⁻¹) as well as gross margin (Tk. 193955 ha⁻¹) were estimated in T₄ intercrop treatment (Table 4).

Effect of intercropping on onion: The maximum plant height, leaf number and bulb weight of onion were recorded when onion was grown alone because there was no competition for soil nutrients for plant growth. Growth of onion plants decreased significantly when groundnut was intercropped in onion due to competition for essential nutrients, moisture, light, soil space and applied chemical fertilizer between two crops. Similarly, the maximum bulb weight was obtained when onion was grown alone. The maximum bulb yield (9.25 t ha⁻¹) was recorded in onion when grown as single crop was due to maximum bulb weight. A significant decrease (38.05-55.71%) was occurred in bulb yield when groundnut was intercropped in onion probably due to decrease in bulb weight.

Farmers' opinion

Farmers are happy for higher yield and gross margin of two rows of onion in between two rows of groundnut intercropping system. They are interested in cultivating groundnut and onion as intercropping system.

Table 1. Bulb yield and yield components of onion affected by intercropping with groundnut at MLT site Bhuapur, Tangail during rabi, 2020-21

Treatment	Days to maturity	Plant height (cm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)
T ₁	-	-	-	-
T ₂	105	60.62	16.00	9.25
T ₃	105	57.48	15.38	4.54
T ₄	105	55.27	14.22	6.35
LSD _{0.05}	NS	4.50	1.99	0.92
CV (%)	6.42	6.90	9.00	10.90

T₁ = Sole groundnut (100%), T₂ = Sole onion (100%), T₃ = Groundnut (100%) + one row of onion between two rows of groundnut and T₄ = Groundnut (100%) + two rows of onion between two rows of groundnut

Table 2. Pod yield and yield component of groundnut affected by intercropping with onion at MLT site Bhuapur, Tangail during rabi, 2020-21

Treatment	Plant height (cm)	Effective pod plant ⁻¹ (no.)	1000-Kernel weight (g)	Pod yield (t ha ⁻¹)
T ₁	42.40	20.33	588.57	2.00
T ₂	-	-	-	-
T ₃	39.32	19.60	539.20	1.86
T ₄	36.50	19.60	533.00	1.78
LSD _{0.05}	NS	NS	NS	0.09
CV (%)	6.63	4.20	6.40	5.32

Table 3. Yield of groundnut, onion and groundnut equivalent yield of groundnut intercropping with onion at MLT site Bhuapur, Tangail during rabi, 2020-21

Treatment	Yield of groundnut (t ha ⁻¹)	Yield of onion (t ha ⁻¹)	Groundnut equivalent yield (t ha ⁻¹)
T ₁	2.00	-	2.00
T ₂	-	9.25	7.40
T ₃	1.86	4.54	3.63
T ₄	1.78	6.35	6.86

T₁ = Sole groundnut (100%), T₂ = Sole onion (100%), T₃ = Groundnut (100%) + one row of onion between two rows of groundnut and T₄ = Groundnut (100%) + two rows of onion between two rows of groundnut, Onion: Tk. 40 kg-l, Groundnut: Tk 50. kg-l

Table 4. Cost and return analysis of groundnut intercropping with onion at MLT site Bhuapur, Tangail during rabi 2020-21

Treatment	Groundnut equivalent yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	2.00	100000	47045	52955
T ₂	7.40	370000	182000	188000
T ₃	3.63	181500	107045	74455
T ₄	6.86	343000	149045	193955

T₁ = Sole groundnut (100%), T₂ = Sole onion (100%), T₃ = Groundnut (100%) + one row of onion between two rows of groundnut and T₄ = Groundnut (100%) + two rows of onion between two rows of groundnut, Onion: Tk. 40 kg-l, Groundnut: Tk 50. kg-l

Conclusion

From the results of present study, it can be concluded that groundnut can be grown successfully as intercropped in onion without significant reduction in the yield of groundnut. However, yield of onion was significantly decreased. Results revealed that two rows of onion in between two rows of groundnut might be suitable combination for higher productivity and economic return. For further confirmation this experiment may be repeated in the next year.

INTERCROPPING OF SHORT DURATION VEGETABLES AND SPICES WITH BUSHBEAN IN SYLHET REGION

M. I. Nazrul, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was laid out during 2020-21 in winter season at MLT site, Moulvibazar. Four different intercropping combinations, T₁ = Bush bean (100%) + Radish (100%), T₂ = Bush bean (100%) + Coriander (100%), T₃ = Bush bean (100%) + Chilli (100%) and T₄ = Bush bean sole (100%) were considered. The experiment was randomized complete block design with three replications. Highest bush bean equivalent yield (18.82 t ha⁻¹) was obtained from the combination of Bush bean + Radish, whereas, the lowest yield (12.62 t ha⁻¹) was found from the Bush bean + Chilli. The highest gross return (Tk. 8,46,900 ha⁻¹) and gross margin (Tk. 5,85,988 ha⁻¹) was obtained from the combination of Bush bean + Radish whereas the lowest gross return (Tk. 2,04,750 ha⁻¹) and gross margin (Tk. 50,088 ha⁻¹) was obtained from Bush bean sole cultivation. Maximum percent increased of bush bean equivalent yield (314) and highest benefit ratio (3.25) was obtained from the inter crop combination of bush bean + radish.

Introduction

Intercropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. The main effect of intercropping is because of more efficient utilization of available resources and increased productivity compared with each sole crop (Mao *et al.*, 2012). Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Moreover, farmers may be better able to cope with seasonal price variability of commodities, which often can destabilize their income. Intercropping may result in increased yield of main or companion or both crops as compared to sole cropping. However, in intercropping systems, not the yield but economic return is more important due to net benefit to the growers. In Sylhet, especially bush beans are cultivated as sole crop in haor areas. But it can be cultivated with short durated vegetable and spices as intercrop without hampering the main crop. Hence, the study has been conducted to find out suitable intercrop combination for increasing production and economic return.

Materials and Methods

The experiment was conducted at MLT site, Moulvibazar during the year 2020-21. Four intercrop combinations, T₁ = Bush bean (100%) + Radish (100%), T₂ = Bush bean (100%) + Coriander (100%), T₃ = Bush bean (100%) + Chilli (100%) and T₄ = Bush bean sole (100%) were considered. The experiment was setup in randomized complete block design with three dispersed replications (Ferdous *et al.* 2018). The seed of bushbean were sown with maintaining the spacing of 30 cm × 15 cm. The sole crop of bush bean and intercropped treatments were fertilized with cow dung 5 t ha⁻¹ and 93-40-75-10-4-2 kg ha⁻¹ of N-P-K-S-Zn-B in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and all other fertilizers and cowdung were used at final land preparation. Remaining N fertilizer was applied in top dress in two equal splits at 15 & 30 days after sowing. The seeds of bush bean and companion crop were sown during 24-30 November, 2020. Intercultural operations were done as and when necessary. There was no remarkable disease and pest attack. The companion crop was harvested on 10-15, January 2021 and bush bean harvested during 17-23 February, 2021. Data on yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous *et al.*, 2020, Ferdous *et al.* 2021). The collected data were analyzed statistically using “STAR” software package and means were separated by LSD.

Results and Discussion

Yield and yield attributes of bushbean: There was no statistically difference in yield and some other yield attributes of bush bean due to intercropping of vegetables and spices. The highest pod length was obtained in sole bush bean (13.03 cm) with the highest pod diameter (1.17 cm) and maximum pod weight (5.27 g) followed by bush bean + chilli combination (5.03 g). On the other hand statistically similar number of pods per plant and weight of 100 seeds was produced by bush bean + chilli and sole bush bean. Among the intercropped combinations the maximum dry seed yield (4.55 t ha⁻¹) was recorded by bush bean sole followed by bush bean + chilli (4.45) combination. The lowest seed yield (4.12 t ha⁻¹) was obtained from the combination of bush bean + radish.

Bush bean Equivalent Yield (BEY): Bush bean equivalent yield was expressed in total productivity of this system. Bush bean equivalent yields were higher in all the intercrops (12.62-18.82 t ha⁻¹) than sole crop of bush bean (4.55 t ha⁻¹). The maximum bush bean equivalent yield (18.82 t ha⁻¹) was recorded in bush bean + radish intercropped combination which was followed by bush bean + coriander (15.81 t ha⁻¹) and bush bean + chilli (12.62 t ha⁻¹) and the total productivity also increase of 314, 247 and 177 percent over sole bush bean (Table 2).

Companion crops yield: On an average, the yields of radish, coriander and chilli under intercrops was 42.35, 5.93 and 5.68 t ha⁻¹, respectively (Table 2). Results showed that, among the vegetables and

spices; radish gave the highest yield (42.35 t ha^{-1}) in intercropping system followed by coriander (5.93 t ha^{-1}) respectively.

Cost benefit analysis

Intercrop combination of bush bean with vegetables and spices showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 846900 ha^{-1}) was recorded from bush bean + radish intercrop combination which was more than 3 percent higher over sole bush bean. This intercropping combination also gave the higher gross margin (Tk. 585988 ha^{-1}) followed by bush bean + coriander. Among the intercrop combinations, the lowest gross return (Tk. 204750 ha^{-1}) and gross margin (Tk. 50088 ha^{-1}) were obtained from bush bean as sole crop.

Farmer's opinions

Bush bean with short duration vegetable and spices (radish, coriander, chilli) was found a profitable practice. As such farmers can earn extra income easily without hampering the main crop (bush bean) and also boost up their family nutrition from companion crops.

Table 1. Yield and yield attributes of bush bean based intercropping at MLT site, Moulvibazer 2020-21

Treatment	Plant height (cm)	Pod length (cm)	Pod diameter (cm)	Pod plant ⁻¹	Pod wt. (g)	Seed pod ⁻¹	100 seed wt.(g)	Dry seed yield (t ha ⁻¹)
T ₁ : Bush bean + Radish	35.37	12.47	1.09	8.40	4.57	5.00	39.67	4.12
T ₂ : Bush bean + Coriander	36.07	12.80	1.16	9.63	4.97	5.03	40.00	4.31
T ₃ : Bush bean + Chilli	36.67	13.00	1.15	10.03	5.03	5.13	42.00	4.45
T ₄ : Bush bean sole	36.50	13.03	1.17	10.00	5.27	5.23	42.00	4.55
CV (%)	12.11	3.45	2.20	3.26	3.58	2.13	3.71	4.04
LSD (0.05%)	NS	2.45	2.45	2.45	2.45	NS	2.45	NS

Table 2. Yield of companion crops and bush bean equivalent yield (BEY) under bush bean base intercropping system 2020-21

Treatments	Yield of companion crops (t ha ⁻¹)	BEY (t ha ⁻¹)	% increase of BEY over sole bush bean
T ₁ : Bush bean (100%) + Radish (100%)	42.35	18.82	314
T ₂ : Bush bean (100%) + Coriander(100%)	5.93	15.81	247
T ₃ : Bush bean (100%) + Chilli (100%)	5.68	12.62	177
T ₄ : Bush bean sole (100%)	-	4.55	-

BEY: Bush bean equivalent yield

Table 3: Cost benefit analysis of bush bean base intercropping system during 2020-21.

Treatments	Gross return (Tk.ha ⁻¹)	Total cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
T ₁ : Bush bean (100%) + Radish (100%)	846900	260912	585988	3.25
T ₂ : Bush bean (100%) + Coriander (100%)	711450	268962	442488	2.65
T ₃ : Bush bean (100%) + Chilli (100%)	567900	289662	278238	1.96
T ₄ : Bush bean sole (100%)	204750	154662	50088	1.32

Price in Tk. Kg⁻¹: Bush bean: 45.00, Radish: 20.00, Coriander: 120.00, Chilli: 100.00.

Conclusion

From the result it was found that intercrop combination bush bean + radish was best in terms of yield and economic return. The experiment will be repeated in the next year for more confirmation of the results.

INTERCROPPING OF CORIANDER WITH GROUNDNUT ON YIELD AND ECONOMICS OF SYSTEM PRODUCTIVITY IN HAOR AREAS OF SYLHET

M. I. Nazrul, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at farmer's field during winter 2020-21 under MLT site, Moulvibazar. Six intercrop combinations viz. T₁: Groundnut sole, T₂: Coriander sole, T₃: Groundnut + coriander (100%), T₄: Groundnut + coriander (90%), T₅: Groundnut + coriander (80%) and T₆: Groundnut + coriander (70%) were considered as treatments. The variety BARI Chinabadamm-8 and Local coriander was used in this trial. The experiment was setup in randomized complete block design with three replications. Among the combinations, the highest pod yield (2.57 t ha⁻¹) of groundnut and green leaf yield of coriander (3.95 t ha⁻¹) was found in their respective sole crops. On the contrary, in intercrop situation the maximum yields of coriander leaf (3.58) and GEY (7.17 t ha⁻¹) was obtained in T₃ (groundnut+100% coriander) which was increased over 178 % than sole groundnut. This intercropping combination also gave the maximum gross margin (Tk. 315200 ha⁻¹) with higher marginal rate of return (MRR) followed by T₄ (groundnut + 90 % coriander).

Introduction

Intercropping is recommended to be used in many parts of the world for food or fibers productions, because of its overall high productivity, effective control of pests and diseases, good ecological services and economic profitability. In practice, most intercropping systems involve only two crops, as inclusion of more crops results in higher labor costs. Mostly, intercropping is practiced with the aim of maximum plant competition rather than plant competition for maximum crop yield.

Groundnut (*Arachis hypogaea* L.) is the third most important legume crop in Bangladesh which grown on 31,579 ha of land and produces 56713 metric tons of nut with an average yield of 1.79 t ha⁻¹ (BBS, 2015). Recently the area of groundnut is being decreased due to the competition with rabi crops like wheat, potato, Boro rice and mustard (Alom *et. al.*, 2009). Groundnut var. BARI Chinabadam-8 is successfully growing in haor areas of Sylhet during rabi season. At the same time farmers cultivating coriander alone and or with groundnut as intercrop. Considering the benefits of intercropping system, the research has been undertaken to find out the suitable intercrop combination for increasing yield and economic return for the farmers in haor areas of Sylhet region.

Materials and Methods

The experiment was conducted at MLT site, Moulvibazer during the year 2020-21. Six intercrop combinations such as T₁: Groundnut sole, T₂: Coriander sole, T₃: Groundnut + coriander (100%), T₄: Groundnut + coriander (90%), T₅: Groundnut + coriander (80%) and T₆: Groundnut + coriander (70%) were considered as treatments. The variety BARI Chinabadamm-8 and local coriander was used in this trial. The experiment was setup in randomized complete block design with three dispersed replications (Ferdous *et al.* 2018). The seed of groundnut were sown with maintaining the spacing of 40 cm × 15 cm. The crop was fertilized as per fertilizer recommendation guide (FRG, BARC, 2018). The seeds of groundnut and coriander were sown on 15-18 December, 2020. Intercultural operations were done as and when necessary. There was no remarkable disease and pest attack. The coriander was harvested on 05 February 2021 and groundnut was harvested during 15-17 May, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous *et al.*, 2020 and Anwar *et al.* 2021). Data on yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analyzed statistically using "STAR" software package and means were separated by LSD.

Results and Discussion

Yield and yield attributes of groundnut: The yield and yield contributing characters of groundnut intercropped with coriander varied significantly except seeds per pod. The maximum pods per plant were obtained in sole groundnut (44.23) followed by T₆ (Groundnut + 70 % coriander) but the lowest

Pods per plant in T₃ (Groundnut + 100% coriander). The similar trend was observed in 100 kernel weight. Sole groundnut provided highest 100 kernel weight (41.60 g), followed by T₆ (Groundnut + 70 % coriander). Statistically similar shelling percent of groundnut was found in T₁ (sole groundnut) and T₆ (Groundnut + 70 % coriander). The sole groundnut (T₁) cultivation practice contributed the highest pod yield (2.57 t ha⁻¹) followed by T₆ (Groundnut + 70 % coriander) and T₅ (Groundnut + 80 % coriander) and T₃ (Groundnut + 100 % coriander) gave the lowest pod yield (1.80 t ha⁻¹).

Yield of coriander as companion crop: On an average, the yield of coriander under intercrop situation was 3.95, 3.58, 3.21, 2.72, and 2.45 in the combinations of T₂, T₃, T₄, T₅, and T₆, respectively (Table 2). Results showed that T₂ (sole coriander) produced higher yield (3.95 t ha⁻¹) of coriander followed by T₃, whereas the lower amount of coriander leaves was produced by T₆ (groundnut + 70% coriander).

Groundnut Equivalent Yield (GEY): Groundnut equivalent yield was expressed in total productivity of this system. Groundnut equivalent yields (7.17, 6.72 and 6.08 t ha⁻¹) were higher in intercrop with coriander at T₃, T₄ and T₅ than sole coriander (T₂). The maximum groundnut equivalent yield (7.17 t ha⁻¹) was recorded in T₃ (groundnut + 100 % coriander) followed by T₄ and T₅. The highest increment of total productivity (178 %) was also found in T₃ (groundnut + 100 % coriander) over sole groundnut (Table 2).

Cost benefit analysis

Intercrop combination of groundnut with coriander showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 430200 ha⁻¹) was recorded from T₃ (groundnut + 100 % coriander) intercrop combination which was more than 179 percent higher over sole groundnut. This intercropping combination also gave the maximum gross margin (Tk. 315200 ha⁻¹) with higher marginal rate of return (MRR) followed by T₄ (groundnut + 90 % coriander).

Dominance analysis was employed to determine the most efficient marginal rate of return (MRR). Gross margin of different treatments were arranged in ascending order to identify the cost dominated. The undominated treatments were arranged (Table 3) and indicated gross margins, total variable cost (TVC) and marginal rate of return. The result shows that the highest MRR (824 %) was obtained from T₃ (groundnut + 100 % coriander) and signified that investment of an additional Tk.100 in the production process increase return as 824 % to the total benefit. The results showed that intercropping earn higher money return compared to sole crop.

Farmer's opinions

Farmers cultivating groundnut in Hakaluki area mainly as sole crop but through the experimentation they learned a profitable intercropping practice. As such farmers can earn extra income easily without hampering the main crop and also boost up their family nutrition.

Table 1. Pod yield and yield attributes of groundnut intercropped with coriander at farmer's field under MLT site, Moulvibazar during 2020-21

Treatment	Pods plant ⁻¹	Seeds pod ⁻¹	100 kernel wt.(g)	Shelling %	Pod yield (t ha ⁻¹)
T ₁ : Groundnut sole	44.23	2.00	41.60	76.02	2.57
T ₂ : Coriander sole	-	-	-	-	-
T ₃ : Groundnut + coriander (100%)	37.80	2.00	38.13	75.13	1.80
T ₄ : Groundnut + coriander (90%)	38.67	2.00	38.87	75.69	1.90
T ₅ : Groundnut + coriander (80%)	39.63	2.00	39.33	75.99	2.00
T ₆ : Groundnut + coriander (70%)	40.10	2.00	40.23	76.04	2.10
CV (%)	4.09	-	4.50	2.32	10.65
LSD (0.05%)	3.87	NS	4.22	NS	0.52

Table 2. Seed yield of coriander and groundnut equivalent yield (GEY) in intercropping system 2020-21

Treatments	Seed yield of coriander (t ha ⁻¹)	Pod yield (t ha ⁻¹)	GEY (t ha ⁻¹)	% increase of GEY over sole groundnut
T ₁ : Groundnut sole	-	2.57	2.57	-
T ₂ : Coriander sole	3.95	-	5.93	131
T ₃ : Groundnut + coriander (100%)	3.58	1.80	7.17	178
T ₄ : Groundnut + coriander (90%)	3.21	1.90	6.72	162
T ₅ : Groundnut + coriander (80%)	2.72	2.00	6.08	137
T ₆ : Groundnut + coriander (70%)	2.45	2.10	5.78	125

GEY: Groundnut equivalent yield; Price (Tk. Kg⁻¹): groundnut: 60.00, coriander: 90.00

Table 3. Marginal analysis of un-dominated groundnut-coriander intercropping system, 2020-21

Treatments	GR (Tk.ha ⁻¹)	MGM (Tk.ha ⁻¹)	TVC (Tk.ha ⁻¹)	MVC (Tk.ha ⁻¹)	GM (Tk.ha ⁻¹)	MRR (%)
T ₂ : Coriander sole	355800	-	73000	-	282800	-
T ₁ : Groundnut sole	154200	-	81500	-	72700	-
T ₃ : Groundnut + coriander (100%)	430200	276000	115000	33500	315200	824
T ₄ : Groundnut + coriander (90%)	403200	249000	112000	30500	291200	816
T ₅ : Groundnut + coriander (80%)	364800	210600	109000	27500	255800	765
T ₆ : Groundnut + coriander (70%)	346800	192600	106000	24500	240000	786

Price (Tk. Kg⁻¹): groundnut: 60.00, chilli: 80.00; GR: gross return; GM: gross margin; MGM: marginal gross margin; TVC: total variable cost; MVC: marginal variable cost; MRR: marginal rate of return

Conclusion

From the result it was found that intercrop combinations was better than sole crop in terms of yield and economic return. The experiment will be repeated in the next year for more confirmation of the results.

INTERCROPPING PEA WITH HYBRID MAIZE AT VARYING PLANTING SYSTEM

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Abstract

The experiment was conducted at Ramnagar village under Shibaloya upazila of Manikganj district during Rabi season of 2020-21 to validate the developed pea and hybrid maize intercropping in farmers' field and its economic performance. Three intercrop combinations, T₁ = Maize normal row (60cm x 25cm) + two row pea, T₂ = Maize paired row (120cm x 25cm) + four row pea, T₃ = Sole maize (60cm x 25cm) were evaluated. The experiment was laid out in RCB design with three replications. The variety of hybrid maize was BARI Hybrid maize-16 and the variety of field pea was BARI Motor-3. The highest maize equivalent yield (11.45 t ha⁻¹), Land equivalent ratio (1.43), gross return (Tk.206100.00ha⁻¹), gross margin (Tk. 84915.00ha⁻¹) and MBCR (1.26) were obtained from treatment T₁ = Maize normal row (60cm x 25cm) + two row pea. The lowest maize equivalent yield (10.43 t ha⁻¹), gross return (Tk.187740.00 ha⁻¹), gross margin (Tk.81080.00ha⁻¹) were obtained from sole cropping of maize.

Introduction

Intercropping is the practice of growing two or more crops simultaneously in the same land area, particularly in the tropics (Andrews and Kassam, 1976). Successful intercropping system gives higher cash return and total production per unit area and diversifies crop production than that of growing sole crop (Qasim *et al.*, 2013). Intercropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood

and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Moreover, farmers may be better able to cope with seasonal price variability of commodities, which often can destabilize their income.

Maize is spaced crop and cultivated throughout the year, so there is a scope of using this space through growing another crop as intercrop. Fieldpea is also cultivated in *Rabi* season and it is a short statured crop. Its demand especially to the urban people is increasing day by day. Peas are an excellent source of protein, fibre, minerals and vitamins (McPhee, 2004; Corre-Hellou and Crozat, 2005). Garden pea can play an important role to overcome our national protein deficit. So, pea may be intercropped with maize under variable pea population, which may increase total productivity as well as increase crop diversity. In this context, the present investigation was undertaken to validate the developed pea and hybrid maize intercropping in farmers' field.

Materials and Methods

The experiment was conducted at Ramnagar village under Shibaloyaupazila of Manikganj district during *Rabi* season of 2020-21. The experiment was laid out in RCB design with three dispersed replications (Ferdous et al. 2018). The variety of hybrid maize was BARI Hybrid maize-16 and the variety of fieldpea was BARI Motor-3. Three intercrop combinations, T_1 = Maize normal row (60cm x 25cm) + two rows pea, T_2 = Maize paired row (120cm x 25cm) + four rows pea, T_3 = Sole maize (60cm x 25cm) were evaluated. The crop was fertilized with 250-55-115-40-3-1 kg N-P-K-S-Zn-B ha^{-1} along with 5.0 t ha^{-1} of cowdung in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. One-third of urea and full amount of all other fertilizers were applied at the time of final land preparation. The remaining urea was applied in two equal splits at 8-10 leaf stage (35DAS) and tasselling stage (55 DAS) of maize and mixed thoroughly with the soil as soon as possible for better utilization. Both maize and fieldpeaseeds were sown on 29 November, 2020. The crop was irrigated twice after fertilization at 35 and 55 DAS. Weeding, earthing up and other intercultural operations were done as per requirement. Green field pea was harvested time to time from 15 February to 2 March, 2021 and maize was harvested on 26 April, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous et al., 2020 and Anwar et al. 2021). The yield of both crops was recorded and analyzed statistically. Different parameters such as Maize equivalent yield (GEY) and land equivalent ratio (LER) were calculated as per Appendix Table 1.

Results and Discussion

Yield of maize: Yield of maize under different intercropping systems is shown in Table 1. However, yield of sole maize was higher than those of other treatment combinations. The grain yield of maize in intercropped combinations ranged from 5.10 to 9.83 t ha^{-1} . The highest maize grain yield (9.83 t ha^{-1}) was recorded in sole maize (T_3) followed by treatment T_1 producing 7.15 t ha^{-1} of maize with 2.50 t ha^{-1} of green field pea. Yield from treatment T_2 was obtained 5.10 t ha^{-1} of maize with 3.20 t ha^{-1} of field pea. The cause of lower yield of maize (5.10 t ha^{-1}) in treatment T_2 was due to lower plant population m^{-2} (4.33) than T_1 (8.33) and T_3 (9.33) planting system.

Maize equivalent yield: All the intercrop combinations produced the highest maize equivalent yield than sole maize (Table 2). The maximum maize equivalent yield (11.45 t ha^{-1}) was obtained from T_1 = Maize (60cm x 25cm) + 2 rows of fieldpea (30cm x 10cm) followed by T_2 = Maize (120cm x 25cm) + 4 rows of fieldpea (30cm x 10cm) producing yield maize equivalent yield 10.78 t ha^{-1} . The lowest maize equivalent yield (10.43 t ha^{-1}) was found in sole cropping of maize. From maize equivalent yield, about 4 to 10% higher yield advantage was found from intercropping system over the sole maize cultivation.

Cost and return analysis

Cost and return of maize and field pea intercropping system is shown in Table 2. The highest gross return (Tk. 206100.00 ha^{-1}) and gross margin (Tk. 84915.00 ha^{-1}) was recorded in T_1 = Maize (60cm x 25cm) + 2 rows of fieldpea (30cm x 10cm) followed by gross return (Tk. 193950.00 ha^{-1}) and gross

margin (Tk. 72165.00ha⁻¹) in T₂= Maize (60cm x 25cm) + 4 rows of fieldpea (30cm x 10cm). On the other hand, the lowest gross return (Tk. 187740.00ha⁻¹) and gross margin (Tk. 81080.00ha⁻¹) was obtained from sole maize (Table 2). Total variable cost (Tk. 106660.00 ha⁻¹) in sole maize cultivation was lower due to lower number of labour involvement.

Pest and disease incidence:

Cut worm infestation was observed in the seedling stage and it was controlled by application of Dersban @ 2 ml L⁻¹ water in the root zone of maize seedlings. Primary infestation of Fall Army Worm was observed in the plots. At early stage of growth Nitro @ 2ml L⁻¹ was also sprayed to control this insect. The crop was also sprayed with Desis @ 1 ml L⁻¹ of water at later stage of growth.

Farmers' opinion

Farmers showed interest in cultivation of maize intercropped with fieldpea for higher economic return. They opined that cultivation of two crops in the same piece of land is a profitable practice. Though two rows of fieldpea in between two rows of maize are profitable but farmers opined that four rows of fieldpea in paired row of maize are suitable for intercultural operations.

Table1. Yield and yield contributing characters of maize under varying planting system with pea at Manikganj during 2020-21

Treatment	Maize						Field pea
	Plant popn (m ⁻²)	Plant height (cm)	No. of grain cob ⁻¹	1000-grain wt. (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Green pod yield (t ha ⁻¹)
T ₁	8.33	190.30	509.00	227.50	7.15	8.60	2.50
T ₂	4.33	190.70	542.00	230.00	5.10	6.15	3.20
T ₃ (sole)	9.33	205.00	551.00	232.53	9.83	10.80	3.50
LSD (0.05)	0.75	6.732	43.92	3.74	1.36	1.432	0.39
CV (%)	4.70	1.52	3.63	1.72	8.15	7.43	2.40

Table 2. LER, MEY, Cost and return of maize and fieldpea intercropping system during 2020-21

Treatment	Land equivalent ratio (LER)	Maize equivalent yield (MEY) (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
T ₁	1.43	11.45	206100.00	121185.00	84915.00	1.26
T ₂	1.39	10.78	193950.00	121185.00	72765.00	0.42
T ₃	1.00	10.43	187740.00	106660.00	81080.00	-

Price of input and output: Urea Tk. 16.00 kg⁻¹, TSP Tk. 22.00 kg⁻¹, MoP Tk. 15.00 kg⁻¹, Gypsum Tk. 15.00 kg⁻¹, Zinc sulphate Tk. 230.00 kg⁻¹, Boric acid Tk.460.00 kg⁻¹, Cost of maize seed: Tk. 84.00 kg⁻¹ cost of fieldpea seed: Tk. 50.00 kg⁻¹, Price of maize seed: Tk. 18.00 kg⁻¹ and Stover: Tk. 1.00 kg⁻¹, Green fieldpea: Tk.30.00 kg⁻¹

Conclusion

Maize equivalent yield, Land equivalent ratio, gross margin and MBCR over sole cropping were found higher in T₁ treatment. It could be concluded that two rows of field pea in between two rows of maize was the most productive and profitable among the treatments tested in maize + field pea intercropping system.

SUITABILITY OF INTERCROPPING SHORT DURATION WINTER VEGETABLES WITH SWEET GOURD IN HILL VALLEYS OF BANDARBAN

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment on intercropping of five winter leafy vegetables viz. radish, Chinese cabbage (batishak), red amaranth, spinach and bushbean with sweet gourd was conducted at farmer's field of hill valleys of Bandarban hill district during Rabi season of 2020-2021 and to evaluate the performance of sweet gourd production, land use efficiency and best intercrop combination. Five intercrop combinations such as T_1 = Sweet gourd + Radish (leaf), T_2 = Sweet gourd + Chinese cabbage, T_3 = Sweet gourd + Red amaranth, T_4 = Sweet gourd + Spinach, T_5 = Sweet gourd + bushbean and sole sweet gourd (T_0) were used in the study. Intercropping short duration winter vegetables with pumpkin i.e. T_3 = Sweet gourd + Red amaranth, T_4 = Sweet gourd + spinach and T_5 = Sweet gourd + bushbean combinations performed better than sole sweet gourd. However, the results indicating that highest sweet gourd equivalent yield (43.77 t ha^{-1}), gross return (Tk. 875400 ha^{-1}), net return (Tk. 677400 ha^{-1}) and BCR (4.42) was obtained from T_3 = Sweet gourd + red amaranth crop combination which indicating that this intercropping system might be suitable for higher crop productivity, better land and time utilization as well as economic return for the hilly areas of Bandarban.

Introduction

Intercropping system, two or more crops are grown together to increase productivity per unit area of land. Crop productivity may increase by cultivating short duration crop like radish (leaf), Chinese cabbage (leaf), red amaranth (leaf), spinach (leaf) and bushbean with sweet gourd. Sweet gourd is a popular vegetable grown extensively throughout the tropical and subtropical countries (Hossain *et al.* 2015). Fruits of sweet gourd are used as vegetables both at immature (green) and mature (ripe) stage (Hossain *et al.* 2015). It is a long duration (95 to 120 days to mature) and wider spacing crop (1.8-3.0 m) with plant spacing 0.8-2.0 m (Napier 2009). There is a great scope to cultivate short duration leafy vegetables in the inter-row space of pumpkin to utilize the land and other resources to the maximum extent. It was observed that up to 40 days the canopy of the sweetgourd cannot cover the whole plot. Leafy vegetables on the other hand are an important constituent of fresh vegetables which can be grown with minimum investment and by growing leafy vegetables within 35-40 days (Biswas 2015). These nutritious vegetables are source of minerals, vitamins and fibers. Therefore, to utilize the land intensively this experiment was conducted to find out suitable intercrop combination with sweet gourd for higher productivity and maximum economic return.

Materials and Methods

The experiment was laid out at bikricchara hill valleys of Bandarban in a randomized complete block design with $2 \text{ m} \times 2 \text{ m}$ plots replicated thrice. Five crop combinations along with sole sweet gourd were evaluated: T_1 = sweet gourd + radish (leaf), T_2 = sweet gourd + chinese cabbage (Batishak), T_3 = sweet gourd + red amaranth, T_4 = sweet gourd + spinach and T_5 = sweet gourd + bushbean. Sole sweet gourd was also cultivated as control (T_0). Seeds of sweet gourd (var. BARI Mistikumra 2), radish (var. BARI Mula 1), chinese cabbage (var. Hybrid chinese cabbage), red amaranth (var. BARI Lalshak 1), spinach (var. BARI Palongshak 1) and bushbean (var. BARI Bushbean-2) were sown on same day i.e. 03 December, 2020.

For sweet gourd, pits of $50 \text{ cm} \times 50 \text{ cm} \times 45 \text{ cm}$ size were dug at a spacing of $2 \text{ m} \times 2 \text{ m}$. Sweet gourd seeds were directly sown in pits (2 seeds per pit and 1 plant was allowed to grow) whereas leafy vegetables seeds were sown by broadcasting method and bushbean were sown maintaining $30 \text{ cm} \times 15 \text{ cm}$ spacing. Intercrop seeds were sown in the whole plot excluding pit areas and therefore the approximate intercropped areas were 95%. Seeds of all crops were treated with a recommended fungicide, Bavistin at 2 g/L before sowing to control disease organisms, such as bacterial spot, fusarium root rot and damping-off disease, which may be on the seed surface. The crop was fertilized with N, P, K, S, Zn, B and cowdung at 69, 35, 75, 18, 3, 2 kg ha^{-1} and 10 t ha^{-1} , respectively. Entire amount of cowdung, TSP, gypsum, zinc sulphate, boric acid and one third ($1/3$) of MOP were applied during pit

making (5 days prior to seed sowing of pumpkin). Total amount of Urea and rest of MoP were applied in four equal installments for at 15, 35, 55, and 75 days after seed sowing in pit at ring method. An additional 46 kg ha⁻¹ N was top dressed only on leafy vegetables at their early vegetative stage at 15 days after sowing. Hand weeding was done before top dress and split application of fertilizer. Three irrigations were provided with ground water at 15, 35 and 55 days after sowing (DAS). Insect pest and disease infestations were generally low for most of the seasons during the experimental years. However, sex pheromone trap (Cuelure) was used to control shoot and fruit borers. Chemical protection measures were also taken against powdery and downy mildew diseases by spraying sulphur fungicide, Thiovit 80 WP at 2 g /L. Radish (leaf), chinese cabbage, red amaranth, spinach and bushbean were harvested manually at 25, 25, 33, 33 and 66 DAS respectively. Harvesting of sweet gourd was done at 120 DAS on 02 April, 2021. Total gross return was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous et al., 2020 and Anwar et al. 2021). Data on yield and yield contributing characters were recorded plot wise. Plot yields were then converted to tons per hectare.

Results and Discussion

Yield components of sweet gourd: Fruit plant⁻¹, fruit length, fruit breadth, average fruit weight was influenced by intercropping system (Table 1). Highest fruit plant⁻¹ was obtained from T₄= Sweet gourd + spinach combination (5.67) where lowest from T₁= Sweet gourd + radish leaf (2.67). Highest fruit length was obtained from T₃= Sweet gourd + red amaranth combination (14.47 cm) followed by sole sweet gourd (14.41) while lowest from T₅= Sweet gourd + bushbean (13.29 cm). Sole sweet gourd showed highest fruit breadth (20.03 cm) and average fruit weight (2.74 kg) over all other treatments. Lowest average fruit weight (2.01) was obtained from T₄= Sweet gourd + spinach combination.

Crop Yield and Sweet gourd equivalent yield (SEY): The highest fruit yield (29.02 t ha⁻¹) was recorded in sole sweet gourd. The lowest fruit yield (13.94 t ha⁻¹) found in T₁= Sweet gourd + radish (leaf) crop combination. Highest vegetable yield (25.51 t ha⁻¹) was found in T₃= Sweet gourd + red amaranth crop combination followed by T₁ (23.61 t ha⁻¹), T₅ (12.63 t ha⁻¹), T₄ (12.42 t ha⁻¹) and lowest result (11.85 t ha⁻¹) was found from T₂= Sweet gourd + chinese spinach combination. Highest SEY (43.77) was found from T₃= Sweet gourd + red amaranth crop combination followed by T₄ (40.72) and T₅ (39.83) crop combination. Lowest SEY (28.10) was found from T₁ crop combination.

Economics analysis

Cost and return analysis revealed that highest gross return (875400 Tk. ha⁻¹), gross margin (677400 Tk. ha⁻¹) and BCR (4.42) was obtained from intercrop combination T₃= Sweet gourd + red amaranth followed by T₄= Sweet gourd + spinach (Tk. 814400 ha⁻¹, Tk. 617030 ha⁻¹ and 4.13 respectively), T₅= Sweet gourd + spinach (796600 Tk. ha⁻¹, Tk. 603255 ha⁻¹ and 4.12 respectively). Lowest gross return (562000 Tk. ha⁻¹), gross margin (Tk. 364270 ha⁻¹) and BCR (2.84) was obtained from intercrop combination T₁= Sweet gourd + radish (leaf) which was almost similar with sweet gourd (sole) (Tk. 58040 ha⁻¹, Tk. 386600 ha⁻¹ and 2.99 respectively) and T₂= Sweet gourd + chinese spinach crop combination (Tk. 562000 ha⁻¹, Tk. 364270 ha⁻¹ and 2.91 respectively).

Table 1. Fruit number, fruit length, fruit breadth and fruit weight of sweet gourd as influenced by vegetables intercropping during 2020-21

Intercrop combinations	Fruits plant ⁻¹	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (kg)
T ₀ = Sweet gourd (sole)	4.33	14.41	20.03	2.74
T ₁ = Sweet gourd + radish (leaf)	2.67	13.39	19.44	2.16
T ₂ = Sweet gourd + chinese spinach	4.00	13.50	19.42	2.10
T ₃ = Sweet gourd + red amaranth	4.67	14.47	19.94	2.41
T ₄ = Sweet gourd + spinach	5.67	13.46	19.72	2.01
T ₅ = Sweet gourd + bushbean	4.00	13.29	19.71	2.09
CV (%)	23.55	4.88	3.92	12.89
LSD (0.05)	0.81	0.55	0.63	0.24

Table 2. Individual crop yield and sweet gourd equivalent yield (SEY) in sweet gourd-vegetables intercropping system during 2020-21

Intercrop combinations	Fruit Yield (t ha ⁻¹)	Vegetable yield (t ha ⁻¹)	SEY (t ha ⁻¹)
T ₀ = Sweet gourd (sole)	29.02	-	29.02
T ₁ = Sweet gourd + radish (leaf)	13.94	23.61	28.10
T ₂ = Sweet gourd + chinese spinach	20.98	11.85	28.68
T ₃ = Sweet gourd + red amaranth	28.46	25.51	43.77
T ₄ = Sweet gourd + spinach	28.30	12.42	40.72
T ₅ = Sweet gourd + bushbean	20.88	12.63	39.83
CV (%)	28.75	5.90	19.95
LSD _(0.05)	5.54	0.83	5.90

Selling price (Tk kg⁻¹): Sweet gourd: 20, radish leaf: 12, chinese cabbage: 13, red amaranth: 12, spinach: 20 and bushbean: 30.

Table 3. Economic performance of sweet gourd-vegetables intercropping system during 2020-21

Intercrop combinations	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₀ = Sweet gourd (sole)	580400	193800	386600	2.99
T ₁ = Sweet gourd + radish (leaf)	562000	197730	364270	2.84
T ₂ = Sweet gourd + chinese spinach	573600	197200	376400	2.91
T ₃ = Sweet gourd + red amaranth	875400	198000	677400	4.42
T ₄ = Sweet gourd + spinach	814400	197370	617030	4.13
T ₅ = Sweet gourd + bushbean	796600	193345	603255	4.12

Farmers' opinion

Farmers in these areas can be grown red amaranth, spinach and bushbean as intercrop with sweet gourd because of high profitability over sole sweet gourd cultivation.

PERFORMANCE OF INTERCROPPING BLACK CUMIN WITH GROUNDNUT AT BANDARBAN HILL DISTRICT

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was carried out at the farmers' field of On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Bandarbanduring the rabi season, 2020-2021 to find out the suitable intercropping system for increasing crop productivity and profitability of black cumin with groundnut intercropping system. The treatments were T₁=sole groundnut, T₂=sole black cumin, T₃= One row of black cumin in between two rows of groundnut and T₄= Two rows of black cumin in between two rows of groundnut. Treatments were arranged in a randomized complete block design with three replications. Between intercropped treatments, single row of black cumin within paired rows of groundnut (T₃) showed higher groundnut equivalent yield (2503.69 kg ha⁻¹), highest land equivalent ratio (1.42), gross return (Tk. 125184 ha⁻¹), gross margin (Tk. 86084 ha⁻¹) and benefit cost ratio (3.20) over the respective sole groundnut crop. The result showed that groundnut + black cumin (single row) intercrop system was most productive and profitable than sole groundnut cultivation in Bandarban region.

Introduction

Intercropping is widely practiced by many farmers in the tropics. Intercropping gives a greater stability of yield over monoculture (Willey and Reddy, 1981). Besides, intercropping ensure greater resource use efficiency (Herrera and Harwood, 1974; Poathick and Malla, 1979). Seeds of black cumin contain about 21% protein, 35% carbohydrates and 35-38% plant fats and oils. It contains all essential amino acids and rich source of vitamins and minerals. Total cultivable area of Bangladesh is 14.86 million

hectare. Black cumin is an annual plant, originally grown in arid and semi-arid regions. On the other hand, groundnut is the third major oil crop in Bangladesh in area and production. Groundnuts are cultivated in the tropical and subtropical regions of the world on sandy soils. In Bandarban district, it is grown in the river bank of Sangu during rabi season where farmers normally grow groundnut as sole crop. The cropping intensity of this area is 150%. An extra crop may be introduced as intercrop and cropping intensity may be increased. As such the experiment was taken to evaluate the performance of intercropping black cumin with groundnut.

Materials and Methods

The experiment was conducted in a farmer's field of sangu river bank in Bandarban during the rabi season, 2020-2021. Four treatments viz. T₁: Sole groundnut, T₂: Sole black cumin, T₃: Groundnut + Black cumin (single row) and T₄: Groundnut + Black cumin (double row) were used for the experiment. It was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 5 m × 4.5 m. Local Groundnut (Tridana Badam) and Black cumin (var. BARI Black cumin-1) were used as testing material. For groundnut, spacing was 40 cm × 15 cm and in between two line of groundnut, black cumin seed were sown maintaining 10 cm distance from each other for single line. For double row of black cumin (T₄), 15 cm line-line and 10 cm plant-plant distance were maintained. Both seeds were sown on 21 November, 2020. Fertilizers were applied @ 15-35-20-15 kg N-P-K-S ha⁻¹ for groundnut. All fertilizers were applied as basal at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash and gypsum respectively. Two times weeding and earthing up were done. The component crop was harvested on 12 March, 2021 and groundnut was harvested on 04 April, 2021. At harvest, the yield and yield attributes were recorded and analyzed statistically. Groundnut equivalent yield, LER and economic analysis were done for each treatment on a hectare basis considering the farm rate of crop. Groundnut equivalent yield (GEY) was calculated by converting the yield of black cumin to the yield of groundnut. Index of yield was calculated by the following formula: (Index of yield= Intercrop yield/Sole crop yield × 100).

Results and Discussion

Yield of groundnut and black cumin was significantly differing from one another in each treatment. Yield of sole groundnut and sole black cumin was higher due to no intercrop competition. Black cumin yield was converted into groundnut equivalent yield and sole black cumin (T₂) showed highest GEY (3781 kg ha⁻¹) and lowest GEY (2096.45 kg ha⁻¹) from treatment T₄ due to low groundnut and black cumin yield (2096 kg ha⁻¹). The highest LER (1.42) was found from treatment T₃: Groundnut + Black cumin (single row). Index of yield for both sole groundnut and black cumin showed that 15-36% yield reduction from sole groundnut but in black cumin reduction more i.e. 44-49% than sole black cumin.

The maximum gross return, net return and BCR was found from T₂ (175500 Tk. ha⁻¹, 123400 Tk. ha⁻¹ and 3.36) followed by T₃ (125184 Tk. ha⁻¹, 86084 Tk. ha⁻¹ and 3.20) and T₁ (114000 Tk. ha⁻¹, 76950 Tk. ha⁻¹ and 2.96). Lowest gross return, net return and BCR was found from T₄ (104825 Tk. ha⁻¹, 64825 Tk. ha⁻¹ and 2.62).

Table 1. Yield, groundnut equivalent yield (GEY) and LER of Groundnut-Black cumin intercropping system in Bandarban during the year of 2020-2021

Treatments	Yield (kg ha ⁻¹)		GEY (kg ha ⁻¹)	LER	Crop Index (%)	
	Groundnut	Black cumin			Groundnut	Black cumin
T ₁ = Sole groundnut	2280	-	2280	1.00	100	-
T ₂ = Sole black cumin	-	975	3781	1.00	-	100
T ₃ : Groundnut + Black cumin (single row)	1943.3	550	2503.69	1.42	85.23	56.41
T ₄ : Groundnut + Black cumin (double row)	1473.3	505	2096.45	1.16	64.62	51.79
CV(%)	2.14	1.45	-	-	-	-
LSD (0.05)	0.03	8.01	-	-	-	-

LER= Land equivalent ratio

Table 2. Economic analysis of Groundnut-Black cumin intercropping system in Bandarban during the year of 2020-2021

Treatments	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ = Sole groundnut	114000	38500	76950	2.96
T ₂ = Sole black cumin	175500	52100	123400	3.36
T ₃ : Groundnut + Black cumin (single row)	125184	39100	86084	3.20
T ₄ : Groundnut + Black cumin (double row)	104825	40000	64825	2.62

Conclusion

The combination of Groundnut + Black cumin (single row) was found to be more profitable practice with high economic return. Therefore, this intercropping system could help to meet up the medicinal spice crop requirement of the family without hampering the main crop.

INTERCROPPING OF BUSHBEAN WITH MAIZE IN HILL VALLEYS OF BANDARBAN

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was conducted to evaluate the suitability and economic performance of BARI Bushbean intercrop with BARI Hybrid Maize at farmer's field of hill valleys in Bandarban during the rabi season, 2020-2021. Two treatments viz. T₁: Sole Maize and T₂: Maize+Bushbean were used for the experiment. The results revealed that Maize+Bushbean combination did not influence yield and yield contributing characters of maize as compared to sole maize. The intercropping combination performed better in terms of maize equivalent yield (24.63 t ha⁻¹), gross return (492600 tk ha⁻¹) and benefit cost ratio (BCR) (4.48) over sole crops.

Introduction

Intercropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. The main effect of intercropping is because of more efficient utilization of available resources and increased productivity compared with each sole crop (Mao *et al.*, 2012). Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Intercropping may result in increased yield of main or companion or both crops as compared to sole cropping. However, in intercropping systems, not the yield but economic return is more important due to net benefit to the growers.

Maize is second most important cereal crop of Bangladesh and its cultivation is increasing day by day. Most of the farmers of the farmers grow Maize as a sole crop in Bandarban. Maize is a long duration crop. In that case, farmers can easily cultivate different short duration vegetables with Maize. Bushbean is a popular vegetable in Bandarban as well as Chattogram region. Its pod is consumed as vegetables and seed as khishya which can be easily incorporated with maize as intercrop of short duration. BARI has released BARI Jharsheem-2 which green tender fruit is consumed as vegetables. Hence, the present experiment was conducted to increase yield and economic return of farmers and improve the productivity of existing cropping pattern.

Materials and Methods

The experiment was conducted in a farmer's field of hill valleys in Bandarban during the rabi season, 2020-2021. Two treatments viz. T₁: Sole Maize and T₂: Maize+Bushbean were used for the experiment. It was laid out in randomized complete block design (RCBD) with three dispersed replications. The unit plot size was 12 m × 10 m. Hybrid Maize (BARI Hybrid Maize-9) and Bushbean (BARI Bushbean-2) were used. For maize, spacing was 60 cm × 20 cm and in between two line Bushbean seed were sown

maintaining 10 cm distance from each other. Both seeds were sown on 5 December, 2020. Fertilizers were applied @ 250-55-110-40-5-1.5 kg N-P-K-S-Zn-B ha⁻¹ for maize. One third urea and full amount of all other fertilizers were applied as basal at final land preparation. The rest urea was applied as top dress in two equal splits at 8 leaves and tasseling stages. Two times weeding and earthing up were done after each top dress. The crop was irrigated at 20-40-70 and grain filling stage. The component crop was harvested on 17 February 2021 and Maize harvested from 01-10 April 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. At harvest, the yield and yield attributes were recorded and analyzed statistically.

Results and Discussion

Yield and yield attributes: From the results it is revealed that yield contributing characters of Maize was not significantly influenced by intercrop combination where the highest plant height, cob length, cob breadth, cob weight, grains cob⁻¹, 1000 grain weight was obtained from Maize sole than intercrop (Maize+ Bushbean).

Grain yield of Maize was not influenced by intercrop combination but higher yield (10.54 t ha⁻¹) was obtained from sole Maize followed by T₂ (Maize+Bushbean) (Table 1). The highest Maize equivalent yield 24.63 t ha⁻¹ was recorded from T₂ (Maize+Bushbean) intercropped combination (Table 2) while lowest 10.54 t ha⁻¹ from T₂ (sole Maize).

Economics analysis: Cost and return analysis revealed that highest gross return (Tk. 492600 ha⁻¹), gross margin (Tk. 382600 ha⁻¹) and BCR (4.48) was obtained from intercrop combination T₂ (Maize + Bushbean) over T₁ (Tk. 126480 ha⁻¹, Tk. 66480 ha⁻¹ and 2.11 respectively).

Table 1. Yield and yield contributing characters of Maize and Bushbean under intercrop combinations at Bandarban during the year of 2020-2021

Treatments	Plant height (cm)	Cob length (cm)	Cob breadth (cm)	Grains cob ⁻¹	1000 grain wt. (g)	Maize grain yield (t ha ⁻¹)	Vegetable yield (t ha ⁻¹)
T ₁ = Maize + Bushbean	282.33	35.10	6.33	684.33	291.10	9.96	9.78
T ₂ = Maize as sole	290.33	37.23	6.87	712.67	295.67	10.54	-
CV (%)	1.31	3.37	4.46	4.74	1.17	4.16	-
LSD (0.05)	3.06	0.10	0.24	27.02	2.80	NS	-

Table 2. Maize equivalent yield and economics of Maize and intercrops at Bandarban during the year of 2020-2021

Treatments	Maize equivalent yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ = Maize + Bushbean	24.63	492600	110000	382600	4.48
T ₂ = Maize as sole	10.54	126480	60000	66480	2.11

Price (Tk. Kg⁻¹): Maize- 20.00; Bushbean- 30.00

Conclusion

Maize with short duration intercrop (Bushbean) was found as a profitable practice. Therefore, they can earn extra income easily without hampering the main crop (Maize) and could help to meet up the vegetable requirement of the family.

INTERCROPPING MUNGBEAN WITH MUKHIKACHU AT VARYING PLANTING SYSTEM IN KISOREGANJ

M. Mohiuddin, M.N Sarker, M Akkas Ali, M Shahiduzzaman

Abstract

A field experiment was conducted at the MLT site Karimganj, kishoreganj during 2019-20 to validate the developed mungbean and mukhikachu intercropping at farmers and to increase yield and economic profitability of farmers. Three treatment combinations viz., T_1 = Mukhikachu normal row (100%) + 2 rows mungbean (80%); T_2 = Mukhikachu normal row (100%) + 2 rows mungbean (60%) and T_3 = Sole mukhikachu were considered. The average highest mukhikachu equivalent yield was recorded from the treatment (Mukhikachu normal row (100%) + 2 rows mungbean (60%) (28.76 t ha^{-1}) and the lowest mukhikachu equivalent yield from the treatment (mukhikachu normal row (100%) + 2 rows mungbean (80%) (28.57 t ha^{-1}). The highest gross return (Tk. 287600 ha^{-1}) was obtained from the treatment T_2 but highest gross margin (Tk. 158573 ha^{-1}) and BCR (2.87) was obtained from the treatment T_3 and the lowest gross return (Tk. 285700 ha^{-1}) and gross margin (Tk. 155855 ha^{-1}) and BCR (2.20) was obtained from treatment T_1 .

Introduction

Intercropping system is an important feature of tropical agriculture that increases total productivity per unit area than sole cropping. One of the advantages of this system is that it gives an assurance against crop failure which is common in developing countries. Inter-specific competition may be minimized through judicious choice of crops (Santalla et al., 2001). Intercropping may result in increased yield of main or companion or both crops as compared to sole cropping. However, in intercropping systems, not the yield but economic return is more important due to net benefit to the growers.

Mukhikachu (*Colocasia esculenta*) is an important edible aroid in Bangladesh as well as in some other countries in the world (Rashid, 1999 and Ghosh et al., 1988). It is grown in kharif-1 season. Mukhikachu is an important summer vegetable when most of the vegetables are not available. It is spreading type vegetable and cultivated with a wide spacing, so there is a scope of using this space through growing other crop as intercrop. Mungbean is also cultivated in kharif 1 season and it is a short durated crop. So mungbean may be intercrop with mukhikachu under variable mungbean population, which may increase total productivity as well as increase crop diversity. In the above context, the present investigation was conducted to verify the developed technology in farmers' field.

Materials and Methods

The experiment was conducted at the MLT stie, Karimganj, kishoreganj during the Rabi season 2019-2020. Three intercropping combinations, viz. T_1 = Mukhikachu normal row (100%) + 2 rows mungbean (80%); T_2 = Mukhikachu normal row (100%) + 2 rows mungbean (60%) T_3 = Sole mukhikachu were considered. It was laid out in Randomized Complete Block Design (RCBD) with three dispersed replications. The unit plot size was 3.60 x 4 m². Mukhikachu-1 (Bilashi) and Mungbean (BARI Mungbean-6) were used as the experimental materials. Plant to plant 40 cm and row to row 60 cm (single row) distance was followed for mukhikachu planting. In case of double row system plant to plant 45 cm and row to row 55 cm (double row) distance was followed for mukhikachu and sowing of mungbean was followed by 30 cm x 10 cm spacing. Sowing/ planting, harvesting and fertilizer dose of mukhikachu and mungbean are presented in Table 1. In case of mukhikachu Urea and MoP was applied in two equal splits at 40 DAP and 75 DAP. The all quantity of P, S, Zn and cow dung were applied at final land preparation 2 to 3 days prior to planting. Weeding, irrigation and crop protection measures were taken properly. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on yield and yield contributing characters were recorded and analyzed by Statistix 10.

Results and Discussion

The results revealed that plant height, No of corm/plant, Weight of corm/plant, corm yield was influenced by intercropping which were significant (Table 2). The highest plant height was recorded from T₃ treatment (113.7 cm), it's due to minimum crop competition and lowest plant height was recorded from T₂ treatment (92.23 cm). The maximum no. of corm/ plant was found from T₃ treatment (34.5 no.) and minimum no. of corm/ plant from T₁ treatment (26.07 no.). The highest weight of corms/ plant was recorded from T₁ treatment (566.67 gm) and lowest from T₃ treatment (500 gm). Finally the maximum corm yield was obtained from T₃ treatment (24.31 t ha⁻¹) and minimum corm yield from T₁ treatment (18.43 t ha⁻¹). On the other hand, the highest mukhikachu equivalent yield was obtained from T₂ treatment (28.76 t ha⁻¹) and the lowest from T₁ treatment (28.57 t ha⁻¹) (Table 3). The highest gross return (287600 Tk ha⁻¹) was obtained from T₂ treatment but the highest gross margin (158573 Tk ha⁻¹) and BCR (2.87) was obtained from T₃ treatment (Table 3). The lowest gross return (285700 Tk ha⁻¹) and gross margin (155855 Tk ha⁻¹) and BCR 2.20 was obtained from T₁ treatment.

Pest incidence

In mukhikachu proraniam caterpillar, mite and leaf spot was observed and controlled by spraying tracer and abamectine and tilt respectively. Flee beetle, leaf roller and powdery mildew were observed in mungbean and controlled by spraying Mipsine, karate and tilt in the study plot.

Table 1. Agronomic practices of Mukhikachu and Mungbean intercrops during 2019-20

Crop	Sowing/ planting	Harvesting	Fertilizer dose (NPKSZnB) kg ha ⁻¹
Mukhikachu	14.01.20	20.08.20	165-38-155-22-4.32 and 1.8
Mungbean	13.01.20	20.03.20 to 25.04.20	20.7-18-20-9-0 and 1.6

Table 2. Yield and yield contributing characters of mukhikachu with mungbean during 2019-20

Treatment	Plant height (cm)	No. of corm/ plant	Weight of corm/ plant (gm)	Rhizome yield (t ha ⁻¹)
T ₁	95.3	23.6	566.7	18.43
T ₂	92.23	29.3	541.7	20.63
T ₃	113.7	32.7	500	24.31
LSD _{0.05}	8.14	4.7	88.6	3.25
CV (%)	3.58	6.98	7.29	6.56

T₁ = Mukhikachu normal row (100%) + 2 rows mungbean (80%), T₂ = Mukhikachu normal row (100%) + 2 rows mungbean (60%), T₃ = Sole mukhikachu

Table 3. Yield and economic performance of mukhikachu and mungbean as intercrop during 2019-20

Treatment	Mukhikachu (t ha ⁻¹)	Mungbean (t ha ⁻¹)	MEY (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	18.43	1.56	28.57	285700	129845	155855	2.2
T ₂	20.63	1.25	28.76	287600	129845	157755	2.21
T ₃	24.31	-	24.31	243100	84527	158573	2.87

Price (Tk. kg⁻¹): Mukhikachu = 10/- and Mungbean = 65/-

Conclusion

Sole mukhikachu cultivation was found more profitable practice than the other treatment of intercropping systems. So intercrop fails to show higher return.

INTERCROPPING OF SOYBEAN WITH MAIZE IN BHOLA

Gazi Nazmul Hasan, Md. Rashidul Hasan Anik, M Akkas Ali, M Shahiduzzaman

Abstract

A field trial was conducted at Bhola sadar during the rabi season of 2021 at the farmer's field under AEZ-18 to verify the agro-economic performance of intercropping of Soybean with Maize and to ensure the maximum yield and economic return. The experiment was laid out in Randomized Complete Block Design on farmer's field at Bhola sadar, Bhola. Four treatments combination of different seed rate of mustard and cowpea viz., T_1 = Sole maize, T_2 = Sole Soybean, T_3 = Two row maize (60cm x 25cm) with 2 row Soybean (30cm x 6cm), T_4 = Pair row maize (120cm x 25cm) with 4 row Soybean (30cm x 6cm). Variety was BARI Hybrid Maize-16 and BARI Soybean-6. The highest grain yield (7.83 t ha^{-1}) was obtained from sole maize followed by T_3 (7.46 t ha^{-1}) and the lowest was obtained from T_4 (6.50 t ha^{-1}). Seed yield (1.72 t ha^{-1}) of sole soybean was higher followed by two rows soybean intercropped with maize (1.54 t ha^{-1}) and lowest grain yield (1.38 t ha^{-1}) from four row soybean intercropped with paired row maize. The Land Equivalent Ratio (LER) was higher 1.85 & 1.63 in two row soybean with two row maize and four row soybean with paired row maize respectively as compared with sole cropping. The highest gross return (Tk. 248000 ha^{-1}), gross margin (Tk. 161650 ha^{-1}) and BCR (2.87) was obtained from intercrop combination T_3 (2 row soybean + 2 row maize) over sole soybean of Tk. 68750, 26575 ha^{-1} and 1.63 respectively.

Introduction

Cereal-grain legume intercropping has potential to address the soil nutrient depletion on smallholder farms (Sanginga and Woomer, 2009). Flexibility, maximization of profit, minimization of risk, soil conservation and soil fertility improvement are some of the principal reasons for smallholder farmers to intercrop their farms/crops (Matusso et al., 2012).

Maize is a very popular grain crop among all cereals over the world as well as Bangladesh. Day by day cultivation of maize is increasing at Bhola because of high profit. At present near about 3000 ha area are occupied under maize cultivation in Bhola that was only 140ha by the year of 2010. On the other hand, at the same period the area under soybean in Bhola was 1415 ha and it was increased by 7572 ha in 2019 (Source-DAE-Bhola). Both of those crops are grown at Rabi season in the region. But farmers cultivate this crop singly. It can be possible to intercrop with these crops for several benefits. Cereals like maize, sorghum and pearl millet can be used for intercropping with soybean (Singh *et al.*, 2008) due to their dissimilar growing patterns, morphology, phenology and nutrient requirement. Intercropping has shown potential as a land-use efficient and sustainable agricultural practice (Li et al. 2014). Different references are available about intercropping of soybean with maize increase yield and farmers' income. Therefore, the present study was undertaken to verify the agro-economic performance of intercropping of Soybean with Maize with the following objectives-

1. To find out the appropriate intercrop combination for higher yield and economic return.

Materials and Methods

The experiment was conducted at Bhola sadar during the rabi season of 2020-21 at the farmer's field under AEZ-18. The design of the experiment was Randomized Complete Block with six dispersed replications. Four treatments combination viz., T_1 = Sole maize, T_2 = Sole Soybean, T_3 = Two row maize (60cm x 25cm) with 2 row Soybean (30cm x 6cm), T_4 = Paired row maize (120cm x 25cm) with 4 row Soybean (30cm x 6cm) were tested. Maize variety was BARI Hybrid Bhutta-16 and Soybean variety BARI Soybean-6. Unit plot size was 8m x 5m. Fertilizer dose for intercropping was 100-30-35-18-2 kg ha^{-1} N-P-K-S-Zn, respectively in the form of urea, TSP, MOP, gypsum and ZnSO_4 respectively. As the crop was cultivated in rainfed condition all fertilizers were applied during final land preparation except urea. Both Maize and Soybean seeds were sown in line sowing method. Sowing date was 07-12 January, 2021 and harvesting date of Soybean was 17-22 April 2021. For controlling Soybean hairy caterpillar, nitro 505 EC @2ml Lit^{-1} water was sprayed once. Leaf roller was controlled by spraying of Sevin 20EC @2 ml Lit^{-1} water twice after 10 days interval. Maize was harvested 5-10 May 2021. Standard cultural practices were done as and when necessary. Total gross return under a treatment was

calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data were collected plot wise and analyzed statistically.

Land Equivalent Ratio (LER): Land Equivalent Ratio (LER) is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping (Brintha and Seran, 2009). The LER was calculated as per Appendix Table 1.

Result and Discussions

Yield and yield attributes: From the results it is revealed that maximum plant height (212 cm) was recorded from T₄ treatment followed by T₁ (198 cm), cob length was higher in T₄ followed by T₁. The maximum no. of grains cob⁻¹ (545) was recorded from T₁ followed by T₄ (532) and the lowest (518) from T₃. The maximum grain yield (7.83 t ha⁻¹) was obtained from sole maize followed by T₃ (7.46 t ha⁻¹) and the lowest from T₄ (6.50 t ha⁻¹), this lower yield obtained due to paired row system of maize where plant population was less compared to sole maize.

The maximum number of pods plant⁻¹ was obtained from sole soybean followed by soybean intercropped with maize. Seed yield (1.72 t ha⁻¹) of sole soybean was higher followed by two row soybean intercropped with two row maize (1.54 t ha⁻¹) and lowest seed yield (1.38 t ha⁻¹) from four row soybean intercropped with paired row maize.

The highest Maize Equivalent Yield 9.92 t ha⁻¹ was recorded from T₃ (2 row soybean +2 row maize) intercropped combination (Table 3) while the lowest equivalent yield 2.75 t ha⁻¹ from T₂ (sole soybean).

Land equivalent ratio (LER): The LER was 1.85 in maize–soybean intercrop of two row soybean with two row maize and 1.63 for four rows soybean with paired row maize.

Economics

Cost and return analysis revealed that highest gross return (Tk. 248000 ha⁻¹), gross margin (Tk. 161650 ha⁻¹) and BCR (2.87) was obtained from intercrop combination T₃ (2 rows soybean +2 rows maize) over sole soybean, Tk. 68750 and 26575 ha⁻¹ and 1.63 respectively.

Table 1. Yield and yield contributing characters of Maize under intercrop combinations at Bhola during the year of 2020-21

Treatments	Plant height (cm)	Cob length (cm)	Grains cob ⁻¹ (no.)	1000-grain wt. (g)	Grain yield (t ha ⁻¹)
T ₁ = Sole maize	198	24.00	545	32	7.83
T ₂ = Sole Soybean	-	-	-	-	-
T ₃ = 2 rows soybean +2 rows maize	182	21.34	518	31	7.46
T ₄ = 4 rows soybean + paired row maize	212	26.18	532	29	6.50
CV (%)	9.32	7.26	14.05	2.44	10.26
LSD (0.05)	20.46	2.86	25.12	NS	3.72

Table 2. Yield and yield contributing characters of Soybean under intercrop combinations at Bhola during the year of 2020-21.

Treatments	Plant height (cm)	Pods plant ⁻¹ (No.)	Seeds pod ⁻¹ (no.)	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
T ₁ = Sole maize	-	-	-	-	-
T ₂ = Sole Soybean	46.32	52.23	2.54	11.15	1.72
T ₃ = 2 rows soybean +2 rows maize	40.68	43.96	2.50	11.06	1.54
T ₄ = 4 rows soybean + paired row maize	45.58	48.78	2.45	10.98	1.38
CV (%)	9.45	11.60	4.27	5.42	8.45
LSD (0.05)	5.63	6.21	NS	NS	0.48

Table 3. Maize equivalent yield, LER and economics of intercrops combination at Bhola during the year of 2020-21.

Treatments	Maize Equivalent Yield (t ha ⁻¹)	LER	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁ = Sole maize	7.83	1.0	195750	78350	117400	2.49
T ₂ = Sole Soybean	2.75	1.0	68750	42175	26575	1.63
T ₃ = 2 row soybean +2 row maize	9.92	1.85	248000	86350	161650	2.87
T ₄ = 4 row soybean + pair row maize	8.71	1.63	217700	88350	129350	2.46

Price of output: (Tk. Kg⁻¹): Maize- 25; Soybean- 40

Farmer's opinion

Maize with soybean intercropped was found as a profitable practice at Bhola region though they faced some difficulties on intercultural operations but they can earn more income easily without hampering the main crop (Maize). It was very difficult to irrigate the crops due to water scarcity in the crop growing period.

Conclusion

It can be concluded that intercropping two rows soybean with two rows maize is more profitable than the sole cropping and risk of cultivation of one crop can be reduced by mixed cropping. This is one year result. So for more confirmation the experiment should be repeated in the next year.

INTERCROPPING OF CAULIFLOWER WITH Bt. BRINJAL

K U Ahammad, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was carried out at MLT site Tularampur, Narail during 2020-21. Four treatments viz. T₁= 1 row cauliflower between 2 rows of brinjal, T₂= 2 row cauliflower between 2 rows of brinjal, T₃= 1 cauliflower between 2 brinjal plant and T₄= Sole brinjal were used in the experiment. The experiment was laid out in RCB with 3 replications. Cauliflower (White Snow) was intercropped with Bt begun. The highest Bt begun yield (27.48 t ha⁻¹) was produced from T₄ (Sole brinjal) followed by T₂ (2 row cauliflower between 2 rows of brinjal), T₁ (1 row cauliflower between 2 rows of brinjal) and this was lowest (25.77 t ha⁻¹) from T₃ (1 cauliflower between 2 brinjal plant). The highest equivalent yield (49.52 t ha⁻¹) of Bt begun was obtained from T₂ and this was lowest (27.48 t ha⁻¹) from T₄. The highest gross margin (1012500 Tk.ha⁻¹) and benefit cost ratio (5.51) was found from T₂ (2 row cabbage between 2 rows of brinjal). and the lowest gross margin (651750 Tk.ha⁻¹) and benefit cost ratio (3.99) was found from T₄ (Sole Bt begun).

Introduction

Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Moreover, farmers may be better able to cope with seasonal price variability of commodities, which often can destabilize their income. Intercropping may result in increased yield of main or companion or both crops as compared to sole cropping.

Brinjal is one of the major vegetable crops in Bangladesh grown round the year. The main growing season of this crop is winter and the farmers of Narail district cultivate it as a sole crop. BARI has released some Bt brinjal varieties like BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4. Among the varieties, BARI Bt Begun-4 is cultivated by some farmers of Narail district in winter season. At the time of marketing they get fewer prices for Bt brinjal compared to local varieties. So, cauliflower intercropping with BARI Bt Begun-4 may compensate the loss of Bt begun cultivation as well as increase the total productivity and economic return. But no scientific study has

been done in this regard earlier. Therefore, the present experiment was conducted to find out the performance of cauliflower as intercrop with brinjal in Narail district.

Materials and Methods

An experiment was carried out at MLT site Tularampur, Narail during 2020-21. Four treatments viz. T_1 = 1 row cauliflower between 2 rows of brinjal, T_2 = 2 row cauliflower between 2 rows of brinjal, T_3 = 1 cauliflower between 2 brinjal plant and T_4 = Sole brinjal were used in the experiment. The experiment was laid out in RCB with 3 dispersed replications. Cauliflower white snow variety was intercropped with Bt begun. The plot size of the experiment was 4m × 5m. Bt begun and cauliflower were transplanted on 20 November maintaining the spacing according to the program as per treatments. Fertilizers were used @ 45-30-20-15-0.5-0.5 kg Urea, TSP, MoP, Gypsum, Zinc and Boron/bigha respectively and cow dung 10 t ha⁻¹. Cow dung and all fertilizers except urea were used as basal during final land preparation. Urea was applied in three installments after transplanting (DAT) of Bt begun. Weeding, irrigation and other intercultural operations were done properly. Cabbage was harvested during 08-14 February and Bt begun was harvested from 02 March to 31 May. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on all operations and yield and yield attributes were recorded properly and analyzed statistically.

Results and Discussion

The results indicated that most of the parameters of Bt brinjal were not influenced significantly due to intercropping with cauliflower except yield (Table 1). The maximum Bt begun fruit yield (27.48 t ha⁻¹) was produced from T_4 (Sole brinjal) followed by T_2 (2 row cauliflower between 2 rows of brinjal), T_1 (1 row cauliflower between 2 rows of brinjal) and the lowest (25.77 t ha⁻¹) from T_3 (1 cauliflower between 2 brinjal plant). The highest equivalent yield (49.52 t ha⁻¹) of Bt begun was obtained from T_2 and the lowest (27.48 t ha⁻¹) from T_4 . The highest gross margin (1012500 Tk.ha⁻¹) and benefit cost ratio (5.51) was found from T_2 (2 row cauliflower between 2 rows of brinjal) and the lowest gross margin (651750 Tk.ha⁻¹) and benefit cost ratio (3.99) from sole Bt begun.

Farmers' Opinion

Farmers were impressed with BARI Bt begun-4 intercropping with cauliflower. They preferred 2 row cauliflowers between 2 rows of brinjal intercropping system.

Table 1. Yield and yield contributing character of Bt brinjal intercropping with cauliflower during 2020-21

Treatment	Plant height	Fruits/plant	Fruit wt (kg)	Bt brinjal fruit yield (t ha ⁻¹)	Cauliflower curd yield (t ha ⁻¹)
T_1	107.23	13.15	235	25.97	25.77b
T_2	107.20	11.83	233	26.28	48.37a
T_3	108.30	12.12	232	25.77	18.85c
T_4	109.60	13.27	236	27.48	-
F test	NS	NS	NS	NS	**
CV (%)	2.71	7.68	2.68	5.39	

T_1 = 1 row Cauliflower between 2 rows of brinjal, T_2 = 2 row Cauliflower between 2 rows of brinjal. T_3 = 1 Cauliflower between 2 brinjal plant, T_4 = Sole brinjal

Table 2. Cost and return analysis of Bt brinjal intercropping with cauliflower during 2020-21

Treatment	Bt begun equivalent yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T_1	38.34	958500	220000	738500
T_2	49.52	1237500	225000	1012500
T_3	34.79	869750	218000	651750
T_4	27.48	687000	210000	477000

Sale price (Tk./kg): Bt begun = 25, Cauliflower = 12

C. Mixed Cropping

MIXED INTERCROPPING OF BLACK CUMIN WITH GROUNDNUT AT THE CHARLAND OF TANGAIL

S. Roy, M. A. H. Khan, M. M. Rahman, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at MLT site, Bhuapur during the Rabi season of 2020-21 to verify the agronomic and economic performance of mixed cropping of groundnut with kalozira and also ensure the maximum utilization of the land for higher yield and income. There were five treatments viz., T₁= Sole groundnut (100%), T₂= Groundnut (100%) + 20% black cumin, T₃= Groundnut (100%) + 30% black cumin, T₄= Groundnut (100%) + 40% black cumin, T₅= Groundnut (100%) + 50% black cumin. Higher groundnut equivalent yields were recorded from all intercropping treatments as compare to sole groundnut production. The highest average groundnut equivalent yield (4.16 t ha⁻¹) as well as gross margin (Tk. 225144 ha⁻¹) was recorded from T₅ and the lowest yield (2.09 t ha⁻¹) as well as gross margin (Tk. 79494 ha⁻¹) was obtained from sole groundnut.

Introduction

In Bangladesh, about 30 thousand hectares of land is under cultivation of groundnut and the total production is around 47 thousand tons (Krishi ProjuktiHatboi, 2014). The farmers of Tangail cultivate groundnut in a vast area of charland. Most of the farmers are cultivating locally available groundnut varieties. In this charland local kalozira also grown scattered. Both ground nut and kalozira are cultivated as sole crop. Mixed cropping reduces the risk of total crop failure as two or more crops are cultivated simultaneously in the same land. In Bhuapur char most of the farmers cultivate groundnut mixed with lentil, sesame and tishi which were recommended ratio developed by OFRD, BARI. Some farmers of Bhuapur char area are interested to cultivate kalozira as a mixed crop with groundnut. But they do not maintain proper seeding ratio, planting time and other management practices. Therefore, the present study was undertaken to verify the agronomic and economic performance of mixed cropping of groundnut with kalozira for higher yield and income.

Materials and methods

The experiment was conducted at the MLT site, Bhuapur, Tangail under AEZ-8 during the rabi season 2020-21. The experiment was laid out following RCB design with five dispersed replications. The unit plot size was 8 m x 5 m. There were five treatments viz., T₁= Sole groundnut (100%), T₂= Groundnut (100%) + 20% black cumin, T₃= Groundnut (100%) + 30% black cumin, T₄= Groundnut (100%) + 40% black cumin, T₅= Groundnut (100%) + 50% black cumin. Spacing of groundnut was maintained 40 cm × 15 cm and black cumin seeds were broadcasted according to the percentage of treatments. The plot was fertilized with 12-32-43-54-2 N-P-K-S-B ha⁻¹ for sole and intercropping treatments. All fertilizers and 2/3rd of urea was applied during final land preparation and rest urea was top dressed at two equal installments. The variety of groundnut was BARI Chinabadam-9 and BARI Kalozira-1 for black cumin. Seeds of groundnut and black cumin were planted on 18 November, 2020. The black cumin was harvested 15 March, 2021 and groundnut on 20 April, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on yield and yield attributes were recorded and analyzed with CropStat analytical package.

Results and discussion

Yield and yield contributing characters of groundnut were influenced significantly due to intercropping except thousand seed weight. The maximum plant height was observed in T₁ treatment (42.67 cm) followed by T₃ (39.50 cm) and T₂ (39.30 cm). The lowest plant height 36.33 cm was observed in T₄ treatment. The highest number of effective pod plant⁻¹ was observed in T₁ and the lowest number of pod plant⁻¹ (17.33) in T₅. It may be due to increased population which leads to increase competition among the crops. The maximum thousand seed weight 596.33 g was observed in T₂ followed by T₁ (590.23 g) and T₄ (585.53 g). The lowest thousand seed weight was observed in T₅ (579.20 g) followed

by 579.27 g in T₃ treatment. The highest pod yield was recorded in T₁ (2.02 t ha⁻¹) might be due to less competition compare to intercropping system. Nut yield of groundnut in all intercrop combination was decreased as the competition increases with the increase of black cumin population (Table 1). The average highest groundnut equivalent yield of two consecutive year was 4.16 t ha⁻¹ as well as highest gross margin (Tk. 225144 ha⁻¹) were found in T₅ treatment (Table 2 and Table 3).

Farmers' opinion

Farmers are happy for higher yield and gross margin in groundnut (100%) and black cumin (50%) intercropping system. They are interested in cultivating groundnut and black cumin as intercropping system due to higher productivity and reduce the risk of total crop failure.

Table 1. Yield and yield contributing characters of groundnut affected by intercropping with black cumin at MLT site Bhuapur during the Rabi, 2020-21

Treatment	Plant height (cm)	Effective pod palnt ⁻¹ (no.)	1000 seed weight (g)	Nut yield (t ha ⁻¹)
Sole groundnut (100%)	42.67	21.67	590.23	2.02
Groundnut (100%) + kalozira (20%)	39.30	18.93	596.33	1.83
Groundnut (100%) + kalozira (30%)	39.50	18.80	579.27	1.79
Groundnut (100%) + kalozira (40%)	36.33	17.87	585.53	1.75
Groundnut (100%) + kalozira (50%)	37.17	17.33	579.20	1.65
LSD _{0.05}	0.99	1.69	33.02	0.09
CV (%)	1.30	4.70	4.01	3.70

Table 2. Yield of groundnut, black cumin and groundnut equivalent yield of groundnut intercropping with black cumin at MLT site Bhuapur, Tangail during the rabi, 2020-21

Treatment	Yield of groundnut (t ha ⁻¹)	Yield of black cumin (t ha ⁻¹)	Groundnut equivalent yield (t ha ⁻¹)
			2020-21
Sole groundnut (100%)	2.02	-	2.02
Groundnut (100%) + kalozira (20%)	1.83	0.32	3.11
Groundnut (100%) + kalozira (30%)	1.79	0.50	3.79
Groundnut (100%) + kalozira (40%)	1.75	0.52	3.83
Groundnut (100%) + kalozira (50%)	1.65	0.66	4.29

Groundnut: 75 Tk. kg⁻¹, Black cumin: 300 Tk. kg⁻¹

Table 3. Cost and return analysis of groundnut intercropping with black cumin at MLT site, Bhuapur, Tangail

Treatment	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Sole groundnut (100%)	156750	77256	79494
Groundnut (100%) + kalozira (20%)	230250	81646	148604
Groundnut (100%) + kalozira (30%)	280500	84646	195854
Groundnut (100%) + kalozira (40%)	291750	86036	205714
Groundnut (100%) + kalozira (50%)	312000	86856	225144

Conclusion

Results revealed that 100% groundnut with 50% black cumin mixed intercropping system might be suitable combination for higher productivity and economic return. However, the experiment can be repeated 2nd year for recommendation.

EFFECT OF SEED RATE OF MUSTARD AND COWPEA MIXED CROPPING IN BHOLA

Gazi Nazmul Hasan, Rashidul Hasan Ani, M Akkas Ali, M Shahiduzzaman k

Abstract

A field trial was carried out at Daulatkhan and Bhola sadar during the rabi season of 2019-20 and 2020-21 at the farmer's field under AEZ-18 to evaluate the performance of mixed cropping of cowpea with mustard and to ensure the maximum utilization of the land for higher yield and economic return. Four treatments combination of different seed rate of mustard and cowpea viz., T_1 = Sole mustard (100% seed rate), T_2 = Mustard (100% seed rate + 20% of cowpea seed rate), T_3 = Mustard (100% seed rate + 30% of cowpea seed rate), T_4 = Mustard (100% seed rate + 40% of cowpea seed rate) were tested. In case of mustard yield T_1 treatment gave the highest seed yield in both the year (in 2019-20 1.05 t ha⁻¹ and 1.34 t ha⁻¹ in 2020-21) on the other hand cowpea yield was obtained higher consecutive two years (in 2019-20 yield 0.49 t ha⁻¹ and 0.65 t ha⁻¹) in T_4 treatments. On an average the highest Mustard Equivalent Yield (1.52 t ha⁻¹), gross return (Tk.76000) and gross margin (Tk.27020) was obtained from T_4 treatment. The highest average BCR (1.55) was also obtained from T_4 treatment.

Introduction

Mixed cropping is the practice of growing two or more crops simultaneously in the same land area, particularly in the tropics (Andrews and Kassam, 1976). Successful mixed cropping system gives higher cash return and total production per unit area and diversifies crop production than that of growing sole crop (Qasim *et al.*, 2013). Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Mixed cropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Mixed cropping may result in increased yield of main or companion or both crops as compared to sole cropping.

Cowpea is a traditional crop in Bhola. Farmers of Bhola grow at least some cowpea for home consumption, beside commercial cultivation. Farmers like to utilize this fallow period using cowpea mixed with the main crop. More than 7000-hectare land is occupied by mustard in Bhola. Farmers use seed rate of both crops from their assumption. Therefore, the present study was undertaken to verify the agro-economic performance of mixed cropping of cowpea with mustard and to ensure the maximum utilization of the land for higher yield and economic return in Bhola with the following objective:

- i. To verify the agro-economic performance of mixed cropping of cowpea with mustard with higher yield and return.

Materials and Methods

The experiment was conducted at Daulatkhan and Bhola sadar during the rabi season of 2020-21 at the farmer's field under AEZ-18. The design of the experiment was Randomized Complete Block with four dispersed replications. Four treatment combination of different seed rate of mustard and cowpea viz., T_1 = Sole mustard (100% seed rate), T_2 = Mustard (100% seed rate + 20% of cowpea seed rate), T_3 = Mustard (100% seed rate + 30% of cowpea seed rate, T_4 = Mustard (100% seed rate + 40% of cowpea seed rate) were tested. Mustard variety was BARI Sarisha-14 and cowpea variety was BARI Felon-1. Unit plot size was 8m × 5m. Fertilizer dose for mustard was applied. It was 100-30-35-18-2 kg ha⁻¹ N-P-K-S-Zn, respectively in the form of urea, TSP, MOP, gypsum and ZnSO₄, respectively. As the crop was cultivated in rainfed condition all fertilizers were applied during final land preparation. Both mustard and cowpea seeds were sown in broadcast system. Sowing date was 17-25 December, 2020 and harvesting date of mustard was 10-16 March, 2021. Mustard duration was 81 days. For controlling mustard aphid, Malathion @2ml Lit⁻¹ water was sprayed once. Alternaria leaf blight was controlled by spraying of Rovral @2 g Lit⁻¹ water once. Mustard sample was harvested from an area of 2m×2m of each unit plot. After harvesting mustard, cowpea plant condition was poor but due to agronomic practices it was grown well. Cowpea was harvested 20-25 April, 2021. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically.

Results and Discussion

Results of the present study showed that yield and yield contributing characters differ significantly (Table 1, 2, 4, 5). The results indicated that most of the yield attributes of cowpea were influenced due to intercropping with Mustard (table 2,4) except no. of seeds pod⁻¹ and branch number plant⁻¹. The maximum no of siliqua per plants and no of seeds siliqua⁻¹ was obtained from sole mustard (100%) (Table-1, 4). The maximum mustard yield was observed in the sole mustard (T₁) treatment with 1.05 t ha⁻¹ in 2019-20 and 1.34 t ha⁻¹ in 2020-21 followed by T₂ treatment (0.95 and 1.26 t ha⁻¹) and lowest in T₄ (0.91 and 1.10 t ha⁻¹). The maximum cowpea yield was observed in T₄ treatment with 0.49 t ha⁻¹ in 2019-20 and 0.65 t ha⁻¹ in 2020-21 followed by T₃ treatment (0.36 and 0.43 t ha⁻¹) and lowest in T₂ (0.25 and 0.27 t ha⁻¹) treatment.

Mustard Equivalent Yield (MEY): The highest mustard equivalent yield was found with an average of 1.52 t ha⁻¹ in the T₄ treatment which was higher compared to all other treatments. The lowest mustard equivalent yield was found in T₁ with an average of 1.20 t ha⁻¹. The reason of highest MEY in T₄ treatment mainly due to the higher yield of cowpea than the other combination.

Cost and return analysis (average of 2 years): An analysis on cost-return of mixed cropping mustard with cowpea has been given in Table 7. The highest gross return (Tk. 76000 ha⁻¹) and gross margin (Tk. 27020 ha⁻¹) was obtained from the treatment T₄ (100% mustard + 40% cowpea) followed by T₃ (100% chilli + 30% cowpea). The lowest gross return (Tk. 60000 ha⁻¹) and gross margin (Tk. 17500 ha⁻¹) was obtained from treatment T₁ (Sole mustard). The height BCR (1.55) was found in T₄ treatment.

Table 1. Seed yield and yield attributes of Mustard at Bhola during the year of 2019-20.

Treatments	Plant m ⁻² (no.)	Plant height (cm)	Silique plant ⁻¹ (no)	Seeds silique ⁻¹ (no)	1000-grain weight (g)	Seed yield (t ha ⁻¹)
T ₁	58.37	88.20	29.67	22.60	3.10	1.05
T ₂	57.63	87.13	28.90	19.67	3.27	0.95
T ₃	57.13	87.45	25.73	18.87	3.16	0.93
T ₄	58.33	85.87	19.87	20.45	2.98	0.91
LSD (0.05)	3.36	10.29	7.57	3.19	3.43	5.24
CV (%)	3.52	5.53	14.55	8.42	6.43	12.40

T₁= Sole mustard (100%), T₂= 100% Mustard + 20% cowpea, T₃= 100% Mustard + 30% cowpea, T₄= 100% Mustard + 40% cowpea

Table 2. Seed yield and yield attributes of Cowpea at Bhola during the year of 2019-20.

Treatments	Plant no. m ⁻²	Plant height (cm)	Branch no. plant ⁻¹	No. of pods plant ⁻¹	Pod length (cm)	Seeds pod ⁻¹	1000 seed wt (g)	Seed yield (t ha ⁻¹)
T ₁	-	-	-	-	-	-	-	-
T ₂	3.14	58.5	4.23	7.85	15.17	11.36	98.27	0.25
T ₃	4.72	56.8	4.16	9.33	13.67	10.58	98.53	0.36
T ₄	6.29	56.5	3.81	8.72	13.24	11.52	97.36	0.49
LSD (0.05)	7.24	5.44	3.75	6.82	6.71	9.26	4.73	5.62
CV (%)	9.87	2.91	4.97	11.53	4.74	8.25	8.90	8.17

T₁= Sole mustard (100%), T₂= 100% Mustard + 20% cowpea, T₃= 100% Mustard + 30% cowpea, T₄= 100% Mustard + 40% cowpea

Table 3. Cost and return analysis of Mustard and Cowpea mixed cropping at Bhola during the year of 2019-20.

Treatment	Yield (kg ha ⁻¹)		MEY (kg ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
	Mustard	Cowpea					
T ₁ = Sole mustard (100%)	1050	-	1050	52500	42500	10000	1.23
T ₂ = 100% Mustard + 20% cowpea	950	250	1175	58750	46980	11770	1.25
T ₃ = 100% Mustard + 30% cowpea	930	360	1254	62700	47980	14720	1.31
T ₄ = 100% Mustard + 40% cowpea	910	490	1351	67550	48980	18570	1.40

Note: Mustard @ 50 Tk/kg and Cowpea @ 45 Tk/kg, MEY=Mustard Equivalent Yield

Table 4. Yield and yield attributes of Mustard at Bhola during the year of 2020-21

Treatments	Plant m ⁻² (no.)	Plant height (cm)	Siliqua plant ⁻¹ (no)	Seeds siliqua ⁻¹ (no)	1000-grain weight (g)	Seed yield (t ha ⁻¹)
T ₁	59.12	87.65	29.56	23.56	3.10	1.34
T ₂	57.69	87.19	27.86	20.66	3.21	1.26
T ₃	57.36	86.39	25.49	18.76	3.19	1.14
T ₄	58.47	85.65	19.83	20.45	2.92	1.10
LSD _(0.05)	2.56	4.29	6.89	4.67	3.34	5.24
CV (%)	3.38	5.53	9.55	9.12	5.34	7.40

T₁= Sole mustard (100%), T₂= 100% Mustard + 20% cowpea, T₃= 100% Mustard + 30% cowpea, T₄= 100% Mustard + 40% cowpea.

Table 5. Yield and yield attributes of Cowpea at Bhola during the year of 2020-21

Treatments	Plant no. m ⁻²	Plant height (cm)	Branch no. plant ⁻¹	No. of pods plant ⁻¹	Pod length (cm)	Seeds pod ⁻¹	1000 seed wt (g)	Seed yield (t ha ⁻¹)
T ₁	-	-	-	-	-	-	-	-
T ₂	3.28	57.86	4.12	8.34	14.77	11.21	97.43	0.27
T ₃	4.32	56.75	4.17	9.16	13.59	10.52	98.31	0.43
T ₄	5.29	55.63	3.82	8.62	13.29	11.46	97.64	0.65
LSD _(0.05)	6.24	5.44	3.53	5.88	6.37	3.26	4.89	5.23
CV (%)	7.80	2.91	4.92	9.53	4.82	7.32	7.81	6.18

T₁= Sole mustard (100%), T₂= 100% Mustard + 20% cowpea, T₃= 100% Mustard + 30% cowpea, T₄= 100% Mustard + 40% cowpea.

Table 6. Cost and return analysis of Mustard and Cowpea mixed cropping at Bhola (average of 2 years).

Treatments	Mustard Equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	1.20	60000	42500	17500	1.41
T ₂	1.34	67000	46980	20020	1.43
T ₃	1.39	69500	47980	21520	1.45
T ₄	1.52	76000	48980	27020	1.55

Note: Mustard @ 50 Tk/kg and Cowpea @ 45 Tk/kg, MEY=Mustard Equivalent Yield

Farmer's opinion

- The farmers obtained more yield from mustard and cowpea as mixed cropping which is profitable than the sole cropping
- Risk of cultivation of one crop can be reduced by mixed cropping.

Conclusion

It may be concluded that that mixed 100% mustard with 40% cowpea is the most profitable as compared to other treatment combination in Bhola. It is evident that, mixed cropping is more profitable than the sole cropping and risk of cultivation of one crop can be reduced by mixed cropping. The experiment should be repeated in the next year for more conformation with higher seed rate of cowpea with mustard.

PERFORMANCE OF MIXED CROPPING IN CHAR AREAS OF GAIBANDHA

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Abstract

The experiment was undertaken at Chinirpotol char, Saghata, Gaibandha during 2019-20 and 2020-21 to find out the suitable ratio of chilli, brinjal, radish and coriander under mixed cropping and ensure higher yield and economic return. The experiment was designed in a randomized complete block design with three dispersed replications. In this experiment, chilli (BARI morich-3), brinjal (BARI bt begun-4), radish (BARI mula-1) and coriander (BARI dhanial-1) were grown mixed using additive percentages.

Four mixed cropping ratios with one sole chilli viz: T_1 : 100% chilli + 70% brinjal + 20% Radish + 10% coriander, T_2 : 100% chilli + 50% brinjal + 30% radish + 20% coriander and T_3 : 100% chilli + 30% brinjal + 40% radish + 30% coriander, T_4 : Sole chilli (100%) and T_5 : Farmers practices' (100% chilli + 80% brinjal + 70% radish + 50% coriander). The maximum chilli equivalent yield 29.9 t ha^{-1} (29.7 t ha^{-1} in 2019-20 and 30.1 t ha^{-1} in 2020-21), gross return (aver. Tk. 897000 ha^{-1}) and gross margin (aver. Tk. 782700 ha^{-1}) was found from T_3 (100% chilli + 30% brinjal + 40% radish + 30% coriander) treatment. The minimum chilli equivalent yield 11.8 t ha^{-1} (11.7 t ha^{-1} in 2019-20 and 11.9 t ha^{-1} in 2020-21), gross return (aver. Tk. 353250 ha^{-1}) and gross margin (aver. Tk. 241200 ha^{-1}) was found from T_4 (Sole chilli) treatment. The maximum MBCR (241.7) was also recorded from the same T_3 treatment where 100% chilli mixed cropped with 30% brinjal + 40% radish + 30% coriander. It was found that 100% chilli mixed with 30% brinjal, 40% radish and 30% coriander produced the highest crop and system yield and economic return.

Introduction

Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Successfully intercropping system gives higher cash return total production per unit area and diversified crop production than that of growing sole crop and provides greater resource use efficiency. In char areas of Gaibandha, farmers usually practiced mixed cropping of different crops like chill, brinjal, radish, coriander with other leafy vegetables. But they don't practice appropriate seed ratio when they sow seeds. Only they practice their own assumption and it vary farmers to farmers. They have not the idea about the proportion for mixed cropping. The present study was therefore, undertaken to find out the suitable mixed cropping combinations of chilli, brinjal, radish and coriander for higher yield and economic return.

Materials and Methods

The field experiment was conducted at the farmer's field of Chinirpotol, Saghata, Gaibandha during the *rabi* season of 2019-20 and 2020-21 to verify the agro-economic performance of mixed cropping of chilli with brinjal. The experiment was laid out in a randomized complete block design with three dispersed replications. The unit plot size was 6 m x 6 m. There were five treatments combination viz., T_1 : 100% chilli + 70% brinjal + 20% Radish + 10% coriander, T_2 : 100% chilli + 50% brinjal + 30% radish + 20% coriander and T_3 : 100% chilli + 30% brinjal + 40% radish + 30% coriander, T_4 : Sole chilli (100%) and T_5 : Farmers practices' (100% chilli + 80% brinjal + 70% radish + 50% coriander). The variety of chilli, brinjal, radish and coriander were BARI Morich-3, BARI Bt begun-4, BARI Mula-1 and BARI Dhania-1, respectively. Seeds of all crops were mixed and sown on 15-20 November in each of the year. The fertilizer doses were N-P-K-S-Zn-B @ 142-58-61-18-3-2 kg ha^{-1} , respectively in all the treatment. The plot was fertilized with 100% of fertilizer for main crop in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All the fertilizer was applied as basal dose during final land preparation. Full dose of P, S, Zn, and $1/4^{\text{th}}$ of K was applied during final land preparation. The remaining $3/4^{\text{th}}$ K and full dose of N were divided into 3 equal split and applied 25, 50, and 75 days after sowing. All intercultural operations viz. weeding, thinning etc were done when needed. Radish was the first harvested crop after one month of sowing (15-20 December) as leafy vegetable, after that coriander harvested within two months after sowing (15-20 January). After the harvest of radish and coriander, chilli and brinjal remain together in the field. The chilli started to harvest 1 March and continued up to 31 March in both the year. After one chilli harvest the plants became slightly thin in the meantime brinjal get more space and started to be fruiting. Even after chilli harvest brinjal remain two months more in the field. The bt brinjal harvest commenced from 15 March and continued up to 31 May. Chilli equivalent yield was calculated by converting the yield of brinjal, radish and coriander into the yield of chilli based on prevailing market prices. Marginal benefit cost ratio (MBCR) was calculated. The data were analyzed statistically with open-source software CROPSTAT 7.2.

Table 1. Initial soil status of Chinirpotol char at Saghata, Gaibandha

	pH	OM (%)	Total N (%)	K	P	S	Zn	B
				meq/100 g	µg/g soil			
<i>Initial status</i>								
Value	6.5	0.78	0.05	0.12	9.60	14.9	0.23	0.24
Interpretation	Slightly acidic	VL	VL	L	L	M	VL	L

VL=Very low, L=Low, M=Medium

Results and Discussion

Yield of crops in mixed cropping system: There was a significant yield variation among the different treatments (Table 2 and 3). The maximum chilli yield was observed in the sole chilli (T₄) treatment with 11.5 t ha⁻¹ in 2019-20 and 11.9 t ha⁻¹ in 2020-21 followed by T₃ treatment (10.0 t ha⁻¹ in 2019-20 and 10.5 t ha⁻¹ in 2020-21) and lowest in T₁ (7.50 and 7.45 t ha⁻¹). In case of bt brinjal the significant highest yield recorded in T₃ treatment (16.5 t ha⁻¹ in 2019-20 and 16.83 t ha⁻¹ in 2020-21) and the lowest in T₁ treatment. Similarly, in radish, the highest value observed in the same T₃ treatment (10.0 and 10.33 t ha⁻¹ in both the year), next to T₅ and T₂ treatment. The highest coriander yield performed in the T₃ treatment (2.47 to 2.50 t ha⁻¹), similar to T₂ treatment and lowest in T₁ treatment (2.25 t ha⁻¹ in 2019-20 and 2.00 t ha⁻¹ in 2020-21).

Chilli Equivalent Yield (CEY): The highest chilli equivalent yield was found in T₃ with 29.9 t ha⁻¹. The lowest chilli equivalent yield was found in T₄ (11.8 t ha⁻¹) where sole chilli was used. The reason of highest CEY in T₃ treatment mainly due to the higher yield of bt brinjal, radish and coriander than the other combination and sole chilli treatment. However, the treatment T₃ where 100% chilli mixed cropping with 30% bt brinjal, 40% radish and 30% coriander performed best in farmer's field.

Cost and return analysis (average of 2 years):

Cost-return analysis of mixed cropping chilli with bt brinjal, radish and coriander has been given in Table 4. The highest gross return (Tk. 897000 ha⁻¹) and gross margin (Tk. 782700 ha⁻¹) was obtained from the treatment T₃ (100% chilli + 30% brinjal + 40% radish + 30% coriander) followed by T₅ (100% chilli + 80% brinjal + 70% radish + 50% coriander) due to the performance of mixed cropping. The lowest gross return (Tk. 353250 ha⁻¹) and gross margin (Tk. 241200 ha⁻¹) was obtained from treatment T₄ (Sole chilli).

Farmer's opinion

Farmer showed their interest for growing chilli mixed cropping with bt brinjal, radish and coriander for their highest yield and less insect infestation than sole chilli production.

Table 2. Yield of different crops and chilli equivalent yield (CEY) during 2019-20 at mixed cropping.

Treatments	Chilli yield (t ha ⁻¹)	Bt brinjal yield (t ha ⁻¹)	Radish yield (t ha ⁻¹)	Coriander yield (t ha ⁻¹)	Chilli equivalent yield (t ha ⁻¹)
T ₁	7.50	12.5	5.00	2.25	22.4
T ₂	9.00	14.0	7.50	2.50	26.2
T ₃	10.00	16.5	10.00	2.50	29.7
T ₄	11.50	-	-	-	11.7
T ₅	9.50	14.5	7.50	2.25	26.5
LSD0.05	0.84	0.42	0.42	0.42	0.29
CV (%)	5.2	6.4	6.8	5.9	5.5

T₁: 100% chilli + 70% brinjal + 20% Radish + 10% coriander, T₂: 100% chilli + 50% brinjal + 30% radish + 20% coriander and T₃: 100% chilli + 30% brinjal + 40% radish + 30% coriander, T₄: Sole chilli (100%) and T₅: Farmers practices' (100% chilli + 80% brinjal + 70% radish + 50% coriander).

*Price (Tk./kg): Chilli=30, Bt brinjal=20, Radish=10 and Coriander=60.

Table 3. Yield of different crops and chilli equivalent yield (CEY) during 2020-21 at mixed cropping.

Treatments	Chilli yield (t ha ⁻¹)	Bt brinjal yield (t ha ⁻¹)	Radish yield (t ha ⁻¹)	Coriander yield (t ha ⁻¹)	Chilli equivalent yield (t ha ⁻¹)
T ₁	7.45	12.67	5.33	2.00	21.7
T ₂	9.17	14.08	7.83	2.26	25.7
T ₃	10.50	16.83	10.33	2.47	30.1
T ₄	11.85	-	-	-	11.9
T ₅	9.83	13.50	8.50	2.42	26.5
LSD0.05	1.32	1.31	0.63	0.28	1.83
CV (%)	7.2	6.8	8.1	8.5	6.6

Table 4. Cost and return analysis of mixed cropping at Chinirpotol char, Saghata, Gaibandha (average of 2 years).

Treatments	Chilli Equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
T ₁	22.0	661050	115110	545940	100.6
T ₂	25.9	778200	114500	663700	173.4
T ₃	29.9	897000	114300	782700	241.7
T ₄	11.8	353250	112050	241200	0
T ₅	26.5	795000	115650	679350	122.7

Conclusion

It may be concluded that mixed cropping of 100% chilli with 30% Bt brinjal, 40% radish and 30% coriander found best combination of mixed cropping in the char areas of Gaibandha due to higher crop yield and economic performance compared to other mixed cropping combinations as well as sole chilli cultivation.

D. Relay Cropping

DETERMINATION OF OPTIMUM SOWING TIME OF JUTE AS RELAY WITH ONION UNDER ONION/JUTE-T. AMAN CROPPING PATTERN

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at Saltha upazilla of Faridpur during the Kharif I, 2020 to find out suitable sowing time of jute as relaying with onion in Faridpur. The tested variety of jute was JRO-524. The experiment was laid out in randomized complete block (RCB) design with five replications. Four treatments were considered as T₁: Jute seed sowing 6 days before of onion harvest as relay, T₂ (farmers practice): Jute seed sowing 13 days before of onion harvest as relay, T₃: Jute seed sowing 19 days before of onion harvest as relay, T₄: Sole jute. Higher fiber yield was obtained from T₁ (2.78 t ha⁻¹) followed by T₂ (2.47 t ha⁻¹) where jute seed was sown 13 days before of onion harvest as relay. The lowest fiber yield was calculated from sole jute (2.31 t ha⁻¹). The maximum stick yield was calculated from T₃ (5.02 t ha⁻¹) followed by T₄ (4.86 t ha⁻¹) and T₁ (4.70 t ha⁻¹). The highest gross margin (57800 Tk ha⁻¹) was calculated from T₁ and the lowest from T₂.

Introduction

Farmers of Faridpur generally sow sole jute seeds in late March to April in Onion-Jute-T. Aman cropping pattern due to delay of monsoon shower but harvest earlier due to early flood or heavy rainfall in the month of June-July. As a result farmers get lower yield and poor fibre quality. To overcome this problem, a few of farmers sow jute seed as relay in onion field without any tillage before 10-20 days of onion harvest on the last week of March irrespective of farmers. This type of farmer's innovation is

practiced in about 4600 ha of land where yield of jute is average 1.8 t ha⁻¹ (DAE, 2019). Early crop gets optimum growing duration and produce higher yield with minimum cost. So, farmers grow jute as relay from their experience with onion for getting higher yield and minimizing production cost. But still the sowing date of relay jute was not be validated. Therefore, the present study was undertaken to find out suitable sowing time of jute as relaying with onion in Faridpur.

Materials and Methods

The trial was conducted at Saltha upazilla of Faridpur during the *Kharif* I, 2020 to find out suitable sowing time of jute as relaying with onion in Faridpur. The tested variety of jute was JRO-524. The experiment was laid out in randomized complete block (RCB) design with five replications. Four treatments were considered as T₁: Jute seed sowing 6 days before of onion harvest as relay, T₂ (farmer's practice): Jute seed sowing 13 days before of onion harvest as relay, T₃: Jute seed sowing 19 days before of onion harvest as relay, T₄: Sole jute. Unit plot size was 400 m². Jute seed was sown according to treatment (seed was sown on 28 March 2020 for T₁, 21 March, 2020 for T₂, 15 March for T₃ and sole jute (T₄) was sown on 6 April, 2020). Fertilizers were applied as NPK@ 46-30-50 kg ha⁻¹ according to FRG 2018. Half of N and all P, K was applied as basal during final land preparation. Remaining N was top dressed at 28-30 DAS under moist soil condition. Three hand weeding and thinning were done at 11-13 DAS, 27-30 DAS and 77-94 DAS. The crop was harvested at 102 to 108 DAS. Data on plant population (m⁻²), plant height (cm), fibre yield (t ha⁻¹) and stick yield (t ha⁻¹) were recorded. The data on yield and yield attributes were analyzed statistically with the help of "R" and the means were separated by DMRT (Gomez and Gomez, 1984). The cost and return analysis were also done using market price of input and output product.

Results and Discussion

From the Table 1, it was revealed that, the maximum number of plants m⁻² was obtained from T₁ (23.00) followed by T₃ (22.00) and sole jute (22.00). This might be due to for minimum damage of seedling of jute (seed was sown before 6 days of onion harvest) during the harvesting of onion bulb through foot pressing. The lowest plant population m⁻² was calculated from T₂ might be due to maximum damage of seedling during harvesting of onion bulb. The plant height varied between 290.96 cm (T₃) to 306.06 cm (T₄). The highest fiber yield was obtained from T₁ (2.78 t ha⁻¹) might be due to highest plant population per m² followed by T₂ (2.47 t ha⁻¹) where jute seed was sown 13 days before of onion harvest as relay. The lowest fiber yield was calculated from sole jute (2.31 t ha⁻¹). The highest stick yield was calculated from T₃ (5.02 t ha⁻¹) followed by T₄ (4.86 t ha⁻¹) and T₁ (4.70 t ha⁻¹).

The cost and return analysis were presented in Table 2. The maximum gross return (Tk. 178650 ha⁻¹) was calculated from T₁ followed by T₂ (Tk. 158225 ha⁻¹). The gross return was higher in T₁ due to higher fiber yield. The maximum gross margin (Tk. 57800 ha⁻¹) was calculated from T₁ and the lowest from T₂. Variable cost was different for variation in fiber and stick yield, jute retting, processing cost, etc. Therefore, treatment T₁ is more profitable than other treatments for cultivation of jute as relay with onion.

Farmer's opinion

Farmers preferred the practice where jute seed was sown 6 days before of onion harvest as relay due to less damaged of jute seedlings and getting higher fibre yield.

Table 1. Yield and yield contributing characters of jute as affected by relay sowing with onion during *Kharif* I season of 2020 in Faridpur

Treatments	Plants m ⁻² (nos.)	Plant height (cm)	Fiber yield (t ha ⁻¹)	Stick yield (t ha ⁻¹)
T ₁	23.00 a	301.77	2.78 a	4.70 a
T ₂	21.00 b	305.79	2.47 b	4.05 b
T ₃	22.00 ab	290.96	2.37 bc	5.02 a
T ₄	22.00 ab	306.06	2.31 c	4.86 a
CV (%)	5.10	4.40	3.24	9.09

T₁: Jute seed sowing 6 days before of onion harvest as relay, T₂: Jute seed sowing 13 days before of onion harvest as relay, T₃: Jute seed sowing 19 days before of onion harvest as relay, T₄: Sole jute

Table 2. Cost and return of jute as affected by relay sowing with onion during *Kharif*I season of 2020 in Faridpur

Treatments	GR (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)
T ₁	178650	120850	57800
T ₂	158225	107374	50851
T ₃	156355	103027	53328
T ₄	152265	100419	51846

T₁: Jute seed sowing 6 days before of onion harvest as relay, T₂: Jute seed sowing 13 days before of onion harvest as relay, T₃: Jute seed sowing 19 days before of onion harvest as relay, T₄: Sole jute GR: Gross Return, TVC: Total Variable Cost, GM: Gross margin

Price of input (Tk. kg⁻¹): Urea Tk. 16.00, TSP Tk. 22.00, MoP Tk. 15.00

Price of output (Tk. kg⁻¹): Fibre: Tk. 57.50 and stick: 4.00

Conclusion

Jute seed sowing 6 days before of onion harvest as relay appeared as the best suitable practice for higher fibre yield and economic return. For further verification, the trial may be repeated in next year.

PERFORMANCE OF MUSTARD VARIETIES AS RELAY CROP WITH T. AMAN RICE

Gazi Nazmul Hasan, Rashidul Hasan Anik, M Akkas Ali, M Shahiduzzaman

Abstract

A field trial was conducted in the farmer's field at Alinagar, Char-Kumaria under Bhola sadar and at Doulatkhan upazila in Bhola district during 2020-21 cropping season to know the performance of Mustard varieties as relay crop with T. Aman. Three varieties of mustard viz. BARI Sharisha-14, BARI Sharisha-15 and BARI Sharisha-17 were tested in the farmer's field. Among the tested varieties, BARI Sharisha-17 gave the maximum seed yield (1.30 t ha⁻¹) and BARI Sharisha-15 gave the minimum one (1.19 t ha⁻¹).

Introduction

Relay cropping is essentially a special version of double cropping, where the second crop is planted into the first crop before harvest, rather than waiting until after harvest. Relay cropping leads to zero tillage which improves the structure, reduces soil compaction and helps in maintaining organic matter content of soil. The soil remains covered and thereby reduces the chances of erosion of the upper fertile layer of soil. It also reduces farm labor and consumption of fuel resulting in reduction of expenses. Mustard is one of the most important winter oil seed crop grown in Bangladesh. In Bhola more than 7000 ha areas remain under mustard cultivation (DAE-Bhola). Delay sowing of mustard due to late T. Aman harvest causes different problems like excessive rain after cultivation, severe insect attacked in hot climatic condition resulting yield loss. The short duration variety, relay cropping of Mustard with T. Aman rice will be a promising technology for reduction of turnaround time. But the successful establishment of relay mustard mostly depends on available soil moisture, which might be influenced by sowing time and also by the T. Aman rice and mustard variety. Considering that point of view, the present experiment was designed for successful mustard production as relay crop and to evaluate the performance of Mustard varieties as relay crop with T. Aman.

Materials and Method

An experiment on mustard was conducted at farmer's field at Alinagar, Char-Kumaria under Bhola sadar and at Doulatkhan upazila in Bhola district during 2020-21 cropping season. Three varieties of mustard viz. BARI Sharisha-14, BARI Sharisha-15 and BARI Sharisha-17 were tested in the farmer's field as relay crop with T. Aman rice. The experiment was set up in Randomized Complete Block Design with three dispersed replications. The unit plot was 60 m². The seeds were broadcasted after harvesting the aman rice from 25 November to 01 December, 2020 when the soil moisture was

optimum. Fertilizer @115-35-35-30-2 kg N-P-K-S-B ha⁻¹ was applied. Half of the urea and all other inorganic fertilizers were applied according to individual plot. The rest urea was top dressed after 20-25 days. First weeding was done at the time of first thinning. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity and harvested 26 February to 07 March, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data were collected on different yield and yield components and analyzed statistically.

Result and Discussion

The seed yield and yield attributes of short duration mustard varieties are presented in Table 2. The maximum days to flowering and days to maturity were found in BARI Sharisha-15 and the lowest in BARI Sharisha-17. The maximum plant height was found in BARI Sharisha-15 and minimum in BARI Sharisha-14. The maximum silique plant⁻¹ (102), 1000 seed weight (3.01 g) and seed yield (1.30 t ha⁻¹) were found in variety BARI Sharisha-17. The minimum silique plant⁻¹ (90), seeds silique⁻¹ (29), 1000-seed weight (2.68 g) and seed yield (1.19 t ha⁻¹) were found in variety BARI Sharisha-15. The maximum straw yield was found in BARI Sharisha-17 (2.48 t ha⁻¹) and the minimum in BARI Sharisha-14 (2.21 t ha⁻¹).

Table 2. Seed yield and yield attributes of Mustard varieties in Bhola during 2020-21 cropping season

Treatment	Days to flowering	Days to maturity	Plant height (cm)	Number of plants m ⁻²	Silique plant ⁻¹ (no)	Seeds Silique ⁻¹ (no)	1000 seed wt. (g)	Seed yield (t/h)	Straw yield (t/h)
BARI Sharisha-14	30	87	105.07	56	91	42	2.88	1.26	2.21
BARI Sharisha-15	33	89	119.09	57	90	29	2.68	1.19	2.31
BARI Sharisha-17	28	85	105.60	60	102	41	3.01	1.30	2.48
LSD	1.81	2.23	5.49	NS	8.9	3.11	0.15	0.08	0.49
CV (%)	3.29	1.34	2.98	8.84	5.23	3.89	2.58	3.63	6.25

Conclusion

Mustard variety BARI Sharisha-17 is a promising variety as relay in T. Aman rice field. So, BARI Sharisha-17 may be considered as relay crop for mustard production in Bhola region. However, the trial may be repeated for the next year for confirmation of the results.

PERFORMANCE OF LENTIL RELAY WITH T. AMAN RICE IN BHOLA

Gazi Nazmul Hasan, Rashidul Hasan Anik, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was carried out at Sadar, Bhola during rabi season of 2020-2021 under AEZ-18. BARI Moshur-8 was tested in two different sowing methods like relaying with T. Aman and traditional methods under farmers' field condition to select suitable and profitable planting method for Bhola region. The experiment was laid out in a RCB design with three dispersed replications. Lentil variety BARI Masur-8 produced higher seed yield (1.38 t ha⁻¹) at relay methods than traditional method (1.12 t ha⁻¹). Higher gross return (Tk.82800 ha⁻¹) and gross margin (Tk. Tk.35000 ha⁻¹) was found in relay method than traditional method. The benefit cost ratio of BARI released lentil variety in relay method and traditional method were 1.72 and 1.24 respectively.

Introduction

Lentil is the second most important pulse crop in terms of area (154,000 ha) and production (116,000 t), but ranks the highest in consumer preference and total consumption (BBS, 2002). BARI has released high yielding and disease resistant/tolerant varieties of lentil. Yield potentialities of those varieties are 2-3 times higher than national average yields. Relay cropping is essentially a special version of double cropping, where the second crop is planted into the first crop before harvest. Relay cropping leads to

zero tillage which improves the structure, reduces soil compaction and helps in maintaining organic matter content of soil. The soil remains covered and thereby reduces the chances of erosion of the upper fertile layer of soil. It also reduces farm labor and consumption of fuel. As such, the present trial was undertaken with a view to observe the performance of BARI released lentil variety in relation to yield with the sowing method (relay and line sowing) in farmer's field.

Materials and Methods

The experiment was laid out in RCB design with three dispersed replications at Sadar, Bhola under AEZ-18. BARI Moshur-8 was tested in two different sowing methods like relaying with T. Aman and traditional methods under farmers' field condition. Unit plot size was 2-5 decimal. Seed was sown in standing T. Aman rice prior to 12-16 days of harvesting. Sowing date of seed was ranged 20-25 November 2020. Fertilizers were applied @ 17.28-12.0-15.0-12.0-1.35-0.64 kg ha⁻¹ of NPKSZnB, respectively. All amounts of fertilizers were applied as basal during final land preparation. One weeding was done at 30- 37 Days After Sowing (DAS). The crop was sprayed one time by Carbendazim (Bavistin DF/Ridomil Gold/CM) @ 2 gm L⁻¹ at 15 -25 DAS to control root rot and the crop was sprayed two times by Iprodione (Rovral 50 WP) @ 2 gm L⁻¹ at 30 -35 DAS and 40 -45 DAS to control stemphylium blight. The crop was harvested during 22 Feb -15 Mar 2021. Cost benefit analysis was done. Data on yield was recorded. Data on all operations and yield and yield attributes were recorded properly and analyzed statistically.

Results and Discussion

Results of the present study revealed that all yield contributing characters like plant population, plant height and yield ha⁻¹ differed significantly due to different sowing method (Table 1). In relay condition, plant population m⁻² (32), plant height (31 cm), 1000 seed weight (20 gm) were higher than in traditional method. In relay method BARI Masur-8 gave higher seed yield (1.38 t ha⁻¹) and the lowest in traditional method (1.12 t ha⁻¹).

Cost and return analysis

Cost and return analysis showed that Total Variable Cost (TVC) was higher in traditional method due to ploughing cost (Table 2). Gross return was maximum (Tk.82800 ha⁻¹) in relay methods due to higher yield and gross margin (Tk. Tk.35000 ha⁻¹). Gross return was minimum in traditional method due to lower yield and gross margin. The benefit cost ratio of BARI released lentil variety in relay method and traditional method were 1.73 and 1.24 respectively.

Farmers' opinion: Farmers are happy to see the performance and seed yield of lentil variety BARI Masur-8. They kept seeds from their plots for the next year cultivation.

Table 1. Seed yield and yield attributes of Lentil variety in different sowing methods at Bhola during rabi season, 2020-21

Method of sowing	No. Plants m ⁻²	Plant height (cm)	1000- seed weight (g)	Seed yield (t ha ⁻¹)
Relay method	32	32	20	1.38
Traditional method	25	26	18	1.12
CV (%)	6.52	7.59	4.38	5.42
T-test	***	**	NS	**

Table 2. Cost and return analysis of Lentil variety in different sowing methods at Bhola during rabi season, 2020-21

Method of sowing	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Benefit-cost ratio
Relay method	82800	47800	35000	1.73
Traditional method	67200	54300	12900	1.24

Unit price (Tk kg⁻¹): Lentil-60

Conclusion: Relay method of lentil is new practice in Bhola. However, one more year trial is needed to make final conclusion.

PERFORMANCE OF GRASS PEA VARIETIES RELAYING WITH T. AMAN RICE IN BHOLA

Gazi Nazmul Hasan, Rashidul Hasan Anik, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at Sadar, Bhola under AEZ-18 in Rabi season 2020-21 to observe the performance of BARI developed grasspea varieties and to compare it with local variety in relay with T. Aman rice under farmers' field condition. BARI Khesari-2, BARI Khesari-3 and local variety was tested in this study. The experiment was laid out in a RCB design with three dispersed replications. BARI Khesari-3 produced higher seed yield (1.31 t ha^{-1}) followed by BARI Khesari-2 (1.19 t ha^{-1}). The lowest seed yield (0.96 t ha^{-1}) was obtained from local grasspea variety. Due to higher seed yield BARI Khesari-3 showed higher gross return (Tk.52400 ha^{-1}) gross margin (Tk.28635 ha^{-1}) and higher BCR (2.20).

Introduction

Sowing of grass pea is very critical for a successful crop production due to its limited sowing time. For this reason, in low lying area, there is a traditional and popular practice of sowing seeds of grasspea in the standing rice crop field, just before 15-20 days of rice harvest to ensure germination using residual soil moisture and to avoid tillage operations. Grass pea is a major rabi crop in Bhola district. In 2017-18 grasspea area in Bhola was 17200 ha (DAE, Bhola). Grasspea is grown under rainfed condition. Farmers in Bhola normally cultivate local variety of grasspea, which produce lower seed yield. BARI has developed five improved grasspea varieties which have performed better over local varieties in different parts of the country. So, the present study was carried out to evaluate the performance of BARI developed grass pea variety; BARI Khesari-2, BARI Khesari-3 in relay condition and to popularize the variety among the farmers.

Materials and Methods

The experiment was laid out in RCB design with three dispersed replications at Sadar, Bhola under AEZ-18 in rabi season during 2020-21. BARI developed grasspea variety: BARI Khesari-2, BARI Khesari-3 and local variety was tested under farmers' field condition. Unit plot size was 5 decimals. Seeds were sown in standing T. Aman rice field prior to 15-20 days of harvesting. Date of sowing was 20 November to 25 November 2020. Fertilizer rate was 16-12-23-7 kg ha^{-1} N-P-K-S. All fertilizers were applied just after T. Aman rice harvest. No weeding was done. Aphid infestation occurred at pod stage. It was controlled by Malathion spray once. No other disease or pest infestation was observed. Crop was harvested on 10-15 March 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on all operations and yield and yield attributes were recorded properly and analyzed statistically.

Results and Discussion

Results of the present study revealed that plant height, 1000 seed weight and seed yield varied significantly due to variety (Table 1). BARI Khesari-3 produced higher plant height (62 cm) and number of pods plant^{-1} (36) followed by BARI Khesari-2 and local khesari produce lower no of pods plant^{-1} (27). Though all yield contributing characters did not differ significantly, their cumulative effect made significant difference in seed yield. BARI Khesari-3 gave higher seed yield (1.31 t ha^{-1}). It was 36% higher in BARI Khesari-3 than local variety. BARI Khesari-2 produced higher stover biomass that is used for cattle feed both in green and dry after harvesting.

Cost and return analysis

Cost and return analysis showed that Total Variable Cost (TVC) was little bit higher in BARI Khesari-2 & 3 (Tk. 23765 ha^{-1}) due to extra labor cost for additional production (Table 2). Both gross return (Tk. 52400 ha^{-1}) and gross margin (Tk. 28635 ha^{-1}) and Benefit Cost Ratio (BCR) was also higher in BARI Khesari-3 (2.20) compared to local variety.

Pest and disease incidence: Aphid and pod borer infestation was observed which was controlled by spraying of Volume Flexi.

Farmers' opinion: Farmers preferred grasspea variety BARI Khesari-3 due to higher seed yield as well as higher biomass compared to local variety.

Table 1. Yield and yield attributes of relay Grass pea varieties at Bhola during 2020-21

Variety	No. Plants m ⁻²	Plant height (cm)	No. Pods plant ⁻¹	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
BARI Khesari-2	26	56	30	55	1.19
BARI Khesari-3	29	62	36	51	1.31
Local	30	55	27	45	0.96
LSD (0.05)	7.12	5.63	4.51	6.59	6.31
CV (%)	6.45	6.82	7.98	5.76	9.42

Table 2. Cost and return analysis of relay grass pea varieties at Bhola during 2020-21

Variety	Seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Benefit- cost ratio
BARI Khesari-2	1.19	47600	23765	23835	2.00
BARI Khesari-3	1.31	52400	23765	28635	2.20
Local	0.96	38400	21730	16670	1.76

Note: Grass pea @ 40 Tk/kg

Conclusion

Grass pea is a traditional rabi crop in Bhola and most of the farmers grow local variety. So, there is a good scope to disseminate BARI Khesari-3 through pilot production program.

PERFORMANCE OF GRASS PEA VARIETIES AS RELAY WITH T. AMAN RICE IN LOW LYING AREAS

K U Ahammad, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was carried out at Tularampur MLT site, Narail during 2020-21. Five treatments viz. T₁= BARI Khesari-1, T₂= BARI Khesari-2, T₃= BARI Khesari-3, T₄= BARI Khesari-5 and T₅= Local were used in the experiment. The experiment was laid out in RCB with 3 replications. Yield and yield contributing characters of of khesari were influenced significantly due to relay cropping with T. aman. The maximum yield (1.75 t ha⁻¹) was obtained from variety BARI Khesari-5 variety followed by BARI Khesari-3 (1.56 t ha⁻¹), Local (1.53 t ha⁻¹) and the lowest from BARI Khesari-2 (1.32 t ha⁻¹). The maximum gross margin (Tk. 51250 ha⁻¹) was found from BARI Khesari-5 followed by BARI Khesari-3. The minimum gross margin (Tk. 34050 ha⁻¹) was found from BARI Khesari-2.

Introduction

Grass pea (*Lathyrus sativus* L.) is one of the hardiest pulses suitable for relay cropping with paddy rice (Sharma RN *et al* 2000). It has potential among grain legumes for its tolerance to harsh conditions and its adaptability to unfavorable environments with little disease or insect problems. It requires no major input costs and is easy to cultivate under relay cropping system with paddy rice and also a cheap source of protein and fodder. In addition to nutritional benefits, grass pea has an important role for improving soil fertility by adding around 67 kg ha⁻¹ of nitrogen through biological nitrogen fixation in a single season, thereby conferring yield and protein benefits for the subsequent non-legume crop (Wang *Fetal.*, 2000). Grass pea is grown as relay crop with rice in other countries like Nepal, India etc. In Bangladesh, it is also grown as relay cropping in some pocket areas. Over long period of time, farmers of Narail have

been growing local variety of grass pea in their low-lying areas. Introduction of BARI developed varieties may increase their yield and income. Keeping this view in mind, the experiment has been undertaken to evaluate the performance of BARI grasspea varieties for increasing yield and farmers' income.

Materials and Methods

An experiment was carried out at Tularampur MLT site, Narail during 2020-21. Five treatments viz. T₁= BARI Khesari-1, T₂= BARI Khesari-2, T₃= BARI Khesari-3, T₄= BARI Khesari-5 and T₅= Local were used. The experiment was laid out in RCB with 3 dispersed replications. The plot size of the experiment was 4m × 5m. Seeds of khesari were broadcast (before 15 days of T. aman harvesting) on 5-7 November 2020. Fertilizers were used @ 20-20-15-10kg N-P-K-S kg ha⁻¹ (FRG, 2012). All fertilizers were applied after harvesting of T. aman. Weeding, irrigation and other intercultural operations were done properly. Khesari was harvested during 05-08 March 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on yield and yield contributing characters were recorded and analyzed statistically.

Results and Discussion

Yield and yield contributing characters of khesari were influenced significantly due to relay cropping with transplant aman rice (Table 1). Maximum plant height and thousand grain weights were found in BARI Khesari-5. The maximum yield (1.75 t ha⁻¹) was obtained from BARI Khesari-5 followed by BARI Khesari-3 (1.56 t ha⁻¹), Local (1.53 t ha⁻¹) and the lowest was from BARI Khesari-2 (1.32 t ha⁻¹). The highest gross margin (Tk. 51250 ha⁻¹) followed by BARI Khesari-3. The lowest gross margin (34050 Tk.ha⁻¹) was found from BARI Khesari-2.

Table 1. Yield and yield contributing character of grasspea as relay cropping with T. aman during 2020-21

Treatment	Plant height (cm)	Plant population/m ²	TGW (g)	Yield (kg ha ⁻¹)	Straw yield (t ha ⁻¹)
BARI Khesari-1	63 bc	94b	47.73 c	1.34 c	1.63 c
BARI Khesari-2	64 b	95b	48.25 c	1.32 c	1.74 bc
BARI Khesari-3	61c	97a	51.43b	1.56b	1.81b
BARI Khesari-5	68a	98a	52.13a	1.75a	2.04a
Local	65 b	92 c	49.15 bc	1.53b	1.79 b
CV (%)	3.71	8.68	2.54	6.33	4.29
LSD (0.05)	0.458	3.748	0.753	0.071	0.072

Table 2. Cost and return analysis of grasspea as relay cropping with T. aman during 2020-21

Treatment	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Khesari-1	1.34	53600	18750	34850
BARI Khesari-2	1.32	52800	18750	34050
BARI Khesari-3	1.56	62400	18750	43650
BARI Khesari-5	1.75	70000	18750	51250
Local	1.53	61200	18750	42450

Sale price (Tk./kg): Grass pea=40

Conclusion

Farmers are satisfied with the seed yield of BARI Khesari-5 and BARI Khesari-3 compared to local variety. So, the experiment may be repeated for the next year for final conclusion.

RELAY CROPPING OF KENAF WITH MAIZE IN KISHOREGANJ

M. Mohiuddin, M. N Sarker, M Akkas Ali, M Shahiduzzaman

Abstract

A field study was conducted at MLT site Karimganj under OFRD, BARI, Kishoreganj during 2020-21 to observe the performance of BJRI Kenaf-2 in relay with BARI hybrid Maize-9 under farmers field condition. The experiment was laid out in a RCBD with three replications with three treatments i. e; a. Single row kenaf with maize, b. Double row kenaf with maize and c. broadcast kenaf with maize. Among the treatments, higher fibre yield was found from broadcast kenaf with maize (2.50 t ha^{-1}) followed by single row kenaf with maize (1.61 t ha^{-1}) which is statistically at par to the double row kenaf with maize (1.50 t ha^{-1}). The highest gross return ($150200 \text{ Tk ha}^{-1}$), gross margin ($107944 \text{ Tk ha}^{-1}$) and BCR (2.79) was calculated from broadcast kenaf with maize followed by single row kenaf with maize.

Introduction

Total area of T. Aman rice in Kishoreganj district is about 81250 hectares. After harvest of late sowing of T. Aman rice, farmers of that area produce maize in their field at December first week to second week. After maize cultivation land remain fallow upto next T. Aman rice. Two crops areas in Kishoreganj is 24%. If kenaf is inserted to relay with maize just one month before of maize harvest, farmers can get easily a crop without facing any difficulties of producing next T. Aman rice. Kenaf can give yield even in the marginal, fallow and char lands with less care. Farmer can easily get kenaf as an additional crop to relay with maize after harvesting T. Aman rice from the same land. As a result, at least 15-20 percent of the two crop based cultivable land in Kishoreganj area can be transformed from two crops into three crops land.

The use of relaycropping system of one method of increasing crop productivity and intensity of crops which indicated that land equivalent ratio was the highest under relay cropping system compared with sole cropping. Crop productivity in relay cropping system depends on many factors including variety used, plant density, cropping season and land and crop management. Therefore, this experiment has been taken to know the suitable relay cropping combination and increase total productivity and economic return of the farmers.

Objectives:

1. To find out the suitable inter relay cropping combination and
2. To increase productivity and economic return of the farmers

Materials and Methods

The experiment was carried out in farmer's field at MLT site Karimganj, Kishoreganj 2020-21 to observe the performance of relay kenaf with maize after T. Aman harvest. Three treatments were included in this study viz; i) Single row kenaf with maize ii) Double row kenaf with maize and iii) Broadcast kenaf with maize. The design was RCBD with three dispersed replications. The variety of maize and kenaf were BARI hybrid maize-9 and BJRI kenaf-2, respectively. Seeds of maize were sown on 23 November, 2020. The unit plot size was $8 \times 5 \text{ m}^2$. Plant to plant 25 cm and row to row 60 cm distance was followed for maize. In case of single and double row of kenaf continuous sowing method was followed. Kenaf seed was sown on 03 March, 2021 in standing Maize prior to 30-35 days of harvesting. Fertilizer dose of maize and kenaf are 265-50-110-40-5-1.5 and 61-5-20-4-0-0 Kg N-P-K-S-Zn-B ha^{-1} respectively. In case of maize, all of P, K, S, Zn, B fertilizers and one third of N were applied as basal dose after final land preparation. The remaining N was applied in two equal installments. The first installment was applied 30-35 days after seed germination (8-10 leaves stage) and second installment was applied 60-65 days after seed germination. In case of Kenaf, entire amount of P, K, S and half of N fertilizers were applied as basal after final land preparation. The remaining N was applied 45 days after seed sowing. All intercultural operations were done as and when necessary. Maize was partially infested by cut worm and fall army worm which was controlled by sex pheromone of fall army worm and sprayed one time of carate @ 2 g L^{-1} water and give one flash flood and sprayed also virtako @ 2 g L^{-1} water at 7 days interval for 2 times. The harvesting of maize and kenaf was done on 08 April and

30 June, 2021 respectively. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on yield and yield contributing characters were recorded and analyzed by Statistix 10 for windows 1998. Analytical software. Tallahassee, SLA, USA.

Results and Discussion

The results revealed that plant population, plant height, base diameter of kenaf plant, fibre yield and stick yield was influenced by relay cropping which were statistically significant (Table 1). The highest plant population was found in broadcast kenaf with maize (47.23 no.) and lowest from T₁ treatment (24.13 no.). The highest plant height was recorded from T₁ treatment (3.05 m), it's due to minimum crop competition and lowest plant height from T₃ (2.83 m). The maximum base diameter of plant was found from T₁ (21.51 mm) and minimum from T₃ (17.23 mm). The maximum fibre yield was found from T₃ treatment (2.50 t ha⁻¹) and lowest from T₂ (1.50 t ha⁻¹) which is statistically similar with T₁ (1.61 t ha⁻¹). The highest stick yield was found in T₃ (5.04 t ha⁻¹) and lowest from T₂ (3.11 t ha⁻¹) which was statistically at par with T₁ (3.23 t ha⁻¹). The study revealed that the highest gross return was estimated at Tk. 150200 ha⁻¹ from T₃ treatment and lowest from T₂ (Tk. 90550 ha⁻¹).

Table 1. Yield and yield contributing characters of relay kenaf with maize during 2020-21

Treatment	Plants /m ² (No.)	Plant ht. (m)	Base diameter (mm)	Stick thickness (mm)	Fibre yield (t ha ⁻¹)	Stick yield (t ha ⁻¹)
T ₁	24.13c	3.05a	21.51a	18.71	1.61b	3.23b
T ₂	33.60b	2.95ab	18.35b	16.24	1.50b	3.11b
T ₃	47.23a	2.83b	17.23b	15.83	2.50a	5.04a
Mean	34.82	3.01	19.05	17.04	1.90	3.81
CV(%)	4.63	2.78	5.62	7.66	8.58	8.63

T₁ = Single row Kenaf with Maize, T₂ = Double row Kenaf with Maize, T₃ = Broadcast Kenaf with Maize

Table 2. Cost and return analysis of relay kenaf with maize cultivation in Kishoreganj

Treatment	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
T ₁	96650	42256	54394	1.79
T ₂	90550	42256	48294	1.68
T ₃	150200	42256	107944	2.79

Price of fibre=50tk/kg, Stick=5tk/kg

Conclusion

Maize with broadcast kenaf was found as a profitable practice. Therefore, they can earn extra income easily without hampering the main crop (Maize) and could help to increase farmers income.

EFFECTS OF CROP ESTABLISHMENT METHOD ON YIELD AND YIELD ATTRIBUTES OF DIFFERENT NEW VARIETIES OF LENTIL

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Abstract

On-farm field experiemnt was conducted at Multi Location Sites of OFRD, BARI, Kolabagan, Atghoria, Pabna during rabi season 2020-21 to evaluate the performance of different varieties of lentil under different crop establishment method in low land rice growing areas. The experiment was laid in a RCB design with two sowing methods (relay sowing and conventional method) in factor A and three varieties (BARI Masur-6, BARI Masur-7 and BARI Masur-8) in factor B. Seeds of all varieties of lentil were sown on 9 November for relay and 22 November for conventional method, and harvested at a time on 20-22 March, 2021. The highest seed yield was obtained from BARI Masur-8 under conventional method, however, the lowest seed yield was obtained from BARI Masur-6 and BARI Masur-7 under relay sowing method. The straw yield was also higher from BARI Masur-8 under conventional method and lower in BARI Masur-6 under relay method. From the economic analysis it was found that BARI

Masur-8 had the highest gross return (Tk. 98538 ha⁻¹), gross margin (Tk. 60222 ha⁻¹) and the highest BCR (2.6) under relay sowing method.

Introduction

Lentil is the major food legumes and it ranks first in respect of consumers' preference in South Asia. It is commonly grown under rainfed condition during winter on soils that conserve soil moisture after harvest of transplanted lowland monsoon rice in low land rice growing areas. The productivity of lentil suffers from different factors such as the lack of better crop establishment method and suitable varieties. PRC released several new lentil varieties (BARI Masur-7, BARI Masur-8 and BARI Masur-9) but yet to be determining the optimum cultivation method in low land rice growing area of farmer's field. Broadcast seeding into traditional cultivated land/ conventional cultivated land (2-3 times tillage and 1-time laddering) is practiced in Bangladesh. However, the method is labour and input intensive. Relay cropping lentil with T. Aman rice is a promising technology that successfully practiced in the areas where sowing of lentil at optimum time is quite impossible due to cultivation of long duration T. Aman rice and remain moist soil at the optimum sowing time. In a method of relay cropping lentil with T. Aman rice, lentil is sown in rice field 10-15 days before harvesting of monsoon rice crop. Therefore, the present experiment has been undertaken to study the effect of crop establishment method on yield and yield attributes of different varieties of lentil.

Materials and Methods

On-farm field experiemnt was conducted at Multi Location Sites of OFRD, BARI, Kolabagan, Atghoria, Pabna during *rabi* season 2020-21. The soils of the experimental areas belong to the High Gangis River Flood Plain (AEZ 11). The soils of the experimental plots were clay loam in texture. The experiment was laid in a RCB design with two sowing methods (relay sowing and conventional method) in factor A and three varieties (BARI Masur-6, BARI Masur-7 and BARI Masur-8) in factor B. The unit plot size was 300 m² (20 m X 15 m). The lands were fertilized with 20-20-20 NPK kg N-P-K ha⁻¹, respectively and all the fertilizers were applied at final land preparation. Seeds of all varieties of lentil were sown on 9 November for relay and 22 November for conventional method. Rovral(@ 2 g L⁻¹) were used one time for controlling diseases at 65 DAS. All crops were harvested at a time on 20-22 March, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. The R-software package was used for all statistical analyses. The mean differences between treatments were separated by the least significant difference (LSD) at P≤ 0.05 for the measured variables.

Results and Discussion

Effect of sowing method: The plant height, seed and straw seed yield of lentil was significantly influenced by different sowing methods (Table 1). The highest plant height (29 cm) was recorded at conventional method while the lowest plant height (28.3 cm) at relay sowing. The highest seed yield (1346 kg ha⁻¹) and straw yield (996 kg ha⁻¹) was found in conventional method, but the lowest seed yield (1246 kg ha⁻¹) and straw yield (843 kg ha⁻¹) in relay sowing method.

Effect of different varieties: Different varieties of lentil had significantly influenced on plant height, 1000- seed weight, seed and straw yield of lentil (Table 2). The highest plant height (30 cm) was recorded from BARI Masur-8 while the lowest plant height (27.8 cm) from BARI Masur-6. Thousand seed weight was also higher in BARI Masur-8 (17.9 g) while the lowest from BARI Masur-7 (17.4 g). The highest seed yield (1320 kg ha⁻¹) and straw yield (952 kg ha⁻¹) were found from BARI Masur-8, but the lowest seed yield (1283 kg ha⁻¹) and straw yield (888 kg ha⁻¹) were recorded from BARI Masur-6.

Interaction effects of sowing method and varieties: Interaction of sowing method and varieties also influenced on plant height, 1000- seed weight, seed and straw yield of lentil (Table 3). The plant height was higher of BARI Masur-8 under conventional method (30.9 cm). However, the lowest plant height was recorded from BARI Masur-6 under relay sowing method (27.6 cm). The highest thousand seed weight was also recorded from BARI Masur-8 (18.1 g) under conventional method while the lowest in

BARI Masur-7 under conventional method (17.3 g). Finally, the highest seed yield (1350-1354 kg ha⁻¹) was obtained from BARI Masur-8 and BARI Masur-7 under conventional method, however, the lowest seed yield (1220-1231 kg ha⁻¹) BARI Masur-6 and BARI Masur-7 under relay sowing method. The straw yield (1055 kg ha⁻¹) were higher from BARI Masur-8 under conventional method and lower in BARI Masur-6 under relay method.

Economic analysis

Lentil var. BARI Masur-8 under conventional method had the maximum gross return (Tk. 98538 ha⁻¹) but the minimum gross return (Tk. 87740 ha⁻¹) was obtained from BARI Masur-7 sowing under relay method (Table 4). The highest gross margin (Tk. 60222 ha⁻¹) was obtained from BARI Masur-8 sowing on relay method while the lowest gross margin (Tk. 55865 ha⁻¹) from BARI Masur-7 sowing under relay method. The highest BCR (2.6) from BARI Masur-8 sowing under relay method, but the lowest BCR (2.0) was obtained from BARI Masur-6 and BARI Masur-7 sowing under conventional method.

Farmer's Opinion

Farmers expressed their satisfaction to see higher economic performance of lentil var. BARI Masur-8 under relay sowing method over BARI Masur-6 and 7 and conventional method. They preferred the BARI Masur-8 and relay sowing method because of high profit.

Table 1. Effects of different sowing method on yield and yield attributes of lentil during rabi season of 2020-21 at MLTs, Atghoria, Pabna.

Sowing time	Plants /m ²	Plant height (cm) at 60 DAS	Pods Plant ⁻¹	Seeds Pod ⁻¹	TSW (g)	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
Relay method	54	28.3	70.0	2.1	17.6	1246	843
Conventional method	60	29.4	71.0	2.1	17.7	1346	996
LSD ¹ _(0.05)	ns	0.38**	ns	ns	ns	11.7**	20.1**
CV (%)	8.3	7.4	6.4	9.7	3.7	7.4	9.6

¹the least significant difference (LSD) at the P≤0.05, ns - not significant; CV – coefficient of variation

Table 2. Effect of different varieties on yield and yield attributes of lentil during rabi season of 2020-21 at MLTs, Atghoria, Pabna.

Varieties	Plants /m ²	Plant height (cm) at 60 DAS	Pods Plant ⁻¹	Seeds Pod ⁻¹	TSW (g)	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
BARI Masur-6	55	27.8	71	2.0	17.8	1283	888
BARI Masur-7	55	28.8	71	2.1	17.4	1285	918
BARI Masur-8	62	30.0	69	2.1	17.9	1320	952
LSD ¹ _(0.05)	ns	0.47**	ns	ns	0.2**	14.3**	25.0**
CV (%)	9.3	7.8	6.4	4.7	3.0	8.9	9.1

Table 3. Interaction effect of different varieties and sowing method on yield and yield contributing characters of lentil during rabi season of 2020-21 at MLTs, Atghoria, Pabna

Sowing time × varieties	Plants /m ²	Plant height (cm) at 60 DAS	Pods Plant ⁻¹	Seeds Pod ⁻¹	TSW (g)	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
Relay method × BARI Masur-6	55	27.6	68	2.0	17.7	1231	838
Relay method × BARI Masur-7	53	28.3	70	2.1	17.5	1220	842
Relay method × BARI Masur-8	55	29.0	72	2.1	17.7	1285	848
Conventional method × BARI Masur-6	55	28.1	75	2.0	17.8	1335	938
Conventional method × BARI Masur-7	57	29.3	73	2.1	17.3	1350	995
Conventional method × BARI Masur-8	69	30.9	67	2.1	18.1	1354	1055
LSD ¹ _(0.05)	ns	0.66**	ns	ns	0.3*	20.2**	35.0**
CV (%)	9.3	7.8	6.4	4.7	3.0	8.9	9.1

Table 4. Cost and return analysis of different varieties of lentil under various sowing method on yield and yield contributing characters of lentil during rabi season of 2021-21 at MLTs, Atghoria, Pabna.

Sowing method x varieties	Return from		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
	Grain (Tk. ha ⁻¹)	Straw (Tk. ha ⁻¹)				
Relay method × BARI Masur-6	80037	8383	88420	31875	56545	2.5
Relay method × BARI Masur-7	79322	8417	87740	31875	55865	2.5
Relay method × BARI Masur-8	83547	8550	92097	31875	60222	2.6
Conventional method × BARI Masur-6	86753	9383	96137	39375	56762	2.0
Conventional method × BARI Masur-7	87750	9950	97700	39375	58325	2.0
Conventional method × BARI Masur-8	87988	10550	98538	39375	59163	2.1
LSD _(0.05)	1317**	369**	1260**	ns	-	0.07**
CV (%)	8.9	7.2	7.7	6.4	-	8.2

Price: Urea = 18 Tk. kg⁻¹, TSP = 24 Tk. kg⁻¹, MOP = 15 Tk. kg⁻¹, Boron = 460 Tk. kg⁻¹, power tiller (3 pass) = 6750 Tk. ha⁻¹, Insecticide and fungicide = 2250 Tk. kg⁻¹, Harvesting = 11250 Tk. kg⁻¹, Labour: 500 Tk. Day⁻¹ 8 hours⁻¹, Lentil seed = 100 Tk. kg⁻¹, Lentil grain = 65 Tk. kg⁻¹, Lentil straw = 10 Tk. kg⁻¹,

Conclusion

It can be concluded that lentil var. BARI Masur-8 under relay method performed well in terms of improving yield and economic benefit. However, it should be continued for the next season for further confirmation.

E. Component Technologies

PERFORMANCE OF TOMATO HYBRIDS IN HIGH BARIND TRACT

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Abstract

Six tomato hybrids were evaluated in the farmer's field of FSRD site, Basantapur, Rajshahi during early Rabi 2019-20 and 2020-21 to find out the yield potentiality and adaptability of tomato hybrids in High Barind environments. The tomato hybrids were namely BARI Hybrid Tomato-8, BARI Hybrid Tomato-10, BARI Hybrid Tomato-11, VL-642, Bipul plus and Maharaja. The BARI released tomato hybrids took shortest time for flowering and fruit maturity. Among the six hybrids significantly the highest yield was found from BARI Hybrid Tomato-11 in both the years (48.72 t ha⁻¹ in Yr1 and 91.63 t ha⁻¹ in Yr2) followed by Bipul plus (43.74 and 84.95 t ha⁻¹ in Yr1 and Yr2, respectively). The BARI Hybrid Tomato-10 (45.30 t ha⁻¹) gave similar fruit yield to BARI Hybrid Tomato-11 in Yr1 but later year performed inferior. The hybrids VL-642 and BARI Hybrid Tomato-8 produced significantly lower yield than BARI Hybrid Tomato-11 but they were identical each other regarding fruit yield in both the years. On the other hand, Maharaja contributed the lowest yield (22.07 and 66.07 t ha⁻¹ in Yr1 and Yr2, respectively). In later year, no. of total fruit harvest was eight while it was six in 1st year. In respect of economic analysis, the maximum gross return (Tk. 941162 and 1514567 ha⁻¹ in Yr1 and Yr2, respectively), gross margin (Tk. 795937 and 1313092 ha⁻¹, in Yr1 and Yr2, respectively) and BCR (6.48 and 7.5 in Yr1 and Yr2, respectively) were obtained from BARI Hybrid Tomato-11. The lowest gross, Gross margin and BCR were found from Maharaja in both the years.

Introduction

Tomato is a popular vegetable in Bangladesh especially in the urban areas. Tomato is a cash crop and growing commercially in High Barind Region. Different industries are using locally produced tomatoes for pulp or other product preparation for processing purposes. The farmers of High Barind Tract extensively cultivate various exotic hybrid tomato varieties at early rabi season (September) after the harvest of T. aus rice. Though a large number of exotic tomato varieties are available in the country for

cultivation but most of them are not well known as high yielding varieties to the tomato growers. Moreover, some exotic tomato varieties enter into vegetable seed market every year by the seed importers without any performance test in different agroclimatic zones of Bangladesh (Islam, 1999). BARI released some summer tomato hybrids have potentiality to grow in Barind condition. In these circumstances, the present study was undertaken to evaluate the productivity and profitability of BARI hybrid tomato varieties along with exotic varieties under High Barind environment.

Materials and Methods

The field trial was carried out at the FSRD site, Basantapur, Godagari, Rajshahi during early rabi 2019-20 and 2020-21 in the farmers' field of High Barind Tract. The experiment was laid out in replicated complete block design having three replications. The unit plot size was 6 m x 7 m. The seed was sown in seed bed on mid-August in both the years. Around one-month old seedlings were transplanted in the main plots on mid-September with spacing 60 cm row to row distance and 50 cm plant to plant distance. The experimental plot was fertilized with 250-90-125-30-1 kg ha⁻¹ N-P-K-S-B, respectively in the form of urea, TSP, MoP, gypsum and boric acid, respectively and 10-ton cowdung ha⁻¹ (FRG, 2018). The TSP, boric acid and cowdung were applied during final land preparation as basal. The MoP and urea fertilizers were used in two installments after 25 and 40 days after planting, respectively. The tomato hybrids tested in the trial presented in Table 1 with their source of collection. Irrigation was applied three to five times during the crop-growing period. Insecticide (Admire @ 0.5 ml/L water) and fungicide (Ridomil Gold @ 2g/L water) were sprayed four times for controlling insect and diseases of tomato plant. Weeding and other intercultural operations were done as per need for better growth and development of the crop plant. The tomato was harvested ranging from late November to end of January. At fruiting stage, a participatory varietal selection (PVS) was done by 20 tomato farmers in presence of BARI, DAE and BADC officials on early January to choose tomato hybrid for Barind condition. Total 20 farmers was divided into 4 groups and one scientist was facilitated in each group. So that farmer can easily understand the evaluating characters and scoring system. The scoring range was 1-10 and the best one received 10 points. Yield was recorded plot wise and then converted into ton per hectare. Recorded data were analyzed statistically and means were separated open-source software R (R Core Team, 2020) following Least Significant Different Test (Gomez and Gomez, 1984).

Table 1. Tomato varieties and their source of collection tested in HBT

Sl. no.	Tomato variety	Source of collection
1.	BARI Hybrid Tomato-8 (BHT-8)	HRC, BARI
2.	BARI Hybrid Tomato-10 (BHT-10)	HRC, BARI
3.	BARI Tomato-11 (BHT-11)	HRC, BARI
4.	VL-642	3S Agro-service Ltd
5.	Bipul Plus	Syngenta, Bangladesh
6.	Maharaja	United Seeds Ltd

Results and Discussion

Yield and yield components of hybrid tomato

Yield and yield component of tomato responded significantly due to different tomato hybrids (Table 2). Days to flowering and maturity were considered for choosing suitable variety, because these varied widely in different varieties. In second year, no. of harvest was more than 1st year. Among the tested tomatoes, BARI released tomato hybrids (BHT) namely BHT-8, BHT-10 and BHT-11 took least days for their flowering (27-35 days) and fruit maturity (39-46 days). Bipul plus (48.3 and 47.3 days in Yr1 and Yr2, respectively) took the maximum days for its maturity that was identical with Maharaja (47.6 and 49.3 days Yr1 and Yr2, respectively). Unit fruit weight was highest in BHT-11 (48-77 g) followed by other two BARI hybrids and ranging from 42-72 g. Other commercial hybrids showed similar unit fruit weight and ranging from 42-70 g. However, unit fruit weight was higher in 2nd year than 1st year. BARI hybrids produced higher no. of fruits plant⁻¹ (44-50) compared to exotic hybrids (23-41). The BHT-11 gave the highest no. of fruit per plant in both the years. Among the six hybrids significantly the maximum fruit yield was found in BHT-11 (48.72 and 91.63 t ha⁻¹ in Yr1 and Yr2, respectively)

which was statistically identical to BHT-10 in Yr1 (45.30 t ha⁻¹) and Bipul plus in both the years (43.74 and 84.95 t ha⁻¹ in Yr1 and Yr2, respectively). On the other hand, BHT-8 and VL-642 produced similar fruit yield. The Maharaja contributed the poorest yield (22.07 and 66.07 t ha⁻¹ in Yr1 and Yr2, respectively). However, the fruit yield was higher in later year than 1st year is due to higher no. of fruit per plant, fruit size and more no. of harvest. In 2nd year, the no. of harvest was 8 while it was 6 in 1st year.

Cost and return analysis

Gross return and gross margin were much higher in 2nd year than those of 1st year due to higher fruit yield and also market price (Table 5). In respect of economic analysis, the maximum gross return (Tk. 941162 and 1514567 ha⁻¹ in Yr1 and Yr2, respectively), gross margin (Tk. 795937 and 1313092 ha⁻¹ in Yr1 and Yr2, respectively) and BCR (6.48 and 7.51 in Yr1 and Yr2, respectively) were obtained from BHT-11 in both the years. The lowest gross return (Tk. 368874 and 875262 ha⁻¹ in Yr1 and Yr2, respectively), gross margin (Tk. 223649 and 673787 ha⁻¹ in Yr1 and Yr2, respectively) and BCR (2.54 and 4.34 in Yr1 and Yr2, respectively) were recorded in Maharaja (Table 5). However gross return in each harvest in both the years are shown in Table 3 and 4. The BHT-11 produced more in early period of harvest (1st to 5th harvest) while market price of tomato was higher and that contributed to higher gross margin.

Table 2. Fruit yield and yield components of Tomato hybrid in High Barind Tract

Hybrid	DF	DM	PH (cm)	Cluster Plant ⁻¹	Fruit Plant ⁻¹	Unit Fruit wt. (g)	Fruit yield (t ha ⁻¹)
2019-20							
BHT-8	27.6d	40.0b	108.0ab	15.0ab	45.8a	45.03ab	33.32b
BHT-10	31.0c	40.0b	113.7a	13.2abc	43.9a	42.27b	45.30a
BHT-11	30.0c	39.0b	109.6ab	16.4a	50.5a	46.30ab	48.72a
VL-642	33.0b	47.6a	101.6b	8.40d	28.6bc	48.33a	26.65b
Bipul plus	33.6b	48.3a	107.0ab	8.2d	32.3b	42.60b	43.74a
Maharaja	36.0a	47.6a	100.5b	10.9bcd	23.5c	43.00b	22.07c
LSD (0.05)	1.62	1.31	9.34	5.00	7.23	5.20	5.21
CV (%)	2.79	1.65	4.81	22.89	10.61	6.41	7.73
2020-21							
BHT-8	30.7d	42.00d	155.57bc	6.97a	39.33b	70.30b	73.30bc
BHT-10	35.3b	46.33bc	147.13c	7.10a	40.33b	72.30ab	73.85b
BHT-11	32.7c	42.33d	153.43bc	6.83a	47.00a	77.40a	91.63a
VL-642	34.0bc	45.33c	166.03a	6.36ab	41.00b	69.70bc	76.07b
Bipul plus	37.0a	47.33b	156.03abc	6.53ab	40.33b	69.63bc	84.95a
Maharaja	37.0a	49.33a	157.86ab	3.76b	33.33a	64.53c	66.07c
LSD (0.05)	1.55	1.39	10.01	0.94	5.49	5.61	7.42
CV (%)	5.46	5.68	6.53	7.84	7.50	7.37	7.25

Table 3. Gross return achieved from different tomato hybrids tested in HBT during 2019-20

Tomato hybrids	1st harvest (24 Nov. 19)		2nd harvest (4 Dec. 19)		3rd harvest (11 Dec. 19)		4th harvest (22 Dec. 19)		5th harvest (01 Jan. 20)		6th harvest (15 Jan. 20)	
	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹
BHT-8	3.33	112387	8.75	236250	5.41	101437	5.00	62500	8.33	124950	2.50	12500
BHT-10	5.00	158750	11.25	303750	5.00	93750	8.75	109375	12.8	121800	2.50	12500
BHT-11	4.16	140400	12.50	337500	8.33	156187	7.91	98875	12.91	193650	2.91	14550
VL-642	2.50	84375	4.58	123660	4.16	78000	3.33	41625	7.08	106200	5.00	25000
Bipul plus	3.75	126562	7.5	202500	7.08	132750	8.33	104125	10.83	162450	6.25	31250
Maharaja	1.67	56362	3.75	101250	3.33	62437	3.75	46875	5.41	811500	4.16	20800

N.B. Local market price of tomato was 33.75 Tk./kg at 1st harvest, 27.0 Tk./kg at 2nd harvest, 18.75 Tk./kg at 3rd harvest, 12.50 Tk./kg at 4th harvest, 15.00 Tk./kg at 5th harvest and 5.00 Tk./kg at 6th harvest

Table 4. Gross return achieved from different tomato hybrids tested in HBT during 2020-21

Tomato hybrids	1st harvest 8 Dec 2020		2nd harvest 15 Dec 2020		3rd harvest 23 Dec 2020		4th harvest 31 Dec 2020		5th harvest 5 Jan 2021		6th harvest 11 Jan 2021		7th harvest 20 Jan 2021		8th harvest 30 Jan 2021	
	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹	t ha ⁻¹	Tk. ha ⁻¹
BHT-8	5.55	205350	6.66	199800	9.44	236000	11.66	221540	16.11	225540	12.22	109980	7.22	43320	4.44	16650
BHT-10	5.00	185000	7.22	216600	8.88	222000	11.11	211090	14.44	202160	13.88	124920	7.77	46620	5.55	20812
BHT-11	5.00	185000	7.77	233100	11.11	277750	15.55	295450	19.44	272160	15.55	139950	8.88	79920	8.33	31237
VL-642	2.77	102490	5.55	166500	7.22	180500	10.55	200450	14.44	202160	16.66	149940	13.88	124920	13.88	52050
Bipul plus	2.22	82140	4.44	133200	5.55	138750	7.77	147630	11.11	155540	16.66	149940	16.11	144990	12.22	45825
Maharaja	1.66	61420	3.88	116400	5.55	138750	7.22	137180	10.00	140000	13.88	124920	12.77	114930	11.11	41662

N.B. Local market price of tomato was 37.0Tk./kg at 1st harvest, 30.0 Tk./kg at 2nd harvest, 25.0 Tk./kg at 3rd harvest, 19.0 Tk./kg at 4th harvest, 14.0 Tk./kg at 5th harvest, 9.00 Tk./kg at 6th harvest, 6.00 Tk./kg at 7th harvest and 3.75 Tk./kg at 8th harvest

Table 5. Cost and return analysis of tomato at FSRD site, Basantapur, Rajshahi

Treatments	Fruit yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
2019-20					
BHT-8	33.32	650024	145225	504799	4.48
BHT-10	45.30	799925	145225	654700	5.51
BHT-11	48.72	941162	145225	795937	6.48
VL-642	26.65	458860	145225	313635	3.16
Bipul plus	43.74	759637	145225	614412	5.23
Maharaja	22.07	368874	145225	223649	2.54
2020-21					
BHT-8	73.3	1255210	201475	1053735	6.23
BHT-10	73.85	1229208	201475	1027733	6.10
BHT-11	91.63	1514567	201475	1313092	7.51
VL-642	84.95	1179010	201475	977535	5.85
Bipul plus	76.08	998015	201475	796540	4.95
Maharaja	66.07	875262	201475	673787	4.34

Table 6. Participatory varietal selection by tomato famers at FSRD site, Basantapur, Rajshahi

Hybrid	Clus pl ¹	Fruit Cl ¹	Hardness	Shape	Earliness	No. of picking	Yield	Overall Evaluation
2019-20								
BHT-8	6.25b	7.25b	6.75c	7.25c	8.75ab	6.50c	6.75c	6.75c
BHT-10	7.50ab	7.75ab	7.75bc	7.75bc	9.50a	7.25c	7.75bc	8.00b
BHT-11	8.75a	8.75ab	8.75ab	9.25a	9.25a	8.75b	9.25a	9.75a
VL-642	8.50a	8.00ab	9.00ab	8.75ab	7.50bc	9.50ab	8.75ab	8.50b
Bipul plus	8.25ab	9.25a	9.50a	9.50a	7.25c	10.00a	9.50a	9.50a
Maharaja	7.75ab	7.50b	7.75bc	8.75ab	7.00c	8.75b	8.00b	8.00b
LSD (0.05)	2.02	1.71	1.58	1.14	1.28	0.85	1.17	0.78
CV (%)	17.12	14.11	12.71	8.88	10.33	6.68	9.29	6.14
2020-21								
BHT-8	6.75c	7.00b	6.50c	6.25b	8.75ab	7.25b	6.75b	7.50b
BHT-10	7.25bc	7.75ab	7.25bc	6.75b	7.50bc	7.25b	6.75b	7.75b
BHT-11	9.50a	9.50a	9.50a	9.50a	9.75a	9.25a	9.25a	10.00a
VL-642	7.00bc	7.00b	8.12b	8.50a	6.25cd	7.12b	7.25b	7.00b
Bipul plus	8.25ab	7.50ab	8.50ab	8.75a	6.75cd	7.75ab	7.75ab	8.25ab
Maharaja	6.25c	6.50b	6.25c	7.00b	5.50d	6.50b	7.25b	6.75b
LSD (0.05)	1.29	2.02	1.33	1.41	1.65	1.75	1.71b	1.92
CV (%)	11.41	12.77	11.47	12.00	12.83	15.47	11.20	12.21

Farmer's opinion in participatory varietal selection program (PVS)

To know farmer opinion, a PVS program was arranged in both the years. Eight characters was evaluated in the program (Table 6). The BHT-11 and Bipul plus scored the highest and similar (8.50-9.50) considering cluster plant⁻¹, fruit plant⁻¹, hardness, shape and yield performance in both the years. But BARI released hybrids (BHT-8, BHT-10 and BHT-11) took the highest score regarding earliness. Eventually the BHT-11 was the best considering overall evaluation.

Conclusion

From the two years evaluation, it can be suggested that the tomato var. hybrid BHT-11 could become profitable for early rabi season in High Barind Tract.

WEED MANAGEMENT FOR DRY DIRECT SEEDED AUS RICE IN HIGH BARIND TRACT

M. S. Hossain, J. C. Barman, M.E.A. Pramanik, M Akkas Ali, M Shahiduzzaman

Abstract

Conservation agriculture (CA) is based on minimum soil disturbance, permanent soil cover, and crop rotation; it is promoted as a sustainable alternative to systems involving conventional tillage. Direct seeded rice (DSR) is one of the CA technologies. A field experiment was conducted at Farming System Research and Development (FSRD) site, Basantapur, Godagari, Rajshahi during 2020 to develop effective weed management strategies for DSR Aus rice in High Barind Tract. Six weed management strategies such as-WM₁: Pre-emergence (no spray) +post-emergence (no spray); WM₂: Pre-emergence (Pendimethalin)+post-emergence (no spray); WM₃: Pre-emergence (no spray) + post-emergence (Bispyribac + Pyrazosulfuron Ethyl), WM₄: Pre-emergence (Pendimethalin) +post-emergence (Bispyribac + Pyrazosulfuron), WM₅: Pre-emergence (Pendimethalin)+post-emergence (Penoxulam) and WM₆: Pre-emergence (Pendimethalin)+post-emergence (Hand weeding). A randomized complete block design with three replications was used with strip tillage system. Weed management treatment WM₄ recorded the highest grain (4.63 t ha⁻¹) and straw yield (5.10 t ha⁻¹) of Aus rice. The WM₅ was identical with WM₄ considering the yield performance. The WM₄ and WM₅ also showed minimum weed population and dry weed biomass. Considering cost and return analysis these two packages also gave higher gross return and gross margin.

Introduction

Conservation agriculture (CA) is said to result in sustainable farming systems as it saves time, economic inputs and natural resources. An increasing trend has been observed in CA to enhance sustainability without compromising land productivity over the last decade in South Asia. Potato-Aus or Boro-T. Aman rice is one of the major cropping patterns in High Barind Tract (HBT) covering an area of 12500 ha (Ali et al., 2018). Farmers normally cultivate late Boro or early Aus rice after harvest of Potato. BRRI dhan82 and Bina dhan19 are recently developed Aus rice varieties have high yield potentiality. Dry direct seeded rice (DSR) in no-till or till soil is an alternate option for transplanting rice. It can easily save those resources. But due to weed management constraints farmers are hesitate to adopt the DSR technology. Weed control is a greater challenge to achieve the success of DSR. Till now little effort has been taken for managing weed and improving crop yields in Bangladesh. Hence, the present investigation was undertaken to find out the effective and sustainable weed management strategy for increasing yield of Aus rice in DSR system.

Materials and Methods

A field experiment was conducted at Farming System Research and Development (FSRD) site, Basantapur, Godagari, Rajshahi during 2020 to develop sustainable and effective weed management strategies for DSR technology in HBT. The soil of the experimental plots belongs to Amnura series under AEZ 26. Six weed management packages were compared for Strip tillage system. A RCB design with three replications was used. The treatments were as follows-

Treatment		Pre-emergence	Post-emergence
WM ₁	:	No-spray	No-spray
WM ₂	:	Pendimethalin	No-spray
WM ₃	:	No-spray	Bispyribac+Pyrazosulfuron Ethyl
WM ₄	:	Pendimethalin	Bispyribac+Pyrazosulfuron Ethyl
WM ₅	:	Pendimethalin	Penoxsulam
WM ₆	:	Pendimethalin	Hand weeding

After harvest of potato, the land was tilled with rotarvator. The seeds of Aus rice (var. Bina dhan19) were sown with strip tillage machine in dry soil on 4 April 2020. A flood irrigation was provided immediately after seed sowing to create proper soil moisture for seed germination. Different weed management strategies were applied as per treatment specimen. Pendimethalin is a pre-emergence herbicide. It was sprayed soil moist condition before germination of weed (1-2 days after irrigation). Bispyribac + Pyrazosulfuron Ethyl or Penoxsulam was used as post-emergence herbicides and applied at 3-leaf stage of weeds. Fertilizer dose was used as per Fertilizer Recommendation Guide (BARC, 2018). The unit plot size was 8 m × 5 m. All the fertilizers except urea were applied as basal. Urea was applied as top dressing in three equal splits at 20, 40 and 60 days after seed sowing. Intercultural operations viz. thinning, irrigation, fungicide and insecticide spray were done in order to support normal plant growth. Yield of main and by-product under various treatments were measured in each plot (6 m²) at physiological maturity stage. For weed count data, four permanent 0.20 m² (40 cm × 50 cm) quadrates were established in each of the plot. Weed was counted separately as grasses, broadleaf and sedges at 40 days after sowing and counted weed was uprooted and oven dried for measuring dry biomass. The recorded data for weed number and biomass were converted to gram per square meter. Data on yield was recorded and converted into ton per hectare (t ha⁻¹). All the yield and weed data was analyzed statistically with open-source software R (R Core Team, 2019).

Results and Discussions

Effect of weed managements on DSR Aus rice: Yield and yield components of Aus rice responded significantly to different weed management practices (Table 1). The maximum grain yield (4.63 t ha⁻¹) and straw yield (5.10 t ha⁻¹) were obtained from WM₄ where pre-emergence (Pendimethalin) and Post emergence (Bispyribac+Pyrazosulfuron) herbicides were applied. This is due to the best performances of all yield contributing characters viz., effective tiller m⁻², grain panicle⁻¹ and 1000-grain weight in the WM₄. The WM₅ showed second highest grain yield (4.27 t ha⁻¹) where both pre-emergence (Pendimethalin) and Post emergence (Penoxsulam) herbicides were also applied. Treatments WM₆ (3.97 t ha⁻¹) and WM₃ (3.90 t ha⁻¹) showed similar performance in respect of grain and straw yield. The WM₃ contained only post emergence herbicide gave significantly higher grain yield (3.90 t ha⁻¹) than that of WM₂ (3.40 ha⁻¹) wherever only pre-emergence herbicide was applied. The minimum grain (1.20 t ha⁻¹) and straw yield (2.20 t ha⁻¹) were obtained from treatment WM₁ where no weed was controlled.

Effect of weed managements on different types of weeds on DSR Aus rice at 40 DAT: Weed management treatments significantly affected the number and biomass of different types of weeds. Significantly higher total number of weeds and maximum biomass were found in treatment WM₁ where no weed management option was applied (Table 2). Minimum number of weeds was found in treatment WM₄.

Cost and return analysis of different treatments

Economic analysis of weed management strategies in DSR Aus rice are given in Table 3. The maximum gross return (Tk. 120850 ha⁻¹) and gross margin (Tk.116981 ha⁻¹) were obtained from treatment with WM₄ (Pendimethalin, Bispyribac+Pyrazosulfuron) followed by treatment WM₅ (Pendimethalin, Penoxsulam). The lowest gross margin (Tk. 32200 ha⁻¹) was obtained from WM₁ (no weed management). Any single herbicide application either pre-emergence or post-emergence did not give higher gross return and gross margin. But the highest MBCR over weedy treatment (WM₁) was found from treatment WM₃ (40.02) and followed by WM₂ (27.19) as the treatment cost was lower. The lowest MBCR over control (8.87) was recorded from WM₆ where pre-emergence + hand weeding was applied.

Table 1. Effect of weed managements on the yield and yield attributes of DSR Aus rice in at FSRD site, Basantapur Rajshahi during 2020

Treatment	Plant height (cm)	Tiller m ⁻²	Panicle length (cm)	Grains panicle ⁻¹	1000-grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
WM ₁	66.07e	87.67d	9.83d	51.33d	18.17c	1.20e	2.20c
WM ₂	86.27d	328.33c	16.77c	88.67c	19.47b	3.40d	4.63b
WM ₃	95.33bc	359.00bc	18.30bc	122.33ab	20.10d	3.90c	5.03ab
WM ₄	101.73a	403.33a	21.50a	136.33a	21.13a	4.63a	5.10a
WM ₅	100.50ab	378.67ab	20.37a	129.00a	20.33ab	4.27b	5.07a
WM ₆	92.43c	353.00bc	18.40b	106.67bc	19.63b	3.97c	4.93ab
LSD	5.89	38.89	1.59	21.57	0.95	0.24	0.40
CV (%)	5.58	6.71	5.01	11.22	5.65	6.72	6.93

Table 2. Different characters of weeds as influenced by different weed managements in DSR rice 40 DAT at FSRD site, Basantapur Rajshahi during 2020

Treatment	Grass		Broad leaf		Sedge		Total	
	No.	Biomass (g m ⁻²)	No.	Biomass (g m ⁻²)	No.	Biomass (g m ⁻²)	No.	Biomass (g m ⁻²)
WM ₁	103.33a	30.83a	90.00a	19.17a	50.00a	18.33a	243.33a	68.33a
WM ₂	66.67b	12.67b	54.17b	5.00c	26.67b	5.00c	147.50bc	22.67c
WM ₃	36.67cd	6.83bc	45.00bc	5.83c	11.67c	4.00c	93.33de	16.67d
WM ₄	30.00d	5.67c	20.83c	4.17c	10.00c	5.50c	60.83e	15.33d
WM ₅	47.33bcd	9.83bc	45.00bc	6.17c	15.00bc	5.33c	107.33cd	21.33c
WM ₆	61.67bc	11.67bc	68.33ab	12.50b	25.00b	9.50b	155.00b	33.67b
LSD	25.25	6.75	26.33	3.35	13.83	3.21	40.41	7.25
CV (%)	14.10	18.75	16.73	12.38	15.88	15.28	16.50	12.69

Table 3. Cost and return analysis of different weed management options at FSRD site, Basantapur Rajshahi during 2020

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
WM ₁	32200	0	32200	-
WM ₂	89630	2112	87518	27.19
WM ₃	102530	1757	100773	40.02
WM ₄	120850	3869	116981	22.91
WM ₅	111820	4787	107033	16.63
WM ₆	104180	8112	96068	8.87

NB., Pendimethalin (3.0 L ha⁻¹)- Tk. 2625, Bispyribac (600 g ha⁻¹)-Tk. 525, Penoxsulam (94 ml ha⁻¹)- Tk. 1875, Pyrazosulfuron Ethyl (188 g)- Tk. 375.

Conclusion

From the results, it can be concluded that application of pre-emergence (pendimethalin) and post-emergence (Bispyribac+Pyrazosulfuron) (WM₄) can be a promising practice for higher yield as well as economic benefit in DSR Aus rice.

EFFECT OF TRANSPLANTING TIME ON ONION BULB YIELD LOSS OF BARI PIAZ-4

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

A trial was conducted at the FSRD site, Sholakundu, Faridpur during the Rabi, 2020-21 to find out optimum planting time of BARI Piaz-4 for reducing bulb yield. The experiment was laid out in randomized complete block (RCB) design with four compact replications. Four treatments were

considered as T_1 = seedling transplanting at 20 December, T_2 = seedling transplanting at 30 December T_3 = seedling transplanting at 10 January and T_4 = seedling transplanting at 20 January. BARI Piaz-4 was used as planting material in the study. The highest bulb yield (31.13 t ha^{-1}) was obtained from T_1 followed by T_2 (28.79 t ha^{-1}). The lowest bulb yield (18.82 t ha^{-1}) was recorded in T_4 . Considering economic benefit, maximum gross return (Tk. 778250 ha^{-1}) and gross margin (Tk. 577135 ha^{-1}) were obtained from early transplanted seedling. The minimum gross margin (Tk. 187440 ha^{-1}) was observed in late transplanted seedling (20 January). The bulb yield loss gradually increasing 8%, 30% and 65% in 30 December, 10 January and 20 January, respectively in against of 20 December seedling transplanting.

Introduction

Onions are photo-thermo-periodic; that means they are sensitive to temperature and also to daylight. Day length or daylight hours stimulates the onion plant to start making a bulb (and to stop making leafy growth). Each onion variety will form a bulb only after it has received a certain number of hours of daylight each day for a certain number of days. For vegetative growth, 9-10 hours day length is necessary and for bulb development, 10-12 hours day length is better. Temperature stimulates the onion plant to stop making a bulb. Around 15°C temperature is needed for vegetative growth and upto 21°C temperature is essential for bulb development. Onion prefers moderate temperature and short days for the vegetative growth. Thus, Sunshine hour and temperature is correlated for bulb production. Bulbing begins in response to increasing day-length. Temperature and light spectral quality also affect the onset of bulbing, but these effects are minor compared to day-length. Planting time of seedling is very important for onion cultivation as it affects bulb yield, quality and shelf life. In a trial, during 2019-20 in Faridpur and in Rajbari, bulb yield was decreased gradually with planting time varied every ten days onward. Farmers normally plant onion seedling on 30 December to 20 January depending on weather or zoe condition of lands. With these views, the trial was undertaken to find out optimum planting time of BARI Piaz-4 in Faridpur region.

Materials and Methods

The trial was conducted at the FSRD Site, Sholakundu, Faridpur during the Rabi, 2020-21 to find out optimum planting time of BARI Piaz-4 for minimizing yield loss. The experiment was laid out in randomized complete block (RCB) design with four compact replications. Four treatments were considered as T_1 =Seedling transplanting at 20 December, T_2 =Seedling transplanting at 30 December T_3 = Seedling transplanting at 10 January and T_4 =Seedling transplanting at 20 January. BARI Piaz-4 was used as planting material in the study. The unit plot size was $3\text{m} \times 3\text{m}$. The land preparation was done with power tiller. Forty-five to Fifty days old seedlings were transplanted on according to treatment maintaining $15\text{cm} \times 10\text{cm}$ spacing. The land was fertilized with 140-60-60-30-3-1.5 kg N-P-K-S-Zn-B ha^{-1} in the form of urea, TSP, MOP, gypsum, zinc sulphate and boric acid, respectively. All of fertilizer, P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 21 DAT and 39-43 DAT under moist soil condition and mixed thoroughly with the soil. Weeding and mulching was done thrice at 16-17, 26-28 & 48-49 DAT and the cropland was irrigated four times at pre planting, immediate after planting, 21 and 39-43 DAT. Four times fungicides (Rovral at 10-11, 40-45 DAT, Amister top at 22 DAT, and Nativo at 54-64 DAT) and insecticide (Imitaf at 22, 40-45, 54-64 DAT and Amamectin benzoet at 62-72 DAT) were applied. The crop was harvested on March 22-31 at 71 to 92 DAT during the study period. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software. Mean comparison were done using DMRT value at 5% level of probability.

Results and Discussions

The 10 days interval data of average maximum & minimum temperature ($^\circ\text{C}$), relative humidity (%) and sunshine hour for different transplanting time of onion seedling was stated in Table 1. Growth parameters, yield attributes and bulb yield of onion as influenced by different transplanting time of onion seedling during 2020-21 shown in Table 2 and 3. The highest plant height (55.80 cm) was

recorded in T₂ treatment followed by T₁ (55.05 cm). The lowest plant height (49.80 cm) was recorded in T₄ treatment. Number of leaves per plant was ranged between 5.25 (T₄) to 6.00 (T₃). The highest number of bulb kg⁻¹ was calculated from T₄ treatment (45.30 nos) followed by T₃ (30.42 nos) and the lowest from T₁ (25.28 nos). The highest single bulb wt. was calculated in T₁ (39.57 g) followed by T₂ (37.04 g) and lowest single bulb wt. from T₄ (22.65 g). The early transplanted seedling (20 Dec and 30 Dec) received maximum sunshine hour (7.03 to 8.03) and minimum temperature (12.37 to 13.86 °C) upto 9 January which was helpful for vegetative development resulting better bulb formation. The number of bulbs m⁻² was ranged between 72.89 (T₃) to 82.99 (T₄). Late transplanted seedling (20 January) produced the highest number of bulb m⁻² (82.99) but lowest in single bulb weight (22.65 g), number of leaves plant⁻¹ (5.25) and plant height (49.80 cm) which might be lowest minimum temperature (11.89°C) at vegetative growth stage. The highest % of bolting bulb (2.80%) was calculated from T₁ and lowest (0%) from T₄. The maximum base diameter (4.09 cm) was obtained from T₁ followed by T₂. The lowest base diameter was 3.36 cm which was found from T₄ treatment. The maximum bulb yield (31.13 t ha⁻¹) was obtained from T₁ followed by T₂ (28.79 t ha⁻¹). The lowest bulb yield (18.82 t ha⁻¹) was recorded in T₄. Early transplanted onion showed better bulb yield due to favorable weather condition especially minimum temperature and higher sun shine hour resulting well vegetative growth and bulb development. The bulb yield loss gradually increasing 8, 30 and 65% in 30 December, 10 January and 20 January, respectively against of 20 December seedling transplanting.

Considering economic benefit, maximum gross return (Tk. 778250 ha⁻¹) and gross margin (Tk. 577135 ha⁻¹) were obtained from early transplanted seedling. The minimum gross margin (Tk. 187440 ha⁻¹) was observed in late transplanted seedling (Table 4).

Table 1. Average maximum & minimum temperature (°C), relative humidity (%) and sunshine hour every 10 days interval for different transplanting time of onion seedling

Date with 10 days interval	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Sunshine (hour)
20 Dec to 29 Dec 2020	24.99	12.37	77.1	7.03
30 Dec 2020 to 9 Jan 2021	27.76	13.86	74.3	8.03
10 Jan to 19 Jan 2021	24.07	13.67	79.4	1.96
20 Jan to 29 Jan 2021	23.88	12.86	83.8	4.34
30 Jan to 8 Feb 2021	25.76	11.89	69.1	7.32
9 Feb to 18 Feb 2021	29.1	14.07	72.5	5.73
19 Feb to 28 Feb 2021	31.94	17.86	67.9	7.23

Source: Meteorology Dept. Faridpur, 2020-21

Table 2. Growth parameter of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatments	Plant height (cm)	Leaves plant ⁻¹ (Nos)	Base diameter (cm)	Bulbs kg ⁻¹ (nos)	Bolted bulb (%)
T ₁ (20 Dec)	55.05 a	5.75 a	4.09 a	25.28 c	2.80 a
T ₂ (30 Dec)	55.80 a	5.85 a	4.08 a	27.03 bc	1.70 a
T ₃ (10 Jan)	53.45 ab	6.00 a	3.83 b	30.42 b	0.28 b
T ₄ (20 Jan)	49.80 b	5.25 b	3.36 c	45.30 a	0.00 b
CV (%)	5.12	3.70	3.69	9.88	61.25

Table 3. Yield attributes and yield of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatments	Bulbs m ⁻² (nos)	Single bulb wt (g)	Bulb yield (t ha ⁻¹)	Bulb yield loss (%) over 20 Dec transplanting
T ₁ (20 Dec)	78.66 b	39.57 a	31.13 a	--
T ₂ (30 Dec)	77.66 b	37.04 a	28.79 a	8
T ₃ (10 Jan)	72.89 c	32.96 b	24.01 b	30
T ₄ (20 Jan)	82.99 a	22.65 c	18.82 c	65
CV (%)	2.75	5.26	6.49	--

Table 4. Cost and returns analysis of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ (20 Dec)	778250	201115	577135
T ₂ (30 Dec)	719750	199145	520605
T ₃ (10 Jan)	540225	193555	346670
T ₄ (20 Jan)	376400	188960	187440

Price of average input (Tk kg⁻¹): Urea: 16, DAP: 16.00, MoP: 15.00, Gypsum: 10.00, Zinc: 190.00, Boron: 240.00, seed: 3000
Output price (Tk kg⁻¹): Onion bulb: 20 December: 25.00, 30 December: 25.00, 10 January: 22.50, 20 January: 20.00

Farmers' opinion

Farmers were happy to observe the results of better bulb yield which was transplanted on 20 to 30 December.

Conclusion

From the result, it can be revealed that yield loss may be reduced by planting of onion seedling on 20 December against later on. For concrete/final decision, the experiment may be repeated in next year.

IDENTIFICATION OF CRITICAL WEED COMPETITION PERIODS FOR BLACK CUMIN IN FARIDPUR

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

*A field trial was conducted at the FSRD site, Faridpur during the Rabi 2020-21 to find out the critical weed competition periods for black cumin. Five treatments were considered as T₁: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T₂ (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T₃: weeds are allowed to compete with black cumin for 50 DAE, T₄: weeds are allowed to compete with black cumin for 60 DAE and T₅: No weeding (control). Among the weed species, *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Vicia sativa* (Bon masur) and *Saussurea affinis* (Bon shimul) were the most dominant broad leaf weeds. The highest number of weed density (432 m⁻²) were recorded from T₁ followed by T₂ and the lowest from T₅ (74 m⁻²). The highest weed biomass (51.06 g m⁻²) was obtained from no weeding (control) plot and the lowest dry weight (9.8 g m⁻²) T₁. Weed persistence index (WPI) was also varied from 0.03 (T₁) to 0.55 (T₅). The maximum seed yield (1087 kg ha⁻¹) was recorded in T₁ treatment which was at par with T₂. The seed yield decreased with increase in competition periods. The lowest seed yield (604 kg ha⁻¹) in no weeding plot. The highest gross margin (Tk 139329 ha⁻¹) was obtained from T₁ and the lowest from no weeding plot (Tk 60144 ha⁻¹). Weeds must be controlled within 40 days after emergence of black cumin to avoid the risk of economic yield loss as 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.*

Introduction

There is a period during the life cycle of a crop when it is most sensitive to presence of weeds. This period is known as critical period of competition (Mubeen et al., 2009). The critical weed crop competition period is very important for planning efficient weed control strategy. It varies with season and nature of crops and weeds. Black seed (*Nigella sativa* L.) is an annual herbaceous plant belonging to family Ranunculaceae, also known as black cumin. In Faridpur, a total of 3000 ha land remains engaged in black cumin cultivation. In winter, black cumin crop face a severe competition with weeds like sedge, grass and broad leaf type weed resulting lower yield (0.94-1.10 t ha⁻¹). Literature cited that, 2/3 times weeding is required for black cumin. Farmers generally make one weeding or thinning at 40 DAE. However, there is no information available about the critical weed competition period in black

cumin production in the context of Bangladesh. Therefore, the trial was designed with the objective to find out the critical weed competition periods for black cumin.

Materials and Methods

The trial was conducted in medium highland with irrigation facilities under the farmers' field situation at FSRD Site, Faridpur in AEZ#12 during the *Rabi* 2020-21. The experiment was laid out in a randomized complete block design with four dispersed replications. Five treatments were considered as T₁: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T₂ (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T₃: weeds are allowed to compete with black cumin for 50 DAE, T₄: weeds are allowed to compete with black cumin for 60 DAE and T₅: No weeding. BARI Kalojira-1 was used as planting material. The unit plot size was 2 m x 1.5 m. Seeds were sown in line maintaining 40 cm spacing with continuous seed sowing on 26-30 November 2020. The crop was fertilized with 100-40-30-18-2-1 kg ha⁻¹ N-P-K-S-Zn-B, respectively. All amount of P, K, S, Zn & B and half of N was applied as basal during final land preparation. The remaining N were applied in two splits at 33-35 and 50-55 days after sowing (DAS) under moist soil condition and mixed thoroughly with the soil for better utilization. Three times irrigations were provided at immediately after sowing, 1st and 2nd top dressing of N. Weeding was done according to experimental design. Each treatment received only one weeding at different time. Insecticide under the group Emamectin benzoate was applied to control pod borer for two times at 85-89 and 99-103 DAS. The crop was harvested during 28-31 March 2021 at 123 DAS. Necessary data on population of weed species in black cumin plot (weed density), relative weed density (%), green weight and dry weight of weed (g), weed persistence index were recorded. Species wise weed population was counted at random from an area of one 1 m² per each plot with quadrat (1m x 1m) at 30 DAE (days after emergence) and the dry weight of weed species was determined after in an oven-drying for 72 hours at 70°C. The weight of the dried samples was taken and the average data were expressed as weed biomass (g m⁻²). The frequency of different weeds was determined and the density of each species was calculated according to Odum (1971).

$$\text{Weed density (no. m}^{-2}\text{)} = \frac{\text{Total number of weeds}}{\text{Total survey areas}}$$

$$\text{Relative weed density} = \frac{\text{Density of each weed species}}{\text{Total density of all weed species}} \times 100$$

Weed persistence index (WPI) was computed using the given formula as suggested by Mishra and Mishra (1997). It indicates the resistance in weeds against the tested treatment and confirms the effectiveness of the weeding competition period.

$$\text{WPI} = \frac{\text{Weed population in control plot}}{\text{Weed population in treated plot}} \times \frac{\text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}}$$

Five plants of black cumin in each plot were selected randomly to gather data on yield components. Data on plant population m⁻² were recorded at physiological maturity and the crop was harvested plot-wise at full maturity. Seed and stalk were dried in the sun to minimize the moisture and converted to yield (kg ha⁻¹). Data were recorded and performed statistically using 'R' software (version: R-3.3.1) (R Core Team, 2016) and mean separation was done by DMRT.

Results and Discussion

Weed indices: The number of weed species and relative weed density was affected by different weed competition period. It was observed that *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Vicia sativa* (Bon masur), *Saussurea affinis* (Bon shimul), *Digitaria sanguinalis* (Anguli) and *Cynodon dactylon* (Durba) were the common weeds in black cumin field. Among the weed species, *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Vicia sativa* (Bon masur) and *Saussurea affinis* (Bon shimul) were the most dominant broad leaf weeds (Table 1). Anguli and durba were not found in T₃, T₄ and T₅ treatments. The highest number of weed density (432 m⁻²) was recorded from T₁ followed by T₂ and the lowest (74 m⁻²) from control. The total weed density decreased with increased in competition periods due to might be enhancing intra weed competition. Thus, early germinated weeds suppressed

the late germinated weeds resulting lower weed density in no weeding plot. The relative weed density of *Chenopodium album* decreased with increase in competition period (89.80% for T₁ and 43.24% for control plot). Seeds of *C. album* present in the soil at various depths continued to germinate with the passage of time resulting in lower weed density where weeds were allowed to compete for longer period. In case of *Convolvulus arvensis*, the relative weed density increased (2.08% for T₁ and 32.43% for control) with each increase in competition period. Dry weight (weed biomass) of all the weeds was affected by weed crop competition period (Table 2). The highest weed biomass (51.06 g m⁻²) was obtained from no weeding (control) plot and the lowest dry weight (9.8 g m⁻²) from T₁. As the weeds were allowed to grow for longer period, they produced greater biomass resulting in the greater dry weight. The differences in the dry weight of weeds can be attributed to the differences in the density of weeds (Table 1) and fresh weight of the weeds (Table 2) depending upon the duration of competition period. The results are in accordance with those of Hussain et al. (2009) who reported increase in weed dry weight with increased competition periods in black cumin crop. Weed persistence index (WPI) was also varied from 0.03 (T₁) to 0.55 (T₅). The lowest value of WPI from T₁ stated that, weed was effectively controlled where weed crop competition period was 30 DAE. This may be attributed to better control of weeds due to suppress of weed emergence through weed control at 30 DAE.

Yield components and yield of black cumin: The highest plant height (54.70 cm) was documented in T₁. The lowest plant height (45.70 cm) was in the treatment T₅. The minimum plant height in no weeding can be attributed to greater competition and suppressive effect of weeds. The highest number of plant population m⁻² (108.75) was obtained from T₁ followed by T₂ (104.50). The lowest number of plants m⁻² (86.50) was obtained from T₅. The maximum number of capsules (13.05) was recorded in T₁ followed by T₂ (11.70). The minimum number of capsules (8.70) was recorded in no weeding. The differences among competition periods of 40 and 50 days after emergence were statistically similar. The highest number of seeds per capsules (64.00) was recorded in T₁ followed by T₂ (62.10). The minimum number of seeds per capsules (59.25) was recorded in no weeding (T₅). The maximum seed weight (1.93 g) was recorded in T₁ and T₂ treatment which was at par with other treatments except T₄ where weed crop competition was 60 DAE. The maximum seed yield (1087 kg ha⁻¹) was recorded in T₁ treatment which was at par with T₂. The seed yield decreased with increase in competition periods but the difference between 30 and 40 DAE were statistically similar. The lowest seed yield (604 kg ha⁻¹) in no weeding. Seed yield was increased 80% in T₁ over control (no weeding) which was followed by T₂ (70%). The improvement in seed yield under these treatments may be attributed to more weed reduction at critical growth stages of crops which favored healthy plant growth.

Economic analysis of different weed competition period on black cumin has shown in Table 4. The highest gross return (Tk. 211965 ha⁻¹) was registered with T₁ followed by T₂ (Tk 200655 ha⁻¹) and the lowest gross return (Tk 117780 ha⁻¹) from control plot due to lowest seed yield. But, T₁ and T₂ treatments attributed the highest cost (Tk. 72636 ha⁻¹) due to excess 10 labors for weeding than other treatments and less cost in (Tk. 57636 ha⁻¹) in control (T₅). At early stage of weeding at 30 and 40 DAE, weeds were smaller in size resulting excess labor was needed. The highest gross margin (Tk 139329 ha⁻¹) was obtained from T₁ and the lowest from no weeding plot (Tk 60144 ha⁻¹).

The results showed that the maximum seed yield in black cumin could be obtained by keeping the plots weed free during initial growth phase of the crop. Therefore, weeds must be controlled within 40 days after emergence of black cumin to avoid the risk of economic yield loss. Thus, weed crop competition period of 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

Farmer's opinion

Weeding was done at 40 days after emergence of black cumin in farmers level. Farmers were interested to apply weeding at 30 DAE for highest seed yield and economic return.

Table 1. Effect of different weed species population and their relative weed density in black cumin field during the Rabi 2020-21 at Faridpur

Treatment	<i>Chenopodium album</i> (Bathua)		<i>Convolvulus arvensis</i> (Bindu)		<i>Vicia sativa</i> (Bon masur)		Saussurea affinis (Bon shimul)		Others (Anguli and durba)		Total weed density (no. m ⁻²)
	Weed density (no. m ⁻²)	Relative weed density (%)	Weed density (no. m ⁻²)	Relative weed density (%)	Weed density (no. m ⁻²)	Relative weed density (%)	Weed density (no. m ⁻²)	Relative weed density (%)	Weed density (no. m ⁻²)	Relative weed density (%)	
T ₁	388	89.80	9	2.08	17	3.94	15	3.47	3	0.69	432
T ₂	311	88.60	23	6.55	8	2.28	8	2.28	0.7	0.20	351
T ₃	135	71.43	27	14.29	11	5.82	16	8.47	0	0	189
T ₄	65	52.85	34	27.64	12	9.76	12	9.76	0	0	123
T ₅	32	43.24	24	32.43	9	12.16	9	12.16	0	0	74

T₁: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T₂ (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T₃: weeds are allowed to compete with black cumin for 50 DAE, T₄: weeds are allowed to compete with black cumin for 60 DAE and T₅: No weeding (control)

Table 2. Green weight, weed biomass and weed persistence index of black cumin in different weed competition period at Faridpur during 2020-21

Treatment	Green weight (g m ⁻²)	Weed biomass (g m ⁻²)	Weed persistence index
T ₁ (Competition for 30 DAE)	51.1	9.8	0.03
T ₂ (Competition for 40 DAE)	42.43	15.16	0.06
T ₃ (Competition for 50 DAE)	237.72	39.04	0.29
T ₄ (Competition for 60 DAE)	229.13	46.65	0.55
T ₅ (Control/No weeding)	257.55	51.06	--

Table 3. Effect of different weed competition periods on yield and yield contributing characters of black seed

Treatment	Plant height (cm)	Plant population m ⁻² (nos.)	Capsules plant ⁻¹ (nos.)	Seeds Capsules ⁻¹ (nos.)	1000 seed weight (g)	Seed yield (kg ha ⁻¹)	Seed yield increase over control
T ₁ (Competition for 30 DAE)	54.70 a	108.75 a	13.05 a	64.00 a	1.93 a	1087 a	80
T ₂ (Competition for 40 DAE)	50.55 b	104.50 b	11.70 b	62.10 b	1.93 a	1029 a	70
T ₃ (Competition for 50 DAE)	51.10 b	99.00 c	10.85 bc	60.75 bc	1.90 ab	912 b	51
T ₄ (Competition for 60 DAE)	48.70 b	98.50 c	10.10 c	61.40 b	1.85 b	850 c	41
T ₅ (Control/No weeding)	45.70 c	86.50 d	8.70 d	59.25 c	1.87 ab	604 d	--
CV (%)	3.28	2.53	6.78	1.93	1.86	4.34	

Table 4. Cost and return of black cumin as affected by weed competition during *rabi* season of 2020-21 in Faridpur

Treatment	Seed yield (t ha ⁻¹)	GR (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)
T ₁ (Competition for 30 DAE)	1087	211965	72636	139329
T ₂ (Competition for 40 DAE)	1029	200655	72636	128019
T ₃ (Competition for 50 DAE)	912	177840	67636	110204
T ₄ (Competition for 60 DAE)	850	165750	67636	98114
T ₅ (No weeding)	604	117780	57636	60144

Conclusion

Weeding at 30 days after emergence decreased the weed infestation, weed biomass and weed persistence index followed by weed crop competition period of 40 DAE resulting the highest seed yield and gross margin. Thus, weed crop competition period of 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

PERFORMANCE OF GARLIC WITH ZERO TILLAGE METHOD IN COASTAL REGION

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Abstract

An experiment was conducted at MLT site Bauphal, Patuakhali in the Rabi season of 2020-21 to observe the performance of garlic production under zero tillage condition. Two types of sowing methods i.e. T_1 = Sowing in zero till field and T_2 = Sowing in ploughed field (traditional) was tested in the trial. It was observed that all the studied traits were higher in zero-tillage condition. Plant establishment was higher in zero tillage plots as the plants absorbed required moisture during early growing stage. Higher bulb yield (9.37 t ha^{-1}) was obtained from zero tillage field compared to tillage system (8.43 t ha^{-1}). Zero tillage system also gave higher gross return (Tk. 421650) and gross margin (Tk. 337650) as its production cost was lower than tillage system.

Introduction

Garlic (*Allium sativum* L) is an aromatic herbaceous plant and the second most widely used Allium after onion. This crop is extensively cultivated in many countries of the world including Bangladesh as a popular spice crop. Garlic is a rich source of carbohydrate and phosphorus (Rahman et al., 2007). The average yield of garlic in this country is only 5.21 t ha^{-1} (BBS, 2012). The poor yield of garlic may be due to the lack of inadequate soil and water management practices with reference to soil water shortage in the soil profile. Zero tillage crop production need low water requirement and other cultural practices. Fallow – Fallow - T. Aman is the major cropping pattern in coastal region where some lands remain fallow in Rabi season due to excessive moisture in the field. In these land garlic may be cultivated in zero tillage. With these views the production trial has been undertaken.

Materials and Methods

The trial was conducted at MLT site Bauphal, Patuakhali in the Rabi season of 2020-21 to observe the performance of garlic under zero tillage condition. Two types of sowing methods i.e., T_1 = Sowing in zero till field and T_2 = Sowing in ploughed field (traditional) was tested in the trial. The experiment was laid out in randomized complete block design with 3 replications. The unit plot size was 4m x 5m. Local garlic variety was used as the test crop. The crop was planted in line, maintaining 15 cm x 10 cm spacing on the muddy soil just 2 to 3 days after harvesting T. aman rice. Then the muddy soil surface was covered by rice straw. Planting was done manually using one clove per hole. The crop was planted on 25 November 2020 and harvested on 29 March 2021. The crop was fertilized with 155-35-125-20 kg N-P-K-S ha^{-1} . One third nitrogen was applied as basal and two third was top dressed in two equal installments at 25 and 50 days after planting. Other fertilizers were applied on the muddy soil as basal before planting and covering the soil surface by rice straw. In case of tillage system, the experimental plots were ploughed by a power tiller followed by laddering up to a depth of 10 cm were done until the desired depth was achieved for planting the clove. The plots were fertilized as zero tillage system cited above. The crop was planted on 15 December 2020 and harvesting was done on 10 April 2021 when the plants reached maturity showing the normal sign of drying out of most of the leaves and the top leaves started drying and natural dropping at the neck.

Results and Discussion

It was observed that the emergence of clove, plant height and leaf number was significantly influenced by planting systems. In zero tillage plot the emergence of clove (89%), plant height (51.27cm) and leaf number (6.20) was higher than tillage plots (82%, 46.31cm and 5.87 respectively). Bulb diameter was higher in tillage (8.96 cm) compared to zero-tillage (8.53 cm). Statistically similar number of cloves was found in both the tillage system. Higher bulb yield was found in zero-tillage (9.37 t ha^{-1}) compared to tillage (8.43 t ha^{-1}) system (Table 1). In zero-tillage system straw mulch was used after planting of cloves which help to conserved soil moisture as well as suppressed weed infestation therefore vegetative growth of plant was improved. Zero-tillage system helps to increase water and fertilizer use efficiency of crop as results yield increase as compared to tillage condition (Triplett Jr & Dick, 2008). Zero tillage with mulch using water hyacinth (Kabir et al., 2011) and rice straw (Islam et al., 2015) significantly retained soil moisture and suppressed weed growth which enhanced crop growth and development

(Karaye & Yakubu, 2006). Jamil et al. (2005) reported that straw mulch increased yield and yield contributing traits of garlic. From the economic point of view, higher gross return (Tk.421650), gross margin (Tk.337650) and BCR (5.02) was recorded from Zero tillage method. Lower gross return was recorded from tillage plot (Tk.379350) and BCR (4.46).

Farmers Opinion: Farmers were very much interested to zero tillage system of its early planting, no tillage cost and higher yield.

Table 1. Plant populations, growth and yield contributing parameters of Garlic at Bauphal, Patuakhali during 2020-21

Variety	% Emergence at 30 DAP	Plant height at 80 DAP	Leaf number	Bulb diameter (cm)	Cloves/bulb (Nos)	Bulb yield (t ha ⁻¹)
T ₁	89	51.27	20.13	8.53	15.85	9.37
T ₂	82	46.31	19.91	8.25	15.79	8.43
P-value	0.87	0.048	1.68	0.039	0.032	0.049
LSD _{0.05}	NS	*	NS	*	*	*

Table 2: Economic analysis of Garlic at Patuakhali during 2020-21

Variety	Yield (t ha ⁻¹)	Gross Return (Tk. ha ⁻¹)	Variable Cost (Tk ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)	BCR
T ₁	9.37	421650	84000	337650	5.02
T ₂	8.43	379350	85000	294350	4.46

Garlic Price (Tk kg⁻¹) = 45

Conclusion

In zero-tillage system, seeds/bulbs are planted directly into untilled soil which contains previous crop residues. Zero-tillage conserved soil moisture during the entire growth period of crop as mulch is used as well as reduce irrigation frequency and production cost. Available moisture at the root zone enhanced vegetative growth and ultimately improved yield in the zero-tillage system. However, the trial may be repeated for the next year for confirmation of the results.

EFFECT OF MULCHING ON YIELD OF WATERMELON IN COASTAL AREA

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Abstract

An experiment was conducted at MLT site, Kuakata, Patuakhali in the Rabi season of 2020-21 to observe the effect of seedling transplantation in different mulch materials for watermelon production under farmers field condition. Three different mulch materials e.g., T₁= Silver color polythene mulch, T₂= Straw mulch, T₃= No mulch with three planting methods viz., P₁=15 days old polybag seedling, P₂=20 days old poly bag seedling and P₃= direct seeding were tested in the experiment. Plant growth and yield was the better in mulch treated plots. Silver polythene with 20 days old polybag seedling gave the highest yield (32.69 t ha⁻¹) while plants without mulch (control) and direct seeding treatments gave with poor growth and yield (26.77ton ha⁻¹). With economic point of view, silver mulch and 20 days old poly bag seedling gave the highest gross return (Tk. 394420) as well as highest benefit-cost ratio (3.03).

Introduction

Watermelon is one of the most growing crops in southern coastal region (Bhella, H. S. 1988.). After T. Aman rice harvest, it is cultivated as a cash crop. Watermelon production during 2017-18 at Patuakhali district was 13350 ha (DAE, Patuakhali). In coastal region usually watermelon seeds are sown after mid-December that sometimes faces drought, rainfall and hail storm during March-April (Biswas, et al., 2009). For this reason, watermelon production hampered seriously and farmers become looser

(Haque S. A. 2006). Seedling transplantation is a method of watermelon cultivation that reduces 15-20 days field duration of the crop. It also helps to escape adverse effect of drought, rainfall and hail storm at harvesting stage (Chaves, M.M., *et al*, 2009). Watermelons could be harvested earlier from transplanted plants that offer higher market price. Transplanted seedling establishment in field is difficult if soil moisture is not maintaining properly. So, to minimize mortality rate and to reduce irrigation frequency and to harvest early escaping hail storm watermelon seedling transplantation with different mulch materials be better alternatives. With the above view the experiment has been designed.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali in *Rabi* season of 2020-21. Three different mulch materials i.e. T_1 = Silver color polythene mulch, T_2 = Straw mulch, T_3 = No mulch was used with P_1 = 15 days old poly bag seedling, P_2 = 20 days old poly bag seedling and P_3 = direct seeding. So, total treatment combination was 9. The experiment was laid out in RCB design with three compact replications having unit plot size 6 m x 5 m. Fertilizer were applied as 180-150-160-125-10 kg ha⁻¹ as Urea, TSP, MoP, Gypsum and Boric Acid respectively. Seedlings were transplanted on 29 December 2020 and harvesting started on 20 March 2021. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically.

Result and Discussion

Among different mulching treatments, treatment (T_1) silver mulch resulted higher plants per plot, vine length, no. of fruits per pit whereas control recorded the minimum growth. The increase in growth parameters was attributed to sufficient soil moisture near root zone and minimum evaporation loss due to mulching. The result indicated that the effect of different mulching material on fruit weight of watermelon was significantly increased than control. Maximum fruit yield (33.54 t ha⁻¹) was observed in silver mulched plot, whereas the minimum yield (26.89 t ha⁻¹) in control. It was found that all treatments of mulching material increased the average fruit weight (6.40 kg) of watermelon than control. Different aged poly bag seedling produced higher yield than direct seeding. Seedling transplantation also helps in early maturity and harvesting to ensure higher market value and escape natural disaster. Plants under polyethylene (Silver mulch) produced larger fruit and have higher fruit yield per vine because of better plant growth due to favorable hydrothermal regime of soil and weed free environment. Soil salinity differs with different mulch materials. Higher soil salinity at the fruit development and harvesting stage were observed in T_3 treatment (5.96 and 9.35 ds/m). Minimum soil salinity observed in T_1 (6.03 ds/m) treatment at harvesting stage. The highest gross return Tk. 588420 was obtained from silver polythene mulch with 20 days old seedlings (T_1P_2) and the lowest one from T_3P_3 (Tk. 481860).

Farmer's opinion: Farmers opined that mulching and seedling transplantation is a new technology. They also opined that higher plant establishment, plant growth and yield made them optimistic to plant 20 days old poly bag seedling of watermelon using silver color polythene mulch next year.

Table 1. Interaction effect of mulch with Seedling age on watermelon yield and yield attributes during *Rabi*, 2020-21

Interaction (TxP)	Plants/plot	Vine length (cm)	No. of fruits/pit	Fruit wt.(kg)	Fruit yield (t ha ⁻¹)
T_1P_1	22.68	269	1.90	6.10	31.88
T_1P_2	23.23	271	2.00	6.40	32.69
T_1P_3	22.58	265	1.70	5.95	30.10
T_2P_1	22.14	266	1.80	5.75	30.93
T_2P_2	22.69	268	1.90	6.05	31.74
T_2P_3	22.04	262	1.60	5.60	29.15
T_3P_1	20.56	261	1.65	5.50	28.55
T_3P_2	21.11	263	1.75	5.80	29.37
T_3P_3	20.46	257	1.45	5.35	26.77
LSD (.05)	6.46	6.98	0.99	2.65	6.34
CV(%)	3.76	4.61	10.23	4.98	9.21

Table 2. Cost and return analysis of watermelon during Rabi, 2020-21

Interaction (TxP)	Gross return (Tk. ha ⁻¹)	Total variable Cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁ P ₁	573840	194000	379840	2.96
T ₁ P ₂	588420	194000	394420	3.03
T ₁ P ₃	541800	191000	350800	2.84
T ₂ P ₁	556740	199000	357740	2.80
T ₂ P ₂	571320	196000	375320	2.91
T ₂ P ₃	524700	191000	333700	2.75
T ₃ P ₁	513900	195000	318900	2.64
T ₃ P ₂	528660	189000	339660	2.80
T ₃ P ₃	481860	182000	299860	2.65

Note: Watermelon @ 18 Tk/kg

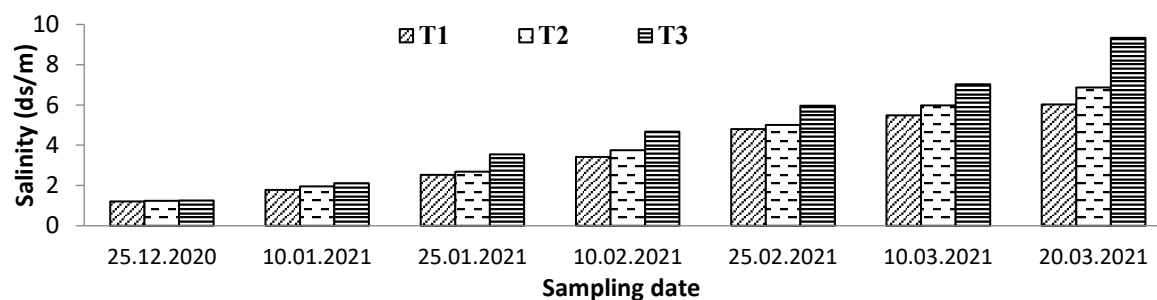


Fig-1: Salinity level of different mulching treatments

Conclusion

Seedling transplantation helps in early maturity and harvesting to ensure higher market price and escape natural disaster of watermelon production in coastal region. Mulching reduce salinity and retain soil moisture in watermelon field. So, it may be concluded that plantation of seedling using mulches technology may be maximize farmers income in watermelon production in coastal region.

PERFORMANCE OF MULCHING TO MITIGATE SOIL SALINITY IN TOMATO FIELD IN COASTAL AREA

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Abstract

An experiment was conducted at MLT site, Kuakata, Patuakhali in the Rabi season of 2020-21 to investigate the effects of drip mulches to mitigate soil salinity, water use efficiency and yield performance of tomato. Two different treatments were as follows: T₁: polythene mulch, T₂: conventional practice was used. The yield and yield-contributing characters in the polythene mulch treatment were significantly higher compared to those in the unmulched treatment. The lowest level of salinity & high moisture content was recorded from T₁ treatment in every growth stage of crops ranges from 1.27-5.65 whereas soil salinity was much higher in the treatment T₂ (1.26-10.21dS/m). The yield of mulching treatment was 84.13 t ha⁻¹ for polyethylene. Lower yield from conventional system with no mulch was 71.78 t ha⁻¹. Higher gross margin Tk. 805950 and BCR (2.77) was obtained from T₁ treatment and lower performance from T₂.

Introduction

Patuakhali region is a distinctive physiologic unit in the southern part of Bangladesh, which is characterized by extreme environmental conditions for agricultural production. Southern part of the region is called problematic area/saline area. This area is characterized by high soil salinity and scarcity of sweet water for irrigation in the dry season. Most of the T. Aman of Kalapara are harvested within November 30 to December 15. Then these lands remain fallow due to scarcity of irrigation water and

increasing salinity. Fresh water is a prime factor to minimize soil salinity to a greater extent. Judicial application of water is necessary to irrigate the crops. Raise bed planting and mulching with different materials like polythene, straw mulches are documented in different literature to be a measures of soil salinity mitigation and soil water conservation. Mulch reduces placing of soil onto the fruits, leaves and other parts of the plant. This keeps the product cleaner and free from diseases (Lamnot, 1991). The plastic mulch may be transparent, black, red, yellow or others depending on the purpose of the mulch (Rudich, 1979). We used blue polythene mulch in experimental plot. Mulch also helps reduce the disease incidence. Mulch application increased microbial activity and biomass in soil (Marr et al. 1992) and reduced the severity of some above ground diseases of plants in crops such as tomatoes (Baron, J.J et al. 1981). Organic mulches reduce the soil temperature by protecting the soil from direct heat of the Sun. Decoteau et al. (1988) and Sing et al. (1966) observed reduced soil temperature with the use of organic mulches in potato. Hence, this experiment was undertaken to evaluate the feasibility of polythene mulches for tomato cultivation to minimize the salinity and water use efficiency with the following objectives.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali in the Rabi season of 2020-21 to evaluate the performance of polythene mulching to mitigate soil salinity as well as conserve soil moisture in tomato field. It was consisted with two treatments: T₁: polythene mulch, T₂: conventional practice. The experiment was laid out in randomized complete block design (RCBD) with six disperse replications. The tomato (Hybrid: Bijli super) seedlings of 30 days old were transplanted in unit plots of 5 m × 1.2 m with 60 cm × 40 cm spacing on 15-17 December 2020. For mulching, 10 µm blue polyethylene sheet having holes of 50 mm diameter at a distance of 60 cm × 40 cm was spread over the beds and tomato seedlings were transplanted in the holes. Recommended fertilizer doses (N₁₁₀, P₄₀, K₈₀ kg ha⁻¹) for fertigation were used except conventional one. Total amount of P in the form of triple super phosphate (TSP) was applied at the time of final land preparation while N and K in the form of urea and muriate of potash (MOP), respectively, were applied with drip irrigation into four equal splits at 15 days intervals. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed two simple t-test. Ripened tomato was harvested 6-8 times starting from 02 March to 04 April 2021.

Results and Discussion

Soil salinity: The variations in the soil salinity for the treatments were measured and variation of the soil salt was dissimilar across the different treatments. The soil salinity was a considerable level (1.27-5.65dS/m) in polythene mulch treatment for proper plants growth and yield but it was not suitable for better crop yield in no-mulched treated plots that's salinity varies from 1.26-10.21dS/m.

Tomato yield: Plant height, fruits per plant and individual fruit wt. of tomato under different treatments are shown in Table 1. The mulch treatment enhanced the plant height, no. of fruits/plant. The plant height was higher in polythene mulch (117.89 cm) and lower from conventional practices (106.73cm). All the parameters gave higher value in polythene mulch. So, fruit yield was also greater (84.13 t ha⁻¹) in the same treatment. Lower yield was found from without mulch plot (71.78 t ha⁻¹).

Weed incidence: The higher weed infestation was found in conventional practice without mulch and lowest infestation in polythene mulch.

Cost and return

The results indicated that higher gross margin Tk.805950 was obtained from T₁: polythene mulch with better BCR- 2.77. The lowest yield was obtained from T₂ treatment.

Farmer's opinion

1. The farmers obtained more yield and profit from polythene mulch than the other treatments.
2. Initial cost is higher but less irrigation required in that area.

Table1: Yield and yield attributes of tomato during Rabi season 2020-21 at Kuakata, Patuakhali

Treatments	Plant height (cm)	Fruits/plant 30-35	Wt. of fruits/plant (kg)	Individual fruit wt (g)	Fruit yield (t ha ⁻¹) 2020-21
T ₁	117.89	38.45	2.74	78.51	84.13
T ₂	106.73	31.47	2.16	74.35	71.78
P value	0.027	0.043	0.029	0.092	0.019
LSD _{0.05}	*	*	*	NS	*

T₁: polythene mulch, T₂: conventional practice

Table 2. Cost analysis of tomato production under mulching system

Treatments	Gross return (Tk.ha ⁻¹)	Cost of production (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
T ₁	1261950	456000	805950	2.77
T ₂	1076700	421700	655000	2.55

Tomato-15 tk/kg

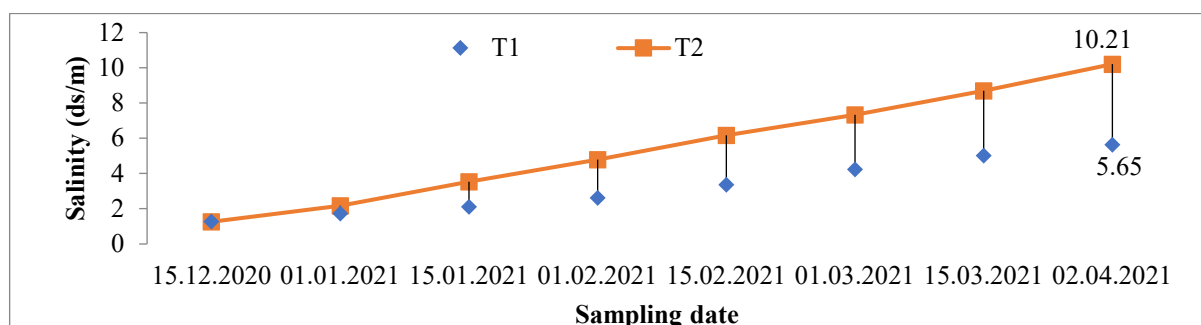


Fig-1: Salinity level of different treatments

Conclusion

The use of mulch is a good option not only for water saving & mitigating salinity but also for improved yield. Polythene mulch system economized 55% of irrigation water and reduced salinity level upto 50% compared to control treatment.

EFFECT OF BORDER TREES ON POTATO IN NORTHERN REGION OF BANGLADESH

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Abstract

The experiment was conducted at multi-location testing (MLT) site Gobindaganj, Gaibandha during the rabi season of 2018-2019, 2019-2020 and 2020-2021 to evaluate the effect of border trees on crop production in northern region of Bangladesh. The experiment consisted of two treatments viz. T₁=Normal potato field, T₂=Tree surrounded potato field a popular potato variety was used in this study. The experiment was laid out in randomized complete block design with three replications. Open field potato cultivation produced higher tuber yield compare to tree surrounded potato field. In 2018-2019, the highest tuber yield was recorded in T₁ (31.10 t ha⁻¹). The lowest tuber yield was recorded in T₂ (18.45 t ha⁻¹). The highest gross margin (Tk.114219 ha⁻¹) was found from T₁ and lowest was in T₂. It was found that border trees reduced the crop yield as well as decreased the economic income of the farmers. Similar results also found in 2019-2020 and 2020-2021.

Introduction

Potato (*Solanum tuberosum*) is the world's fourth most economically important food crop, after wheat, rice and maize. In Bangladesh, the crop is the third most important crop in Bangladesh next to rice and wheat. According to DAE, the crop occupies 4.963 lac hectare lands with the annual production of 103.04 lac metric tons during 2015-16. The national average yield of potato is very low (20.77 tha⁻¹)

compare to its potential yield, due to lack of quality seed, cultivation of indigenous potato and high price of quality seed. Tuber Crop research Centre (TCRC), BARI has developed a good number of potato varieties which are supposed to be higher yielder and less susceptible to insect pest and diseases.

When assessing all the ways that extreme drought affects crops, a subtle factor to consider is the impact of tree roots on the water supply available to nearby plants. While gardeners and farmers tend to think of trees primarily in terms of shade (as competitors for sunlight), under these extreme drought conditions trees can become serious competitors for water too. Trees are increasingly being planted on the levees of crop fields in northern region of Bangladesh. But little information available about the effect of border trees on crop production. Thus, the experiment was carried out to see the effect of border trees on potato in the northern region of Bangladesh.

Materials and Methods

The experiment was conducted at Multi-location testing (MLT) site Gobindaganj, Gaibandha during the *rabi* season of 2018-2019, 2019-2020 and 2020-2021. The soil texture of the land was sandy loam. The pH, organic matter, total N, available P, K, S, Zn and B were 5.7, 1.05%, 0.06%, 10.2 µg/g soil, 0.18 meq/100g soil, 59.3 µg/g soil, 0.49 µg/g soil and 0.17 µg/g soil, respectively (Table 1). The experiment consisted of two treatments viz. T₁=Normal potato field, T₂=Tree surrounded potato field a popular potato variety was used in this study. The experiment was laid out in randomized complete block design with three disperse replications. The unit plot size was 8m × 5m. BARI Alu-25 variety was used for this study. The tuber were planted on 2 November to 03 December 2018 and 28 November to 30 November 2019 and 27 November to 30 November 2020 maintaining standard seed rate. The crop was irrigated twice at 30 DAS and 55 DAS. Half of urea and entire amount of all fertilizers were applied during the final land preparation. Tubers were covered by soil after planting. The rest half of urea was top dressed at 30 DAP. The necessary data on yield contributing characters were collected during the maturity stage by sampling 10 plants plot⁻¹. Finally, potato tuber was harvested on 01-05 March, all the year. For the determination of tuber yield crop cut was done from whole area from each plot and accordingly yield ha⁻¹ was calculated.

Production costs of potato included the cost of all operations. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return.

Data recorded on plant parameters which were statistically analysed using statistical program IRRISTAT 5.0 (IRRI, 2005). Means were averaged over treatments/growing seasons, and were separated by using least significant difference (LSD 0.05).

Table 1. Initial soil status of the experimental plot of stable charland at Gobindaganj, Gaibandha

	pH	OM (%)	Total N (%)	P	S	Zn	B	K
				µg/g soil				meq/100g soil
Value	5.7	1.05	0.06	10.2	59.3	0.49	0.17	0.18
Interpretation	Slightly acidic	L	VL	L	VH	L	L	L

VL=very low, L=Low, M=Medium, VH=Very high, OM=Organic Matter

Results and Discussion

Effect of border trees on potato during 2018-2019

The yield and yield attributes varied significantly with different treatments presented in Table 8. Higher plant height was measured in T₁ (85.07 cm) treatment and the lowest plant height was in tree surrounded potato field. Maximum number of stem hill⁻¹ was counted in T₁ (3.80) treatment and the lowest from tree surrounded potato field. Maximum number of tuber hill⁻¹ was recorded from T₁ (6.87) and the lowest was T₂ treatment (5.00). Higher tuber weight per hill⁻¹ was observed in T₁ (543.00 g) and the lowest tuber weight hill⁻¹ was in T₂ (373 g). The highest tuber yield was recorded in T₁ (31.10 t ha⁻¹) treatment and the lowest was in T₂ (18.45 t ha⁻¹). It was found that border trees have significant effect on tuber yield.

The highest volumetric water content (%) at harvest stage of potato was found in normal potato field which was 14.9 % and the lowest from tree surrounded potato field distance from border 1 m which was 2.0%. In case of tree surrounded potato field the highest volumetric water content (%) was found in distance from border 5 m which was 7.85% (Table-2). The SPAD reading at harvest indicates that highest SPAD reading was produced with normal potato field which was 37.2 (table-5) and the lowest was in tree surrounded potato field. Nitrogen being the major constituent of chlorophyll therefore increased in nitrogen availability leads to increase in chlorophyll content (Baharvandet *et al.*, 2014). Border trees also reduced the crop yield due to the low moisture, less amount of chlorophyll production.

Cost and return analysis: The highest gross margin (Tk.114219 ha⁻¹) was found from T₁ and lowest in T₂ = Tree surrounded potato field (Table 11).

Pest incidence: Slightly aphid infestation was found during the vegetative stage, which was controlled successfully by spraying insecticide.

Effect of border trees on potato during 2019-2020

The yield and yield attributes varied significantly with different treatments presented in Table 9. Higher plant height was measured in T₁ (87.67 cm) treatment and the lowest plant height in tree surrounded potato field. Maximum number of stem hill⁻¹ was counted in T₁ (3.60) treatment and the lowest from tree surrounded potato field. Maximum number of tuber hill⁻¹ was recorded from T₁ (5.98) treatment and the lowest was in T₂ treatment (4.00). Higher tuber weight per hill⁻¹ was observed in T₁ (564 g) and the lowest tuber weight hill⁻¹ was in T₂ (388 g). The highest tuber yield was recorded in T₁ (30.78 t ha⁻¹) treatment. The lowest tuber yield was recorded in T₂ (20.46 t ha⁻¹). It was found that a border tree has significant effect on tuber yield.

The highest volumetric water content (%) at harvest stage of potato was found in normal potato field which was 13.6 % and the lowest was recorded from tree surrounded potato field distance from border 1 m which was 2.3%. In case of tree surrounded potato field the highest volumetric water content (%) was found in distance from border 5 m which was 7.2%. The SPAD reading at harvest indicates that highest SPAD reading was produced with normal potato field which was 36.9 and the lowest was found in tree surrounded potato field. Nitrogen being the major constituent of chlorophyll therefore increased in nitrogen availability leads to increase in chlorophyll content (Baharvandet *et al.*, 2014). Border trees also reduced the crop yield due to the low moisture, less amount of chlorophyll production.

Cost and return analysis: The highest gross margin (Tk. 172020 ha⁻¹) was found from T₁ and lowest in T₂ = Tree surrounded potato field (Table 12).

Pest incidence: Slightly aphid infestation was found during the vegetative stage, which was controlled successfully by spraying insecticide.

Farmers' opinion

Tree surrounded field required more irrigation compare to open field potato cultivation in northern region of Bangladesh. They also opined that potato cultivation under tree surrounded gave lower yield compare to open field.

Effect of border trees on potato during 2020-2021

The yield and yield attributes varied significantly with different treatments presented in Table 10. Higher plant height was measured in T₁ (86.87 cm) treatment and the lowest plant height in tree surrounded potato field. Maximum number of stem hill⁻¹ was counted in T₁ (3.8) treatment and the lowest from tree surrounded potato field. Maximum number of tuber hill⁻¹ was recorded from T₁ (6.67) treatment and the lowest in T₂ treatment (5.00). Higher tuber weight per hill⁻¹ was observed in T₁ (556 g) and the lowest tuber weight hill⁻¹ in T₂ (395 g). The highest tuber yield was recorded in T₁ (29.78 t ha⁻¹) treatment. The lowest tuber yield was recorded in T₂ (21.76 t ha⁻¹). It was found that a border tree has significant effect on tuber yield.

The highest volumetric water content (%) at harvest stage of potato was found in normal potato field which was 14.2 % and the lowest was recorded from tree surrounded potato field distance from border

1 m which was 2.5%. In case of tree surrounded potato field the highest volumetric water content (%) was found in distance from border 5 m which was 7.3%. The SPAD reading at harvest indicates that highest SPAD reading was produced with normal potato field which was 36.6 and the lowest was found in tree surrounded potato field. Nitrogen being the major constituent of chlorophyll therefore increased in nitrogen availability leads to increase in chlorophyll content (Baharvandet *et al.*, 2014). Border trees also reduced the crop yield due to the low moisture, less amount of chlorophyll production.

Cost and return analysis: The highest gross margin (Tk. 161130 ha⁻¹) was found from T₁ and lowest was in T₂ = Tree surrounded potato field (Table 13).

Pest incidence: Slightly aphid infestation was found during the vegetative stage, which was controlled successfully by spraying insecticide.

Farmers' opinion

Tree surrounded field required more irrigation compare to open field potato cultivation in northern region of Bangladesh. They also opined that potato cultivation under tree surrounded gave lower yield compare to open field.

Table 2. Volumetric water content (%) at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2018-19.

Treatments	Distance from border (1m)	Distance from border (2m)	Distance from border (3m)	Distance from border (4m)	Distance from border (5m)
T ₁ =Normal potato field	14.9	14.9	14.9	14.9	14.9
T ₂ =Tree surrounded potato field	2.0	4.5	5.3	6.3	7.85
t-value	5.37	8.07	16.22	8.22	8.85
Level of significant	**	**	**	**	**

Table 3. Volumetric water content (%) at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2019-2020.

Treatments	Distance from border (1m)	Distance from border (2m)	Distance from border (3m)	Distance from border (4m)	Distance from border (5m)
T ₁ =Normal potato field	13.6	13.6	13.6	13.6	13.6
T ₂ =Tree surrounded potato field	2.3	4.9	5.1	6.6	7.2
t-value	6.67	7.08	11.33	5.79	9.12
Level of significant	**	**	**	**	**

Table 4. Volumetric water content (%) at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2020-2021

Treatments	Distance from border (1m)	Distance from border (2m)	Distance from border (3m)	Distance from border (4m)	Distance from border (5m)
T ₁ =Normal potato field	14.2	14.2	14.2	14.2	14.2
T ₂ =Tree surrounded potato field	2.5	4.6	5.5	6.4	7.3
t-value	5.87	7.66	11.89	7.78	10.67
Level of significant	**	**	**	**	**

Table 5. Border trees impact on SPAD at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2018-19

Treatments	SPAD	
	Distance from border (2m)	Distance from border (5m)
T ₁ =Normal potato field	37.2	37.2
T ₂ =Tree surrounded potato field	36.6	36.9
t-value	5.92	9.78
Level of significant	**	**

Table 6. Border trees impact on SPAD at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2019-20.

Treatments	SPAD	
	Distance from border (2m)	Distance from border (5m)
T1=Normal potato field	35.9	35.9
T2=Tree surrounded potato field	35.2	35.2
t-value	6.78	8.34
Level of significant	**	**

Table 7. Border trees impact on SPAD at harvest stage of potato field under different treatments at Gobindaganj, Gaibandha during the rabi season of 2020-2021

Treatments	SPAD	
	Distance from border (2m)	Distance from border (5m)
T1=Normal potato field	36.6	36.6
T2=Tree surrounded potato field	36.1	35.8
t-value	7.78	8.89
Level of significant	**	**

Table 8. Yield and yield contributing characters of potato under different treatments at Gobindaganj, Gaibandha during the rabi season of 2018-19.

Treatments	Plant height (cm)	Number of Branch plant ⁻¹	Number of tuber plant ⁻¹	Weight of tuber plant ⁻¹ (kg)	Tuber yield (t ha ⁻¹)
T1=Normal potato field	85.07	3.80	6.87	0.543	31.10
T2=Tree surrounded potato field	64.33	2.67	5.00	0.373	18.45
t value	17.22	11.0	4.91	13.94	14.02
Level of significant	**	**	**	**	**

Table 9. Yield and yield contributing characters of potato under different treatments at Gobindaganj, Gaibandha during the rabi season of 2019-20.

Treatments	Plant height (cm)	Number of Branch plant ⁻¹	Number of tuber plant ⁻¹	Weight of tuber plant ⁻¹ (kg)	Tuber yield (t ha ⁻¹)
T1=Normal potato field	87.67	3.60	5.98	0.564	30.78
T2=Tree surrounded potato field	69.98	2.87	4.00	0.388	20.46
t value	11.77	5.78	3.67	11.00	9.33
Level of significant	**	**	**	**	**

Table 10. Yield and yield contributing characters of potato under different treatments at Gobindaganj, Gaibandha during the rabi season of 2020-21.

Treatments	Plant height (cm)	Number of Branch plant ⁻¹	Number of tuber plant ⁻¹	Weight of tuber plant ⁻¹ (kg)	Tuber yield (t ha ⁻¹)
T1=Normal potato field	86.87	3.80	6.67	0.556	29.78
T2=Tree surrounded potato field	71.56	3.10	5.00	0.395	21.76
t value	9.98	3.22	3.87	8.98	11.56
Level of significant	**	**	**	**	**

Table 11. Cost and return analysis of Potato production under different management at Gobindaganj, Gaibandha during the rabi season of 2018-19

Treatment	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T1=Normal potato field	31.10	248800	134581	114219
T2=Tree surrounded potato field	18.45	147840	140931	6909

Price: (Tk kg⁻¹): Urea: 16, TSP: 25, MoP: 15, Gypsum: 10, ZnSO₄: 160, Boric acid: 460, Magnesium: 25 and Potato: 8

Table 12. Cost and return analysis of Potato production under different management at Gobindaganj, Gaibandha during the rabi season of 2019-2020

Treatment	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T1=Normal potato field	30.78	307800	135780	172020
T2=Tree surrounded potato field	20.46	204600	141970	62630

Price: (Tk kg⁻¹): Urea: 16, TSP: 25, MoP: 15, Gypsum: 10, ZnSO₄: 160, Boric acid: 460, Magnesium: 25 and Potato: 10

Table 13. Cost and return analysis of Potato production under different management at Gobindaganj, Gaibandha during the rabi season of 2020-2021

Treatment	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T1=Normal potato field	29.78	297800	136670	161130
T2=Tree surrounded potato field	21.76	217600	143990	73610

Price: (Tk kg⁻¹): Urea: 16, TSP: 25, MoP: 15, Gypsum: 10, ZnSO₄: 160, Boric acid: 460, Magnesium: 25 and Potato: 10

Conclusion

From the results, it was revealed that under tree surrounded land required more irrigation compare to open field as well as the border tree has significant effects on potato yield. So, the tree surrounded potato field decreased average 10 t ha⁻¹ potato yield compare to open field normal potato. Border tree has significant effects on potato yield, and it has reduced around 30 % potato yield compare to open field.

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EFFECT OF DIFFERENT PLATING TIME AND VARIETY ON THE YIELD OF GLADIOLUS

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Abstract

An experiment was conducted in the farmers field at FSRD site, Atia during the two consecutive years of 2019-20 and 2020-21 to find out the effect of planting time and variety on the yield of flower and corm of gladiolus to increase productivity and economic return of farmers'. The treatment combinations used for this experiment were three sowing time (T₁: 15 October, T₂: 30 October, T₃: 15 November) with three variety (V₁: BARI Gladiolus-3, BARI Gladiolus-4, and BARI Gladiolus-5). Among the treatment combinations the highest spike yield (184000) was found in BARI Gladiolus-4 planted 30 October. But the maximum gross return (1767997 Tk. ha⁻¹) and gross margin (1495642 Tk. ha⁻¹) were recorded from BARI Gladiolus-5 planted in 15 October.

Introduction

Gladiolus (*Gladiolus grandiflorus*), popularly known as "Sword Lily" is an ornamental cormelous plant native to South Africa. It belongs to monocot family Iridaceae, having approximately one hundred and fifty known species (Negi *et al.* 1982). This plant is commercially used for cut flowers and occasionally used for landscape purpose. Gladiolus produces very attractive flowers and there is a great consumer demand in the market. To satisfy the customers' demand, it is important to make gladiolus flower available round the year in the market. Date of planting plays an important role in regulating growth and quality of gladiolus (Khan *et al.* 2008). Vegetative growth and quality of gladiolus is improved by proper planting times which also satisfies the consumer's demands (Zubair *et al.* 2006). Planting schedule vary because of differences in photoperiods, temperatures and light intensity (Susan *et al.* 1991). Growth and yield of gladiolus, like other plants, depend on proper planting time. The present

research work was planned to investigate the best planting time so that farmers can harvest flowers for a long duration with best variety suitable for Tangail region.

Materials and Methods

The experiment was conducted at the FSRD site, Atia to find out the best planting time and suitable variety for Tangail under AEZ 8. The experiment was laid out in factorial RCB design with three dispersed replications. The unit plot size was 10 m². Corm was planted with maintaining 25 cm × 15 cm spacing. The treatment comprised with three planting time T₁: 15 October, T₂: 30 October, T₃: 15 November and three variety V₁: BARI Gladiolus-3, V₂: BARI Gladiolus-4, V₃: BARI Gladiolus-5. The land was fertilized with 152-82-165-0.09-3-2 kg NPKSZnB, respectively and 5 ton cow dung per hectare. Entire quantity of cow dung, P, K, S, Zn, and B were applied during the final land preparation. Urea was applied in two equal installments at 25 and 50 days after emergence. One irrigation was provided. Weeding was done two times. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on the yield and yield contributing characters were taken and statistically analyzed following CropStat.

Results and Discussions

Effect of planting time: Yield and yield contributing characters of gladiolus were found significantly influenced by different planting time (Table-1). The spike length, rachis length, flower spike⁻¹ showed significant difference among the planting times except spike yield. The longest spike (74.07 cm) and rachis (44.30 cm) length as well as highest number of florets spike⁻¹ (10.87) and spike yield (190333 no. ha⁻¹) were observed in 15 November planting. On the other hand, the lowest spike (60.96) and rachis length (42.56) was observed in 30 October planting. The lowest number of florets spike⁻¹ (9.33) and spike yield (186889 no. ha⁻¹) was recorded from 15 October planting time.

Effect of variety: Gladiolus varieties showed significant variation only in spike yield parameter. The highest yield was observed in BARI Gladiolus-3 (194900 no. ha⁻¹) and the lowest yield (185700 no. ha⁻¹) in BARI Gladiolus-4.

Planting time and variety interaction effect: In interaction effect of planting time and variety significant variations were observed in spike length, floret spike⁻¹ and spike yield. The highest spike length was found in T₃V₃ (74.40 cm) and the lowest in T₂V₃ (59.73 cm). The highest number of florets spike⁻¹ was recorded from T₃V₁ combination (11.40) and the lowest 8.87 in T₁V₃ combination. The highest spike yield was observed in T₂V₂ combination, which was at par with T₁V₁, T₁V₃, T₁V₂ and the lowest spike yield (160416.50) was observed in T₃V₃ combination. In cost and return analysis the maximum gross return (Tk. 1767997 ha⁻¹) and gross margin (Tk. 1495642 ha⁻¹) were recorded from T₁V₃ combination. It may be due to the higher market price of BARI Gladiolus-5 and better yield.

Pest incidence: Dithene M-45 @ 4 g/L was sprayed for controlling tip burn disease. Recommended dose of furadan 5G was applied in the soil to control mole cricket.

Farmer's opinion

Farmers of shown keen interest on gladiolus cultivation. They opined that gladiolus is highly profitable crop. Farmers need training about the production technology and postharvest management of gladiolus.

Table 1. Effect of planting time on the yield and yield contributing characters of gladiolus FSRD site, Atia, Tangail during 2019-20

Planting time	Spike length (cm)	Rachis length (cm)	Floret spike ⁻¹ (no.)	Spike yield (no. ha ⁻¹)
T ₁	64.87	43.4667	9.33333	186889
T ₂	60.96	42.5556	10.1778	188889
T ₃	74.07	44.3000	10.8667	190333
LSD _{0.05}	4.25	1.70571	0.815791	7838.66
CV (%)	7.50	4.60	9.10	3.80

T₁: 15 October, T₂: 30 October, T₃: 15 November

Table 2. Effect of variety on the yield and yield contributing characters of gladiolus FSRD site, Atia, Tangail during 2020-21

Variety	Spike length (cm)	Rachis length (cm)	Floret spike ⁻¹ (no.)	Spike yield (no. ha ⁻¹)
V ₁	68.14	44.14	10.44	194900
V ₂	67.02	43.44	10.20	185700
V ₃	66.96	43.00	9.96	186000
LSD _{0.05}	6.92	1.79	1.00	6804.92
CV (%)	7.50	4.60	9.10	3.80

V₁: BARI Gladiolus-3, V₂: BARI Gladiolus-4, V₃: BARI Gladiolus-5

Table 3. Interaction effect of planting time and variety on the average yield and yield contributing characters of gladiolus FSRD site, Atia, Tangail during 2019-20 and 2020-21

Planting time *variety	Spike length (cm)	Rachis length (cm)	Floret spike ⁻¹ (no.)	Spike yield (no. ha ⁻¹)		
				2019-20	2020-21	Mean
T ₁ V ₁	67.40	44.13	9.40	169000	194000	181500.00
T ₁ V ₂	62.93	43.47	9.73	180000	179333	179666.50
T ₁ V ₃	64.27	42.80	8.87	175333	187333	181333.00
T ₂ V ₁	61.27	43.80	10.20	166667	191000	178833.50
T ₂ V ₂	61.87	42.20	10.00	175000	193000	184000.00
T ₂ V ₃	59.73	41.67	10.33	169667	182667	176167.00
T ₃ V ₁	73.85	44.40	11.40	136667	198500	167583.50
T ₃ V ₂	73.95	44.35	10.70	140000	185000	162500.00
T ₃ V ₃	74.40	44.15	10.50	133333	187500	160416.50
LSD _{0.05}	8.61	3.38	1.58	22538.3	12029.3	17283.80
CV (%)	7.50	4.60	9.10	8.20	3.80	6.00

Table 4. Cost and return analysis of gladiolus influenced by variety and different plating time at FSRD site, Atia, Delduar, Tangail

Planting time *variety	Gross return (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁ V ₁	1270500	272355	998145
T ₁ V ₂	1527165	272355	1254810
T ₁ V ₃	1767997	272355	1495642
T ₂ V ₁	1251835	272355	979479.5
T ₂ V ₂	1564000	272355	1291645
T ₂ V ₃	1717628	272355	1445273
T ₃ V ₁	1173085	272355	900729.5
T ₃ V ₂	1381250	272355	1108895
T ₃ V ₃	1564061	272355	1291706

Market price (Tk. stick⁻¹): BARI Gladiolus-3: 7, BARI Gladiolus-4: 8.5 and BARI Gladiolus-5: 9.75

Conclusion

Two years result indicates that BARI Gladiolus-4 planted in 30 October provided maximum spike yield. But due to higher market price of BARI Gladiolus-5 gave maximum gross margin planted in 30 october. It may be recommended as extension message for cultivation in large area in Tangail region.

PERFORMANCE OF GARLIC VARIETIES UNDER ZERO TILLAGE METHOD WITH MULCH IN TANGAIL

S. Roy, M. A. H. Khan, M. M. Rahman, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at FSRD site Atia, Tangail during rabi 2019-20 and 2020-21 to evaluate the performance of garlic cultivation under zero tillage and conventional method as well as to introduce conservation agricultural technique. The treatments comprised with three variety of garlic viz. BARI Rashun-2, BARI Rashun-3, and farmers' variety along with two mulching material rice straw and water hyacinth. Among the treatment combinations the highest average bulb yield (10.27 t ha^{-1}) and gross margin (Tk. 345640 ha^{-1}) were obtained from BARI Rashun-2 along with rice straw mulch in two consecutive years. The lowest yield (6.52 t ha^{-1}) and gross margin (Tk. 161890 ha^{-1}) were obtained from BARI Rashun-3 along with water hyacinth mulch.

Introduction

Garlic (*Allium sativum*) is a promising spices and cash crop in Bangladesh. There are some progressive farmers grow garlic after harvest of *B. Aman* rice with no or less care in Delduar and Basailupazilaof Tangail district in very limited scale. Garlic could not express its yield potentiality and as a result farmer do not get the maximum return from garlic cultivation. In Tangail district, a large area remains fallow after *B. Aman* harvest. Garlic can easily be grown in that area for large scale production under zero tillage. Before that an experiment is required in that area to select a suitable variety of garlic and mulching materials which increasing crop production by utilizing fallow land as well as farmers' income. BARI has developed HYV garlic varieties viz. BARI Rashun-2 and BARI Rasun-3. Conservation agriculture is a promising technology for increasing productivity with less cost of cultivation. Therefore, the present experiment was undertaken to evaluate the performance of garlic cultivation under zero tillage condition.

Materials and methods

The experiment was conducted at the FSRD site Atia, Tangail during the rabi season of 2019-20 and 2020-21 to evaluate the performance of garlic cultivation under zero tillage and conventional method as well as to introduce conservation agricultural technique. The experiment was laid out in factorial RCB design with six dispersed replications. The unit plot size was 5 m x 2 m. Cloves of garlic were sown on 8 November, 2020 with 10 cm x 10 cm spacing. Three garlic varieties were considered following two mulching method viz. mulching with rice straw and mulching with water hyacinth. The land was fertilized with 100-53-166-20 kg NPKS ha^{-1} . The full dose of PKS and $1/3^{\text{rd}}$ of N was applied during final land preparation. The remaining $2/3^{\text{rd}}$ urea were applied in two equal installments at 3 and 6 weeks after sowing (DAS). One irrigation was provided at 40 DAS. Required amount of rice straw and water hyacinth as mulching material was 1875 and 3750 kg ha^{-1} , respectively. Other necessary management was done for the normal growth and development of the crop. The crop was harvested during 17 to 23 April, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Necessary data were collected plot wise and analyzed statistically using Crop Stat analytical package.

Results and Discussion

Effect of variety: Days to maturity, plant height (cm), individual bulb weight (g), and bulb yield (t ha^{-1}) showed significant variation among the treatments (Table 1). The lowest days to maturity (136 day) was recorded in BARI Rashun-2 whereas longest days to maturity (141 day) in farmers' variety. Farmers' variety showed the longest plant height (80.53 cm) and the shortest plant in BARI Rashun-2 (55.93 cm). BARI Rashun-2 produced the highest individual bulb weight (16.59 g) followed by BARI Rashun-3 and the lowest by farmers variety. The highest bulb yield (10.30 t ha^{-1}) was recorded in BARI Rashun-2 which was statistically significant differ from other varieties. BARI Rashun-2 produced higher bulb yield might be due to higher number of plant population per m^2 and higher individual bulb weight. The lowest bulb yield (7.51 t ha^{-1}) was recorded from farmer's variety.

Effect of mulching: There was no significant difference among the yield contributing characters of two mulching material. Rice straw mulch produced the highest bulb yield (9.14 t ha⁻¹) whereas water hyacinth mulch produced the bulb yield (8.22 t ha⁻¹). This might be due to number of plants per m² and individual bulb weight was higher in rice straw mulch (Table 2).

Interaction effect of variety and mulch material: Interaction effect of variety and mulch on yield and yield contributing characters of garlic varied significantly (Table 3). The highest number of plants m⁻² was higher in V₁M₁ (66.00) treatment combination and the lowest in V₂M₂ (61.00) treatment. The highest days to maturity (146 day) was observed in V₃M₂ and shortest time to maturity (137 day) in V₁M₂ combination. The highest plant height was observed in V₃M₁ (78.73 cm) followed by V₃M₂ (78.33 cm) and the shortest plant in V₁M₁ (52.20 cm) combination. Individual highest bulb weight was recorded in V₁M₁ (16.93 g) and the lowest bulb weight from V₃M₂ (10.10 g). Average maximum bulb yield (10.27 t ha⁻¹) was found in V₁M₁ followed by V₁M₂ (9.08 t ha⁻¹) treatment combination. This might be due to higher plants per m² and higher individual bulb weight from V₁M₁ treatment combination. The lowest bulb yield was recorded in V₃M₂ (6.52 t ha⁻¹) might be due to lower plants per m² and individual bulb weight. The average highest gross return (Tk. 513500 ha⁻¹) and gross margin (Tk. 345640 ha⁻¹) were recorded from V₁M₁ treatment combination and the lowest gross return (Tk. 326000 ha⁻¹) and gross margin (Tk. 161890 ha⁻¹) from V₃M₂ treatment combination (Table 4).

Pest incidence: Tip burn disease was successfully controlled by applying Rovral.

Farmers' opinion: This technology is new one in Atia, Tangail. The farmers of this area are interested in growing garlic along with rice straw mulch.

Table 1. Effect of variety on yield and yield contributing characters of garlic at FSRD site Atia, Tangail during rabi season of 2020-21

Variety	Plants m ⁻²	Days to maturity (cm)	Plant height (cm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)
V ₁	65	136.00	55.93	16.59	10.30
V ₂	63	137.00	71.15	12.97	8.18
V ₃	61	141.00	80.53	11.17	7.51
LSD _{0.05}	2.56	3.86	4.25	1.46	0.97
CV (%)	6.10	5.98	5.30	8.60	7.80

V₁ = BARI Rashun-2, V₂ = BARI Rashun-3, V₃ = Farmer's variety

Table 2. Effect of mulching on yield and yield contributing characters of garlic at FSRD site Atia, Tangail during rabi season of 2020-21

Mulching	Plants m ⁻²	Days to maturity (cm)	Plant height (cm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)
M ₁	65.30	137	65.12	13.68	9.14
M ₂	63.28	139	67.27	13.09	8.22
LSD _{0.05}	NS	NS	NS	NS	0.70
CV (%)	4.40	1.90	4.10	8.70	8.50

M₁ = Mulch with rice straw and M₂ = mulch with water hyacinth

Table 3. Interaction effects of different variety and mulching on the yield contributing characters and bulb yield of garlic at FSRD site Atia, Tangail during rabi season of 2019-20 and 2020-21

Variety × mulching	Plants m ⁻²	Days to maturity (cm)	Plant height (cm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)		
					2019-20	2020-21	Mean
V ₁ M ₁	66.00	138	52.20	16.93	10.47	10.07	10.27
V ₁ M ₂	64.00	137	53.67	14.60	9.13	9.03	9.08
V ₂ M ₁	64.00	138	65.93	11.60	7.60	7.30	7.45
V ₂ M ₂	61.00	141	70.37	10.97	6.97	6.57	6.77
V ₃ M ₁	63.00	142	78.73	11.00	7.00	6.81	6.91
V ₃ M ₂	62.00	146	78.33	10.10	6.67	6.37	6.52
LSD _{0.05}	3.77	3.76	3.88	2.06	1.25	1.15	-
CV (%)	6.40	5.90	7.50	9.60	8.80	9.40	-

V₁ = BARI Rashun-2, V₂ = BARI Rashun-3, V₃ = Farmer's variety, M₁ = Mulch with rice straw, M₂ = mulch with water hyacinth

Table 4. Cost and return analysis of garlic influenced by variety and mulching at FSRD site Atia, Tangail during rabi season (average 2019-20 and 2020-21).

Variety × mulching	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
V ₁ M ₁	513500	167860	345640
V ₁ M ₂	454000	164110	289890
V ₂ M ₁	372500	167860	204640
V ₂ M ₂	338500	164110	174390
V ₃ M ₁	345500	167860	177640
V ₃ M ₂	326000	164110	161890

Garlic bulb price (Tk. kg⁻¹) = 50

Conclusion

Results of the two years trial clearly indicated that garlic variety BARI Rashun-2 along with rice straw mulch was more productive and profitable than other treatments. Thus, garlic can be successfully grown in zero tillage condition after T. Aman rice harvest in Delduarupazila of Tangail district to increase cropping intensity and system productivity with profitability. Therefore, this technology may be recommended for large scale dissemination.

EFFECT OF DIFFERENT PLANTING METHODS ON THE YIELD AND MATURITY DURATION OF SUNFLOWER IN THE HAOR AREA OF KISHOREGANJ

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Abstract

A field study was conducted at Guroy, Nikli upazilla under OFRD, BARI, Kishoreganj during 2020-21, to observe the effects of different ages poly bag seedlings on yield and maturity duration of sunflower in the haor areas of Kishoreganj. The experiment was laid out in a RCBD with three replications with three treatments i. e; a. Poly bags seedling at 7 days, b. Poly bags seedling at 14 days and c. Direct seeding. The variety was BARI Surjomukhi-3. Among the treatments the highest yield was found from direct seeding (1.83 t ha⁻¹) followed by poly bags seedling at 7 days (1.75 t ha⁻¹) and poly bags seedling at 14 days (1.73 t ha⁻¹). The highest gross return (91500 Tk ha⁻¹), gross margin (41361 Tk ha⁻¹) and BCR (1.83) was calculated from direct seeding followed by Poly bags seedling at 7 days but maturity is earlier in poly bags seedling at 14 days.

Introduction

Haor is bowl-shaped large tectonic depression and receive surface runoff water by rivers, Khals and consequently, a haor becomes very extensive water body in monsoon period. In Bangladesh, 17% of the country's land covering by haor area. From the month of April-May haor get its sea like appearance and relief up to October. Most of the farmers are haor agriculture, practicing Boro-fallow-fallow cropping pattern. They transplant Boro in the last week of January to first week February. Before going to Boro season most the land remain fallow i.e; about 90 days. In some lands are high lands in the haor farmers are cultivating sweet potato, chilli, maize and other vegetable crops. Like mustard, sunflower is one of the vital oil seed crops and has scope to adapt. BARI has developed three sunflower varieties. But at rabi season sunflower takes 90 to 100 days to mature that creates a problem to next Boro crop. Late transplanting of Boro at haor areas could be destroyed by early flash flood. Keeping this problem in mind the experiment has been undertaken to shortening the life duration of sunflower. According to the Ministry of Commerce, the country imports 2.2-2.6 million tonnes of crude soybean and palm oils annually against the domestic demand of 2.2 million tones. Therefore the sunflower cultivation in the haor area meet up the oil scarcity in Bangladesh to a small extent.

Objectives

- To find out the suitable planting system of sunflower in haor areas
- To increase yield and farmers' income

Materials and Methods

The experiment was carried out in farmer's field at Guroi, Nikli, Kishoreganj during 2020-2021 to observe the performance of transplanting poly bags seedling and line sowing (Farmer's practice). Three treatments were included in this study viz; i) Transplanting poly bags seedling at 7 days, ii) Transplanting poly bags seedling at 14 days iii) Direct line sowing (Farmer's practice). The design was RCB with three dispersed replications (Ferdous et al. 2018). The variety was BARI Surjomukhi-3. In Polybags 6:1 ratios of soil and poultry manure mix soil media was filled up with 250 g soil containing poly pack than sunflowers seed was placed in the 2-3 cm depth. For the seedling establishment, the poly bags 7 days and the poly bags 14 days were sown in 11 November 2020 and 4 November 2020. Again, transplanting and sowing (Farmers practice) were executed followed by 60 cm × 25 cm spacing in 10 m x 8 m individual plots on 18 November 2020. The seeds rate was 28 kg ha⁻¹ in farmers practice and 25 kg ha⁻¹ for transplanting purposes. Fertilizer dose was N₉₂ P₃₆ K₇₀ S₂₇ Zn_{3.7} B_{1.7} Kg ha⁻¹. One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used. All intercultural operations were done as and when necessary. In case of cutworm infestation, Karate was used three times at the rate of 1.5 ml L⁻¹ water. The 7 days poly bags seedlings, 14 days poly bags seedlings and direct line sowing (Farmer's practice) crops were harvested at 10 January, 1 January and 22 January after the maturity of flowers. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data recorded on yield, and yield-contributing characters were adjudged by (LSD) Statistix 10 for windows 1998. Analytical software. Tallahassee, SLA, USA.

Results and Discussion

Yield and yield contributing attributes of sunflower were influenced significantly by the different planting system (Table 1). The plant height was found higher at poly bags seedling at 14 days (84.37 cm) followed by farmer's practice (84.3 cm) and poly bags seedling at 7 days (81.4 cm). The highest head diameter was found in farmer practice (12.43 cm) and the lowest from poly bags seedling at 7 days (10.7 cm). The highest weight of head (164.1 gm) and seed/ head (285.7 No.) was found at farmer practice and the lowest from poly bags seedling at 7 days (128.8 gm) and (253.7 No.), respectively. It might be due to transplanting shock. The highest seed weight/head was found at farmer practice (18.4 gm) and the lowest from poly bags seedling at 14 days (16.1 gm). The maximum 1000 grain weight was found from poly bags seedling at 7 days (66.7 gm) and minimum from farmer practice (60.6 gm). The highest yield was obtained from farmer practices (1.83 t ha⁻¹) and the lowest from poly bag seedling at 14 days (1.73 t ha⁻¹). The yield contributing characters showed superiority at farmers practice because of lifetime difference. According to the planting method, total field duration was found highest in farmers practice (95 days) followed by poly bags seedling at 7 days (83 days) and poly bags seedling at 14 days (73 days). Though the farmers practice had high yield potential (1.83 t ha⁻¹) but it had long field duration (12-22 days more) than other treatments.

Farmers' assessment

Since sunflower cultivation was totally new in the haor area thus farmers are very much keen to grow dwarf type and short duration sunflower variety for going to next crop Boro rice.

Table 1. Yield and Yield contributing characters of sunflower under different planting methods during 2020-2021

Treatments	Pl./ ht. (cm)	Head dia. (cm)	Wt. of head (gm)	Seed/ head (No.)	Seed wt/head (gm)	1000 seed wt. (gm)	Seed yield (t ha ⁻¹)	Duration (days)
Poly bags seedlings at 7 days	81.4	10.7	128.8	253.7	17.1	66.7	1.75	83
Poly bags seedlings at 14 days	84.37	12.1	161.93	269.0	16.1	60.7	1.73	73
Direct seeding	84.3	12.43	164.1	285.7	18.4	60.6	1.83	95
CV (%)	3.13	8.18	7.09	1.51	1.96	3.94	5.44	-
LSD (0.05)	5.91	2.18	24.35	9.24	0.76	5.59	0.22	-

Table 2. Economic performance of sunflower in different planting methods during 2020-21

Treatments	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
Poly bags seedlings at 14 days	86500	52135	34365	1.66
Poly bags seedlings at 7 days	87500	52135	34365	1.68
Farmer's prentice	91500	52135	41361	1.83

Conclusion

Though the polybag practice had lower yield potential (1.73 t ha⁻¹) but it had short field duration (12-22 days less) than other treatments. There was unavailability of sunflower seeds at growing season because the rabi season starts early in the haor areas. If the seeds are available at first week of September to first week of October in haor area then they willingly produce sunflower and harvest it by second week of January and they can easily cultivate Boro rice also.

EFFECT OF SPACING ON POTATO YIELD UNDER ZERO TILLAGE IN COASTAL SALINE SOIL OF BANGLADESH

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Abstract

Zero tillage potato cultivation could be an alternative way of crop intensification in the coastal fallow land of Bangladesh. However, tuber yield in zero tillage practice is lower and less economically viable in comparison to conventional practice if followed recommended spacing of 60 cm X 25 cm. Since canopy coverage and plant growth is lower in zero tillage practice in comparison to conventional tillage practice. An experiment was conducted at farmer's field at Dacope, Khulna during rabi, 2019-20 and 2020-21 by determining an optimum spacing of zero tillage potato. There were four spacing treatments viz. S1= 60 cm X 20 cm, S2 = 50 cm X 20 cm, S3= 40 cm X 20 cm and 30 cm X 20 cm and two potato varieties viz. BARI Alu-72 and 73. The experiment was conducted following the randomized complete block design with three replications. Results showed that the highest tuber yield was produced from S3 (23.6 t ha⁻¹) followed by S4 (20.15 t ha⁻¹) in 2019-20 and 2020-21, respectively. Based upon tuber yield, cost of production and potato price @15 Tk. kg⁻¹, the highest benefit-cost ratio was also calculated from S3 (3.30 and 2.59 in 2019-20 and 2020-21, respectively) treatment.

Introduction

Most of the lands in the south-western coastal region (viz. Khulna, Satkhira, Bagerhat) remain fallow after harvest of *Kharif* season rice. The harvest goes on from the first week of December to mid-January, which delays *rabi* crop cultivation in that area. As a result, in the *Rabi* season, most of the land remains fallow mainly due to late T. Aman harvest, shorter winter period, increasing soil and water salinity. In the project site at Tildanga village of Dacope Upazila (polder 31), farmers usually cultivate BR23 as T. Aman variety, which is a longer duration (about 150 days) and photosensitive. As a result, late T. Aman harvest is likely, moreover, poor sluice gate management aggravates the situation, which leads to late water recession from the land. Since clay soil retains more moisture than sandy loam soil. To increase cropping intensity, zero tillage cultivation with mulch could be an alternative way of crop production in that region.

A common practice of coastal saline area is farmers usually left about two-third of rice straw from bottom in the field, which can be reused as mulch material. However, from field data (unpublished) we showed that tuber yield under zero tillage practice with conventional 60 cm X 25 cm spacing is much lower. BARI has developed some heat and salt tolerant potato variety (e.g. BARI Alu-72, 73, 78 and 79), which is saline tolerant (up to 8 dS m⁻¹) as well as heat tolerant. So, heat tolerant variety with appropriate spacing could increase zero tillage potato yield in saline soils of Bangladesh.

Materials and Methods

The experiment was conducted at farmer's field at Dacope, Khulna (22° 35' 54.011" N latitude and 89° 27' 42.642" E longitude) during rabi, 2019-20. The objective of the experiment was to determine appropriate spacing for increasing tuber yield of zero tillage potato in saline soil. The soil of the location is generally clay to clay loam, which become moderate to high saline in April- May. Yearly average rainfall is about 1800 to 2200 mm. January is the coldest month (average temperature 15 to 20 °C) and highest temperature prevails between April to May (>35 °C).

There were four spacing treatments viz. S₁ = 60 cm X 20 cm, S₂ = 50 cm X 20 cm, S₃ = 40 cm X 20 cm and 30 cm X 20 cm. These spacings were tested on two potato varieties viz. BARI Alu-72 and 73. Treatments were designed in randomized complete block design with three dispersed replications. Seed potatoes (45-55 g) were sown on 22 December 2019. Unit plot size was 3 m X 3 m. Potatoes were sown by mild pressing into the wet soil so that about two-third of the potato remain above the ground. The ideal soil condition for zero tillage potato is when upon walking with bare feet, heels and toes do not get muddy but feels softness under feet. Each potato tubers were covered with compost and then covered with rice straw according to treatment. Before planting, seed potatoes were treated with Provex @ 2.5 g/l of water for 15 minutes, then air dried in shade. Fertilizers were applied @ 300-200-220-120-14-6 kg of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid per hectare respectively (FRG, 2018). Full amount of TSP, MoP, Gypsum, Zinc sulphate, Boric acid and half of the urea were applied at basal after covering the seed with compost. The remaining urea was applied as fertigation at 35 days after planting. Only one light irrigation with urea top dress was done at 45 days after sowing. The crop was sprayed with Furadan 5G @ 20 kg ha⁻¹ was applied to prevent the crop from the attack of soil insects. Ridomil Gold and Dithan M-45 0.2% was sprayed at two times respectively as a preventive measure against late blight disease. Insecticide Karate 0.4 kg ha⁻¹ and Actor @ 3 g L⁻¹ were applied against aphid and leaf miner. No weeding was needed during growing period for observing weed infestation. Three plant samples were collected from each plot every 30 days after sowing (DAS) for taking dry matter. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Similarly soil samples were collected from each plot three times during growing period. Growth, yield and yield component data were analyzed statistically with R3.6.3 using standard packages and Jamovi 0.9.1.10. Means were separated with least significant difference test at 0.05 level of significance (R core team, 2020).

Results and Discussion

Effect of spacing on tuber yield, 2019-20: Analysis of variance shows that tuber yield was varied significantly only with difference in spacing (Table 1). Highest tuber yield (23.6 t ha⁻¹) was found from S₃ (40 cm × 20 cm), which was identical with S₄ (22.1 t ha⁻¹). On the other hand, the lowest tuber yield was recorded from S₂ (15.7 t ha⁻¹) and S₁ (16.3 t ha⁻¹) (Figure 1).

Effect of variety and spacing on tuber yield, 2020-21: Tuber yield varied significantly between two varieties. Variety, BARI Alu-72 produced significantly higher tuber yield (18.30 t ha⁻¹) than BARI Alu-73 (15.00 t ha⁻¹) (Figure 2).

Row spacing also had significant effect on tuber yield in potato cultivation by zero tillage method. Significantly, highest tuber yield (20.15 t ha⁻¹) was recorded from S₄ (30 cm), which was statistically similar to S₃ (40 cm) (18.64 t ha⁻¹). The lowest tuber yield (12.77 t ha⁻¹) was recorded from S₂ (50 cm), which was statistically similar to S₁ (15.05 t ha⁻¹) (Figure 3).

Benefit-cost analysis

From benefit cost analysis it is apparent that major expenditure was in purchasing seed potato. As spacing decreased seed rate also increased. Other operation cost was similar in all spacing treatments. As a result total variable cost was highest in S₄ (Tk. 129,722 and Tk. 129,800 in 2019-20 and 2020-21, respectively) and lowest from S₁ (Tk. 84722 and Tk. 85800 in 2019-20 and 2020-21, respectively). Based on potato price @15 Tk. kg⁻¹, highest gross return (Tk. 354,000) was calculated from S₃ (40 cm X 20 cm) in 2019-20 and from S₄ (30 cm X 20 cm) (Tk. 302176) in 2020-21. However, there were no

significant difference in tuber yield S_3 and S_4 in both the years. So, in terms of cost and market price of tuber highest benefit cost ratio was calculated from S_3 (3.30 and 2.59) treatment in 2019-20 and 2020-21, respectively (Table 1 and 2).

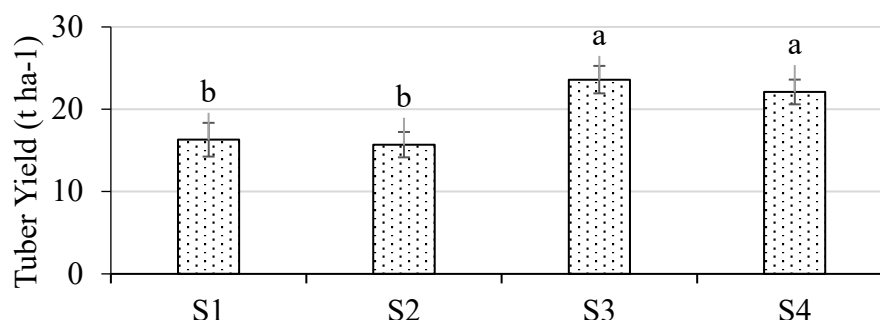


Figure 1. Tuber yield of potato at different spacing under zero tillage practice at Dacope, Khulna, 2019-20. Means with the same letter are not significantly different and vertical bar showing standard error ($\pm$ SE).

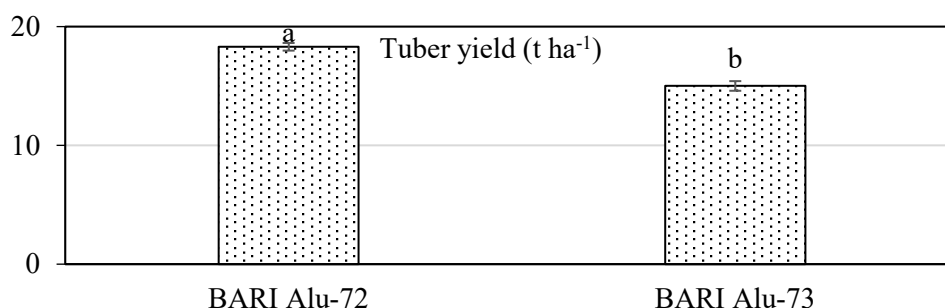


Figure 2. Varietal effect on the yield performance of BARI Alu-72 and BARI Alu-73 at Dacope, Khulna, 2020-21.

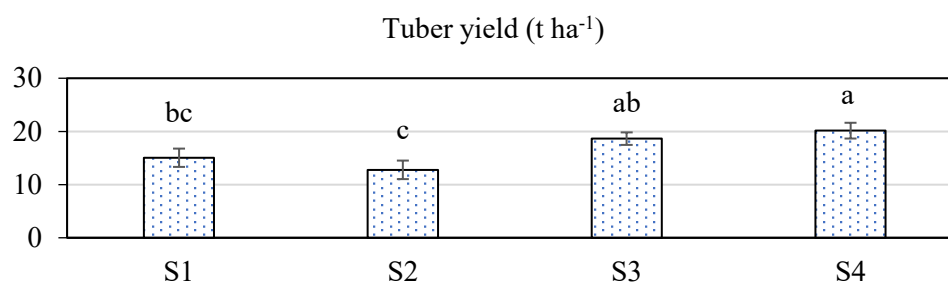


Figure 3. Tuber yield of potato by zero tillage practice at different row spacing. Where, S_1 - 60 cm $\times$ 20 cm, S_2 - 50 cm $\times$ 20 cm, S_3 - 40 cm $\times$ 20 cm, S_4 - 50 cm $\times$ 20 cm and S_4 - 30 cm $\times$ 20 cm.

Table 1. Cost-benefit analysis of zero tillage potato at different spacing grown in saline soil of Dacope, Khulna, 2019-20

Spacing	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
S_1 (60 cm $\times$ 20 cm)	16.3	244500	84722	159778
S_2 (50 cm $\times$ 20 cm)	15.7	235500	93722	141778
S_3 (40 cm $\times$ 20 cm)	23.6	354000	107222	246778
S_4 (30 cm $\times$ 20 cm)	22.1	331500	129722	201778

Tuber price (Tk. kg⁻¹): 15

Table 2. Cost-benefit analysis of zero tillage potato at different spacing grown in saline soil of Dacope, Khulna, 2020-21

Spacing	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
S ₁ (60 cm × 20 cm)	15.05	225729	85800	139929
S ₂ (50 cm × 20 cm)	12.77	191615	94750	96865
S ₃ (40 cm × 20 cm)	18.64	279618	108000	171618
S ₄ (30 cm × 20 cm)	20.15	302176	129800	172376

Conclusion

The highest tuber yield (23.6 t ha⁻¹) was recorded from 40 cm × 20 cm spacing (S₃) in 2019-20 and 30 cm × 20 cm (S₄) (20.15 t ha⁻¹). So, tuber yield under zero tillage condition could be increased by reducing spacing if other cultural managements are followed properly.

EFFECT OF COVER CROPS FOR SALINITY MANAGEMENT IN SUNFLOWER

Mustafa Kamal Shahadat, Harunor Rashid, Kamarul Islam, Mashfiquir Rahman, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at farmer's field at Dacope, Khulna during rabi, 2019-20 and 2020-21 in order to evaluate yield performance of sunflower with different leafy vegetables as cover crops so that soil salinity is reduced and increase system productivity. The experiment treatment consisted five treatment in 2019-20 viz. T₁= Sunflower with rice straw, T₂= Sunflower + Spinach, T₃= Sunflower + Ghee Kanchan (Shobuj Shak), T₄= Sunflower + Red Amaranth and T₅= Sunflower without mulch (control) and six treatments in 2020-21 viz. T₁ = Sunflower + No Mulch, T₂ = Sunflower + Rice straw, T₃ = Sunflower + Spinach, T₄ = Sunflower + Ghee Kanchan, T₅ = Sunflower + Red Amaranth, T₆ = Sunflower + Kangkong. Treatments were designed in randomized complete block design with three replications. Growth, yield and yield components of sunflower did not varied significantly in both the years. However, in 2019-20, numerically highest seed yield (2.51 t ha⁻¹) of sunflower was recorded from T₃ treatment and 2020-21, highest seed yield recorded from sunflower+red amaranth (1.11 t ha⁻¹). Highest sunflower equivalent yield (2.95 t ha⁻¹) was calculated from T₂ treatment in 2019-20 and from T₆ (2.18 t ha⁻¹) in 2020-21. As a result, both the treatments produced higher benefit cost ratio 4.10 and 3.92, respectively.

Introduction

In coastal area sunflower cultivation is expanding in some pocket areas where irrigation facilities are available. For higher yield sunflower requires at least three irrigations. So, moisture conservation is a primary concern for crop production in coastal area. Rice straw mulch is readily available mulch in coastal area for conserving moisture and reducing soil salinity. Once rice straw used to remain fallow in the field but in recent years it has been using for fodder purpose, which becomes costly. To overcome the situation, short duration green leafy vegetables could be used as cover crops in between sunflower rows, which could conserve soil moisture as well as reduce soil salinity. Moreover, farmers could get extra income from cover crops, thereby system productivity would be increased. So, the present experiment was conducted in order to minimize soil salinity effect on sunflower thereby increasing system productivity as well as farmers income.

Materials and Methods

An experiment was conducted at farmer's field at Dacope, Khulna (22° 36' 0" N latitude and 89° 27' 36" E longitude) during rabi, 2019-20 and 2020-21 in order to evaluate the performance of sunflower with leafy vegetables intercrop. The soil is generally clay to clay loam, which become moderate to high saline in April- May. Yearly average rainfall is about 1800 to 2200 mm. In 2020, the land was cultivated with traditional power tiller on 10 January. Since the clay-loam texture of the soil, fine tillage was not

possible with power tiller. In the first year, five treatment viz. T_1 = Sunflower with rice straw, T_2 = Sunflower + Spinach, T_3 = Sunflower + *Ghee Kanchan* (Shobuj Shak), T_4 = Sunflower + Red Amaranth and T_5 = Sunflower without mulch (control). In 2021, the land was cultivated with high speed rotary tiller, which makes soil friable and fine tilth was obtained. In the second year the treatments were: T_1 = Sunflower + No Mulch, T_2 = Sunflower + Rice straw, T_3 = Sunflower + Spinach, T_4 = Sunflower + *Ghee Kanchan*, T_5 = Sunflower + Red Amaranth, T_6 = Sunflower + Kangkong. The experiment was laid out in randomized complete block design with three dispersed replications. Seeds were sown on 19 January 2020 and 20 January 2021 at 50 cm X 25 cm spacing. During first year three irrigations were done from nearby canal on 14 February 2020, 27 February 2020 and 6 March 2020. No weeding was done during growing period. Sunflower were harvested on 21 April 2020. In 2021, irrigations were done on 19 February 2021, 27 February 2021 and 22 March 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data were analyzed with R3.6.3 using standard packages and means were separated with LSD test at 0.05 level of significance (R core team, 2020).

Results and Discussions

In 2020, growth, yield and yield components of sunflower did not varied significantly by treatments. However, numerically highest plant height (134.33 cm), head (6.23 cm), number of seeds per head (816.13), seed weight per plant (79.07 g) and 1000 seed weight (99.67 g) were recorded from T_4 , T_3 , T_3 , T_4 , T_3 and T_5 , respectively. On the other hand, numerically highest seed yield (2.51 t ha^{-1}) of sunflower was recorded from T_3 treatment (Sunflower + *Ghee Kanchan*) (Table 1).

Vegetable yield varied significantly where highest vegetable yield was recorded from spinach (3.85 t ha^{-1}) and lowest from gheekanchan (0.27 t ha^{-1}) (Table 1). Vegetables yield were low because of improper tillage with power tiller which affects the germination of vegetable seeds.

In 2021, there no significant variations were observed in growth and yield of sunflower. The range of sunflower yield was from 0.89 to 1.11 t ha^{-1} . However, vegetables yield varied significantly. Whereas, the highest vegetable yield was recorded from sunflower with Kangkong (T_6) (3.66 t ha^{-1}) and lowest from sunflower with spinach (0.99 t ha^{-1}) (Table 2).

In 2020, highest sunflower equivalent yield (2.95 t ha^{-1}) was calculated from T_2 treatment (Sunflower + Spinach), which ultimately brought highest gross return Tk. 132550 ha^{-1} , gross margin (Tk. 106550 ha^{-1}) and highest BCR (4.10) (Table 2).

In 2021, sunflower equivalent yield was highest from sunflower with kangkong (T_6) (2.18 t ha^{-1}), which was mainly because of highest yield of kangkong (3.66 t ha^{-1}) among the vegetables. As a result, highest gross return (98100 Tk ha^{-1}), gross margin (73100 Tk. ha^{-1}) and benefit-cost ratios (3.92) was obtained from sunflower with kangkong cover crop (Table 4).

In both the years, vegetables yield was lower than optimum level because in first year poor tillage affected germination and in second year it was due to lack of moisture, since there was no rainfall throughout the growing period and land became dried quickly after irrigation.

Table 1. Growth, yield and yield components of sunflower and yield of leafy vegetables grown as cover crops at Dacope, Khulna during 2019-20

Treatment	Plant height (cm)	Head diameter (inch)	#Seeds per head	Seed weight per head (g)	1000 seed weight (g)	Seed yield (t ha^{-1})	Vegetable yield (t ha^{-1})
T_1	130.00	5.62	749.87	61.20	65.67	2.17	-
T_2	124.13	5.46	676.20	61.47	81.67	2.09	3.85 a
T_3	125.53	6.23	766.00	79.07	89.33	2.51	0.27 c
T_4	134.33	5.93	816.13	72.33	91.33	1.98	1.75 b
T_5	121.93	5.51	702.13	62.47	99.67	2.31	-
LSD _{0.05}	NS	NS	NS	NS	NS	NS	0.67
CV%	8.75	6.48	16.86	12.76	16.50	10.29	15.02

Where, T₁ = Sunflower with rice straw, T₂ = Sunflower + Spinach, T₃ = Sunflower + Ghee Kanchan, T₄ = Sunflower + Red Amaranth and T₅ = Sunflower without mulch.

Table 2. Growth, yield and yield components of sunflower and yield of leafy vegetables grown as cover crops at Dacope, Khulna during 2020-21

Treatment	Plant height (cm)	LAI	Seed weight per head (g)	1000 seed weight (g)	Seed yield (t ha ⁻¹)	Vegetable yield (t ha ⁻¹)
T ₁	132.20	3.71	11.83	89.00	0.95	-
T ₂	135.60	5.12	13.19	101.00	1.05	-
T ₃	136.87	4.84	13.27	94.67	1.06	0.99 b
T ₄	129.20	2.87	11.16	91.00	0.89	1.46 b
T ₅	137.07	6.31	13.93	103.33	1.11	1.37 b
T ₆	138.40	3.50	12.03	96.33	0.96	3.66 a
LSD _{0.05}	NS	NS	NS	NS	NS	0.67
CV%	5.60	33.97	22.77	9.19	22.96	15.02

T₁ = Sunflower + No Mulch, T₂ = Sunflower + Rice straw, T₃ = Sunflower + Spinach, T₄ = Sunflower + Ghee Kanchan, T₅ = Sunflower + Red Amaranth, T₆ = Sunflower + Kangkong.

Table 3. Cost benefit analysis of sunflower and leafy vegetables grown as cover crops at Dacope, Khulna during 2019-20

Treatment	Sunflower Equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	-	97650	24700	72950	2.95
T ₂	2.95	132550	26000	106550	4.10
T ₃	2.60	117000	26000	91000	3.50
T ₄	2.56	115350	26000	89350	3.44
T ₅	-	103950	24700	79250	3.21

Where, T₁ = Sunflower with rice straw, T₂ = Sunflower + Spinach, T₃ = Sunflower + Ghee Kanchan, T₄ = Sunflower + Red Amaranth and T₅ = Sunflower without mulch.

Price (Tk. kg⁻¹): Sunflower seed = 45, Spinach = 10, Red amaranth = 15 and Ghee Kanchan = 15.

Table 4. Cost benefit analysis of sunflower and leafy vegetables grown as cover crops at Dacope, Khulna during 2020-21

Treatment	Sunflower Equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	-	42750	25000	17750	1.71
T ₂		47250	25000	22250	1.89
T ₃	1.39	62550	25000	37550	2.50
T ₄	1.38	61950	25000	36950	2.48
T ₅	1.57	70500	25000	45500	2.82
T ₆	2.18	98100	25000	73100	3.92

T₁ = Sunflower + No Mulch, T₂ = Sunflower + Rice straw, T₃ = Sunflower + Spinach, T₄ = Sunflower + Ghee Kanchan, T₅ = Sunflower + Red Amaranth, T₆ = Sunflower + Kangkong.

Price (Tk. kg⁻¹): Sunflower seed = 45, Spinach = 15, Red amaranth = 15, Ghee Kanchan = 15, Kangkong = 15.

Conclusion

Cover crop did not affect sunflower yield, hence there was no significant yield variation in sunflower. However, yield of vegetables were far lower than expected because of poor tillage and lack of moisture. In 2020, highest yield and return was recorded from sunflower with spinach and in 2021, sunflower with kangkong gave highest yield and return. So, it was appeared that leafy vegetable as cover crop did not interfere sunflower yield rather increased system productivity.

EFFECT OF FOXTAIL MILLET AS INFLUENCED BY DIFFERENT WEEDING METHOD

M. S. Rahman, M. F. Islam, A.K.M.Z.U. Noor, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment of Foxtail millet was conducted at Melandah, Jamalpur during rabi season of 2020-21. Three treatments viz., T_1 = Control (No weeding), T_2 = Hand weeding and T_3 = Chemical control (Affinity) were tested at the farmer's field of Melandah, Jamalpur during 2020-21. Results obtained from the study indicated that the highest grain yield (2.70 t ha^{-1}) was produced in T_2 treatment and the lowest grain yield (2.33 t ha^{-1}) in T_1 treatment. The highest gross return (Tk. 45,900 ha^{-1}) and gross margin (Tk. 9,741 ha^{-1}) were found from T_2 treatment and T_1 treatment, respectively. The lowest gross return (Tk. 39,610 ha^{-1}) and gross margin (Tk. 7,231 ha^{-1}) were observed from T_1 and T_2 treatments, respectively.

Introduction

Foxtail millet (kaon) is considered as minor cereals of Bangladesh. The crop is tolerant to drought. It can play partial role in fulfilling the food crisis of our country. Weeds are the major competitor of the crop and reduce the yield considerably. Because of wider row spacing and slow initial growth in millets, weeds are more problematic during initial crop growth period, and hence, early weed control is needed to optimize the yield. Millet is a short duration and drought tolerant crop. Farmers are often taking negligibility for its production thus the area and production is declining day by day in Bangladesh. Although its production and area is declining now but its demand is high. Weed control may be one of the ways to increase yield and area coverage successfully. So, the experiment was undertaken to identify the appropriate weed control method.

Materials and Method

The experiment was conducted at Melandah, Jamalpur during rabi season 2020-21. The land was medium high and the soil was sandy loam in texture. The experiment was laid out in a randomized complete block design with three dispersed replications. Three treatments viz., T_1 = Control (No weeding), T_2 = Hand weeding and T_3 = Chemical control (Affinity) were tested in the study. Foxtail millet (BARI Kaon-2) variety was used as a planting material in this experiment. The land was fertilized with 78-25-45-10-1.4-0 kg ha^{-1} of NPKSZnB, respectively. Half of N and all fertilizers were applied at final land preparation. Rest half of N was top dressed at 35 DAS. Plant protection measures and other intercultural operations were done as and when necessary. Seeds were sown on 19 November, 2020 and the crop was harvested on 27 March, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data were collected plot wise and collected data were analyzed following MSTAT software package and mean separation was done as per LSD test.

Results and Discussion

All the parameters were significant except plant height and panicle length. From table 1, it was found that the maximum (83.30) plants/ m^2 was recorded in T_1 treatment and the minimum (76.73) in T_3 . The tallest plant (127.9 cm) was found from T_2 treatment and the shortest plant (121.2 cm) from T_3 treatment. The longest panicle (14.47 cm) was recorded from T_2 treatment and the shortest (12.93 cm) from T_1 treatment. The highest grain yield (2.70 t ha^{-1}) was produced in T_2 treatment mainly due to longest panicle and the lowest grain yield (2.33 t ha^{-1}) was produced in T_1 treatment. The highest gross return (Tk. 45,900 ha^{-1}) and gross margin (Tk. 9,741 ha^{-1}) were found from T_2 treatment and T_1 , respectively. The lowest gross return (Tk. 39,610 ha^{-1}) and gross margin (Tk. 7,231 ha^{-1}) were observed from T_1 treatment and T_2 treatment.

Farmer's opinion

Farmers are highly satisfied with hand weeding due to higher income as well as low cost.

Table 1. Yield and yield contributing characters of Foxtail millet at different weed control method at

Melandah, Jamalpur during 2020-21

Treatment	Plant population/m ²	Plant height (cm)	Panicle length (cm)	Grain yield/m ² (g)	Grain yield (t ha ⁻¹)
T ₁	83.30	121.9	12.93	235.7	2.33
T ₂	82.97	127.9	14.47	272.3	2.70
T ₃	76.73	121.2	13.60	251.3	2.50
LSD (0.05)	4.69	NS	NS	7.26	0.07
CV (%)	2.56	2.65	11.54	1.27	1.33

T₁=Control (No weeding), T₂= Hand weeding and T₃= Chemical control (Affinity)

Table 2. Cost and return of Foxtail millet weed control method at Melandah, Jamalpur during 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	39,610/-	29,869/-	9,741/-
T ₂	45,900/-	38,669/-	7,231/-
T ₃	42500/-	33,219/-	9,281/-

T₁=Control (No weeding), T₂= Hand weeding and T₃= Chemical control (Affinity)

Price of kaon (grain): Tk 17.0 kg⁻¹.

Conclusion

Considering the yield potentiality and economic point of view, No weeding treatment is better due to higher income as well as low cost than hand weeding and chemical control treatment. So, the study needs to be repeated in the next year for confirmation the result.

EFFECT OF IRRIGATION ON SWEET POTATO IN CHAR LAND OF JAMALPUR

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Abstract

The experiment of sweet potato was conducted at Melandah, Jamalpur during the rabi season of 2020-21. Four treatments viz., T₁=Control (No irrigation), T₂= One irrigation after 30 days of planting, T₃= One irrigation after 50 days of planting and T₄= Two irrigations after 30 and 50 days of planting were tested in the farmers field. The highest tuber yield was obtained from T₃ treatment (34.75 t ha⁻¹) and the lowest (25.66 t ha⁻¹) in T₁ treatment. It revealed that the highest gross return (Tk. 6, 95,000 ha⁻¹) and gross margin (Tk. 5, 46,930 ha⁻¹) were found from T₃ treatment. The lowest gross return (Tk. 5, 13,200 ha⁻¹) and gross margin (Tk. 3, 67,630 ha⁻¹) was recorded from T₁ treatment.

Introduction

Sweet potato is one of the most important tuber crops in Bangladesh. The average yield of sweet potato in the country is quite low compared to world context. The total production of sweet potato in Bangladesh increased 3.16% (from 254,633 to 262,702 metric tons (MT) in 2015 to 2017), and area increased by 1.94% (from 25,260 to 25,750 ha in 2015 to 2017) (FAOSTAT, 2017). This is due to the introduction and adoption of Bangladesh Agricultural Research Institute (BARI) releasing modern varieties, improved cultivation techniques, and awareness building by sweet potato growers. This crop also contributes greatly to farmers' income in Bangladesh. The typical yield of sweet potato in Bangladesh is only 10.20 t ha⁻¹, while the probable or achievable yield has been stated to be as much as 40 t ha⁻¹. There are considerable opportunities for increasing the yield of sweet potato by limiting the yield gap (BARI, 2019).

The farmers of the char areas grow sweet potato without irrigation. So, yield of sweet potato of that area is low. Water is the most important component in actively growing plants and constitutes more than 80 % of the growing tissue. The growth, development and consequently yield of crops are highly influenced by available soil moisture. So, the present study was conducted to find out the effect of irrigation on the yield of sweet potato.

Materials and Methods

The experiment of sweet potato was conducted at Melandah, Jamalpur during the rabi season of 2019-2020. The experiment was laid out in a randomized complete block design with three dispersed replications. Four treatments viz., T₁=Control (No irrigation), T₂= One irrigation after 30 days of planting, T₃= One irrigation after 50 days of planting and T₄= Two irrigations after 30 and 50 days of planting were tested in the farmers field. The sweet potato variety of BARI Misti alu-8 was used as a planting material. The vines were planted on 09 November, 2020 with a spacing of 60 cm x 30 cm. The unit plot size was 6m x 3m. The crop was fertilized with 70-25-85 kg ha⁻¹ NPK and 5.0 t ha⁻¹ cowdung. Half of N and all other fertilizers were applied at final land preparation. Remaining N was top dressed in two equal splits at 35 and 65 DAT. Two hand weeding was done at 25 and 60 DAT. The crop was harvested on 05 April, 2021. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Data on yield and yield contributing characters were taken and statistically analyzed following MSTAT software package and mean separation was done as per LSD test.

Results and Discussion

Yield and yield contributing characters of sweet potato varieties have been presented in Table 1. It was observed that all parameters were significant. The maximum (5.2) plants/m² was recorded in T₃ treatment and the minimum in T₁. The highest number of tuber plant⁻¹ (5.33) was recorded in T₂ and the lowest (4.13) in T₁ treatment. The highest tuber wt plant⁻¹ (670.0 g) was observed in T₃ and the lowest (544.0 g) in T₁. The highest tuber yield was obtained from T₃ treatment (34.75 t ha⁻¹) because it produced maximum tuber wt plant⁻¹ and the lowest (25.66 t ha⁻¹) was in T₁ treatment due to minimum tuber wt plant⁻¹.

Cost and return analysis

From Table 2, it revealed that the highest gross return (Tk.6, 95,000 ha⁻¹) and gross margin (Tk. 5, 46,930 ha⁻¹) were found from T₃ treatment. The lowest gross return (Tk. 5, 13,200 ha⁻¹) and gross margin (Tk. 3, 67,630 ha⁻¹) was recorded from T₁ treatment.

Farmer's Opinion

Farmers are impressed for higher yield of sweet potato as well as higher income with one irrigation after 50 days of planting.

Table-1. Yield and yield contributing characters of sweet potato at Melandah during rabi 2020-21

Treatment	Plant population m ⁻²	Tuber Plant ⁻¹ (no.)	Tuber wt Plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)
T ₁	4.73	4.13	544.0	25.66
T ₂	4.83	5.33	581.7	28.23
T ₃	5.2	4.20	670.0	34.75
T ₄	8.3	5.13	620.0	30.04
LSD (0.05)	0.32	0.66	28.40	1.09
CV (%)	3.28	7.06	2.35	1.85

T₁=Control (No irrigation), T₂= One irrigation after 30 days of planting, T₃= One irrigation after 50 days of planting and T₄= Two irrigations after 30 and 50 days of planting

Table-2. Economic performance of sweet potato varieties at Melandah, Jamalpur during 2020-21

Treatment	GR (Tk ha ⁻¹)	TC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)
T ₁	5,13,200/-	1,45,570/-	3,67,630/-
T ₂	5,64,600/-	1,48,070/-	4,16,530/-
T ₃	6,95,000/-	1,48,070/-	5,46,930/-
T ₄	6,00,800/-	1,50,570/-	4,50,230/-

T₁=Control (No irrigation), T₂= One irrigation after 30 days of planting, T₃= One irrigation after 50 days of planting and T₄= Two irrigations after 30 and 50 days of planting. Price of sweet potato= Tk 20.0 kg⁻¹ is

Conclusion

Considering yield potentiality and economic point of view, it was found that one irrigation after 50 days of planting treatment gave better performance. The experiment should be repeated for the next year for confirmation of the results.

PERFORMANCE EVALUATION OF POWER OPERATED SEEDER IN FARIDPUR

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Abstract

Power operated seeder (POS) was carried out at farmers' fields of the Farming System Research and Development (FSRD) site, Sholakundu, Faridpur during 2019-20 and 2020-21. The seeder performed (av. 1095 decimal) seeding operation utilizing the soil moisture after harvesting T. Aman rice along with the use of Hi-speed Rotary Tiller (HSRT). Seed of wheat, lentil, black cumin and coriander were sown. It maintained uniform seeding depth, uniform seed distribution and better seed soil contact which transferred soil moisture to seeds quickly for enhance better plant establishment and yield. Power operated seeder was able to complete seeding and laddering operation in a single pass with an average field capacity of average 22.5 dec.h⁻¹. The increase yield percentage in POS over conventional was 33, 25, 20 and 13 % in lentil, black cumin, coriander and wheat, respectively. The gross return, gross margin and benefit cost ratio was higher in all crops due to higher yield and lower cultivation cost. The BCR percentage was 30, 21, 14 and 10 % higher in black cumin, coriander, lentil and wheat in POS over conventional, respectively.

Introduction

Effects of tillage and seeding techniques on crop yield may be positive or negative (Pittel kow et al., 2015) depending upon the crop species, growing environment, and the duration and extent of the cropping system. Cropping system depends on different tillage, stubble retention and seeding can slow down the growth of crops (Hobbs et al., 2008). Farmers mainly after harvesting of transplanting aman rice, wheat, lentil, coriander and black cumin seeded broadcast after one pass tillage operation by High Speed Rotary Tiller (HSRT). As a result, cultivation cost is higher and obtain lower yield. But, Bangladesh Agricultural Research Institute (BARI) has developed a power operated seeder (POS). The seeder acts as seeding in line and seed covering at a time. Different winter season crops (wheat, lentil, black cumin, coriander) can be established after T. Aman rice harvest by the POS along with one pass high speed rotary tillage operation (POS) that can reduce the cultivation cost and possible yield loss. Farmers can be used this seeder as custom hire basis. However, no data are yet available to assess the performance of POS. Thus, the present study was undertaken to reduce the cultivation cost in Faridpur region (AEZ 12) and to evaluate the performance of power operated seeder for different rabi crops in aspect of yield.

Materials and Method

Power tiller operated seeder (POS) was used for sowing coriander, wheat, lentil and black cumin directly at the farmers field of Farming System Research and Development (FSRD) site under On-Farm Research Division, Faridpur during *rabi* season of 2019-20 and 2020-21. The fluted type seed meter was used for seeding small to large size seeds. The metering plates are interchangeable and allow minimum tilth to change one plate to another. Under this program, POS demonstrated in different locations in Faridpur to show its efficient work performance in field condition. Recommended doses of fertilizers and standard seed rate were followed and after care was taken as and when necessary. The following data were collected during the test: depth of seed placement (cm), effective field capacity (dec.h⁻¹), no. of plant m⁻², yield and cost and return. Different data of respective crops under POS were shown in Table 1 and 2.

Table 1. Area, date of sowing, harvesting and fertilizer dose planted by power tiller operated seeder (POS) in Faridpur during 2019-20.

Crops	Variety	Area (dec.)	Date of sowing	Date of harvesting	Fertilizer dose NPKSZnB (kg.ha ⁻¹)
Wheat	BARI Gom-33	700	17 Nov. 3 Dec.2019	8 to 19 March 2020	140-40-60-15-3-1
Lentil	BARI Masur-7	160	29 Nov-3 Dec. 2019	12-18 March 2020	28-24-14-9-2-1
Black cumin	BARI Kalozira-1	100	4-5 Dec. 2019	30 March 2020	100-40-30-18-2-1
Coriander	BARI Dhonia-2	150	4-5 Dec. 2019	23 Mar. 2020	120-48-40-15-3-1

Table 2. Area, date of sowing, harvesting and fertilizer dose planted by power tiller operated seeder (POS) in Faridpur during 2020-21

Crops	Variety	Area (dec.)	Date of sowing	Date of harvesting	Fertilizer dose NPKSZnB (kg.ha ⁻¹)
Wheat	BARI Gom-33	400	22-30 Nov.2020	13 to 20 March 2021	140-40-60-15-3-1
Lentil	BARI Masur-8	330	15-30Nov. 2020	6-14 March 2021	28-24-14-9-2-1
Black cumin	BARI Kalozira-1	200	26 Nov-10 Dec. 2020	25-31 March 2021	100-40-30-18-2-1
Coriander	BARI Dhonia-2	100	8-12 Dec. 2020	22-25 Mar. 2021	100-40-30-15-2-1.5

Results and Discussion

Seeding performance: Field performance of crop cultivation by the POS and conventional method were shown in Table 3. The power tiller operated seeder (POS) performed planting operation maintaining standard seed rate and line spacing. POS able to complete planting operation in a single pass. The average field capacity of POS and conventional method were 22 dec.hr⁻¹ and 16 dec.hr⁻¹, respectively. Crops residue of previous crops crushed by high rotational speed (400-450 rpm) of rotary blades by High speed rotary tiller (HSRT). It was observed that POS along with HSRT can finish planting operation within one day for Faridpur region of previous crop harvest, whereas conventional methods it takes average 7-9 days from harvest to seeding. POS reduces turnaround time which enhances cropping intensity.

Wheat, lentil, black cumin and coriander were planted by the fluted type seed metering devices. Black cumin was mixed with saw dust maintaining ratio 1:4. Weeding operation was easier and quicker in POS planted plots. In POS plots, depth of seeding was uniform and seed covered by proper laddering and seed comes soil contact easily.

Crop yield

Two years yield of different crops sown by POS were shown in Table 4. Average yield of lentil, wheat, black cumin and coriander in POS along with HSRT tillage and conventional method were 1.85, 4.22, 1.15 and 1.47 tha⁻¹ and 1.39, 3.72, 0.92 and 1.22 tha⁻¹, respectively (Table 5). Even though significant yield difference between two same crops were not observed. But the higher crop yield in all cases were found in POS planted plots in against of conventional practice (following broadcast method) plot. It was possible due to depth of seeding was uniform and obtained standard plant population. The yield difference in POS was 33%, 13%, 25% and 20% for lentil, wheat, black cumin and coriander over conventional tillage, respectively.

Cultivation cost performance

Cost components between conventional method and POS along with HSRT in crop cultivation were shown in Table 6a, 7a, 8a and 9a. Cultivation cost of all crops (lentil, wheat, black cumin and coriander) were considered in this cost comparison. Seeding cost by POS was a little bit higher than the conventional planting method. Irrigation and weeding cost by POS were also less than conventional method. Major advantages of POS were less volume water application compare to conventional method. So, water cost can be saved by POS for direct seeding. Weeding operation was easier and less cost in lentil and wheat cultivation due to line sowing. The total cultivation cost was observed lower in coriander (4.8%) and black cumin (3.4%) by POS per hectare over conventional method, respectively.

Cost and return

The gross return, gross margin and benefit cost ratio was higher in all crops due to higher yield and lower cultivation cost (Table 6b, 7b, 8b and 9b). The higher gross return, gross margin and BCR were observed in POS over conventional method. The BCR percentage was 30%, 21%, 14% and 10% higher in cumin, coriander, lentil and wheat in POS over conventional, respectively.

Table 3. Field performance of the power tiller operated seeder (POS) for direct seeding and the conventional (CON) method

Sl. No.	Particulars	Lentil		Wheat		Black cumin		Coriander	
		POS	CON	POS	CON	POS	CON	POS	CON
2	Seed rate (kg ha ⁻¹)	35	50	120	140	5	6-7	6	8-10
3	Line spacing (cm)	30	--	20	--	30	--	30	--
4	Depth of seeding (cm)	1	--	3	--	0.5-1	--	0.5-1	--
5	Plant population (m ⁻²)	115	165	359	260	245	270	74	86
6	Field capacity (dec.h ⁻¹)	25	16	25	16	20	16	20	16

Table 4. Yield performance between POS and conventional method Faridpur during 2019-20 and 2020-21

Sl No.	Planting method	Lentil		Wheat		Black Cumming		Coriander	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
1	Tilth by HSRT and seeding by POS	1.82	1.87	4.11	4.32	1.27	1.03	1.42	1.52
2	Conventional method	1.42	1.35	3.63	3.80	1.05	0.78	1.23	1.20
3	t- test	ns	ns	ns	ns	ns	ns	ns	ns

Table 5. Yield performance between POS and conventional method in Faridpur (avr. of 2 years)

Sl No.	Planting method	Lentil	Wheat	Black Cumin	Coriander
1	Tilling by HSRT and seeding by POS	1.85	4.22	1.15	1.47
2	Conventional method	1.39	3.72	0.92	1.22
	Yield increase in POS over conventional	33	13	25	20

Table 6a. Comparative cultivation cost of lentil in POS with conventional under OFRD, Faridpur during 2019-20 and 2020-21

Cost items	Lentil (2019-20)		Lentil (2020-21)	
	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)
Seed price	4000	3500	3500	4000
Land ploughing	5000	5000	5000	5000
Seeding	800	2000	1000	2000
Fertilizer	6808	8200	6438	7680
Irrigation	5000	4500	5000	4500
Weeding	4200	3700	5000	4500
Harvesting and threshing	19040	21550	16162	18020
Total cost	44848	48450	42100	45700
Average cost of conventional	43474			
Average cost of POS	47075			

Table 6b. Cost and return of lentil in POS with conventional under OFRD, Faridpur (av. 2 years)

Practice	Year	Yield (t ha ⁻¹)	GR (t ha ⁻¹)	TVC (t ha ⁻¹)	GM (t ha ⁻¹)	BCR
POS	2019-20	1.82	136500	48450	88050	2.82
	2020-21	1.87	126225	45700	80525	2.76
	Average	1.85	131363	47075	84288	2.79
Conventional	2019-20	1.42	113600	44848	68752	2.53
	2020-21	1.35	97875	42100	55775	2.32
	Average	1.39	105738	43474	62264	2.43

Output price (Tk kg⁻¹): BARI Mosur-7, 75.00 & Local- 80.00 (2019-20). BARI Mosur-8, 67.50 & Local- 72.50 (202-21)

Table 7a. Comparative cost of wheat in POS with conventional under OFRD, Faridpur

Cost items	Wheat (2019-20)		Wheat (2020-21)	
	Conventional (Tk. ha ⁻¹)	POS (Tk ha ⁻¹)	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)
Seed price	4375	4375	4800	4800
Land ploughing	5000	5000	5000	5000
Seeding	800	1500	1000	2000
Fertilizer	14270	14890	14270	15773
Irrigation	15000	14500	16000	15500
Herbicide +labor	2400	2200	3000	2200
Fungicide +labor cost	4450	4250	5100	4600
Harvesting and threshing	14250	15250	15250	17250
Total cost	60545	61965	64420	67123
Average cost of conventional	62483			
Average cost of POS	64544			

Table 7b. Cost and return of wheat in POS with conventional under OFRD, Faridpur (av.2 years)

Practice	Year	Yield (t ha ⁻¹)	GR (t ha ⁻¹)	TVC (t ha ⁻¹)	GM (t ha ⁻¹)	BCR
POS	2019-20	4.11	94530	61965	32565	1.51
	2020-21	4.32	108000	67123	40877	1.61
	Average	4.22	101265	64544	36721	1.57
Conventional	2019-20	3.63	83490	60545	22945	1.38
	2020-21	3.80	95000	64420	30580	1.47
	Average	3.72	89245	62483	26763	1.43

Output price (Tk kg⁻¹): Wheat 23.00 (2019-20) and 25.00 (2020-21)

Table 8a. Comparative cost of b.cumin in POS with conventional under OFRD, Faridpur

Cost items	B. cumin (2019-20)		B. cumin (2020-21)	
	Conventional (Tk. ha ⁻¹)	POS (Tk ha ⁻¹)	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)
Seed price	1250	1250	1250	1250
Land ploughing	5000	5000	5000	5000
Seeding	800	1500	800	1500
Fertilizer	8712	9892	8552	9892
Irrigation	10000	9500	15000	14000
Herbicide +labor	12000	8000	16200	12500
Fungicide +labor cost	3520	3020	4240	3330
Harvesting and threshing	16000	17500	20000	21000
Total cost	57282	55662	71042	68472
Average cost of conventional	64162			
Average cost of POS	62067			

Table 8b. Cost and return of black cumin in POS with conventional under Faridpur (av. 2 years)

Practice	Year	Yield (t ha ⁻¹)	GR (t ha ⁻¹)	TVC (t ha ⁻¹)	GM (t ha ⁻¹)	BCR
POS	2019-20	1.27	254000	55662	198438	4.57
	2020-21	1.03	200460	68472	131988	2.93
	Average	1.15	227230	62067	165213	3.75
Conventional	2019-20	1.05	21000	57282	152718	3.67
	2020-21	0.78	149623	71042	78581	2.11
	Average	0.92	85312	64162	115650	2.89

Output price (Tk kg⁻¹): Black cumin 200.00 (2019-20) and 195.00 (2020-21)

Table 9a. Comparative cost of coriander in POS with conventional under Faridpur during 2019-20 and 2020-21

Cost items	Coriander (2019-20)		Coriander (2020-21)	
	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)	Conventional (Tk. ha ⁻¹)	POS (Tk. ha ⁻¹)
Seed price	1000	1000	1000	1000
Land ploughing	5000	5000	5000	5000
Seeding	800	1500	800	1500
Fertilizer	12462	12442	11306	12442
Irrigation	10000	9500	10000	9500
Weeding	12000	8000	15000	13000
Harvesting and threshing	16000	19348	21000	21500
Total cost	57262	56790	64106	63942
Average cost of conventional	60684			
Average cost of POS	60366			

Output price (Tk kg⁻¹): Coriander- 70.50 (2019-20) and 70.00 (2020-21)

Table 9b. Cost and return of coriander in POS with conventional under Faridpur (av. 2 years)

Practice	Year	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)	BCR
POS	2019-20	1.42	99400	56790	43010	1.75
	2020-21	1.52	106050	63942	42108	1.66
	Average	1.47	102725	58298	44627	1.71
Conventional	2019-20	1.23	86100	57262	28838	1.50
	2020-21	1.20	84210	64106	20104	1.31
	Average	1.22	85155	61102	24053	1.41

Output price (Tk kg⁻¹): Coriander- 70.50

Conclusion

- i. Power operated seeder (POS) performed seeding operation efficiently in one pass.
- ii. Uniform depth of seeding and better seed soil contact which transfer soil moisture to the seed quickly for better germination and standard plant population.
- iii. POS saving labor, water, production cost and reduce climatic hazard compare to conventional method.
- iv. Economically profitable

F. Plant Protection Measures

BIO-RATIONAL BASED MANAGEMENT TECHNIQUES FOR THE CONTROL OF MANGO FRUIT FLY, *BACTROCERA DORSALIS* IN RAJSHAHI REGION

J.C. Barman, M.E.A. Pramanik, M.S. Hossain, M Akkas Ali, M Shahiduzzaman

Abstract

Adaptive trials were conducted at farmer's field of Charchat and Bagha upazilla of Rajshahi district during the mango fruiting season of 2021 in a randomized complete block design with 3 treatments and 10 replications. Among the treatments, Methyl eugenol pheromone trap was more effective in catching mango fruit fly male adult populations as compared to attract and kill method. But attract and kill method can catch both of male and female populations. Maximum abundance of male populations was found during mid-May to mid-June while that of female populations during mid-May to first week of June. The lowest fruit infestation (3.1–4.4%) was found in attract and kill method as compared to methyl eugenol pheromone trap (3.9–4.7%). The highest infestation was found in farmer's practice (7.6–10.9%). Both of methyl eugenol and attract & kill method effectively reduced mango fruit fly infestation as compared to farmer's practice. Considering marginal cost benefit ratio, attract & kill method produced the highest marketable fruit yield (122.7 kg/tree) and higher MBCR (11.45).

Introduction

In Bangladesh, the mango growing area is expanding each year, especially in north-western region and hilly areas. Like many other crops, it also has some problems in cultivation. Many factors are responsible for the yield loss of mango of which insect pests play a vital role for the low yield and poor quality of mango fruits. Among insect pests, the mango fruit fly, *Bactrocera dorsalis* (Hendel) (Tephritidae: Diptera) is a major pest of mango fruits Khirsapat, Langra and Fazli varieties of mango (Karim, 1989). It reduces the marketable yield of mango. A huge quantity of mango fruits may be lost due to the fruit fly infestation each year. Farmers use only chemical pesticides indiscriminately even mixture of several chemicals at very high frequency and over dose to save their mango crop which have several limitations like ineffectiveness, killing of pollinators, parasitoids and predators, resulting in resurgence of other pest populations, develop resistant insect biotypes and excessive residues in marketable fruits. Therefore, the present study was undertaken for the management of the mango fruit fly, which is eco-friendly and safe for the environment.

Materials and Methods

The trial was conducted at farmer's field of Charchat and Bagha upazilla of Rajshahi district during the mango fruiting season of 2021 in a randomized complete block design with 3 treatments and 10 replications. One mango tree was considered as one treatment replication. Around 20 years old mango trees of BARI Aam-2 (Lakhna) variety were used for the study. The treatments were assigned as follows: T₁= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of methyl eugenol pheromone trap, T₂= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of attract and kill method and T₃= Farmer's practice (2 sprays with Malathion/Shobicon/Sevin).

Year-round activities were done in the mango orchards starting from August 2020 with removal of dead and decaying, unnecessary shoots, ploughing the orchard, application of fertilizers and soil drenching. Soil recharge was applied at two splits: first application was done on August 2020 and the second on the first week of April 2021. Fifty-gram *Metarhizium anisopliae* was applied on the soil of the tree canopy area and the soil was drenched and watered with a hand water shower. Methyl eugenol pheromone trap and attract & kill method were installed on 26 April 2021. Randomly selected 100 fruits from each tree were tagged for the study. In 1989, Karim reported that *Bactrocera dorsalis* prefer to lay eggs on mango fruits at 30 to 40 days before crop harvest. So, 40-45 days before crop harvest was selected as proper time of installation of methyl eugenol pheromone trap and attract and kill methods for the protection of fruit fly infestation. Randomly selected 100 fruits were also tagged for the control treatment in the same way. Methyl eugenol was used in a transparent plastic jar containing soap water at the bottom. The number of male fruit fly captured in the trap was counted at every 7 days interval.

Similarly, the number of male and female fruit flies captured in attract and kill methods was counted at every 7 days interval. At the time of harvest, harvested fruits of all treatments were checked for recording fruit fly infestation and recorded yield data. Per cent fruit fly infestation was calculated using the following formula:

$$\% \text{ Fruit fly infestation} = \frac{\text{No. of infested fruits}}{\text{Total no. of harvested fruits}} \times 100$$

Results and Discussion

Fruit fly catch: Male fruit fly catch in both locations has been shown in figure 1 and figure 2. Methyl eugenol pheromone trap was more effective in catching mango fruit fly male adult populations as compared to attract and kill method in both locations. The abundance of mango fruit fly adult male populations was noticed from first week of May 2021 and maximum number of populations was found during the period of mid-May to mid-June i.e., up to crop harvest. Higher number of male populations was found at Charghat as compared to Bagha upazilla.

Attract and kill method can catch both of male and female populations. Higher number of mango fruit fly female populations was found at Bagha as compared to Charghat upazilla (Figure 3). The figure reveals that abundance of female populations was more during the period of mid-May to first week of June showing the peak during the last week of May.

Fruit infestation: Efficacy of different treatments in controlling mango fruit fly infestation during 2021 mango season at Charghat and Bagha upazilla of Rajshahi district has been illustrated in Table 1 and 2. The lowest fruit infestation (3.1–4.4%) was found in plants where attract and kill methods were installed as compared to methyl eugenol pheromone trap (3.9–4.7%). The highest infestation was found in farmer's practice (7.6–10.9%) where insecticides were sprayed to control mango fruit fly.

Considering marginal cost benefit ratio attract & kill method produced the highest marketable yield (122.7 kg/tree) and higher MBCR (11.45) followed by methyl eugenol pheromone trap (10.33). The lowest marketable yield (99.3 kg/tree) was obtained from farmer's practice (Table 3).

Farmer's reaction

Farmers obtained better crop yield from the attract and kill method, and methyl eugenol pheromone trap installed trees. Neighboring farmers visited the field and were impressed to see the eco-friendly mango fruit fly management techniques. Farmers preferred attract and kill methods for its easy application. They also expressed their eager to get both attract and kill methods, and methyl eugenol pheromone trap.

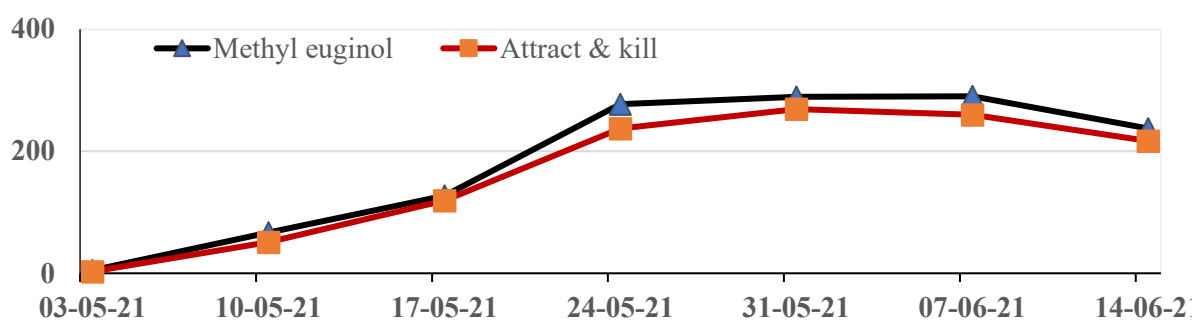


Fig.1. Male catch on different dates in methyl eugenol pheromone trap and attract & kill method at Charghat, Rajshahi during 2021 mango crop season.

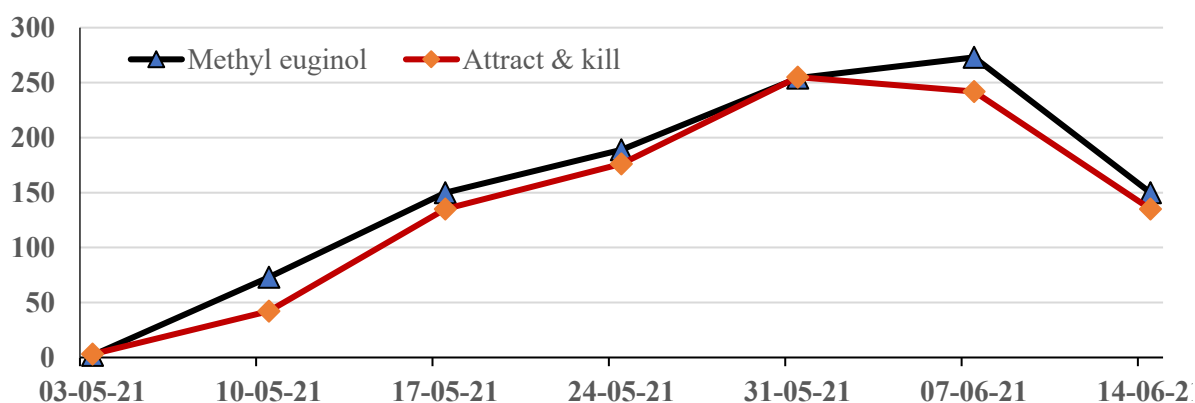


Fig.2. Male catch on different dates in methyl eugenol pheromone trap and attract & kill method at Bagha, Rajshahi during 2021 mango crop season.

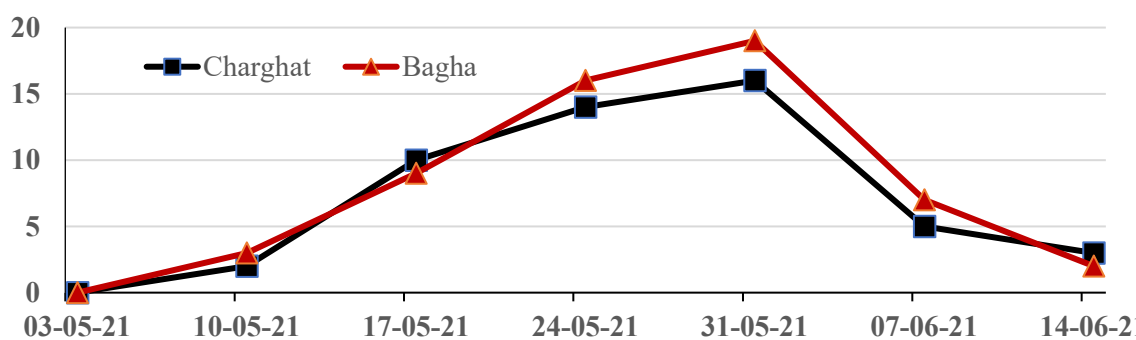


Fig.3. Female catch on different dates in attract & kill method at Charghat and Bagha of Rajshahi district during 2021 mango crop season.

Table 1. Efficacy of different treatments in controlling mango fruit fly, *Bactrocera dorsalis* (Hendel) during 2021 mango season at Charghat, Rajshahi (average of 10 plants)

Treatment	No. of tagged fruits	No. of harvested fruits	No. of healthy fruits	No. of infested fruits	% Fruit infestation
Methyl eugenol	100	88.4	84.8	4.2	4.7
Attract & Kill method	100	91.2	87.2	4	4.4
Farmer's practice	100	81.6	72.7	8.9	10.9

Table 2. Efficacy of different treatments in controlling mango fruit fly, *Bactrocera dorsalis* (Hendel) during 2021 mango season at Bagha, Rajshahi (average of 10 plants)

Treatment	No. of tagged fruits	No. of harvested fruits	No. of healthy fruits	No. of infested fruits	% Fruit infestation
Methyl eugenol	100	92.0	88.4	3.6	3.9
Attract & Kill method	100	89.0	86.2	2.8	3.1
Farmer's practice	100	92.4	85.4	7.0	7.6

Table 3. Benefit cost analysis after application of different treatments for controlling mango fruit fly during 2021 mango season (average data of Charchat and Bagha upazilla was used)

Treatments	Pest management cost (Tk/tree)	Marketable yield (Kg/tree)	Gross return (Tk/tree)	Net return (Tk/tree)	Adjusted net return (Tk/tree)	Marginal Benefit Cost Ratio
Methyl eugenol	60.00	116.33	4653.20	4593.2	620.00	10.33
Attract & Kill method	75.00	122.67	4906.80	4831.80	858.60	11.45
Untreated Control	0.00	99.33	3973.20	3973.20	-	-

Market price of Mango = Tk 40/ kg

Cost of methyl eugenol @ Tk 60/tree, Cost of attract & kill method @ Tk 75/tree.

Conclusion

Both of methyl eugenol and attract & kill method effectively reduced mango fruit fly infestation as compared to farmer's practice. Attract and kill method got more popularity for it's easy installation.

ICM TECHNIQUES IN REDUCING FLOWER AND FRUIT DROPPING OF MANGO IN HIGH BARIND TRACT

J.C. Barman, M.E.A. Pramanik, M.S. Hossain, M Akkas Ali, M Shahiduzzaman

Abstract

On-farm trials of Integrated Crop Management (ICM) techniques were conducted during 2020-21 mango season at farmer's field of two different regions of high Barind tract (HBT) to increase mango production by reducing flower and fruit dropping following randomized complete block design (RCBD). ICM package includes: application of recommended fertilizer dose; two sprays with imidacloprid (Confidor) 70 WG @ 0.2 g/litre of water with mancozeb (Indofil) M 45 @ 2.0 g/litre of water- 1st spray within 10 days of flowering and 2nd after one month of the first application; three irrigations starting from full bloom to fruit maturity at 15 days interval; two sprays with 2% urea solution at pea and marble stages of fruit growth were done. On the other hand, non-ICM package includes farmer's practice only. Results indicated that 28 to 32.35% mango fruits by number and 9.12 to 17.15% yield by weight were increased in ICM packages as compared to non-ICM practices at two different study areas.

Introduction

In Bangladesh, the mango growing area is expanding each year, especially in north-western region and hilly areas. Like many other crops, it also has some problems in cultivation. Many factors are responsible for the yield of mango. Besides many other factors, insect pests and diseases; lack of optimum doses of fertilizers application and irrigation play a vital role for the low yield and poor quality of mango fruits. Among insect pests, Mango leafhoppers (MLHs) are the most destructive pests of all the mango varieties in Bangladesh (Karim, 1989). If not properly controlled, MLHs may cause a loss of 20-100 per cent of the inflorescences (Karim, 1989). Damage is mostly caused by the enormous number of hopper nymphs which feed on inflorescences and new leaves by sucking plant sap. The voracious feeding of the nymphs causes the inflorescences to wither and turn brown. Even fertilized flowers may not give fruits and very young fruits may drop due to withering of florets for reasons of physical injury and sap sucking by the nymphs. The MLHs also excrete honeydew which encourages development of sooty mould on the surface of leaves and shoots where the honeydew is retained. The black coating of the sooty mould interferes photosynthetic activity of the affected plant parts resulting non-setting of flowers and dropping of immature fruits (Karim 1989; Wen and Lee 1978).

Till now, chemical control is considered as the best way to control hopper populations and anthracnose diseases of mango in major mango growing areas of Bangladesh. In recent years, a drastic change in cropping pattern is seen in high Barind areas of Rajshahi and Naogaon districts. Mango orchards are growing there rapidly and farmers are getting lower yield due to their shallow knowledge about how to

control mangooppers and reduce flower and fruit dropping. Bangladesh Agricultural Research Institute has developed Integrated crop management techniques, that comprise Spraying of chemicals in proper time for hopper and anthracnose control, timely application of fertilizers and irrigation, can reduce flower and fruit dropping and enhance fruit yield (Sarker *et al.*, 2017). Therefore, the present study was undertaken to validate ICM technologies for increased mango production by reducing flower and fruit dropping caused by mainly insects, diseases, inadequate and improper application of fertilizers and irrigation in high Barind regions.

Materials and Methods

The trial was conducted at farmer's field of 2 different locations viz. Godagari of Rajshahi and Sapahar of Naogaon districts during 2020-21 mango season following randomized complete block design (RCBD) with 2 treatments (ICM and Non-ICM) and 10 replications. One mango tree was considered as one treatment replication. Around 15 years old mango trees of Khirsapat (at Godagari) and 10 years old mango trees of BARI Aam 3 (at Sapahar) varieties were used for the study. ICM package includes: application of recommended fertilizer dose; two sprays with imidacloprid (Confidor) 70 WG @ 0.2 g/litre of water with mancozeb (Indofil) M 45 @ 2.0 g/litre of water- 1st spray within 10 days of flowering and 2nd after one month of the first application; three irrigations starting from full bloom to fruit maturity at 15 days interval; two sprays with 2% urea solution at pea and marble stages of fruit growth were done. On the other hand, non-ICM package includes farmer's practice only.

In ICM package, recommended full doses of fertilizers (except urea and MoP) were applied at the end of September following standard method. Remaining fertilizers were split into two parts 1st of which was applied at pea stage and 2nd at mature stage of fruit growth. The insecticide Confidor 70 WG @ 0.2 g/litre of water and fungicide Indofil M 45 @ 2.0 g/Litre of water were applied twice as a full cover spray on mango trees from the ground with the help of a high volume and high-pressure power sprayer: the first application within 10 days of flowering (before opening of the flower) and the second at pea stage of the fruit growth (after 30 days of the first application). Three irrigations were applied starting from full bloom to fruit maturity at 15 days interval. At the time of harvest, the number of mango fruits counted and recorded by weight and number for comparing the yield of ICM and non-ICM packages.

Results and Discussion

Fruit retention and fruit yield: The results on the effect of Integrated Crop Management (ICM) packages in reducing flower and fruit dropping of mango in two different regions of high Barind tract (HBT) are presented in Table 1 & 2. Results indicated that 28 to 32.35% mango fruits by number and 9.12 to 17.15% yield by weight were increased in ICM packages as compared to non-ICM practices at two different study areas. Year-round management of the orchard and fertilizer application in splits might enhance the production of mango. Report says that yearly soil application of NPK markedly increased the number of mango fruit per plant, fruit weight, yield and fruit quality (Reddy *et al.*, 2000; Satapathy and Banik, 2002; Sharma *et al.*, 2000; Suriyapananont and Subhadrabandhu, 1992; Zhou *et al.*, 2001)

Farmer's reaction

Farmers obtained better crop yield from trees where ICM packages were applied. Neighboring farmers visited the field and were impressed to see improved management techniques for better mango yield.

Table 1. Effect of ICM packages in reducing flower and fruit dropping of mango (variety: Khirsapat of 15 years old) at Godagari, Rajshahi during 2020-21 mango season

Treatments	No. of healthy fruits (mean of 10 plants)	%Increase (+)/ Decrease (-) over non-ICM	Average fruit weight (g)	%Increase (+)/ Decrease (-) of fruit weight
ICM	233.0	28 (+)	240.5	9.12 (+)
Non-ICM	182.0	-	220.4	-

Table 2. Effect of ICM packages in reducing flower and fruit dropping of mango (variety: BARI Aam 3 of 10 years old) at Sapahar, Naogaon during 2020-21 mango season

Treatments	No. of healthy fruits (mean of 10 plants)	%Increase (+)/ Decrease (-) over non-ICM	Average fruit weight (g)	%Increase (+)/ Decrease (-) of fruit weight
ICM	135.0	32.35 (+)	201.5	17.15 (+)
Non-ICM	102.0	-	172.0	-

Conclusion

ICM packages increased 28% mango fruits retention and 9.12% yield on Khirsapat at Godagari, Rajshahi, and 32.35% mango fruit retention and 17.15% yield on BARI Aam 3 at Sapahar, Naogaon over non-ICM practices.

INCIDENCE OF CHICKPEA POD BORER, *HELICOVERPA ARMIGERA* HUBNER ON THE PROMISING VARIETIES OF CHICKPEA

J.C. Barman, M.E.A. Pramanik, M.S. Hossain, M.A. Hossain, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at farmer's field at Basantapur FSRD site, Godagari, Rajshahi during Rabi 2020-21 crop season to find out the abundance of chickpea pod borer and to provide indication of chickpea pod borers infestation level/status and its effect on seed yield of chickpea following randomized complete block design (RCBD) with 6 promising varieties and 3 replications. First appearance of chickpea pod borer larvae was found 76 days after sowing which was rapidly increased just two weeks after the first appearance. The highest appearance of pod borer larvae was recorded 2nd and 3rd week after first appearance. The infested pod ranged from 7.30 to 13.71% and the highest pod damage was obtained from BARI chola-11 where the lowest from BINA chola-8. BARI chola-9 produced the highest grain yield (1260 kg ha⁻¹) though a moderately higher per cent pod damage (11.12%) was found on it.

Introduction

Chickpea, *Cicer arietinum* L. is one of the important pulse crops in Bangladesh. It is generally grown under rainfed or residual soil moisture conditions in rabi season. Recent years chickpea growing areas and production are decreasing in trend because of crop competition with rabi crops and other factors. Although most of the people thinks that chickpea areas and production were decreased due to pod borer infestation. Yes, the pod borer, *Helicoverpa armigera* (Hubner) is a major and most serious pest in most of the chickpea growing areas. A country wide survey indicated that averages of 30 to 40 per cent pods were found to be damaged by pod borer with 400 kg ha⁻¹ grain loss (Rahman, 1990). In favourable condition, pod damage goes upto 90-95 per cent (Shengal and Ujagir 1990; Sachan and Katti 1994). The young caterpillar skeletonizes the leaves, while grown up caterpillar bores into the pods and feeds the seeds inside and cause significant yield loss. At present, the status of pod borer infestation level in the growing areas and effect on seed yield is not ascertained. With this view, the present study was taken to find out the abundance and infestation status of pod borer and its effect on grain yield.

Materials and Methods

The trial was conducted at farmer's field at Basantapur FSRD site, Godagari, Rajshahi during Rabi 2020-21 crop season to find out the abundance of chickpea pod borer and to provide indication of chickpea pod borers infestation level/status and its effect on grain yield of chickpea following randomized complete block design (RCBD) with 6 treatments and 3 replications. Six promising varieties of chickpea considered as treatments of the experiment which were: T₁ = BARI Chola-5, T₂ = BARI Chola-9, T₃ = BARI Chola-10, T₄ = BARI Chola-11, T₅ = BINA Chola-4 and T₆ = BINA Chola-8. Experimental plot size was 4m x 4m and planting spacing was 40cm x 10cm. The was prepared by ploughing and recommended fertilizers viz. Urea, TSP, MoP and Boric acid were applied at the rate of

40-90-40-7.5 kg ha⁻¹ as basal. No irrigation was applied. Regular observations were made to monitor the incidence of pod borer. First incidence of pod borer in chickpea field was recorded. Pod borer population per square meter was recorded.

At maturity, all the pods were collected from randomly placed 1 m² quadrants in each plot and examined. The damaged (bored) and total number of pods were counted and the per cent pod damage was determined using the following formula:

$$\% \text{ Pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Crops of the central four rows were harvested and then threshed. The grains were cleaned and dried in the bright sunshine. The grain yield obtained from each plot was converted into per hectare.

Results and Discussion

Abundance of pod borer: First appearance of chickpea pod borer larvae was found 76 days after sowing which was rapidly increased just two weeks after the first appearance. The highest appearance of pod borer larvae was recorded 2nd and 3rd week after first appearance (Fig.1). Total number of pod borer was found highest in BARI chola-9 plot (33.7) where the lowest in BARI chola-10 plot.

Pod damage and yield: The infested pod ranged from 7.30 to 13.71% and the highest pod damage was obtained from BARI chola-11 where the lowest from BINA chola-8. BARI chola-9 produced the highest grain yield (1260 kg ha⁻¹) though a moderately higher per cent pod damage (11.12%) was found on it and it might be happened due to the higher yield potentiality of the variety. The yield must be more if proper management practice is done to control pod borer infestation.

Farmer's reaction

Farmers were pleased to get better seed yield from BARI Chola-9 and BARI Chola-10 plot. Neighboring farmers visited the field and were impressed to see the better performance by BARI Chola-9 and BARI Chola-10 varieties.

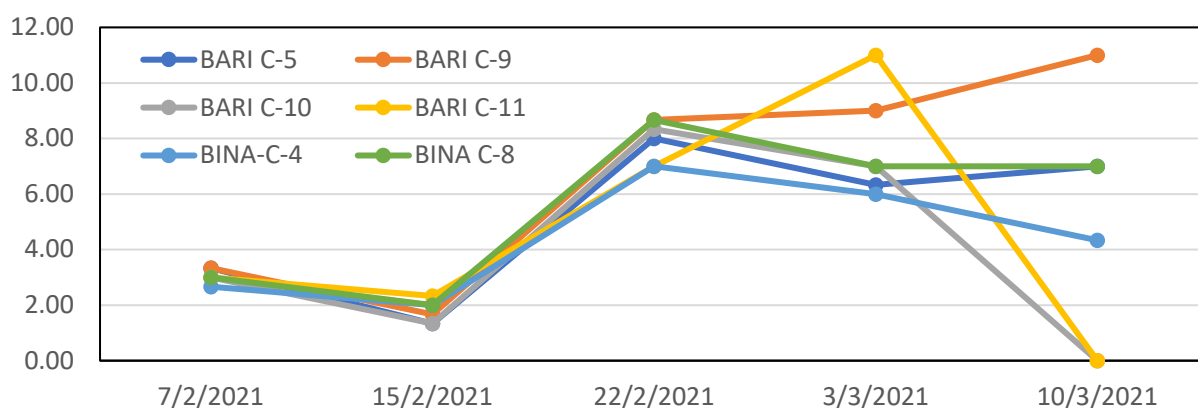


Fig.1. Abundance of chickpea pod borer on different varieties over time during Rabi season 2020-21 at Basantapur, Godagari, Rajshahi

Table 1. Pod borer infestation and seed yield of chickpea under different treatments during Rabi season 2020-21 at Basantapur, Godagari, Rajshahi

Treatments	No. of Fresh Pod	No. of Damaged Pod	Total No. of Pod	Pod Damage (%)	Seed yield (kg ha ⁻¹)
BARI Chola-5	343	33.6	377	8.92	1063
BARI Chola-9	318	39.8	358	11.12	1260
BARI Chola-10	283	40.2	324	12.42	1153
BARI Chola-11	232	36.8	269	13.71	1068
BINA Chola-4	314	29.9	344	8.70	953
BINA Chola-8	335	26.4	362	7.30	1067

Conclusion

Chickpea var. BARI Chola-9 and BARI Chola-10 varieties produced higher seed yield. The yield must be more if proper management practice is done to control pod borer infestation.

SURVEY AND DOCUMENTATION OF INSECT PESTS ATTACKING POTATO IN RAJSHAHI REGION

J.C. Barman, M.E.A. Pramanik, M.S. Hossain, M Akkas Ali, M Shahiduzzaman

Abstract

Survey was conducted at farmer's field of Godagari, Tanor and Mohanpur upazilla of Rajshahi district during Rabi 2020-21 crop season to document insect pests attacking potato. Six different insects were found and among them, two insects e.g. cutworm and aphids were major. Other insects like crickets, leaf miner and Spodoptera were minor pests in potato fields.

Introduction

Bangladesh became the seventh largest potato producing country in the world. It produced 1.09 crore tones of potato in 2018-19 (DAE). The weather condition favours potato production but because of the tropical and humid climate the potato cultivation is severely affected by the pests such as insect, diseases and weeds etc. However, the current status of insect pests has not been properly investigated in Bangladesh. For managing insect pests, farmers rarely imply integrated pest management (IPM) tactics. Rather, they often apply chemical pesticides to get rid of insect infestation (Alam *et al.*, 2016). The yield and production of potato are hampered by insect pest attack. Different sucking pests, common cutworm, *Helicoverpa*, leaf miner, root aphids etc. are causing serious damage to potato in Bogura and Joipurhat regions. These pests may be migrated to newly expanded potato growing areas of high Barind tract (HBT) and may cause serious damage to potato production. Therefore, the present study was undertaken for the documentation of insect pests attacking potato in HBT of Rajshahi.

Methodology

Survey work on the incidence of insect pests of potato was conducted at farmer's fields of Godagari, Tanor and Mohanpur upazilla of Rajshahi district during Rabi 2020-21 crop season. Data were collected by face to face interview and visiting potato fields. Incidence of insect pests were documented and damage severity was recorded following standard procedures. The information of the farmers' knowledge on insect pests of potato and their management practices has been discussed.

Results and Discussion

The data obtained from the survey are presented in Table 1. In response of the farmers in the surveyed area, the maximum farmers used BARI alu-7 (Diamant) comprising about 95% crop areas and rest 5% area comprised by other varieties including BARI alu-25 (Asterix). Farmers reported insect pests attack and disease infection as major hurdle of potato production. Most of the farmers reported that the potato was infested in the field by cutworm, which was followed by aphid infestation. Some farmers also reported that the potato was attacked by potato tuber worms, followed by leaf miner, mole cricket, field cricket, leaf hoppers and whitefly. The insect pests attacking potato in the fields in Bangladesh are enlisted in Table 2 (Nasif *et al.* 2018). The potato farmers faced high incidence of disease (late and early blight of potato, fusarium and brown rot, leaf roll virus, common scab, black heart, root knot etc.) and insect/pests (cut worm, aphids, tuber moth, cricket, leaf hopper etc.) still remain a drawback to attain maximum yield of potato (Siddique *et al.*, 2015). General activities taken by farmers for the management of insect pests and diseases in the potato fields are given in the Table 3.

Farmer's reaction

Farmers expressed their eager to get good potato seed and IPM techniques for the management of insect pests and diseases in the potato fields.

Table 1. Insect pests of potato in field condition at Godagari, Tanor and Mohanpur of Rajshahi during 2020-21 Rabi crop season.

Name	Family	Plant parts infested	Destructive stage of the pest	Status
Cutworm (<i>Agrotis ipsilon</i>)	Noctuidae	Root, seedling stage	Larvae	Major
Aphid (<i>Macrosiphum euphorbiae</i>)	Aphididae	Vegetative parts	Nymph and adult	Major
Leaf miner (<i>Liriomyza huidobrensis</i>)	Gelechiidae	Leaf, vegetative stage	Larvae	Minor
Mole cricket (<i>Gryllotalpa africana</i>)	Gryllotalpidae	Root, seedling stage	Adult	Minor
Field cricket (<i>Brachypterypes portensus</i>)	Gryllidae	Root, seedling stage	Adult	Minor
<i>Spodoptera litura</i>	Noctuidae	Leaf, vegetative stage	Larvae	Minor

Table 2. Various insect pests of potato in field condition (Nasif *et al.* 2018; ZH Prodhan).

Name	Family	Plant parts infested	Destructive stage of the pest	Status
Cutworm (<i>Agrotis ipsilon</i>)	Noctuidae	Root, seedling stage	Larvae	Major
Aphid (<i>Macrosiphum euphorbiae</i>)	Aphididae	Vegetative parts	Nymph and adult	Major
Potato tuber worm (<i>Phthorimaea operculella</i>)	Gelechiidae	Tuberization stage	Larvae	Minor
Leaf miner (<i>Liriomyza huidobrensis</i>)	Gelechiidae	Leaf, vegetative stage	Larvae	Minor
Mole cricket (<i>Gryllotalpa africana</i>)	Gryllotalpidae	Root, seedling stage	Adult	Minor
Field cricket (<i>Brachypterypes portensus</i>)	Gryllidae	Root, seedling stage	Adult	Minor
Leaf hoppers (<i>Empoasca fabae</i>)	Cicadellidae	Leaf, vegetative stage	Nymph and adult	Minor
Whitefly (<i>Bemisia tabaci</i>)	Aleyrodidae	Leaf, vegetative stage	Nymph and adult	Minor
<i>Helicoverpa armigera</i>	Noctuidae	Leaf, vegetative stage	Larvae	Minor
<i>Spodoptera litura</i>	Noctuidae	Leaf, vegetative stage	Larvae	Minor
Mealy bug (<i>Dysmicoccus brevipes</i>)	Pseudococcidae	Leaf, stem, twig	Nymph and adult	Minor
Root aphid (first reported by ZH Prodhan in Bd.		Root, tuber	Nymph and adult	Major (localized)

Table 3. Activities taken by farmers for the management of insect pests and diseases in potato field during 2020-21 crop season in Rajshahi region.

Name of insecticides/fungicides	Group name	Time of application	Target insects/diseases
Furadan	Carbofuran	During planting of seed tubers	Cutworm
Irrigation followed by herbicide spray	Roundup (glyphosate), pendimethalin	3-5 days after planting, during earthing-up	Weeds
Dursban	Chlorpyrifos	During plant initiation period	Cutworm, sucking insects
Fungicide(s) + Insecticides + Vitamins	Mancozeb/ Mancozeb Metalaxyl + Chlorpyrifos	Starts at 10-12 days after plant initiation & continued at 7-10 days intervals.	Disease & insects
Fungicide(s) + Insecticides	Carbendazim + Chlorpyrifos	At 55 days after plant initiation, 1-2 sprays	To enhance tuber formation
If the weather becomes foggy or rains occur, farmers spray a cocktail of several chemicals			

Conclusion

Potato var. BARI Alu-7 (Diamant) is the most popular variety in the study area. Potato production and yield is being attacked by various insect pests and diseases. Common cutworm was found to be the major insect pest in the field. The farmers are used to spray various types of insecticides and fungicides indiscriminately to get rid of insect and disease attack in the potato fields.

SURVEY, MONITORING AND DOCUMENTATION OF MAJOR INSECT PESTS OF PULSE CROPS IN HIGH BARIND TRACT

M.E.A. Pramanik, M.S. Hossain, J.C. Barman, M Akkas Ali, M Shahiduzzaman

Abstract

A field survey was conducted in western region of Bangladesh during rabi season 2020-21 to record the infestation and major pest of pulse crops in High Barind Tract. Insects have not been a major problem in lentil production in HBT. But Aphid and pod borer occasionally cause some problems. Six pests are recorded in lentil crops, e.g., cutworms, aphid, pod borer, whitefly, green sting bug and thrips. Besides, several insects live and feed on chickpea plant. Foliage, buds, flowers, pods, roots and even root nodules are eaten by one or more insect pests. In Barind area, seven pests are seldom infested in the chickpea field, e.g., black cutworm, common cutworm, green semilooper, green sting bug, aphid, whitefly and pod borer. On the other hand, four types of insect pests were observed in grasspea, e.g., aphid, green sting bug, thrips and cowpea weevil/bruchid.

Introduction

The High Barind Tract (HBT) (AEZ-26) having clay loam and clayey soils. Low precipitation during monsoon results soil moisture stress that hinders proper establishment of rabi crops even after early kharif-1 crops. Pulse is an important crops its introduced newly in HBT area. Recently, in Barind area, most of the farmers are interested to cultivate pulse crops for off-chance crop. Unfortunately, the crop is attacked by a number of insect pests. The pests are attacking the crop on leaves and roots and causing considerable losses. So, it is necessary to document the pests for developing appropriate management strategies. The present study is undertaken to identify the pests and damage potentiality.

Materials and Methods

Survey was carried out in two upazilla of Godagari, Rajshahi and Nachole, Chapainawabganj during rabi season 2020-21. Three pulse growing areas of each upazilla and five samples were selected per location. Ten plants was selected from each sample and examined carefully to identify the insect pests and their infestation status. The collected data have processed and analyzed properly.

Results and Discussion

Infestation of pests of pulse crops (Lentil, chickpea and grasspea) are started after sowing average 40 days (Table 1). Aphids damage lentil plants directly by feeding on them and more seriously transmit plant viruses. Both nymphs and adults suck the plant sap from the tender leaves, stems and pods, and mostly colonize on the young leaves and growing points, which become characteristically deformed. Host reaction to insect feeding are not characteristic but large populations on young plants can prevent their normal growth, affecting yield. The infestations of crops are always initiated by alate forms produced on pre-infested plants (Table 2). Thrips are minute (1 to 2 mm), elongate insects with four extremely slender wings in which the developmental stages resemble the adults, but are lighter coloured and wingless. Thrips attack leaves, flowers and pods by puncturing the plant organs and sucking up the sap, causing silvery blotches and dashes. As the attack increases the leaves and flowers become distorted and under heavy infestation can occasionally cause serious economic damage (Table 2). The adults are large and brown and up to 20 mm long, are active at night and lay hundreds of eggs singly on the underside of leaflets. Larvae can reach 40 mm, and have different and quite attractive coloration, but mostly green. Fully grown larvae, usually 6th instars drop to the soil to pupate. The larvae cause damage to the leaves with young instars scraping the surface of leaflets and feeding on flowers, while older larvae feed on foliage and more damagingly on pods (Table 2).

Among the insect-pests, pod borer is the most severe yield reducer throughout Bangladesh, while the bruchids cause severe damage in storage. Other minor insect pests of chickpea are cutworm, green semilooper, green sting bug and whitefly. *Helicoverpa* is the main pest in chickpeas. Chickpeas are susceptible to significant yield loss caused by *helicoverpa* from pod set through to harvest. Whilst

helicoverpa can cause reductions in both yield and quality, the economic threshold for minimising yield loss is much lower than that which would result in a reduction in grain quality (Table 3).

Major pests of Aphid and Thrips can have a significant effect on the establishment, yield and longevity of grasspea crop (Table 4). Aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae) is a serious threat to the crop yield of *Lathyrus sativus* L. (Fabaceae), commonly known as grass pea. The aphid produces honeydew (a sweet and watery anal excrement), which serves as a medium for growth of sooty mould, causing blackening of leaves and thereby reducing photosynthesis (Table 4).

Table 1. Sowing date and appearance of insect pests in lentil, chickpea and grass pea during rabi season 2020-21 at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT

Crops	Date of sowing	No infestation	First infestation started
Lentil	17-18 November 2020	40 days of sowing	12 January 2021
Chickpea	16-20 November 2020	45 days of sowing	20 January 2021
Grass pea	25 Oct. to 7 Nov. 2020	42 days of sowing	10 January 2021

Table 2. List of Insect pest of lentil with infested plant parts at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT

SL. No.	Common Name	Scientific Name	Order: Family	Infested Parts	Status
1	Cutworm	<i>Agrotis ipsilon</i> <i>Hufnagel</i>	Lepidoptera: Noctuidae	Cut the leaves, stems and roots	Minor
2	Aphid	<i>Aphis Craccivora</i> Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
3	Whitefly	<i>Bemisia tabaci</i>	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
4	Green Stink bug	<i>Nezara viridula</i> Linn	Homoptera: Pentatomidae	Suck sap from shoots and pods	Minor
5	Thrips	<i>Megalurothrips distalis</i> Korny	Thysanoptera: Thripidae	Suck sap from flowers	Major
6	Pod borer	<i>Helicoverpa armigera</i> Hubner	Lepidoptera: Noctuidae	Bore to the pod	Major

Table 3. List of Insect pests of chickpea with infested plant parts at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT

SL. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
1	Black Cutworm	<i>Agrotis Ipsilon</i> <i>Hufnagel</i>	Lepidoptera: Noctuidae	Disconnect the base of seedlings	Minor
2	Common Cutworm	<i>Spodoptera litura</i> <i>Fabricius</i>	Lepidoptera: Noctuidae	Cut the seedlings roots	Minor
3	Green Semilooper	<i>Plusia Signata</i> <i>Fabricius</i>	Lepidoptera: Noctuidae	Feed on foliage and young plants	Minor
4	Green Stink bug	<i>Nezara viridula</i> Linn	Hemiptera: Pentatomidae	Suck sap from shoots and pods	Minor
5	Aphid	<i>Aphis craccivora</i> Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
6	Whitefly	<i>Bemisia tabaci</i> <i>Gennadius</i>	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
7	Pod borer	<i>Helicoverpa armigera</i> <i>Hubner</i>	Lepidoptera: Noctuidae	Bore to the pod	Major

Table 4. List of Insect pests of grasspea with infested plant parts at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT

SL. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
1	Aphid	<i>Aphis craccivora</i> Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
2	Green Stink bug	<i>Nezara viridula</i> Linn.	Hemiptera: Pentatomidae	Suck sap from shoots and pods	Minor
3	Thrips	<i>Megalurothrips distalis</i> Korney	Thysanoptera: Thripidae	Suck sap from flowers	Major
4	Cowpea weevil/bruchid	<i>Callosobruchus maculatus</i> Fabricius	Coleoptera: Bruchidae	Boring on grain	Minor

CONTROLLING OF BIRD PESTS IN SUNFLOWER CROP USING DIFFERENT REPELLENT TOOLS AT COASTAL AREAS OF BANGLADESH

K.N. Islam, M.M. Islam, P. Chakraborti, M.S.I. Khan, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment for controlling of bird pests in sunflower production was conducted at farmer's field condition in Patuakhali sadar, Patuakhali and Amtoli, Borguna during *Rabi* season of 2020-21 to find out the appropriate repellent options. Five management techniques (MT) namely: MT₁= Hanging red ribbon, MT₂= Making scarecrow, MT₃= Plastic bottle windmill, MT₄= Bird repellent mechanical device and MT₅= Control were evaluated. Among the different repellent tools the maximum seed yield of sunflower was obtained from Plastic bottle windmill (1.91 t ha⁻¹) as repellent tool which was followed by Bird repellent mechanical device (1.90 t ha⁻¹), Hanging red ribbon (1.82 t ha⁻¹) and Making scarecrow (1.80 t ha⁻¹) while the minimum was in control (1.50 t ha⁻¹). Similarly different repellent tools showed increase in yield of sunflower over control. Over the using different repellent tools, the maximum BCR was obtained from Plastic bottle windmill (1.50) used plot followed by Hanging red ribbon (1.46), Bird repellent mechanical device (1.40), Making scarecrow (1.40) while the minimum one from control (1.23).

Introduction

Sunflower (*Helianthus annuus* L.) is a globally important oilseed and a high-value crop. It is very susceptible to birds. So susceptible, in fact, that bird damage can lead to the entire crop being destroyed and abandoned. Bird damage to sunflower is recognized as an international economic problem for sunflower producers. Bird attacks on sunflower crops occur from the sowing stage. Sometimes they occur later - in most cases - affecting the flower head. Attacks can be very frequent and cause substantial damage to the sunflower crop. However, in order to limit the damage caused by these birds, measures have to be taken to protect the sunflower crop from its inception. Different repellents options may reduce the attacking of bird pests which may help in crop production. Therefore, the present experiment was undertaken to find out the appropriate repellent options for sunflower production and to enhance production of the farmers at coastal areas of Bangladesh.

Materials and Methods

The experiment was conducted under farmer's field condition at Patuakhali sadar, Patuakhali and Amtoli, Borguna during *Rabi* season of 2020-21. Five management techniques (MT) namely: MT₁= Hanging red ribbon, MT₂= Making scarecrow, MT₃= Plastic bottle windmill, MT₄= Bird repellent mechanical device and MT₅= Control were evaluated. BARI Surjomukhi-2 was used as test crop. The unit plot size was 33 decimal for each site. Seeds were sown on 17-25 January at Patuakhali sadar and Amtoli which 50 cm x 25 cm spacing was maintained. The trial plot was fertilized with 180-150-120-120-10 kg ha⁻¹ in the form of Urea, TSP, MoP, Gypsum, Boric acid, respectively in the field. Half of

Urea and full doses of all other fertilizers were applied at final land preparation. The rest Urea was applied in two equal splits at 25 DAS and 45 DAS in the growing season. All intercultural operations were done in proper time for better growth of the crop. Yield data were recorded properly.

The management techniques (MT) are details in the following table:

Management techniques (MT)	Making required materials	Cost of preparing each device (Tk.)	Per hectare of land		Installation Process
			number of required device	Total cost (Tk.)	
Hanging red ribbon	Red ribbon, thin plastic rope etc.	Remarks: In the case of Hanging red ribbon, approximate Tk. 200 was spent on each 33 decimal of land.		1500	After maintaining the thin plastic rope at a distance of 5 m, a 1.5 feet long red ribbon was cut and tied at 2 feet intervals to the thin plastic rope.
Making scarecrow	Unused handle shirt, thick stiff stick, earthen pot etc.	25	150	3750	Each device was maintained at a distance of 10m x 10m which would require approximate 150 devices per hectare of land.
Plastic bottle windmill	Plastic bottle, red sticky tape, thin stiff stick etc.	20	150	3000	Each device was maintained at a distance of 10m x 10m which would require approximate 150 devices per hectare of land.
Bird repellent mechanical device (Remarks: The cost of making each device was estimated at Tk. 3,000. However, if the device is suitable for usable of 3 (three) seasons, the cost of making the device can be economically analyzed at Tk. 1000 per season)	Calling bell, battery, timer etc.	1200 (Remarks: If the cost of making the device for each season is Tk. 1000 and electricity cost is Tk. 200)	7	8400	Each device was installed at 1 bigha which would require 7-8 devices per hectare of land.

Results and Discussion

The results presented in Table 1 reveal that the yield of sunflower varied by using different repellent tools. The maximum seed yield (1.91 t ha⁻¹) was received from the plot where Plastic bottle windmill was used as repellent tool for controlling of bird pests which was followed by Bird repellent mechanical device (1.90 t ha⁻¹) as repellent tool and the minimum (1.50 t ha⁻¹) was in control. Different repellent tools showed increase in yield of sunflower over control (Table 1). The maximum percent yield increase over control (27.33%) was recorded in Plastic bottle windmill used plot followed by Bird repellent mechanical device (26.67%), Hanging red ribbon (21.33%) and Making scarecrow (20.00%).

The gross margin and benefit cost ratio (BCR) varied depending on the cost of using different repellent tools in the experiment. The maximum gross margin (Tk. 38395 ha⁻¹) was recorded from Plastic bottle windmill used plot followed by Hanging red ribbon, Bird repellent mechanical device and Making scarecrow. Similarly, the maximum benefit cost ratio was calculated from Plastic bottle windmill (1.50)

used plot followed by Hanging red ribbon, Bird repellent mechanical device, Making scarecrow while the minimum was in control (1.23) (Table 2).

Farmers' opinion

- Farmers are very interested in producing sunflower crop if proper measures are taken to control the bird pests.
- Among different repellent tools for controlling bird pests, the Plastic bottle windmill is an effective approach for saving, preparing and using.
- This device is wind dependent but even if there is no air, the birds don't come to the crop field in panic as there is red sticky tape with the Plastic bottle windmill.
- They hope to make this technique more effective and efficient in repelling birds.

Table 1. Performance of yield of sunflower as influenced by using different repellent tools during *Rabi* season of 2020-21

Management techniques	Sunflower var. BARI Surjomukhi-2				
	Plant height (cm)	Head diameter (cm)	1000 seed weight (g)	Seed yield (t ha ⁻¹)	% Yield increase over control
MT ₁	138.83	18.68	60.97	1.82	21.33
MT ₂	135.33	18.07	60.11	1.80	20.00
MT ₃	142.23	19.53	61.11	1.91	27.33
MT ₄	143.53	19.51	62.04	1.90	26.67
MT ₅	134.53	16.21	58.66	1.50	-

MT₁ = Hanging Red Ribbon, MT₂ = Making Scarecrow, MT₃ = Plastic Bottle Windmill, MT₄ = Bird Repellent Mechanical Device, MT₅ = Control

Table 2. Cost and return analysis of sunflower as influenced by different repellent tools during *robi* season of 2020-21

Management techniques	Sunflower var. BARI Surjomukhi-2				
	Total yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
MT ₁	1.82	109200	74705	34495	1.46
MT ₂	1.80	108000	76955	31045	1.40
MT ₃	1.91	114600	76205	38395	1.50
MT ₄	1.90	114000	81605	32395	1.40
MT ₅	1.50	90000	73205	16795	1.23

Selling Price Sunflower= Tk 60/ kg

Conclusion

Considering effectiveness and profitability, it could be concluded that the using of Plastic bottle windmill is the best approach for the controlling of bird pests in sunflower production followed by Hanging red ribbon.

MANAGEMENT OF POD BORER, *MARUCA VITRATA* USING CHEMICALS, BOTANICALS AND BIOPESTICIDES IN MUNGBEAN AT SOUTHERN DISTRICTS

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Abstract

The experiment was conducted at Patuakhali Sadar, Patuakhali during late Rabi 2020-21 to find out effective control measure against pod borer, Maruca vitrata of mungbean by various means, including chemicals, botanicals and bio-pesticides. Mungbean variety, BARI Mung-6 was grown in the field and five treatments viz., T₁ [Azadirachtin (Fytomax aza 3%)], T₂ [Spinosad (Success 2.5SC)], T₃ [Chlorpyrifos + Cypermethrin (Nitro 505EC)], T₄ [Thiamethoxam + Chlorantraniliprole (Voliam flexi 300SC)] and T₅ [Untreated control (water spray)] were set in randomized complete block design

(RCBD) with three replications. The insecticidal treatment options showed significantly different performance against pod borer, *Maruca vitrata* on mungbean. The lowest population of pod borer was found in Fytomax aza 3% treated plot and the lowest percent of pod infestation observed by the same treatment. The maximum yield (1.51 t ha^{-1}) and the highest (5.09) marginal benefit cost ratio (MBCR) were obtained from Fytomax aza 3%. Considering effectiveness and marginal benefit cost ratio, Fytomax aza 3% was more effective among the treatments for controlling pod borer of mungbean followed by Nitro 505EC.

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the most important pulse crops of Bangladesh. It is a rich source of protein and several essential micronutrients. Additionally, this leguminous plant fixes atmospheric nitrogen through symbiosis with a *Rhizobium* species into the soil. Apart from these, addition of organic matter to the soil is important factors in maintaining soil fertility. The reasons of low yield are numerous but yield losses due to insect pests are distinct one. Insect pests attack is considered as the most important one limiting mungbean production. Several insect pests are found to infest mungbean in Bangladesh among them pod borer is considered major one. Pod borer damages flowers, flower buds and developing or mature pods. Some management options like chemicals, botanicals and biopesticides may reduce the attacking of pod borer which may help in crop production. Therefore, the present experiment was carried out to evaluate the effectiveness of chemicals, botanicals and bio-pesticides against pod borer, *Maruca vitrata* for mungbean production in southern districts of Bangladesh.

Materials and Methods

The experiment was conducted at Patuakhali Sadar during late *Rabi* season of 2020-21. The experiment was laid out in RCB design with 3 replications. The unit plot size was $4\text{m} \times 2.5\text{m}$. BARI Mung-6 was used as experimental material and was sown on 1 February at the rate of 30 kg ha^{-1} in rows maintaining spacing ($30\text{cm} \times 10\text{cm}$). The land was fertilized with 50-85-35 kg N-P-K ha^{-1} in the form of Urea, TSP, MoP, respectively during the final land preparation. All intercultural operations were done as and when necessary to ensure normal growth and development of crops. Five treatments of the experiment were assigned as follows: (1) T_1 = Azadirachtin (Fytomax aza 3%) @ 1 ml l^{-1} of water, (2) T_2 = Spinosad (Success 2.5SC) @ 1.2 ml l^{-1} of water; (3) T_3 = Chlorpyrifos+Cypermethrin (Nitro 505EC) @ 1 ml l^{-1} of water, (4) T_4 = Thiamethoxam+Chlorantraniliprole (Voliam flexi 300SC) @ 0.5 ml l^{-1} of water, (5) T_5 = Untreated control. The spray solutions at the pre-fixed concentration of the respective treatments were prepared in Knapsack sprayer by mixing with water as required just before spraying. The spray solutions were sprayed at flowering stage and podding stage. Number of pod borer was recorded at flowering stage and podding stage. The data on the population of pod borer were collected before and after 1 day of spray application from each unit plot. The selected 1m^2 ($1\text{m} \times 1\text{m}$) area of the center of each unit plot was kept undisturbed for recording yield data. Grains were recorded from 1m^2 area per plot wise and the yields were expressed in t ha^{-1} . For collecting data on the percentage of pod borer infested pods, the number of infested pods and the total number of pods from randomly selected 10 plants from each unit plot were counted at ripening stage and recorded. The following formula was used for taking the infestation percentage:

$$\% \text{ Pod infestation} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

At harvest, yield and yield components data were recorded and analyzed statistically. The population data were transformed to square root transformation for statistical analysis and mean comparisons were separated by critical difference (CD) values at 5% level of significance.

Marginal benefit cost ratio (MBCR) for each treatment was calculated by using the following formula:

$$\text{MBCR} = \frac{\text{Benefit over control}}{\text{Cost of treatment}}$$

Results and Discussion

Effect of treatments on pod borers' population at different growth stages: The results are mean comparison of the data, regarding the treatment effect on pod borer, *Maruca vitrata* and percent

reduction at different growth stages (flowering stage and podding stage) presented in Table 1. The treatments also showed significant influence on pod borer. After 1 day of spray application, the lowest number of pod borer (1.06/plot at flowering and 1.09/plot at podding stage) was observed in T₁ treated plot followed by T₂ treated plot having significant difference between them. The highest number of pod borer was found in T₅ plot which was significantly higher than all other treated plots. The results of the present study revealed that all the insecticides significantly reduced pod borer infesting mungbean. However, T₁ was the most effective treatment against pod borer infesting mungbean in field condition while T₂ was the second most effective treatment. In both the flowering and podding stage, the highest percent reduction of pod borer was found in T₁ and the lowest was in T₅.

Effect of treatments on yield attributing characters and yield of mungbean: Yield and yield contributing characters are presented in Table 2. Among different treatments, no. of plant population per m², no. of pods per plant, no. of seeds per pod, 1000 seed weight and yield were significantly different. The highest number of plant population/m² (21.33) were recorded in T₁ which statistically similar to that of (20.33) T₂ and (19.33) T₃ whereas the lowest (10.33) were observed on T₅ [Untreated control]. The highest number of pods/plant (35.33) was recorded in T₁ followed by (32.53) T₃ and the lowest (20.47) were observed on T₅. The highest number of seeds/pod (12.47) was recorded in T₂ followed by (12.20) T₁ and the lowest (11.13) were observed on T₅. 1000 seed weight ranged from 50.67-44.00 g. The highest 1000 seed weight (50.67 g) were recorded on T₃ followed by (49.33 g) T₁ and the lowest one (44.00 g) from T₅. In respect of seed yield, statistically significant variation was observed among the treatments (Table 2). Seed yield ranged from 1.51-1.21 t ha⁻¹. The highest yield (1.51 t ha⁻¹) were recorded in T₁ treated plot which was statistically similar to that of (1.50 t ha⁻¹) T₂ and the lowest yield (1.21 t ha⁻¹) was found on T₅.

Percentage of pod infestation by pod borer at ripening stage: Pod borer infestation was moderate and it ranged from 2.10 to 14.20% (Table 3). The lowest pod infestation was observed 2.10% in T₁ which was followed by (7.07%) T₃. The highest pod infestation was 14.20% in T₅.

Return and Marginal benefit cost ratio (MBCR)

Economic analysis of treatments applied against pod borer on mungbean has been done in Table 3. The gross return and marginal benefit cost ratio (MBCR) varied depending on the cost of different insecticidal (chemicals, botanicals and bio-pesticides) application in treatments. The T₅ did not incur any pest management cost. The highest net return (Tk. 16300 ha⁻¹) was recorded from Fytomax aza sprayed plots followed by Success, Nitro and Voliam flexi. The highest marginal benefit cost ratio (5.09) was calculated from Fytomax aza sprayed plots. For each taka spent, Fytomax aza gave profit of Tk. 5.09 as against Tk. 3.18, Tk. 2.48 and Tk. 1.45 in Nitro, Success and Voliam flexi, respectively. These profit findings showed very encouraging results of spraying in mungbean. Spraying Azadirachtin (Fytomax aza 3%) @ 1 ml l⁻¹ of water gave highest benefit followed by Chlorpyrifos+Cypermethrin (Nitro 505EC) and Spinosad (Success 2.5SC).

Table 1. Effect of treatments on pod borers' population at different growth stages in mungbean during 2020-21

Treatments	Flowering stage			Podding stage		
	Pod borer/plot		Reduction of pod borer after 1 day of spray (%)	Pod borer/plot		Reduction of pod borer after 1 day of spray (%)
	Before spray	After 1 day of spray		Before spray	After 1 day of spray	
T ₁	2.22 b	1.06 c	52.25	2.39 b	1.09 c	54.39
T ₂	2.12 b	1.31 bc	38.21	2.29 b	1.47 bc	35.81
T ₃	2.33 b	1.40 bc	39.91	2.49 b	1.54 b	38.15
T ₄	2.28 b	1.49 b	34.65	2.34 b	1.56 b	33.33
T ₅	2.96 a	2.05 a	30.74	3.04 a	2.29 a	24.67
CV (%)	7.90	18.43	-	8.13	17.54	-
CD (0.05)	0.29	0.42	-	0.32	0.43	-

T₁ = Azadirachtin (Fytomax aza 3%) @ 1 ml l⁻¹ of water; T₂ = Spinosad (Success 2.5SC) @ 1.2 ml l⁻¹ of water; T₃ = Chlorpyrifos+Cypermethrin (Nitro 505EC) @ 1 ml l⁻¹ of water; T₄ = Thiamethoxam+Chlorantraniliprole (Voliam flexi 300SC) @ 0.5 ml l⁻¹ of water; T₅ = Untreated control.

Table 2: Yield attributes and yield of mungbean during 2020-21

Treatments	Plants per m ²	No. of pods per plant	No. of seeds per pod	1000 seed weight (g)	Yield (t ha ⁻¹)
T ₁	21.33 a	35.33 a	12.20 ab	49.33 ab	1.51 a
T ₂	20.33 a	29.47 bc	12.47 a	48.00 abc	1.50 a
T ₃	19.33 a	32.53 ab	11.80 bc	50.67 a	1.39 b
T ₄	15.33 b	26.73 c	12.00 abc	46.67 bcd	1.31 c
T ₅	10.33 c	20.47 d	11.13 d	44.00 d	1.21 d
CV (%)	7.74	6.31	2.76	4.08	0.94
CD (0.05)	2.52	3.19	0.60	3.52	24.57

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV = Coefficient of Variation, CD = Critical Difference.

Table 3. Efficacy of treatments on pod infestation by pod borers and Cost-benefit analysis of mungbean production during 2020-21

Treatments	Pod infestation by Pod borers (%)	Yield (t ha ⁻¹)	Increase yield over control (t ha ⁻¹)	Additional return over control (Tk. ha ⁻¹)	Cost of insecticide application (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Marginal benefit cost ratio (MBCR)
T ₁	2.10 c	1.51 a	0.30	19500	3200	16300	5.09
T ₂	7.54 b	1.50 a	0.29	18850	5416	13434	2.48
T ₃	7.07 bc	1.39 b	0.18	11700	2800	8900	3.18
T ₄	8.18 b	1.31 c	0.10	6500	2650	3850	1.45
T ₅	14.20 a	1.21 d	-		-	-	-
CV (%)	30.03	0.94					
CD (0.05)	4.53	24.57					

Market price of mungbean seed @ Tk. 65/kg, Fytomax aza 3% @ Tk. 220/100 ml, Success 2.5 SC @ Tk. 92/25 ml, Nitro 505EC (50 ml) @ Tk. 90/50 ml and Voliam flexi 300SC @ Tk. 330/100 ml. Labor wage for spraying insecticides @ Tk. 500/man/day (8 hours)

Conclusion

Considering effectiveness and profitability, it could be concluded that the application of Azadirachtin (Fytomax aza 3%) is the most profitable approach for the management of pod borer of mungbean followed by Chlorpyrifos+Cypermethrin (Nitro 505EC) for suppressing pod borer, *Maruca vitrata*.

INTEGRATED MANAGEMENT OF SIGATOKA LEAF SPORT AND PANAMA DISEASE OF BANANA IN KUSHTIA

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Abstract

The experiment was conducted in the farmers' field at Kushtia sadar upazila during 2020-2021 to control Sigatoka leaf sport and Panama disease of banana in Kustia to increase yield and farmers' income. The treatment combinations used for the experiment were T₁: Furadan 5G during pit preparation+ refuse/mustard oil cake @ 2kg/pit+Deep plantlet before planting in 1.0% Autostin solution+Spray Tilt 1ml/L with soap, T₂: Farmers' Practice (Only Spraying Tilt) and T₃: Control. Plant mortality was lower (4.33%) in T₁ (Furadan 5G during pit preparation+ refuse/mustard oil cake @ 2kg/pit+Deep plantlet before planting in 1.0% Autostin solution+Spray Tilt 1ml/L with soap) which the treatment package suggested by BARI was followed. The highest plant mortality was recorded from T₃ (control) and that was 13.67%. Plant mortality was found 8.67% in farmers' practice. The highest yield was obtained from T₁ (34.66 t ha⁻¹) followed by farmers' practice (31.34 t ha⁻¹) and control (23.64 t ha⁻¹).

Introduction

Banana (*Musa spp.*) is one of the world's most important crops and it serves as a staple food in many developing tropical and subtropical countries. Over 100 million metric tons of the crop are produced annually. However, this crop production is severely hampered by Panama disease (also known as

Fusarium wilt disease) caused by *Fusarium oxysporum* f. sp. cubense race 4 (FOC), leading to extensive failure of commercial plantations (Ploetz RC, 2015). The soil-borne fungal pathogen colonizes and occludes the host xylem to cause vascular wilt. So far not yet a practically effective approach of controlling this notorious disease in the field is available. Soil sterilization using fungicides has been used only for intensive agriculture in greenhouses on a limited scale (Fu et al. 2017). Environmentally friendly cultural practices and fungicides are urgently needed (Fu et al. 2017).

An integrated approach appears to be feasible in management of banana disease that includes use of improved/resistant cultivars and disease free planting stocks, judicious use of pesticides, irrigation water, removal of diseased plants and plant parts, proper sanitation in plantation and a close monitoring of the diseases in relation to weather parameters. The total production was decreased 1004520 tons to 800840 tons due to decreasing cultivated area. The farmers of Kushtia are habituated to cultivate banana intensively as a commercial crops. The cause of reducing production area in recent year due to Sigatoka and panama disease. So the experiment was undertaken to produce disease free banana at farmers' field of Kushtia.

Materials and Methods

The experiment was conducted at Kushtia sadar upazila in Kushtia districts during 2020-21 in farmer's field to observe the efficacy of different management options on controlling Sigatoka leaf sport and Panama disease of banana. The land was medium-high land, and the soil was loam in texture. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering to break the clods as well as to level the soil. Three treatments were arranged in Randomized Complete Block Design with three dispersed replications. The unit plot size was 100 square meter in each treatment. The treatment combinations used for the experiment were T₁: Furadan 5G during pit preparation+ refuse/mustard oil cake @ 2kg/pit+Deep plantlet before planting in 1.0% Autostin solution+Spray Tilt 1ml/L with soap, T₂: Farmers' Practice (Only Spraying Tilt) and T₃: Control. Banana plants were planted on 17 June, 2020. Fertilizers were applied (Urea-TSP-MoP-Gypsum@600-400-600-300 g plant⁻¹ according to BARI Krishi Projukti Hatboi. Irrigation was done two time at 40-60 DAP. Treatment package was done following suggested package. The Fruit was harvested during 15 May, 2020. All the collected data were recorded and analyzed as per objectives.

Results and Discussion

Plant mortality was lower (4.33%) in T₁ (Furadan 5G during pit preparation+ refuse/mustard oil cake @ 2kg/pit+Deep plantlet before planting in 1.0% Autostin solution+Spray Tilt 1ml/L with soap) which the treatment package suggested by BARI was followed. The highest plant mortality was recorded from T₃ (control) and that was 13.67%. Plant mortality was found 8.67% in farmers' practice. The highest fruit yield was obtained from T₁ (34.66 t ha⁻¹) followed by farmers' practice (31.34 t ha⁻¹) and control (23.64 t ha⁻¹).

Table 1. Effect of different treatments on banana in Kushtia during 2020-21

Treatments	Plant height (m)	Plant mortality (%)	No. of finger branch ⁻¹	Yield (t ha ⁻¹)
T ₁	4.93	4.33	110.25	34.66
T ₂	4.95	8.67	105.33	31.34
T ₃	4.91	13.67	107.66	23.64
CV(%)	8.43	9.67	13.67	8.33
F-test	NS	*	NS	*

Conclusion

Based on findings, it may be concluded that use of Furadan 5G during pit preparation with use poultry refuse/mustard oil cake @ 2kg/pit. Deep plantlet before planting in 1.0% Autostin solution and spray Tilt 1ml/L with soap to minimize yield loss due to disease. So, this message should be circulated among the farmers through GO and NGOs as well as different media.

MANAGEMENT OF TIP BURN OF GARLIC

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Abstract

The experiment was conducted at Agriculture Research Station, BARI, Bogura during 2019-20 and 2020-21 to observe the effect of various treatments on the tip burn, a leaf blight disease of garlic. To assess the efficacy of different control measures on tip burn of garlic. There were 10 treatments including control. The tip burn incidence varied with the different management approaches ranging from 75.32 -90.54% in 2019-20 and 85.15-97.38% in 2020-21 cropping season. From the two years study, it was observed that application of ash, soil amendment with Zn, timely irrigation schedule, application of K_2SO_4 and $CaSO_4$, spraying with a fungicide like Amistar Top and Nutraphos-N3 were helpful for a slight reduction in burning of the tips of garlic plants as compared to no spray (control) condition. However, the highest tip burn incidence was obtained from T_{10} (Control) treatment, and the lowest incidence was obtained from T_8 (Amistar Top @ 1 mL^{-1} of water) and T_9 (Nutraphos-N 3 times foliar spraying @ 4 gL^{-1}). Boron application either in soil or by spray as Solubor did not affect reducing burning incidence. More burning resulted in the reduction of bulb yield of garlic and vice versa. The highest number of cloves per bulb and single bulb weight were obtained from T_9 treatment followed by T_8 treatment, but the control treatment resulted in the lower number of cloves per bulb and single bulb weight with which burning incidence was the maximum. Yield varied from $7.77\text{--}10.42\text{ t ha}^{-1}$ in 2019-20 and from $6.72\text{--}7.53\text{ t ha}^{-1}$ in 2020-21. Higher yield was recorded in T_9 and T_8 which were statistically identical to the yield secured from other treatments except for T_{10} (control). Higher bulb yield contributed to the higher gross return and gross margin. Maximum gross return and gross margin were recorded from T_9 treatment followed by T_8 and the minimum from T_{10} treatment.

Introduction

Garlic (*Allium sativum* L) is one of the most important bulb crops commercially grown in all parts of the country. The total production area was 60776 ha and the total production was 381851 metric tons with an average yield of 6.28 metric tons per hectare in Bangladesh (BBS, 2016). Technology developed through research to produce garlic under Bangladesh's condition is very limited. However, very little effort was given to the management of tip burn in Bangladesh. As a result, a vast area of garlic crop was seriously affected and reduced yield. Researchers of different parts of the world reported that water shortage, lack of potassium and micronutrient may cause tip burn in garlic. Somebody said that it may occur due to some physiological causes which are associated with imbalance nutrient and lack of irrigation water. Another researcher reported that it may cause by primary or secondary infection of fungus. Considering the above fact, the present study was undertaken to study the effective control measures of tip burn of garlic.

Materials and Methods

The experiment was conducted for the two consecutive years at Agriculture Research Station, BARI, Bogura during 2019-20 and 2020-21 cropping seasons to observe the efficacy of different management options on controlling tip burn of garlic. The land was medium-high land, and the soil was loam in texture. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering to break the clods as well as to level the soil. Ten treatments were arranged in Randomized Complete Block Design with three replications. The treatments were T_1 = Five irrigation at an interval of 15 days starting after emergence, T_2 = Soil amendment with ash 2.0 t ha^{-1} , T_3 = Soil amendment with Boron @ 2 kg ha^{-1} , T_4 = Five times foliar spraying with boric acid @ 3 gL^{-1} at an interval of 15 days starting after emergence at 3-4 leaf stage, T_5 = Soil amendment with Zn @ 3 kg ha^{-1} , T_6 = Foliar spray of Potassium sulfate (K_2SO_4) @ 5 gL^{-1} twice at the fortnightly interval at 3-4 leaf stage, T_7 = Foliar spray of Calcium sulfate ($CaSO_4$) @ 5 gL^{-1} twice at the fortnightly interval at 3-4 leaf stage, T_8 = Amistar Top @ 1 mL^{-1} of water, T_9 = Nutraphos-N 3 times foliar spraying @ 4 gL^{-1} at an interval of 15 days starting at 3-4 leaf stage and T_{10} = Control. The entire quantity of cow dung, TSP, Gypsum, half Urea & half MoP will be applied at the time of final land preparation. Rest Urea & MoP will be applied in two equal installments at 25 and 50 DAS. BARI Rashun-1 was used in this experiment. Planting was done on 23-27 November 2019 and 2020 maintaining $15\text{ cm} \times 10\text{ cm}$ spacing. The unit plot size was $2.5\text{ m} \times 4\text{ m}$.

To control Thrips infestation, the crop was sprayed with Gain-20 (imidacloprid) @ 0.5ml per liter of water three times at 30, 45, and 80 DAS. A sticky substance like shampoo was used with insecticide and fungicide. Three weddings were done at 25, 50 & 75 days after planting. During the growing period, the plots were inspected regularly to record all the incidences of tip burn from seedling to the maturity stage of the crop. The crop was harvested on March 18 2020 and March 26, 2021, respectively. Data were recorded on plant height, the incidence of tip burn, number of cloves per bulb, the weight of a single bulb, and yield. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return (Ferdous et al., 2020 and Anwar et al. 2021). The collected data were statistical analyses by Statistics package software and mean values were separated.

Results and Discussion

Effect of treatments on tip burn

Results of the effect of treatments on tip burn of garlic are presented in Table 1. Treatments showed a significant effect of tip burn of garlic. The tip burn incidence varied with the different management approaches ranging from 75.32 -90.54% in 2019-20 and 85.15-97.38% in 2020-21 cropping season. From the two years study, it was observed that application of ash, soil amendment with Zn, timely irrigation schedule, application of K_2SO_4 and $CaSO_4$, spraying with a fungicide like Amistar Top and Nutraphos-N3 were seemingly helpful for the slight reduction in burning of the tips of garlic plants as compared to no spray (control) condition. However, the highest tip burn incidence was obtained from T_{10} (Control) treatment, and the lowest incidence was obtained from T_8 (Amistar Top @ 1 mL⁻¹ of water) and T_9 (Nutraphos-N 3 times foliar spraying @ 4 gL⁻¹). Boron application either in soil or by spray as Solubor has little or no effect on reducing burning incidence.

Effect of treatments on morphological, yield, and yield attributes

Morphological, yield and yield contributing characters are presented in Tables 2 and 3. Plant height was varied non-significantly among the treatments ranging from 68.37 cm to 73.03 cm in 2019-20 and 56.4 cm to 63.27 cm in 2020-21 seasons. Plant height was slightly higher in 2019-20 than that of 2020-21 might be due to the prolonged favourable winter season prevailed in the former year in comparison to the later one. Although the plant height did not differ significantly, however, numerically higher plant height was recorded from T_9 (Nutraphos-N 3 times foliar spraying @ 4 gL⁻¹) and lower from T_{50} (Control) treatment in both the years.

The plant population was statistically identical among the treatments ranging from 65.08 to 67.12 in 2019-20 and 58.49 to 63.45 in 2020-21 cropping year. The highest number of cloves per bulb and single bulb weight were obtained from T_9 treatment followed by T_8 treatment, but the control treatment resulted in the lower number of respective parameters with which burning incidence was the maximum. Yield varied from 7.77-10.42 t ha⁻¹ in 2019-20 and from 6.72-7.53 t ha⁻¹ in 2020-21. The highest yield was recorded in T_9 and T_8 which are statistically identical to the yield secured from other treatments except for T_{10} (control).

Cost and return analysis

Cost and return related information against different treatments are presented in Table 4. The higher gross return 718000 Tk.ha⁻¹ was obtained from T_9 which was followed by T_8 and the lowest gross return 452260 Tk.ha⁻¹ was obtained from T_{10} treatment. Higher gross return contributed to the higher gross margin 452260 Tk.ha⁻¹ in T_9 and lower gross return secured lower gross margin in T_{10} . The lowest gross margin was 313710 Tk.ha⁻¹.

Table 1. Effect of treatments on tip burn of garlic during 2019-20 and 2020-21 cropping season

Treatment	Tip burn incidence (%)	
	2019-20	2020-21
T ₁ = Five irrigation at an interval of 15 days starting after emergence	83.37 bc	94.33 abc
T ₂ = Soil amendment with ash 2.0 t ha ⁻¹	81.69 bc	93.41 bcd
T ₃ = Soil amendment with Boron @ 2 kg ha ⁻¹	85.16 b	96.23 ab
T ₄ = Five times foliar spraying with boric acid @ 3 gL ⁻¹ at an interval of 15 days starting after emergence at 3-4 leaf stage	85.78 b	97.33 a
T ₅ = Soil amendment with Zn @ 3 kg ha ⁻¹	80.45 c	90.67 de
T ₆ = Foliar spray of Potassium sulphate (K ₂ SO ₄) @ 5 gL ⁻¹ twice at fortnightly interval at 3-4 leaf stage	78.33 cd	92.67 cd
T ₇ = Foliar spray of Calcium sulphate (CaSO ₄) @ 5 gL ⁻¹ twice at fortnightly interval at 3-4 leaf stage	77.67 cd	95.47 abc
T ₈ = Amistar Top @ 1 mL ⁻¹ of water	76.67 d	87.25 f
T ₉ = Nutraphos-N 3 times foliar spraying @ 4 gL ⁻¹ at an interval of 15 days starting at 3-4 leaf stage	75.32 d	85.15 f
T ₁₀ = Control	90.54 a	97.38 a
CV (%)	3.76	4.39

Table 2. Effect of treatments on yield and yield attributes of garlic

Treatment	Plant height (cm)		Plant population/m ²		No. of cloves/bulb	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T ₁	71.90 ab	60.13 ab	66.67 ab	61.26 ab	21.13 b	16.8 b
T ₂	72.87 ab	62.4 a	66.38 ab	61.52 ab	22.8 ab	17.4 ab
T ₃	69.50 ab	58.47 ab	64.43 b	58.49 c	20.67 bc	16.47 b
T ₄	70.03 ab	58.67 ab	65.18 b	60.63 b	22.27 ab	17.2 ab
T ₅	70.57 ab	59.8 ab	66.85 ab	61.35 ab	23.47 ab	17.87 ab
T ₆	73.03 a	63.27 a	67.12 ab	62.78 a	20.73 bc	16.93 ab
T ₇	70.50 ab	58.4 ab	65.33 b	59.27 bc	22.07 ab	17.27 ab
T ₈	71.57 ab	60.93 ab	66.67 ab	61.18 ab	24.67 a	18.27 ab
T ₉	72.20 ab	61.6 a	68.67 a	63.45 a	24.93 a	19.4 a
T ₁₀	68.37 b	56.4 b	65.08 b	60.98 b	18.23 c	16.4 b
CV (%)	3.78	4.95	9.58	8.46	6.47	10.54

Table 3. Effect of treatments on yield and yield attributes of garlic

Treatment	Individual bulb weight (g)		Bulb yield (t ha ⁻¹)	
	2019-20	2020-21	2019-20	2020-21
T ₁	28.25 bc	25.14 ab	8.93 bc	7.23 ab
T ₂	28.36 bc	25.25 ab	10.11 ab	7.30 a
T ₃	28.15 bc	24.05 ab	9.08 abc	7.15 ab
T ₄	27.46 cd	25.10 ab	9.44 ab	7.20 ab
T ₅	29.23 bc	25.32 ab	10.07 ab	7.13 ab
T ₆	31.46 ab	25.41 ab	10.35 ab	7.40 a
T ₇	29.14 bc	24.11 bc	10.25 ab	7.33 a
T ₈	32.8 ab	25.65 ab	10.40 a	7.50 a
T ₉	33.18 a	26.86 a	10.42 a	7.53 b
T ₁₀	26.16 d	22 c	7.77 c	6.72 c
CV (%)	2.39	3.37	4.53	2.58

*In a column, similar letter(s) do not differ significantly at 5% level of probability.

Table 4. Cost and return analysis of garlic by using different treatment

Treatment	Average yield (t ha ⁻¹)	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
T ₁	8.08	646400	265410	380990
T ₂	8.71	696400	265680	430720
T ₃	8.12	649200	265750	383450
T ₄	8.32	665600	265310	400290
T ₅	8.60	688000	265010	422990
T ₆	8.88	710000	265630	444370
T ₇	8.79	703200	265320	437880
T ₈	8.95	716000	265480	450520
T ₉	8.98	718000	265740	452260
T ₁₀	7.25	579600	265890	313710

Urea-Tk.18/kg, TSP-Tk. 22/kg, MoP-Tk. 18/kg, Clove-140 Tk/kg, Garlic Sale Price-Tk. 70/kg bulb.

T₁= Five irrigation at an interval of 15 days starting after emergence, T₂= Soil amendment with ash 2.0 t ha⁻¹, T₃= Soil amendment with Boron @ 2 kg ha⁻¹, T₄= Five times foliar spraying with boric acid @ 3 g L⁻¹ at an interval of 15 days starting after emergence at 3-4 leaf stage, T₅= Soil amendment with Zn @ 3 kg ha⁻¹, T₆= Foliar spray of Potassium sulphate (K₂SO₄) @ 5 g L⁻¹ twice at fortnightly interval at 3-4 leaf stage, T₇= Foliar spray of Calcium sulphate (CaSO₄) @ 5 g L⁻¹ twice at fortnightly interval at 3-4 leaf stage, T₈= Amistar Top @ 1 mL⁻¹ of water, T₉= Nutraphos-N 3 times foliar spraying @ 4 g L⁻¹ at an interval of 15 days starting at 3-4 leaf stage and T₁₀ = Control

Conclusion

From the above study, it may be concluded that the higher tip burn incidence resulted in lower yield as compared to the plants which have minimum burning. However, burning could be minimized through the application of some management options such as application of irrigation water, soil amendment with Zn especially in poor Zn rich soils, application of ash, timely spraying with fungicides like Amistar Top and Nutraphos-N3. However, the management options could be utilized in an integrated way.

INCIDENCE OF CHICKPEA POD BORER, *Helicoverpa armigera* Hubner ON THE PROMISING VARIETIES OF CHICKPEA

Selim Ahmed, A F M Ruhul Quddus, M Akkas Ali, M Shahiduzzaman

Abstract

The field trial was conducted at the FSRD site, Faridpur under the project “Strengthening of oil seed and pulses research and development project in Bangladesh” with supervision of Pulses Research Centre, Ishurdi, Pabna during the rabi 2020-21 to find out the abundance of chickpea pod borer, to provide indication of chickpea pod borers infestation level/status and its effect on pod yield of different chickpea varieties. The experiment was laid out in a randomized complete block design with three compact replications. Six (6) promising chickpea varieties i.e. BARI Chola-5, BARI Chola-9, BARI Chola-10, BARI Chola-11, Binachola-4 and Binachola-8 were evaluated at farmer’s field condition against the incidence of chickpea pod borer. The highest yield loss was observed from BARI Chola-5 (227.83 kg ha⁻¹) due to might be the highest number (28.47) of pods plant⁻¹, higher number (4.84) of pod borer m⁻² and number (5.22) of bored pods plant⁻¹. Statistically the highest pod yield (1069.66 kg ha⁻¹) was found from BARI Chola-5 and the lowest pod yield (540.33 kg ha⁻¹) was calculated from BARI Chola-10. The highest percentage of yield loss was obtained from Binachola-8 (21.98%) and lowest from BARI Chola-10 (16.7%).

Introduction

Chickpea, *Cicer arietinum* L. is one of the important pulse crops in Bangladesh. It is generally grown under rainfed or residual soil moisture conditions in rabi season. Recent years chickpea growing areas and production are decreasing in trend because of crop competition with rabi crops and other factors. Although most of the people thinks that chickpea areas and production were decreased due to pod borer infestation. Yes, the pod borer, *Helicoverpa armigera* (Hubner) is a major and most serious pest in most of the chickpea growing areas (Begum *et al.*, 1992). A country wide survey indicated that averages of

30 to 40 per cent pods were found to be damaged by pod borer with 400 kg ha⁻¹ grain loss (Rahman, 1990). The young caterpillar skeletonizes the leaves, while grown up caterpillar bores into the pods and feeds the seeds inside and cause significant yield loss. At present, the status of pod borer infestation level in the growing areas and exactly its effect on pod yield of the latest released varieties is not known. With this view, the present study has been taken to finding out the abundance and infestation status of pod borer and its effect on pod yield.

Materials and Methods

The field trial was conducted at the FSRD site, Faridpur under the project “Strengthening of oil seed and pulses research and development project in Bangladesh” with supervision of Pulses Research Centre, Ishurdi, Pabna during the *rabi* 2020-21 to find out the abundance of chickpea pod borer, to provide indication of chickpea pod borers infestation level/status and its effect on pod yield of different chickpea varieties. The experiment site was situated at 23°32'35.5" North Latitude and 89°47'14.1" East Longitude. The experiment was laid out in a randomized complete block design with three compact replications. Six (6) promising chickpea varieties *i.e.* BARI Chola-5, BARI Chola-9, BARI Chola-10, BARI Chola-11, Binachola-4 and Binachola-8 were evaluated in the farmer's field condition against the incidence of chickpea pod borer. The unit plot size was 4 m x 3 m. A total of 10 rows was established for each variety. Seeds treated with Bavistin @ 45 kg ha⁻¹ were sown on 2 December 2020 maintaining a spacing of 40 cm in row to row and continuous placement of seed in the row. After two tillage, all fertilizers was applied with 18-18-20-0-0-1 N-P-K-S-Zn-B kg ha⁻¹ in the form of urea, triple super phosphate (TSP), muriate of potash (MoP) and boric acid, respectively. Two irrigations were done at 8 and 68 Days after sowing (DAS). The crop was harvested on 1 April 2021. For collecting pod borer incidence in the field from a treatment (10 rows), border rows were avoided to collect any data. Pod borer population data was collected from both sided 2nd and 3rd rows *i.e.* four linear meter from both sided rows at weekly interval after 100% flowering to pod maturity. Central four lines was kept undisturbed for yield data and pod bored infestation/damage data. At maturity, 20 plants were selected randomly from central 4 lines and total pods and bored pods number was counted and % of pod damage was calculated. First incidence of pod borer in chickpea was recorded at 25 February 2021 (86 DAS). Pod borer population was counted on 89 DAS, 96 DAS, 103 DAS and 110 DAS. No insecticides were applied. The data on yield and yield loss % due to pod borer damage were analyzed statistically using open source software R and the means were separated by DMRT (Gomez and Gomez 1984).

Yield loss due to pod borer damage (g m⁻²) was calculated as follows:

$$= \frac{\text{Wt (g) of fresh pod/m}^2 \times \text{No. of bored pod/m}^2}{\text{No. of fresh pod/m}^2}$$

Then value was converted into kg ha⁻¹.

Results and Discussion

A significant variation was observed among the varieties on yield and yield attributes (Table 1). Higher number of plant population m⁻² was calculated from BARI Chola-5 (30.33) followed by Binachola-4 (27.66). The lowest number of plant population m⁻² was observed from Binachola-8 (16.66) which was identical with BARI chola-9, BARI Chola-10 and BARI Chola-11. It may be due to the poor germination of that variety. Total number of pods plant⁻¹ (including bored pods) ranged between 20.30 (BARI Chola-10) to 28.47 (BARI Chola-5). The highest pod yield (1069.66 kg ha⁻¹) was found from BARI Chola-5 and the lowest pod yield (540.33 kg ha⁻¹) was calculated from BARI Chola-10. A significant variation was observed among the varieties on tested on pod borer incidence of chickpea except no. of bored pods plant⁻¹ (Table 2). Significant lower number of pod borer population m⁻² was found from BARI Chola-11 (2.39) and BARI Chola-10 (15.00). The highest number of pod borer population m⁻² was calculated from Binachola-8 (6.45). The highest number of bored pods plant⁻¹ was calculated from Binachola-8 (5.47) followed by BARI Chola-5 (5.22). The lowest number of bored pods plant⁻¹ was found from BARI Chola-10 (3.57). Percentage of pod damage ranged between 17.43 (BARI Chola-9) to 22.73 (BARI Chola-5). The highest yield loss was observed from BARI Chola-5 (227.83 kg ha⁻¹) due to might be highest number (28.47), of pods plant⁻¹, higher number (4.84) of pod borer population m⁻², number (5.22) of bored pods plant⁻¹. The second highest yield loss was calculated

from Binachola-8 (204.53 kg ha⁻¹). BARI Chola-10 showed the lowest yield loss (99.76 kg ha) due to erected stem, not bushy might be lowest bored pods per plant (3.57). Pod yield was lowest due to might be lower plant population m⁻² (19.33). The highest percentage of yield loss was obtained from Binachola-8 (21.98%) and the lowest from BARI Chola-10 (16.7%).

Table 1. Yield and yield attributes of different chickpea varieties in Faridpur during 2020-21

Variety (S)	Plant m ⁻² (nos.)	Total pods plant ⁻¹ (nos.)	Pod yield (kg ha ⁻¹)
BARI Chola-5	30.33 a	28.47 a	1069.66 a
BARI Chola-9	20.33 b	21.22 ab	828.33 b
BARI Chola-10	19.33 b	20.30 b	540.33 c
BARI Chola-11	18.33 b	20.40 b	671.00 bc
Binachola-4	27.66 a	23.85 ab	720.66 bc
Binachola-8	16.66 b	24.47 ab	727.00 bc
CV (%)	9.33	18.43	16.45

Table 2. Abundance, infestation level and yield loss of pod borer of different chickpea varieties in Faridpur during 2020-21

Variety (S)	Pod borer population m ⁻² (nos.)	Bored pods plant ⁻¹ (nos.)	Pod damage (%)	Yield loss (kg ha ⁻¹)	Yield loss for pod borer (%)
BARI Chola-5	4.84 b	5.22	22.73 a	227.83 a	17.5
BARI Chola-9	2.55 c	4.75	17.43 b	196.20 a	19.15
BARI Chola-10	3.75 bc	3.57	17.61 b	99.76 b	16.7
BARI Chola-11	2.39 c	4.42	18.52 b	175.73 ab	21.0
Binachola-4	4.37 b	5.00	18.28 b	184.66 a	20.4
Binachola-8	6.45 a	5.47	22.31 a	204.53 a	21.98
CV (%)	20.19	23.98	9.40	25.09	--

Conclusion

The performance of chickpea variety BARI Chola-5 against pod borer was appeared to be promising among the varieties tested at Faridpur. For final decision, the experiment may be repeated in next year.

G. Agroforestry System

PERFORMANCE OF PULSES IN MANGO BASED AGROFORESTRY SYSTEM IN HIGH BARIND TRACT

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Abstract

Fruit orchards are the principal agricultural crops that generate sustainable economic income to the farmers in High Barind Tract. An experiment was conducted at the FSRD site, Basantapur, Godagari, Rajshahi during 2020-21 with a view to assess the performance of mango based agroforestry with pulse crops to increase cropping intensity and productivity in the High Barind Tract. Four pulse crops i.e. pea, grass pea, chickpea and lentil were evaluated in mango orchard. The mango+chickpea system recorded the highest mango equivalent yield (MEY) (11.26 t ha⁻¹) than rest of the system. The mango+grass pea (9.30 t ha⁻¹) and mango+pea (9.21 t ha⁻¹) systems were found to be equally effective. However, the sole mango system (7.85 t ha⁻¹) recorded the lowest MEY. Among the different system, mango + chickpea had a maximum gross return (Tk. 394100 ha⁻¹), gross margin (Tk. 300070 ha⁻¹) and MBCR (4.04) than all other system. The mango + lentil ranked second in respect of gross return

(Tk.362600 ha⁻¹), gross margin (Tk. 267450 ha⁻¹) and MBCR (2.87). The minimum gross return (Tk. 274750ha⁻¹) and gross margin (Tk. 210250 ha⁻¹) was found in sole mango system.

Introduction

In Bangladesh, fruit orchards especially Mango, Litchi and Guava have increased considerably over last few years. As High Barind Tract has 94% high land, there is a big scope to cultivate fruit in the main crop field. Thus, vast area is going under orchard every year, which may be a threat for attaining self-sufficiency in food especially in vegetables and pulses. In this circumstances, cultivation of some pulse crops under agroforestry system will be a good option for increasing food production from the same piece of land. In the tropics and sub-tropics, rapid degradation of soil organic matter is a major problem, where through cereal production less chance to add biomass in the soil. To sustain productivity of soil, production of leguminous crops may be helpful. Keeping this view in mind, the present experiment has been undertaken to select pulse crop(s) suitable for agroforestry system.

Materials and methods

The field experiment was conducted at Farming System Research and Development (FSRD) site, Basantapur, Godagari, Rajshahi during 2020-21 to find out the performance of mango based agroforestry with pulse crops. The experimental area was high land of silty clay loam soils and belongs to the Amnura series of HBT under Agro Ecological zone 26 (Anonymous, 1988). About 8-10 years old mango orchard was selected for the trial. The orchard with local popular variety of mango (*Khirshapat*) was selected for the study. Four pulses named, Chickpea (BARI Chola-5), Lentil (BARI Masur-8), Grass pea (BARI Kheshari-1) and Pea (BARI Motor-3) were tested in the mango orchard. The experiment was laid out in a Randomized Complete Block Design with three replications. The land was prepared by ploughing and cross ploughing with power tiller. Fertilizers were applied at the rate of 80-40-90-30-2 kg N- P-K-S-B ha⁻¹ for pulses and mango cultivation. Chickpea, lentil, pea and grass pea seeds were broadcasted at 25 November, 2020. During final land preparation, all the fertilizer was applied for pulses as recommended dose and fertilizer was applied on late-September for mango as ring placement. The pulse crops and mango were harvested on 8-26 March and 5-10 June, 2020 respectively. Data for pulses and mango were recorded plot wise and converted to ton per hectare. Recorded data were analyzed statistically using software R (R Core Team, 2019).

Results and Discussion

For comparison of different pulses in mango-based agroforestry system, all the yield of component crops was converted to mango equivalent yield (MEY) and system productivity was considered as MEY (Table 1). The MEY differed significantly among pulses in mango-based agroforestry system (Table 1). In general, mango orchard involving pulses produced significantly higher mango equivalent yield (MEY) than that having sole orchard. However, mango+chickpea system recorded the highest MEY (11.26 t ha⁻¹) than rest of the system. The mango+lentil system ranked second in terms of MEY. The mango+grass pea (9.30 t ha⁻¹) and mango+pea (9.21 t ha⁻¹) systems were found to be equally effective. However, the sole mango system (7.85 t ha⁻¹) recorded the lowest MEY during the study year. The MEY was mainly influenced by component crops yield and their market price. During the study year the price of chickpea was comparatively higher than other tested pulses though the lentil yield was higher than chickpea.

Production cost and annual gross return were considered for choosing suitable system, because these varied widely in different systems. Among the different system, mango+lentil (Tk. 95150 ha⁻¹) and mango + chickpea (Tk. 94030 ha⁻¹) had relatively higher cost of cultivation. The mango+grass pea (Tk. 84400 ha⁻¹) and mango + pea (Tk. 84215 ha⁻¹) systems recorded equal and intermediate cost of cultivation, whereas the sole mango system (Tk. 64500 ha⁻¹) had the lowest cost of cultivation. The mango + chickpea had maximum gross return (Tk. 394100 ha⁻¹), gross margin (Tk. 300070 ha⁻¹) and MBCR (4.04) than all other system. The mango + lentil ranked second in respect of gross return (Tk.362600 ha⁻¹), gross margin (Tk. 267450 ha⁻¹) and MBCR (2.87). The lowest gross return (Tk. 274750ha⁻¹) and gross margin (Tk. 210250 ha⁻¹) was found in sole mango system.

Farmer's reaction

Farmers obtained higher economic benefit from chickpea and lentil in mango based agroforestry system. Neighboring farmers visited the field and impressed to see the crop performance.

Table 1. Yield of different pulses in mango-based agroforestry system at FSRD sites, Barind, Rajshahi during 2020-21

Crops	Mango yield (t ha ⁻¹)	Pulse yield (t ha ⁻¹)	Mango equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
Mango + Pea	7.90	1.15	9.21	322350	84215	238135	2.41
Mango +Grass pea	8.05	1.25	9.30	325500	84400	241100	2.55
Mango + Chickpea	8.64	1.35	11.26	394100	94030	300070	4.04
Mango + Lentil	8.35	1.36	10.36	362600	95150	267450	2.87
Mango	7.85	-	7.85	274750	64500	210250	-

Price of Input (Tk.): Urea=16 kg⁻¹, TSP=22 kg⁻¹, MOP=15 kg⁻¹, Gypsum=6 kg⁻¹, ZnSO₄=120 kg⁻¹, Boric acid=150 kg⁻¹, power tiller (1 pass): 2350 ha⁻¹, Irrigation (1 time): 950 ha⁻¹ and Labour: 400 day⁻¹ (8 hours), Lentil seed=115 kg⁻¹, Pea seed = 120 kg⁻¹, Pea seed = 120 kg⁻¹ and Grass Pea seed =95 kg⁻¹ Price of Output: Lentil=52 kg⁻¹, Pea= 40 kg⁻¹, Chickpea= 60 kg⁻¹ and Grass Pea=35 kg⁻¹, Mango= 35 kg⁻¹

Conclusion

From the experiment it is revealed that chickpea and lentil are suitable pulse crops to grow in mango-based agro-forestry system at High Barind Tract in respect of yield economic return which was economically profitable.

PERFORMANCE OF INTERCROPPING JUTE LEAF WITH SUMMER VEGETABLES UNDER MANGO BASED AGROFORESTRY SYSTEM

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Abstract

An experiment was conducted at the farmers' fields of Sadar Dakkhin of Cumilla and Kachua of Chandpur during the summer season of 2020 to evaluate the performance of intercropping jute leaf with mukhikachu, bottle gourd, sponge gourd and okra under mango based agroforestry system, to increase the production of vegetables by using unutilized space of mango garden and income of the farmers. The highest mango equivalent yield (16.08t ha⁻¹), gross return (1125.60 ThTk ha⁻¹), net return (1011.43Th.Tk ha⁻¹) and BCR (9.86), were found from inter cropping jute leaf with mukhikachu followed by inter cropping jute leaf with sponge gourd and the lowest from inter cropping jute leaf with bottle gourd in mango based agroforestry system. Sole mango gave much lower yield and economic return than all the agroforestry systems.

Introduction

Bangladesh is constrained with insufficient forest resources and these scarce resources are being destroyed at an alarming rate. Because of increasing environmental hazards and demand for food, timber, fuel wood, fodder, fruits and poles etc. production of multiple products from the same land management unit are urgently needed. Vegetables are also most important crops for our daily diet. But there acreage (409350.2 ha) and production (4024932 metric ton) is far below then our needs (Anonymous. 2017). So, increase their production in the country is usually needed. Recently, climate change is a big constrain for successful agricultural production in our country. Field crops are damaged by unpredictable heavy rainfall, hail storm, drought etc. So, farmers are being interested to grow tree crops. In the young tree orchards, spices, vegetables, rice, wheat etc. may be grown successfully following agroforestry system. If proper combination of tree and crops are selected, this technology would be stable and beneficial for fruit tree growers undoubtedly. Therefore, this study has been taken with the following objectives-

1. To observe the performance of jute leaf (*patshak*) as intercrop between the summer vegetables especially in the seedling stage.
2. To observe the performance of under storey summer vegetables in the fruit tree based agroforestry system and
3. To increase production and economic return

Materials and Methods

The experiment was conducted at the farmers' field of Sadar Dakkhin of Cumilla and Kachua of Chandpur during the summer season of 2020. Around 8 years old mango orchards was selected for the study. Average spacing of mango trees was 4m×4m, clean bole height was 1.5m, canopy spread was 2.2m×2.1m and tree height was 4m. So, there were some gaps between the tree canopy in the garden, where direct sunlight may reach to the under storey crops. Vegetables varieties were BARI Mukhikachu-2 for mukhikachu, BARI Lau-4 for bottle gourd, white proud hybrid for sponge gourd and BARI Dherosh-2 for okra were used as under storey crop. Binapatshak-1 was used as inter crop to use the fallow spaces between the vegetables, especially during the seedling period. The experiment was laid out in Randomized Complete Block (RCB) Design with three dispersed replications. The unit plot size was 5m×4m. The spacings were 60cm×45cm for mukhikachu, 2m×2m for bottle gourd, 2m×2m for sponge gourd and 50cm×40cm for okra. Binapatshak-1 was broadcasted in all plots of summer vegetables. Land was prepared by three times ploughing followed by laddering during 20-28 March, 2020. Soil test based fertilizer dose for every crop and location were used. The seeds/seedlings were planted on 24, March 2020 to 1 April, 2020. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Binapatshak-1 was harvested during 2-22/05/2020. Okra was harvested during 25/05/2020 to 03/07/2020. Sponge gourd was harvested from 28/05/2020 to 25/08/2020. Bottle gourd was harvested from 28/05/2020 to 11/07/2020 and mukhikachu was harvested during 01/09/2020 to 20/09/2020. Necessary data were recorded and analyzed by using Statistic 10 computer program.

Results and Discussion

Average yield and partial economic analysis of intercropping under mango based agroforestry systems at farmer's field of different locations of Cumilla region is presented in Table 1 and Table 2. The maximum vegetable yield (16.62 t ha⁻¹) was found from Sponge gourd (White proud hybrid) which was identical to mukhikachu (BARI Mukhikachu-2) (15.23 t ha⁻¹). The lowest vegetable yield (7.98 t ha⁻¹) was found from bottle gourd (BARI Lau-4), which was identical to ladyfinger (BARI Dherosh-2) (8.18 t ha⁻¹). The highest Jute leaf equivalent yield was found from mukhikachu (67.08 t ha⁻¹) cultivation due to much higher price of mukhikachu than all other vegetables. The lowest jute leaf equivalent yield was calculated from bottle gourd cultivation due to lower yield and market price; which was identical to okra. Sponge gourd gave moderate jute leaf equivalent yield. Jute leaf inter crop yield was the highest (14.13 t ha⁻¹) with mukhikachu plot. The lowest jute leaf yield (4.25 t ha⁻¹) was found from bottle gourd plot. The mango trees were small, so, the mango yield was not satisfactory in the experimental plots. But the yield of mango in the experimental plots were much higher than the sole mango plots; because the farmers of Cumilla region don't take enough care to get higher mango yield from their garden like Chapai Nowabgonj or Rajshahi area.

The results indicated that the yield of all the agroforestry systems were higher than sole mango. The highest mango equivalent yield (16.08 t ha⁻¹) was found from Mukhikachu, which was much higher than all other vegetables due to higher yield as well as higher price of mukhikachu. Thus, the highest gross return (Tk 1125.60 Th. ha⁻¹), gross margin (Tk. 1011.43 Th. ha⁻¹) and BCR (9.86) also found from intercropping jute leaf with mukhikachu. The lowest mango equivalent yield (6.05 t ha⁻¹) as well as gross return (Tk 420.35 Th. ha⁻¹), gross margin (Tk 298.18 Th. ha⁻¹) and BCR (3.44) were found from bottle gourd due to lower yield and price of bottle gourd than all other three vegetables under the agroforestry systems.

Table 1. Performance of inter cropping jute leaf with summer vegetables under mango based agroforestry system in Cumilla region during summer 2020

AGF systems	Veg. yield (t ha ⁻¹)	Jute leaf yield (t ha ⁻¹)	Mango yield (t ha ⁻¹)	Mango equivalent yield (t ha ⁻¹)
Mukhi+ jute leaf+ Mango	15.23	14.13	4.27	16.08
Bottle gourd+ jute leaf+ Mango	7.98	4.25	4.03	6.05
Sponge gourd+ jute leaf+ Mango	16.62	6.63	4.37	7.97
Okra+ jute leaf+ Mango	8.18	7.32	4.0	6.33
Sole mango	-	-	3.8	3.8
CV (%)	14.52	8.41	1.13	-
LSD (0.05)	3.950	1.357	0.094	-

Table 2. Total system yield and economic return from inter cropping jute leaf with summer vegetables under mango based agroforestry system in Cumilla region during summer 2020

AGF systems	Mango equivalent yield (t ha ⁻¹)	Gross return (Th. Tk ha ⁻¹)	Total cost (Th. Tk ha ⁻¹)	Gross margin (Th. Tk ha ⁻¹)	BCR
Mukhi+ jute leaf+ Mango	16.08	1125.60	114.17	1011.43	9.86
Bottle gourd+ jute leaf+ Mango	6.05	420.35	122.17	298.18	3.44
Sponge gourd+ jute leaf+ Mango	7.97	557.97	119.32	438.65	4.68
Okra+ jute leaf+ Mango	6.33	442.96	116.83	326.13	3.79
Sole mango	3.8	266.00	70.00	196	3.8
CV (%)	-	-	-	-	-
LSD (0.05)	-	-	-	-	-

Average price of Mukhikachu, bottle gourd, sponge gourd, okra, jute leaf and mango were 45, 12, 11.18, 10.97, 10 and 70 Tk Kg⁻¹ only]

Conclusion

Cultivation of intercropping jute leaf (*patshak*) with mukhikachu under mango based agroforestry system gave higher productivity in terms of mango equivalent yield and economic return than other three vegetables.

PERFORMANCE OF INTERCROPPING JUTE LEAF WITH TURMERIC UNDER MANGO BASED AGROFORESTRY SYSTEM

M. M. Bashir, M. H. Hossain, S. K. Bhowal, M Akkas Ali, M Shahiduzzaman

Abstract

An experiment was conducted at the farmers' fields of Sadar Dakkhin, Cumilla and Kachua, Chandpur during April 2020 to March 2021 to evaluate the performance of intercropping jute leaf with three BARI developed turmeric varieties with one local as check variety under mango based agroforestry system, to increase the production and income. The highest mango equivalent yield, net return and BCR (15.91 t ha⁻¹, Tk 828800 ha⁻¹ and 7.59, respectively) were found from intercropping jute leaf with BARI Halud-3 under mango based agroforestry system and the lowest were found from sole mango. All agroforestry system gave much higher yield and economic return than sole mango.

Introduction

Fruits are the important source of vitamins and minerals but due to high price of fruits, the majority of people can't afford to buy them. Besides, increasing environmental hazards and demand for food, timber, fuel wood, fodder, fruits and poles etc. production of multiple products from the same land management unit are urgently needed. Spices are also most important crops for our daily diet. Turmeric is such a crop, which takes ten month field duration. So, in the early stage some leafy vegetables eg. Jute leaf/red amaranth etc. might be grown in the earlier stage successfully. So, attempt should be needed to increase their production in the country by adopting intercropping and agroforestry systems

simultaneously. Recently DAE have some fruit garden establishment program to intensify the fruit garden and increase yield and return of the farmers, so, use intercropping and agroforestry system may be viable. If proper combination of tree and crops are selected, this technology would be stable and beneficial for fruit tree growers undoubtedly. Therefore, this study has been under taken with the following objectives.-

1. To observe the performance of jute leaf with turmeric varieties in the fruit tree based agroforestry system.
2. To select the suitable turmeric variety in the mango based agroforestry system.
3. To increase production and economic return

Materials and Methods

The experiment was conducted at the farmers' mango fields of SadarDakkhin, Cumilla and Kachua, Chandpur during April 2020 to March 2021. Ages of trees were 4-9 years. Average spacing of mango trees was 4 m², clean bole height was 1.5m, canopy spread was 2.2m×2.1m and tree height was 4.5m. So, there was some gaps between the tree canopy in the garden, where direct sunlight may reach to the under storey crops. BARI developed turmeric varieties BARI Halud-3, BARI Halud-4, BARI Halud-5 and Lalmai local turmeric variety were used as under storey crop. Jute leaf (var. CVL-1) was used as intercrop with turmeric. The experiment was laid out in Randomized Complete Block (RCB) Design with four dispersed replications. The unit plot size was 5 m×4 m. The spacing of turmeric was 60cm×25cm. Seeds of jute leaf was broadcasted with turmeric in the same time. The land was prepared by three times ploughing followed by laddering. Soil test based fertilizer dose was used for every location. The seeds were sown on 25- 27 April 2020, depending on variation in land preparation time of different replication. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Jute leaf was harvested during 23 May- 21 June, 2020. Turmeric was harvested during 2nd January to 10th March 2021. Necessary data were recorded and analyzed by using Statistix10 computer program.

Results and Discussion

Yield and yield contributing characters of turmeric at farmer's field of different locations at Cumilla, and Chandpur is presented in Table 1. The highest plant height (134.8 cm) was observed in BARI Halud-3, which was similar to local Lalmaihalud (134.0 cm) and BARI Halud-5 (130.9). The lowest plant height (124.2 cm) was recorded in BARI Halud-4. The highest whole clump weight (527.75 g) was found from BARI Halud-3 while the lowest whole clump weight (296.60 g) in BARI Halud-4. The highest No. of mother rhizome (2.3) was found from BARI Halud-3, which was identical to BARI Halud-5 (2.1). The lowest No. of mother rhizome (1.8) was found from Lalmai. Highest weight of mother rhizome (115.2 g) was found from BARI Halud-3 which was identical to BARI Halud-4 (103.6g). The lowest weight of mother rhizome (82.45g) was found from local Lalmai. No. of primary finger was the highest (10.40) in BARI Halud-5 and the lowest (5.50) in BARI Halud-4. Weight of primary finger was the highest (224.5g) in BARI Halud-3 and the lowest (132g) was from BARI Halud-4. No. of secondary finger was the highest (17.7) in BARI Halud-5 and the lowest (6.9) in BARI Halud-4. BARI Halud-3. Weight of secondary finger was the highest (144g) in BARI Halud-3 and the lowest (79.7g) was from BARI Halud-4. The highest fresh turmeric yield (23.33 t ha⁻¹) was found from BARI Halud-3 and the lowest fresh turmeric yield (14.30 t ha⁻¹) was found from BARI Halud-5.

Yield was converted to mango equivalent yield and analyzed, which is given in Table-2. Mango equivalent yield was also the highest (15.91 t ha⁻¹) from BARI Halud-3 and the lowest from sole mango (3.5 t ha⁻¹). All the agroforestry system gave higher mango equivalent yield than sole mango. Thus, gross return, gross return and BCR were also the highest from BARI Halud-3 (Tk. 954600 ha⁻¹, Tk. 828800 ha⁻¹ and 7.59, respectively) and the lowest from BARI Halud-5.

Table 1. Yield and yield contributing characters of turmeric in intercropping jute leaf with turmeric under mango based agroforestry system

Variety	Plant height (cm)	Whole clump weight (g)	Mother rhizome (No.)	Weight of mother rhizome (g)	No. of primary finger	Weight of primary finger (g)	No. of secondary finger	Weight of secondary finger (g)	Fresh rhizome yield (t ha ⁻¹)
BARI Halud-3	134.8	527.75	2.30	115.20	8.35	224.5	12.9	144	23.33
BARI Halud-4	124.2	296.60	1.95	103.60	5.50	132.0	6.9	79.7	16.36
BARI Halud-5	130.9	347.75	2.10	83.55	10.40	139.2	17.7	121.4	14.30
Local (Lalmal)	134.0	373.50	1.80	82.45	7.35	171.0	9.3	117.1	18.74
CV (%)	2.36	4.59	8.46	11.47	13.83	7.62	6.43	9.07	12.76
LSD (0.05)	4.94	28.36	0.28	17.65	1.75	20.32	1.20	16.77	3.71

Table 2: Yield and economic return of intercropping jute leaf with turmeric under mango based agroforestry system

Variety	Fresh turmeric yield (t ha ⁻¹)	Jute leaf yield (t ha ⁻¹)	Mango yield (t ha ⁻¹)	Mango equivalent yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
BARI Halud-3	23.33	7.88	6.83	15.91	954600	828800	7.59
BARI Halud-4	16.36	7.23	7.13	13.78	826800	702550	6.65
BARI Halud-5	14.30	8.28	7.08	13.22	793200	670950	6.49
Local (Lalmal)	18.74	6.83	7.07	14.45	867000	742100	6.94
Sole Mango			3.5	3.5	210000	150000	2.04
CV %	12.76	8.99	8.07	5.95	-	-	-
LSD (5 %)	3.71	1.09	0.91	5.77	-	-	-

[Price of turmeric, jute leaf and mango were @ 20, 10 and 60 Tk kg⁻¹]

Conclusion

The result revealed that turmeric var. BARI Halud-3 performed better regarding yield and economic return. However, considering system productivity jute leaf intercropping with BARI Halud-3 under mango based agroforestry system exhibited better performance in respect of productivity and economic return.

PERFORMANCE OF INTER CROPPING CORIANDER WITH TOMATO AND SWEET GOURD VARIETIES UNDER MANGO BASED AGROFORESTRY SYSTEM

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Abstract

An experiment was conducted at the farmers' fields of Debidwer, Chandina and Sadar Dakkhin of Cumilla and Kachua of Chandpur during the Rabi season of 2020-21 to evaluate the performance of intercropping coriander with tomato and sweet gourd varieties under mango based agroforestry system, to increase the production of culinary herb by using the fallow land under mango garden and income of the farmers. Intercropping coriander with Tomato var. BARI Tomato-19 in agroforestry system gave the highest yield as well as economic return among the six tested crops/varieties which was similar to the yield of intercropping coriander with BARI Tomato-16 and intercropping coriander with BARI Hybrid Mishtikumra-2 in agroforestry system. All the combinations of tomato gave higher yield and economic return than sweet gourd except BARI Hybrid mishtikumra-2 in agroforestry system.

Introduction

Bangladesh is constrained with insufficient forest resources and these scarce resources are being destroyed at an alarming rate. Because of increasing environmental hazards and demand for food, timber, fuel wood, fodder, fruits and poles etc. production of multiple products from the same land management unit are urgently needed. Vegetables are most important crops for our daily diet. But there acreage and production is far below then our needs. So, increase their production in the country is necessary. Spices also have medicinal effect on human health. Coriander leaf is widely used in salad, curry and in food items. Recently DAE have some fruit garden establishment program. DAE, B. Baria requested to take initiative to intensify the fruit garden by agroforestry system. If proper combination of tree and crops are selected, this technology would be stable and beneficial for fruit tree growers undoubtedly. Therefore, this study has been taken with the following objectives-

1. To observe the performance of intercropping coriander leaf with tomato and sweet gourd varieties in the mango based agroforestry system.
2. To select suitable vegetable/variety for mango based agroforestry system.
3. To increase production and economic return.

Materials and Methods

The experiment was conducted at the farmers' field of Debidwer, Chandina and SadarDakkhin of Comilla and Kachua of Chandpur during the Rabi season of 2020-21. Tomato varieties were BARI Tomato-16 (Ratan), BARI Tomato-17 and BARI Tomato-19; Sweet gourd varieties were BARI Hybrid Mishtikumra-2, BARI Hybrid Mishtikumra-3 and Hybrid Mishtikumra (Asha). These were used as under storey crop in this experiment. Coriander variety was BARI Dhania-2. The experiment was laid out in Factorial Randomized Complete Block (RCB) Design with four dispersed replications. The unit plot size was 5 m ×4 m. The spacing was 60cm×40cm for tomato and 2m×2m for sweet gourd. Coriander was broadcasted several times. Land was prepared by three times ploughing followed by laddering. Soil test based fertilizer dose for every crop and location were used. Seedlings/seeds were planted/sown on 15 Nov. to 30Dec. 2020. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Coriander harvesting was started on 04.01.2021. Tomato harvesting was started from 12 February, 2021 and continued up to 15 April, 2021. Sweet gourd was harvested during 04 March to 18 April, 2021and. Necessary data were recorded and analyzed by using Statistics 10 computer program.

Results and Discussion

Yield and yield contributing characters of intercropping coriander with tomato varieties under mango based agroforestry system and open field at farmer's field of different locations of Cumilla and Chandpur is presented in Table 1. The highest plant height (124.85 cm) was found from BARI Tomato-19 in agroforestry system, which was identical to rest two varieties in agroforestry system. The lowest plant height (99.45cm) was observed in BARI Tomato-19 in open field condition, which was also identical to the rest two varieties in open field condition. The highest fruit plant⁻¹ was calculated in BARI Tomato-19 in agroforestry system and the lowest fruit plant⁻¹ in BARI Tomato-17 in open field condition. Fruit weight plant⁻¹ was the highest in BARI Tomato-17 in open field condition, which was identical to all the treatment combinations except BARI Tomato-17 in agroforestry system and BARI Tomato-16 in open field condition. The lowest fruit weight plant⁻¹ was observed in BARI Tomato-16 in open field condition. The highest individual fruit weight (156.70g) was observed in BARI Tomato-17 in agroforestry system, followed by open field condition (140.77g). The lowest individual fruit weight (55.25g) was observed in BARI Tomato-19 in agroforestry system, followed by open field condition (59.27g). There was no significant difference in plat population m⁻² of all the treatment combinations. The maximum BARI Tomato-16 in open field condition (51.22t ha⁻¹). The lowest yield (39.94t ha⁻¹) was observed in BARI Tomato-17 in agroforestry system. Other three treatment combinations showed moderate yield.

Yield and yield contributing characters of intercropping coriander with sweet gourd varieties under mango based agroforestry system and open field at farmer's field of different locations is presented in Table 2. There was no significant difference in plat population m⁻² of all the treatment combinations. The maximum fruits plant⁻¹ (3.35) was calculated in BARI Hybrid Mishtikumra-2 in open field

condition, which was identical to BARI Hybrid Mishtikumra-3 (3.01) in same condition. The lowest No. of fruits plant⁻¹ (2.15) was observed in Hybrid Mishtikumra-Asha in agroforestry system. Other two treatments had moderate fruits plant⁻¹. Fruit weight plant⁻¹ was the highest (6.60Kg) in BARI Hybrid Mishtikumra-3 in agroforestry system and the lowest fruit weight plant⁻¹ (4.796Kg) in Hybrid Mishtikumra-Asha in open field condition, which was identical to rest four treatment combinations. The maximum individual fruit weight (3.108 kg) was observed in Hybrid Mishtikumra-Asha in open field condition, which was identical to Hybrid Mishtikumra-Asha in agroforestry system and BARI Hybrid Mishtikumra-3 in open field condition (2.868Kg). The lowest individual fruit weight (2.263Kg) was observed in BARI Hybrid Mishtikumra-2 in agroforestry system, which was identical to rest two treatment combinations. The highest fruit yield (17.21t ha⁻¹) was observed in BARI Hybrid Mishtikumra-2 in open field condition, which was identical to BARI Hybrid Mishtikumra-3 in open field condition (17.11t ha⁻¹). The lowest yield (14.08 t ha⁻¹) was observed in Hybrid Mishtikumra-Asha in agroforestry system.

Among the six treatment combinations, total mango equivalent yield was highest (14.06 t ha⁻¹) in BARI Tomato-19 in agroforestry system, followed by BARI Tomato-16 and BARI Hybrid Mishtikumra-2 in agroforestry system. The lowest total mango equivalent yield (5.81 t ha⁻¹) was calculated in Hybrid Mishtikumra-Asha in open field condition. All the hybrid varieties of sweet gourd gave higher yield in agroforestry system than in open field condition.

Partial economic analysis of intercropping coriander with tomato and sweet gourd varieties under mango based agroforestry system and open field in Table 4. The highest gross return (m 843300 Tk ha⁻¹) and gross margin (m 683300 Tk ha⁻¹) were calculated from intercropping coriander with BARI Tomato-19 in agroforestry system, followed by BARI Tomato-16 and BARI Hybrid Mishtikumra-2 in agroforestry system. The lowest gross return (m 234000 Tk ha⁻¹) and net return (m 174000 Tk ha⁻¹) were calculated from sole mango plot followed by intercropping coriander with Hybrid Mishtikumra-Asha in open field condition. But the highest BCR (5.5) was found from BARI Tomato-19 and coriander in open field condition followed by agroforestry system (5.3). The lowest BCR was found from Hybrid Mishtikumra-Asha and coriander in open field condition, followed by BARI Hybrid Mishtikumra-2 and BARI Hybrid Mishtikumra-3 with coriander in open field condition.

Farmer's Reaction: Farmers were preferred tomato var. BARI Tomato-19 and BARI Tomato-16 for their higher yield and economic return and higher market demand.

Table 1. Fruit yield and yield contributing characters of tomato under mango based agroforestry system and in open field during winter 2020-21

Tomato varieties	System	Plant population (No.)	Plant height (cm)	Branch plant ⁻¹ (No.)	Fruits plant ⁻¹ (No.)	Fruit weight plant ⁻¹ (kg)	Individual fruit weight (g)	Fruit yield (t ha ⁻¹)
BARI Tomato-16	Agroforestry	3.64	121.88	4.95	32.35	1.36	65.63	47.13
	Open	3.73	102.75	5.27	27.73	1.24	68.13	51.22
BARI Tomato-17	Agroforestry	3.74	117.18	4.88	14.50	1.27	156.70	39.94
	Open	3.63	101.25	5.07	12.83	1.53	140.77	50.57
BARI Tomato-19	Agroforestry	3.78	124.85	5.58	37.50	1.35	55.25	48.26
	Open	3.78	99.45	5.87	31.83	1.33	59.27	56.74
CV (%)		3.45	10.15	5.63	7.17	11.20	5.85	7.40
LSD (0.05)		NS	18.06	0.47	2.99	0.241	8.51	5.798

Table 2. Fruit yield and yield contributing characters of sweet gourd under mango based agroforestry system and in open field during winter 2020-21

Tomato varieties	System	Plant population m ⁻² (No.)	Fruits plant ⁻¹ (No.)	Fruit weight plant ⁻¹ (Kg)	Individual fruit weight (g)	yield (t ha ⁻¹)
BARI Hybrid Mishtikumra-2	Agroforestry	0.31	2.41	5.040	2.263	14.86
	Open	0.31	3.35	5.296	2.298	17.21
BARI Hybrid Mishtikumra-3	Agroforestry	0.32	2.69	6.600	2.308	16.01
	Open	0.31	3.01	5.086	2.868	17.11
Hybrid Mishtikumra (Asha)	Agroforestry	0.31	2.15	5.573	3.035	14.08
	Open	0.31	2.62	4.796	3.108	14.61
CV (%)		0.69	8.21	10.26	10.06	3.62
LSD (0.05)		NS	0.362	0.903	0.434	0.923

Table 3. Yield and partial economic analysis of intercropping coriander with tomato and sweet gourd varieties under mango based agroforestry system and open field during Rabi 2020-21.

Vegetables	System	Tomato/ sweet gourd yield (t ha ⁻¹)	Coriander yield (t ha ⁻¹)
BARI Tomato-16	Agroforestry	47.13	2.22
	Open	51.22	1.93
BARI Tomato-17	Agroforestry	39.94	2
	Open	50.57	2.4
BARI Tomato-19	Agroforestry	48.26	2.42
	Open	56.74	3.3
BARI Hybrid Mishtikumra-2	Agroforestry	14.86	7.08
	Open	17.21	3.15
BARI Hybrid Mishtikumra-3	Agroforestry	16.01	5.6
	Open	17.11	2.93
Hybrid Mishtikumra (Asha)	Agroforestry	14.08	6.23
	Open	14.61	3.2

Table 4. Partial economic analysis of intercropping coriander with tomato and sweet gourd varieties under mango based agroforestry system and open field during Rabi 2020-21.

Vegetables	System	Mango fruit yield (t ha ⁻¹)	Mango equivalent yield (t ha ⁻¹)	Gross return ('000'Tk ha ⁻¹)	Gross margin ('000'Tk ha ⁻¹)	BCR
BARI Tomato-16+ coriander	Agroforestry	4.30	13.75	825.2	665.2	5.2
	Open		9.93	595.6	465.6	4.6
BARI Tomato-17 + coriander	Agroforestry	4.25	12.35	740.8	580.8	4.6
	Open		10.16	609.4	479.4	4.7
BARI Tomato-19 + coriander	Agroforestry	4.27	14.06	843.3	683.3	5.3
	Open		11.83	710.0	580	5.5
BARI Hybrid Mishtikumra-2 + coriander	Agroforestry	4.23	12.89	773.6	611.6	4.8
	Open		6.40	383.9	248.9	2.8
BARI Hybrid Mishtikumra-3 + coriander	Agroforestry	4.18	12.06	723.3	561.3	4.5
	Open		6.22	373	238	2.8
Hybrid Mishtikumra (Asha) + coriander	Agroforestry	4.22	12.09	725.1	563.1	4.5
	Open		5.81	348.6	213.6	2.6
Sole mango		3.9	3.90	234	174	3.9

[Note: Av. price of mango, tomato, sweet gourd and coriander were 60.0, 10.0, 14.4 and 43.2 Tk Kg⁻¹ respectively.]

Conclusion

Intercropping coriander with BARI Tomato-19 in agroforestry system gave the highest yield as well as economic return among the six tested crops/varieties which was similar to the yield of intercropping coriander with BARI Tomato-16 and intercropping coriander with BARI Hybrid Mishtikumra-2 in agroforestry system. All the combinations of tomato gave higher yield and economic return than sweet gourd except BARI Hybrid mishtikumra-2 in agroforestry system. The lowest mango equivalent yield, gross return and net return were calculated from Hybrid Mishtikumra (Asha) + coriander in open field condition. It was first year trial. So, it may be repeated next year for more concrete result.

DEVELOPMENT OF GUAVA BASED AGROFORESTRY SYSTEM WITH HIGH VALUE CROPS

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Abstract

The experiment was carried out at FSRD site Ganggarampur, Pabna Sadar, Pabna during 2020-21 to evaluate the performance of high value crops in agroforestry system and to increase productivity of farmer's income. Different high value crops such as tomato, cauliflower and cabbage were grown with existing guava orchard under guava based agroforestry system. Maximum fruit equivalent yield was obtained from guava+ tomato (18.65 t ha⁻¹) which was at par with guava + cauliflower (16.56 t ha⁻¹) and guava+ cabbage (13.86 t ha⁻¹). Regarding economic benefit, higher gross return (Tk. 727400 ha⁻¹) and gross margin (Tk. 569100 ha⁻¹) was achieved from guava + tomato followed by guava+ cauliflower and guava+ cabbage. Considering total system productivity and economic benefit guava+ tomato followed by guava+ cauliflower agroforestry system was found more profitable and economic viable at Pabna region.

Introduction

Agroforestry system can contribute stable income, food and nutrition security, savings and insurance and a potential means of risk management under climate change induced stress (Akter et al. 1989; Evans 1988). At present the research addressing soil and water conservation, reduce soil erosion, livestock feed management, fuel energy, tree-crop interaction for higher productivity and environmental benefit under integrated agroforestry system are getting high priority to combat climate change challenges (SAC, 2015). The increasing trend of fruit tree orchard in Pabna area is opening good scope of agroforestry based production. Guava is now a popular fruit and its off season fruiting and good market price encourage the farmers to establish more guava orchards. For this reason many farmers have established guava orchards. Guava trees have small canopy structure which favours more sunlight to the ground as compared to other denser canopy fruits. In some cases farmers grow some perennial spices crops in association with fruit trees which requires long time for income generation. Many orchards are not under this practice. Growing high value vegetable crops in fruits orchards can be better options for higher productivity and income generation.

Materials and Methods

The experiment was carried out at extrapolation areas of FSRD site Ganggarampur, Pabna Sadar, Pabna during 2020-21 to evaluate the performance of high value crops in agroforestry system and to increase productivity of farmer's income. Different high value crops such as tomato, cauliflower and cabbage were selected for guava based agroforestry system. Around 5 years aged guava (var. BARI Peyara-2) orchard was selected. Thirty days old seedlings of tomato (var. BARI Tomato-19), spacing of 60 cm x 50 cm for tomato and 60 cm x 45 cm for both cauliflower and cabbage. Application of fertilizers and other intercultural operation were made as per recommendation of individual crops. The harvesting of tomato was initiated on February 12 and continued up to March 16, 2021. The harvesting of cauliflower was initiated on January 14 and continued up to March 11, 2021. The harvesting of cabbage was initiated on January 07 and continued up to March 08, 2021. The harvesting of guava was initiated on

February 15 and continued up to March 14, 2021. Data on yield of vegetables and guava fruits were recorded and necessary table were prepared with mean values.

Results and Discussion

The performance of different high value vegetable crops and fruits under guava based agroforestry system are presented in Table-1. Maximum fruit equivalent yield was obtained from guava+ tomato (18.65 t ha^{-1}) which was at par with guava + cauliflower (16.56 t ha^{-1}) and guava+ cabbage (13.86 t ha^{-1}). Minimum fruit equivalent yield was recorded in sole guava (5.06 t ha^{-1}). Regarding economic benefit, higher gross return (Tk. 747200 ha^{-1}) and gross margin (Tk. 569100 ha^{-1}) was achieved from guava + tomato followed by guava+ cauliflower and guava+ cabbage. The results revealed that guava based agroforestry system with high value crops demonstrated showed very encouraging results in total system productivity and economic return.

Farmers' opinion

Farmers expressed their satisfaction to this agroforestry technology because-

- Increased production and economic benefit as compared to their sole guava cultivation
- More time harvesting and marketing generate cash income
- Intensive labour utilization
- Less pest and disease infestation
- Feel proud due to visit of neighboring farmers and govt. officials

Table 1. Performance of yield of vegetables and fruits in guava based agroforestry system at FSRD site Ganggarampur, Pabna Sadar, Pabna during the *rabi* season 2020-21.

Treatment	Vegetable yield (t ha^{-1})	Fruit yield (t ha^{-1})	Fruit equivalent yield (t ha^{-1})
Guava + Tomato	53.23	4.80	18.65
Guava+ Cauliflower	46.25	5.00	16.56
Guava+ Cabbage	49.95	5.12	13.86
Guava	-	5.06	5.06
CV(%)	6.44	7.82	6.57
Level of significance	*	ns	*

Table 2. Cost and return of vegetables and fruits in guava based agroforestry system at FSRD site Ganggarampur, Pabna Sadar, Pabna during the *rabi* season of 2020-21.

Treatment	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Guava+ Tomato	747200	178100	569100
Guava+ Cauliflower	662400	194100	468300
Guava+ Cabbage	554400	194100	360300
Guava	202400	66900	135500

Price: Cauliflower 10.00 Tk kg^{-1} , Cabbage-7.00 Tk kg^{-1} , Tomato-10.00 Tk kg^{-1} , Guava- 40.00 Tk kg^{-1} .

Conclusion

The results revealed that guava based agroforestry system with high value crops showed very encouraging results in total system productivity and economic return. All the tested vegetables in agroforestry system exhibited three to four time's higher production and economic return as compared with sole guava. However, considering total system productivity guava+ tomato followed by guava+ cauliflower agroforestry system seems more promising at Pabna region. However, this study needs to continue at least another year to get comprehensive findings.

PRODUCTION OF FODDER CROP UNDER MANGO BASED AGROFORESTRY SYSTEM

M. Robiul. Alam, M.A. Islam, M. Maniruzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

The production program was carried out at farmers field of FSRD site Ganggarampur, Pabna Sadar, Pabna during 2020-21 to evaluate the performance of fodder crop in agroforestry system and to increase fodder production and farmers income. The mango equivalent yield (MEY) of the agroforestry system with fodder crop was 5.16 while relatively lower MEY (3.60) was noted in sole mango cultivation. Higher gross return (309600 Tk. ha⁻¹) and gross margin (218260 Tk. ha⁻¹) was also obtained from agroforestry system. The results indicated that this agroforestry technology with mango and fodder crop was found more profitable with higher production and economic return as compared to famer's traditional sole mango cultivation.

Introduction

Intensive utilization of agricultural land for food based crops results in shrinkage of free grazing land for cattle. Production of fodder crops for feed management of cattle is now being considered as a priority issue for livestock sector. Establishment of fruit orchard is rapidly expanded in Pabna region. High land and medium high land is being brought under fruit cultivation. Development of high yield potential fruits varieties with dwarf canopy structure enhance increasing trend of fruit cultivation in rural areas. Development of agroforestry based production is deemed important for raising sustainable total production per unit area of land. Napier is a popular high yield potential fodder crop and can be grown under niches of fruit trees. For this reason the production program was undertaken to increase fodder production and farmers income.

Materials and Methods

The production program was carried out at farmers field of FSRD site Ganggarampur, Pabna Sadar, Pabna during 2020-21. An existing 5 years aged unutilized mango orchard with an area of 33 decimal was selected at FSRD site, Ganggarampur, Pabna during 2020-21. The variety of mango of the selected orchard was BARI Am-4. Exotic variety (var. Pakchong) of napier grass was used for this production program. The cuttings of napier grass was planted in between spaces of mango fruit trees maintaining spacing of 100 cm x 50 cm on December 10, 2018 (Table 1). Fertilizer management was done for fodder and fruit crops for better crop growth. Other management practices were done when required. The harvesting of fodder crop was initiated on July 15 and continued up to December 24, 2020. Mango fruit was harvested on July 5-12, 2020. The details of crop management practices are presented in Table 1. The yield and economic analysis of crops is presented in Table 2.

Results and Discussion

The results showed that agroforestry system with fodder crop showed relatively higher productivity as compare to sole mango cultivation. The mango equivalent yield (MEY) of the agroforestry system with fodder crop was 5.16 while relatively lower MEY (3.60) was noted in sole mango cultivation. Higher gross return (Tk. 309600 ha⁻¹) and gross margin (Tk. 218260 ha⁻¹) was also obtained from agroforestry system. The MBCR was recorded 1.87. The results indicated that this agroforestry technology with mango and fodder crop found more profitable and contributed to the higher production and economic return as compared to famers' traditional sole mango cultivation.

Conclusion

The results indicated that Mango-based agroforestry system with fodder crop demonstrated encouraging results in view of total system productivity and economic return. This agroforestry technology with Mango and fodder crop can be recommended for wider scale extension at extrapolation areas.

Table 1. Details of crop management under existing fruit (mango) orchard and agroforestry system FSRD Site Gonggarampur pabna during 2020-21

Topics	Existing fruit orchard	Agroforestry system with existing fruit orchard	
Crop	Mango	Fodder	Mango
Variety	BARI Aum-4	Napier (Var. Pakchong)	BARI Aum-4
Spacing	5 m x 5 m	100 cm x 50 cm	5 m x 5 m
Plot size (dec.)	33	33	33
Fertilizer dose N-P-K-S-Zn-B	38-17-32-8-1-0.5	100-38-56.20-1.5-1.0	38-17-32-8-1-0.5
Date of sowing/planting	16.06.2020	10.12.2018	16.06.2016
Date of harvest	5.7.20 to 12.7.20	15.7.2020 to 24.12.2020	5.7.2020 to 12.7.2020

Table 2. Yield and economics performance of existing fruit orchard and agroforestry system.

Production system	Crop yield (t ha ⁻¹)			Economic analysis (Tk. ha ⁻¹)			MBCR
	Fodder	Mango	MEY	Gross return	Total variable cost	Gross margin	
Existing sole fruits	-	3.60	3.60	216000	41140	174860	
Agroforestry system with fodder crop	26.81	3.6	5.16	309600	91300	218260	1.87

Market price (Tk kg⁻¹): Mango-60.00, Fodder-3.50

Farmer's opinion

Co-operator farmers were happy and convinced to this agroforestry system based production approach. This agroforestry technology created a good impact among the rural farm families having livestock farming.

DEVELOPMENT OF MANGO BASED AGROFORESTRY WITH PULSE CROP

M. Robiul. Alam, M.A. Islam, M. Maniruzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was carried out at farmers field of FSRD site Ganggarampur, Pabna during 2020 to evaluate the performance of pulse crop in agroforestry system and to increase productivity and farmers' income. Blackgram (var. BARI Mash-3) was selected for growing with mango orchard in this study. The mango equivalent yield (MEY) of the agroforestry system with blackgram was 5.65 while relatively lower MEY (3.50) was recorded in sole mango cultivation. Higher gross return (339000 Tk. ha⁻¹) and gross margin (274300 Tk. ha⁻¹) was also obtained from the agroforestry system.

Introduction

Mango is popular and commercially profitable fruit crops in Pabna region. The increasing trend of mango tree orchard in Pabna area is opening good scope of agroforestry based production. In most cases the ground space of mango orchard is remain unused. So the unutilized space can be easily utilized with suitable crops. Nutrient enriched crops specially pulse crops are getting priority for family nutrition of rural household. Due to competition with other crops, pulse growing areas are gradually declining. Growing pulse crops in kharif season is really a challenge due to unfavourable climate. However, an effort was made to develop mango based agroforestry with kharif pulse specially blackgram. Considering this issue growing pulse crops in association with mango fruit orchards can be better options for higher productivity and income generation.

Materials and Methods

The experiment was carried out at farmers field of FSRD site Ganggarampur, Pabna during 2020 to evaluate the performance of pulse crop in agroforestry system and to increase productivity and farmers' income. About 5 years aged mango orchard (var. BARI Aam-4) was selected for the study. Blackgram was selected for growing with mango orchard in kharif season. The seeds of blackgram (var. BARI Mash-3) were broadcasted in the unutilized spaces of existing mango orchard on August 19, 2020.

Application of fertilizers and other intercultural operation were made as per recommendation of pulse and fruit crops. The crop was harvested on November 05, 2020. The mango was harvested on July 05-07, 2020. The details of crop management practices are presented in Table 1. Data on yield of blackgram and mango fruits were recorded and necessary table were prepared with mean values.

Results and Discussion

The results showed that agroforestry system with blackgram showed relatively higher productivity as compare to sole mango cultivation. The mango equivalent yield (MEY) of the agroforestry system with blackgram was 5.65 while relatively lower MEY (3.50) was recorded in sole mango cultivation. Higher gross return (339000 Tk. ha⁻¹) and gross margin (274300 Tk. ha⁻¹) was also obtained from the agroforestry system. The results suggest that this agroforestry technology with mango and blackgram found more profitable and contributed to the higher production and economic return (MBCR: 3.44) as compared to famers traditional sole mango cultivation.

Farmers opinion

Farmers were happy and convinced to this agroforestry system based production approach. Neighboring farmers were visited the plot and motivated to adopt this technology in their land.

Table-1: Detail of crop management under existing fruit (Mango) orchard and Agroforestry system.

Parameters	Existing fruit orchard	Agroforestry system with existing fruit orchard	
Crop	Mango	Blackgram	Mango
Variety	BARI Aam-4	BARI Mash-3	BARI Aam-4
Spacing	5 m x 5 m	Broadcast	5 m x 5 m
plot size (dec.)	132	132	132
Fertilizer dose N-P-K-S-Zn-B (kg ha ⁻¹)	52-25-42-12-1.5-0.7	21-13-20-10-0-1	52-25-42-12-1.5-0.7
Date of sowing/planting	10.6.2017	19.8.2020	10.6.2017
Date of harvesting	July 05-07	Nov. 05, 2020	July 05-07, 2020

Table-2 : Yield and _ performance of crops in existing fruit orchard and agroforestry system.

Production system	Crop yield (t ha ⁻¹)			Economic analysis (Tk. ha ⁻¹)			
	Blackgram	Mango	MEY	Gross return	Total variable cost	Gross margin	MBCR
Existing sole fruits	-	3.50	3.50	210000	26600	183400	
Agroforestry system with pulse crop	1.29	3.50	5.65	339000	64100	274300	3.44

Market price (Tk kg⁻¹): Mango-60.00, Blackgram-100.00

Conclusion

Mango-based agroforestry system with blackgram exhibited very encouraging results in view of total system productivity and economic return. The current study agroforestry technology with mango and blackgram would be continued in the next year for conclusion.

PERFORMANCE LATE BLIGHT RESISTANT POTATO VARIETY AT RANGPUR UNDER MANGO BASED AGROFORESTRY SYSTEMS

M. Z. Ferdous, M. S. H. Molla, Md. A. H. Talukder, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at farmers field during the rabi season of 2020-2021 to promote and disseminate newly released late blight resistant potato variety, BARI Alu-46, BARI Alu-53 and BARI Alu-77 among the potato growers of Rangpur under OFRD, BARI, Rangpur under mango based

agroforestry systems. BARI Alu-46 and BARI Alu-53 showed excellent performance against late blight and produced higher yield compared to BARI Alu-25. Farmers were happy to observe the performance of the varieties and demanded quality seed for next year cultivation.

Introduction

Late blight is the most devastating disease of potato in Bangladesh. It causes around 30-50% annual yield loss. It may cause total loss of the crop if attack at early stage of the crop. Late blight can become epidemic within few days under favorable environmental conditions. Tuber Crops Research Center of BARI has developed two late blight resistant varieties viz. BARI Alu-46 and BARI Alu-53 which are higher yielder and resistant to late blight disease. These newly varieties need to be evaluated for their performance under different late blight prone areas under mango based agroforestry systems. The present studies were conducted to evaluate and popularize the variety under mango based agroforestry systems at farmer's field condition in Rangpur.

Materials and Methods

Total six hundred (600) kg of seed tubers of BARI Alu-46, BARI Alu-53 and BARI Alu-77 were distributed among 4 farmers having mango orchard at FSRD site Ajoddhampur, Rangpur. Each farmer received 50 kg of quality seed tubers of each variety for cultivating 5 decimals of land which totally covered 15 decimals of mango orchard area. BARI Alu-25 was cultivated as check. Plantings started on 28 November 2020 and continued up to 3 December 2020. TCRC standard fertilizer doses were applied and standard intercultural management practices were followed in the trial plots. Orientation was given to the farmers before and during the cropping season on improved seed production techniques as well as irrigation, disease management practices etc. Farmers were also suggested to follow a routine spray schedule for BARI Alu-25 to control Late Blight infection. But, in case of BARI Alu-46, BARI Alu-53 and BARI Alu-77, 1-2 spray may require if the infection appeared in the potato field. Haulms were pulled after 80 days of planting. The crop was harvested on 23 February to 18 March 2021. The fruit bearing of mango trees were very little and did not count in this study. Finally, the yield data and diseases observation data were taken from the trial plots and farmers' fields and finally compared.

Results and Discussion

The result revealed that three late blight resistant potato varieties BARI Alu-46, BARI Alu-53 and BARI Alu-77 showed better performance compared to BARI Alu-25 under mango based agroforestry. In Rangpur the mean yield of BARI Alu-53, BARI Alu-46, BARI Alu-77 and BARI Alu-25 were 29.12, 31.17, 30.77 and 22.49 t ha⁻¹, respectively. BARI Alu-46, BARI Alu-53 and BARI Alu-77 produced average 23%, 28% and 25% more tuber yield compare to BARI Alu-25 under mango based agroforestry system.

Table 1. Yield of newly released late blight resistant potato variety at farmer's field under mango based agroforestry systems during 2020-2021.

Location	Farmers (no)	BARI Alu-53	BARI Alu-46	BARI Alu-77	Control (BARI Alu-25)
Rangpur	F(1)	29.65	32.66	31.88	24.59
	F(2)	27.66	29.85	32.67	21.45
	F(3)	31.33	33.56	29.58	22.67
	F(4)	29.67	31.34	28.98	23.77
	Mean	29.12	31.17	30.77	22.49

Farmer's opinion

Farmers were incredibly happy to observe the performance of the BARI Alu-46, BARI Alu-53 and BARI Alu-77 under mango based agroforestry systems against the Late Blight disease and higher yield potentials. They preferred BARI Alu-53 and BARI Alu-77 varieties due to red color and higher market price. They demanded quality seed for (BARI Alu-53 and BARI Alu-77) next year cultivation.

PRODUCTION OF CAULIFLOWER UNDER MANGO BASED AGROFORESTRY SYSTEM

M. Z. Ferdous, M. S. H. Molla, M. A. H. Talukder, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at farmers field during the rabi season of 2020-2021 to evaluate the performance of cauliflower at mango based agroforestry systems at Ajodhapur, FSRD site Rangpur. The cauliflower under mango based agroforestry system exhibited satisfactory yield (33.88 t ha^{-1}), gross return (Tk 271040 ha^{-1}) as well as the gross margin (Tk.109140 ha^{-1}).

Introduction

In Bangladesh, due to increasing population, which turned, to be 200 millions in 2030 poses a big challenge to existing agriculture system for their vegetables requirements. Horizontal expansion of vegetable production is not possible with available land source. Because, due to the rapid expansion of population the available per capita land areas is decreasing at an alarming rate. Traditionally, farming practices and monoculture production system that are prevalent in Bangladesh often results in subnormal production from the farmland and homestead. Therefore, development of appropriate and satisfactory safeguards against such situations should be the primary concern for optimal utilization of marginal lands. It is possible to bring unutilized land like the floor of different orchard under vegetable production by using latest technologies. The utilization of the floor of mango orchard by growing vegetables i.e. vegetables-mango based agroforestry system may be an alternative avenue to overcome the increasing demand of vegetables for increasing population (Gill, et. al. 1992). Regarding this view, the present study was conducted with mango based agroforestry in association with cauliflower at farmers' field to assess the productivity and economic return.

Materials and Methods

A field experiment was carried out at the agroforestry farm, Ajodhapur, FSRD site, under OFRD, BARI Rangpur during 2020-2021 to evaluate the performance of cauliflower under mango based agroforestry system. The experiment was conducted in newly established four years old Mango orchard where the spacing of tree saplings was 10 m×10 m. The experiment was laid out in RCBD with three dispersed (Ferdous et al. 2018) replications. Before planting the seedlings of cauliflower, the land was fertilized by using fertilizer as per required doses. Seedlings of cauliflower were planted 5th November 2020 in to the main plots. All P and K were applied at the time of final land preparation. N was applied in three equal. Plant protection measures were taken as required. Other intercultural operations were done when necessary. The crop was harvested from 01 to 7 February 2021. Production of cauliflower included costs of field preparation, planting, irrigation, organic manure and synthetic fertilizer, plant protection chemicals, and harvesting. Gross return under a treatment was calculated by multiplying the gross amount of cabbage produced by the farm-gate price. The gross margin was calculated by subtracting cost of production from the gross return (Ferdous et al., 2016, 2017).

Results and discussion

The cauliflower under mango based agroforestry system exhibited satisfactory yield (33.88 t ha^{-1}), gross return (Tk 271040 ha^{-1}) as well as the gross margin (Tk.109140 ha^{-1}). Agroforestry systems provide more output in terms of more biological yield than single cropping. The findings of the present investigation indicate that diversification of farming system and growing cauliflower as ground layers crops in Mango based orchard is a viable option for increasing income of farmers.

Pest incidence: There was no remarkable disease or insect found during the growing period.

Table 1. Dates of all operations, yield, cost and return of cauliflower under mango based agroforestry

Crop	Planting date	Harvesting date	Cauliflower Yield (t ha^{-1})	Gross Return (Tk ha^{-1})	Total variable Cost (Tk ha^{-1})	Gross Margin (Tk ha^{-1})
Cauliflower	Nov. 05, 2020	Feb. 01-07, 2021	33.88	271040	161900	109140

Conclusions

The findings of the present investigation indicate that diversification of farming system and growing cauliflower as ground layers crops in mango tree orchard is a viable option for increasing income of farmers.

PRODUCTION OF CABBAGE UNDER MANGO BASED AGROFORESTRY SYSTEM

M. Z. Ferdous, M. S. H. Molla, Md. A. H. Talukder, M Akkas Ali, M Shahiduzzaman

Abstract

The trial was conducted at farmers field during the rabi season of 2020-2021 to evaluate the performance of cauliflower at mango based agroforestry systems at Ajodhapur, FSRD site Rangpur. The cabbage under mango based agroforestry system exhibited satisfactory yield (54.55 t ha⁻¹), gross return (Tk 381850 ha⁻¹) as well as the gross margin (Tk.219950 ha⁻¹).

Introduction

In Bangladesh, due to increasing burgeoning bovine population, which turned, to be 200 millions in 2030 poses a big challenge to existing agriculture system for their vegetables requirements. Horizontal expansion of vegetable production is not possible with available land source. Because, due to the rapid expansion of population the available per capita land areas is decreasing at an alarming rate. Traditionally, farming practices and monoculture production system that are prevalent in Bangladesh often results in subnormal production from the farmland and homestead. Therefore, development of appropriate and satisfactory safeguards against such situations should be the primary concern for optimal utilization of marginal lands. It is possible to bring unutilized land like the floor of different orchard under vegetable production by using latest technologies. The utilization of the floor of mango orchard by growing vegetables i.e. vegetables-mango based agroforestry system may be an alternative avenue to overcome the increasing demand of vegetables for increasing population (Gill, et. al. 1992). Keeping in view the investigation was conducted with integration cabbage and mango into agroforestry production system.

Materials and Methods

A field experiment was carried out at the agroforestry farm, Ajodhapur, FSRD site, under OFRD, BARI Rangpur during 2020-2021 to evaluate the performance of Cabbage under mango based agroforestry system. The experiment was conducted in newly established four years old Mango orchard where the spacing of tree saplings was 10 m×10 m. The experiment was laid out in RCBD with three dispersed replications. Before planting the seedlings of cabbage, the land was fertilized by using fertilizer as per required doses. Seedlings of cabbage were planted 10th November 2020 in to the main plots. All P and K were applied at the time of final land preparation. N was applied in three equal. Plant protection measures were taken as required. Other intercultural operations were done when necessary. The crop was harvested from 05 to 10 February 2021. Production of cabbage included costs of field preparation, planting, irrigation, organic manure and synthetic fertilizer, plant protection chemicals, and harvesting. Gross return under a treatment was calculated by multiplying the gross amount of cabbage produced by the farm-gate price. The gross margin was calculated by subtracting cost of production from the gross return (Ferdous et al., 2016, 2017).

Results and Discussion

The cabbage under mango based agroforestry system showed satisfactory yield (54.55 t ha⁻¹), gross return (Tk. 381850 ha⁻¹) as well as the gross margin (Tk.219950 ha⁻¹). Agroforestry systems provide more output in terms of more biological yield than single cropping. The findings of the present investigation indicate that diversification of farming system and growing cabbage as ground layers crops in Mango based orchard is a viable option for increasing income of farmers.

Pest incidence: There was no remarkable disease or insect found during the growing period.

Table 1. Dates of all operations, yield, cost and return of cabbage under mango based agroforestry.

Crop	Planting date	Harvesting date	Head yield (t ha ⁻¹)	Gross Return (Tk ha ⁻¹)	Total variable Cost (Tk ha ⁻¹)	Gross Margin (Tk ha ⁻¹)
Cabbage	Nov. 10, 2020	Feb. 01-07, 2021	54.55	381850	161900	219950
Mango	?	?	?	?	?	?

Conclusions

The findings of the present investigation indicate that diversification of farming system and growing cauliflower as ground layers crops in mango tree orchard is a viable option for increasing income of farmers.

DEVELOPMENT OF CROPPING PATTERN IN MANGO BASED AGROFORESTRY SYSTEM

M. A. Siddique, M. Anwar, M Akkas Ali, M Shahiduzzaman

Abstract

The field experiment was conducted at Multi-Location Testing (MLT) site, Shibpur, Puthia, Rajshahi during 2019-2020 to find out the performance of different cropping patterns in the context of increase productivity and income under mango based agro-forestry systems. The experimental area was medium land of silty clay loam –loamy soils and belongs to the Agro Ecological Zone 11 (FRG, 2018). The experiment was laid out in a Randomized Complete Block Design with three replications. There were four treatments under mango orchard viz. T₁= Control (Mango orchard without any associated crops), T₂= High value crops (Onion-sweet gourd- T Aman) in association with mango orchard, T₃= High value crops (Garlic-sweet gourd- T Aman) in association with mango orchard and T₄= High value crops (Lentil-sweet gourd- T Aman) in association with mango orchard. The sole treatments of the patterns were conducted in the adjacent open fields. The highest rice equivalent yield 41.39 t ha⁻¹ was achieved in treatment T₃ followed by 35.85 t ha⁻¹ in T₂ and 27.44 t ha⁻¹ in T₄. The lower REY was found in all sole crop treatments compare to their respective agro-forestry system. The maximum gross margin of Tk. 421237 ha⁻¹ was achieved in treatment T₃ followed by Tk. 349562 in T₂ and Tk. 294676 in T₄. The sole patterns are produced the lower gross margin compare to their respective agro-forestry system. The farmers' preference rank was T₃>T₄>T₂.

Introduction

Agroforestry is an ancient practice and now it is becoming an integral part of the traditional farming systems in Bangladesh in the context of changing climate. "Agro forestry is a practices where woody perennials or deliberately grown on the same land management unit with agricultural crops and or animals in some form of spatial mixture of in temporal sequence" (Nair, 1984). The present national forest cover is only 5.4% (Anonymous 1990), which is far below the critical level (25%). Due to rapid growth of population, there is a tremendous pressure on the forest lands. Annual deforestation rate is estimated to be 8,000 ha (FAO, 1981). Village forest mainly covered by homesteads accounts only 0.27 million ha. Out of 64 districts, 28 districts have no public forest land (Islam, 1991).

In Rajshahi district, farmers have been establishing orchards of different fruits at the field. Fruits orchard is one of the most prominent practice here. Farmers get economic return from orchards only during the fruiting seasons. For the remaining period, they grow some vegetables in association with trees or remain fallow. Up to 15 years of planting saplings, sometimes farmers utilized the land space between two rows of trees for growing short duration crops as well as rice but thereafter the growing tree canopy make substantial shading on the ground. The production period can be increased by periodically pruning the tree levels to prevent shading the companion crops. Branch pruning after bearing has a beneficial effect on mango yield. In these circumstances, the ground land remains totally unutilized or partially

utilized with traditional spices crops. So, cultivation of some high value crop based cropping patterns under agroforestry system may be good options for the farmers to generate additional income from these fruit gardens. As such a field experiment with special objectives to find out the performance of different cropping pattern under mango based agro-forestry systems and to increase productivity and income of the agro-forestry systems.

Materials and Methods

The field experiment was conducted at Multi-Location Testing (MLT) site, Shibpur, Puthia, Rajshahi during 2019-2020 to find out the performance of different cropping patterns in the context of increase productivity and income under mango based agro-forestry systems. The experimental area was medium land of silty clay loam –loamy soils and belongs to the Agro Ecological Zone 11 (FRG, 2018). The experiment was laid out in a Randomized Complete Block Design with three replications. There were four treatments under mango orchard viz. T₁= Control (Mango orchard without any associated crops), T₂= High value crops (Onion-sweet gourd- T Aman) in association with mango orchard, T₃= High value crops (Garlic-sweet gourd- T Aman) in association with mango orchard and T₄= High value crops (Lentil-sweet gourd- T Aman) in association with mango orchard. The sole treatments (T₅, T₆ and T₇) of the patterns were conducted in the adjacent open fields. The recommended fertilizers of the crops were applied in both agroforestry and open field following the methods described in the fertilizer recommendation guide (FRG, 2018). The intercultural operations, irrigations and pest control were done as and when necessary. Ten years aged mango orchards were selected for the trial.

Table 1. Details of cultural practices adopted for different crops in the diverse cropping sequences with association of Mango in Mango orchard.

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm or m)	Date of sowing	Date of harvest	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Garlic†	Local (Italy)	800	10 x 10 cm	28Nov. 2019	1 April 2020	125	54	167	20	3	1.5
Onion†	BARI Peaj 1	6	12 x 6 cm	5 Jan 2020	2April 2020	140	52	113	18	3	1.5
Lentil	BARI Masur 8	45	Broadcast	28Nov. 2019	21 March 2020	23	18	25	-	2	1.5
Sweet gourd†	Hybrid	0.4	2m x 2m	7 April 2020	18 July 2020	80	35	75	16	3	1.5
T. Aman	BRRI Dhan 87	35	20 x 15 cm	25 July 2020	6 Nov 2020	76	18	28	8	-	-
Mango‡	Mixed	-	8 m x 8m	Harvest duration: 25 May-10 July 2020		N-P-K-S- Zn-B @ 460-100-125-40-5-5 g/plant respectively.					

†, Cowdung was applied @ 5 t ha⁻¹ with above chemical fertilizers in Garlic, Onion and Sweet gourd; ‡, Cowdung@ 25 kg/pit was applied with chemical fertilizers.

Results and Discussion

Yield and Rice Equivalent Yield (REY) of different agro-forestry system

Component crops yield and rice equivalent yield of different agroforestry systems were presented in Table 2. The highest rice equivalent yield 41.39 t ha⁻¹ was achieved in treatment T₃ (Garlic-sweet gourd- T Aman cropping pattern in association with mango orchard) followed by 35.85 t ha⁻¹ in T₂ (Onion-sweet gourd- T Aman cropping pattern in association with mango orchard) and 27.44 t ha⁻¹ in T₄ (Lentil-sweet gourd- T Aman cropping pattern in association with mango orchard). The lower REY was found in all sole crop treatments compare to their respective agro-forestry system.

Cost and return analysis

The economic analysis of the different agroforestry and sole cropping systems was presented in Table 3. The maximum gross return of Tk. 910643 ha⁻¹ was achieved in treatment T₃ followed by Tk. 788765 in T₂ and Tk. 603733 in T₄. On the other hand, similar trend was found in case of gross margin. The

maximum gross margin of Tk. 421237 ha⁻¹ was achieved in treatment T₃ followed by Tk. 349562 in T₂ and Tk. 294676 in T₄. The sole patterns are produced the lower gross margin compare to their respective agro-forestry system.

Farmer's reaction: Farmers showed interest to adopt the Garlic-Sweet gourd-T. Aman cropping pattern in their existing unutilized mango orchards for additional income. Neighboring farmers visited the field and impressed to see the crop performance under mango based agroforestry system.

Table 2 Yield of different crops in diverse high value cropping sequences in mango based agroforestry and open field system.

Treatments	Yield of component crops (kg ha ⁻¹)					Yield of Mango (kg ha ⁻¹)	REY (t ha ⁻¹)
	Onion	Garlic	Lentil	Sweet gourd	T. Aman		
T ₁ = Control (Mango orchard without any associated crops)	-	-	-	-	-	5897	12.06 d
T ₂ = High value crops (Onion-sweet gourd- T Aman) in association with mango orchard	13560	-	-	22267	3823	5297	35.85 b
T ₃ = High value crops (Garlic-sweet gourd- T Aman) in association with mango orchard	-	7187	-	21780	3963	4917	41.39 a
T ₄ = High value crops (Lentil-sweet gourd- T Aman) in association with mango orchard	-	-	1153	22567	3917	5107	27.44 d
T ₅ = Onion-sweet gourd- T Aman in open field	18167	-	-	22733	4297	-	31.15 c
T ₆ = Garlic-sweet gourd- T Aman in open field	-	8107	-	22733	4089	-	36.53 b
T ₇ = Lentil-sweet gourd- T Aman in open field	-	-	1297	23233	4217	-	19.20 e
CV (%)							2.65
LSD (0.05)							2.21

Table 3: Economic return of different high value cropping sequences in mango based agroforestry and open field system.

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁ = Control (Mango orchard without any associated crops)	265350	71973	193377
T ₂ = High value crops (Onion-sweet gourd- T Aman) in association with mango orchard	788765	439203	349562
T ₃ = High value crops (Garlic-sweet gourd- T Aman) in association with mango orchard	910643	489406	421237
T ₄ = High value crops (Lentil-sweet gourd- T Aman) in association with mango orchard	603733	309058	294576
T ₅ = Onion-sweet gourd- T Aman in open field	367230	681593	317963
T ₆ = Garlic-sweet gourd- T Aman in open field	417433	803699	386266
T ₇ = Lentil-sweet gourd- T Aman in open field	237085	422350	185265

Output price: Onion =20 taka per kg, Garlic = 60 taka per kg, Lentil =75 taka per kg, Sweet gourd =10 taka per kg, Mango=45 taka per kg and T. Aman = 22 taka per kg

Conclusion

The result revealed that cropping pattern Garlic-Sweet gourd-T. Aman is suitable in mango-based agro-forestry system in AEZ 11 in respect of total system yield and economic return.

DEVELOPMENT OF SORJAN-BASED AGROFORESTRY SYSTEM WITH QUICK GROWING FRUITS AND VEGETABLES IN COASTAL AREA

Abstract

The research work was carried out at Jamla village of FSRD site, Dumki, during 2020 to evaluate sorjan based agroforestry system with quick growing fruits and vegetables for increasing production and farmers income. Cultivation of high value vegetables with quick growing fruits in sorjan based agroforestry system showed satisfactory yield of vegetables (230 kg sorjan⁻¹) and fruits (245 kg sorjan⁻¹) with total gross return of Tk 14325 sorjan⁻¹ and gross margin of Tk 10325 sorjan⁻¹. Moreover additional income may be possible from fish cultivation in the sorjan ditch.

Introduction

In coastal areas agricultural production through Sorjan system is an age old traditional practice adopted by the farmers. Unplanned cultivation with low yielding varieties of vegetables and fruits and unutilized water bodies often results in lower production and economic. High yielding popular varieties of quick growing fruits and vegetables along with modern management practices would contribute higher production and income. In addition, seasonal fish culture in ditches also may be a good technology for poor farm households. Regarding this concern an integrated production system including fruits, vegetables, fishes through sorjan method is deemed imperative for sustainable production in coastal ecosystem like Patuakhali. Therefore, the present study was undertaken to increase production and income of farm households in Patuakhali.

Materials and methods

In coastal region farmers usually cultivate vegetables or timber trees in sorjan bed. In this study farmer's existing sorjan was renovated and cultivated high value vegetables and quick growing fruits in dyke in a sequential order round the year. The average size of sorjan was 30 decimal. This sorjan has three beds and two canals. The average length and wide of sorjan bed was 55 m × 24 m. Each bed was 2 m wide at the top and more or less 1 m height above ground level. Existing sorjan of cooperative farmers was renovated providing with all sorts of required inputs like seeds, fertilizers and pesticides. In kharif-II season, cucumber, snake gourd, ridge gourd, bottle gourd, Indian spinach, jute as vegetables and sweet gourd were cultivated. Quick growing fruits like Papaya, Guava and Banna were cultivated in sorjan bed. Seasonal fish like tilapia and thaiputi was cultivated within sorjan ditch in kharif season. The yield performance and cost return analysis of vegetables; fruits insorjan based agroforestry system are presented in Table 2.

Table 1. Production of vegetables & fruits and seasonal fish in Sorjan of FSRD site Dumki of Paruakhali during July-December, 2020.

Types	Vegetable & fruits in Sorjan	Remarks
Vegetables	Cucumber, Snake gourd, Ridge gourd, Bottle gourd, Indian spinach, country bean etc.	Some vegetables already harvested and rest are now in sorjan bed
Fruits	Bannana, Papaya, Guava	Round the year
Fish	---- Seasonal fish like Telapia and Thaiputi	

Results and Discussion

The results revealed that Sorjan based agroforestry system with high value crops showed very encouraging results in view of total system productivity and economic return. Cultivation of high value vegetables with quick growing fruits in sorjan based agroforestry system showed satisfactory yield of vegetables (230 kg sorjan⁻¹) and fruits (245 kg sorjan⁻¹) during the study period with total gross return of Tk 14325 sorjan⁻¹ and gross margin of Tk 10325 sorjan⁻¹ (Table-2). However, it can be concluded that cultivation of high value vegetables with quick growing fruits in sorjan bed is a good option to intensify cropping intensity compare to single cropping system. Moreover additional income may be possible from fish cultivation in the sorjan ditch.

Table 2. Yield, cost and return analysis from sorjan at FSRD site Jamla, Dumki of Patuakhali district during July-December 2020.

Vegetables (Kharif-II)	Yield (kg per sorjan)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. per Sorjan) in Kharif-II	Gross margin (Tk. ha ⁻¹)
Bombay chilli, Cucumber, Snake gourd, Ridge gourd, Bottle gourd, Indian spinach and sweet gourd	230	5750/-	2500/-	3250/-
Banana, Papaya, Guava	245	8575/-	1500/-	7075/-
Fish	-	-	-	-
Total	475	14325/-	4000/-	10325/-

***Average price of vegetable @ 25tk kg⁻¹, fruit @ 35tk kg⁻¹

Conclusion

Cultivation of high value vegetables with quick growing fruits in sorjan based agroforestry system showed satisfactory yield of vegetables and fruits during the study period with good economic returns.

PERFORMANCE OF SWEET GOURD VARIETIES UNDER FRUIT TREE BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at the farmers' field of Tetulia para hill slopes of Rowangchari upazilla in Bandarban during the rabi season of 2020-21 to evaluate the performance of different sweet gourd varieties viz. V_1 =BARI Mistikumra-2, V_2 =BARI Hybrid Mistikumra-2 and V_3 =Hybrid Maya under Mango+Papaya based agroforestry system. However, the results indicating that highest sweet gourd yield (11.89 t ha⁻¹), mango equivalent yield (25.00 t ha⁻¹), gross return (Tk. 998210 ha⁻¹), gross margin (Tk. 670210 ha⁻¹) and BCR (3.04) was obtained from mango+papaya+BARI Mistikumra-2 agroforestry system and this might be suitable for the hilly areas of Bandarban because of higher crop productivity, better land and time utilization as well as economic return.

Introduction

Chittagong hill tracts has great potentiality for growing different types of fruit specially mango, litchi, banana, pineapple, papaya, citrus etc. This region is about one tenth of the total area of Bangladesh and has great potentiality for growing different fruits and vegetables. Around 45866 ha area of land in Bandarban district is under fruit cultivation. Agroforestry system can be more profitable than mono-crop fruit cultivation. But incorporation of all kind of vegetables at hill slope is not possible like plain land or valleys due to soil erosion. Therefore, introducing creeper vegetables is a good option where tillage practice can be avoided and plantation is done by making pit to check soil erosion. In 2019, an experiment showed that sweet gourd performed best among different creeper vegetables in kharif season under mango based agroforestry system. In the early establishment period (2-3 years) of the mango orchard, competition for growth resources (light, water and nutrition) between tree and associated crops are minimum or absent. To use the land more efficiently, papaya was planted in between two mango trees in mango base agroforestry system to introduce mango+papaya based agroforestry system. Papaya is a short duration fruit tree which can add extra farm income for 2-3 years at the early establishment period (0-3 years) of mango orchard. So, the present study was undertaken to find out the performance of BARI released sweet gourd varieties under mango+papaya based agroforestry system in the hill slopes of Bandarban.

Materials and Methods

The experiment was conducted at the 2.5 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the rabi season of 2020-21. Average spacing of mango trees was 6 m × 4 m, clean bole height was 1.5 m, canopy spread was 2 m × 2 m and tree height was 2.5 m. So, there

was much gaps between the tree canopy in the garden and direct sunlight may reach to the under storey crops. Three sweet gourd varieties viz. V_1 =BARI Mistikumra-2, V_2 =BARI Hybrid Mistikumra-2 and V_3 =Hybrid Maya used as treatments under Mango+Papaya based agroforestry system and the experiment was laid out in RCBD desing with three replications. The unit plot size was 6m×4m. The spacing was 4m×2m for each sweet gourd varieties. In Mango+Papaya based agroforestry system, one papaya plant was planted in between two mango trees in a mango row to utilize the land more efficiently. Hence the distance between two papaya trees became 6m and average spacing of papaya trees was 6m×4 m. In this agroforestry plantation system, one bed of vegetable was cultivated maintaining 2m pit-pit distance. Pit size was 45cm×45cm×40cm and prepared by digging. Papaya seedlings were planted on 17 March to 18 March, 2020 and sweet gourd seeds were sown directly to the pits of different planting system on 11 November, 2020. Irrigation was provided when necessary. Insecticide and fungicide were sprayed to control the pest and diseases after leaf emergence. Data was recorded and analyzed by using Statistic 10 computer program.

Results and Discussion

Fruit number per plant, fruit length (cm), fruit breadth (cm), fruit weight (kg) and yield ($t\ ha^{-1}$) of sweet gourd at farmer's field is presented in Table 1. Mango equivalent yield was presented in Table 2.

Fruit number per plant: Per plant fruit number was significantly influenced in different sweet gourd varieties under mango+papaya based agroforestry system. Highest fruits per plant (3.46) was observed in BARI Mistikumra-2 followed by BARI Hybrid Mistikumra-2 (3.01) and lowest number was found from Hybrid maya variety (2.73). (Table 1)

Fruit length and breadth (cm): Maximum fruit length and breadth was recorded from BARI Mistikumra-2 (13.41 cm and 19.70 cm) followed by BARI Hybrid Mistikumra-2 (13.39 cm and 19.44 cm) and lowest number from Hybrid maya variety (13.08 cm and 18.79 cm). (Table 1)

Fruit weight (kg): Maximum fruit weight was found from BARI Mistikumra-2 (2.31 kg) followed by Hybrid maya (2.04 kg) and lowest fruit weight from BARI Hybrid Mistikumra-2 (2.02 kg) at mango+papaya based agroforestry system. (Table 1)

Yield ($t\ ha^{-1}$): About 30% of mango tree produced fruit for the first time in this orchard and the average yield of mango was $2.08\ t\ ha^{-1}$. Average papaya yield for all intercrop combination was $18.72\ t\ ha^{-1}$. Higher yield was recorded from BARI Mistikumra-2 ($11.89\ t\ ha^{-1}$) followed by BARI Hybrid Mistikumra-2 ($9.00\ t\ ha^{-1}$) and lowest from Hybrid maya variety ($8.24\ t\ ha^{-1}$). The highest mango equivalent yield ($25.00\ t\ ha^{-1}$) was obtained from mango+papaya+BARI Mistikumra-2 followed by mango+papaya+BARI Hybrid Mistikumra-2 ($23.15\ t\ ha^{-1}$), mango+papaya+Hybrid maya ($22.67\ t\ ha^{-1}$) and lowest in sole mango ($2.08\ t\ ha^{-1}$). (Table 2)

Cost and return

Cost of cultivation for mango, papaya and all sweet gourd varieties was Tk. 45000 ha^{-1} , Tk. 175000 ha^{-1} and Tk. 108000 ha^{-1} respectively. Higher gross return (Tk. 998210 ha^{-1}) was obtained from mango+papaya+BARI Mistikumra-2 combination due to high yield of BARI Mistikumra-2 followed by mango+papaya+BARI Hybrid Mistikumra-2 (Tk. 925960 ha^{-1}), mango+papaya+Hybrid maya (Tk. 906960 ha^{-1}) and lowest in sole mango (Tk. 83200 ha^{-1}) (Table 3). The result revealed that the highest gross margin (Tk. 670210 ha^{-1}) and benefit cost ratio (3.04) was recorded in the mango+papaya+BARI Mistikumra-2 intercrop combination followed by mango+papaya+BARI Hybrid Mistikumra-2 (Tk. 597960 ha^{-1} and 2.82), mango+papaya+Hybrid maya (Tk. 578960 ha^{-1} and 2.77) and lowest in sole mango (Tk. 38200 ha^{-1} and 1.85) (Table 4).

Farmer's Reaction

Farmers preferred Mango+Papaya+BARI Mistikumra-2 agroforestry system for higher yield and economic return over sole mango cultivation. They also preferred sweet gourd variety BARI Mistikumra-2 among three sweet gourd varieties because of its good color, size, yield and seed storing quality.

Table 1. Yield contributing characters and average yield of different sweet gourd varieties under mango+papaya based agroforestry system during the rabi season of 2020-21.

Varieties	Fruit number per plant	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (kg)	Fruit yield (t ha ⁻¹)
BARI Mistikumra-2 (V ₁)	3.46a	13.41a	19.70a	2.31a	11.89a
BARI Hybrid Mistikumra-2 (V ₂)	3.01ab	13.39a	19.44a	2.02a	9.00ab
Hybrid Maya (V ₃)	2.73b	13.08a	18.79a	2.04a	8.24b
CV (%)	10.19	8.59	3.20	12.12	16.27
LSD (0.05)	0.26	0.93	0.50	0.21	1.29

Table 2. Mango equivalent yield under mango+papaya based agroforestry system during the rabi season of 2020-21.

Treatments	Crop yield (t ha ⁻¹)			Mango equivalent yield (t ha ⁻¹)
	Mango	Papaya	Intercrop	
Mango+Papaya+BARI Mistikumra-2	2.08	18.72	11.89	25.00
Mango+Papaya+BARI Hybrid Mistikumra-2	2.08	18.72	9.00	23.15
Mango+Papaya+Hybrid Maya	2.08	18.72	8.24	22.67
Sole Mango	2.08	-	-	2.08

: About 30% of mango tree produced fruit (1st harvest). Sale price: Mango- Tk. 40 kg⁻¹, Papaya- Tk. 33 kg⁻¹ and Mistikumra- Tk. 25 kg⁻¹ only.

Table 3. Cost of cultivation and gross return of mango+papaya based agroforestry system.

Treatment	Total cost of cultivation (Tk. ha ⁻¹)				Gross return (Tk. ha ⁻¹)			
	Mango	Papaya	Sweet gourd	Total	Mango	Papaya	Sweet gourd	Total
Mango+Papaya+BARI Mistikumra-2	45000	175000	108000	328000	83200	617760	297250	998210
Mango+Papaya+BARI Hybrid Mistikumra-2	45000	175000	108000	328000	83200	617760	225000	925960
Mango+Papaya+Hybrid Maya	45000	175000	108000	328000	83200	617760	206000	906960
Sole Mango	45000	-	-	45000	83200	-	-	83200

Note: Sale price:- Mango- Tk. 40 kg⁻¹, Papaya- Tk. 33 kg⁻¹ and Mistikumra- Tk. 25 kg⁻¹ only.

Table 4. Gross margin and benefit cost ratio of mango+papaya based agroforestry system.

Treatment	Gross margin (Tk. ha ⁻¹)				Benefit cost ratio
	Mango	Papaya	Sweet gourd	Total	
Mango+Papaya+BARI Mistikumra-2	38200	442760	189250	670210	3.04
Mango+Papaya+BARI Hybrid Mistikumra-2	38200	442760	117000	597960	2.82
Mango+Papaya+Hybrid Maya	38200	442760	98000	578960	2.77
Sole Mango	38200	-	-	38200	1.85

Conclusion

Sweet gourd variety BARI Hybrid Mistikumra-2 in Mango+Papaya based agroforestry system performed better regarding yield and economic return. However, the experiment should be repeated for at least one year to validate the findings.

PERFORMANCE OF BOTTLE GOURD VARIETIES UNDER FRUIT TREE BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted at the farmers' field of Tetulia para hill slopes of Rowangchari upazilla in Bandarban during the rabi season of 2020-21 to evaluate the performance of different bottle gourd varieties viz. BARI Lau-3, BARI Lau-4, BARI Lau-5 and Commercial hybrid Lau under mango+papaya based agroforestry system to increase the total system productivity and economic return farmers. The maximum mango equivalent yield (29.22 t ha^{-1}), gross return (Tk. 1168800 ha^{-1}), gross margin (Tk. 848800 ha^{-1}) and BCR (3.65) was obtained from mango+papaya+BARI Lau-4 agroforestry system and this might be suitable for the hilly areas of Bandarban because of higher crop productivity, better land and time utilization as well as economic return.

Introduction

Chittagong hill tracts has great potentiality for growing different types of fruit specially mango, litchi, banana, pineapple, papaya, citrus etc. This region is about one tenth of the total area of Bangladesh and has great potentiality for growing different fruits and vegetables. Agroforestry system can be more profitable than mono-crop fruit cultivation. Incorporation of creeper vegetables like bottle gourd at hill slope is profitable where tillage practice can be avoided and plantation can be done by making pit to minimize soil erosion. Hill farmers of Bandarban use different local and hybrid varieties of bottle gourd. Yield potentiality of these varieties is very poor and susceptible to pest and diseases. BARI has developed a good number of bottle gourd varieties which are high yielding, tolerant to different pest and diseases and seed producing potentiality. The present study has been undertaken to evaluate the performances of bottle gourd varieties in mango+papaya based agroforestry system and to increase production and economic return.

Materials and Methods

The experiment was conducted at the 2.5 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the rabi season of 2020. Average spacing of mango trees was $6 \text{ m} \times 4 \text{ m}$, clean bole height was 1.5 m, canopy spread was $2 \text{ m} \times 2 \text{ m}$ and tree height was 2.5 m. So, there was much gaps between the tree canopy in the garden and direct sunlight may reach to the under storey crops. Four varieties of bottle gourd viz. BARI Lau-3, BARI Lau-4, BARI Lau-5 and Commercial Hybrid Lau were used as under storey crop in this experiment. The experiment was laid out in Randomized Complete Block (RCB) Design with three replications. The unit plot size was $6\text{m} \times 4\text{m}$. The spacing was $4\text{m} \times 2\text{m}$ for each sweet gourd varieties. In Mango+Papaya based agroforestry system, one papaya plant was planted in between two mango trees in a mango row to utilize the land more efficiently. Hence the distance between two papaya trees became 6m and average spacing of papaya trees was $6\text{m} \times 4 \text{ m}$. In this agroforestry plantation system, one bed of vegetable was cultivated maintaining 2m pit-pit distance. Pit size was $45\text{cm} \times 45\text{cm} \times 40\text{cm}$ and prepared by digging. Papaya seedlings were planted on 17 March to 18 March, 2020 and sweet gourd seeds were sown directly to the pits of different planting system on 11 November, 2020. Irrigation was provided when required. Insecticide and fungicide were sprayed to control the pest and diseases after leaf emergence. Data was recorded and analyzed by using Statistic 10 computer program.

Results and Discussion

Fruit number per plant: Per plant fruit number was significantly influenced in different lau varieties under mango+papaya based agroforestry system. Highest fruits per plant (8.33) was observed in BARI Lau-4 followed by BARI Lau-5 (7.03), BARI Lau-3 (6.63) and lowest number was found from Hybrid Diana Lau variety (6.24). (Table 1)

Fruit length and breadth (cm): Significant variation in fruit length was observed among these varieties. Highest fruit length was recorded from Hybrid Diana Lau (53.67 cm) and highest breadth was recorded from BARI Lau-4 (14.31 cm) (Table 1).

Fruit weight (kg): Highest fruit weight was found from BARI Lau-4 (2.52 kg) followed by Hybrid diana (2.49 kg), BARI Lau-5 (2.48 kg) and lowest fruit weight was found from BARI Lau-3 (2.28 kg) at mango+papaya based agroforestry system. (Table 1)

Yield (t ha⁻¹): About 30% of mango tree produced fruit for the first time in this orchard and the average yield of mango was 2.08 t ha⁻¹. Average papaya yield for all intercrop combination was 18.72 t ha⁻¹. All bottle gourd varieties in mango+papaya based agroforestry system showed significant variation among them where highest yield was recorded from BARI Lau-4 (31.19 t ha⁻¹) followed by BARI Lau-5 (25.85 t ha⁻¹), Hybrid diana (23.01 t ha⁻¹) and lowest from BARI Lau-3 (22.32 t ha⁻¹). The highest mango equivalent yield (29.22 t ha⁻¹) was obtained from mango+papaya+BARI Lau-4 followed by mango+papaya+BARI Lau-5 (27.22 t ha⁻¹), mango+papaya+Hybrid diana (26.15 t ha⁻¹), mango+papaya+ BARI Lau-3 (25.89 t ha⁻¹) and lowest in sole mango (2.08 t ha⁻¹) (Table 2).

Cost and return

Cost of cultivation for mango, papaya and bottle gourd was Tk. 45000 ha⁻¹, Tk. 175000 ha⁻¹ and Tk. 100000 ha⁻¹ respectively. The highest gross return (Tk. 1168800 ha⁻¹) was obtained from mango+papaya+BARI Lau-4 combination due to high yield of BARI Lau-4 followed by mango+papaya+BARI Lau-5 (Tk. 1088800 ha⁻¹), mango+papaya+Hybrid diana (Tk. 1046000 ha⁻¹), mango+papaya+BARI Lau-3 (Tk. 1035600 ha⁻¹), and the lowest in sole mango (Tk. 83200 ha⁻¹) (Table 3). Highest gross margin (Tk. 848800 ha⁻¹) and benefit cost ratio (3.65) was recorded in the mango+papaya+BARI Lau-4 intercrop combination followed by mango+papaya+BARI Lau-5 (Tk. 768800 ha⁻¹ and 3.40), mango+papaya+Hybrid diana (Tk. 726000 ha⁻¹ and 3.27) and the lowest in sole mango (Tk. 38200 ha⁻¹ and 1.85) (Table 4).

Farmer's Reaction

Farmers preferred bottle gourd variety BARI Lau-4 for their attractive color, size, higher yield and economic return under mango-based agroforestry system.

Table 1. Yield contributing characters and average yield of different Bottle gourd varieties under mango+papaya based agroforestry system during the rabi season of 2020-21.

Varieties	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (kg)	Fruit yield (t ha ⁻¹)
BARI Lau-3	6.63b	41.92b	13.55a	2.28a	22.32b
BARI Lau-4	8.33a	44.49b	14.31a	2.52a	31.19a
BARI Lau-5	7.03b	46.25b	13.13a	2.48a	25.85b
Hybrid Daina	6.24b	53.67a	13.77a	2.49a	23.01b
LSD (0.05)	0.45	2.24	1.18	0.18	1.99
CV (%)	7.81	5.88	10.53	9.22	9.51

Table 2. Mango equivalent yield under Mango+Papaya+Bottle gourd based agroforestry system during the rabi season of 2020-21.

Treatments	Crop yield (t ha ⁻¹)			Mango equivalent yield (t ha ⁻¹)
	Mango	Papaya	Intercrop	
Mango+Papaya+BARI Lau-3	2.08	18.72	22.32	25.89
Mango+Papaya+BARI Lau-4	2.08	18.72	31.19	29.22
Mango+Papaya+BARI Lau-5	2.08	18.72	25.85	27.22
Mango+Papaya+Hybrid Diana	2.08	18.72	23.01	26.15
Sole Mango	2.08	-	-	2.08

About 30% of mango tree produced fruit (1st harvest). Sale price: Mango- Tk. 40 kg⁻¹, Papaya- Tk. 33 kg⁻¹ and Lau- Tk. 15 kg⁻¹ only.

Table 3. Economic analysis of Mango+Papaya+Bottle gourd based agroforestry system

Treatment	Total cost of cultivation (Tk. ha ⁻¹)				Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
	Mango	Papaya	Bottle gourd	Total			
Mango+Papaya+BARI Lau-3	45000	175000	100000	320000	1035600	715600	3.24
Mango+Papaya+BARI Lau-4	45000	175000	100000	320000	1168800	848800	3.65
Mango+Papaya+BARI Lau-5	45000	175000	100000	320000	1088800	768800	3.40
Mango+Papaya+Hybrid Diana	45000	175000	100000	320000	1046000	726000	3.27
Sole Mango	45000	-	-	45000	83200	38200	1.85

Note: Sale price:- Mango- Tk. 40 kg⁻¹ only.

Conclusion

Bottle gourd variety BARI Lau-4 in Mango+Papaya based agroforestry system performed better regarding yield and economic return. However, the experiment should be repeated for at least one year to validate the findings.

PERFORMANCE OF DIFFERENT CREEPER VEGETABLES UNDER MANGO BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Mohammad Tanharul Islam, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was set up at the farmers' field of Tetulia para hill slopes of Rowangchari upazilla in Bandarban during the rabi season of 2020-21 to evaluate the performance of different creeper vegetables viz. sweet gourd, bottle gourd and marpha under mango+papaya based agroforestry and to increase the production and income of the farmers in this region. Highest intercrop vegetable yield (27.38 t ha⁻¹) was found from bottle gourd followed by sweet gourd (13.39 t ha⁻¹) and lowest yield (10.09 t ha⁻¹) from marpha under agroforestry system. Highest mango equivalent yield was found from bottle gourd (27.79 t ha⁻¹), sweet gourd (25.89 t ha⁻¹), marpha (21.31 t ha⁻¹) and lowest in sole mango (2.08 t ha⁻¹). Highest gross return, gross margin and BCR (Tk. 1111600 ha⁻¹, Tk. 786600 ha⁻¹ and 3.42 respectively) was obtained from mango+papaya+bottle gourd combination.

Introduction

Chittagong hill tracts has great potentiality for growing different types of fruit specially mango, litchi, banana, pineapple, papaya, citrus etc. This region is about one tenth of the total area of Bangladesh and has great potentiality for growing different fruits and vegetables. There are many established fruit orchard in hill slope of Bandarban. Agroforestry system can be more profitable than mono-crop fruit cultivation. But incorporation of all kind of vegetables at hill slope is not possible like plain land or valleys due to soil erosion. Therefore, introducing creeper vegetables can be a good option where tillage practice can be avoided and plantation is done by making pit to check soil erosion. Vegetables like sweet gourd, marpha and bottle gourd are being cultivated in traditional Jhum practice. The present study has been undertaken to evaluate the performances of these vegetables in mango+papay based agroforestry system to increase production and economic return.

Materials and Methods

The experiment was conducted at the 2.5 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the rabi season of 2020. Average spacing of mango trees was 6 m × 4 m, clean bole height was 1.5 m, canopy spread was 2 m × 2 m and tree height was 2.5 m. So, there was much gaps between the tree canopy in the garden and direct sunlight may reach to the under storey crops. Three creeper vegetables viz. sweet gourd, bottle gourd and marpha were used as under storey crop in this experiment. The experiment was laid out in Randomized Complete Block (RCB) Design with three replications. The unit plot size was 6m×4m. The spacing was 4m×2m for each sweet gourd

varieties. In Mango+Papaya based agroforestry system, one papaya plant was planted in between two mango trees in a mango row to utilize the land more efficiently. Hence the distance between two papaya trees became 6m and average spacing of papaya trees was 6m×4 m. In this agroforestry plantation system, one bed of vegetable was cultivated maintaining 2m pit-pit distance. Pit size was 45cm×45cm×40cm and prepared by digging. Papaya seedlings were planted on 17 March to 18 March, 2020 and sweet gourd seeds were sown directly to the pits of different planting system on 11 November, 2020. Irrigation was provided when required. Insecticide and fungicide were sprayed to control the pest and diseases after leaf emergence. Data was recorded and analyzed by using Statistic 10 computer program.

Results and Discussion

Average yield of mango, papaya, sweet gourd, marpha and bottle gourd under agroforestry system at farmer's field is presented in Table 1. About 30% of mango tree produced fruit for the first time in this orchard and the average yield of mango was 2.08 t ha⁻¹. Average papaya yield for all intercrop combination was 18.72 t ha⁻¹. Highest intercrop vegetable yield (27.38 t ha⁻¹) was found from bottle gourd followed by sweet gourd (13.39 t ha⁻¹) and lowest yield (10.09 t ha⁻¹) from marpha under agroforestry system. Highest mango equivalent yield was found from bottle gourd (27.79 t ha⁻¹), sweet gourd (25.89 t ha⁻¹) and marpha (21.31 t ha⁻¹) and lowest in sole mango (2.08 t ha⁻¹) (Table 1). Gross return, net return and BCR also followed the same trend like vegetables yield and mango equivalent yield (Table 2). Highest gross return, net return and BCR (Tk. 1111600 ha⁻¹, Tk. 786600 ha⁻¹ and 3.42 respectively) was obtained from mango+papaya+lau combination due to high yield of BARI Lau-4 followed by mango+papaya+sweet gourd (Tk. 1035600 ha⁻¹, Tk. 705600 ha⁻¹ and 3.14 respectively), mango+papaya+marpha (Tk. 852400 ha⁻¹, Tk. 537400 ha⁻¹ and 2.71 respectively) and lowest in sole mango (Tk. 83200 ha⁻¹, Tk. 38200 ha⁻¹ and 1.85 respectively) (Table 2).

Farmer's Reaction

Farmers preferred both bottle gourd and sweet gourd for their higher yield and economic return in mango+papaya based agroforestry system. They also found this agroforestry system beneficial for increasing their farm yield and to fulfill their vegetable requirements.

Table 1. Average yield of crops and mango equivalent yield under Mango+ Papaya based agroforestry system during the rabi season of 2020-21.

Treatments	Crop yield (t ha ⁻¹)			Mango equivalent yield (t ha ⁻¹)
	Intercrop vegetables	Mango	Papaya	
Mango+Papaya+Sweet gourd	13.39	2.08	18.72	25.89
Mango+Papaya+Bottle gourd	27.38	2.08	18.72	27.79
Mango+Papaya+Marpha	10.09	2.08	18.72	21.31
Sole Mango	-	2.08	-	2.08
LSD (0.05)	1.29	-	-	-
CV (%)	12.03	-	-	-

Table 2. Economic analysis of creeper vegetables under Mango+Papaya based agroforestry system during the rabi season of 2020-21.

Treatment	Total cost of cultivation (Tk. ha ⁻¹)				Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
	Mango	Papaya	Intercrop	Total			
Mango+Papaya+Sweet gourd	45000	175000	110000	330000	1035600	705600	3.14
Mango+Papaya+Lau	45000	175000	105000	325000	1111600	786600	3.42
Mango+Papaya+Marpha	45000	175000	95000	315000	852400	537400	2.71
Sole Mango	45000	-	-	45000	83200	38200	1.85

Note: Mango, Papaya, Sweet gourd, Bottle gourd and Marpha prices were 40, 33, 25, 15 and 15 Tk./kg only respectively.

Conclusion

The result reveal that both sweet gourd and bottle gourd can be cultivated as intercrop in Mango + Papaya based agroforestry system in hill slopes of Bandarban for better yield and economic return. However, further experimentation is needed to validate the findings.

H. Seaweed

MONTHLY VARIATION ON THE YIELD OF *GRACILARIA* SEAWEED IN RELATION WITH DIFFERENT ESSENTIAL WATER PARAMETERS AT NUNIARCHARA, COX'S BAZAR

M. Sarfuddin Bhuiyan, M Akkas Ali, M Shahiduzzaman

Abstract

Seaweeds are crops of winter season. The best time to cultivate seaweed is from October to March of the year, i.e. six months a year. During these six months six cuts can be made which means that we can harvest seaweeds after one month of each seeding. But each harvest did not produce the same yield because of variation in water quality and wave pressure from month to month during the cultivation season. To find out this yield variation along with the variation in water quality, this experiment has been carried out. At Nuniarchara sand-flat, Cox's Bazar during October 2020 to March 2021. The highest yield was obtained in the month of December (fresh yield- 10.60 ton ha⁻¹ and dry yield 1.87 ton ha⁻¹). On the other hand, the lowest yield was obtained in October (fresh yield- 3.68 ton ha⁻¹ and dry yield 0.68 ton ha⁻¹).

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. The important characteristics of seaweeds are its ability to absorb nutrients from water through their body surface, and can grow on any artificial hard substratum once attached. Bangladesh has a coastline of 710 km that constitutes about 25,000 km² coastal areas extending over 76 Upazilas (Sub-districts) with a large inhabitant. Those people depend for their livelihood on fishing, fishery exploitation and other associated activities (Ahmed, 1997). From Bangladesh, over 250 species of seaweeds or marine macro-algae (used extensively in many countries as food and industries having pharmaceutical values) grow abundantly in restricted areas like the rocky coast of the St. Martin's Island (SMI) and Inani beach, Cox's Bazar and a few on mangrove trees along the coast and Sundarbans are being reported (Islam 1976, Islam and Aziz 1982, 1987, Aziz *et al.* 2001, 2008a, 2008b, 2015, Islam *et al.* 2002, 2004, 2010). However, people of Bangladesh are not aware of the seaweed potential. Seaweed has plenty of essential nutrients, especially trace elements and bioactive substances. Seaweed protein contains very high quality and all the essential and non-essential amino acids. Seaweed has an abundance of vitamins, including beta-carotene, which is the precursor of vitamin A, the vitamins of the B group, including B12, vitamin C, D, E and K. Seaweed, if systematically cultured and explored, could emerge as a vital agricultural product for coastal people, be consumed as dishes and used in the pharmaceutical and cosmetic industries. Like other countries especially China, Japan, Korea and Indonesia; Bangladesh can boost its economic dimension through exploration of seaweed resources.

Materials and Methods

Naturally grown healthy *Gracilaria* seeds were collected from the sand flat of Nuniarchara. After cleaning and sorting, seeds were seeded on synthetic ropes having a length of 15 m and a diameter of 1.0 to 1.5 cm. and maintaining a distance of 50 cm between consecutive ropes. Ropes were placed in open sea three days after full moon and harvested three days prior to the next full moon. The approximate weight of each seed was 1.5 to 2.0g on an average. To protect the ropes from being washed away by sea waves, they were tightly bound with deeply placed bamboo poles at the two distal ends of

each rope. Plastic floats were used @ 2 floats per rope to keep the ropes moving upwards during high tides so that seeds could get sufficient sunlight for photosynthesis during day time. But during low tide ropes were laid on the sand flat. Thus, the technique is called “semi-floating method of cultivation”. As sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. Moreover, no pesticides, insecticides etc. was used. Timely removal of *Enteromorpha prolifera*, a green seaweed, which is regarded as the weed of *Gracilaria tenuistipitata* was carried out once a week. Crop was allowed to grow for 24-26 days in open sea and after that harvesting was done. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface. Each plant was cut separately but the total samples of each rope were weighed collectively by using a digital weight measuring machine. Data of environmental factors of Nuniarchara sand-flat (Salinity, Turbidity, Rainfall, Temperature and pH) were also recorded.

Results and Discussion

Yield gradually increased from October 2020 to December 2021. Highest yield obtained in December when turbidity was the lowest in the whole growing period, moderate salinity (25.55 ppt) prevailed and temperature was relatively high (29.11 °C). Lowest yield (3.68 ton ha⁻¹) was obtained in October when temperature was maximum (30.63 °C), turbidity was highest (49 NTU) and salinity was low (21.35 ppt). Salinity gradually increased from October to March. Rainfall occurred heavily in October and November and as a result, turbidity values for these months ranked the highest positions. Seawater remained less turbid during January-February-March. During the whole season of six months, the pH reading remained almost similar.

Table 1. Monthly Variation on the yield of *Gracilaria tenuistipitata* in relation with different essential water parameters during October 2020 to March 2021 at Nuniarchara, Cox's Bazar.

Month	Fresh wt. (ton ha ⁻¹)	Dry wt. (t ha ⁻¹)	Temp. (°C)	Salinity (‰)	Turbidity (NTU)	pH
October'20	3.68±0.63	0.65±0.11	30.63±0.95	21.35±1.31	49.92±10.53	8.01±0.13
November'20	8.74±0.69	1.54±0.12	29.15±1.51	21.27±1.91	42.50±11.93	7.34±0.26
December'20	10.60±0.59	1.87±0.10	29.11±1.20	25.55±1.23	20.25± 9.71	7.73±0.34
January'21	7.07±0.60	1.25±0.11	22.58±1.82	27.77±1.65	22.76±3.25	7.14±0.57
February'21	8.28±0.56	1.46±0.09	25.33±2.87	30.00±1.61	26.89±4.38	7.46±0.23
March'21	5.20±0.50	0.92±0.08	29.22±1.69	31.65±1.31	30.07±3.25	7.41±0.20

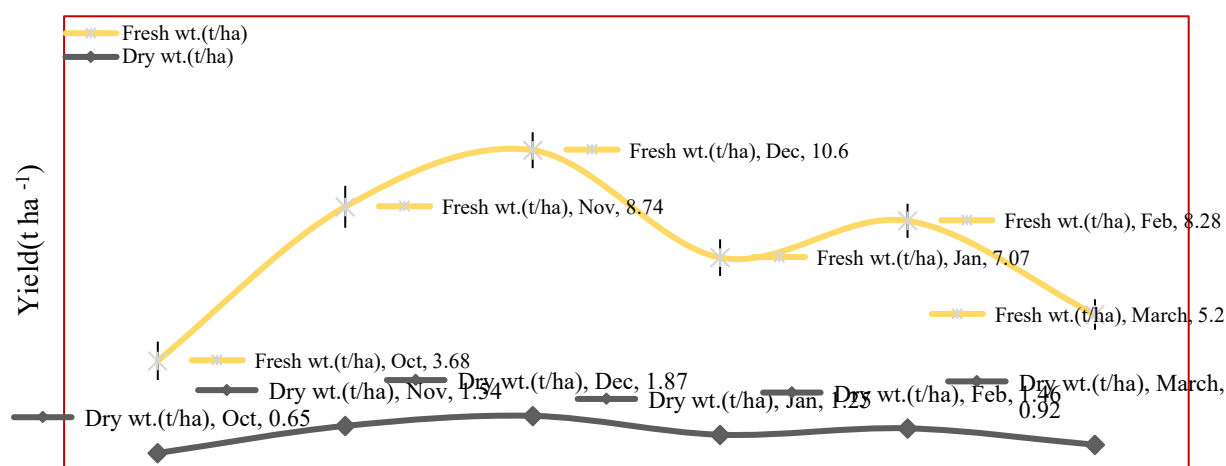


Fig 1. Variation in yield of *Gracilaria tenuistipitata* during October 2020 to March 2021 at Nuniarchara coast, Cox's Bazar

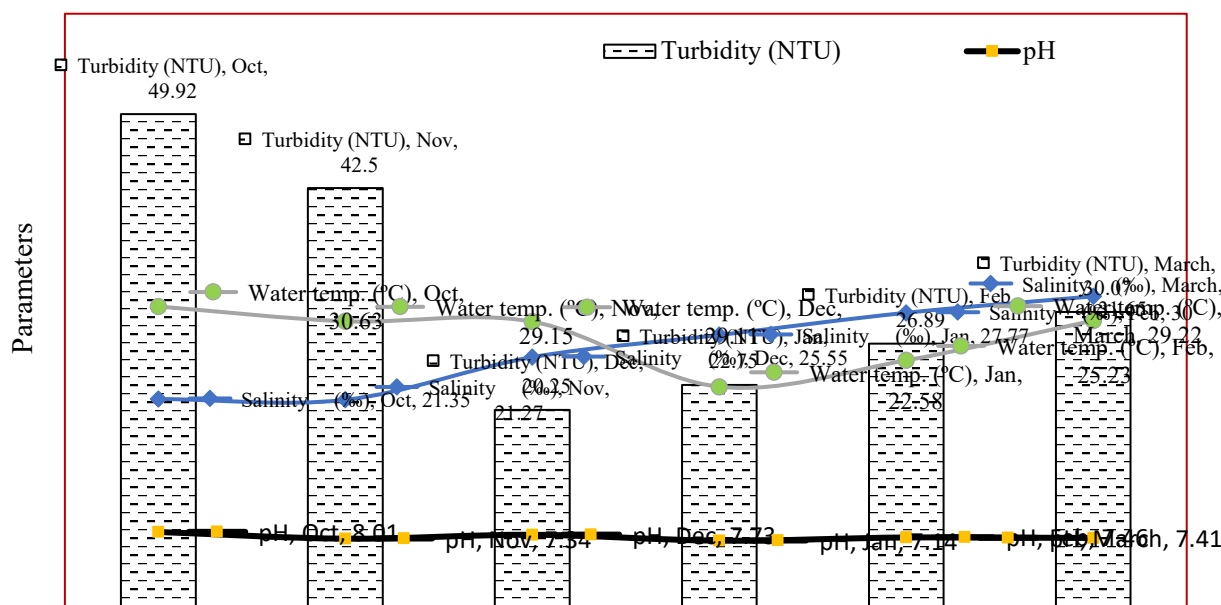


Fig 2. Variations of water temperature, salinity and pH, and rainfall from October 2020 to March 2021 at Nuniarchara sand flat site, Cox's Bazar for cultivating *Gracilaria tenuistipitata*

Conclusion

Open sea cultivation of seaweed is very much challenging because this technique is entirely prone to different environmental conditions. Monthly changes in different water parameters such as; salinity, water temperature, turbidity, pH and rainfall can affect the yield positively or negatively. November, December and January is the most suitable period to get handsome yields of seaweeds in comparison with other months of the season.

PERFORMANCE OF *ULVA LACTUCA* IN OPEN SEA USING LABORATORY RARING SEEDLINGS AT NUNIARCHARA, COX'S BAZAR

M. Sarfuddin Bhuiyan, M Akkas Ali, M Shahiduzzaman

Abstract

This experiment has been conducted to find out the yield of Ulva lactuca in open sea at Nuniarchara under Cox's Bazar district during rabi season (2020-2021). Seedlings were raised in the laboratory from multi-step seeds of Ulva lactuca. Seeds were prepared by cutting seedlings into pieces and attached into ropes. Ropes were placed in open sea three days after full moon and harvested three days prior to next full moon. The highest yield (4.92 ton ha⁻¹ fresh, equivalent to 0.79 ton ha⁻¹ dry) was obtained in March. Average fresh yield was 4.05 ton per hectare per month.

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. They can take nutrients using their whole body parts called thallus. Seaweeds are rich in minerals, vitamins, antioxidants, trace elements, bioactive compounds and thus they are of great importance in food, beverage, cosmetics and pharmaceutical industries. In many countries of the world, e.g. China, Japan, Korea, Indonesia, seaweeds are being used as food for nutrition and at the same time as export materials to earn foreign currencies. Seaweeds are categorized in three broad sections on the basis of color- red, green and brown. Red and brown seaweeds are mostly used for industrial and pharmaceutical purposes. On the other hand, green seaweeds are suitable for direct consumption. According to seaweed experts green seaweeds could be suitable to culture in Bangladesh. The green seaweeds, such as *Ulva*

lactuca, *Ulva linza* and *Caulerpa racemosa*, rich in protein, amino acids, vitamins and minerals have multiple uses of fodder, fertilizer, and human food, industrial and pharmaceutical raw materials. They contain compounds that help reduce high blood pressure, cholesterol, and prevent strokes. Seaweeds have effective remedial power against rheumatism, diarrhea and checking growth of tumors. It contains enough calcium, protein, phosphorus and good cholesterol that helps erase diseases in human body. More than one million people are exposed to goiter and related diseases in Bangladesh. Most seaweeds contain more iodine than sea water and are a much better alternative than iodized salt or drugs in regulating the production of thyroid hormone. Besides iodine, seaweed is a perfect source of calcium, phosphorus, iron, sodium, potassium, magnesium, sulphur, copper, zinc, cobalt etc. People of Bangladesh are still not aware of the seaweed potential and its uses. This study was conducted to find out the adaptability and yield potential of an important green seaweed, *Ulva lactuca* which could enable to develop seaweed farming.

Materials and Method

Ulva lactuca is a cold loving seaweed which cannot be grown in open sea during summer and monsoon. Through gametogenesis and sporogenesis, *Ulva lactuca* seeds were produced in laboratory during summer. This technique is called multi-step seed production. Spores were attached to synthetic ropes and cultured in controlled environment of the laboratory. Seeds turned into juvenile seedlings within two months. When seedlings became a height of 2 to 3 cm, these were separated from ropes and cultured in aquariums and tanks till winter. When the seedlings achieved a height of about 10 to 15 cm, they were transplanted to the open sea. One-step seeds were made by cutting the plants into small pieces and attached into ropes (15 m long). Seeded ropes were placed in a ditch made in the sand-flat of Nuniarchara coast. A distance of 50 cm between ropes and 20 cm between seeds was maintained. Ropes were placed in open sea three days after full moon and harvested three days prior to the next full moon. Samples of each rope were weighed separately and after drying recorded the dry weight. No additional fertilizer was applied. No pesticides and insecticides were also used.

Results and Discussion

The highest yield was obtained in the month of March, which was 4.92 ton ha⁻¹ fresh *Ulva lactuca*. After drying we got 0.79 ton ha⁻¹ dry yield. In January fresh yield was 3.25 ton per hectare (0.52 t ha⁻¹ dry) which was the lowest among three months. Yield gradually increased from January to March. In February, obtained 3.97 ton fresh *Ulva* from one hectare of land which was almost similar to the average yield (4.05t ha⁻¹ fresh) of the whole period.

Table 1: Yield of *Ulva lactuca* at Nuniarchara sand-flat during Jan-Feb-March, 2021

Month	Date of seeding	Date of harvesting	Fresh wt. (t ha ⁻¹)	Dry wt. (t ha ⁻¹)
January	03.01.21	26.01.21	3.25±0.35	0.52±0.06
February	02.02.21	25.02.21	3.97±0.68	0.64±0.11
March	03.03.21	26.03.21	4.92±0.48	0.79±0.08
Average	-	-	4.05±0.50	0.65±0.08

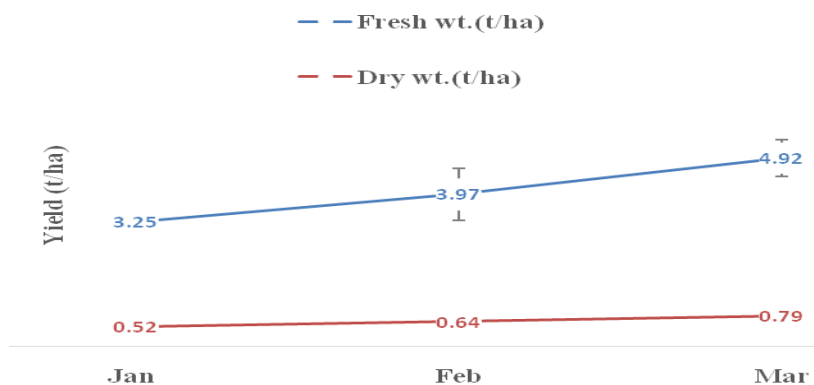


Fig 1. Yield variation of *Ulva lactuca* during January to March 2021

Conclusion

Almost all seaweeds are winter loving crops. Green seaweed *Ulva lactuca* prefers relatively cooler environment to adapt in open sea. January to March is the best season to cultivate sea lettuce in sea.

ADAPTIVE TRIAL OF SEAWEED SPECIES COLLECTED FROM SAINT MARTIN'S ISLAND IN OPEN SEA

M. Sarfuddin Bhuiyan, M Akkas Ali, M Shahiduzzaman, M Akkas Ali, M Shahiduzzaman

Abstract

The experiment was conducted during late winter season (March-April, 2021) at Nuniarchara sea beach and Rejukhal to find out the suitable seaweed species. After few days of transplanting all species were died due to high temperature, turbidity and rainfall. Two species, Chrysomenia and Caulerpa maxicana survived relatively more days than other species. Survival rate was relatively higher in Rejukhal area than Nuniarchara.

Introduction

Seaweeds are rich in minerals, vitamins, antioxidants, trace elements, bioactive compounds and have been used as food for centuries in China, Korea and Japan. Seaweeds reduce high blood pressure, cholesterol, and prevent strokes. Phycocolloids (agar, carrageenan and alginate) extracted from cell walls have high industrial and pharmaceutical value. The coastal people will have the opportunity to produce compost and biogas using the seaweeds. In the last two decades seaweed cultivation has doubled and about 94% of all products are derived from the cultured seaweeds. The Philippines started seaweed farming since 1980 and now produce nearly 80% of the world's total *Kappaphycus alvarezii* production for carrageenan (Khan & Satam, 2003). About one million Philippines depend on seaweed farming and only 1000 m² farm serves as a main source of income of an average family (Cuyugan, 2000). India started seaweed farming in 1980s, established 25 chemical industries fulfilling the demand of Agar and Alginate (Reddy et al., 2006). According to the FAO (2014) statistics, seaweed farming has a value of over US\$ 7.5 billion. The importance and economic value of seaweeds are not realized by many of the people in the coastal areas. Only collection of seaweeds from nature can extinct many species. It is already reported that abundance of some species has declined. In this circumstances open sea culture of seaweeds may be helpful to increase its availability. An adaptive trial with 7 species was conducted in the open sea to find out their adaptability for cultivation which will enabling to develop seaweed farming method (s)/process (s).

Materials and Methods

Twenty species of seaweeds were collected from Saint Martin's Island with the assistance of scuba team. Collected seaweeds were taken into tanks and transported to Cox's Bazar. Adaptive trials have been conducted with only seven species which are of high commercial and nutritional importance. Healthy seaweeds were prepared by cutting seaweeds into pieces and cut pieces ("seeds") were inserted quickly at 20 cm gap into the 15 m long, 1.0 to 1.5 cm diameter synthetic ropes/strings. Small ponds were previously made in the sand flat of Nuniarchara beach to keep water during low tide. Seed ropes were transferred immediately to the open sea. In Rejukhal, no ponds were made because there always remained water. No additional fertilizer was applied. No pesticides and insecticides were also used.

Results and Discussion

Seaweeds grown under deep sea were collected by scuba divers from SMI and transferred to Cox's Bazar. To find out their adaptability and productivity in open sea the experiment was set in Nuniarchara and Rejukhal. The environment and water quality of these two areas are very much dissimilar with the environment of SMI. Due to high temperature and turbidity, seaweeds did not survive long. Among seven species, *Chrysomenia* sustained relatively more days than others. It was alive 5 days in Nuniarchara and 10 days in Rejukhal. Green seaweed *Caulerpa maxicana* survived 4 days and 9 days in Nuniarchara and Rejukhal respectively. *Sargassum*, *Hypnea* and *Caulerpa fergusonii* got rotten after 5 days of seeding. On an average, survival rate of seaweeds was relatively higher in Rejukhal than in Nuniarchara.

Table 1. Performance of different seaweed species in open sea

Name of species	Nuniarchara			Rejukhal		
	Date of inoculation	Dead on	Days survived	Date of inoculation	Dead on	Days survived
<i>Chrysomenia sp.</i>	25.03.21	30.03.21	5	26.03.21	05.03.21	10
<i>Sargassum sp.</i>	25.03.21	27.03.21	2	26.03.21	01.04.21	5
<i>Halymenia venusta</i>	25.03.21	27.03.21	2	26.03.21	29.03.21	3
<i>Hypnea boergesenii</i>	25.03.21	27.03.21	2	26.03.21	01.04.21	5
<i>Spatoglossum asperum</i>	25.03.21	27.03.21	2	26.03.21	29.03.21	3
<i>Caulerpa fergusonii</i>	25.03.21	28.03.21	3	26.03.21	01.04.21	5
<i>Caulerpa maxicana</i>	25.03.21	29.03.21	4	26.03.21	04.04.21	9

Conclusion

Seaweeds are marine macro algae. In our country, more than 200 species are identified. Saint Martin's Island is the live museum of seaweeds. Seaweeds grow mostly in deep region of sea during winter season. There are two worldwide recognized systems to cultivate seaweeds-open sea cultivation and land based cultivation method. In open sea system, water environment effects much in farming seaweeds. Whereas, land based system is much more effective but costly. Farming seaweeds in green house and hatcheries can be introduced to cultivate environment sensitive seaweeds which cannot be grown in open sea.

EXTRACTION AND CHARACTERIZATION OF AGAR FROM *GRACILARIA TENUISTIPITATA*

M. Sarfuddin Bhuiyan, M Akkas Ali, M Shahiduzzaman

Abstract

Seaweeds are sources of different important hydrocolloids such as agar, carrageenan, alginate etc. Agar has the highest usage among these hydrocolloids. Agar is mainly a solidifier which is used as raw materials in food and pharmaceutical industries. *Gracilaria tenuistipitata*, a red seaweed, is the most abundant seaweeds in our country has the potential to produce agar. This study was conducted to develop protocols to produce agar from locally available seaweed- *Gracilaria tenuistipitata* and characterize the agar produced. Eight (08) grams agar from 50 grams dry *Gracilaria* (i.e. 16%) were produced.

Introduction

Seaweeds are marine macro algae. They are marine resources and are renowned worldwide for their uses in food, beverage and chemical industries. Seaweeds are rich in vitamins, minerals, trace elements, antioxidants etc. Important hydrocolloids can be extracted from cell walls of seaweeds, e.g. agar, carrageenan, alginate etc. which are of great uses in pharmaceutical industries. Among these hydrocolloids, agar has the highest usage due to its gelling properties. Agar is a plant source gelatin which is extracted from seaweeds and is mainly used to solidify the liquid. Bangladesh imports large amount of agar every year. *Gracilaria tenuistipitata* (Red seaweed) is used worldwide as a main source of extracting agar. This seaweed has the abundance among all the available seaweed species in Bangladesh. Besides, we have a coastline of 710 km that constitutes about 25,000 km² coastal areas extending over 76 Upazilas (Sub-districts) with a large population. India started seaweed farming in 1980s, established 25 chemical industries fulfilling the demand of Agar and Alginate (Reddy et al., 2006). According to the FAO (2014) statistics, seaweed farming has a value of over US\$ 7.5 billion. Our coastal community can easily cultivate seaweeds to produce agar which can be new source of income for Bangladesh in world markets and can fulfill our domestic demand of agar as well.

Materials and Methods

Dried *Gracilaria* was cleaned several times with tape water to remove unwanted particles like sand, mud, foreign particles etc. Cleaned seaweeds were treated with sodium hydroxide solution. After treating with hydroxide, it was washed thoroughly. Then again seaweeds were cleaned. During this process pH was maintained. Treated seaweeds were then boiled in high temperature and pressure. After boiling the extract were separated with thin filter paper. To make the extract more concentrated, it was again boiled. Then it was kept in room temperature until it became solidified. After solidification, alternate freezing and thawing was done. Finally, it was dried under sun and milled to get agar powder.

Results and Discussion

Agar was extracted from a locally available seaweed species (*Gracilaria tenuistipitata*) in Seaweed Research Laboratory of OFRD, Cox's Bazar. To develop a new protocol to produce agar in which 8 gm agar was produced from 50 gm dried *Gracilaria tenuistipitata*. In percentage, it is about 16%.

$$\text{Weight(\%)} = \frac{\text{Produced agar (dry)}}{\text{Dried seaweeds used}} \times 100 = \frac{8 \text{ gm}}{50 \text{ gm}} \times 100 = 16\%$$

Conclusion

Agar is the most demandable phycocolloid in the world today. It is used as an important raw material in food, medicine, cosmetics and pharmaceutical industries. The whole agar demand of our country is fulfilled by importing from foreign countries. Agar can be produced from locally available seaweed- *Gracilaria tenuistipitata*. To meet up our domestic agar demand and can also earn foreign currencies by farming seaweeds and producing agar.

Appendix Table 1. Measurement of some agro-economic parameters

Parameters	Equation	Reference
Rice equivalent yield (REY)	$REY (t\ ha^{-1}) = Yr + Yc \times \frac{Pc}{Pr}$ Where, Yr= Yield of rice (t ha⁻¹) Yc= Yield of component crop (t ha⁻¹) Pc= Price of component crop Pr= Price of Rice	Ahlawat and Sharma, 1993
Marginal benefit-cost ratio (MBCR):	$MBCR = \frac{Gross\ Return\ (GR_1) - Gross\ Return\ (GR_0)}{Variable\ cost\ (VC_1) - Variable\ cost\ (VC_0)}$ Where, GR₁= Gross return of main crop (Tk. ha⁻¹) GR₀= Gross return of component crop (Tk. ha⁻¹) VC₁= Variable cost of main crop (Tk. ha⁻¹) VC₀= Variable cost of component crop (Tk. ha⁻¹)	CIMMYT (1988).
Land use efficiency (LUE)/Land utilization index(LUI):	$LUE(\%) = \frac{d_1 + d_2 + d_3 + d_4}{365} \times 100$ Where, d_1, d_2, d_3, and d_4 = duration of 1st, 2nd, 3rd, and 4th crop of the pattern, respectively	
Production efficiency (PE)	$PE = \frac{Y_1 + Y_2 + Y_3 + Y_4}{d_1 + d_2 + d_3 + d_4} \times 100$ Where, y_1, y_2, y_3, and y_4= Yield of 1st, 2nd, 3rd, and 4th crop of the pattern, respectively. d_1, d_2, d_3, and d_4 = duration of 1st, 2nd, 3rd, and 4th crop of the pattern, respectively.	
Groundnut equivalent yield (GEY)	Yield of each crop (t ha ⁻¹) x Economic value of respective crop (Tk t ⁻¹) / Price of groundnut (Tk t ⁻¹)	Ahlawat and Sharma, 1993
Land equivalent ratio (LER)	$LER = \sum_{i=1}^m \frac{IY_i}{SY_i}$ Where m is the number of different crops intercropped, IY_i is the yield for the i^{th} crop under intercropping, and SY_i is the yield for the i^{th} crop under a sole-crop regime on the same area.	

Table 2. Monthly air temperature, total rainfall and relative humidity in the experimental area of Mymensingh

Months	Temperature (°C)			Rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Mean		
January	22.75	13.99	18.37	00	83
February	26.44	16.03	21.24	00	77
March	31.11	19.98	25.55	33.00	76
April	30.45	21.44	25.95	268.10	79
May	30.08	23.51	26.80	437.70	83
June	31.28	25.95	28.62	301.39	85
July	32.41	26.82	29.62	305.9	85
August	32.54	26.95	29.75	214.70	84
September	31.78	26.00	28.89	143.90	84
October	30.92	22.56	26.74	95.10	85
November	29.28	17.41	23.35	36.20	82
December	25.96	13.52	19.74	17.70	80
Yearly average	29.58	21.18	25.39	154.47	82

Cereal Crops

ADAPTIVE TRIALS OF BARI DEVELOPED BARLEY VARIETIES IN DIFFERENT REGIONS OF BANGLADESH

Abstract

Adaptive trials were conducted at three different locations such as Debidwer, Titas Upazilas of Cumilla and Sadar Upazila in Chandpur, Kuakata in Patuakhali, Ramnagar village under Shibaloya upazila of Manikganj during Rabi season 2020-2021 to evaluate the better performance of BARI developed Barley varieties and to popularize among the farmers under on-farm situation in different AEZ's. A total of four varieties of barley viz. BARI Barley-6, BARI Barley-7, BARI Barley-8 and BARI Barley-9 were tested in the trial. Among them, the average highest yield of BARI Barley-9 were recorded from two locations (Cumilla and Manikganj) (3.13 t ha^{-1}). The highest yield of BARI Barley-8 was received from Patuakhali (2.45 t ha^{-1}). The lowest yield (1.97 t ha^{-1}) from BARI Barley-9 in Patuakhali, BARI Barley-6 (2.30 t ha^{-1}) in Manikganj and BARI Barley-8 (3.1 t ha^{-1}) in Cumilla, respectively.

Introduction

Barley (*Hordeum vulgare*) is the most adaptive cereal crop in different environment which is recognized as salt tolerant (Amin *et. al.* 2012) than other cereals and also tolerant to drought. It can be grown in less fertile soil with minimum inputs whereas it is still a minor crop in Bangladesh mainly grown in northern districts. Vast saline area in the central and southern coastal region of Bangladesh, remain fallow after harvesting of T. Aman where crop intensifying is the major challenge. Cultivation of salt-tolerant crop cultivars of wheat, barley and pulses with careful management practices can bring substantial change in the agricultural practice towards increased cropping intensity of the country (Rahman, *et. al.* 1995). With the aim of increased cropping intensity, barley can be profitably grown in the coastal districts and char land where soil salinity and water-stressed prohibits growing most crops during the dry season. BARI has recently developed some high yielding barley varieties which has potentiality to grow harsh environment with satisfactory yield. Therefore, the field trial was undertaken to evaluate the performances of these varieties in Cumilla region for dissemination and popularizing among the farmers.

Materials and Methods

An Adaptive trial were conducted at three different locations such as Debidwer, Titas Upazilas of Cumilla and Sadar Upazila in Chandpur, Kuakata in Patuakhali, Ramnagar village under Shibaloya Upazila of Manikganj during the Rabi season of 2020-2021 to evaluate the better performance of BARI developed Barley varieties and to popularize among the farmers under on-farm situation in different AEZ's. A total of four varieties of barley viz. BARI Barley-6, BARI Barley-7, BARI Barley-8 and BARI Barley-9 were tested in the trial. Treatment combinations were randomly assigned in each replication. The land was ploughing and cross ploughing were done with power tiller followed by laddering. The crop was slightly infested with leaf spot disease and it was controlled spraying three times with Tilt- 250 EC @ 1 ml L^{-1} water. The experimental plots were infested by rats and toxic bait was used to control the rats. No other significant diseases and pest infestation was observed in the plots. Salinity data was recorded at 15 days' interval during the crop growing period with harvested date. The salinity of experiment field was 1.54-10.75 dS/m (Fig.1).

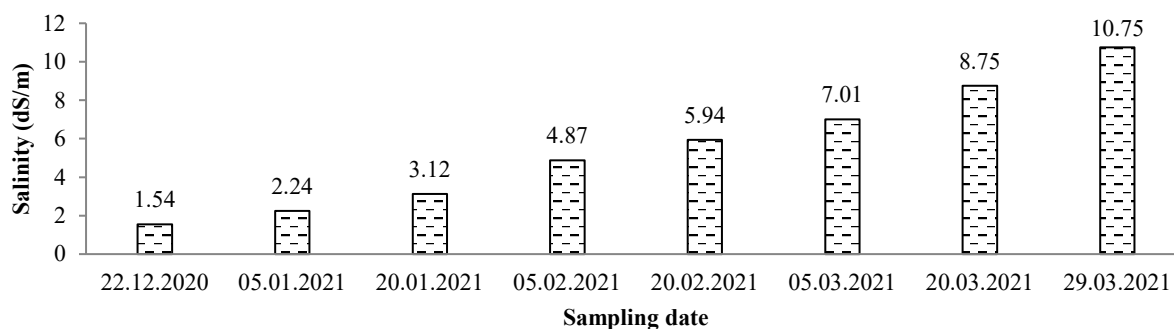


Fig-1: Salinity level of experimental plot

Data on maturity, plant height, yield and yield contributing characters were collected and analyzed statistically following the analysis of variance (ANOVA) technique using 'R 3.4.4' software and MSTAT-C. Means were separated by using LSD at 5% level and DMRT. Crop management practices including design; plot size used in different locations is stated in Table 1.

Table 1. Crop management practices used in different locations during the Rabi season, 2020-21

Location coverage	Variety	Exp design/ Rep.	Spacing	Unit plot size	Sowing time	Fertilizer dose N-P-K-S-Zn-B kg ha ⁻¹)	No. of irrigation (DAS)	No. of weeding (DAS)	Harvesting time
Cumilla & Chandpur	BARI Barley-7, BARI Barley-8 and BARI Barley-9	RCB Rep: 3 dispersed	25 cm × continuous sowing @100 kg ha ⁻¹	20m x 20m	23 Nov. to 3 Dec. 20	100-60-40	1	2	9-16 March, 21
Shibaloya Upazila of Manikganj	. BARI Barley-6, BARI Barley-7 and BARI Barley-9		25 cm × continuous sowing @120 kg ha ⁻¹	20m x 20m	23 December, 2020	100-32-55-22-5.5-1.5	1	2 (first thinning and 35 DAS)	21-23 March, 2021
Kuakata, Patuakhali	BARI Barley-6, BARI Barley-8 and BARI Barley-9	-	20 cm × continuous sowing @120 kg ha ⁻¹	4m x 3m	20 December 2020	36.87-10-30-4.55—1.7	-	-	29 March, 2021

Results and Discussion

In case of variety, the average highest yield of BARI Barley-9 were recorded 3.13 t ha⁻¹ from two locations Viz. Cumilla and Manikganj. The highest yield of BARI Barley-8 was received from Patuakhali (2.45 t ha⁻¹). The lowest yield (1.97 t ha⁻¹) from BARI Barley-9 in Patuakhali, BARI Barley-6 (2.30 t ha⁻¹) in Manikganj and BARI Barley-8 (3.1 t ha⁻¹) in Cumilla, respectively. In case of location, maximum grain yield was recorded from Cumilla (3.47t ha⁻¹) and minimum (2.18 t ha⁻¹) in Patuakhali due to salinity.

Cumilla: The results of this trial are presented in Table 3. From the research trial, it was reveals that the tallest plant was found in BARI Barley-7 variety (95.4 cm) which was statistically similar with BARI Barley-8 (92.2 cm) whereas the shortest plant was found in BARI Barley-9 (90.4 cm). Maximum number of spikes m⁻² (175) was obtained from BARI Barely-9 which was at per with BARI Barely-7. The lowest number of spikes per m⁻² (145.2) was recorded in BARI Barley-8. The highest number of grains per spike (50.6) was recorded from BARI Barley-9 which was significantly differed from the BARI Barley-7 but at par with BARI Barley-8. Maximum 1000-grain weight (33.2g) was recorded from the variety BARI Barley-9 and minimum 1000-grain weight (31.2 g) was obtained from the BARI Barley-8. The highest grain yield was observed in BARI Barley-9 (3.9 t ha⁻¹) while the lowest yields was found from BARI Barley-8 variety (3.1 t ha⁻¹). The BARI Barley-9 gave 25.8% higher yield over the BARI Barley-8 in the trial.

Manikganj: Yield and yield characters of BARI Barley varieties are shown in Table 4. The plant height of barley varieties ranged from 88.20 to 97.40 cm. The plants of BARI Barley-9 were tallest (97.40 cm) than plants of BARI Barley-6 (90.60 cm) and Barley-7 (88.20 cm). The number of spike m⁻² differed significantly among the varieties and the higher in BARI Barley-6 (55.00) than BARI Barley-9 (45.00) and BARI Barley-7 (40.00). Seed size is a stable varietal character and governs by the genotype. The highest 1000 seed weight was in BARI Barley-9 (38.00g) followed by BARI Barley-7 (36.00g) which was statistically similar with BARI Barley-6 (35.00g). Grain yield did not differ statistically among the barley varieties. The higher grain yield (2.35 t ha⁻¹) was obtained from of BARI Barley-9 might be due to larger seed size followed by BARI Barley-6 (2.31 t ha⁻¹) which was identical with BARI Barley-6 (2.30 t ha⁻¹).

Patuakhali: Yield and yield contributing characters are presented in Table 5. Statistically no significant difference was found in yield contributing parameters. Among the varieties, BARI Barley-8 gave the

highest grain yield (2.45 t ha⁻¹) followed by BARI Barley-6 (2.13 t ha⁻¹). This might be happened due to higher number of effective spikes per plant, seeds per spike than that of other varieties. Number of spikes per plant, number of grains per spike, spike length and 1000 grain weight were the highest in BARI Barley 8 and consequently gave the highest yield. BARI Barley-9 produced the lowest grain yield (1.97 t ha⁻¹). From cost and return analysis BARI Barley produce the highest gross margin (24450 Tk ha⁻¹) and BCR (1.66). Salinity of the trail plots increased with time and it ranges from 1.54 to 10.35 in the whole growing period.

Farmer's opinion

Cumilla: Farmers of Cumilla region are not habituated with barley cultivation. locally it is called *Payra*. As a new crop they showed their keen interest to BARI Barley-9 due to the higher yield potentialities and less disease and pest infestation.

Manikganj: Farmers opined that Barley is a new crop in the area and locally it is called *Payra*. They knew that grain meal in the local market is costly (Tk.120.00 kg⁻¹) and it is consumed by the diabetic patients. Farmer commented that grain yield reduced due to the infestation of rats. However, the selected farmer was interested to grow this crop in the next year.

Patuakhali: Among the varieties farmers opined to cultivate BARI Barley-8 next year as it is high yielder. They also opined that usually their land remains fallow during Rabi due to salinity and irrigation water scarcity. So, barley may be an alternative Rabi crop for this unfavorable situation.

Table 2. Yield performance of different barley varieties at a glance in different locations during the Rabi season, 2020-21

Location	Grain yield (t ha ⁻¹)				
	BARI Barley-6	BARI Barley-7	BARI Barley-8	BARI Barley-9	Mean
Cumilla	-	3.4	3.1	3.9	3.47
Manikganj	2.30	2.31	2.13	2.35	2.27
Patuakhali	2.13	-	2.45	1.97	2.18
Average	2.21	2.86	2.56	2.74	

Table 3. Yield and yield contributing characters of BARI Barley varieties at farmer's field of Debidwer, Titas of Cumilla and Sadar, Chandpur during the Rabi season, 2020-21

Variety	Plant height (cm)	Spike m ⁻² (no.)	Spike length (cm)	Grain spike ⁻¹ (no.)	1000 seed wt. (gm)	Grain yield (t ha ⁻¹)
BARI Barley-7	95.4	149.0	9.3	46.1	32.4	3.4
BARI Barley-8	92.2	145.2	9.7	49.6	31.2	3.1
BARI Barley-9	90.4	175.0	9.8	50.6	33.2	3.9
LSD (0.05)	4.11	33.87	0.113	9.14	1.02	0.13
CV (%)	2.10	9.00	6.31	7.70	7.89	3.90

Table 4. Performance of BARI Barley varieties in the farmers' field at Shibaloia, Manikganj during Rabi season of 2020-21

Variety	Plant height (cm)	No. of panicle m ⁻²	1000-seed wt. (g)	Grain yield (t ha ⁻¹)
BARI Barley-6	90.60	55.00	35.00	2.30
BARI Barley-7	88.20	40.00	36.00	2.31
BARI Barley-9	97.40	45.00	38.00	2.35
LSD (0.05)	3.023	6.905	4.719	0.0716
CV (%)	2.45	6.69	5.89	2.04

Table 5. Yield and yield contributing characters of Barley during the Rabi season of 2020-21 at MLT site, Kuakata, Patuakhali

Treatment	Plant height (cm)	Effective tiller plant ⁻¹	Spike length (cm)	No. of seeds spike ⁻¹	No of spikelet's spike ⁻¹	1000-grain wt. (g)	Grain yield (t ha ⁻¹)
BARI Barley-6	77.65	2.92	8.15	42.81	15.35	31.65	2.13
BARI Barley-8	63.52	3.41	8.35	44.34	16.29	33.27	2.45
BARI Barley-9	84.85	3.39	7.84	39.75	15.25	31.64	1.97
LSD (0.005)	6.34	0.94	1.76	3.27	4.93	2.65	1.78
CV (%)	3.22	7.35	4.29	10.32	7.41	1.98	11.62

Table 6. Cost benefit analysis of BARI Barley varieties at farmer's field of Debidwer, Titas of Cumilla and Sadar, Chandpur during the Rabi season of 2020-21

Variety	Hull character	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Barley-7	Hull Less	148000.00	36625.00	111375.00
BARI Barley-8	Hull Less	136000.00	36625.00	99375.00
BARI Barley-9	Hull Less	164000.00	36625.00	127375.00

Price (Tk. kg⁻¹): Barley grain= hull less- 40.00

Table 7. Cost and return of BARI Barley varieties at Shibaloya Manikganj during the Rabi season of 2020-21

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Barley-6	69000.00	48155.00	20845.00
BARI Barley-7	69300.00	48155.00	21145.00
BARI Barley-9	70500.00	48155.00	22345.00

Farm gate price of seed @ Tk. 30.00 kg⁻¹

Table 8: Economic analysis of Barley production at Kuakata, Patuakhali during 2020-21

Variety	Yield (t ha ⁻¹)	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)	BCR
BARI Barley-6	2.13	53250	36800	16450	1.45
BARI Barley-8	2.45	61250	36800	24450	1.66
BARI Barley-9	1.97	49250	36800	12450	1.34

Barley Price (Tk. kg⁻¹) = 25

Conclusion

Barley is a promising cereal crop for environmentally harsh growing area due to its salt and drought tolerant properties. Among the tested varieties, BARI Barley-9 produced the higher yield under Cumilla and Manikganj. The trial should be repeated in the next year for confirmation of the result. Farmer kept seeds of all the varieties of barley to grow in the next winter season

Yield performances of the varieties are statistically similar and the profit of barley cultivation is marginal in coastal region. it may be concluded that barley may be an alternative Rabi cereal crop for coastal region though its yield performance is low.

ADAPTIVE TRIAL WITH BARLEY ADVANCE LINES IN BARIND TRACT

Abstract

The trial was conducted at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during the Rabi season of 2020-21 with a view to select high yielding barley advance lines for drought areas. The trial consists of three advance lines viz. BHL-25, BHL-26 and BHL-28 and three barley varieties namely BARI Barley-6, BARI Barley-7 and BARI Barley-8. The genotypes were evaluated for yield, and yield components like days to flowering, days to maturity, plant height, No. of spike m^{-2} , thousand grain weight (TGW) and grain yield with the close supervision of OFRD, Barind Station, Rajshahi. Out of six barley varieties/lines BARI Barley-6 gave the highest grain yield ($2.17 t ha^{-1}$) followed by BHL-26 ($2.04 t ha^{-1}$). The lowest grain yield was produced by BARI Barley-8 ($1.44 t ha^{-1}$). Considering the yield and yield contributing characters BARI Barley-6 is the suitable one for Barley production in High Barind Tract.

Introduction

Barley is the most adaptive cereal crop in different environment. It is also grown under rainfed condition due to deep root zone. It is used for making various delicious foods like baby food, Horlicks, Ovaltine etc. It contains about 12-14% proteins. In respect of nutrient quality barley is better than wheat. In Bangladesh, the total area under barley cultivation is about 814 acre of land and the production is about 287 metric ton (Year Book of Agricultural Statistics, 2017). It has potentiality to grow under water stress condition. Several studies revealed that it can be successfully grown after harvest of T. Aman rice under Barind water-stressed environment. Thus, barley can be considered as beneficial crop in the drought prone areas like High Barind Tract (AEZ-26). Therefore, the field trial was undertaken to select early and high yielding variety to release as a new barley variety for drought areas.

Materials and Methods

The field trial was conducted at FSRD site, Basantapur, Rajshahi to select suitable variety/lines for drought areas during the Rabi season of 2020-21. The trial consists of three barley varieties namely BARI Barley-6, BARI Barley-7 & BARI Barley-8 and three advance lines viz. BHL-25, BHL-26 and BHL-28. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three dispersed replications. The unit plot size was 10m x 10m. Fertilizers were applied at the rate of 100-60-40-1 kg N-P-K-B kg ha^{-1} in the form of urea, triple super phosphate, muriate of potash and boric acid, respectively. All the fertilizers were incorporated with soil during final land preparation. The crop was sown on 03 December 2020. The line-to-line distance was 25 cm with continuous sowing and seed rate was 120 kg ha^{-1} . One hand weeding was done in all plots at 30 DAS. Malataf 57 EC@ 2 ml/L water was applied to control aphids before flowering stage. The crop was harvested on 16 March 2021. Data were collected on different yield and yield components and analyzed statistically with open-source software R (R Core Team, 2017).

Results and Discussion

The performance of yield and yield parameters of barley were presented in Table 1. The results revealed that BARI Barley-6 gave the highest grain yield ($2.17 t ha^{-1}$) followed by BHL-26 ($2.04 t ha^{-1}$) due to the higher number of grains spike $^{-1}$ and thousand seed weight. The variety, BARI Barley-8 contributed the lowest grain yield ($1.44 t ha^{-1}$) followed by BARI Barley-7 ($1.92 t ha^{-1}$) due to their lower no. of spike m^{-2} . Maximum straw yield was obtained from BARI Barley-6 ($3.48 t ha^{-1}$) that was followed by BHL-26 ($3.25 t ha^{-1}$). The straw yield was significant to each other. All the genotypes/varieties required 54-58 days for flowering and 91-97 days for maturity under rainfed condition in the High Barind Tract.

Farmers preferred BARI Barley-6 for its better yield.

Table 1. Yield and yield contributing character of different barley varieties/lines in HBT during the Rabi season, 2020-21

Variety/ lines name	Days to flowering	Days to maturity	Plant height (cm)	No. of spike m ⁻²	Spike length (cm)	No. of grains spike ⁻¹	TGW (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
BARI Barley-6	57.67	96.67	102.27	285.40	8.31	68.89	34.96	2.17	3.48a
BARI Barley-7	55.67	91.33	98.33	269.87	7.13	46.87	34.15	1.92	3.24
BARI Barley-8	55.00	91.67	79.53	273.53	6.68	48.17	33.75	1.44	2.83
BHL-25	57.67	93.00	108.00	284.17	7.75	57.83	34.08	1.94	3.19
BHL-26	54.33	96.33	92.33	289.07	8.53	65.42	35.39	2.04	3.25
BHL-28	55.33	93.00	100.87	216.73	8.36	66.20	34.62	1.94	3.22
CV (%)	1.78	0.85	8.61	20.90	6.19	11.39	8.08	6.32	6.08
LS	**	**	*	NS	**	**	NS	**	*

Conclusion

Among the tested varieties/lines, BARI Barley-6 produced the highest yield under drought condition. So, it can be extended for drought prone areas.

ADAPTIVE TRIALS WITH FOXTAIL MILLET VARIETY IN CHAR AREAS IN DIFFERENT SEASON

Abstract

An adaptive trial was conducted at five different locations in different AEZ such as Barura, Chandina and Debidwer of Cumilla and Saharasti of Chandpur, FSRD site Basantapur, Godagari, Rajshahi, Saghata, Gaibandha, Bonogram, Chilmari, Kurigram and Bhuapur, Tangail during the Rabi season of 2020-21 to evaluate the better performance of different millet varieties and to popularize among the farmers under on-farm situation. A total of four BARI developed varieties; BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, BARI Kaon-4 and local were used in different locations. Among them, two varieties were used in all locations except Gaibandha. They used three variety. Four different varieties were used in different locations. Among them, the average highest yield over the location was recorded from BARI Kaon -3 (2.95 t ha⁻¹), the second highest in BARI Kaon-4 (2.48 t ha⁻¹) and the lowest from local (1.49 t ha⁻¹). In case of locations where the tested Cumilla gave maximum grain yield (2.78 t ha⁻¹) and Tangail gave minimum grain yield (1.35 t ha⁻¹).

Introduction

Millets are small-seeded cereals that are often termed nutritious-cereals or dryland cereals found to be domesticated around 8000 years ago in the highlands of central China (Amgai *et al.*, 2011). They comprise of different types like finger millet, foxtail millet, Foxtail millet, pearl millet including sorghum which are well considered as the crops of antiquity mainly known for their drought resistance, insects, pests and disease resistance (Devi *et al.*, 2011). Foxtail millet (*Setaria italica* (L.) Beauv.) is thought to be indigenous to southern Asia and is considered one of the oldest cultivated millets (Oelke, 1990). Foxtail millet provides the richness of different amino acids and nutritional minerals taken as food. It contains 12.3g protein, 8.0g fiber, 3.3g mineral, 2.8mg iron, and 31 mg calcium per 100 gm (Sarita & Singh, 2016). They are rich source of phytochemicals and micronutrients; phenolics, tannins that reduce the risk for colon and breast cancer. It provides different health benefits as it improves glycemic control, inhibits hyperinsulinemia and decreases lipid concentrations in patient with type-2 diabetes (Jali *et al.*, 2012). Foxtail millet comes under drought tolerant crop usually grown in the marginal lands having low level of nutrients and organic matter.

Foxtail millet also considered as minor cereals of Bangladesh but becoming a major cereal specially in char areas of Gaibandha. It can be cultivated easily with low input in the char areas of Bangladesh. The crop is tolerant to drought. It can play partial role in fulfilling the food crisis of our country. The farmers of char areas usually use their own local varieties. They are not familiar with high yielding BARI foxtail

millet varieties. BARI released some high yielding varieties. As foxtail millet can grow well in char lands. So, the released varieties could be fitted in char area and farmers would be benefited to introduce this crop in their cropping pattern.

Materials and Methods

The adaptive trial was conducted at five different locations in different AEZ such as Barura, Chandina and Debidwer of Cumilla and Saharasti of Chandpur, FSRD site Basantapur, Godagari, Rajshahi, Saghata, Gaibandha, Bonogram, Chilmari, Kurigram and Bhuapur, Tangail during the Rabi season of 2020-21 to evaluate the performance of different millet varieties and to popularize among the farmers under on-farm situation. A total of four BARI developed varieties and local were tested. Four varieties; BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, BARI Kaon-4 and local were used in different locations. Treatment combinations were randomly assigned in each replication. The land was opened with a power tiller. Later on, ploughing and cross ploughing were done with country plough followed by laddering. Crop management practices including design; plot size used in different locations is stated in Table 1.

Data on maturity, plant height, yield and yield contributing characters were collected and analyzed statistically following the analysis of variance (ANOVA) technique using 'R 3.4.4' software and MSTAT-C. Means were separated by using LSD at 5% level and DMRT.

Table 1. Crop management practices, design, plot size was used in different locations during the year of 2020-21

Location coverage	Variety	Exp design/ Rep.	Spacing	Unit plot size	Sowing time	Fertilizer dose N-P-K-S-Zn kg ha ⁻¹)	No. of irrigation (DAS)	No. of weeding (DAS)	Harvesting time
Barura, Debiwder Cumilla	BARI Kaon-2 and BARI Kaon-3	RCB Rep: 3 dispersed	25 cm × continuous sowing	10.0 m × 8.0 m.	28Nov. 20 to 04 Feb. 21	60-20-45-9-1.5	1	2	4April- 4 March, 21
FSRD site Basantapur, Godagari, Rajshahi	BARI Kaon-2, BARI Kaon-4	-	Broadcast	-	8 Dec. 20	FRG-2012	As and when necessary		23April, 21
Saghata, Gaibandha	BARI Kaon-2, BARI Kaon-4& Local	RCBD Rep: 4 Dispersed		30.0 m × 20.0 m.	5 January 21	40, 30 and 20 (N, P &K)	-		5-10 May, 21
Bonogram, Chilmari, Kurigram	BARI Kaon-1 and local	RCB Rep: 3 dispersed		10m × 10m	16 Dec.20 & 2March,21	45-30-20-6-0.7	1	1	30, March 13 April, 21 & 05-15 June, 21
Bhuapur, Tangail	BARI Kaon-1 and local			8 m x 5 m	24 Dec.20	45-30-20 (N, P &K)	1	-	4 April, 21

Results and Discussion

The average grain yields of different location are presented in Table 2. The average highest yield over the location was recorded from BARI Kaon -3 (2.95 t ha⁻¹), the second height in BARI Kaon-4 (2.48 t ha⁻¹) and the lowest from local (1.49 t ha⁻¹). In case of locations where the tested, Cumilla gave maximum grain yield (2.78 t ha⁻¹) and Tangail gave minimum grain yield (1.35 t ha⁻¹).

Cumilla: The results of this experiment are presented in Table 3. Significant variations were observed in plant height, seeds panicle⁻¹, plant population m⁻² and yield of Foxtail millet varieties (Table 3). On the basis of research trial at farmer's field, it was recorded that, statistically the higher plant height (143.27cm) and seeds panicle⁻¹ (4550.7) were observed in BARI Kaon-2. Numerically the higher panicle plant-1 (3.33) and panicle length (19.39cm) were found from BARI Kaon-3. Ultimately, significantly the higher yield (2.95 t ha⁻¹) was observed from BARI Kaon-3. From the economic analysis, it was documented that the gross return and gross margin was also the higher in Bari Kaon-3 than BARI Kaon-2.

Basantapur, Godagari, Rajshahi: The yield and yield attributes of kaon were presented in Table 4. The higher days to flowering (81 days) and days to maturity (126.3 days) were found in BARI Kaon-4 and the lowest was found in BARI Kaon-2 (77.3 and 124 days, respectively). Maximum plant height (115.87 cm) was found in BARI Kaon-4 and minimum (108.47 cm) was found in BARI Kaon-2. The tallest plants m^{-2} (282.67), length of tail (15.73 cm), no of seeds tail⁻¹ (1840.30), 1000 grain weight (1.89 g) and grain yield (1.95 t ha⁻¹) were found in variety BARI Kaon-4 and minimum yield was observed in in variety BARI Kaon-2. All the results showed statistically significant except plant per m² and 1000-grain yield. It was found that BARI Kaon-4 gave the higher yield in the farmer's field.

Saghata, Gaibandha: The days to maturity in BARI Kaon-2 ranged from 120-124 days with an average of 121 days, plant height ranged from 120-125 cm with an average of 122 cm (Table 5). In BARI Kaon-4, days to maturity ranged from 107-110 d with an average of 109 days and plant height ranged from 102-107 cm with an average of 104 cm. The in-field duration of BARI Kaon-4 is on an average 12 days earlier than BARI Kaon-2 whereas the longest in-field duration recorded in the local kaon variety (140 day). The plant height in BARI Kaon-2 is higher (122 cm) compared to BARI Kaon-4 (104 cm) and the local variety (100 cm). However, the average highest grain yield (3.01 t ha⁻¹) was recorded in BARI Kaon-4 followed by BARI Kaon-2 (2.86 t ha⁻¹) and the lowest yield recorded in local variety (1.49 t ha⁻¹). No lodging, disease and insect incidence occurred in the BARI Kaon-2 and BARI Kaon-4 but some (20%) lodging recorded in the local millet variety.

Chilmari, Kurigram: The yield and yield attributes of Foxtail millet produced in Rabi season are presented in Table 6 and in Kharif season are presented in Table 7. In general, the yield and yield attributes of Foxtail millet were found relatively poor in Kharif season compared to Rabi season.

Rabi season: The total crop duration was 104 days in BARI Kaon-1 and 117 days in local variety during Rabi season. The plant height was measured 87.55 and 82.66 cm in BARI Kaon-1 and local variety, respectively. Plant population and number of tillers per plant was more or less same in both varieties but the higher grains per spike (159.75) and 1000-grain weight (4.84g) contributed more for the higher grain yield (2.30 t ha⁻¹) in BARI Kaon-1. The lower grain yield (1.73 t ha⁻¹) was obtained from local variety.

Kharif season: The total crop duration was 93 days in BARI Kaon-1 and 103 days in local during Kharif season. Plant height was the higher (76.21cm) in BARI Kaon-1 compared to local variety (73.35cm). Plant population and number of tillers per plant were more or less same in both varieties but the higher grains per spike (148.21) and 1000-grain weight (4.46g) contributed more for the higher grain yield (2.05 t ha⁻¹) in BARI Kaon-1. The lower grain yield (1.53 t ha⁻¹) was obtained from local variety.

Bhuapur, Tangail: Table 8 revealed that yield and yield attributes were influenced significantly by the varieties. Minimum days to maturity were observed in BARI Chenna-1 (94 days) compare to farmers' variety (97 days). The higher plant height was observed in BARI Chenna-1 (79 cm) whereas 59 cm in case of local variety. Significantly higher grain yield was observed in BARI Chenna-1 (1.43 t ha⁻¹) and farmers variety provides 1.26 t ha⁻¹.

Farmer's opinion

Cumilla: Farmers of Cumilla region are not habituated with Foxtail millet cultivation. locally it is called Kaon. As a new crop they showed their keen interest to BARI Kaon-3 due to the higher yield potentialities and less disease and pest infestation.

Basantapur, Godagari, Rajshahi: Farmers were happy to get the higher yield from BARI kaon-4 and they were interested to cultivate kaon in Rabi season because the yield was high.

Saghata, Gaibandha: Farmers preferred BARI developed Foxtail millet varieties due to higher yield. Farmer's demanded timely supply of more quality seed to spread in char areas.

Chilmari, Kurigram: Though the yield performance of Foxtail millet is relatively poor in Kharif season, but farmers are more interested to produce Foxtail millet in Kharif season. This is mainly due to their cropping pattern. They are used to produce zero tillage grass pea with very low cost or produce high value black cumin during Rabi season and then they produce Foxtail millet in Kharif season and

after that they produce Aman rice as a chance crop. Farmers showed very much interest to produce BARI Kaon-1 variety and for this purpose they kept seed of BARI Kaon-1 for the next year.

Bhuapur, Tangail

Farmers of Bhuapur char land had shown their keen interest in cultivating the variety BARI Kaon-1 due to its higher yield potentiality. They urged to available seed supply during the growing season.

Table 2. Yield performance of different barley varieties at a glance in different locations during the Rabi season, 2020-21

Location	Grain yield (t ha ⁻¹)					
	BARI Kaon-1	BARI Kaon-2	BARI Kaon-3	BARI Kaon-4	Local	Mean
Cumilla	-	2.61	2.95	-	-	2.78
Rajshahi	-	1.73	-	1.95	-	1.84
Gaibandha	-	2.86	-	3.01	1.49	2.45
Kurigram	2.30	-	-	-	1.73	2.02
Tangail	1.43				1.26	1.35
Average	1.87	2.40	2.95	2.48	1.49	

Table 3. Yield and yield attributes of Foxtail millet varieties at different locations of Cumilla and Chandpur during the Rabi season of 2020-21

Variety	Plant height (cm)	Panicle plant ⁻¹ (no.)	Panicle length (cm)	Seed's panicle ⁻¹ (no.)	1000 seed weight (g)	Yield (t ha ⁻¹)
BARI Kaon-2	143.27	2.97	18.83	4550.7	2.49	2.61
BARI Kaon-3	57.27	3.33	19.39	3934.7	2.42	2.95
CV (%)	7.76	12.36	8.77	4.03	1.88	2.44
LSD (0.05)	27.368	NS	NS	600.59	NS	0.2387

Table 4. Yield and yield attributes of Kaon under FSRD site, Godagari, Rajshahi during the Rabi season of 2020-2021

Treatment	No. of Plants m ⁻²	Days to flowering	Days to maturity	Plant height (cm)	Length of tail (cm)	No. of seeds tail ⁻¹	1000 grain wt. (g)	Grain yield (t ha ⁻¹)
BARI Kaon-2	279.33	77.33	124.00	108.47	13.63	1532.00	1.83	1.73
BARI Kaon-4	282.67	81.00	126.33	115.87	15.73	1840.30	1.89	1.95
T test	0.4306	0.0257	0.0124	0.0495	0.0144	0.0388	0.1971	0.0064
LS	NS	*	*	*	*	*	NS	**

LS= Level of Significance, NS= non-significant, *= Significant at 5% level, **= Significant at 1% level

Table 5. Yield and other parameters of BARI developed millet varieties in farmer's field of char areas, Gaibandha during the Rabi season of 2020-21

Variety	Days to maturity	Plant height (cm)	Grain yield (t ha ⁻¹)	Lodging (%)	Disease (%)	Insect
BARI Kaon-2	121	122	2.86	x	x	x
BARI Kaon-4	109	104	3.01	x	x	x
Local	140	100	1.49	20	x	x

Table 6. Yield and yield attributes of Foxtail millet variety at Char Bonogram, Chilmari, Kurigram during the Rabi season, 2020-21

Treatment	Days to maturity	Plant height (cm)	Plant population (no. m ⁻²)	No. of effective tiller plant ⁻¹	No. of grains spike ⁻¹	1000-grain wt. (g)	Grain yield (t ha ⁻¹)
BARI Kaon-1	104.00	87.55	257.66	4.90	159.75	4.84	2.30
Local	117.00	82.66	251.21	4.70	141.33	4.12	1.73

Table 7. Yield and yield attributes of Foxtail millet variety at Char Bonogram, Chilmari, Kurigram during the Kharif season, 2021

Treatment	Days to maturity	Plant height (cm)	Plant population (no. m ⁻²)	No. of effective tillers plant ⁻¹	No. of grains spike ⁻¹	1000-grain wt. (g)	Grain yield (t ha ⁻¹)
BARI Kaon-1	93.00	76.21	258.33	4.72	148.21	4.46	2.05
Local	103.00	73.35	259.67	4.51	135.33	4.03	1.53

Table 8: Yield performance of Foxtail millet varieties at MLT site, Bhuapur, Tangail during the Rabi season of 2020-21

Variety	Days to maturity (no.)	Plant height (cm)	Grain yield (t ha ⁻¹)
BARI Kaon-1	94.00	79	1.43
Farmers variety	97.00	59	1.26
LSD _{0.05}	1.50	7.74	.13
CV (%)	3.56	5.00	6.70

Table 9. Cost and Return analysis of Foxtail millet varieties at different locations of Cumilla and Chandpur during Rabi season of 2020-21

Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Kaon-2	208800	80000	128800
BARI Kaon-3	236000	80000	156000

The price of foxtail millet is Tk. 80 kg⁻¹

Conclusion

BARI Kaon-3 in Cumilla and BARI Kaon-4 in Rajshahi gave the higher yield and economic return than BARI Kaon-2, respectively. It was 1st year trial. So, it may be continued for next year for more accurate result. The performance of BARI Kaon-1 was better than local Foxtail millet variety tested at Char Bonogram, Chilmari, Kurigram and Bhuapur, Tangail during both Rabi and Kharif season. So, BARI Kaon-1 may be recommended for Foxtail millet production in that Char land area.

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EFFECT OF FOXTAIL MILLET VARIETY AS INFLUENCED BY DIFFERENT WEEDING METHOD

Abstract

The experiment of Foxtail millet was conducted at Melandah, Jamalpur during the Rabi season of 2020-21. Three treatments viz., T₁ = Control (No weeding), T₂ = Hand weeding and T₃ = Chemical control (Affinity) were tested at the farmer's field of Melandah, Jamalpur during 2020-21. Results obtained from the study indicated that the highest grain yield (2.70 t ha⁻¹) was produced in T₂ treatment and the lowest grain yield (2.33 t ha⁻¹) was produced in T₁ treatment. The highest gross return (Tk. 45,900 ha⁻¹) and gross margin (Tk. 9,741 ha⁻¹) were found from T₂ treatment and T₁ treatment, respectively. The lowest gross return (Tk. 39,610 ha⁻¹) and gross margin (Tk. 7,231 ha⁻¹) were observed from T₁ treatment and T₂ treatment, respectively.

Introduction

Foxtail millet (kaon) is considered as minor cereals of Bangladesh. The crop is tolerant to drought. It can play partial role in fulfilling the food crisis of our country. Weeds are the major competitor of the crop and reduce the yield considerably. Because of wider row spacing and slow initial growth in millets, weeds are more problematic during initial crop growth period, and hence, early weed control is needed

to optimize the yield. Millet is a short duration and drought tolerant crop. Farmers are often taking negligibility for its production thus the area and production is declining day by day in Bangladesh. Although its production and area are declining now but its demand is high. Weed control may be one of the ways to increase yield and area coverage successfully. So, the experiment was undertaken to identify the appropriate weed control method.

Materials and Method

The experiment was conducted at Melandah, Jamalpur during the Rabi season, 2020-21. The land was medium high and the soil was sandy loam in texture. Three treatments viz., T₁=Control (No weeding), T₂= Hand weeding and T₃ = Chemical control (Affinity) were tested in the study. Foxtail millet (BARI Kaon-2) variety was used as a planting material in this experiment. The land was fertilized with 78-25-45-10-1.4-0 kg ha⁻¹ of N-P-K-S-Zn-B, respectively. Half of N and all fertilizers were applied at final land preparation. Rest half of N was top dressed at 35 DAS. Plant protection measures and other intercultural operations were done as and when necessary. Seeds were sown on 19 November, 2020 and the crop was harvested on 27 March, 2021. Data were collected plot wise and collected data were analyzed following MSTAT software package and mean separation was done as per LSD test.

Results and Discussion

Results obtained from the study have been presented in Tables 1 and 2. All the parameters were significant except plant height and panicle length. From table 1, it was found that maximum (83.30) plant population m⁻² was recorded in T₁ treatment and minimum (76.73) in T₃. The tallest plant (127.9 cm) was found from T₂ treatment, and the shortest plant (121.2 cm) was from T₃ treatment. The longest panicle (14.47 cm) was recorded from T₂ treatment and the shortest (12.93 cm) was from T₁ treatment. The highest grain yield (2.70 t ha⁻¹) was produced in T₂ treatment mainly due to the longest panicle and the lowest grain yield (2.33 t ha⁻¹) was produced in T₁ treatment. The highest gross return (Tk. 45,900 ha⁻¹) and gross margin (Tk. 9,741 ha⁻¹) were found from T₂ treatment and T₁ treatment, respectively. The lowest gross return (Tk. 39,610 ha⁻¹) and gross margin (Tk. 7,231 ha⁻¹) were observed from T₁ treatment and T₂ treatment.

Farmer's opinion

Farmers are highly satisfied with T₁ treatment due to higher income as well as low cost.

Table 1. Yield and yield contributing characters of Foxtail millet variety at Melandah, Jamalpur during the rabi season, 2020-21

Treatment	Plant population m ⁻²	Plant height (cm)	Panicle length (cm)	Grain yield m ⁻² (g)	Grain yield (t ha ⁻¹)
T ₁	83.30	121.9	12.93	235.7	2.33
T ₂	82.97	127.9	14.47	272.3	2.70
T ₃	76.73	121.2	13.60	251.3	2.50
LSD (0.05)	4.69	NS	NS	7.26	0.07
CV (%)	2.56	2.65	11.54	1.27	1.33

NS= Non-significant ;T₁=Control (No weeding), T₂= Hand weeding and T₃ = Chemical control (Affinity)

Table 2. Cost and return of Foxtail millet variety at Melandah, Jamalpur during the Rabi season, 2020-21

Treatment	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	39,610/-	29,869/-	9,741/-
T ₂	45,900/-	38,669/-	7,231/-
T ₃	42500/-	33,219/-	9,281/-

T₁ =Control (No weeding), T₂= Hand weeding and T₃ = Chemical control (Affinity), Price of kaon (grain): Tk 17.0 kg⁻¹.

Conclusion

Considering the yield potentiality and economic point of view, T₁ treatment is better due to the higher income as well as low cost than T₂ and T₃ treatment. So, the study needs to be repeated in the next year for confirmation the result.

Tuber Crops

ADAPTIVE TRIAL WITH NEWLY RELEASED POTATO VARIETIES IN DIFFERENT LOCATIONS

Abstract

A set of trials were conducted at farmers' fields of fifteen different locations (Chandpur, Faridpur, Manikganj, Gaibandha, Bhola, Patuakhali, Borguna, Rangpur, Rajshahi, Khulna, Sherpur, Tangail, Mymensingh, Narsingdi and Kishoreganj) under the supervision of the On-Farm Research Division during the rabi season of 2020-21 to evaluate the performance of the recently released high yielding potato varieties and to know farmers' assessment about the varieties. Ten potato varieties viz. BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62, and BARI Alu-63 was used across the locations except for Faridpur and Manikganj (used 9 varieties) of Bangladesh. In all trial sites, trials were laid following RCB design with four-five dispersed replications. The yield performance of most of the varieties appeared to be promising in the tested location. Among the tested potato varieties BARI Alu-40 produced the highest average tuber yield (34.65 t ha^{-1}). Followed by BARI Alu-62 (33.80 t ha^{-1}) and BARI Alu-41 (33.73 t ha^{-1}) whereas it was lowest in BARI Alu-37 (29.56 t ha^{-1}). Considering the location, the highest tuber yield (41.26 t ha^{-1}) was recorded in Narsingdi, followed by Sherpur (39.41 t ha^{-1}) and Kishoreganj (38.78 t ha^{-1}) whereas it was the lowest in the southern region of Bangladesh like Patuakhali (21.16 t ha^{-1}) and Borguna (22.23 t ha^{-1}). No variety was found tolerant to Late Blight and the foliage infestation was a wide range from 0-40% across the locations among the tested varieties. The average foliage infection by late blight was the highest in BARI Alu-63 (16.06%) and the lowest in BARI Alu-47 (7.69%). In the case of locations, the average highest late blight infestation was recorded in Gaibandha (23%) and the lowest in Rajshahi with a very minimum by only 0.6%. On the contrary, the virus infection was the highest in BARI Alu-49 (1.66%), like BARI Alu-37 (1.63%) and the lowest in BARI Alu-62 (0.57%). The average highest virus infection was recorded in Rangpur (1.77%) and the lowest in Rajshahi (0.37%). The average highest gross return (Tk. 591090 ha^{-1}) and gross margin (Tk. 420980 ha^{-1}) recorded in Sherpur and the lowest (Tk. 288960 ha^{-1}) and gross margin (Tk. 101147 ha^{-1}) in Tangail, and the variation founded mainly due to the variation of the local market price of potato across the locations.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops in Bangladesh and is being cultivated throughout the country. In potato production, Bangladesh ranks in 8th position in production in the world and 2nd in the country (FAOSTAT, 2018). Currently, 9.74 million tons (Mt) of potato were produced from around 0.47 million hectares (Million ha) of land and the average yield was 20.41 t ha^{-1} (FAOSTAT, 2018). Over the two decades, total potato production has been reached from 1.55 Mt to 9.47 Mt, in an area of 0.47 million ha from 0.136 million ha. The demand for potato production in the country is increasing to feed the ever-increasing population and by 2030 the country needs to increase yield from 20.43 t ha^{-1} to 41.50 t ha^{-1} of potatoes to attain food and nutrition security also (CIP, 2007). In Bangladesh, the crop is the third most important crop in Bangladesh next to rice and wheat. It is grown not only for food but also for animal feed, industrial uses, and seed tuber production. Potatoes are also a good source of minerals, at least 12 essential vitamins, and an extremely high content of vitamin C comparable to other food crops.

The national average yield of potato is very low (20.41 t ha^{-1}) compared to its potential yield, due to lack of quality seed, cultivation of indigenous potato, and the high price of quality seed. Tuber Crop Research Centre (TCRC), BARI has developed a good number of potato varieties that are supposed to be higher yielders and less susceptible to insect pests and diseases. These new varieties need to be evaluated for their performance under different agro-ecological zones. Therefore, an adaptive trial with BARI-developed potato varieties/lines was conducted to evaluate their yield performance and know farmer's opinions about the newly released improved potato varieties in different locations of Bangladesh.

Materials and Methods

Adaptive trials with recently released high yielding potato varieties were carried out in the farmers' field of Chandpur, Faridpur, Manikganj, Gaibandha, Bhola, Patuakhali, Borguna, Rangpur, Rajshahi, Khulna, Sherpur, Tangail, Mymensingh, Narsingdi and Kishoreganj during the *rabi* season of 2020-21 to evaluate the performance of the different potato varieties and to popularize the potato varieties among the potato growers. In the trial, 10 (ten) recently released potato varieties were used (Table-1) except Faridpur and Manikganj (9 varieties used). The unit plot size was varied in the trial locations. Seed tubers were planted at a spacing of 60 cm × 25 cm. The total amount of fertilizer dose @ N₉₀₋₁₃₅P₂₀₋₃₀K₉₀₋₁₃₅S₁₀₋₂₀Zn₂B₁ kg ha⁻¹ was uses as urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively across the locations. The total amount of all fertilizers and half of the total urea was applied as basal during final land preparation. The rest of the urea was applied at 30-35 DAP as a top dressing (FRG, 2018). The crop was irrigated two to three times at 24-29, 36-39, and 57-60 DAP. Weeding and earthing up were done once at 30-35 DAP. The crop was sprayed one time with Dursban (33-35 DAP) for cutworm control and sprayed 3 times with Indofil (18-19, 33-35, and 46-48 DAP) and secure (63-64 DAP) for controlling Late blight infection. Haulm pulling was done at 85-86 DAP in all locations. The tubers were harvested after 8-10 days after haulm pulling. Data on yield was taken and analyzed statistically in all locations.

Table 1. Crop management practices used for Potato in different locations during the Rabi season of 2020-21.

Location	Variety	Planting time	Harvesting time	Unit Plot size
Chandpur	BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62 and BARI Alu-63	28 Nov. -6 Dec.20	25 Feb. – 4 March, 21	12.5 m x 6.6 m
Faridpur	BARI Alu-36, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62 and BARI Alu-63	28 Nov-7 Dec.20	08-14 March, 21	10 m x 8 m
Manikganj	BARI Alu-36, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62 and BARI Alu-63	28 Nov-7 Dec.20	08-14 March, 21	10 m x 8 m
Gaibandha	BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62 and BARI Alu-63	22-28 Nov. 20	21-26 Feb. 21	5m x 4m
Bhola		1-17 dec, 20	1-20 March, 21	10 m x 8 m
Patuakhali		10-25 dec, 20	8-22 March, 21	6m x 5 m
Borguna		10-25 dec, 20	8-22 March, 21	6m x 5 m
Rangpur		29 Nov. -5 Dec. 20	28 Feb. to 7 March 21	10 m x 8 m
Rajshahi		20-25 Nov.20	22-Feb., 21	5 m x 8 m
Khulna		29 Nov-12 Dec.20	22 Feb.-5 March, 21	10 m x 8 m
Sherpur		19-24 Nov.20	22-23 Feb, 21	10 m x 8 m
Tangail		02 Dec.20	08 March, 21	10 m x 8 m
Mymensingh		25 Nov-3 Dec.20	22Feb-03 March, 21	11 m x 5 m
Narsingdi		25-30 Nov. 20	27-29 Feb, 21	10 m x 11 m
Kishoreganj		19 Nov-7 Dec.20	17 Feb, 21	10 m x 10 m

Results and Discussions

Yield of potato (t ha⁻¹): Tuber yield among the varieties across the locations were ranged from 18.23 to 49.06 t ha⁻¹ (Table 2) where, BARI Alu-40 was the highest yielder in Chandpur (36.68 t ha⁻¹), Manikganj (45.00 t ha⁻¹), Patuakhali (25.73 t ha⁻¹), Borguna (26.92 t ha⁻¹). Sherpur (43.75 t ha⁻¹) and Mymensingh (40.25 t ha⁻¹) whereas, BARI Alu-36 in Faridpur (37.57 t ha⁻¹); BARI Alu-41 in Gaibandha (35.70 t ha⁻¹) and Bhola (31.92 t ha⁻¹); BARI Alu-48 in Tangail (34.30 t ha⁻¹); BARI Alu-49 in Rangpur (40.51 t ha⁻¹); BARI Alu-62 in Rajshahi (39.70 t ha⁻¹) and Kishoreganj (41.53 t ha⁻¹) and BARI Alu-63 in Narsingdi (49.06 t ha⁻¹) and Khulna (29.76 t ha⁻¹). The reasons for the yield variation in different locations are mainly due to the difference of agro-climatic conditions. Similarly, The lowest tuber yield recorded in BARI Alu-36 in Chandpur (31.37 t ha⁻¹); BARI Alu-37 in Gaibandha (27.80 t ha⁻¹), Rangpur (29.75 t ha⁻¹), Tangail (25.80 t ha⁻¹), Kishoreganj (35.60 t ha⁻¹), and Narsingdi (28.30 t ha⁻¹); BARI Alu-47 in Khulna (24.92 t ha⁻¹); BARI Alu-49 in Manikganj (31.50 t ha⁻¹), Rajshahi (23.70 t ha⁻¹) and Mymensingh (33.01 t ha⁻¹); BARI Alu-56 in Faridpur (26.95 t ha⁻¹) and BARI Alu-63 in Patuakhali (18.23 t ha⁻¹) and Borguna (19.29 t ha⁻¹), respectively.

Pest and diseases incidence: There had some disease infestation (late blight, common scab, and virus) recorded in Gaibandha, Rangpur, Rajshahi, Khulna, Chandpur and Faridpur areas. The late blight infestation was ranged from 0-40% (Table 3) where the highest late blight infestation (40%) recorded in BARI Alu-63 in Gaibandha and the lowest (0%) recorded in BARI Alu-40 in Rajshahi. The average late blight infestation in all the potato varieties was much higher (23%) in Gaibandha whereas it was the lowest in Rajshahi (0.6%). Among the varieties, the highest late blight infestation (12.9%) was recorded in BARI Alu-36 and the lowest in BARI Alu-47 (7.7). In case of virus infestation, the range was low by only 0-2.7% in all the varieties across the locations (Table 3). In case of common scab, the highest value (6.78%) was recorded in BARI Alu-36 in Gaibandha as well as the average highest scab infestation (3.05%) in all the varieties while it was minimum in Rajshahi (0-1.40%) with an average of 0.37% (Table 4). Among the varieties, the average highest common scab infestation (1.98) was recorded in BARI Alu-37 and the lowest in BARI Alu-47 (0.51%). The average cutworm infestation was the highest in Faridpur (8.29%) while it was minimum in Rajshahi (0.31%). Among the varieties, the highest cutworm infestation was recorded in BARI Alu-56 (4.3%) and the lowest in BARI Alu-36 (1.1%).

Cost and return analysis

The highest gross return (Tk. 591090 ha⁻¹) and gross margin (Tk. 420980 ha⁻¹) were observed in Sherpur and the lowest (Tk. 288960 ha⁻¹) and gross margin (Tk. 101147 ha⁻¹) observed in Tangail (Table 5). Among the varieties the highest gross return (Tk. 447088 ha⁻¹) and gross margin (Tk. 274959 ha⁻¹) recorded in BARI Alu-40 the lowest (Tk. 381891 ha⁻¹) and gross margin (Tk. 210092 ha⁻¹) recorded in BARI Alu-36.

Farmers' opinion

Framer's choices regarding variety selection have differed on tuber shape and size, skin color of the tuber, vigorous plant growth and high yielding potentialities of the potato variety and higher gross return/market price. Farmer's choices were varied from location to location. They also consider disease and pest reactions on the variety during the crop growth period. In Chandpur, farmers preferred new varieties because of less disease infection and less pest infestation with higher tuber yield. But in the Cumilla region, potato growers gave more emphasis on white skin potato varieties than red skin. Farmers in the Faridpur, Gaibandha and Rangpur district preferred red skin potato varieties like BARI Alu-36, BARI Alu-41, BARI Alu-56 and BARI Alu-63. But the farmers in Bhola gave more preference on yield regarding variety selection, and they choose BARI Alu-41 and BARI Alu-48. In the southern parts of the country (In Patuakhali and Borguna) potato growers choose variety on after cooking quality like a smashed potato. The market price was similar for both red and white skin potatoes, but red-colored potatoes are preferable as it looked attractive. Again, BARI Alu-41. BARI Alu-62 was preferred by the potato growers in Rajshahi, Mymensingh and Kishoreganj and BARI Alu-63 in Faridpur, Gaibandha and Rangpur, Khulna, Narsingdi, Tangail and Kishoreganj.

Conclusion

Based on the yield performance of the potato varieties, it may be concluded that BARI Alu-40 suited best in all tested locations followed by BARI Alu-41, BARI Alu-48, BARI Alu-62 and BARI Alu-63. Farmer's choices were varied from location to location depends on yield, color, taste, and market price. To disseminate and popularization of the selected varieties for the desired location community-based pilot production program should be initiated.

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Table 2. Yield (t ha⁻¹) of different Potato varieties in different locations during the year of 2020-21.

Varieties	Tuber yield (t ha ⁻¹)															Mean
	Chan dpur	Faridpu r	Manik ganj	Gaiba ndha	Bhola	Patuakha li	Borgu na	Rangpu r	Rajshah i	Khuln a	Sherpur	Tangail	Mymensi ngh	Narsingdi	Kishoreg anj	
BARI Alu-36	31.37	37.57	41.00	28.89	25.74	21.61	22.89	32.19	25.40	28.28	33.65	26.81	37.14	40.07	37.36	31.33
BARI Alu-37	32.98	-	-	27.80	28.43	21.50	22.39	29.75	33.80	28.43	34.04	25.80	35.52	28.30	35.6	29.56
BARI Alu-40	36.68	30.57	45.00	33.09	29.20	25.73	26.92	32.90	36.10	26.98	43.75	29.65	40.25	43.32	39.57	34.65
BARI Alu-41	34.83	35.20	41.00	35.70	31.92	19.62	20.76	35.75	24.40	29.38	42.63	32.80	37.39	43.14	41.37	33.73
BARI Alu-47	34.85	34.55	32.50	27.81	29.61	18.89	19.90	36.32	32.80	24.92	42.68	28.15	35.24	41.78	37.83	31.86
BARI Alu-48	33.67	29.92	34.50	34.99	30.00	19.05	20.24	39.20	36.30	26.86	42.77	34.30	34.22	41.53	37.43	33.00
BARI Alu-49	34.43	27.02	31.50	28.17	28.90	23.94	24.87	40.51	23.70	26.15	34.90	30.00	33.01	42.25	37.15	31.10
BARI Alu-56	33.49	26.95	33.00	30.46	27.16	20.27	21.40	32.31	32.30	27.01	37.57	27.00	34.80	40.98	38.53	30.88
BARI Alu-62	33.80	27.30	36.00	32.17	30.44	22.72	23.65	36.61	39.70	28.72	41.42	32.50	38.30	42.12	41.53	33.80
BARI Alu-63	35.18	30.82	32.00	30.11	28.09	18.23	19.29	29.98	37.70	29.76	40.65	32.95	36.40	49.06	41.43	32.78
Mean	34.13	31.10	36.28	30.92	28.95	21.16	22.23	34.55	32.22	27.65	39.41	30.00	36.23	41.26	38.78	
LSD	3.10	2.12	6.34	2.25	3.87	0.85	1.53	2.34	2.14	2.73	1.67	5.52	3.97	6.56	0.78	-
CV (%)	6.27	9.14	12.28	6.78	8.76	10.32	14.87	7.83	5.83	5.77	2.93	8.40	4.51	16.75	1.15	-

Table 3. Late Blight (%) and Virus infection (%) in different potato varieties in different locations during the year of 2020-21.

Varieties	Late Blight (%)				Mean	Virus (%)			Mean
	Gaibandha	Rangpur	Rajshahi	Khulna		Gaibandha	Rangpur	Rajshahi	
BARI Alu-36	30.00	16.25	0.50	5.00	12.94	2.36	2.29	0.00	1.55
BARI Alu-37	20.00	21.25	1.00	4.00	11.56	1.55	1.54	1.80	1.63
BARI Alu-40	25.00	18.75	0.00	5.00	12.19	1.67	1.87	0.01	1.18
BARI Alu-41	15.00	16.25	0.50	4.00	8.94	1.29	2.29	0.29	1.29
BARI Alu-47	10.00	13.75	0.00	7.00	7.69	2.33	1.22	0.95	1.50
BARI Alu-48	15.00	18.75	1.00	6.00	10.19	2.33	1.87	0.61	1.60
BARI Alu-49	25.00	16.25	0.50	6.00	11.94	2.67	2.29	0.03	1.66
BARI Alu-56	30.00	13.75	1.50	4.00	12.31	1.11	1.22	0.00	0.78
BARI Alu-62	20.00	13.75	0.50	4.00	9.56	0.50	1.22	0.00	0.57
BARI Alu-63	40.00	18.75	0.50	5.00	16.06	1.00	1.87	0.00	0.96
Mean	23	16.75	0.6	5.00	-	1.68	1.77	0.37	-

Table 4. Common scab infection (%) and cutworm infestation in tuber in different locations

Varieties	Common scab (%)						Mean	Cutworm infestation (%)				Mean
	Gaibandha	Rangpur	Rajshahi	Khulna	Chandpur	Faridpur		Rajshahi	Khulna	Chandpur	Faridpur	
BARI Alu-36	6.78	0.62	0.00	2.00	1.88	0.00	1.88	0.00	0.00	1.29	3.15	1.11
BARI Alu-37	3.29	1.62	0.75	2.30	1.95	-	1.98	0.81	2.00	2.16	-	1.66
BARI Alu-40	2.01	1.45	1.40	1.00	2.79	0.73	1.56	0.80	2.00	1.36	7.05	2.80
BARI Alu-41	3.40	0.62	0.24	4.30	1.86	0.00	1.74	0.67	0.00	1.41	3.55	1.41
BARI Alu-47	1.02	0.25	0.00	0.00	1.80	0.00	0.51	0.00	2.00	1.54	6.40	2.49
BARI Alu-48	2.31	1.45	0.21	1.30	1.88	2.67	1.64	0.33	2.00	2.02	9.23	3.40
BARI Alu-49	3.12	0.62	0.46	2.50	1.69	0.95	1.56	0.45	2.00	1.57	10.45	3.62
BARI Alu-56	3.15	0.25	0.62	0.00	1.37	0.00	0.90	0.00	0.00	1.78	15.55	4.33
BARI Alu-62	2.33	0.25	0.00	0.00	2.08	0.00	0.78	0.00	2.00	1.50	12.45	3.99
BARI Alu-63	3.11	1.45	0.00	0.00	2.08	0.00	1.11	0.00	0.00	1.00	6.75	1.94
Mean	3.05	0.86	0.37	1.34	1.94	0.48		0.31	1.20	1.56	8.29	

Table 5. Average yield and partial economic analysis of different potato varieties at the farmer's field of different districts of Bangladesh during the Rabi season of 2020-21.

Location	Variety/Genotype	Gross margin (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Price of Potato (Tk kg ⁻¹):
Chandpur	BARI Alu-36	317300	181000	136300	10
	BARI Alu-37	329800	181000	148800	
	BARI Alu-40	366800	181000	185800	
	BARI Alu-41	348300	181000	167300	
	BARI Alu-47	348500	181000	167500	
	BARI Alu-48	336700	181000	155700	
	BARI Alu-49	344300	181000	163300	
	BARI Alu-56	334900	181000	153900	
	BARI Alu-62	338000	181000	157000	
	BARI Alu-63	351800	181000	170800	
	Mean	341640	181000	160640	
Gaibandha	BARI Alu-36	346680	136700	209980	12
	BARI Alu-37	333600	136700	196900	
	BARI Alu-40	397080	136700	260380	
	BARI Alu-41	428400	136700	291700	
	BARI Alu-47	333720	136700	197020	
	BARI Alu-48	419880	136700	283180	
	BARI Alu-49	338040	136700	201340	
	BARI Alu-56	365520	136700	228820	
	BARI Alu-62	386040	136700	249340	
	BARI Alu-63	361320	136700	224620	
	Mean	371028	136700	234328	
Borguna	BARI Alu-36	302540	153700	148840	14
	BARI Alu-37	301000	153700	147300	
	BARI Alu-40	360220	153700	206520	
	BARI Alu-41	274680	153700	120980	
	BARI Alu-47	264460	153700	110760	
	BARI Alu-48	266700	153700	113000	
	BARI Alu-49	335160	153700	181460	
	BARI Alu-56	283780	153700	130080	
	BARI Alu-62	318080	153700	164380	
	BARI Alu-63	255220	153700	101520	
	Mean	296184	153700	142484	
Patuakhali	BARI Alu-36	320460	153700	166760	14
	BARI Alu-37	313460	153700	159760	
	BARI Alu-40	376880	153700	223180	
	BARI Alu-41	290640	153700	136940	
	BARI Alu-47	278600	153700	124900	
	BARI Alu-48	283360	153700	129660	
	BARI Alu-49	348180	153700	194480	
	BARI Alu-56	299600	153700	145900	
	BARI Alu-62	331100	153700	177400	
	BARI Alu-63	270060	153700	116360	
	Mean	311234	153700	157534	
Rajshahi	BARI Alu-36	292100	179680	112420	11.50
	BARI Alu-37	388700	179680	209020	
	BARI Alu-40	415150	179680	235470	
	BARI Alu-41	280600	179680	100920	
	BARI Alu-47	377200	179680	197520	
	BARI Alu-48	417450	179680	237770	
	BARI Alu-49	272550	179680	92870	
	BARI Alu-56	371450	179680	191770	
	BARI Alu-62	456550	179680	276870	
	BARI Alu-63	433550	179680	253870	
	Mean	370530	179680	190850	

Location	Variety/Genotype	Gross margin (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Price of Potato (Tk kg ⁻¹):
Khulna	BARI Alu-36	424200	177824	246358	15.00
	BARI Alu-37	426450	177842	248608	
	BARI Alu-40	404700	177842	226858	
	BARI Alu-41	440700	177842	262858	
	BARI Alu-47	373800	177842	195958	
	BARI Alu-48	402900	177842	225058	
	BARI Alu-49	392250	177842	214408	
	BARI Alu-56	405150	177842	227308	
	BARI Alu-62	430800	177842	252958	
	BARI Alu-63	446400	177842	268558	
	Mean	414735	177840.2	236893	
Sherpur	BARI Alu-36	5,04,750	1,70,110	3,34,640	15
	BARI Alu-37	5,10,600	1,70,110	3,40,490	
	BARI Alu-40	6,56,250	1,70,110	4,86,140	
	BARI Alu-41	6,39,450	1,70,110	4,69,340	
	BARI Alu-47	6,40,200	1,70,110	4,70,090	
	BARI Alu-48	6,41,550	1,70,110	4,71,440	
	BARI Alu-49	5,23,500	1,70,110	3,53,390	
	BARI Alu-56	5,63,550	1,70,110	3,93,440	
	BARI Alu-62	6,21,300	1,70,110	4,51,190	
	BARI Alu-63	6,09,750	1,70,110	4,39,640	
	Mean	591090	170110	420980	
Tangail	BARI Alu-36	268100	187813	80287	10
	BARI Alu-37	258000	187813	70187	
	BARI Alu-40	296500	187813	108687	
	BARI Alu-41	278000	187813	90187	
	BARI Alu-47	281500	187813	93687	
	BARI Alu-48	343000	187813	155187	
	BARI Alu-49	300000	187813	112187	
	BARI Alu-56	270000	187813	82187	
	BARI Alu-62	325000	187813	137187	
	BARI Alu-63	269500	187813	81687	
	Mean	288960	187813	101147	
Mymensingh	BARI Alu-36	557100	219250	337850	15
	BARI Alu-37	532800	219250	313550	
	BARI Alu-40	603750	219250	384500	
	BARI Alu-41	560850	219250	341600	
	BARI Alu-47	528600	219250	309350	
	BARI Alu-48	513300	219250	294050	
	BARI Alu-49	495150	219250	275900	
	BARI Alu-56	522000	219250	302750	
	BARI Alu-62	574500	219250	355250	
	BARI Alu-63	546000	219250	326750	
	Mean	543405	219250	324155	
Kishoreganj	BARI Alu-36	485680	158200	327480	BARI Alu-41 and 56 = 12 BARI Alu-36 and 63 = :13 BARI Alu-49= 14 BARI Alu-40 and 48= 15 BARI Alu-37, 47 & 62=:16.25
	BARI Alu-37	578500	160800	417700	
	BARI Alu-40	593550	161500	432050	
	BARI Alu-41	496440	160200	336240	
	BARI Alu-47	614738	162500	452238	
	BARI Alu-48	561450	161800	399650	
	BARI Alu-49	520100	160500	359600	
	BARI Alu-56	462360	159800	302560	
	BARI Alu-62	674863	165750	509113	
	BARI Alu-63	538590	160650	377940	
	Mean	552627	161170	391457	

ON-FARM TRIALS WITH NEWLY RELEASE POTATO VARIETIES IN DIFFERENT LOCATIONS

Abstract

The On-farm trials were conducted at farmers' fields of MLT site in Noakhali, Faridpur and Sherpur during 2020-21 to evaluate the performance of tuber yield of some selected potato varieties and to know farmers' opinions about the varieties. Four potato varieties were tested in Noakhali, five varieties in Faridpur and nine varieties tested in Sherpur. The tuber yield was varied among the tested potato varieties across the locations. In Noakhali, BARI Alu-72 (40.48 t ha⁻¹) performed the best. In Faridpur, BARI Alu-41 observed the significant highest tuber yield (38.18 t ha⁻¹), like BARI Alu-36 (38.02 t ha⁻¹). In case of Sherpur, BARI Alu-41 yielded the highest (41.74 t ha⁻¹) like Faridpur, followed by BARI Alu-47 (39.95 t ha⁻¹). The highest gross return and gross margin were also recorded from the respective varieties across the locations due to the significant highest tuber yield. The choice of farmers varied across the locations. In Noakhali, farmers preferred BARI Alu-72 and BARI Alu-62; in Faridpur it was BARI Alu-36 and BARI Alu-41 and in Sherpur it was BARI Alu-41 and BARI Alu-47. Farmers' choice of potato variety varied with locations mostly for yield performance and skin color.

Introduction

Potato (*Solanum tuberosum* L.) is the world's fourth most economically important food crop, after wheat, rice and maize. It is a part of the diet of half a billion consumers in developing countries. In Bangladesh, the crop is the third most important crop in Bangladesh next to rice and wheat. It is grown not only for food but also for animal feed, industrial uses and seed tuber production. Potatoes are also a good source of minerals, at least 12 essential vitamins, and an extremely high content of vitamin C comparable to other food crops. According to DAE, the crop occupies 4.963 lac hectare lands with the annual production of 103.04 lac metric tons during 2015-16. The national average yield of potato is very low (20.77 t ha⁻¹) compared to its potential yield, due to lack of quality seed, cultivation of indigenous potato, and the high price of quality seed. Tuber Crop Research Centre (TCRC), BARI has developed a good number of potato varieties that are supposed to be higher yielder and less susceptible to insect pest and diseases. These new varieties need to be evaluated for their performance under different agro-ecological zones. Therefore, on-farm trials with BARI-developed potato varieties/lines were conducted to evaluate their yield performance and know farmer's opinions about the newly released improved potato varieties in different locations of Bangladesh.

Materials and Methods

The experiment was conducted at the farmer's field at the FSRD site, Noakhali, MLT site Faridpur and MLT site Sherpur during the rabi season of 2020-21 to evaluate the performance of the different potato varieties and to popularize them among the farmers. Four potato varieties were tested in Noakhali, five varieties in Faridpur whereas it was nine in Sherpur. The unit plot size was 40 to 80 m² across the locations. The total amount of fertilizers was applied @ N₉₀₋₁₃₅P₂₀₋₃₀K₉₀₋₁₃₅S₁₀₋₂₀Zn₂B₁ kg ha⁻¹ as urea, TSP, MoP, gypsum, zinc sulfate and Boric acid, respectively across the locations. The total amount of all fertilizers and half of the total urea was applied as basal during final land preparation. The rest of the urea was applied at 30-35 DAP as a top dressing (FRG, 2018). The seed potato tubers were planted on 25 November- 07 December 2020 with a seed rate of 2.0 t ha⁻¹ maintaining 60 cm x 25 cm spacing. The crops were irrigated by two to three irrigations as well as one hand weeding (21-25 DAP) and earthing up (32-40 DAP). Aphids were controlled by spraying Emitaf @ 1 ml L⁻¹ and Admire @ 0.5 ml L⁻¹ of water. The late blight was controlled by spraying of Mancozeb @ 2 g L⁻¹ of water at 10 days intervals. The crops were harvested on 01-14 March 2021 across the locations. Data on yield and yield contributing characters were recorded and analyzed statistically.

Results and Discussion

Noakhali: In Noakhali, the highest tuber yield was obtained from BARI Alu-72 (30.48 t ha⁻¹) followed by BARI Alu-62 (27.79 t ha⁻¹) whereas, the lowest tuber yield was recorded from BARI Alu-63 (26.51 t ha⁻¹), similar to BARI Alu-73 (26.59 t ha⁻¹) presented in Table 1. The reason for the highest tuber yield in BARI Alu-72 is mainly due to the highest number of tuber (9.86). The highest gross return

(Tk..426720 ha⁻¹), gross margin (Tk..210870 ha⁻¹) was recorded from BARI Alu-72, due to the highest tuber yield followed by BARI Alu-62 (gross return Tk. 389060 ha⁻¹ and gross margin Tk. 173210 ha⁻¹). The lowest economic return was recorded from BARI Alu-63.

Faridpur: Yield and yield contributing characters varied significantly due to varieties (Table 2). The statistical maximum and minimum plant height was calculated from BARI Alu-53 (96.74 cm) and BARI Alu-29 (54.38 cm), respectively. The potato variety BARI Alu-41 produced the highest number of tubers per hill (12.92 nos.) and the lowest number of tubers per hill recorded in BARI Alu-28 (7.04). However, the highest tuber yield (38.18 t ha⁻¹) was obtained from BARI Alu-41 that was statistically similar to BARI Alu-36 (38.02 t ha⁻¹), mainly due to the highest number of tubers per hill in the respective potato cultivars. The lowest tuber yield (24.90 t ha⁻¹) was calculated from BARI Alu-28, due to the smaller number of tubers per hill. The tuber yield of BARI Alu-41 was 53% higher than that of BARI Alu-28. In the case of economic return, the highest gross return (Tk. 458160 ha⁻¹) and gross margin (Tk. 283160 ha⁻¹) were recorded from BARI Alu-41, similar to BARI Alu-36. The reason for getting the highest gross return and gross margin is due to the significant highest tuber yield obtained from BARI Alu-41 as well as BARI Alu-36.

Sherpur: Yield and yield contributing characters of different potato varieties are presented in Table 3. Results showed that all parameters were significant. The tallest plant (96.87 cm) was found in BARI Alu-53 while the shortest (64.07 cm) was in BARI Alu-47. The significant highest number of tubers per hill (13.47) was found in BARI Alu-50 and the lowest number of tubers per hill (7.80) was recorded in BARI Alu-36. The tuber yield was ranged from 32.46 to 41.74 t ha⁻¹, whereas the highest tuber yield (41.74 t ha⁻¹) was produced by BARI Alu-41 followed by BARI Alu-47 (39.95 t ha⁻¹) due to a standard number of tubers produced per hill (11.03 to 11.73 no. of tubers per hill) and the lowest tuber yield (32.46 t ha⁻¹) recorded in BARI Alu-53. The cost and return analysis of potato varieties is shown in Table 3. Results revealed that the highest gross return (Tk. 6,26,100 ha⁻¹) and gross margin (Tk. 4,56,100 ha⁻¹) was recorded from BARI Alu-41 and BARI Alu-53 gave the lowest gross return (Tk.4,86,900 ha⁻¹) and gross margin (Tk. 3,16,900 ha⁻¹). The reason for the highest gross return and gross margin is mainly due to the significant tuber yield variations among the tested potato varieties.

Farmers' Opinion

Framer's choices regarding variety selection have differed on tuber shape and size, the skin color of the tuber, vigorous plant growth and high yielding potentialities of the potato variety, and higher gross return/market price. Farmers in the Noakhali choose preferred BARI Alu-72 and BARI Alu-62; BARI Alu-36 and BARI Alu-41 in Faridpur and BARI Alu-41 and BARI Alu-47 in Sherpur.

Table 1. Tuber yield and yield contributing characters and economics of potato varieties at Noakhali during the Rabi season, 2020 -21.

Variety	Plant height (cm)	No. tubers per plant	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Alu-62	40.24	9.82	27.79	389060	215850	173210
BARI Alu-63	37.04	9.42	26.51	371140	215850	155290
BARI Alu-72	42.64	9.86	30.48	426720	215850	210870
BARI Alu-73	40.78	7.34	26.59	372260	215850	156410
Mean	40.18	9.11	27.84	389795	215850	173945

Price of potato - Tk. 14.00 kg⁻¹

Table 2. Yield and yield contributing characters of different potato varieties in Faridpur during the Rabi season, 2020-21

Treatment	Plant height (cm)	Tuber hill ⁻¹ (no.)	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Alu-28	55.72	7.04	24.90	298800	175000	123800
BARI Alu-29	54.38	7.44	25.00	300000	175000	125000
BARI Alu-36	82.84	9.52	38.02	456240	175000	281240
BARI Alu-41	88.40	12.92	38.18	458160	175000	283160
BARI Alu-53	96.74	8.72	34.40	412800	175000	237800
Mean	75.62	9.13	32.10	385200	175000	210200

Price of potato - Tk. 12.00 kg⁻¹

Table 3. Yield and yield contributing characters and Cost and return analysis of potato varieties at Sherpur Sadar, Sherpur during the Rabi season, 2020-21

Varieties	Plant height (cm)	Tuber hill ⁻¹ (no.)	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Alu-7	70.87	10.13	38.93	583950	170000	413950
BARI Alu-28	68.73	9.23	32.74	491100	170000	321100
BARI Alu-35	65.00	10.6	37.85	567750	170000	397750
BARI Alu-36	79.20	7.8	34.53	517950	170000	347950
BARI Alu-41	73.67	11.67	41.74	626100	170000	456100
BARI Alu-46	84.54	11.73	32.74	491100	170000	321100
BARI Alu-47	64.07	11.03	39.95	599250	170000	429250
BARI Alu-50	68.4	13.47	34.89	523350	170000	353350
BARI Alu-53	96.87	9.73	32.46	486900	170000	316900
Mean	74.59	10.60	36.20	543050	170000	373050

Price of potato - Tk. 15.00 kg⁻¹

Conclusion

Among all the potato varieties grown in the 3 locations, the yield was varied from location to location. BARI Alu-72 performed better in salinity condition while BARI Alu-41 suited best in the Faridpur and Sherpur and produced the highest yield. Further trials are needed to confirm the yields of these two varieties in the above-mentioned locations.

PROMOTION AND DISSEMINATION OF LATE BLIGHT RESISTANT POTATO VARIETIES IN DIFFERENT LOCATIONS

Abstract

The trial was conducted at farmers' field of MLT site of OFRD, Gaibandha, MLT site of Lalmonirhat; MLT site Kurigram and MLT site of Rangpur during the Rabi season of 2020-21 to evaluate the field performance of BARI released three late blight resistant Potato varieties (BARI Alu-46 and BARI Alu-53) and to know farmers' judgement about the varieties. Among the tested Potato varieties BARI Alu-53 and BARI Alu-46 performed better at all locations and gave 37.44% and 33.98% higher tuber yield than check variety (BARI Alu-25). These two varieties showed less than 0-5% late blight infection in the foliage. Regarding Common Scab susceptibility, its severity was very low (<3%). Farmers' judgement about Potato varieties varied with locations mostly for yield performance and skin color. According to farmers' judgement the popular BARI Alu-46 and BARI Alu-53 were highly resistant to the late blight of Potato disease, which cut the fungicide cost greatly and reduced the cost of production without hampering tuber yield. Considering yield, the skin color of the tuber, market demand, and cost-benefit analysis farmers in all locations choose BARI Alu-53.

Introduction

Late blight is the most devastating disease of Potato in Bangladesh. It causes around 30-50% annual yield loss. It may cause total loss of the crop if attacks at an early stage of the crop. Late blight can become epidemic within a few days under favorable environmental conditions. Tuber Crops Research Center of BARI has released three late blight resistant varieties viz. BARI Alu-46 and BARI Alu-53 are higher yielders and resistant to late blight disease. Genetic disease resistance is an effective tool for sustainable management of late blight, caused by *Phytophthora infestans*, which is economically the most important disease of Potato. Breeding at the beginning of the twentieth century concentrated on major dominant late blight resistance (R) genes from the Mexican wild species *Solanum demissum* and eleven of these R genes were introgressed in Potato (Muller and Black, 1952; Bradshaw et al. 2006). However, the rapid breakdown of resistance in Potato varieties containing S. demissum R1, R2, R3, and R10 [Wastie, 1991] has sparked an increased focus on the introgression of multiple broad-spectrum R genes to impart durability to commercial varieties. It has turned out in various crops and pathosystems that the stacking of multiple R genes is necessary to provide satisfactory resistance in the field [Que et al. 2010]. Although the used R genes provide resistance to broad spectra of late blight strains, the predominant agricultural deployment of only one R gene can drive the evolution of new virulent strains. In the absence of chemical controls, this might even be destroying an entire harvest [Strange and Scott, 2005]. Therefore, the use of combinations of R genes with different spectra must be pursued to increase the durability of resistance and thereby providing food security under no or little fungicide application. These new varieties need to be evaluated for their performance under different late blight-prone areas. The present study was conducted to evaluate and popularize the varieties under farmer's field conditions in Gaibandha, Lalmonirhat, Kurigram, and Rangpur districts.

Materials and Methods

Disease-free seed tubers of BARI Alu-46 and BARI Alu-53 were distributed among 20 farmers of MLT site of OFRD, Gaibandha, MLT site of Lalmonirhat: MLT site of Kurigram and MLT site of Rangpur. Each farmer had received 50 Kg quality seed tubers of each Potato varieties BARI Alu-25 (Asterix) was used as a check variety in Gaibandha, Lalmonirhat, Kurigram, and Rangpur locations. Orientation was given to the farmers during the cropping season subject to newly released late blight resistant Potato varieties; BARI Alu-46 and BARI Alu-53 and its production techniques as well as irrigation, disease management practices, etc. The total amount of fertilizer was applied @ $N_{90-135}P_{20-30}K_{90-135}S_{10-20}Zn_2B_1$ kg ha⁻¹ as urea, TSP, MoP, gypsum, zinc sulfate and boric acid, respectively. The total amount of all fertilizers and half of the total urea was applied as basal during final land preparation. The rest of the urea was applied at 30-35 DAP as a top dressing (FRG, 2018). Seed plantations were started on 22 November and continued up to 4 December 2020. The haulms were pulled after 80 days of planting. The crop was harvested from 20 February to 07 March 2021. Farmers were also suggested to follow a routine spray schedule to control late blight infection in the control plot. But, in the case of BARI Alu-46 and BARI Alu-53. Farmers were suggested not to spray fungicide before appearing Late Blight symptom in the foliage. If disease symptoms appear, apply 1-2 sprays in the Potato field. Finally, the yield data and disease observation data were taken from the trial and farmers' fields and finally compared.

Table-1. Details of the trials of the at different locations during the Rabi season, of 2020-21

Location	Varieties	Number of farmers	Date of planting	Date of Harvesting	Plot size (Decimals)
Gaibandha	BARI Alu-25	5	22-28 Nov. 2020	20- 26 Feb. 2021	40
Lalmonirhat	(Check Variety)	5	29 Nov.- 4Dec. 2020	02 - 07 March 2021	40
Kurigram		5			
Rangpur		5			

Results and Discussion

Tuber yield among the varieties across the locations was ranged from 22.57 to 32.77 t ha⁻¹ (Table 2) where the highest yield was obtained from BARI Alu-53 (32.77 t ha⁻¹) in Kurigram and the lowest was

from check variety BARI Alu-25 (22.57 t ha⁻¹) in Lalmonirhat location. Among the Potato varieties, BARI Alu-53 produced the average highest tuber yield (31.89 t ha⁻¹) followed by BARI Alu-46 (31.09 t ha⁻¹) whereas BARI Alu-25 produced the average lowest tuber yield (23.20 t ha⁻¹) (Table. -1). Among the locations, BARI Alu-46 yielded the highest in Gaibandha followed by Kurigram locations. BARI Alu-53 produced the highest yield in Kurigram followed by Rangpur and Gaibandha. The lowest tuber yield in BARI Alu-53 was achieved in Lalmonirhat.

Disease's incidence: Regarding late blight infection, BARI released two late blight resistant varieties showed excellent resistance to Late Blight disease where the average foliar infection ranged from 1.00 to 4.78% (Table-3) whereas the check variety BARI Alu-25 (Asterix) was badly infected by LB and the foliage damage was ranged from 37.00 to 47.50% which had caused the yield reduction greatly.

Concerning Common scab incidence in the tuber, it was ranged from 1.07 to 2.20% where the lowest was found in BARI Alu-46 in Kurigram and the highest was found in BARI Alu-53 in Kurigram. Among the varieties, the highest common scab infection was found in BARI Alu-53 and the lowest was found in BARI Alu-46 (Table-4).

Farmers' opinion

- Farmers were incredibly happy to observe the performance of the BARI Alu-46 and BARI Alu-53 against the devastating late blight disease as well as higher yield.
- Both the three Late Blight resistant Potato varieties can resist Late Blight greatly and cut the spray cost which lowers the production cost. They also opined that scab infection was also less in the newly released Potato varieties BARI Alu-46 and BARI Alu- 53.
- Farmers preferred Late Blight resistant Potato variety BARI Alu-53 for its red skin color, market demand, and higher economic return.

Table 2. Yield (t ha⁻¹) of newly released late blight resistant Potato variety at farmer's field during the Rabi season, 2020-21.

Location	Tuber yield (t ha ⁻¹)				Mean tuber yield (t ha ⁻¹)
	Gaibandha	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	32.17	30.82	31.37	29.99	31.09±0.92
BARI Alu-53	31.11	30.93	32.77	32.75	31.89±1.01
BARI Alu-25 (Check)	24.46	22.57	22.70	23.08	23.20±0.87
Mean	29.25	28.11	28.95	28.61	-
LSD	2.11				-
CV (%)	8.76				-

Table 3. Late Blight infection (%) of newly released late blight resistant Potato variety at farmer's field during the Rabi season, 2020-21.

Location	Late Blight Infection (%)				Mean
	Gaibandha	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	1.00	3.40	2.60	3.50	2.63±1.16
BARI Alu-53	4.78	3.90	3.10	4.20	4.00±0.70
BARI Alu 25 (check)	47.50	44.00	41.00	37.00	42.38±4.46
Mean	17.76	17.10	15.57	14.90	

Table 4. Common scab incidence (%) of newly released late blight resistant Potato variety at farmer's field during the year of 2020-21.

Location	Common scab infection (%)				Mean
	Gaibandha	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	1.21	1.498	1.07	1.20	1.24±0.18
BARI Alu-53	1.25	1.82	2.20	1.60	1.72±0.40
BARI Alu-25 (check)	1.13	1.70	1.2	1.90	1.48±0.38
Mean	1.20	1.67		1.57	

Conclusion

This program should be continuing to disseminate the Late Blight Resistant potato cultivation in different areas of Bangladesh.

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PROMOTION AND DISSEMINATION OF CLIMATE SMART POTATO VARIETIES IN THE SOUTHERN DISTRICTS

Abstract

BARI released three climate-smart varieties viz. BARI Alu-72, BARI Alu-73 and BARI Alu-78 were evaluated at the farmer's field in the southern region Patuakhali, Borguna, Noakhali, Cox'sbazar, Khulna (Koiria and Dumuria), Satkhira, Bagerhat, Bhola and Borguna to observe their yield performance in the southern districts of Bangladesh. Soil Salinity was recorded for the locations of Cox'sbazar, Khulna (Koiria and Dumuria), Satkhira and Bagerhat locations. The average of soil salinity level ranged from 2.86 to 8.15 dSm⁻¹ in all locations. The trial location of Borguna, Patuakhali, Bhola, and Noakhali was found non-saline. Among the varieties, BARI Alu-72 (29.12 t ha⁻¹) was the average highest yielder and BARI Alu-73 was the 2nd highest yielder and BARI Alu-78 was the lowest yielder. In all locations, BARI Alu-72 performed better due to its higher adaptability to heat and saline conditions. Higher average gross return, gross margin and BCR were accounted from BARI Alu-72 for its higher yield.

Introduction

In Bangladesh, 1.36 lakh hectares of land being under Potato cultivation which produces 15.58 lakh tons of Potato. The coastal area includes 30% of the cultivable land in Bangladesh. About 10 lac hectares (1million ha) of land are affected by varying degrees of soil salinity (Karim and Iqbal, 2001). After harvesting of T. Aman, a vast area of land remains fallow in this region. Again, during the *rabi* season, the soil salinity levels increase through capillary movement. It is a major production constraint in the saline coastal region.

In the Khulna region, the area under Potato cultivation is only 1,584 ha which is negligible (0.79%) in the context of the total Potato cultivated area of the country. In the Cox'sbazar region, a very small area under Potato cultivation. Lack of high yielding salt-tolerant variety, soil salinity, and lack of irrigation facilities are the major problems for Potato cultivation in this area. BARI has developed a new salt-tolerant Potato variety (BARI Alu-72, BARI Alu-73 and BARI Alu-78) having different characteristics such as tolerance to salinity, diseases, storability, etc. It has the capacity of producing more calories and proteins per unit land area with minimum time than most other major food crops (Upadhaya, 1995). Although many modern varieties of Potatoes have been released by the country's research centers for different agro-ecologies, the yield potential is seeming unsatisfactory because the traditional varieties still occupy about 35% of the total Potato cultivation area (Ilantileke *et al.*, 2001). Tuber Crop Research Centre of BARI has released so far 79 high-yielding Potato varieties having good yield potential and tolerant to insect pests and diseases during the last decade and recommended 20 varieties after screening for cultivation under Bangladesh conditions (Hussain, 2008). The performance of this variety needs to be evaluated for cultivation in this saline area. Keeping this view in mind, the experiment was undertaken to find out the performance of BARI Alu-72, BARI Alu-73 and BARI Alu-78 for cultivation in the coastal area of Bangladesh.

Materials and Methods

The trial was conducted at the farmer's field at Patuakhali, Borguna, Noakhali, Cox'sbazar, Khulna (Koiria and Dumuria), Satkhira, Bagerhat, Bhola and Borguna during 2020-21 to observe the

performance of BARI Released climate-smart potato varieties (BARI Alu-72, BARI Alu-73 and BARI Alu-78) in the southern areas of Bangladesh. The unit plot size has differed from location to location. In Bhola, only BARI Alu-72 and BARI Alu-73 were used. Total amount of fertilizers was applied @ $N_{90-135}P_{20-30}K_{90-135}S_{10-20}Zn_2B_1$ kg ha⁻¹ as urea, TSP, MoP, gypsum, zinc sulphate, and Boric acid, respectively across the locations. The total amount of all fertilizers and half of the total urea was applied as basal during final land preparation. The rest of the urea was applied at 30-35 DAP as a top dressing (FRG, 2018). The whole potato tuber was planted from 27 November and continued up to 25 December 2020. Plant spacing was maintained 60 cm x 25 cm. Two irrigations and one weeding were done when required. The crop was started harvesting on 20 February and continued up to 20 March 2021. Soil salinity data were taken at the emergence stage, vegetative stage (25 days), tuberization stage (50 days), and maturity stage (75 days). The average soil salinity level ranged from 2.86 to 8.15 dSm-l in all locations (Table-2). The trial location of Borguna, Patuakhali, Bhola and Noakhali was found non-saline. Soil salinity gradually increased up to the maturity stage of the crop.

Table-1. Details of the trials of the at different locations during the Rabi season, 2020-21

Location	Variety	Date of Planting	Date of Harvesting	Plot size
Patuakhali	BARI Alu-72, BARI Alu-73 and BARI Alu-78	10-20 Dec.20	10-20 March, 21	400 m ²
Borguna		10-25 Dec.20	10-20 March, 21	400 m ²
Noakhali		29 Nov. to 7 Dec., 20	9-15 March, 21	200 m ²
Cox'sbazar		27 Nov. to 5 Dec., 20	25 Feb., 21	200 m ²
Koira		10 Dec., 20	15 March., 21	200 m ²
Dumuria		4 Dec., 20	4 Mar., 21	200 m ²
Satkhira		5 Dec., 20	25 Feb., 21	200 m ²
Bagerhat		30 Nov., 20	25 Feb, 21	105 m ²
Bhola	BARI Alu-72 and BARI Alu-73	1-5 Dec., 20	20-28 Feb., 21	675 m ²

Table 2. Soil Salinity level in the trial site in different locations during 2020-21

Location	Emergence stage	Vegetative stage	Tuber formation stage	Maturity stage
Cox'sbazar	3.00	4.50	5.76	8.15
Koira	3.07	4.17	5.93	6.76
Dumuria	2.86	3.67	4.12	5.01
Satkhira	3.60	3.92	5.38	5.91
Bagerhat				

** Borguna, Patuakhali, Bhola and Noakhali- Non saline

Results and Discussion

The results of the experiment are shown in table 3. The mean yield of the three potato varieties across locations were ranged from 18.63 to 32.00 t. ha⁻¹ where the highest and the lowest tuber yield was obtained from BARI Alu-78 in Cox'sbazar and in Bagerhat, respectively. Among the varieties, the mean highest yield was found in BARI Alu-72 (29.12 t ha⁻¹) followed by BARI Alu-73 (26.08 t ha⁻¹) and the lowest in BARI Alu-78 (29.12 t ha⁻¹). Among the locations, the mean lowest yield was observed in Bagerhat and the highest was in Koira, Khulna.

Economic analysis

From the economic analysis, average gross return and gross margin for BARI Alu-72 were accounted for 425324 Tk. ha⁻¹, and 233229 Tk. ha⁻¹. Again, the gross return and gross margin for BARI Alu-73 were accounted for 371339 Tk. ha⁻¹ and 179244 Tk. ha⁻¹. The average lowest return and gross margin were accounted for BARI Alu-78 (376516 Tk. ha⁻¹ and 184421 Tk. ha⁻¹) (Table-4).

Farmers' opinion

Farmers of each location reported that BARI Alu-72 was high yielding and suitable for cultivation in their land and they also preferred BARI Alu-72 because of its attractive color and yield, but in few farmers showed their interest in BARI Alu-73 for its white skin color. So, promotional works should be taken to disseminate these three varieties in the coastal region.

Table 3. Yield performance of 3 climate smart potato varieties in different southern districts during the year of 2020-21.

Location	Patuakhali	Barguna	Noakhali	Cox'sbazar	Koira	Dumuria	Satkhira	Bagerhat	Bhola	Mean±SD
BARI Alu-72	31.24	30.54	30.48	28.40	30.80	29.19	30.00	22.34	29.12	29.12±2.27
BARI Alu-73	26.53	28.67	26.59	21.40	27.60	25.45	26.50	20.76	31.25	26.08±3.30
BARI Alu-78	21.14	23.25	25.38	32.00	29.80	26.46	28.80	18.63	-	25.68±4.53
Mean	26.30	27.49	27.48	27.27	29.40	27.03	28.43	20.58	30.19	

Table 4: Economic analysis of BARI Alu-72 & BARI Alu-73 during the Rabi season of 2020-21.

Location	Variety	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)	Price of Potato (Tk. ha ⁻¹)
Patuakhali	BARI Alu-72	437360	215850	221510	14
	BARI Alu-73	371420	215850	155570	
	BARI Alu-78	295960	215850	80110	
Mean		368247	215850	152397	
Borguna	BARI Alu-72	427560	215850	211710	14
	BARI Alu-73	401380	215850	185530	
	BARI Alu-78	325500	215850	109650	
Mean		384813	215850	168963	
Noakhali	BARI Alu-72	426720	215850	210870	14
	BARI Alu-73	372260	215850	156410	
	BARI Alu-78	355320	215850	139470	
Mean		384767	215850	168917	
Cox'sbazar	BARI Alu-72	426000	177842	248158	15
	BARI Alu-73	321000	177842	143158	
	BARI Alu-78	480000	177842	302158	
Mean		409000	177842	231158	
Koira	BARI Alu-72	462000	177842	284158	15
	BARI Alu-73	414000	177842	236158	
	BARI Alu-78	447000	177842	269158	
Mean		441000	177842	263158	
Dumuria	BARI Alu-72	437850	177842	260008	15
	BARI Alu-73	381750	177842	203908	
	BARI Alu-78	396900	177842	219058	
Mean		405500	177842	227658	
Satkhira	BARI Alu-72	450000	177842	272158	15
	BARI Alu-73	397500	177842	219658	
	BARI Alu-78	432000	177842	254158	
Mean		426500	177842	248658	
Bagerhat	BARI Alu-72	335100	177842	157258	15
	BARI Alu-73	311400	177842	133558	
	BARI Alu-78	279450	177842	101608	
Mean		308650	177842	130808	
	BARI Alu-72	425324	192095	233229	
	BARI Alu-73	371339	192095	179244	
	BARI Alu-78	376516	192095	184421	

Conclusion

BARI Alu-72 produced satisfactory yield in all locations might be due to its salt and heat tolerance character.

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ADAPTIVE TRIAL OF PROMISING SWEET POTATO VARIETIES IN DIFFERENT LOCATIONS

Abstract

Field trials were conducted in Sylhet, Jamalpur, Mymensingh and Kishoreganj during the year of 2020-21 to evaluate the comparative performance of sweet potato varieties and to know the farmer's view about these cultivars in the respective locations. In Sylhet, four sweet potato varieties viz. BARI Mistialu-8, BARI Mistialu-12, BARI Mistilu-14 and BARI Mistialu-16; in Jamalpur four sweet potato varieties viz. BARI Mistialu-8, BARI Mistialu-12, BARI Mistilu-14 and BARI Mistialu-15; In Mymensingh, four sweet potato varieties viz. BARI Mistialu-11, BARI Mistialu-12, BARI Mistilu-14 and BARI Mistialu-16; and in Kishoreganj three sweet potato varieties viz. BARI Mistialu-8, BARI Mistialu-10 and BARI Mistilu-15 were used in the trial. The root yield of sweet potato varieties was ranged from 20.34 to 38.45 t ha⁻¹, where BARI Mistialu-12 produced the highest average tuberous root yield in Sylhet and local cultivar produced the lowest tuberous root yield in Mymensingh BARI Mistialu-12 produced the highest root yield in Mymensingh and Jamalpur and produced the average highest root yield (36.78 t ha⁻¹) compared to other sweet potato varieties. Among the BARI released sweet potato varieties BARI Mistialu-15 produced the lowest average tuberous root (25.02 t ha⁻¹) in Jamalpur. The highest gross return (Tk. 626935 ha⁻¹) and gross margin (Tk. 514435 ha⁻¹) were calculated from BARI Mistialu-11 in Mymensingh.

Introduction

Sweet potato (*Ipomoea batatas*) is the fourth important food crop in Bangladesh after rice, wheat, and Potato (Delowar and Hakim, 2014). It is mainly cultivated by the marginal or subsistence farmers sporadically in different river belts, char lands, deltas, and seasonally inundated flood plains (Ahmed *et al.*, 1998). It gives satisfactory yield under adverse climatic and soil conditions as well as under low or non-use of external inputs (Ndolo *et al.*, 2001). The average yield is very low as compared to many tropical to subtropical countries due to the cultivation of local and poor-quality indigenous sweet potato varieties. (Vimala and Rajendra, 1998). The prevalence of malnutrition in Bangladesh is still alarming and it is even higher than in countries like Nepal, Cambodia, Ethiopia, and Uganda. Bangladesh is placed in the bottom 25% of the Global Hunger Index and it is estimated that about 33 % of the population suffers from malnutrition. According to UNICEF and the Government of Bangladesh, 48% of children under the age of five across the country are chronically malnourished, 13.5% are acutely malnourished and 3.4% or 600 000 of the under-five population suffers from severe acute malnutrition.

Chronic energy deficiency, protein-energy malnutrition, low birth weight, micronutrient deficiency are critical issues faced by Bangladesh. Although it affects people of all ages, children, women, and female adolescents are mostly affected. Of the various micronutrient deficiencies, vitamin A, iodine deficiency disorders, iron deficiency anemia are major concerns, imparting cognitive development in children, and threatening life to pregnant women (Anonymous, 2013). Orange fleshed sweet potato is a biofortified food crop as it contained beta carotene with a good source of vitamin B, C, E, and other minerals and it has the immense potentiality to combat malnutrition and poverty (CIP, 2008). To combat malnutrition and vitamin A deficiency of the people living in char lands, orange-fleshed sweet potato (OFSP) may be one of the options. Sweet potato has numerous agronomic advantages such as adaptability of diverse (including marginal) growing conditions (Islam *et al.*, 2003 and Islam, 2006). The climatic condition of northern Bangladesh is suitable for sweet potato production. In Bangladesh, Sweet potato is generally harvested during March-May when the supply of cereal like rice is low. In this lean period, the sweet potato could play a vital role to fulfill the demand for the cereal of poor peoples of Bangladesh (Rafique *et al.*, 2015). The char land farmers of Gaibandha cultivated white-fleshed local sweet potato varieties despite lower yield and very low nutritional benefits.

Moreover, it is also reported that by following the yield, farmers' choices, and economic return. This activity considers the preferences of farmers and their socio-economic situations when assessing and selecting varieties (Wangchuk *et al.*, 2015). Since 1985, TCRC, BARI has released 13 high-yielding sweet potato varieties in Bangladesh. But adaptation rate of those varieties among the farmers in different agro-ecological zones is very poor due to the lack of very few promotional activities had been

undertaken by BARI, DAE, and other organizations. Considering this point of view, adaptive trials with BARI released sweet potato varieties have been undertaken at farmers' fields to find out a suitable variety for char lands and to know the farmer's judgment about the varieties regarding yield, economic return, and overall acceptance in different locations of Bangladesh. Keeping these views in mind, the experiment was undertaken.

Materials and Methods

Trials were conducted at farmer's field of FSRD site, Kamal bazar in South Surma Upazila, Sylhet; MLT site at Melandah, Jamalpur; MLT site of Mymensingh and MLT site of Kishoreganj during the Rabi season of 2020-21. Vines of the sweet potato varieties Trials were set up in a randomized complete block design with three dispersed replications in each location for this study. Planting of Sweet potato vines was started on 15 November 2020 and continued up to 22 November 2020. The unit plot size was varied from location to location. The vine was planted at the spacing of 60 cm × 30 cm. Manures and fertilizers were applied at the rate of 10 t ha⁻¹ cowdung and N₈₀₋₁₂₀P₂₅₋₃₅K₈₀₋₁₂₀S₁₀₋₁₅Zn₂B₁ ha⁻¹, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty percent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizer were applied at 30--35 DAP (FRG, 2018). Intercultural operations and plant protection measures were made as and when necessary. Harvesting of the trials was started on 4 April 2021 and continued up to 9 April 2021 in different locations. Data of yield components were collected from 10 plants selected at random in each plot and tuber yield was recorded plot-wise and converted to yield per hectare. Production costs of sweet potato included the cost of all operations (e.g., land preparation, seed, sowing, irrigation, application of organic manure and chemical fertilizer, spraying of insecticides and fungicides, and harvesting). Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. The total gross margin was calculated by subtracting the cost of production from the total gross return (Ferdous *et al.*, 2017).

Table 1. Crop management practices of adaptive trials on sweet potato at different locations during the Rabi season, 2020-21.

Location	Variety	Date of planting	Date of harvesting	Unit Plot size
Sylhet	BARI Mistialu-8, BARI Mistialu-12 BARI Mistialu-14, BARI Mistialu-16	19 Nov., 2020	07-10 April, 2021	10m x10m
Jamalpur	Mistialu-8, BARI Mistialu-12 BARI Mistialu-14, BARI Mistialu-15	15 Nov. 2020	06 April, 2021	6m x3m
Mymensingh	BARI Mistialu-11, BARI Mistialu-12 BARI Mistialu-14, BARI Mistialu-16	20 Nov. 2020	09 April, 2021	6m x3m
Kishoreganj	BARI Mistialu-8, BARI Mistialu-10 BARI Mistialu-15	22 Nov. 2020	04 April, 2021	10m x10m

Results and Discussion

In Sylhet, among the tested sweet potato varieties, BARI Mishti Alu-8 produced the statistically highest root yield (37.30 t ha⁻¹) followed by BARI Mishti Alu-12 (35.24 t ha⁻¹). On the other hand, BARI Mishti Alu-16 gave the lowest root yield (25.19 t ha⁻¹) due to the lower number of roots plant⁻¹ and lowest root yield per unit area.

In Jamalpur, the highest tuberous root yield (36.64 t ha⁻¹) was obtained from BARI Mistialu-12 and the lowest tuberous root yield (23.00 t ha⁻¹) was obtained from BARI Mistialu-14.

In Mymensingh, tuberous root yield was ranged from 20.34 to 38.45 t ha⁻¹ where BARI Mistialu-12 produced the highest tuberous root yield (38.45 t ha⁻¹) followed by BARI Mistialu-16 (36.72 t ha⁻¹) and BARI Mistialu-14 (35.52 t ha⁻¹). The lowest tuberous root yield was obtained from the local cultivar (20.34 t ha⁻¹).

In Kishoreganj, tuberous root yield was ranged from 24.33 to 29.33 t ha⁻¹ where BARI Mistialu-8 produced the highest tuberous root yield followed by BARI Mistialu-15 (27.27 t ha⁻¹) and the lowest tuberous root yield was obtained from BARI MistiAlu-10 (24.33 t ha⁻¹).

Benefit-Cost analysis

In Sylhet, the highest gross return (Tk. 559500 ha⁻¹) and gross margin (Tk. 409300 ha⁻¹) were calculated from BARI Mistialu-8 followed by BARI Mistialu-12. On the contrary, BARI Misti Alu-16 gave the lowest economic return due to the lower yield.

In Jamalpur, the maximum gross return (Tk. 5,28,000 ha⁻¹), gross margin (Tk. 3,77,430 ha⁻¹) was found from BARI Mistialu-8 whereas, the minimum gross return (Tk. 2,87,500 ha⁻¹) and gross margin (Tk. 1,36,930 ha⁻¹) were found from BARI Mistialu-14.

Mymensingh, the gross return and gross margin were varied among the varieties (Table 3). The highest gross return (Tk.6,26,935 ha⁻¹) and gross margin (Tk.5,13,435/- ha⁻¹) was recorded from BARI Mistialu-11 might be due to its higher market price. BARI Mistialu-12 and BARI Mistialu-16 also gave an attractive gross return (Tk.5,76,750 ha⁻¹ and Tk. 5,50,750 ha⁻¹, respectively) and gross margin (Tk. 4,64,250 ha⁻¹ and Tk. 4,38,250 ha⁻¹, respectively). Local Check variety gave the lowest gross return (Tk.3,05,125 ha⁻¹) and gross margin (Tk. 1,92,625 ha⁻¹).

In Kishoreganj, the maximum gross return (Tk. 233840 ha⁻¹), gross margin (Tk.162280 ha⁻¹) was found from BARI Mistialu-8 whereas, the minimum gross return (Tk. 194640 ha⁻¹) and gross margin (Tk. 123080 ha⁻¹) were found from BARI Mistialu-10.

Farmer's opinion

Farmers in the Sylhet, Jamalpur and Kishoreganj showed interest to cultivate BARI-developed color flesh sweet potato especially BARI Mistialu-8 due to its higher root yield and higher market demand. But in Mymensingh, farmers showed their keen interest in growing BARI Mistialu-11 for its attractive colour, highest market price & demand and delicious to eat. On the other hand, BARI Mistialu-12 and BARI Mistialu-16 were more productive than other variety that's why farmers also showed their interest in cultivating above mentioned varieties.

Table 2. Root yield (t ha⁻¹) of sweet potato varieties in two locations during the Rabi season of 2020-21

Variety	Root yield (t ha ⁻¹)				Mean root yield
	Sylhet	Jamalpur	Mymensingh	Kishoreganj	Average
BARI Mistialu-8	37.30	26.40	-	29.33	31.01
BARI Mistialu-10	-	-	-	24.33	24.33
BARI Mistialu-11	-	-	31.35	-	31.35
BARI Mistialu-12	35.24	36.64	38.45	-	36.78
BARI Mistialu-14	26.93	23.00	35.52	-	28.48
BARI Mistialu-15	-	25.02	-	27.27	26.15
BARI Mistialu-16	25.19	-	36.72	-	30.96
Local	-	-	20.34	-	20.34
Average	31.17	27.77	32.48	26.98	

Table 3. Cost and return analysis of sweet potato varieties different locations during the year of 2020-21

Location	Variety	Price (Tk. kg ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Sylhet	BARI Mishtialu-8	15.00	559500	150200	409300
	BARI Mishtialu-12		528600	150200	378400
	BARI Mishtialu-14		403950	150200	253750
	BARI Mishtialu-16		377850	150200	227650
Mean			467475	150200	317275
Jamalpur	BARI Mistialu-8	20.00	528000	150570	377430
	BARI Mistialu-12	12.50	458000	150570	307430
	BARI Mistialu-14	12.50	287500	150570	136930
	BARI Mistialu-15	12.50	528000	150570	287180
Mean			450375	150570	277242
Mymensingh	BARI Mistialu-11	20.00	626935	112500	514435
	BARI Mistialu-12	15.00	576750	112500	464250

Location	Variety	Price (Tk. kg ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	BARI Mistialu-14		532750	112500	420250
	BARI Mistialu-16		550750	112500	438250
	Local		305125	112500	192625
Mean			518462	112500	405962
Kishoreganj	BARI Mistalu-8	8.00	233840	71560	162280
	BARI Mistalu-10		194640	71560	123080
	BARI Mistalu-15		218160	71560	146600
Mean			215547	71560	143987

Conclusion

Among the tested sweet potato varieties BARI Mistialu-8 and BARI Mishtialu-12 performed better in the tested locations and were preferred by the growers due to their higher yield and gross return. But further study is needed for promoting newly developed color flesh carotene-rich varieties of sweet potato in the respected areas.

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ON-FARM TRIAL OF BARI RELEASED SWEET POTATO VARIETIES IN SALINE AREAS

Abstract

On-Farm trial of sweet potato varieties and lines were conducted at nine farmers' field at Koyra Upazilas of saline affected areas of Khulna district during 2020-21. The objective of the trial was to popularize BARI-released sweet potato varieties. The tested varieties were BARI Misti Alu- 4, 6, 7, 8, 12. The varieties had different skin and flesh colors, which attracted farmers. Most of the farmers chose BARI Misti Alu-8 for its red attractive color and its highest yield (31.40 t ha⁻¹) production purpose. Soil types and management variation determined sweet potato yield in coastal saline areas.

Introduction

Sweet potato has been a neglected crop in Bangladesh. Often it is called a 'poor mens' crop but it is a low-cost source of high vitamins and minerals. Especially it is rich in vitamin A. Sweet potato is cultivated in almost every district of Bangladesh. However, farmers usually cultivate local low-yielding varieties. BARI has released high-yielding and nutritionally rich sweet potato varieties. In the saline area of the Khulna region, suitable sweet potato variety selection is needed for higher yield and nutrition. The objective of the trial was to evaluate the performance of sweet potato varieties in saline areas.

Materials and Methods

An On-Farm trial of sweet potato was conducted in the coastal saline area of Khulna during 2020-21. BARI released ten sweet potato varieties. The tested varieties were BARI Misti Alu-4, 6, 7, 8, 12. Sweet potato vines were sown from 06 December 2020 at 60 cm X 30 cm spacing. Manures and fertilizers were applied at the rate of 10 t ha⁻¹ cowdung and N₈₀₋₁₂₀P₂₅₋₃₅K₈₀₋₁₂₀S₁₀₋₁₅Zn₂B₁ ha⁻¹, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty percent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizer were applied at 30--35 DAP (FRG, 2018).. Farmers harvested sweet potatoes from 12 April 2021. Salinity data was recorded at 15 days' intervals during the crop growing period with the harvested date. The salinity of the experiment field was 2.84-6.90 dS/m (Fig.1).

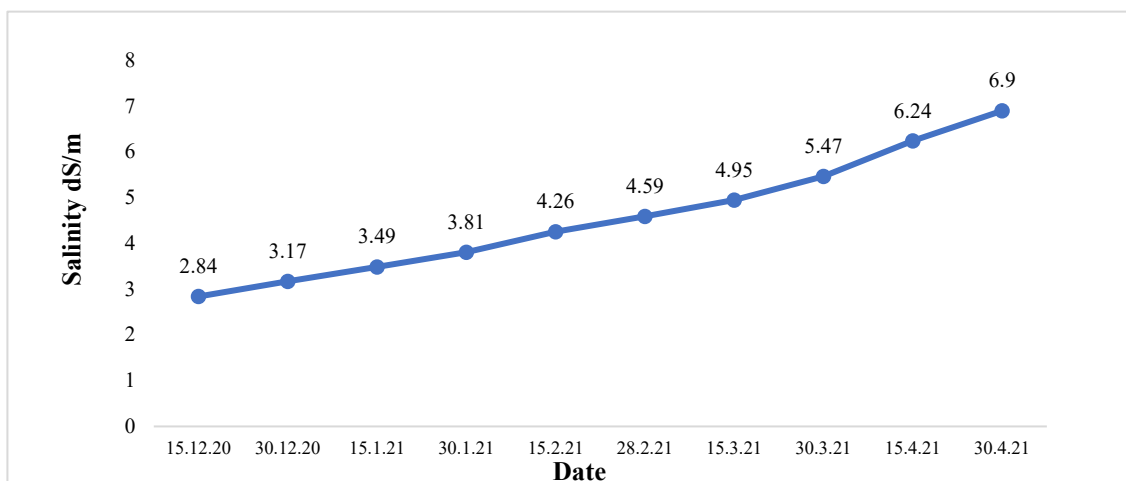


Fig 1. Salinity during crop growing period at Koyra, Khulna

Result and Discussion

The tested varieties had different skin colors and so was flesh color. Even though the outer color does not match with flesh color (Table 1). However, most of the farmers were initially deceived by the outer color while choosing varieties based on visual appearance. After exposing the inner flesh most of the farmers chose orange flesh varieties like BARI Alu-7,8 and 12. Among the varieties based on visual inspection, most of the farmers chose BARI Alu-12, since it got yellowish color outside and orange color inside.

Yield and yield components of varieties were varied from each other's (Table 2). The highest Vine length (140.38 cm) was recorded from BARI Misti Alu-7 and the lowest was recorded from BARI Misti Alu-4 (73.40 cm). The maximum number of tuber vine-1 was found from BARI Misti Alu-12 and the lowest from BARI Misti Alu-4 (2.33). Again, the highest tuber weight (540 g) per vine was recorded from BARI Misti Alu-7 and the lowest (216.0 cm) was recorded from BARI Misti Alu-6. In terms of tuber yield highest tuber yield was recorded from BARI Misti Alu-8 (31.40 t ha⁻¹) and the lowest from BARI Misti Alu-6 (11.88 t ha⁻¹).

Benefit-Cost analysis:

The maximum fruit yield (31.40 t ha⁻¹) was obtained from BARI Alu-8. The highest gross return (471000) and gross margin (328500) were also obtained from BARI Alu-8. The highest benefit cost ratio (3.30) was found from BARI Alu-8 and lowest from BARI Alu-6 (1.25) (Table 3).

Farmers' opinion

Sweet potato requires less care and relatively lower insect and disease attack. However, most of the farmers reported severe rat damage, which was uncontrollable. Moreover, sweet potato has a lower shelf life and low market price. Besides these, most of the farmers chose colored varieties over pale ones.

Table 1. Skin and flesh color of sweet potato varieties used in participatory variety selection trial in the coastal saline area of Khulna during 2020-21

Variety	Skin Color	Flesh Color
BARI Misti Alu-4	Off-white	Off-white
BARI Misti Alu-6	Off-white	Off-white
BARI Misti Alu-7	Off-white	Yellowish
BARI Misti Alu-8	Red	Yellowish
BARI Misti Alu-12	Yellowish	Orange

Table 2. Yield and yield components of sweet potato lines under participatory varietal selection at the coastal saline area of Khulna, 2020-21

Variety	Vine length (cm)	No. of Tuber vine ⁻¹	Weight of tuber vine ⁻¹ (g)	Tuber Yield (t ha ⁻¹)
BARI Misti Alu-4	73.40	2.33	0.275	15.12
BARI Misti Alu-6	93.33	2.60	0.216	11.88
BARI Misti Alu-7	140.38	4.96	0.540	29.70
BARI Misti Alu-8	120.50	5.04	0.571	31.40
BARI Misti Alu-12	125.22	5.38	0.497	27.33

Table 3. Cost and return analysis of BARI Sweet Potato varieties at MLT site, Koyra 2020-21

Variety	Yield (t ha ⁻¹)	Gross return (Tk.ha ⁻¹)	Cost of production (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
BARI Misti Alu-4	15.12	226800	142500	84300	1.59
BARI Misti Alu-6	11.88	178200	142500	35700	1.25
BARI Misti Alu-7	29.70	445500	142500	303000	3.12
BARI Misti Alu-8	31.40	471000	142500	328500	3.30
BARI Misti Alu-12	27.33	409950	142500	267450	2.87

Conclusion

Farmers of the coastal area chose colored sweet potato varieties and most of them chose BARI Mistialu-12 for its higher yield potentialities in the saline area. Farmers are also attracted by its yellowish outer color and orange flesh.

ADAPTIVE TRIALS WITH NEWLY RELEASED PANIKACHU VARIETIES IN DIFFERENT LOCATIONS

Abstract

The experiment was conducted at three locations such as MLT site of Shimakhali, Magura, Sherpur Sadar and Kishoreganj under OFRD during the Kharif season of 2019-20 to evaluate the performance of seven Panikachu varieties which was BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6 and local under farmers' field and to popularize among the farmers. Among them, two were in Sherpur, four were in Kishoreganj and seven were in Jashore including local check. The stolon yield of Panikachu ranged from 5.70 to 24.31 t ha⁻¹, where the highest was recorded from BARI Panikachu-1 in Sherpur and the lowest from BARI Panikachu-5 in Simakhali, Magura. Among the varieties, the average stolon yield was the highest (23.89 t ha⁻¹) in BARI Panikachu-1 and the lowest (6.33 t ha⁻¹) for BARI Panikachu-5. The average highest stolon yield (22.24 t ha⁻¹) was observed in Sherpur and the lowest (11.30 t ha⁻¹) was recorded in Kishoreganj. Similarly, in the case of rhizome yield, the highest rhizome yield (36.32 t ha⁻¹) was recorded from BARI Panikachu-4 and the lowest yield from BARI Panikachu-1 (15.38 t ha⁻¹). Considering the location, the highest rhizome yield (32.73 t ha⁻¹) was observed in Simakhali, Magura and the lowest in Sherpur (20.08 t ha⁻¹). The average highest gross margin (Tk. 602900 ha⁻¹) was founded from BARI Panikachu-3 followed by BARI Panikachu-2 (Tk. 562195 ha⁻¹) across the locations.

Introduction

Aroid (Panikachu) is one of the important tuber crops in Bangladesh during the summer season. The demand of aroids in Bangladesh is increasing day by day, but its yield per unit area is very low. Nutritionally, this crop is highly rich particularly in the stolon, leaf blade, and leaf stalk. The yield of aroids is markedly influenced by planting materials. Farmers in this region grow local variety which is low yield potentiality and susceptible to pests and diseases. BARI has developed some Panikachu varieties, which are high yielders and less susceptible to pests and diseases. BARI has released six improved varieties of Panikachu and these are BARI Panikachu-1, BARI Panikachu-2, Panikachu-3,

Panikachu-4, Panikachu-5 and Panikachu-6. Only BARI Panikachu-1 (Latiraj) has become popular to the farmers. Some local varieties are being also cultivated by the farmers. The newly released variety is not well known to them. So, it is necessary to disseminate this variety through adaptive trials. It is, therefore, necessary to evaluate the performance of these varieties and popularize as well as disseminate them in different locations of the country. With this view in mind, the trial was undertaken.

Materials and Methods

The experiment was conducted at three locations such as MLT site of Shimakhali, Magura, Kishoreganj and Sherpur under the supervision of OFRD Jashore, Kishoreganj and Sherpur, respectively during the Kharif season of 2019-20 under AEZ-9 & 11 to evaluate the performance of seven Panikachu varieties which was BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6 and local under farmers' field and to popularize among the farmers. Among them, two were in Sherpur, four in Kishoreganj and seven were in Jashore including local check collected from farmers. The trial was non replicated. Thirty days old seedlings were transplanted. The land was plowing and cross plowing was done with power tiller followed by laddering. Total amount of fertilizer was used @ $N_{60-90}P_{20-30}K_{65-90}S_{10-15}$ as urea, TSP, MoP and gypsum, respectively with CD @ 5 t ha^{-1} . The full amount of cowdung, TSP, MOP and gypsum was applied at the final land preparation. Urea was side dressed at 20-30 and 55-60 Days after planting (DAP) (FRG, 2018). The crop was slightly infested with leaf spot disease and it was controlled spraying several times with Ridomile Gold- 72 @ 2 ml L^{-1} water. No other significant diseases and pest infestation was observed in the plots. Data on maturity, plant height, yield and yield contributing characters were collected and analyzed statistically following the analysis of variance (ANOVA) technique using 'R 3.4.4' software and MSTAT-C. Means were separated by using LSD at 5% level and DMRT. Crop management practices in different locations have been stated in Table 1.

Table 1. Crop management practices used for Panikachu in different locations during the year, 2020-2021

Location	Variety	Planting time	Harvesting time	Plot size
Shimakhali, Magura	BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6 and local	10 Feb. 2020	20 April - 15 July, 2020	9m x 4.5m
Sherpur	BARI Panikachu-1 BARI Panikachu-2	1 Dec. 2019	04 March to 25 August, 20	10m x 8 m
Kishoreganj	BARI Panikachu-1, BARI Panikachu-4 BARI Panikachu-5, BARI Panikachu-6	26 Dec 2019	20 March to 25 August, 20	9m x 4.5m

Results and Discussion

In Jashore, the stolon yield of the Panikachu varieties was ranged from 5.70 to 23.50 t ha^{-1} , where the highest was observed in BARI Panikachu-1 (23.50 t ha^{-1}) and the lowest was observed in BARI Panikachu-5 (5.30 t ha^{-1}). In case of rhizome yield, it was ranged from 15.30 to 40.50 t ha^{-1} , where the highest was observed in BARI Panikachu-4 (40.50 t ha^{-1}) and the lowest was observed in BARI Panikachu-1 (15.30 t ha^{-1}). In Sherpur, the highest stolon yield was obtained from BARI Panikachu-1 (24.31 t ha^{-1}) and the lowest was obtained from BARI Panikachu-2 (20.17 t ha^{-1}). Considering the rhizome yield, BARI Panikachu-2 (26.46 t ha^{-1}) was the highest yielder and BARI Panikachu-1 (20.35 t ha^{-1}) was the lowest yielder. Again, in Kishoreganj, the highest stolon yield was found from BARI Panikachu-1 (23.87 t ha^{-1}) followed by BARI Panikachu-6 and BARI Panikachu-4 and the lowest from BARI Panikachu-5 (6.95 t ha^{-1}). In case of Rhizome yield, the highest Rhizome yield was obtained from BARI Panikachu-6 (33.31 t ha^{-1}) and the lowest was from BARI Panikachu-1 (17.14 t ha^{-1}).

Cost and return analysis

In Jashore, the highest gross return ($9869500 \text{ Tk. ha}^{-1}$) and gross margin ($741200 \text{ Tk. ha}^{-1}$) were obtained from BARI Panikachu-1 variety. Similarly, In Kishoreganj, the highest gross return ($423560 \text{ Tk. ha}^{-1}$)

and gross margin (197060 Tk. ha⁻¹) were obtained from BARI Panikachu-1 variety. But, In Sherpur, the highest gross return (574740 Tk. ha⁻¹) and gross margin (397390 Tk. ha⁻¹) were obtained from BARI Panikachu-2 variety. The lowest gross return and gross margin were obtained from BARI Panikachu-5 in Magura, BARI Panikachu-1 in Sherpur and, BARI Panikachu-5 in Kishoreganj (Table -4).

Farmers' reaction

Farmers in Jashore expressed their satisfaction with the higher yield of BARI Panikachu-1, BARI Panikachu-2 and BARI Panikachu-3. They are interested to grow this variety in the future. In Sherpur, they showed their interest in BARI Panikachu-2 due to the higher production of rhizome and the highest gross return. On the other hand, farmers opined that BARI Panikachu-1 gave the highest stolon yield. In Kishoreganj farmers are still satisfied with BARI Panikachu-1 for its higher stolon yield.

Table 2. Stolon yield performance of different Panikachu varieties in different locations during the year 2019-20

Variety	Stolon yield (t ha ⁻¹)			Mean stolon yield (t ha ⁻¹)
	Shimakhali, Magura	Sherpur	Kishoreganj	
BARI Panikachu-1	23.50	24.31	23.87	23.89
BARI Panikachu-2	20.60	20.17	-	20.39
BARI Panikachu-3	17.90	-	-	17.90
BARI Panikachu-4	8.20	-	7.12	7.66
BARI Panikachu-5	5.70	-	6.95	6.33
BARI Panikachu-6	8.30	--	7.27	7.79
Local	9.40	-	-	9.40
Mean	13.37	22.24	11.30	13.34

Table 3. Rhizome yield performance of different Panikachu variety's different locations during the year 2019-20

Variety	Rhizome yield (t ha ⁻¹)			Mean rhizome yield (t ha ⁻¹)
	Shimakhali, Magura	Sherpur	Kishoreganj	
BARI Panikachu-1	15.30	13.70	17.14	15.38
BARI Panikachu-2	34.50	26.46	-	30.48
BARI Panikachu-3	29.00	-	-	29.00
BARI Panikachu-4	40.50	-	32.13	36.32
BARI Panikachu-5	37.10	-	30.43	33.77
BARI Panikachu-6	35.40	-	33.31	34.36
Local	37.30	-	-	37.30
Mean	32.73	20.08	28.25	-

Table 4. Cost and return analysis of different Panikachu varieties in Magura, Sherpur and Kishoreganj locations during the year of 2019-20

Location	Treatment	Price (Tk. kg ⁻¹)	Gross return (Tkha ⁻¹)	Total variable cost (Tkha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Shimakhali, Magura	BARI Panikachu-1	Stolon =38, Rhizome = 5	969500	228300	741200
	BARI Panikachu-2		955300	228300	727000
	BARI Panikachu-3		831200	228300	602900
	BARI Panikachu-4		515100	228300	286800
	BARI Panikachu-5		404100	228300	175800
	BARI Panikachu-6		491900	228300	263600
	Local		545200	228300	316900
Mean			673186	228300	444886
Sherpur	BARI Panikachu-1	Stolon =18, Rhizome = 8	547180	177350	369830
	BARI Panikachu-2		574740	177350	397390
Mean			560960	177350	383610

Kishoreganj	BARI Panikachu-1	Stolon =8, Rhizome = 12	423560	226500	197060
	BARI Panikachu-4		342480	226500	115980
	BARI Panikachu-5		326840	226500	100340
	BARI Panikachu-6		353720	226500	127220
Mean			361650	226500	135150

Conclusion

Considering the yield potentiality, BARI Panikachu-1 gave the highest yield of stolon and BARI Panikachu-2 the highest production of the rhizome. BARI Panikachu-1 for stolon and BARI Panikachu-2 for rhizome were found superior.

Acknowledgment: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ADAPTIVE TRIALS WITH MUKHIKACHU VARIETIES IN DIFFERENT LOCATIONS

Abstract

The experiment was conducted at MLT site Shimakhali, Magura and MLT site Karimganj, Kishoreganj during the Kharif season of 2019-20 to evaluate the performance of Mukhikachu varieties (BARI Mukhikachu-1 and BARI Mukhikachu-2) under farmers' field and to popularize and commercialize BARI developed aroid varieties among the farmers. The corm yield ranged from 9.25 to 26.15 t ha⁻¹ across the location and variety. The highest corm yield (18.34 t ha⁻¹) was found from BARI Mukhikachu-2, due to the much corm weight per plant (587 g) and the lowest from local cultivar (13.23 t ha⁻¹). The mean corm yield was comparatively higher (21.91 t ha⁻¹) in Kishoreganj compared to Magura (10.48 t ha⁻¹). The average highest gross margin (Tk. 132,600 ha⁻¹) was recorded in Jashore due to the high market price (Tk. 30 kg⁻¹) and lowest in Kishoreganj (Tk. 108127 ha⁻¹). There was not much difference in gross margin between the two locations in case of varietal difference.

Introduction

Mukhikachu (*Calocassia esculenta* var. *antiquorum*) is one of the important tuber crops of Bangladesh grown during the Kharif season. It is a carbohydrate, protein and iron and vitamin 'A' rich vegetable that is generally grown during February/March to September/October. It is considered as an important vegetable, particularly in the month of August-October when the supply of other vegetables is limited in the market. The demand of Mukhikachu in Bangladesh is increasing day by day but its yield per unit area is very low. Farmers usually grow a local variety of which yield potentiality is low and susceptible to pests and diseases. Tuber Crops Research Centre (TCRC) of BARI has developed two Mukhikachu varieties, which has high yield potential and less susceptible to pest and diseases. Only BARI Mukhikachu-1 (Bilashi) has become popular with the farmers. Some local varieties are being also cultivated by the farmers. The newly released variety is not well known to them. So, it is necessary to disseminate this variety through adaptive trials. It is, therefore, necessary to evaluate the performance of this variety and popularize as well as disseminate it in the country. With this view in mind, the trial was undertaken.

Materials and Methods

The trial was conducted at MLT site Shimakhali, Magura and MLT site Karimganj, Kishoreganj during Kharif season of 2019-20 to evaluate the performance of Mukhikachu varieties under farmers' fields and to popularize among the farmers. A local variety was used as a check which was collected from farmers. The trial was non replicated. The unit plot size was 9 m x 4.5 m (Magura) with 60 cm x 35 cm spacing and 10 m x 8 m (Kishoreganj) with 60 cm x 40 cm spacing. Thirty days old seedlings were transplanted on 7 January and 20 March, 2020 in Kishoreganj and Magura, respectively. Total amount of fertilizer was used @ N₇₀₋₁₀₅P₂₀₋₃₀K₆₀₋₉₀S₁₃₋₁₈ as urea, TSP, MoP and gypsum, respectively with CD @ 5 t ha⁻¹. The full amount of cowdung, TSP, MOP and gypsum were applied at the final land

preparation. Urea was side dressed at 20-30 and 55-60 Days after planting (DAP). The field was irrigated once at the same day of top dressing. Two weeding was done at 40 and 56 DAT. The crops were harvested from 10 September to 05 October 2020.

Results and Discussion

The results of the experiment are presented in Table 1. The highest Plant height (67cm) was recorded from BARI Mukhikachu-1 and this was the lowest in local variety (55cm). Maximum number of corms per plant and weight of corms per plant was also recorded the highest from BARI Mukhikachu-1. The highest corm yield (11.65 t ha⁻¹) was found in BARI Mukhikachu-1 and this was the lowest (9.25 t ha⁻¹) for local. Gross return (349,500 Tkha⁻¹), Gross margin (167,800 Tkha⁻¹) and BCR (1.92) were the highest for BARI Mukhikachu-1 followed by BARI Mukhikachu-2 whereas these were the lowest for Local variety.

Farmers' reaction: Farmers expressed their satisfaction with the higher yield of BARI Mukhikachu-1 and BARI Mukhikachu-2 in both locations. They are interested to grow this variety in the future.

Table 1. Yield contributing characters of BARI Mukhikachu varieties in Magura and Kishoreganj during the Rabi season, 2019-20.

Treatment	Plant height (cm)		Mean plant height (cm)	No. of corm Plant ⁻¹ (no.)		Mean corm Plant ⁻¹ (no.)
	Magura	Kishoreganj		Magura	Kishoreganj	
BARI Mukhikachu-1	67.00	80.47	73.74	12.00	36.00	24.00
BARI Mukhikachu-2	58.00	75.83	66.92	10.00	32.67	21.34
Local	55.00	55.96	55.48	8.00	40.66	24.33
	60.00	70.75	-	10.00	36.44	-

Table 2. Corm yield per plant and corm yield of BARI Mukhikachu varieties in Magura and Kishoreganj during the Rabi season, 2019-20.

Treatment	Weight of corm plant ⁻¹ (g)		Mean weight of corm plant ⁻¹	Corm yield (t ha ⁻¹)		Mean corm yield
	Magura	Kishoreganj		Magura	Kishoreganj	
BARI Mukhikachu-1	510	563	537	11.65	22.36	17.01
BARI Mukhikachu-2	480	694	587	10.53	26.15	18.34
Local	325	440	383	9.25	17.21	13.23
	438	566	502	10.48	21.91	16.19

Table 3. Cost and return analysis of BARI Mukhikachu varieties in Magura and Kishoreganj during the Rabi season, 2019-20

Location	Treatment	Price (Tk. kg ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Magura	BARI Mukhikachu-1	Corm =30	349500	181700	167800
	BARI Mukhikachu-2		315900	181700	134200
	Local		277500	181700	95800
Mean			314300	181700	132600
Kishoreganj	BARI Mukhikachu-1	10Tk/kg (BARI), 12Tk/kg (Local)	223600	125000	98600
	BARI Mukhikachu-2		261500	129560	131940
	Local		206520	112680	93840
Mean			230540	122413	108127

Conclusion

From the results, it may be concluded that BARI Mukhikachu-1 and BARI Mukhikachu-2 were found best for the corm production in Magura and Kishoreganj than the local variety.

Acknowledgment: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

Oilseed Crops

ON FARM TRIAL OF ADVANCED LINES OF RAPESEED

Abstract

An adaptive trial was conducted in the farmer's field of Pabna, Tangail and Cumilla during the Rabi season of 2020-21 with a view to evaluate the yield performance of some advanced lines of short duration mustard so that these lines could fit in the existing cropping pattern. The trial consisted of different advanced lines in the tested locations. Four lines viz. BC-100614(3)-1, BC-120114, BC-100614(4)-10 and BC-20-GS-1 along with BARI Sarisha-14 as check at Pabna; advanced lines viz. BC-100614(3)-1, BC-120114, BC-100614(4)-10, BC-20-GS-1 with one variety as check viz. BARI Sarisha-14 at Tangail; and four advanced lines viz. BC-120114, BC-100614(3)-1, BC-100614(4)-10 and BARI Sarisha-14 as check were used at Cumilla in the trial. The experiment was laid out in RCB design with three replications. Among the tested lines/varieties, the higher grain yield was obtained from BC-100614(3)-1 (1.86 t ha^{-1}) and the lowest from BC-100614(4)-10 (1.37 t ha^{-1}) in the farmer's field of Pabna. At Tangail, the highest seed yield was observed in BC-20-GS-1 (1.84 t ha^{-1}) followed by BC-100614(4)-10 (1.45 t ha^{-1}), and BARI Sarisha-14 (1.45 t ha^{-1}) whereas the lowest seed yield in BC-120114 (1.18 t ha^{-1}). At Cumilla, the advanced line BC-100614(4)-10 produced the highest seed yield (2.4 t ha^{-1}) as compared to other lines (1.9 to 2.3 t ha^{-1}) and check variety BARI Sarisha-14 (1.8 t ha^{-1}).

Introduction

Edible oil plays a key role as a source of high energy component of food in human nutrition. Bangladesh is facing acute shortage of edible oil for several decades. A huge amount of edible oil is imported annually from foreign countries to meet up the national demand. Rapeseed and Mustard are the major oilseed crop of Bangladesh on the basis of its total cultivated area and production. In 2014-15, it was cultivated in 321152 ha producing 359452 metric tons of seed with average yields of 1100 kg ha^{-1} . Farmers mostly grow the traditional variety Tori-7 as Maghi Sarisha from long past for its shorter duration (70-80 days) with average yield of 750 kg ha^{-1} . This variety is advantageous to grow in between T. Aman and Boro rice. BARI has developed a number of Mustard and rapeseed varieties with high yield potentials. Some advanced lines having higher production capacity to be released as varieties suitable for cultivation in between Aman and Boro rice. The incorporation of short duration high yielding varieties in the cropping pattern may lead to increase edible oil production in the country. The trial was undertaken to evaluate the performance of advanced lines of Mustard in the farmers' field and to select suitable high yielding lines for higher production and economic return of farmers.

Materials and Methods

The experiment was conducted in the farmer's field of Pabna, Tangail, Netrakona and Cumilla during the rabi season of 2020-21 with a view to evaluate the yield performance of some advanced lines of short duration mustard so that these lines could fit in the existing cropping pattern. The trial consisted of different advanced lines in the tested locations. Four lines viz. BC-100614(3)-1, BC-120114, BC-100614(4)-10 and BC-20-GS-1 along with BARI Sarisha-14 as check at Pabna; advanced lines viz. BC-100614(3)-1, BC-120114, BC-100614(4)-10, BC-20-GS-1 with BARI Sarisha-14 as check at Tangail; and four advanced lines viz. BC-120114, BC-100614(3)-1, BC-100614(4)-10 and BARI Sarisha-14 as check were used at Cumilla in the trial. The trial was carried out in RCB design with six dispersed replications. Seeds were sown 5 cm apart in line maintaining 30cm row spacing. Seed rate was 7.0 kg ha^{-1} . Crop management practices used in different locations shown in table 1. Half of the nitrogen and total amount of other fertilizers were applied at the time of final land preparation. The remaining half of nitrogen fertilizer was applied as top dressing at 22 DAE. Two weeding operations were done at 15 and 25 DAS. Two irrigations were applied at 25 and 45 DAE but no irrigation was applied at Cumilla. Pest protection measures and other intercultural operations were done as and when required. Data on yield and yield attributes were taken and analyzed statistically.

Table 1. Crop management of rapeseed practiced at different locations during the Rabi season, 2020-2021.

Locations	Date of sowing	Date of harvesting	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)
Pabna	22 November 2020	20 February -1 March 2021	90-27-40-10-1-1
Tangail	22 November 2020	9-17 February 2021	120-34-45-28.8-2
Cumilla	23 November 2020	13-27 February 2021	120-90-60-33-13.5-1.9

Results and Discussion

Pabna: Yield contributing characters of mustard varied significantly among the tested lines/variety in Pabna (Table 2). The advanced line BC-20-GS-1 required maximum days (98 days) whereas BARI Sarisha-14 required minimum days (89 days) to mature. The highest plant height was found in BC-20-GS-1 followed by BC-100614(4)-10 while the rest of the lines and variety showed the lowest plant height. The highest number of siliqua plant⁻¹ (45.5) was obtained from BARI Sarisha-14 and the lowest obtained from BC-20-GS-1 (38.28) which was statistically similar with all the tested lines. The line BC-100614(3)-1 showed significantly the higher number of seeds siliqua⁻¹ (36.10) while the rest of the lines and variety showed the lowest number of seeds siliqua⁻¹. Maximum weight of 1000 seeds (4.65 g) were found in BC-20-GS-1 and the minimum weight of 1000 seeds (3.23 g) was recorded in BC-100614(4)-10. The highest seed yield (1.86 t ha⁻¹) was obtained from BC-100614(3)-1 followed by BC-120114 and BC-20-GS-1. The cumulative effect of higher number of siliqua plant⁻¹ and seeds siliqua⁻¹ might be attributed to increase seed yield in the tested line BC-100614(3)-1. However, the lowest seed yield (1.37 t ha⁻¹) was recorded in BC-100614(4)-10. The tested lines of mustard did not exert significant influence on stover yield.

Tangail: Yield and yield contributing characters varied significantly among the tested lines and variety except pod length, number of effective pod plant⁻¹, seed pod⁻¹, 1000 seed weight (Table 2). The shortest days to maturity was observed in BC-100614 (3)-1 (78 days) followed by BC-120114 (80 days) and the longest days to maturity in BC-20-GS-1 (86 days). The longest plant was BC-100614(4)-10 (118.33 cm) while the shortest plant BARI Sarisha-14 (108.93 cm). The highest number of effective pods plant⁻¹ was found in BC-20-GS-1 (31.64) followed by BC-120114 (30.67) and BC-100614(3)-1 (30.39). The highest seed yield (1.84 t ha⁻¹) was observed in BC-20-GS-1 which may be contributed by the highest number of effective pod plant⁻¹ (31.64) and 1000 grain weight (3.37 g). The highest seed yield was observed in BC-20-GS-1 (1.84 t ha⁻¹) followed by BC-100614(4)-10 (1.45t ha⁻¹), and BARI Sarisha-14 (1.45t ha⁻¹) whereas the lowest seed yield in BC-120114 (1.18t ha⁻¹). In addition, the highest straw yield (3.80 t ha⁻¹) was also observed from BC-20-GS-1 and the lowest from BARI Sarisha-14(2.93 t ha⁻¹).

Cumilla: Significant variations were observed in days to maturity, plant height, Pod plant⁻¹ and Seeds pod⁻¹ (Table 2). The lowest field duration (87) was observed in BC-100614(3)-1, followed by and BC-100614(4)-10. The highest day to maturity was found from the advance line BC-120114. Maximum and minimum plant height (137.6cm) & (99.8 cm) were recorded from BC-100614(3)-1 and BARI Sarisha-14, respectively. The highest no. of pods plant⁻¹ (65.0) was recorded from BC-100614(4)-10 and the lowest (36.4) from the line BC-120114. The highest seeds pod⁻¹ (37.5) was recorded from BC-120114, which was identical to BC-100614(4)-10 lines and the lowest seeds pod⁻¹ was recorded from BARI Sarisha-14. Maximum 1000 seed weight was obtained from BC-120114 and minimum from BC-20-crs-1. The advanced line BC-100614(4)-10 produces the highest seed yield (2.4 t ha⁻¹) among all the lines and variety.

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce (Table 3). Higher gross margin was obtained from BARI developed Mustard varieties than local varieties grown by the farmers in the tested locations.

Disease and pest incidence

Rovral 50 WP @ .02% was applied to control Alternaria blight. For controlling aphids, Impel 20 SL @ .02% were used.

Farmer's opinion

Farmers of Pabna opined that the advanced mustard lines BC-100614(3)-1 had short life cycle as well as higher yield performance as compared to BARI Sarisha-14. Tangail farmers opined that the grain size and market price of new lines were much higher than local cultivar and they were interested to cultivate the improved lines *e.g.*, BC-20-GS-1 for better yield performance. Farmers of Cumilla chose advanced line BC-100614(4)-10 and BC-120114 instead of BARI Sarisha-14. According to the observation of farmers, BC-100614(4)-10 had the lower disease severity and higher grain yield.

Table 2. Yield and yield contributing characters of mustard lines and variety at Pabna, Tangail and Cumilla during the Rabi season of 2020-21.

Lines/varieties	Days to maturity	Plant height (cm)	Siliqua plant ⁻¹	Seeds siliqua ⁻¹	1000 seed wt. (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
Pabna							
BC-100614(3)-1	90 c	95.10 b	41.95 ab	36.10 a	3.45 b	1.86 a	2.72
BC-120114	90 c	97.40 b	41.00 ab	33.03 b	3.53 b	1.65 b	2.48
BC-100614(4)-10	93 b	100.28 b	45.25 ab	31.76 b	3.23 c	1.37 d	2.64
BC-20-GS-1	98 a	114.55 a	38.28 b	31.88 b	4.65 a	1.54 bc	2.81
BARI Sarisha-14	89 d	95.75 b	45.45 a	31.95 b	3.63 b	1.45 cd	2.58
CV (%)	4.54	4.76	7.21	5.57	3.61	4.62	8.27
LSD _{0.05}	0.77	7.38	4.71	2.83	0.21	0.11	ns
Tangail							
BC-100614(3)-1	78	109	30	25.5	3.3	1.4	3.5
BC-120114	81	111	31	26.7	3.2	1.2	3.2
BC-100614(4)-10	84	118	27	27.7	3.3	1.5	3.5
BC-20-GS-1	86	107	32	26.6	3.4	1.8	3.8
BARI Sarisha-14	81	109	27	25.1	3.2	1.5	2.9
LSD _{0.05}	1.5	4.8	5.5	4.3	0.2	0.2	0.7
CV (%)	1.0	2.3	9.9	8.7	3.5	8.0	9.7
Cumilla							
BARI Sarisha-14	89	99.8	43.5	33.7	4.3	1.8	-
BC-120114	91	108.3	36.4	37.5	4.7	2.3	-
BC-100614(4)-10	89	110.5	65.0	36.6	4.6	2.4	-
BC-100614(3)-1	87	137.6	40.0	34.2	4.2	2.1	-
BC-20-crs-1	89	115.7	47.5	36.1	4.1	1.9	-
LSD (0.05)	-	4.96	8.71	4.79	0.37	0.35	-
CV (%)	-	2.27	7.21	6.79	7.94	7.46	-

Table 3. Cost and return analysis of different Mustard varieties at different locations during the year of 2020-21

Location	Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Pabna	BC-100614(3)-1	132920	59250	73670
	BC-120114	117980		58730
	BC-100614(4)-10	97840		38590
	BC-20-GS-1	112020		52778
	BARI Sarisha-14 (check)	104080		44830
Tangail	BC-100614(3)-1	81590	46620	34970
	BC-120114	70480		23860
	BC-100614(4)-10	86130		39510
	BC-20-GS-1	108680		62060
	BARI Sarisha-14	82650		38960

Grain price: Tk. 70 kg⁻¹, 57 kg⁻¹ and Stover: Tk.1 kg⁻¹

Conclusion

Being short duration as well as higher yield potential, the lines BC-100614(3)-1 can be released as a new variety which can be easily fitted into Mustard-Boro-T. Aman cropping pattern in Pabna. In Tangail, the advanced lines BC-20-GS-1, BARI Sarisha-14, BC-100614(4)-10, BC-100614(3)-1 produced the highest seed yield and easily fit in Mustard-Boro-T. Aman rice cropping pattern due to its' short field duration. In Cumilla, the advanced line BC-100614(4)-10 produced the highest seed yield as compared to other line and check variety but took similar days to mature as check variety BARI Sarisha-14. Therefore, suitable advanced lines and varieties to be extended in the tested locations according to yield performance, field duration and farmers choice.

ON FARM TRIAL OF MUSTARD GENOTYPE IN HIGH BARIND TRACT (HBT) AND LEVEL BARIND TRACT

Abstract

A field trial was conducted in the farmer's field at FSRD site, Basantapur, Godagari, Rajshahi under High Baring Tract (HBT) and at MLT site, Joypurhat under Level Barind Tract (LBT) during the Rabi 2020-21 cropping season to assess the performance of mustard genotypes. Two lines and one check variety of mustard viz., BJDH-12, JUN-536 and BARI Sharisha-16 were tested in the trial. In HBT, among the tested genotypes BJDH-12 gave maximum seed yield (1.84 t ha^{-1}) followed by BARI Sarisha-16 (1.67 t ha^{-1}) and the JUN-536 gave minimum yield (1.64 t ha^{-1}). In Level Barind Tract, the highest seed yield 1.96 t ha^{-1} was recorded from BJDH-11 followed by Jun-536 (1.37 t ha^{-1}) whereas the lower seed yield 1.24 t ha^{-1} was obtained from BARI Sarisha-16.

Introduction

High Barind Tract is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2006). Moisture holding capacity of HBT soil is poor due to critical organic matter contents and low infiltration of water (Adham *et al.*, 2010; Ali, 2000). The area also has acute deficit of fuel wood. Thus, farmers normally used cowdung as a cooking fuel. Boro-T. Aman rice is one of the popular cropping patterns in Rajshahi region. There is a big scope to introduce short or semi-long duration mustard variety between T. Aman and Boro rice. Farmers mostly used Tori-7 due to its short duration. The old variety give very low seed yield as well as stover. Oilseed Research Centre of BARI has developed some mustard varieties and also have some promising lines those should test their performance in Barind condition. It needs to evaluate the performance of seed and stover yield in the farmers' field. With this view, the experiment was designed to evaluate the field performance of some mustard genotypes in Mustard-Boro-T. Aman rice cropping pattern in farmer's field in Barind area.

Materials and Methods

An experiment on mustard genotypes was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi under High Baring Tract (HBT) and at MLT site, Joypurhat under Level Barind Tract (LBT) during the Rabi 2020-21 cropping season. Two lines viz. BJDH-12, JUN-536 along with BARI Sharisha-16 (check) were tested in the trial at both sites. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 30 m^2 at HBT and 20 m^2 at Level Barind Tract. Treatments were randomly assigned in each replication. The land was opened with a power tiller. Later on, ploughing and cross ploughing were done followed by laddering. Weeds, stubble and crop residues were removed. Full doses of cowdung, half of the urea and all other inorganic fertilizers were applied according to individual plot and mixed with soil at the time of final land preparation in HBT. The rest urea was top dressed after 1st irrigation at 20-25 days after sowing. Cowdung was not applied and application methods of all fertilizers were same in Level Barind Tract. First weeding was done at the time of first thinning, and second weeding and thinning were done

at 20 days after planting of mustard seeds. The fields were infested with aphid and *Alternaria* leaf spots. Insecticide Sobicron and fungicide Rovral 50wp were applied three times at 7 to 10 days intervals depending on pest incidence. When 80% of the siliques turned brown in colour, the crop was assessed to attain maturity. Data were collected on different yield and yield components and analyzed statistically with open-source software R (R Core Team, 2019). The sowing and harvesting date of mustard of both sites are given in Table 1.

Table 1. Crop management of mustard practiced at different locations.

Locations	Date of sowing	Date of harvesting	Fertilizer dose (N-P-K-S-B- CD kg ha ⁻¹)
High Barind Tract	11 November, 2020	6 March, 2021	115-35-35-30-1-5000
Level Barind Tract	22 November, 2020	5 March, 2021	120-34-45-30-1.8

Results and Discussion

High Barind Tract: The yield and yield attributes of mustard genotypes were presented in Table 2. Maximum days to maturity were found in BJDH-12 (109.33 days) line; and minimum and similar days were required for BARI Sharisha-16 (104 days) and JUN-536 (104 days). Maximum plant height was found in BJDH-12 (193.33 cm) mustard line and minimum was found in BARI Sharisha-16 (156.33 cm). The highest silique plant⁻¹ (154.67), seeds silique⁻¹ (14.13), 1000-seed weight (3.31 g) and seed yield (1.84 t ha⁻¹) were found in BJDH-12 mustard line and the lowest silique plant⁻¹ (127.40) was recorded from JUN-536. The number of seeds silique⁻¹ was the lowest in BARI Sarisha-16 (10.40). The 1000-seed weight was not varied among the three genotypes. The seed yields of mustard genotypes were identical for BARI Sarisaha-16 (1.65 t ha⁻¹) and JUN-536 (1.64 t ha⁻¹). Maximum straw yield was found in BJDH-12 (4.01 t ha⁻¹) mainly due to higher plant height. Minimum yield was found in BARI Sharisha-16 (3.83 t ha⁻¹). It was found that BJDH-12 mustard line gave better performance in the farmer's field.

Level Barind Tract: The yield and yield contributing characters were varied significantly among the treatments (Table 2). Plant height was varied among the mustard genotypes. The highest plant height (182.37 cm) was observed in BJDH-11 followed by BARI Sarisha-16 (170.33 cm) and the lowest plant height was found in Jun-536 (162.97 cm). Maximum silique plant⁻¹ were obtained from BJDH (113.0) which was identical to Jun-536 and BARI Sarisha-16, respectively. Maximum seeds silique⁻¹ were observed in BJDH-11 (12.73) followed by Jun-536 (11.53), and minimum seeds silique⁻¹ was found in BARI Sarisha-16 (10.93). The highest 1000- seeds weight was obtained from BJDH-11 (4.33 g) and the lowest 1000-seeds weight was found in BARI Sarisha-16 (3.50 g) which was statistically similar to that of Jun-536 (3.60 g). The highest seed yield was observed in BJDH-11 (1.96 t ha⁻¹) followed by Jun-536 (1.39 t ha⁻¹) and the lowest was obtained from BARI Sarisha-16 (1.22 t ha⁻¹). Like grain yield, the highest stover yield was found from BJDH-11 (2.97 t ha⁻¹) followed by Jun-536 (2.54 t ha⁻¹) and the lowest stover yield was observed in BARI Sarisha-16 (2.31 t ha⁻¹).

Cost and Return at Level Barind Tract

Economic analysis is presented in Table 3. The highest gross return Tk. 123640.0 was obtained from BJDH-11 followed by Jun-536 (Tk. 88340) and the lowest gross margin Tk. 78080 was from BARI Sarisha-16. The higher gross return contributed to the higher gross margin in BJDH-11 (Tk. 87970 ha⁻¹) and the lower in BARI Sarisha-16 (Tk. 42410 ha⁻¹) against the cultivation cost of Tk. 35670 ha⁻¹.

Farmer's reaction

Farmers of HBT were happy to get higher yield from the BJDH-12 mustard line. Pest attack was lowest in the germplasm. However, farmers of Level Barind Tract were happy to get higher yield both from the BJDH-12 and Jun-536 mustard lines. Pest attack was lowest in that germplasm also.

Table 2. Yield and yield attributes of Mustard genotypes at High Barind Tract and Level Barind Tract during Rabi 2020-21

Treatment	Days to flower	Days to maturity	Plants m ⁻²	Plant height (cm)	Siliqua plant ⁻¹	Seeds Siliqua ⁻¹	1000 Grain wt. (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
High Barind Tract									
BARI Sarisha-16	40	104	53	151	155	10	3.3	1.65	3.83
BJDH-12	41	109	55	170	155	14	3.3	1.84	4.01
JUN-536	37	104	52	146	127 b	13	3.2	1.64	3.97
LSD (0.05)	1.9	2.4	NS	22.2	12.8	2.3	0.6	0.1	0.1
CV (%)	2.3	1.9	4.02	6.3	5.94	8.34	5.98	2.77	0.94
Level Barind Tract									
BARI Sarisha-16			88	170b	103b	11 b	3.5b	1.2 b	2.3 b
BJDH-11			93	182a	113a	13 a	4.3a	2.0 a	3.0 a
Jun-536			90	163c	107ab	12ab	3.6b	1.4 b	2.5 a
CV (%)			10.7	7.0	9.1	6.0	4.2	5.97	4.66

Table 3. Cost and return analysis of different mustard genotypes obtained from experimentation conducted during the Rabi season, 2020-21 at MLT site, Joypurhat (Level Barind Tract)

Treatment	Total return (Tk ha ⁻¹)			Total cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
	From grain	From straw	Total		
BARI Sarisha-16	73460	4620	78080	35670	42410
BJDH-11	117700	5940	123640	35670	87970
Jun-536	83260	5080	88340	35670	52670

*Grain= 60.0 Tk kg⁻¹ *Straw= 2.0 Tk kg⁻¹

Conclusion

The performance of BJDH-12 mustard line was better than other BARI mustard genotypes tested at Basantapur, Godagari, Rajshahi during the study period. So, BJDH-12 mustard line may be recommended for releasing mustard variety for High Barind Tract. In Level Barind Tract, it can be concluded that the tested genotypes i.e., BJDH-11 and Jun-536 were higher yielder than BARI Sarisha-16.

ON-FARM TRIAL OF LONG DURATION BARI MUSTARD VARIETIES

Abstract

The trial was conducted at the MLT site, Shibpur, Puthia, Rajshahi during the rabi season of 2020-21 to evaluate the performance of long duration mustard varieties in the farmers' field. BARI sarisha-11, BARI Sarisha-16 and BARI sarisha-18 were included in the study. The experiment was designed in RCB with six dispersed replications. The highest yield (2.42 t ha⁻¹) and gross margin (Tk. 116255 ha⁻¹) was obtained from BARI Sarisha-11. The lower yield (2.23 t ha⁻¹) obtained from BARI Sarisha-18 in the farmers' field at Rajshahi.

Introduction

Bangladesh imports a huge amount of vegetable oil seed in every year to meet up the annual demand. Mustard is the major oil seed crop in Bangladesh. It covers about 70% of the total oil seed production. The yield of this crop in Bangladesh is much lower than other oilseed producing countries due to lower yield potentiality of the existing local varieties along with poor management practices. The national average yield of Mustard is 0.74 t ha⁻¹ (Mondal and Wahab, 2001). Long duration high yielding varieties of Mustard can be fitted well in the existing cropping pattern of both Faridpur and Puthia upazila of Rajshahi where farmers are used to cultivate short duration Mustard variety between T. Aman and T. Aus rice as a result the lands remain fallow for longer period. To utilize this fallow period, high yielding long duration Mustard varieties can be cultivated. Oilseed Research Centre (ORC) of BARI has

developed some long duration varieties of Mustard which are supposed to be high yielder, less disease susceptible and higher oil content (44%) and can be fitted in the existing cropping pattern. The varieties needed to validate their performance under farmers situation. Hence the study was undertaken to evaluate the performance of the variety under farmer's field condition.

Materials and Methods

The experiment was carried out at MLT site Shibpur, Puthia and Paba Rajshahi during 2020-2021. The experiment was laid out in RCB design with 6 (six) dispersed replications. The unit plot size was 8m x 5m with 10 cm x 10 cm spacing. Tested garlic varieties were BARI Sarisha-11, BARI Sarisha-16 and BARI Sarisha-18. Fertilizers were applied @ 126.70 - 35 - 46.25 - 29.67 - 2.51 - 2.12 kg ha⁻¹ NPKSZn and B, respectively. Full amount of all fertilizers and half of urea were applied as basal. The rest of urea was applied as top dress at 26 days after sowing (DAS). The seed sowing date was on 17-23 November, 2020. Irrigation was applied two times at 25 and 63 DAS. One weeding and thinning was done in mustard field. Rovral@2 ml L⁻¹ was applied for controlling alternaria blight of mustard. The crop was harvested during 04-08 March 2021. Necessary data were recorded and analyzed as per objectives. All necessary data were collected and analyzed through R software.

Results and Discussion

Days to maturity of BARI Sarisha-11, BARI Sarisha-16 and BARI Sarisha-18 were found 105, 107 and 97 days, respectively (Table 1). The tallest plant (142.4 cm) was recorded in BARI Sarisha-16 followed by BARI Sarisha-11 (139 cm) and shortest plant height was recorded in BARI Sarisha-18 (115.4 cm). The height silique/plant was found BARI Sarisha-16 (136.6) followed by BARI Sarisha-11 (115.4) and lowest in BARI Sarisha-18 (79.8) which is statistically similar with BARI Sarisha-11. The height seed/silique was found BARI Sarisha-18 (21.4) followed by BARI Sarisha-11 (12.2) and lowest in BARI Sarisha-16 (9.5). The highest thousand seed weight was obtained from BARI Sarisha-16 (4.18 g) followed by BARI Sarisha-11 (3.77 g) and the lowest from BARI Sarisha-18 (3.48 g). The maximum seed yield (2.43 t ha⁻¹) was obtained from BARI Sarisha-11 followed by BARI Sarisha-16 (2.35 t ha⁻¹) and the minimum in BARI Sarisha-18 (2.23 t ha⁻¹). The highest straw yield was found in BARI Sarisha-16 (4.28 t ha⁻¹) followed by BARI Sarisha-11 (4.24 t ha⁻¹) and the lowest from BARI Sarisha-18 (3.7 t ha⁻¹). The higher gross return (Tk 169400 ha⁻¹) and gross margin (Tk 116225 ha⁻¹) was recorded from BARI Sarisha-11 followed by BARI Sarisha-18 (Tk 167250 ha⁻¹ and Tk 114075 ha⁻¹) and BARI Sarisha-16 (Tk 164500 ha⁻¹ and Tk 111325 ha⁻¹).

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce. Higher gross margin was obtained from BARI developed mustard varieties than local varieties grown by the farmer's in the tested locations (Table 2).

Farmer's opinion

BARI Sarisha-18 should be recommended for wide cultivation in Mustard- T. Aus rice -T. Aman-cropping pattern. BARI Sarisha-18 provides quality oil and very high consumers demand. Farmers get higher price (per Kg) from BARI Sarisha-18. So, they want to cultivate BARI Sarisha-18.

Table 1: Yield and yield attributes of BARI developed long duration mustard varieties at MLT site Shibpur, Puthia and Paba Rajshahi during 2020-2021

Variety	Days to maturity	Plant height (cm)	Branch plant ⁻¹	Silique plant ⁻¹	Seed silique ⁻¹	1000 seed weight (g)	Seed yield t ha ⁻¹	Straw yield t ha ⁻¹
BARI Sarisha-11	105 a	138.8 a	3.6 a	115.4 b	12.2 a	3.77 b	2.42 a	4.24 ab
BARI Sarisha-16	107 a	142.4 a	3.2 a	137.6 a	9.5 b	4.18 a	2.35 a	4.28 a
BARI Sarisha-18	97 b	115.4 b	3.0 a	79.8 b	21.4 a	3.48 c	2.23 a	3.7 b
LSD (0.05)	0.45	9.67	1.37	6.69	3.93	0.25	0.105	0.54
CV (%)	1.94	10.20	18.7	11.44	16.3	4.51	6.66	9.19

Table 2. Cost and return analysis of BARI developed long duration mustard varieties at MLT site Shibpur, Puthia and Paba Rajshahi during 2020-2021

Varieties	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Sarisha-11	2.42	169400	53175	116225
BARI Sarisha-16	2.35	164500	53175	111325
BARI Sarisha-18	2.23	167250	53175	114075

Market price of BARI Sarisha-18 grain @ Tk.75 kg⁻¹, BARI Sarisha-11 and 16 grain @ Tk.70 kg⁻¹ Straw @ Tk.1.00 kg⁻¹

Conclusion

At Rajshahi, BARI Sarisha-11 gave higher yield, but farmers prefer BARI Sarisha-18 (Kanola brand) due to higher consumers demand.

ADAPTIVE TRIAL OF ADVANCED LINES OF MUSTARD

Abstract

An adaptive trial was conducted at the farmer's field of Noapara, Sadar Dakkhin, Cumilla, during the Rabi season of 2020-21 with a view to select short duration high yielding variety of rapeseed to fit in between T. Aman-Boro rice. Six advanced lines i.e. NAP-15029, NAP-16041, NAP-16064, NAP-16068, NAP-0865 and NAP-0876 with two mustard variety (BARI Sarisha-8 and BINA Sarisha-9) were used in the trial as a check. Among the tested varieties/lines, NAP-0876 and NAP-16041 produced higher seed yield (1.68 t ha⁻¹ and 1.673 t ha⁻¹, respectively) with slightly lower days to maturity compared to BARI Sarisha-8 and BINA Sarisha-9.

Introduction

Mustard is the main oil crop in our country covering 70 % of the total area and production of oil crops. An acute shortage of edible oil has been prevailing in our country. It produces only 33 % of the national demand and the rest amount of oil is met up by importing at the cost of huge amount of foreign currency. The average yield of mustard in Bangladesh is very low (990 kg ha⁻¹) compare to world context. The reason behind this lower yield is genetically low yield potential of local varieties and poor management practices. Farmers cultivate mustard mostly low yielder local variety Tori-7. BARI and BINA have developed high yielding varieties BARI Sarisha-8, BINA Sarisha-9, etc. and need to cover large area by replacing Tori-7. Some advanced lines of mustard showed better performance during the previous year. But before releasing these lines as varieties, performance would be tested in the farmers' field. So the present study was undertaken (i) to evaluate the performance of short duration advanced lines of mustard in the farmer's field in the different locations of Bangladesh (ii) To select lines to fit in between T. Aman and Boro rice and (ii) to develop high yielding variety of mustard.

Materials and Methods

The experiment was carried out in the farmer's field of Noapara, Sadar Dakkhin, Cumilla, during the Rabi season of 2020-21 by using Randomized Complete Block Design (RCBD) having three replications. The individual size of the plot was 3.9 m × 3.0 m having 13 rows, where block to block and plot to plot distances were 50 cm and 40 cm, respectively. Line to line and seed to seed distances were 30 cm and 4-5 cm, respectively. Seed rate of mustard was 07 kg ha⁻¹ and seeds were sown on 20 November, 2020. The soil of the experimental plot was clay loam. Fertilizers were applied at the rate of 120- 90- 60- 33- 13.5 and 1.9 kg per ha of N, P, K, S, Zn and B in the form of Urea, Triple Super Phosphate, Muriate of Potash, Gypsum, Zinc Oxide and Boric acid, respectively in the field. Half of Urea and all other fertilizers were applied during final land preparation. The rest of Urea was top dressed at 22 Days after Sowing (DAS). Six advanced lines i.e. NAP-15029, NAP-16041, NAP-16064, NAP-16068, NAP-0865 and NAP-0876 with two mustard varieties BARI Sarisha-8 and BINA Sarisha-9 were used in the trial as check. Two weeding & thinning and no irrigation were done during the cropping period. Necessary measures were taken for controlling aphids, cut worm and Alternaria leaf spot

disease. The crop was harvested on 16 February, 2021. Data were collected days to 50% flowering, days to maturity, plant height (cm), branch plant⁻¹, pods plant⁻¹, seed pod⁻¹, weight of 1000 seed (g) and seed yield(t ha⁻¹). The data were analyzed using Statistix10 program.

Results and Discussion

Yield and yield attributes of different advanced lines and varieties of mustard are presented in Table 1. Variations were observed in yield and yield attributing characters of mustard genotypes. Significant variations were observed in days to 50% flowering, days to maturity, plant height, Pod plant⁻¹ and 1000 Seed weight. The lowest days to 50% flowering (44.67d) was observed in NAP-16068, which was similar to NAP-15029, NAP-0876, NAP-0865 and NAP-16041. The highest days to 50% flowering (47.67d) was observed in BARI Sarisha-8 and BINA Sarisha-9. The lowest days to maturity (87.33) was observed in NAP-16041, which was identical to NAP-0876, NAP-0865 and NAP-15029. The highest days to maturity (89.0d), was required for BINA Sarisha-9, which was similar to BARI Sarisha-8, NAP-16064 and NAP-16068. The lowest plant height (90.47cm) was observed in NAP-15029, followed by NAP-0865 (92.73cm) and the highest plant height (110.73cm) was recorded from BINA Sarisha-9, followed by NAP-16041, BARI Sarisha-8 and NAP-16068. The highest No. of branch plant⁻¹ (4.67) was recorded from NAP-0865 and the lowest (2.8) from the line NAP-16041. Other lines and check varieties produced moderate No. of branch plant⁻¹. The highest No. of Pods plant⁻¹ (64.53) was recorded from BINA Sarisha-9, followed by NAP-0865 and the lowest (42.33) from the line NAP-16041, which was at par with NAP-16064 (45.33). There was no significant difference in seeds pod⁻¹ of all the lines/varieties. Numerically, higher seeds pod⁻¹ (30.8) was recorded from BINA Sarisha-9, followed by NAP-0876 (29.4) and the lower seeds pod⁻¹ was recorded from NAP-16064 (27.57). Maximum 1000 seed weight (3.6) was obtained from NAP-16064 and minimum (3.07) from NAP-16041. Considering the seed yield, there was no significant difference between all the lines/varieties. Numerically the advanced line NAP-0876 produced higher seed yield (1.68 t ha⁻¹), followed by NAP-16041 (1.673 t ha⁻¹) among all the lines and variety. Lower yield (1.43 t ha⁻¹) was found from NAP-16064.

Farmer's Reaction

Farmers opined that more promising mustard line was found from adaptive trial. They chose advanced line NAP-0876 and NAP-16041 instead of BARI Sarisha-8 and BINA Sarisha-9. The farmers of this location preferred these two lines for future cultivation.

Table 1. Yield and yield attributes of different advanced lines and mustard varieties in the farmers field of Noapara, Sadar Dakkhin, Cumilla during the Rabi season of 2020-21

Variety/ Lines	Days to 50% flowering	Maturity Days	Plant height (cm)	Branch plant ⁻¹	Pods plant ⁻¹	Seeds Pod ⁻¹	1000 seeds Wt. (g)	Seed yield (t ha ⁻¹)
NAP-15029	45.3	87.7	90.5	4.1	94.9	29.2	3.20	1.580
NAP-16041	45.7	87.3	104.1	2.8	42.3	29.2	3.07	1.673
NAP-16064	46.3	88.0	96.4	3.6	45.3	27.6	3.60	1.430
NAP-16068	44.7	88.0	103.3	3.4	50.3	28.1	3.20	1.533
NAP-0865	45.7	87.7	92.7	4.7	60.3	27.9	3.33	1.480
NAP-0876	45.7	87.7	100.6	3.3	46.7	29.4	3.47	1.680
BARI Sarisha-8	47.7	88.3	103.9	3.7	56.5	28.8	3.27	1.633
BINA Sarisha-9	47.7	89.0	110.7	3.7	64.5	30.8	3.27	1.487
CV (%)	1.33	0.79	5.51	5.20	4.97	6.54	7.26	9.45
LSD (0.05)	1.07	1.22	9.67	0.33	4.58	NS	0.42	NS

Conclusion

From the field experiment, it may be concluded that the advanced line NAP-0876 produced the highest seed yield compared to other line and check variety. The advanced line required less days to maturity than check variety BARI Sarisha-8 and BINA Sarisha-9. Disease severity was higher in BARI Sarisha-14 than the advanced lines.

ON FARM TRIAL OF BARI SESAME VARIETIES

Abstract

An experiment was conducted at Monipur, Sadardakh, Cumilla; Shauta and Vadalía village under Sadar upazila of Kushtia and the FSRD site, Faridpur during the Kharif I season of 2020 to evaluate the performance of advanced lines of sesame in the farmers' field and to select suitable varieties for the tested locations. Four varieties i.e. BARI Til-3, BARI Til-4, Binatil-1 and Binatil-2 were used at Cumilla. Three BARI released Sesame varieties viz. BARI Til-3 and BARI Til-4 with local variety as check at Vadalía, Kushtia; three advanced lines of sesame viz. Ses-MR-20, Ses-PR-20, Ses-2010-OIR with BARI Til-4 and Binatil-1 were tested at Shauta, Kushtia; and four advanced lines viz. Ses-9768, Ses FR-20, Ses-PR-20 and Ses MR-20 along with a check variety BARI Til-4 at Faridpur were evaluated in the study. In Cumilla, BARI Til-4 produced the highest seed yield compared to other varieties. At Vadalía of Kushtia, BARI Til-4 (1.59 t ha^{-1}) produced the highest seed yield followed by BARI Til-3 (1.41 t ha^{-1}). At Shauta of Kushtia, Ses-MR-20 produced the highest seed yield (1.61 t ha^{-1}) and economic return than other varieties and advanced lines. In Faridpur, Ses MR-20 (0.8 t ha^{-1}) provided the higher yield than BARI Til-4. The yields of all varieties were poor due to water logging condition at seed formation stage in this season.

Introduction

Sesame (*Sesamum indicum*) is one of the important oil crops grown during the kharif season in Bangladesh. It is cultivated in almost everywhere of the country. Sesame contains 42-50% oil and 25% protein. The average yield of Sesame in the country is low compared to world context. In Kushtia and Faridpur district, it is grown intensively. Farmers mostly grow the traditional variety T-6 from long past with minimum input and low yield having average yield of 850 kg ha^{-1} . There is ample scope of replacing the traditional cultivar by the improved high yielding varieties. Oilseed Research Centre, BARI has developed some high yielding Sesame varieties that have significant yield advantage over local variety. Some advanced lines of Sesame showed better performance during the previous years. But before releasing these lines as varieties, performance should be tested in the farmers' field. The present study was undertaken to evaluate the field performance of different varieties and lines at farmers' field.

Materials and Methods

The experiment was conducted at the farmer's field of Monipur, Sadardakh, Cumilla under AEZ-19; at Shauta and Vadalía village under Sadar upazila of Kushtia and the FSRD site, Faridpur during the Kharif I, 2020 to evaluate the performance of advanced lines of Sesame in the farmers' field and to select suitable varieties for the tested locations. Four varieties i.e. BARI TIL-3, BARI TIL-4, Binatil-1 and Binatil -2 were evaluated at Cumilla. Three BARI released Sesame varieties viz. BARI Til-3 and BARI Til-4 with local variety as check at Vadalía, Kushtia; three advanced lines of sesame viz. Ses-MR-20, Ses-PR-20, Ses-2010-OIR with BARI Til-4 and Binatil-1 were tested at Shauta, Kushtia. Four advanced lines viz. Ses-9768, Ses FR-20, Ses-PR-20 and Ses MR-20 along with a check variety BARI Til-4 were evaluated at Faridpur. The trial was carried out in RCB design with five dispersed replications. Seeds were sown @ 7 kg ha^{-1} maintaining 30 cm row spacing. Sowing and harvesting time along with fertilizers details are given in Table 1. Half of urea and all other nutrients were applied as basal during final land preparation. The rest half of urea was applied at 25-30 DAS. One weeding and thinning was done at 20-25 DAS. Irrigation was applied one time at 30-35 DAS. Data on different plant characters were recorded and analyzed statistically.

Table 1. Crop management practices of sesame used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha^{-1}) N-P-K-S-Zn-B
Cumilla	4 April, 2020	23 June, 2020	52-27-22.5-19-1.80-1.50
Vadalía, Kushtia	14-18 March, 2021	2-5 June, 2021	55-28-22.5-19-1.8-1.8
Shauta, Kushtia	18 March, 2021	7 June, 2021	120-140-45-105-5-10
Faridpur	19 March, 2020	28 May to 15 June, 2020	100-40-40-20-3-2

Results and Discussion

Cumilla: Variations were observed in yield and yield attributing characters of sesame genotypes (Table 2). Maximum and minimum plant height (143.4 cm) & (106.2cm) were recorded from BARI Til-3 and Binatil-1, respectively. The highest pods plant⁻¹ (48.20) was recorded from BARI Til-3 followed by BARI Til-4 and the lowest (23.60) from the Binatil-1. The highest seeds pod⁻¹ (92.80) was recorded from BARI Til-4 followed by BARI Til-3 and the lowest seeds pod⁻¹ (60.87) was recorded from Binatil-2. The variety BARI Til-4 produces the highest seed yield (1.50 t ha⁻¹) among the tested variety.

Vadalia, Kushtia: Days to maturity were found 78 days in case of all varieties (Table 2). The highest thousand seed weight was obtained from Local (2.90 g) and the lowest from BARI Til-3 (2.73 g). The highest seed yield (1.59 t ha⁻¹) was obtained from BARI Til-4 followed by local (1.42 t ha⁻¹) and BARI Til-3 (1.41 t ha⁻¹), respectively.

Shauta, Kushtia: Days to maturity of Ses-MR-20, Ses-PR-20, Ses-2010-O1R, BARI Til-4, Binatil-1, were found 78, 77, 78, 80 and 80 days, respectively (Table 2). The highest plant height (99.33 cm) was recorded in BARI Til-4 than other such as Binatil-1 (89.67 cm), Ses-2010-O1R (89.50 cm), Ses-PR-20 (80.23 cm) and Ses-MR-20 (75.93 cm), respectively. Maximum 1000 grain weight was obtained from BARI Til-4 (3.03 g) and minimum from Ses-MR-20 (2.77 g). The highest grain yield (1.61 t ha⁻¹) was obtained from Ses-MR-20 followed by BARI Til-4 (1.60 t ha⁻¹), Ses-2010-O1R (1.59 t ha⁻¹), Ses-PR-20 (1.49 t ha⁻¹), and the lowest in Binatil-1 (1.42 t ha⁻¹). The highest straw yield was found in Ses-PR-20 (2.18 t ha⁻¹) and the lowest from Ses-2010-O1R (1.85 t ha⁻¹).

Faridpur: The highest plant height (110.75 cm) was observed in Ses MR-20 and the lowest in Ses PR-20 (88.60 cm) (Table 2). The highest (25.37) number of siliqua plant⁻¹ was obtained from Ses MR-20 and the lowest in Ses-9768 (17.92) which was statistically similar with other lines/varieties. The 1000-seed weight was the highest recorded from Ses MR-20 (2.65g) and the lowest in Ses- 9768 (2.25g). Maximum seed yield (821 kg ha⁻¹) was obtained from Ses MR-20 and minimum (426 kg ha⁻¹) in Ses-9768. Maximum number of siliqua plant⁻¹ and larger seed size contributed to produce higher seed yield of Ses MR-20. Sesame line Ses MR-20 was survived 5 to 6 days under 2-3 cm waterlogged condition during seed formation stage (Total rainfall during 2nd week of May, 2020 was 75 mm) but others lines even BARI Til-4 do not survive and harvested before maturity as a result yield of all the lines were poor except ses MR-20.

Cost and return analysis

Economic return was differed over the locations due to yield variation and prevailing market price of product. Higher gross margin was obtained from BARI developed Sesame varieties than local varieties grown by the farmers in the tested locations (Table 3). However, cost and return analysis at Faridpur revealed that gross margin was negative in all advance line except MR-20.

Farmer's opinion

At Cumilla, farmers' reaction was very positive to BARI developed BARI Til-4 against BINA developed varieties due to its higher yield and profit. They have chosen BARI Til-4 due to its higher yield and benefit. Farmers of Vadalia village, Kushtia have chosen BARI Til-4 due to its higher yield and farmers of Shauta village, Kushtia have chosen Ses-2010-O1R due to its comparatively higher market price. However, farmers of Faridpur expressed their opinion in favour of SesMR-20 due to its waterlogging tolerance. They are interested to get this line as a variety in the next time.

Table 2. Yield and yield attributes of sesame varieties at different locations during Kharif season 2020

Cumilla						
Varieties /Lines	Plant population m ⁻²	Plant height (cm)	Branch plant ⁻¹	Pods plant ⁻¹	Seeds pod ⁻¹	Seed yield (t ha ⁻¹)
BARI Til-3	66.0	143.4	3.4	48.20	72.40	1.35
BARI Til-4	66.0	129.0	3.6	43.60	92.80	1.50
Binatil-1	67.5	106.2	2.0	23.60	70.24	0.73
Binatil-2	66.50	115.0	3.0	26.20	60.87	1.33

LSD	ns	1.62	1.45	1.45	1.31	0.61
CV (%)	7.11	6.98	4.91	7.21	5.71	8.79
Vadalia, Kushtia						
Varieties /Lines	Days to maturity	Plant population m ⁻²	Pods plant ⁻¹	Seeds Pod ⁻¹	1000 grain weight (g)	Grain yield (t ha ⁻¹)
BARI Til-3	78	37.25	51.70	88.43	2.73	1.41
BARI Til-4	78	38.25	64.55	100.3	2.83	1.59
Local	78	37.50	58.88	77.65	2.90	1.42
CV(%)	11.33	9.61	8.43	9.67	7.33	5.67
F-test	NS	NS	*	*	**	**
Shauta, Kushtia						
Varieties /Lines	Days to maturity	Plant population m ⁻²	Plant height (cm)	1000 grain weight (g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Ses-MR-20	78	37.67	75.93	2.77	1.61	2.02
Ses-PR-20	77	33.67	80.23	2.97	1.49	2.18
Ses-2010-O1R	78	39.33	89.50	2.80	1.59	1.85
BARI Til-4	80	39.00	99.33	3.03	1.60	1.95
Binatil-1	80	34.00	89.67	2.03	1.42	1.99
CV (%)	11.67	10.33	9.67	7.33	8.33	13.05
F-test	NS	NS	NS	*	**	NS
Faridpur						
Varieties /Lines	Plant population (m ⁻²)	Plant height (cm)	Siliqua plant ⁻¹	Seed pod ⁻¹	1000-seed wt. (g)	Seed yield (kg ha ⁻¹)
BARI Til-4	23.71 b	103.15 b	18.08 c	66.88 a	2.45 b	567 b
Ses -9768	19.99 c	96.75 bc	17.92 c	65.40 a	2.25 c	426 c
Ses FR-20	18.97 cd	92.90 cd	18.53 c	61.55 ab	2.38 bc	449 c
Ses PR-20	18.05 d	88.60 d	21.30 d	57.17 b	2.43 b	433 c
Ses MR-20	25.77 a	110.75 a	25.37 a	64.40 ab	2.65 a	821 a
CV (%)	4.94	4.64	8.11	7.68	3.66	12.72

Table 3. Cost and return analysis of different mustard varieties at different locations during the year of 2020-21.

Location	Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Cumilla	BARI Til-3	135000.00	45680.00	89320.00
	BARI Til-4	150000.00		109320.00
	Binatil-1	73000.00		27320.00
	Binatil-2	133000.00		87320.00
Vadalia, Kushtia	BARI Til-3	88125	40810	47315
	BARI Til-4	95000		54190
	Local	92300		52120
Shauta, Kushtia	Ses-MR-20	100625	51400	49225
	Ses-PR-20	93125		41725
	Ses-2010-01R	103350		51950
	BARI Til-4	100000		48600
	Binatil-1	88750		37350
Faridpur	BARI TIL-4	38273	56352	-18079
	Ses -9768	28755	55152	-26397
	Ses FR-20	30308	55152	-24844
	Ses PR-20	40053	55352	-15292
	Ses MR-20	75943	58952	16991

Market price at Cumilla: Unit price of sesame Tk. 100 Kg⁻¹Market price at Kushtia: Price: BARI Till-3 & 4, Binatil-1, Ses-MR-20, Ses-PR-20 @ 62.5 Tk. Kg⁻¹; Ses-2010-01R and local @ 65 Tk. kg⁻¹ Market price at Faridpur: BARI Til-4, SES -9768, SES FR-20: Tk.67.50 kg⁻¹, SES PR-20 and SES MR-20: Tk. 92.50 kg⁻¹

Conclusion

At Cumilla, BARI Til-4 provided the higher yields over the BINA that leads to comparatively higher gross return and gross margin. At Vadalia village under Kushtia, the performance of BARI Sesame varieties, BARI Til-4 was profitable to the farmers. At Shauta village under Kushtia, the performance of advanced lines, Ses-2010-01R was better due to its higher market price. The line Ses MR-20 performed better than all advanced lines and BARI Til-4 in Faridpur.

ON FARM TRIAL OF BARI SUNFLOWER VARIETIES

Abstract

The experiment was conducted at Cumilla, Sylhet and Patuakhali during the Rabi seasons of 2020-21 in the farmers' field to select suitable variety of Sunflower and to increase production and farmers income. Three Sunflower varieties viz. BARI Surjamukhi-2, BARI Surjamukhi-3 and Hysan-33 at Cumilla and Sylhet; five varieties/lines viz. BARI Surjamukhi 2, BARI Surjomukhi-3, SC-01, SC-02 and Hysun-33 were evaluated at Patuakhali. The experiment was conducted in RCB design with three to six dispersed replications in each location. Significant difference was found in grains head⁻¹, 1000-grain weight and grain yield. The yield of BARI Surjamukhi-3 (2.31 t ha⁻¹) was the higher than other varieties at Cumilla. At Sylhet, the highest seed yield (1.81 t ha⁻¹) was obtained from BARI Surjomukhi-3 and the lowest seed yield (1.49 t ha⁻¹) was obtained from BARI Surjomukhi-2. At Patuakhali, the highest yield was observed from the lines SC -01 (3.15 t ha⁻¹) followed by lines SC-02 and Hysun33, and the lowest yield was obtained from the variety BARI Surjomukhi-03 (1.58 t ha⁻¹).

Introduction

Sunflower (*Helianthus annuus*) is the second most important oil crop in the world after Soybean in terms of acreage and production. Sunflower contains 42-44% oil. It also contains 40-50% linoleic acid and 20-22% protein. One kg Sunflower seed brings 500-600ml oil which is greater than any other oil seeds. Bangladesh has to import huge amount of vegetable oil every year to meet up the deficiency. Most of the land in Patuakhali district remains fallow in winter season due to scarcity of rain or irrigation water and soil salinity constraints. A single crop of T. Aman rice is grown in a calendar year. So, there is a scope to introduce saline and drought tolerant crops like Sunflower in these areas. Sunflowers cultivation is increasing in charland areas of Tangail day by day. Vast charland are fallow in Bhuapur, Nagorpur, and Sadar upazila in Tangail which occupied by char areas. Farmers can easily grow Sunflower in that area and get some return from their fallow land. Sunflower cultivation is increasing in day by day in the farmers' field of Faridpur. Farmers of Faridpur region cultivate 62 hectares of land with Sunflower and use imported variety (Hysun-33). Hence the trial was undertaken to evaluate the performance of Sunflower varieties in different locations of Bangladesh and to popularize the Sunflower variety among the farmers.

Materials and Method

The trial was conducted at MLT site Barura, Chandina, Debidwar of Cumilla; at FSRD site, Kamal bazar under South Surma upazila of Sylhet; at the farmers field of Patuakhali during the Rabi season of 2020-21. Three Sunflower varieties viz. BARI Surjamukhi-2, BARI Surjamukhi-3 and Hysan-33 were evaluated at Cumilla and Sylhet; five varieties/lines viz. BARI Surjamukhi 2, BARI Surjomukhi-3, SC-01, SC-02 and Hysun-33 at Patuakhali. The experiment was laid out in RCB design with three to six dispersed replications in each location. Plant spacing was maintained 50 cm x 25 cm. Crop management practices used in different locations are given in Table 1. Half of urea and full doses of all other fertilizers were applied at the final land preparation. The rest urea was applied in two equal splits at 25 and 45 DAS. Weeding and earthing up was done at 20-25 DAS and 40-45 DAS, respectively. The field was irrigated two times, at 25-30 and 44-45 DAS. Other intercultural operations and plant protection measures were done as and when required. Data on yield and yield characters were collected and analyzed statistically by using MSTAT C statistical package program.

Table 1. Crop management practices of Sunflower used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha ⁻¹) (N-P-K-S-Zn-B)
Cumilla	03-08 December, 2020	14-21 March, 2021	100-30-60-20-1.5
Sylhet	20 November, 2020	15-20 March, 2021	90-40-75
Patuakhali	27-30 December, 2020	13-27 April, 2021	95-35-80-30-10

Result and Discussion

Cumilla: The days to maturity, head diameter, weight of seeds per head and 1000 seed weight were statistically varies among the varieties (Table 2). The highest plant height was recorded from BARI Surjomukhi-3 (98.4 cm) where the lowest in BARI Surjomukhi-2 (201.0 cm). The highest individual head diameter (58.5 cm) was recorded from the variety Hysun-33 that was statistically at par with BARI Surjomukhi-3 (56.5 cm). The highest number of seeds per head (623.1) was recorded from the variety Hysun-33 whereas minimum seeds weight per head (38.4 gm) and maximum 1000-seed wt. (65.54 gm) were recorded from BARI Surjomukhi-3. The seed yield and gross margin were numerically the higher in BARI Sunflower-3 than other tested varieties.

Sylhet: Plant height, head diameter, seeds head⁻¹, 1000 seed weight and seed yield of sunflower were significantly different (Table 2). Statistically the longest plant was recorded from BARI Surjomukhi-2 (203.53 cm) followed by Hysun-33 (169.33 cm). On the contrary, BARI Surjomukhi-3 produced the shortest plant among the tested varieties. Maximum head diameter (48.93) was recorded from Hysun-33, followed by BARI Surjomukhi-3 (48.03 m). Maximum number of seeds head⁻¹ (418.63) was recorder in BARI Surjomukhi-3 followed by Hysun-33 (377). On the contrary, BARI Surjomukhi-2 gave the lowest number of seeds head⁻¹ (362.33). The highest 1000 seed weight was found in BARI Surjomukhi-3 (46.98 g) followed by Hysun-33 (45.22 g) but the lowest 1000 seed weight was recorder in BARI Surjomukhi-2 (40.01 g). The highest seed yield (1.81 t ha⁻¹) was produced by BARI Surjomukhi-3 that was statistically close to that of Hysun-33 (1.65 t ha⁻¹) and the lowest seed yield (1.49 t ha⁻¹) was recorded in BARI Surjomukhi-2.

Patuakhali: The yield contributing characters of the tested varieties are presented in Table 2. Among the genotypes flowering started earlier in BARI Surjomukhi-3 and also matured 15-30 days earlier than other genotypes. Genotype SC-01 took maximum times (126 days) to be matured. The tallest plants were found in SC-01 (215.87 cm). The genotype SC-01 produced the biggest size head (129.43 cm) with the highest number of seeds (1325) but 1000 seed weight was lower (61.23 gm). The genotype SC-01 produce higher yield (3.15 t ha⁻¹) but the lowest yield recorded in BARI Surjamukhi-3 (1.58 t ha⁻¹). Among the genotypes, SC-02 performance was better than other locally available varieties.

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce (Table 3). Higher gross margin was obtained from BARI developed Sunflower varieties than farmers' variety at all locations.

Farmers' reaction: Farmers of Cumilla preferred BARI Surjamukhi-2 because of its uniform head size, early maturity, and big head. However, farmers of Sylhet interested to cultivate BARI developed sunflower variety especially BARI Surjomukhi-3 due to its higher seed yield and higher market demand. Farmers of Patuakhali were very much impressed to cultivate the newly planted varieties of sunflower.

Table 2. Seed yield and yield contributing characters of BARI Surjamukhi varieties at different locations during Rabi season of 2020-21

Varieties/lines	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed head ⁻¹	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
Cumilla						
BARI Surjomukhi-2	101	201.0	54.4	534.7	62.20	1.91
BARI Surjomukhi-3	98	98.4	56.5	595.3	65.54	2.31
Hysun-33	105	184.2	58.5	623.1	62.15	2.13
LSD (0.05)	3.48	5.98	6.98	15.6	7.95	0.153
CV (%)	6.12	9.98	3.85	7.53	12.48	10.25
Sylhet						
BARI Surjomukhi-2		203.53	46.13	362.33	46.01	1.49
BARI Surjomukhi-3		123.23	48.93	418.63	46.98	1.81
Hysun-33		169.33	48.03	377.00	45.22	1.65
LSD (0.05)		4.30	3.27	2.07	4.85	4.31
CV (%)		4.88	1.37	9.40	0.89	0.16
Patuakhali						
BARI Surjamukhi- 2	109	129.8	74.4	690	64.2	1.9
BARI Surjomukhi-3	92	76.7	38.9	510	61.9	1.6
Hysun 33	118	138.7	86.9	814	69.7	2.1
SC-01	126	215.9	129.4	1325	61.2	3.2
SC-02	88	109.8	77.5	756	64.4	2.4
LSD(0.05)	6.52	11.7	6.9	10.94	9.0	1.9
CV (%)	3.97	7.6	3.9	9.17	7.0	5.9

Table 3. Economic return of Sunflower at different locations during the rabi season of 2020-21.

Locations	Varieties/lines	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Cumilla	BARI Surjomukhi-2	95500.00	33400.00	62100.00
	BARI Surjomukhi-3	115500.00		82100.00
	Hysun-33	106500.00		73100.00
Sylhet	BARI Surjomukhi-2	104300	54500	49800
	BARI Surjomukhi-3	126700		72000
	Hysun-33	115500		61000
Patuakhali	BARI Surjamukhi-2	147000	71000	76000
	BARI Surjamukhi-3	118000	71000	47000
	Hysun 33	135000	80000	55000

Market price of Sunflower at Patuakhali @ Tk. 60 kg⁻¹ and at Faridpur @ Tk. 50 kg⁻¹

Conclusion

Sunflower var. BARI Surjamukhi-3 gave higher yield than BARI Surjamukhi-2 and Hysun 33 at Cumilla. However, BARI Surjomukhi-3 and Hysun-33 performed better at Sylhet. At Patuakhali, BARI Surjamukhi-2 could be extended in the farmers' field.

ADAPTIVE TRIAL OF SOYBEAN VARIETIES

Abstract

The experiment was conducted in the farmer's field at West Al-Amin, Subarnachar upazila in Noakhali district during Rabi season of 2020-2021 to select suitable soybean variety for char lands under rainfed condition. Among the tested varieties the highest seed yield was obtained from BARI Soybean-6 (2.26 t ha⁻¹) which was statistically similar with BU Soybean-1 (2.20 t ha⁻¹) and BINAsoybean-5 (2.19 t ha⁻¹) and the lowest yield (1.74 t ha⁻¹) was obtained from local variety (Shohag). Highest gross margin was obtained from BARI Soybean-6 (TK.. 63820 ha⁻¹).

Introduction

Soybean is the single most potential *Rabi* cash crop and well adapted to cropping pattern in greater Noakhali. In Noakhali district, 115000 ha land remains fallow during dry season because of varying degrees of soil salinity. Soybean is tolerant to 4-10 dS m⁻¹ of soil salinity (Amin *et al.*, 2010). The similar findings also obtained by Ghassemi-Golezani *et al.* (2009), reported that soybean production may be limited by soil salinity stresses or damaged when the salinity level was >16.78 dS m⁻¹. In greater Noakhali region 76000 ha of land under soybean cultivation with a production of 105000 MT and an average yield is about 1.3- 1.6 t ha⁻¹. The yield per unit area of soybean (Shohag) at farmers' level is much below than the potential yield. The reasons for low yield of soybean are mainly associated with lack of use of improved varieties. The yield of a variety may decrease due to cultivation for several years. To increase the yield potentiality, different organizations (BARI, BINA and BSMRAU) has developed some promising high yielding varieties which need to be tested in the farmers' field along with local variety. Under the circumstances, the experiment was undertaken to find out the suitable variety/varieties for greater Noakhali region.

Materials and Methods

The experiment was conducted in the farmer's field at West Al-Amin, Subarnachar upazila in Noakhali district during the *Rabi* season of 2020-2021 to select suitable soybean variety/varieties for char lands under rainfed condition. The experiment was laid out in RCB design with six dispersed replications. The soil was sandy clay loam to silty clay loam belonging to Young Meghna Estuarine Flood plain of Bangladesh (AEZ 18). Seven (07) soybean varieties namely: BU Soybean-1, Binasoybean-2, Binasoybean-3, Binasoybean-5, Binasoybean-5, BARI Soybean-6 and local variety (Shohag) were included in the experiment as check. The unit plot size was 8.0m x 5.0m. The seeds were sown @ 50 kg ha⁻¹ from 18-20 January, 2020 in line with the spacing of 30 x 5 cm. The crop was fertilized with 25, 25, 55 and 10 kg ha⁻¹ of N, P, K and S respectively. Except Urea, all other fertilizers were applied at the final land preparation as basal dose. Urea was applied at two equal splits- once during first weeding 24 DAS and another 45 DAS during second weeding. Different intercultural operations and plant protection measures were taken as and when necessary to raise healthy crops. Harvesting was done from 26 April to 7 May, 2021 Data on different plant, yield and yield contributing characters were recorded. The collected data were analyzed by the R project for statistical Computing software (Version 3.3.3).

Results and Discussions

Days to 50 % flowering and maturity were recorded in all varieties (Table 1). Especially in farmer's field crop duration is an essential criterion for the selection of that crop which will be well adapted to cropping pattern. In that sense BARI Soybean Soybean-5 & 6 required 109 and 107 days to mature followed by Shohag (112 days). Local variety Shohag took 3-5 days more to mature compared to early maturing varieties BARI Soybean-6.

The highest plant height was found in BARI Soybean-6 (56.8 cm) which was statistically identical with Shohag. The highest number of branch plant⁻¹ was found in BARI Soybean-6 (2.9) followed by BARI Soybean-5 (2.5) and the lowest number of branch plant⁻¹ was observed in local variety Shohag (2.2). Maximum number of pods plant⁻¹ (44.5) was recorded in BARI Soybean-6 which was statistically similar with Shohag-1(41.8). Minimum number of pods plant⁻¹ was found in BARI Soybean-5 (332.1). The highest number of seeds pod⁻¹ (2.6) was recorded in BARI Soybean-6 which was statistically different with BARI Soybean-5 and Shohag, respectively. Maximum 100 seeds weight (11.95 g) was recorded in BARI Soybean-6 which was statistically similar with Shohag (11.35 g) and BARI Soybean-5 (11.85). The highest seed yield (2.18 t ha⁻¹) was obtained in BARI Soybean-6 which was statistically identical with BARI Soybean-5 (1.96 t ha⁻¹) while the lowest yield (1.81 t ha⁻¹) was found in local variety (Shohag). In Table 2, the highest gross margin was recorded in BARI Soybean-6 (TK.. 63820 ha⁻¹) followed by BARI Soybean-5 (TK.. 53920 ha⁻¹) and the lowest gross margin from Shohag (Tk. 47170 ha⁻¹).

Farmers' Opinion:

BARI Soybean-6 is highly accepted by the farmers for its early maturity and higher yield. Sometimes farmers are disabled to collect seeds for the next season when heavy rainfall occurred during maturity stage of soybean.

Table 1. Yield and yield contributing characters of Soybean varieties at Char Wapda and West Al-Amin, Subarnachar upazila in Noakhali district during the Rabi season of 2020-2021

Varieties	Number of Plants m ⁻²	Days to 50% flowering	Days to Maturity	Plant height (cm)	Branches plant ⁻¹	Pods plant ⁻¹	Seeds pod ⁻¹	100 seeds weight (g)	Seed yield (t ha ⁻¹)
BARI Soybean-5	22.7	54	109	52.4	2.5	32.1	2.3	11.85	1.96
BARI Soybean-6	21.5	56	107	56.8	2.9	44.5	2.6	11.95	2.18
Shohag	20	58	112	54	2.2	41.8	2.2	11.35	1.81
LSD (0.05)	ns	ns	ns	3.61	ns	3.28	0.21	0.79	0.48
CV (%)	4.52	3.91	7.83	8.41	2.49	7.02	7.95	5.41	12.49

Table 2. Cost and return analysis of soybean varieties at FSRD site, Char Wapda and West Al-Amin, Subarnachar, Noakhali during Rabi season of 2020-2021

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Soybean-5	88200	34280	53920
BARI Soybean-6	98100		63820
Shohag	81450		47170

Price of Soybean per kg = TK..45.0

Conclusion

The experiment should be repeated for couple of years in different soil types and locations along with sowing time for better selection of suitable varieties in the char lands.

PRELIMINARY YIELD TRIAL OF ADVANCED LINES OF SOYBEAN IN CHANDPUR

Abstract

A preliminary trial was carried out in the farmer's field of Dakkhin Gobindia of Chandpur Sadar upazila of Chandpur district during the Rabi season of 2020-21 with a view to test the yield performance of advanced lines (BS-29, USDA-4, USDA-40, USDA-53, USDA-72, USDA-95, USDA-107 & GMOT-13) with BARI developed two soybean varieties (BARI Soybean-6 and BARI Soybean-7) in the farmers field level in that area. From the trial, it was revealed that USDA-4 had the highest branch plant⁻¹ (5.2), pods plant⁻¹ (80.6) and seed yield (2.92 t ha⁻¹) with less field duration (99 days). BARI Soybean-7 and BARI Soybean-6 had second and third highest seed yield (2.60 and 2.54 t ha⁻¹, respectively). The lowest seed yield (1.65 t ha⁻¹) was obtained from USDA-107.

Introduction

Soybean (*Glycine max*) is an annual legume of the pea family (*Fabaceae*). The soybean is economically the most important bean in the world, providing richest and cheapest source of vegetable protein for millions of people and is a staple in the diets of people and animals in numerous parts of the world. It is an ingredient for hundreds of chemical products. The soybean seed contains 19-22% edible oil and 63 % meal, 50 % of which is protein. In Bangladesh soybean have a bright future. It contains double protein than any other pulse crop. So, to get protein in a low price, we must increase the soybean production. Oilseed Research Centre, BARI already identified one white flowered advanced line having dwarf character with bold seed. But before releasing these lines as variety, performance should be tested in the farmer's field. To increase productivity as well as production, proper variety selection is an important factor. For this reason, to release new promising variety an adaptive trial was taken

comprising promising lines and two varieties in the soybean growing area to test line/variety performance and to popularize the BARI varieties to the farmers.

Materials and Methods

The preliminary yield trial was carried out in the farmer's field of Dakkhin Gobindia village of Chandpur Sadar Upazila, of Chandpur district during the Rabi season of 2021. The soil of the experimental plot was sandy loam. Seeds were sown continuously in lines at 30 cm spacing. Three soybean varieties and one advanced entries were included in this trial. The soybean varieties were BARI Soybean-5, BARI Soybean-6, Shohag and one promising advanced line *e.g.* Santarose. Seeds were treated with Provax -200 and sown @ 50.0 kg ha⁻¹ on at 14 January 2020. Fertilizers were applied at the rate of 27, 35, 60, 21 and 1.7 kg ha⁻¹ of N, P, K, S and B in the form of Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Boric acid, respectively. All the fertilizers were applied during final land preparation. No irrigation was required. Weeding was done twice at 25 and 50 DAS for maintaining hygienic condition. The crop was harvested 103-115 days after sowing dated on 26 April to 07May, 2020, respectively. Data on plant height, days to maturity, number of branch plant⁻¹, number of pods plant⁻¹, seeds pod⁻¹ and seed yield plot⁻¹ were recorded and later converted into ton hectare⁻¹. Moisture per cent of seeds was adjusted to 8 % and seed yield was minimized accordingly. For controlling leaf roller and root rot disease of soybean Autostin @ 2 g L⁻¹ Nitro @ 2 ml L⁻¹ and Virtako @ 0.15 g L⁻¹ of water were sprayed at different growing stage.

Results and Discussion

From the trial it was observed that, all the advanced lines have lower days to maturity (97- 99 days) than BARI Soybean-6 and BARI Soybean-7 except USDA-95 and BS-29 (Table 1). The lowest plant height (59.0 cm) was observed in BARI Soybean-7, followed by GMOT-13 (66.6 cm). The highest plant height (126.8 cm) was observed in USDA-72, followed by BS-29 (111.0 cm). The highest branch plant⁻¹ (5.2) was observed in USDA-4, followed by USDA-95 (4.6). The lowest branch plant⁻¹ (1.0) was observed in GMOT-13 line. The highest pods plant⁻¹ (80.6) was recorded from USDA-4, followed by USDA-53 (65.6). The line GMOT-13 produced the lowest pods plant⁻¹ (28.8), which was similar to BARI Soybean-7 (30.4). Number of seeds pod⁻¹ was the highest (2.5) in BS-29 and USDA-95. The lowest no. of seeds pod⁻¹ (1.8) was observed in BARI Soybean-6, which was similar to USDA-40 (1.9). Maximum hundred seed weight (13.5 g) was found from GMOT-13 line, followed by BARI Soybean-7 (12.7 g) and minimum hundred seed weight was found from USDA-53, USDA-72 and USDA-107 (6.8 g). The highest seed yield (2.92 t ha⁻¹) was found from USDA-4, followed by BARI Soybean-7 (2.60 g) and the lowest seed yield (1.65 t ha⁻¹) was found from USDA-107.

Cost and return analysis

Among the lines and varieties, the higher gross return (Tk. 116830.19 ha⁻¹) and gross margin (Tk. 71830.00 ha⁻¹) were calculated from USDA-4, followed by BARI Soybean-7 (Tk 104150.94 ha⁻¹ and Tk 59150 ha⁻¹, respectively) (Table 2).

Table 1. Yield and yield contributing characters of different lines/varieties of Soybean at Dakkhin Gobindia, Chandpur during Late Rabi 2021

Line/ variety	Population m ⁻²	Field duration (days)	Plant height (cm)	Branch plant ⁻¹	Pods plant ⁻¹	Seeds pod ⁻¹	100 seed weight (g)	Yield (t ha ⁻¹)
BS-29	48.3	107	111.0	1.8	35.6	2.5	12.5	2.12
USDA-4	53.3	99	99.2	5.2	80.6	2.0	11.8	2.92
USDA-40	64.2	99	96.2	2.8	63.8	1.9	11.3	2.38
USDA-53	66.7	99	103.0	3.4	65.6	2.1	6.8	2.11
USDA-72	68.3	97	126.8	2.4	40.6	2.0	6.8	1.92
USDA-95	44.2	110	89.2	4.6	46.0	2.5	9.5	2.02
USDA-107	67.5	99	102.4	4.2	54.8	2.1	6.8	1.65
BARI Soybean-6	61.7	106	94.8	2.4	43.6	1.8	10.0	2.54
BARI Soybean-7	54.2	107	59.0	2.6	30.4	2.1	12.7	2.60
GMOT-13	50.0	99	66.6	1.0	28.8	2.3	13.5	2.08

Table 2. Cost and Return analysis of different lines/varieties of Soybean at Hanarchar, Chandpur during Late Rabi 2021

Line/ variety	Seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BS-29	2.12	84830.19	45000	39830.19
USDA-4	2.92	116830.19	45000	71830.19
USDA-40	2.38	95094.34	45000	50094.34
USDA-53	2.11	84528.30	45000	39528.30
USDA-72	1.92	76679.25	45000	31679.25
USDA-95	2.02	80905.66	45000	35905.66
USDA-107	1.65	65811.32	45000	20811.32
BARI Soybean-6	2.54	101735.85	45000	56735.85
BARI Soybean-7	2.60	104150.94	45000	59150.94
GMOT-13	2.08	83320.75	45000	38320.75

Market price of Soybean @ Tk. 40 kg⁻¹

Conclusion

The line USDA-4 gave the highest seed yield with shorter field duration, which was higher than BARI Soybean-7 and BARI Soybean-6 also. So, it may be released as variety.

ON-FARM TRIAL OF BARI GROUNDNUT VARIETIES

Abstract

The experiment was conducted at North channel (char land area) of Faridpur Sadar, Faridpur; and MLT site Barura, Cumilla during the Rabi season of 2020-21 to find out the suitable Groundnut variety for the charlands and to popularize the varieties among the farmers. At Faridpur, three BARI developed Groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and one local variety (Dhaka-1); three BARI developed Groundnut varieties viz. BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and one BINA developed variety viz. Binachinabadam-4 were evaluated at Cumilla. At Faridpur, the highest average nut yield (2.75 t ha⁻¹) was recorded in BARI Chinabadam-10 and 100 kernel weights were associated with the nut yield. The lowest nut yield (1.72 t ha⁻¹) was obtained from the local variety, Dhaka-1. The yield was 60% higher in BARI Chinabadam-10 over Dhaka-1. In the farmer's field of Cumilla, the highest nut yield was recorded in BARI Chainabadam-9 (2.58 t ha⁻¹) and the lowest in Binachinabadam-4 (1.59 t ha⁻¹).

Introduction

Groundnut (*Arachis hypogaea*) is an important leguminous oilseed crop. It is cultivated both in rabi and kharif seasons in Bangladesh. This crop is an important source of oil (43-55%) and protein (25-28%), hence used as food and feed (Din *et al.*, 2009). It is a good source of edible oil as it contains about 50% oil of good quality. It is also an excellent source of vitamins and contains high levels of thiamine, riboflavin and niacin. Being highly digestible, the children's food made of Groundnut can help in meeting part of the nutritional needs. Groundnut, being a drought tolerant crop, it requires low input and produces high output for the farmer. Since it is a leguminous crop it can fix atmospheric nitrogen enhancing soil health by adding nitrogen to soil. Farmers of charland areas of Bangladesh usually grow Groundnut with local variety which produce lower yield and susceptible to pest and diseases. BARI has developed some modern varieties of Groundnut, which are supposed to be higher yielder and less susceptible to pest and diseases. Therefore, an adaptive trial with BARI developed high yielding Groundnut varieties was conducted for higher yield and economic return and to popularize BARI varieties among the farmers.

Materials and Method

The experiment was conducted at North channel charland of Faridpur under AEZ-10 and MLT site Barura, Cumilla under AEZ-19 during the Rabi season of 2020-21. At Faridpur, three BARI improved

Groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and one local variety (Dhaka-1) were used as check and BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and one BINA developed variety viz. Binachinabadam-4 was evaluated at Cumilla. The experiment was laid out in RCB design with three to six dispersed replications. Seeds were sown maintaining a spacing of 30 cm × 15 cm. Before sowing, seeds were treated with Provax @ 0.2 % to prevent seed and soil borne diseases. Crop management practices used in different locations are given in Table 1. Half amount of urea and whole amount of TSP, MP, gypsum and boric acid were applied during final land preparation. The rest half urea was top dressed at the initial stage of peg developments. One hand weeding was done at 45 DAS. Other intercultural operations and plant protection measures were done as and when required. The cost and return were calculated on the basis of prevailing market price of the commodities. Data on yield and yield characters were collected and analyzed statistically using open source software “R” and the means were separated by DMRT (Gomez and Gomez 1984).

Table 1. Crop management practices of groundnut used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Faridpur	11 February, 2020	10 June, 2021	50-50-30-35-2-1.5
Cumilla	10-16 January, 2021	20 May, 2021	18-33.4-43-54-1.8

Results and Discussion

Faridpur: All the yield and yield contributing characters showed significant difference among the tested varieties (Table 2). The highest plant height (50.92 cm) was obtained from BARI Chinabadam-10 and the lowest from local (37.7 cm). The highest number of mature pods plant⁻¹ (27.68) was recorded in BARI Chinabadam-10 followed by BARI Chinabadam-9 (27.48) and the lowest number of mature pods plant⁻¹ (24.66) was recorded from local. Maximum 100 kernel weight was calculated from BARI Chinabadam-10 (42.8 g) which was statistically similar with BARI Chinabadam-8 (42.6 g) and BARI Chinabadam-9 (42.4g). The highest average nut yield (2.75 t ha⁻¹) was recorded in BARI Chinabadam-10 which was significantly similar among the tested varieties except local and the lowest nut yield (1.72 t ha⁻¹) was obtained from the local variety, Dhaka-1.

Cumilla: The highest plant height, number of pods per plant, weight of pods plant⁻¹, and number of mature pods plant⁻¹ were recorded from Binachinabadam-4 variety and the lowest in BARI Chinabadam-10 (Table 2). Maximum 100 seed weight was recorded in BARI Cinabadam-8 and the lowest 100 seed weight was observed in Binachinabadam-4 (94.0 g), which was statistically similar to BARI Chinabadam-9 and BARI Chinabadam-10. The highest groundnut yield (2.58 t ha⁻¹) was recorded in BARI Chinabadam-9 and the lowest in Binachinabadam-4 (1.59 t ha⁻¹).

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce (Table 3). Higher gross margin was obtained from BARI developed Groundnut varieties than the local variety used by the farmers.

Farmers of Faridpur preferred BARI Chinabadam-10 for its the highest yield, but farmers of Cumilla preferred BARI Chinabadam-9 for its higher yield, bigger nut size and market price as well as less pest infestation compared to local variety.

Table 2. Yield and yield contributing characters of Groundnut varieties at different locations during the Rabi season of 2020-21.

Location	Variety	Plant height (cm)	Mature pods plant ⁻¹	100-seed weight (g)	Nut yield (t ha ⁻¹)
Faridpur	BARICHinabadam-8	46.76	25.84	71.8	2.58
	BARICHinabadam-9	46.09	27.48	72.6	2.64
	BARI Chinabadam-10	50.92	27.68	71.6	2.75
	Local (Dhaka-1)	37.70	24.66	67.8	1.72
	CV (%)	7.83	8.13	2.67	6.21

Location	Variety	Plant height (cm)	Mature pods plant ⁻¹	100-seed weight (g)	Nut yield (t ha ⁻¹)
Cumilla	BARI Chinabadam-8	48.6	15.7	104.0	2.40
	BARI Chinabadam-9	45.85	18.4	98.0	2.58
	BARI Chinabadam-10	50.03	14.9	97.5	2.17
	BINA Chinabadam-4	56.08	18.7	94.0	1.59
	LSD (0.05)	6.10	3.521	5.835	0.115
	CV (%)	7.61	13.02	3.71	3.31

Table 3. Average yield and economic return of Groundnut at different locations during the rabi season 2020-21.

Locations	Varieties/lines	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
Faridpur	BARICHinabadam-8	180600	84698	95902
	BARICHinabadam-9	184800		100102
	BARI Chinabadam-10	192500		107802
	Local (Dhaka-1)	120400		40502
Cumilla	BARI Chinabadam-8	197000	54500	142500
	BARI Chinabadam-9	267000		212500
	BARI Chinabadam-10	300000		245500
	Binachinabadam-4	283000		228500

Market price of Groundnut at Faridpur @ Tk. 120 kg⁻¹, Tangail @ Tk. 57.50 kg⁻¹ and Cumilla @ Tk. 100 kg⁻¹

Conclusion

All the high yielding varieties provided higher yield over the farmer's variety. Therefore, Groundnut var. BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and of Binachinabadam-4 could be extended in the tested locations according to farmer's choice and local market price.

Pulse Crops

ADAPTIVE TRIAL OF BARI RELEASED LENTIL VARIETIES

Abstract

The experiment was conducted at farmer's field of Kushtia sadar, MLT site: Bheramara, Mujibnagar, Gangni and Chuadanga during the Rabi season of 2020-2021 and at MLT site, Tularampur, Narail during the Rabi season of 2019-20 and 2020-21 to observe the performance of BARI released lentil variety in those area. Four BARI released lentil varieties viz. (BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 with local check variety were tested at different regions of Kushtia and two BARI released lentil varieties such as BARI Masur-9, BARI Masur-8 and a local lentil variety were tested in the farmers' field of Narail. Among the tested varieties, BARI Masur-8 performed better and gave the highest seed yield and economic return in all locations.

Introduction

Lentil is one of the most important pulse crops in Bangladesh. It is a rich source of dietary protein and micronutrients for poor consumers who cannot afford animal protein due to high prices. In Bangladesh total production of lentil was 2.69 lac tons from an area of 2.493 lac hectare with an average yield of 1.083 tha⁻¹ which is much lower than its yield potential. Cultivation of low yielding traditional varieties and incidence of disease are mainly responsible for the lower yield. Foot rot in early stage and Stemphylium blight disease in mature stage are the major problems in lentil cultivation. Recently Pulse Research Center BARI has developed some high yielding disease resistant lentil varieties which have higher yield as well as short lived. The present study was undertaken to observe the performance of the new varieties under farmer's field condition and popularize among the farmers and promote their adoption in this area.

Materials and Methods

The experiment was conducted at Kushtia sadar, MLT site: Bheramara, Mujibnagar, Gangni and Chuadanga during the Rabi season of 2020-21 and at MLT site, Tularampur, Narail during the Rabi season of 2019-20 and 2020-21, respectively. The unit plot size was 10 square meters at Kushtia whereas the unit plot size was 5 m x 4 m with 30 cm x 5 cm plant spacing at Narail. Four BARI lentil varieties (BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9) and local variety were used as check in the experiment. The trial was laid out in a RCB design with three dispersed replications. Fertilizers were applied @ 20-17-17.5-9-1 kg ha⁻¹ of N-P-K-S-B, respectively at Kushtia and 40-80-40-20-4-6 N-P-K-S-Zn-B kg ha⁻¹ at Narail. All fertilizers were applied as basal dose during final land preparation. Necessary data were recorded as per objectives. Location wise production technologies are described as follows. Sowing and harvesting date were shown in (table 1).

Kushtia sadar: Seeds were sown on 11 November, 2020. One weeding was done in lentil field. Provex-200 @ 2.5 g and Lunasensation @ 0.2% were applied for controlling foot and root rot and Stemphylium blight disease of lentil. The crop was harvested BARI Masur-9 during 15 February, 2021 and BARI Masur-6, 7, 8 and local 06 March, 2021, respectively.

Bheramara: Seeds were sown on 13 November, 2020. One irrigation was done at 35 DAS. One weeding was done in lentil field. Provex-200 and Rovral 50 WP @ 0.2% were applied for controlling foot and root rot and Stemphylium blight disease of lentil. The crop was harvested BARI Masur-9 during 20 February, 2021 and BARI Masur-6, 7, 8 and local 07 March, 2021.

Gangni: Seeds were sown on 07 December, 2020. Two irrigations were applied at 02-33 DAS. One weeding was done in lentil field. Provex-200 and Rovral 50 WP were applied for controlling foot and root rot and Stemphylium blight disease of lentil. The crop was harvested BARI Masur-9 during 09 March, 2021 and BARI Masur-6, 7, 8 and local 26 March, 2021.

Mujibnagar: The sowing date was 16 November, 2020. Two irrigations were done at 02-30 DAS. One weeding was done in lentil field. Provex-200 and Rovral 50 WP were applied for controlling foot and root rot and Stemphylium blight disease of lentil. The crop was harvested BARI Masur-9 during 02 March, 2021 and BARI Masur-6, 7, 8 and local 12 March, 2021.

Chuadanga sadar: One weeding was done in lentil field. Provex and Rovral were applied for controlling foot and root rot and Stemphylium blight disease of lentil.

Tularampur, Narail: Two weeding was done at 40 and 56 day after sowing. Data on yield and yield contributing character were recorded and analyzed statistically by Statistics 10.

Table 1. Sowing and harvesting dates of lentil at different locations

Locations	Date of sowing	Date of harvesting
Kushtia Sadar	11 November, 2020	15 February (BARI Masur-9) & 6 March, 2021
Bheramara, MLT site	13 November, 2020	20 February (BARI Masur-9) & 7 March, 2021
Gangni, MLT site	7 December, 2020	9 March (BARI Masur-9) & 26 March, 2021
Mujibnagar, MLT site	16 November, 2020	2 March (BARI Masur-9) & 12 March, 2021
Chuadanga, MLT site	3 November, 2020	1 February (BARI Masur-9) & 24 February (BARI Masur-6) & 1-5 March, 2021
Tularampur, Narail	20-25 November, 2019-20 and 2020-21	15-20 February, 2019-20 and 2020-21

Results and Discussion

The results and cost analysis were shown in Table-2 and Table-3, respectively.

Kushtia Sadar: Days to maturity of BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 and local were 115, 115, 115, 91 and 115 days, respectively. The highest plant height (48 cm) was recorded in BARI Masur-6. The highest thousand grain weight was obtained from BARI Masur-9 (24.00 g). The highest grain yield (2.10 t ha⁻¹) was obtained from BARI Masur-8 and the lowest was in

BARI Masur-9 (1.05 t ha^{-1}). The highest straw yield was found in BARI Masur-6 (1.38 t ha^{-1}) and the lowest was in BARI Masur-9 (1.10 t ha^{-1}).

Bheramara: Days to maturity of BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 and Local were 107, 109, 114, 95 and 107 days, respectively. The highest plant height (40 cm) was recorded in BARI Masur-8. The highest thousand grain weight was obtained from BARI Masur-8 (20.60 g). The highest grain yield (1.65 t ha^{-1}) was obtained from BARI Masur-8 and the lowest was in BARI Masur-9 (0.92 t ha^{-1}). The highest straw yield was also found in BARI Masur-8 (1.43 t ha^{-1}) and the lowest was in BARI Masur-9 (0.76 t ha^{-1}).

Gangni: Days to maturity of BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 and local were 111, 113, 113, 92 and 110 days, respectively. The highest plant height (62 cm) was recorded in BARI Masur-8. The highest thousand grain weight was also obtained from BARI Masur-8 (22.10 g). The highest grain yield (2.97 t ha^{-1}) was obtained from BARI Masur-8 and the lowest was in BARI Masur-9 (0.91 t ha^{-1}). The highest straw yield was also found in BARI Masur-8 (1.85 t ha^{-1}) and the lowest was in BARI Masur-6 (1.39 t ha^{-1}).

Mujibnagar: Days to maturity of BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 and local were 115, 114, 115, 93 and 107 days, respectively. The highest plant height (74 cm) was recorded in BARI Masur-8. The highest thousand grain weight was also obtained from BARI Masur-8 (23.00 g). The highest grain yield (3.02 t ha^{-1}) was obtained from BARI Masur-8 and the lowest was in BARI Masur-9 (0.98 t ha^{-1}). The highest straw yield was also found in BARI Masur-8 (1.67 t ha^{-1}) and the lowest was in BARI Masur-9 (1.39 t ha^{-1}).

Chuadanga sadar: Days to maturity of BARI Masur-6, BARI Masur-7, BARI Masur-8, BARI Masur-9 and local were 110, 115, 118, 90, and 121 days, respectively. The highest plant height (54 cm) was recorded in BARI Masur-8. The highest thousand grain weight was obtained from BARI Masur-9 (29.00 g). The highest grain yield (2.20 t ha^{-1}) was obtained from BARI Masur-8 and the lowest was in BARI Masur-9 (1.02 t ha^{-1}). The highest straw yield was also found in BARI Masur-8 (2.35 t ha^{-1}) and the lowest was in BARI Masur-9 (1.25 t ha^{-1}).

Tularampur, Narail: The highest yield (1.89 t ha^{-1}) followed by local variety (1.55 t ha^{-1}) was recorded from BARI Masur-8 and the lowest yield obtained from BARI Masur-9 (1.31 t ha^{-1}). Maturity days were higher of BARI Masur-8 and local variety whereas the lowest duration (85 days) was recorded in BARI Masur-9.

Cost and return

Kushtia sadar: Total variable cost was calculated at Tk. 43147 ha^{-1} for all varieties. The maximum gross return (Tk. 153900 ha^{-1}) and gross margin (Tk. 110753 ha^{-1}) were obtained from BARI Masur-8 and the lowest in BARI Masur-9.

Bheramara: Total variable cost was calculated at Tk. 55200 ha^{-1} for all varieties. The maximum gross return (Tk. 120886 ha^{-1}) and gross margin (Tk. 65686 ha^{-1}) were obtained from BARI Masur-8 and the lowest in BARI Masur-9.

Gangni: Total variable cost was calculated at Tk. 43667 ha^{-1} for all varieties. The maximum gross return (Tk. 217170 ha^{-1}) and gross margin (Tk. 173503 ha^{-1}) were obtained from BARI Masur-8 and the lowest in BARI Masur-9.

Mujibnagar: Total variable cost was calculated at Tk. 41000 ha^{-1} for all varieties. The maximum gross return (Tk. 220533 ha^{-1}) and gross margin (Tk. 179533 ha^{-1}) were obtained from BARI Masur-8 and the lowest in BARI Masur-9.

Chuadanga sadar: Total variable cost was calculated at Tk. 54675 ha^{-1} for all varieties. The maximum gross return (Tk. 163100 ha^{-1}) and gross margin (Tk. 108425 ha^{-1}) were obtained from BARI Masur-8 and the lowest in BARI Masur-9.

Tularampur, Narail: Highest gross return (122850 Tk.ha⁻¹), gross margin (86300 Tk.ha⁻¹) and benefit cost ratio (3.36) was found in BARI Masur-8 followed by local and the lowest gross return, gross margin and benefit cost ratio was recorded in BARI Masur-9.

Farmer's opinion

Kushtia sadar: Farmers were pleased to see the high yielding variety of BARI Masur-7 and BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount of seed for next year sowing. They did not like BARI Masur-9 for its lower yield.

Bheramara: Farmers were pleased to see the high yielding variety of BARI Masur-7 and BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount seed for next year sowing. They disliked BARI Masur-9 for its lower yield.

Gangni: Farmers were pleased to see the high yielding variety of BARI Masur-7 and BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount seed for next year sowing. They did not like BARI Masur-9 for its lower yield.

Mujibnagar: Farmers were happy to see the high yielding variety of BARI Masur-7 and BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount seed for next year sowing. They disliked BARI Masur-9 for its lower yield.

Chuadanga sadar: Farmers were pleased to see the high yielding variety of BARI Masur-7 and BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount of seed for next year sowing. They did not like BARI Masur-9 for its lower yield.

Narail: Farmers expressed their satisfaction with BARI Masur-9 because it is possible to cultivate after harvesting of T. Aman rice for its short duration, however, the yield of the variety is lower than BARI Masur-8 and local variety.

Table 2. Yield and yield attributes of lentil varieties at different location during the rabi season of 2020-21

Variety	Days to maturity	Plant population m ⁻²	Plant height (cm)	1000 grain wt. (g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Kushtia sadar						
BARI Masur-6	115	55.00	48.00	17.10	1.48	1.38
BARI Masur-7	115	62.00	44.20	18.00	1.82	1.25
BARI Masur-8	115	59.00	36.40	22.00	2.10	1.35
BARI Masur-9	91	120.00	31.80	24.00	1.05	1.10
Local	115	68.00	36.00	18.00	1.37	1.07
CV (%)	11.67	6.58	13.33	6.67	8.33	12.33
F-test	**	*	NS	*	**	*
Bheramara						
BARI Masur-6	107	85.00	35.50	17.60	1.42	0.85
BARI Masur-7	109	90.00	38.00	18.60	1.47	0.94
BARI Masur-8	114	100.00	40.00	20.60	1.65	1.43
BARI Masur-9	95	60.00	36.00	17.00	0.92	0.76
Local	106	67.00	37.00	19.00	1.65	0.75
CV (%)	12.33	6.67	8.33	6.58	13.33	11.67
F-test	**	*	*	*	**	*
Gangni						
BARI Masur-6	111	135.33	42.00	21.20	2.56	1.39
BARI Masur-7	113	161.33	45.66	21.00	2.85	1.63
BARI Masur-8	113	190.66	62.00	22.10	2.97	1.85
BARI Masur-9	92	110.66	35.00	22.00	0.91	1.44
Local	110	74.00	38.00	19.00	1.45	1.40
CV (%)	9.33	5.33	9.67	8.21	8.33	14.67
F-test	**	*	*	*	**	*

Variety	Days to maturity	Plant population m ⁻²	Plant height (cm)	1000 grain wt. (g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Mujibnagar						
BARI Masur-6	115	141.30	51.60	21.00	2.52	1.38
BARI Masur-7	114	174.30	46.60	21.20	2.81	1.57
BARI Masur-8	115	195.00	74.80	23.00	3.02	1.66
BARI Masur-9	93	105.30	34.00	21.00	0.98	1.39
Local	107	74.00	36.00	18.00	1.65	1.60
CV (%)	10.56	5.53	11.67	5.68	6.33	14.67
F-test	**	*	*	NS	**	*
Chuadanga						
BARI Masur-6	110	64.50	35.00	20.00	2.10	2.15
BARI Masur-7	115	68.00	39.00	22.00	1.15	2.23
BARI Masur-8	118	74.00	54.00	22.00	2.20	2.35
BARI Masur-9	90	121.00	32.00	29.00	1.02	1.25
Local	121	67.50	45.00	25.00	2.06	2.35
CV (%)	12.7	7.6	12.3	7.7	9.3	13.3
F-test	**	*	*	*	**	*
Narail (Pooled of 2019-20 and 2020-21 cropping season)						
BARI Masur-8	108a	72.67b	37.87	23.60a	1.89a	1.25b
BARI Masur-9	85c	70.33c	38.07	21.90b	1.31c	1.08c
Local	106b	75.33a	38.40	19.50c	1.55b	1.26a
CV(%)	3.21	7.31	5.32	2.27	6.91	6.75

Table 3. Economics of different lentil varieties at different locations during the Rabi season of 2020-21

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Kushtia sadar			
BARI Masur-6	109320	43147	66173
BARI Masur-7	133540	43147	90393
BARI Masur-8	153900	43147	110753
BARI Masur-9	77800	43147	34653
Local	139400	43147	96253
Bheramara			
BARI Masur-6	103700	55200	48500
BARI Masur-7	107480	55200	52280
BARI Masur-8	120886	55200	65686
BARI Masur-9	67533	55200	12333
Local	110400	55200	55200
Gangni			
BARI Masur-6	186974	43667	143307
BARI Masur-7	208322	43667	164655
BARI Masur-8	217170	43667	173503
BARI Masur-9	68324	46307	24657
Local	208800	43667	165133
Mujibnagar			
BARI Masur-6	184677	41000	143677
BARI Masur-7	205467	41000	164467
BARI Masur-8	220533	41000	179533
BARI Masur-9	73580	41000	32580
Local	211800	41000	170800
Chuadanga sadar			
BARI Masur-6	155500	54675	100825
BARI Masur-7	159260	54675	104585
BARI Masur-8	163100	54675	108425
BARI Masur-9	75940	54675	21265
Local	153020	54675	98345

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Narail (Averaged of 2019-20 and 2020-21 cropping season)			
BARI Masur-8	122850	36550	86300
BARI Masur-9	85150		48600
Local	100750		64200

Price at Kushtia @ Lentil seed - 72 Tk/kg, Straw @ 2 Tk/kg; Price at Narail @ Lentil seed - 65 Tk/kg, Urea -16 Tk/kg, TSP - 22 Tk/kg, MoP - 15 Tk/kg, Gypsum -10 Tk/kg and ZnSo4 - 240 Tk/kg

Conclusion

Based on the findings, it can be concluded that BARI lentil varieties BARI Masur-7 and BARI Masur-8 were more profitable to the farmers than other varieties. So, this variety should be expanded to other areas of Bangladesh.

REGIONAL YIELD TRIAL OF CHICKPEA IN HIGH BARIND TRACT

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during the Rabi season 2020-21 to select suitable chickpea variety through Regional Yield Trial (RYT) under drought prone area. Three genotypes of chickpea viz. BCX-13005-3, BCX-13004-4, BCX-13002-2 and two varieties namely BARI Chola-5 and BARI Chola-10 as a check were tested in the farmer's field. Among the tested genotypes, BCX-13002-2 gave maximum seed yield (1.74 t ha⁻¹) followed by BCX-13005-3 (1.57 t ha⁻¹) and minimum seed yield obtained from BARI Chola-5 (1.48 t ha⁻¹) and BCX-13004-4 (1.49 t ha⁻¹) which are statistically similar.

Introduction

Chickpea (*Cicer arietinum* L) is an important pulse crop in Barind area. Traditionally, the farmers of Barind area cultivate chickpea after harvest of T. Aman rice in residual soil moisture condition. The long duration T. Aman rice affect the proper sowing time of chickpea that causes lower seed yield. Therefore, development of suitable chickpea variety is necessary for improving chickpea productivity in Barind area. Its yield is probably most unstable among pulses due to its more sensitivity to microenvironment. Chickpea is found to be a very suitable dry land *rabi* crop with residual soil moisture condition. Under Barind stress situation it can be successfully grown after harvesting of short duration T. Aman rice. The average yield of chickpea is low (600-700 kg ha⁻¹) compared to other neighboring countries (ICRISAT, 1990). Bangladesh has been developing a good number of varieties of chickpea. BARI has released high yielding and disease resistant/tolerant varieties of chickpea. Yield potentialities of those varieties are 2-3 times higher than national average yields under research station/researchers managed trial. It is assumed that this yield gap between research station and farmers field is due to manifold reasons viz. i) knowledge gap, ii) resources constraints of farmers including quality seed, iii) environmental hazard etc. In relation to the above situation the present trial was undertaken with a view to develop variety(s) through farmer's selection under Barind environments.

Materials and Method

An experiment on regional yield trial (RYT) of chickpea was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during the Rabi season of 2020-21. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 4m x 4m. Line to line distance was 50 cm and plant to plant distance was 10 cm. Treatment combinations were randomly assigned in each replication. The land was opened with a power tiller. Later on, ploughing and cross ploughing were done with country plough followed by laddering. Weeds, stubble and crop residues were removed. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha⁻¹ (BARC, 2012) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Chickpea seeds were sown in 13 November, 2020. Weeding and thinning were done at 20 days after planting of chickpea seeds. First weeding was done at the time of first thinning and second weeding and thinning was done at 35 days after planting of chickpea seeds. No irrigation was applied during the experimental period as there was no symptom of moisture stress. To identify any

change in plant characters and attack of pests and disease the crop plots were frequently observed. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Chickpea was harvested in 18 March, 2021. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Result and Discussion

The performance of yield and yield parameters of chickpea were presented in Table 1. The yield and most of the yield contributing characters like days to flower, days to maturity, plant height (cm), and Thousand Grain Weight (g) showed significant variation except plants m^{-2} and straw yield during 2020-21 cropping season. Among the genotypes, BCX-13002-2 showed maximum number of pods $plant^{-1}$ (76.87) followed by BARI Chola-5 (67.53) and the minimum number of pods $plant^{-1}$ (61.47) obtained from BCX-13005-3. Maximum 1000 seed weight (22.67 g) was found in BCX-13002-2 and BARI Chola-5 (13.04 g) gave minimum weight. BCX-13002-2 gave maximum seed yield ($1.74 t ha^{-1}$) followed by line BCX-13005-3 ($1.57 t ha^{-1}$) and minimum seed yield obtained from BARI Chola-5 ($1.48 t ha^{-1}$) and BCX-13004-4 ($1.49 t ha^{-1}$) which are statistically similar.

Farmer's reaction

Farmers obtained some promising cultivars for Barind condition e.g., BCX-13002-2 and BCX-13005-3 and BARI chola-10. Farmers are happy to get higher yield from selected lines/variety. They also observed that pest attack was lowest in selected lines/variety.

Table 1. Yield and yield attributes of Chickpea genotypes at Basantapur under FSRD site, Godagari, Rajshahi during the rabi season of 2020-2021

Treatment	Days to Flowering	Days to maturity	Plant ht.(cm)	Plants m^{-2}	Pods $plant^{-1}$	Seeds pod^{-1}	1000 grain wt. (g)	Grain yield ($t ha^{-1}$)	Straw yield ($t ha^{-1}$)
BARI Chola-5	81a	117b	47c	24	68ab	1.7a	13.0c	1.48b	1.42
BCX-13005-3	79b	118a	55b	24	62b	1.4b	19.3b	1.57ab	1.47
BCX-13004-4	81a	118ab	56b	22	63b	1.5b	20.5b	1.49b	1.51
BCX-13002-2	77c	118a	60a	23	77a	1.7a	22.7a	1.74a	1.68
BARI Chola-10	76c	115c	53b	24	63b	1.3b	20.5b	1.56ab	1.66
CV (%)	0.84	0.53	3.2	5.1	7.9	8.7	3.8	6.3	11.9
LS	**	**	**	NS	*	**	**	*	NS

LS= Level of Significance, NS= Non-significant, *= Significant at 5% level, **= Significant at 1% level

Conclusion

The performance of variety BARI chola-10, line BCX-13002-2 and BCX-13005-3 appeared to be promising among the lines tested at FSRD site, Basantapur, Godagari, Rajshahi during the study period. So, it can be concluded that the experiment may be repeated for further evaluation in the next year.

ADAPTIVE TRIAL OF CHICKPEA VARIETIES IN CHARLAND

Abstract

A field trial was conducted in the farmer's field under stable Charland of Bonogram, Chilmari, Kurigram during the Rabi season of 2020-21 to identify the suitable variety under stable Charland environments. Four varieties of chickpea BARI Chhola-5, BARI Chhola-9, BARI Chhola-10, and BARI Chhola-11 were tested in the farmer's field. The varieties were evaluated for yield and yield components like days to flowering, days to maturity, plant height, no. of pods $plant^{-1}$, 1000 seed weight, grain and stover yield etc. with the close supervision of OFRD, BARI, Rangpur. Among the tested entries, BARI Chhola-9 ($1.41 t ha^{-1}$) gave maximum seed yield and 2nd highest seed yield produced by BARI Chhola-5 ($1.23 t ha^{-1}$) and BARI Chhola-10 ($1.19 t ha^{-1}$), respectively. BARI Chhola-11 gave minimum yield ($1.07 t ha^{-1}$). The maximum gross margin (60375 Tk. ha^{-1}) was obtained from BARI Chhola-9.

Introduction

In Bangladesh, Chickpea (*Cicer arietinum* L.) is the third major pulse crop after Grass pea and Lentil grown during the winter season. Cultivation of Chickpea can improve the physical, chemical and biological properties of soil. It can also increase the soil fertility status through biological nitrogen fixation from the atmosphere (Upadhyaya et al., 2006). The average yield of chickpea is low (600-700 kg ha⁻¹) compared to other neighboring countries (ICRISAT, 1990). Bangladesh has been developing a good number of varieties of chickpea. The area under Chickpea cultivation has been decreasing rapidly, because of increasing demand for staple grains like rice and wheat. This situation is becoming more severe day by day, because of the poor yield of pulses compared to cereals. The major constraints responsible for low yield of Chickpea includes low yield potential, sensitive to high water and fertilizer application, sensitive to climatic factors as excess soil moisture/humidity and rainfall compared with cereals. Its yield is probably most unstable among pulses due to its more sensitivity to microenvironment. Chickpea is found to be a very suitable dry land Rabi crop with residual soil moisture condition. In the contrary, stable charland area is increasing day by day and there is a scope to produce and expand Chickpea in the charland area. Varietal improvement of Chickpea is essentially needed to increase seed yield by creating variability in the available germplasm. For this reason, some genotypes have been evaluated for last few years to find out the suitable one (s). However, suitable variety needs to identify for charland area. From the above views, the present research work was conducted to identify the suitable chickpea variety for charland.

Materials and Methods

The field trial was conducted at stable Charland of Bonogram, Chilmari, Kurigram AEZ-2 during the Rabi 2020-21. The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 5 m x 8 m. The seeds were sown in 50 cm row to row distance and seed to seed were 10 cm, respectively. Seeds were sown on 24 November, 2020. Four varieties of chickpea BARI Chola-5, BARI Chola-9, BARI Chola-10 and BARI Chola-11 were tested in the farmer's field. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha⁻¹ in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. All fertilizers were applied as basal after final land preparation. The crop was harvested on 20-28 March, 2021. The seed yield and yield components of chickpea were recorded and analyzed statistically.

Results and Discussion

A significant variation was observed among the varieties on the yield and most of the yield contributing parameters (Table 1). Among the tested entries, BARI Chhola-9 (1.41 t ha⁻¹) gave maximum seed yield and the 2nd highest yield produced by BARI Chhola-5 (1.23 t ha⁻¹) and BARI Chhola-10 (1.19 t ha⁻¹), respectively which are statistically significant. BARI Chola-11 gave minimum yield (1.07 t ha⁻¹). Maximum number of pods plant⁻¹ (57.93) was recorded from BARI Chhola-9 followed by BARI Chhola-5 (57.80). The highest 1000 seeds weight (15.43 g) was recorded from BARI Chhola-9 followed BARI Chhola-11 (13.82 g). Maximum gross return (105750 Tk. ha⁻¹) and gross margin (60375 Tk. ha⁻¹) was obtained from BARI Chhola-9.

Farmer's opinion

Farmers are opined that this is first time they produce chickpea in their charland and hope that it will be a promising crop for their area. Farmers are narrated that BARI Chhola-9 is high yielder variety for their Charland area. They keep a handsome amount of seed for next year cultivation. They also observed that pest attack was relatively poor in charland condition.

Table 1. Yield and yield attributes of Chickpea varieties at Charland of Chilmari during 2020-21

Treatment	Days to flowering	Days to maturity	Plant height (cm)	Branch plant ⁻¹	Pods plant ⁻¹	Seeds pod ⁻¹	1000 seed wt. (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
BARI Chhola-5	79	124	57	12.47	58	1.61	12.18	1.23	1.28
BARI Chhola-9	77	124	62	8.87	58	1.41	15.43	1.41	1.49
BARI Chhola-10	75	116	61	8.87	51	1.21	12.59	1.19	1.23
BARI Chhola-11	75	116	80	8.53	46	1.41	13.82i	1.07	1.14
LSD (0.05)	0.74	0.67	2.22	0.65	4.6	0.16	1.51	0.05	0.06
CV (%)	1.85	1.91	10.15	12.16	11.2	7.24	2.89	8.74	9.80

Table 2. Cost and return of chickpea varieties at Charland of Chilmari during 2020-21

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Chhola-5	92250	45375	46875
BARI Chhola-9	105750	45375	60375
BARI Chhola-10	89250	45375	43875
BARI Chhola-11	80250	45375	34875

Price (Tk./kg): Chickpea=75

Conclusion

The performance of variety BARI Chhola-9 appeared to be promising among the varieties tested at Charland area of Bonogram, Chilmari, Kurigram during the study period. This is the first time formally grown chickpea in charland of Char Bonogram, though last year informally tested its feasibility. However, the experiment needs to repeat for further evaluation in the next year.

Acknowledgement: Authors are gratefully acknowledged Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial help & logistic support and also acknowledged PRC, BARI for providing seeds of different varieties.

YIELD PERFORMANCE OF DIFFERENT GARDEN PEA VARIETIES AT SHERPUR REGION

Abstract

The experiment of garden pea was conducted at Tarakandi, Sherpur Sadar, Sherpur during rabi season of 2020-21. Three varieties viz., V_1 = BARI Motorsuti-1, V_2 = BARI Motosuti-3 and V_3 = Natore local were tested in the farmers field. The highest green pod yield (12.9 t ha⁻¹) was obtained from BARI Motorsuti-1. The lowest green pod yield (7.48 t ha⁻¹) was recorded in Natore local.

Introduction

Garden pea (*Pisum sativum* L.) is a popular vegetable crop grown winter season in Bangladesh. It is grown mainly for green pods and seeds are used as vegetables. The garden pea is highly nutritious, tasty. Dry seed of garden pea contains 15-35% protein, 20-25% starch, 4-10% sugar, 0.6-1.5% fat and 2-4% minerals. Cultivation of this crop is highly profitable and preferable to the farmers for its short duration. Inclusion of garden pea in crop rotation helps in improvement of soil fertility by nitrogen fixation. So, the present study was taken to observe the yield performance of garden pea varieties in Sherpur region.

Materials and Methods

The experiment of garden pea was conducted at Tarakandi, Sherpur Sadar, Sherpur during rabi season of 2020-21. Three varieties viz., V_1 = BARI Motorsuti-1, V_2 = BARI Motosuti-3 and V_3 = Natore local were tested in the farmers field. Seeds were sown on 24 November, 2020 with a spacing of 25 cm x 10 cm. The unit plot size was 5m x 4m. The crop was fertilized with 48-24-30 kg ha⁻¹ NPK. One-third of N and all other fertilizers were applied at final land preparation. Remaining N was top dressed at 20 and

35 DAS. Other intercultural operations and plant protection measures were taken as and when necessary. BARI Motorsuti-3 was harvested on 31 January, 2021 and BARI Motorsuti-1 and Natore local were harvested on 02 March, 2021. Data on yield and yield contributing characters were taken and statistically analyzed following MSTAT software package and mean separation was done as per LSD test.

Results and Discussion

Yield and yield contributing characters of garden pea varieties have been presented in Table 1. It was observed that all the parameters were significant. The highest plant height (143.1 cm) was recorded in Natore local and the lowest (54 cm) was in BARI Motorsuti-3. Maximum number of pods per plant (11.8) and seeds per pod (6.40) were found in BARI Motorsuti-1 and minimum (8.0) and (4.13) in BARI Motorsuti-3, respectively. The highest green pod yield (12.9 t ha⁻¹) was obtained from BARI Motorsuti-1 because it produced maximum number of pods per plant and green pod weight per m². The lowest green pod yield (7.48 t ha⁻¹) was recorded in Natore local due to minimum green pod weight per m².

Cost and return analysis

From Table 2, it revealed that the highest gross return (Tk. 3,22,500 ha⁻¹) and gross margin (Tk. 2,25,900 ha⁻¹) were found from BARI Motorsuti-1. The lowest gross return (Tk.1,87,000 ha⁻¹) and gross margin (Tk. 90,400 ha⁻¹) was recorded from Natore local.

Farmer's opinion

Farmers' are interested to cultivate BARI Motorsuti-3 due to short duration than other varieties and without hampering Boro cultivation.

Table 1. Yield and yield contributing characters of Garden pea varieties at Tarakandi, Sherpur sadar, Sherpur during rabi 2020-21

Varieties	Plant height (cm)	No. of Pod Plant ⁻¹	No. of seed Pod ⁻¹	Green pod weight m ⁻² (g)	Green pod yield (t ha ⁻¹)
BARI Motorsuti-1	85.93	11.8	6.40	1290	12.9
BARI Motorsuti-3	54	8.0	4.13	846.7	8.47
Natore local	143.1	10.13	6.13	748.3	7.48
LSD (0.05)	1.73	1.36	0.60	78.26	0.78
CV (%)	0.81	6.05	4.80	3.59	3.59

Table 2. Economic performance of Garden pea varieties at Garden pea varieties at Tarakandi, Sherpur sadar, Sherpur during rabi 2020-21

Varieties	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Motorsuti-1	3,22,500/-	96,600/-	2,25,900/-
BARI Motorsuti-3	2,11,750/-	96,600/-	1,15,150/-
Natore local	1,87,000/-	96,600/-	90,400/-

Price of Motorsuti green pod= Tk 25.0 kg⁻¹

Conclusion

BARI Motorsuti-3 variety might be expanded in Sherpur region, because it can be easily fitted in Motorsuti-Boro-T.Aman cropping pattern without hampering Boro cultivation.

Horticultural Crops

ON-FARM TRIAL OF BARI DEVELOPED EGGPLANT VARIETIES AT MANIKGANJ

Abstract

The adaptive trial was conducted at Boinna Prashad village under Ghior upazila of Manikganj district during Rabi season of 2020-21 to evaluate the performance of BARI released eggplant varieties against local variety. Three eggplant varieties viz. BARI Begun-4, BARI Begun-10 and a farmer's variety (Lalteer hybrid) were tested in the study. The experiment was conducted in RCB design with 5 dispersed replications. Out of the tested varieties, local variety Lalteer hybrid gave higher yield (39.53 t ha^{-1}) than another BARI Begun-4 (32.81 t ha^{-1}) and BARI Begun-10 (22.30 t ha^{-1}). BFSB was the main constraint to achieve higher yield and appropriate measures were taken to control the pest. The higher gross return Tk. 328100.00 ha^{-1} and gross margin (Tk. 199559.00 ha^{-1}) was also obtained from Lalteer hybrid followed by BARI Begun-4 (Tk. 328100.00 ha^{-1} and Tk. 99559 ha^{-1}).

Introduction

Brinjal (*Solanum melongena*) is widely cultivated in Bangladesh and is considered as the second most important vegetable crop after Potato in relation to its total production. Average yield of Brinjal in Bangladesh is low compared to other Brinjal growing countries of the world. The acreage of Rabi Brinjal in Manikganj district was 1564 acres and production 8788 metric tons in 2016-17 (BBS, 2017). This low yield may be due to the cultivation of the low yielding local varieties, incidence of diseases and insects, lack of technical know-how etc. During the recent years, BARI has developed some high yielding varieties of Brinjal which are supposed to be high yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI released Brinjal varieties under farmer's field condition and popularize those varieties among the farmers to promote their adoption.

Materials and Methods

The adaptive trial was conducted in the farmers' field at Boinna Prashad village under Ghior upazila of Manikganj district during Rabi season of 2020-21 to evaluate the performance of BARI released eggplant varieties (BARI Begun-4 and BARI Begun-10) over local variety (Lalteer hybrid) as check. The trial was laid out in RCB design with four dispersed replications. The unit plot size was 10m x 10m with a spacing 100cm x 70cm. The experimental plots were fertilized with 140-50-100-20-1-1.5 kg N-P-K-S-Zn-B along with cowdung @ 5.0 t ha^{-1} . Half of the urea and full amount of other fertilizers were applied as a basal dose. The rest of the urea was applied as top dress at 30 days after planting (DAP). Irrigation was provided twice at 15 and 25 DAP. Thirty days old seedlings were planted from 24 November to 03 December, 2020. Other intercultural operations weeding, irrigation and top dressing of urea and plant protection measures were taken as and when required. Nitro @ 2 ml L^{-1} water was sprayed to control aphid, Jassid and leaf minor insect. The crop was harvested from 25 February to 10 May, 2021. Data on different plant characters and yield were collected and analyzed statistically. The economic return was calculated on the basis of prevailing market price of the commodities.

Results and Discussion

Yield and yield attributes of BARI developed eggplant varieties are shown in Table 1. The fruit size ranged from 21.00 cm to 25.00 cm in length. The fruit size was longer in BARI Begun-10 (24.40 cm) similar to local variety (23.60 cm) and the smallest in size was in BARI Begun-4 (21.80 cm). The diameter of fruits was statistically identical among the varieties of BARI Begun-10 (4.58cm) and Lalteer hybrid (4.55 cm) and slightly lower in BARI Begun-4 (4.19 cm). Profuse bearing of fruits (86.00) was observed in farmers' variety (Lalteer hybrid) followed by BARI Begun-4 (78.00) and lower number of fruits were recorded in BARI Begun-10 (30.00). The highest fruit yield was obtained in Lalteer hybrid (39.53 t ha^{-1}) followed by BARI Begun-4 (32.81 t ha^{-1}). The lower yield was recorded in BARI Begun-10 (22.30 t ha^{-1}).

Cost and return

Gross margin (Tk. 263259.00 ha^{-1}) was higher in Lalteer hybrid than BARI Hybrid Begun-4 (Tk. 199559.00 ha^{-1}) and BARI Hybrid Begun-10 (Tk. 94459.00 ha^{-1}).

Disease and insect infestation

Aphid, Jassid and leaf minor insect were observed in the plants at early growth stage. Shoots of all the varieties were infested by BSFB and appropriate measures were taken.

Farmer's opinion

Farmer chooses Lalteer hybrid for higher yield but they opined that BARI Begun-4 is tastier than hybrid varieties and fruit yield was also satisfactory compared to commercial hybrid. They reacted about the BSFB infection in all BARI varieties. The cost of production increased to a great extent due to regular spraying of insecticides.

Table 1. Yield and yield attributes of eggplant varieties grown at Ghior, Manikganj during *Rabi* season of 2020-21.

Treatments	Length of fruits (cm)	Diameter of fruit (cm)	No. of fruit plant ⁻¹	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Begun-4	21.80	4.19	77.85	32.81	199559.00
BARI Begun-10	24.40	4.58	29.30	22.30	94459.00
Local variety (Lalteer hybrid)	23.60	4.55	86.40	39.53	263259.00
LSD (0.05)	2.66	0.054	6.418	0.918	
CV (%)	2.66	1.50	6.06	1.68	

Market price of brinjal Tk. 10.00 kg⁻¹

Conclusion

Among the tested varieties, BARI released brinjal var. BARI Begun-4 performed better regarding yield potentiality and economic return. Therefore, BARI Begun-4 could be extended in the farmers' field at Manikganj.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED HYBRID EGGPLANT VARIETY

Abstract

An on-farm trial was conducted at MLT site, Barura, Chandina and Debidwer of Cumilla and Saharasti of Chandpur during *rabi* season of 2020-21 to evaluate the performance of BARI developed hybrid Eggplant variety and to popularize the varieties among the farmers. BARI released high yielding hybrid brinjal variety BARI Hybrid Begun-4 was evaluated against commercial Hybrid Begun (Chaity) in farmer's field condition. BARI Hybrid Begun-4 (29.99 t ha⁻¹) gave 5.7% higher fruit yield than local variety Chaity (24.99 t ha⁻¹). Higher gross margin (Tk.507288.00 ha⁻¹) was also obtained from BARI Hybrid Begun-4.

Introduction

Brinjal (*Solanum melongena*) is one of the most important and popular vegetables in Bangladesh. Eggplant is widely cultivated in Bangladesh and is considered as the second major important vegetable crop after potato in relation to its total production. It's grown widely round the year throughout the country. The average yield of brinjal is 5.91 t ha⁻¹ in Kharif and 7.02 t ha⁻¹ in *Rabi* which is lower than the other brinjal growing countries of the world. This low yield may be due to the cultivation of low yielding local varieties, incidence of pest and diseases, lack of technical knowledge etc. During the recent years Horticulture Research Centre (HRC) of BARI has developed some hybrid brinjal varieties i.e. BARI Hybrid Begun-4 which is high yielding and tolerant to pest and diseases (Azad *et. al.* 2017). So, it is necessary to evaluate the adaptability and performance of BARI developed hybrid eggplant varieties under farmer's field conditions and to popularize the variety among the farmers in different areas of Bangladesh.

Materials and Methods

The adaptive trial was conducted at MLT site, Barura, Chandina and Debidwer of Cumilla and Saharasti of Chandpur during Rabi season of 2020-21 to evaluate the performance of BARI Hybrid Begun-4 over the local variety (Chaity hybrid) as check under farmer's field condition. The trial was laid out in RCB design with 6 dispersed replications. The unit plot size was 8.0m × 5.0m with a spacing 180cm x 70cm. Crop management practices used in different locations are shown in Table 1. Half quantity of cowdung was applied during final land preparation. The remaining half of cowdung and total amount of TSP and one third of Urea and MoP were applied during pit preparation 7 days before transplanting. The rest amount of Urea and MoP were applied in 2 equal splits at 25 and 35 days after transplanting. Irrigation was provided twice at 15 and 25 days after planting. Bio-ferty @ 3ml L⁻¹ was applied twice at 25 and 45 DAT to promote the plant growth. To control the disease and insect fungicide/pesticides were applied as and when required. Other intercultural operations and plant protection measures were taken as and when required. Data on different yield characters and yield were collected and analyzed statistically. The economic return was calculated on the basis of prevailing market price of the commodities.

Table 1. Crop management practices used in the experiment

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Cumilla	09-14 December, 2020	10 March to 18May, 2021	170-60-125-18-4.3-1.7-5000

Results and Discussion

Significant variations were observed in fruit length (10.11cm), fruit diameter (8.07cm) and individual fruit weight (133.17g) of BARI Hybrid Begun-4 and Chaity hybrid having 21.79cm, 4.06cm and 80.15g, respectively. But the number of fruits plant⁻¹ between BARI Hybrid Begun-4 (16.65) and Chaity Hybrid (17.55) did not differ statistically. The higher fruit yield (29.99 t ha⁻¹) was obtained from BARI Hybrid Begun-4 and local variety Chaity hybrid gave lower yield (24.29t ha⁻¹). Weight of single fruit contributed to produce higher yield in BARI Hybrid Begun-4 compared to commercial hybrid. The maximum BSFB infested plants (37.5%) were observed in Chaity hybrid and minimum (30.0%) in BARI Hybrid Begun-4.

Cost and return: The highest gross margin was obtained from BARI Hybrid Begun-4 (Tk. 507288.00 ha⁻¹) and the lowest in local variety (Tk. 386163.00 ha⁻¹).

Farmer's opinion

Farmers choose BARI hybrid Begun-4 due to higher yield as well as better taste than check hybrid variety (Chaity). They reacted about the BSFB infection in all BARI varieties. The cost of production increased to a great extent due to regular spraying of insecticides.

Table1. Yield and yield attributes of BARI Hybrid Begun-4 and commercial hybrid (Chaity) at Cumilla and Chandpur during Rabi season of 2020-21.

Variety	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield (t ha ⁻¹)	BSFB infestation (%)	Gross margin (Tk. ha ⁻¹)
BARI Hybrid Begun-4	16.65	10.11	8.07	133.17	29.99	30.0	507288
Hybrid brinjal (Chaity)	17.55	21.79	4.06	80.15	24.29	37.5	386163
LSD (0.05)	NS	7.59	16.19	4.06	4.70	4.594	
CV (%)	2.74	2.723	2.209	1.69	12.46	4.67	

Market price of Brinjal: Tk. 21.25 kg⁻¹

Conclusion

Brinjal variety var. BARI Hybrid Begun-4 performed better regarding yield potentiality and economic return. Therefore, BARI Begun-4 could be extended in the farmers' field at Cumilla region.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI WINTER BOTTLE GOURD VARIETY

Abstract

The trial was conducted at Noakhali and Bandarban during rabi season of 2020-21 to evaluate the performance of BARI developed high yielding winter bottle gourd varieties in the farmer's field. BARI Lau-4 was tested against local variety (Martin) under non-saline condition next to homestead at Noakhali. BARI Lau-3, 4 and 5 were tested against local variety (Hybrid Lau) in the hill valleys of Bandarban. The experiment was laid out in Randomized Complete Block design with six dispersed replications. BARI Lau-4 (7.05 t ha^{-1}) produced 7.63% higher fruit yield compared to local variety (6.55 t ha^{-1}) at Noakhali. In the hill valleys of Bandarban, BARI Lau-5 (25.25 t ha^{-1}), BARI Lau-3 (31.65 t ha^{-1}) and BARI Lau-4 (40.92 t ha^{-1}) gave 40.43, 76.02 and 127.58% higher yield than local variety (17.98 t ha^{-1}). The maximum gross margin was also obtained from BARI varieties at all the tested locations.

Introduction

Bottle gourd (*Lagenaria vulgaris*) is one of the most common popular cucurbits grown in Bangladesh. It can play an important role in supplying vegetables throughout the year and can solve the nutritional problem for the low-income earning people round the year. In our country, farmers cultivate local varieties of bottle gourd. Yield potentiality of local variety is very poor and susceptible to pest and diseases. BARI has developed a good number of winter Bottle gourd varieties which are high yielding, tolerant to different pest and diseases and seed producing potentiality. Farmers' can cultivate BARI Lau-3, BARI Lau-4 and BARI Lau-5 in winter season which possess high yield and attractive colour. The experiment was undertaken to evaluate the performance of BARI Lau-3, BARI Lau-4 and BARI Lau-5 under farmer's field condition and popularize the varieties among the farmers to promote their adoption.

Materials and Methods

The experiment was carried out at Subarnachar upazila of Noakhali district and Bikricchara hill valleys of Bandarban during rabi season of 2020-21 under farmers' field condition. BARI released two bottle varieties BARI Lau-3, BARI Lau-4, BARI Lau-5 were evaluated against local variety in different locations. The trial was laid out in Randomized Complete Block design with six dispersed replications. The unit plot size was 10m x 2.5m. Twenty-five days old seedlings were planted with a spacing of 3m x 2m. Crop management practices used in different locations are shown in Table 1. Full amount of cowdung, P, S, Zn, B and $2/6^{\text{th}}$ of K was applied during pit preparation at least 7 days before transplanting. N and the remaining K were applied in 4 equal installments at 20, 40, 60 and 80 days after transplanting. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. Data on yield and yield attributes were collected and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Planting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Noakhali	28 October 2020	20 January to 5 April 2021	80-30-85-18-4-1.7-5000
Bandarban	28 December 2020	10 March to 10 April 2021	81-30-87-19-4-2-5000

Results and Discussion

Fruit yield of BARI Lau-4 ranged from 40.92 t ha^{-1} to 62.45 t ha^{-1} with a mean yield 51.68 t ha^{-1} . On the other hand, the yield of local variety ranged from 17.98 t ha^{-1} to 58.84 t ha^{-1} with an average yield of 38.41 t ha^{-1} (Table 2). BARI Lau-4 at Noakhali gave 62.45 t ha^{-1} yields whereas local variety produced 58.84 t ha^{-1} . Fruit size of BARI Lau-4 was longer (38.10 cm) than local variety Martin (32.12 cm) but other characters viz. fruit plant⁻¹, fruit diameter and weight of single fruit were statistically at par between the varieties. The highest yield of BARI Lau-4 recorded in the hill valleys of Bandarban (58.84 t ha^{-1}) followed by BARI Lau-3 (31.65 t ha^{-1}) and BARI Lau-5 (25.25 t ha^{-1}). All the yield characters differ significantly among the varieties and fruit length of local variety were longer than BARI variety. Fruit yield in local variety decreased due to lower number of fruits plant⁻¹ (4.23).

Farmer's opinion

Farmers of Noakhali and Bandarban preferred BARI Lau-4 due to its higher yield, higher market price for medium size fruit and excellent test compared to local variety. Insect infestation in this variety was very low as commented by the farmers.

Table 2. Fruit yield and yield attributes of winter Bottle gourd at different locations during the rabi season of 2020-21.

Location	Variety	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Fruit diameter (cm)	Single fruit wt. (kg)	Fruit yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Noakhali	BARI Lau-4	10.65	38.10	9.75	2.45	62.45	494925
	Local variety (Martin)	9.95	32.12	7.20	2.06	58.84	451605
	Level of sig.	NS	*	NS	NS	*	
Bandarban	BARI Lau-3	8.50	43.93	13.22	2.21	31.65	169300
	BARI Lau-4	9.23	46.49	13.61	2.66	40.92	280540
	BARI Lau-5	7.43	47.25	12.50	2.04	25.25	92500
	Local variety (Hybrid Lau)	4.23	53.67	13.44	2.52	17.98	5260
	LSD (0.05)	11.06	6.67	10.44	13.39	19.12	
	CV (%)	0.66	2.61	1.12	0.26	4.52	

Market price of Bottle gourd at Noakhali and Bandarban: Tk.12 kg⁻¹

Conclusion

The Bottle gourd var. BARI Lau-4 performed better than local variety regarding yield potentiality. Therefore, these varieties could be cultivated widely in the tested locations.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI SUMMER BOTTLE GOURD VARIETY

Abstract

The experiment was conducted at Jashore and Noakhali during Kharif-I season of 2020 to evaluate the performance of BARI summer Bottle gourd variety at farmers' field. BARI developed summer bottle gourd variety BARI Lau-4 was evaluated against local variety as check at both the location. BARI Lau-4 produced statistically higher yield 48.25 t ha⁻¹ at Jashore and 42.85 t ha⁻¹ at Noakhali in Kharif season than local variety 42.93 and 38.94 t ha⁻¹, respectively. Higher gross margin (Tk. 468320.00 and Tk. 337055 ha⁻¹) was also obtained from BARI Lau-4 than local variety (Tk. 388520.00 and 280360.00 ha⁻¹) in the tested locations.

Introduction

Bottle gourd is one of the popular vegetable crops in our country. The area of bottle gourd is markedly decreased and production also declining day by day. The reason behind the declining of production is probably associated with variety, climatic change and improper management with decreasing soil fertility, deficiency of micro nutrient and quality seed availability during the sowing time. Farmers use traditional low yielding varieties those are susceptible to pest and diseases. Farmers generally grow bottle gourd in winter season but BARI has developed some varieties those can be grown in summer season also. These varieties are supposed to be high yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI released Bottle gourd varieties in Kharif-I season in the farmers field at Jashore and medium high land adjacent to homestead under non-saline condition at Noakhali.

Material and Methods

The experiment was conducted at MLT site Jhikargacha, Jashore and Subarnachar upazila in Noakhali district (AEZ 18f) during Kharif-I season of 2021 to evaluate the performance of BARI developed summer bottle gourd varieties at farmers' field. At Noakhali, the trial was conducted in non-saline condition (next to homestead). At both the location, BARI Lau-4 was evaluated against local variety viz. Hazali Lau at Jashore and Martin at Noakhali. The trial was laid out in RCB design with six dispersed replications. The unit plot size was 10m x 2.5m and 3m x 2m spacing was maintained. Crop management practices used in different locations are shown in Table 1. The plots were fertilized with N-P-K-S-Zn-B Kg ha⁻¹ @ 81-30-87.5-18.18-4.31-1.70 in the form of urea, TSP and MoP, Gypsum, Zinc and Boron, respectively. Cowdung was applied @ 5.0 t ha⁻¹. Half of cowdung and full amount of TSP, half of MoP were applied as basal during final land preparation. The remaining half of cowdung was applied during pit preparation. The whole amount of urea and remaining MoP were applied at 10, 25 and 40 days after transplanting. The field was irrigated three times at the same day of top dressing. Two weeding was done at 40 and 56 DAT. Data on yield and yield contributing character were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Planting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Jashore	02 May, 2020	22 July to 08 September, 2020	80-45-87-25-4-2-5000
Noakhali	03 April 2020	15 June to 08 August 2020	80-30-85-18-4-1.7-5000

Result and Discussions

Fruit yield of BARI Lau-4 ranged from 42.93 to 48.25 t ha⁻¹ with an average yield of 45.59 t ha⁻¹. On the other hand, the yield of local variety ranged from 38.94 t ha⁻¹ to 42.93 t ha⁻¹ with an average yield of 40.93 t ha⁻¹ (Table 2). The yield characters of BARI Lau-4 at Jashore differ significantly with local variety (Hazari). The number of fruit plant⁻¹ (11.00) and weight of single fruit (1.93 kg) were higher in BARI Lau-4 than local variety. The higher yield (48.25 t ha⁻¹) was obtained from BARI Lau-4 and lower (42.93 t ha⁻¹) in local variety. At Noakhali, the yield and yield contributing characters of BARI Lau-4 and local variety in Kharif season were not pronounced. The number of fruits plant⁻¹ (7.05) was slightly higher in BARI Lau-4 than local variety (6.55). The maximum individual fruit weight (2.35 kg) was recorded in BARI Lau-4 and it was (1.92 kg) in local variety (Martin). The highest fruit yield (40.85 t ha⁻¹) was obtained from BARI Lau-4 and the lowest in Martin (38.94 t ha⁻¹).

Cost and return

The economic return was calculated on the basis of prevailing market price of the commodities. Higher gross margin Tk. 468320.00 ha⁻¹ and Tk. 337055.00 ha⁻¹ was found from BARI Lau-4 at Jashore and Noakhali, respectively compared to local variety farmers variety Hazari (Tk. 388520.00 ha⁻¹) and Martin (Tk. 280360.00 ha⁻¹).

Farmer's opinion

Jashore: Farmers expressed their satisfaction with higher yield, single fruit weight and attractive color of BARI Lau-4. This variety is accepted by the farmers and they are interested to grow it in future.

Noakhali: Farmers' preferred BARI Lau-4 due to its good test and softness compared to local variety (Martin).

Table 1. Yield, yield contributing characters and gross margin of summer Bottle gourd varieties at Jashore and Noakhali during Kharif-I season of 2020.

Location	Varieties	Fruit plant ⁻¹	Individual fruit wt. (kg)	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Jashore	BARI Lau-4	11.00	1.93	48.25	468320
	Local variety (Hazari)	9.00	1.71	42.93	388520
	Level of sig.	14.74	9.88	3.01	
Noakhali	BARI Lau-4	7.05	2.35	42.85	337055
	Local variety (Martin)	6.55	1.92	38.94	280360
	Level of sig.	NS	NS	NS	

Market price of Bottle gourd during Kharif season: Jashore: Tk. 15.00kg⁻¹ and Noakhali: Tk. 14.60 kg⁻¹

Conclusion

The Bottle gourd var. BARI Lau-4 performed better than local variety regarding yield potentiality and economic return in summer season. Therefore, this variety could be cultivated widely in the tested locations.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED HYBRID PUMPKIN VARIETY

Abstract

The trial on hybrid pumpkin varieties were conducted at Mymensingh, Cumilla, and Manikganj during rabi season of 2020-21 to evaluate the performance of BARI developed pumpkin varieties in the farmers' field. BARI developed hybrid sweet gourd variety viz. BARI Hybrid Mistikumra-2 was tested against local variety Sweety hybrid at Mymensingh and Maxima hybrid at Cumilla as check. BARI developed three open pollinated varieties viz. BARI Mistikumra-1, BARI Mistikumra-2 and BARI Mistikumra-3 were tested against local variety Lalteer hybrid at Manikganj. The experiment was laid out in RCB design with six dispersed replications. BARI Hybrid Mistikumra-2 produced fruit yield 30.00 and 36.56 t ha⁻¹ at Mymensingh and Cumilla, respectively which were 14.41 and 38.85% higher than farmers' variety Sweety hybrid (26.22 t ha⁻¹) and Maxima hybrid (26.33 t ha⁻¹). At Manikganj, commercial variety Lalteer hybrid gave higher yield ((32.60 t ha⁻¹) than BARI Mistikumra-3 (29.30 t ha⁻¹), BARI Mistikumra-1 (24.30 t ha⁻¹) and BARI Mistikumra-2 (20.80 t ha⁻¹). Higher gross margin (Tk. 110395 and Tk. 421840 ha⁻¹) was also obtained BARI Hybrid Mistikumra-2 at Mymensingh and Cumilla but Lalteer hybrid (Tk. 273055.00 ha⁻¹) at Manikganj.

Introduction

Sweet gourd is a cucurbitaceous vegetable grown throughout the sub-tropical and tropical regions of the world. In Bangladesh, it is a common vegetable crop fulfills a major portion of vegetable demanded of the peoples of the country. It is grown round the year having the longest storage capability and high nutrition value. However, the area and production in Bangladesh is so far low comprising to those sweet gourd producing countries. The total area under cultivation of sweet gourd was 4262 acres and the total production 190644 metric ton in the year 2016-17 (BBS, 2017). While many newer commercial varieties with higher yield potentiality are available that would encourage growers to accept these varieties for higher economic return. BARI has developed high yielding hybrid pumpkin varieties with a remarked family size but their performances in different growing regions have not been well studied. The performance of these varieties needs to be evaluated in the farmers' field. Therefore, the present trial was undertaken with BARI developed sweet gourd varieties to evaluate their yield performance and popularize the varieties among the farmers to promote their adoption.

Materials and Methods

The experiment was conducted at Cumilla, Mymensingh and Manikganj district during rabi season of 2020-21. BARI developed three open pollinated and one hybrid pumpkin varieties were evaluated in different locations. BARI Hybrid Mistikumra-2 against local variety Sweety hybrid at Mymensingh and Maxima hybrid at Cumilla were tested. On the other hand, BARI Mistikumra-1, BARI Mistikumra-2 and BARI Mistikumra-3 against farmers' variety Lalteer hybrid at Manikganj were evaluated. The unit plot size was 7.5m × 1.25m and spacing was maintained 1.5m × 1.5m. The crop management practices used in different locations shown in Table 1. The crop was fertilized with NPKSZnB fertilizers in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively along with 5 t ha⁻¹ cowdung. Total amount of cowdung, one third of MoP and all other fertilizers except N were applied in pit 7 days prior to seed sowing. Rest K was applied twice at 20 days interval and N were applied in four equal instalments at 15, 35, 55 and 75 DAP. Intercultural operations like watering and weeding were done as and when required. Folicure @ 1 ml L⁻¹ water was applied to control white fly insect. Pheromone trap was also used at 12m distance in the plot to control fruit fly insect as well. Fruit yield and yield component were collected and analysed statistically.

Table 1. Crop management practices used in different locations during rabi season of 2020-21.

Locations	Date of sowing	Date of harvest	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Mymensingh	28 November, 2020	08March to 12 April, 2021	78-35-75-18-4-2-5000
Cumilla	27 November to 19 December, 2020	09 to 30 March, 2021	80-40-75-6-1.4-0.7-5000
Manikganj	01 to 10 December, 2020	05 to 30 March, 2021	78-35-75-18-4-2-5000

Results and Discussion

The fruit yield and yield characters varied significantly among the sweet gourd varieties in different tested locations. The number of fruits plant⁻¹ ranged from 4.0 to 6.0 in different sweet gourd varieties and BARI Hybrid Mistikumra-2 produced maximum number of fruits plant⁻¹ at Cumilla (4.16) and Mymensingh (6.2) compared to Maxima hybrid (3.91) at Cumilla, Sweety hybrid (5.9) and Lalteer hybrid (4.40) at Manikganj. The single fruit weight of BARI Hybrid Mistikumra-2 ranged from 2.26 to 2.33 kg. Local hybrids had the maximum single fruit weight (1.89to 2.41 kg) compared to BARI Mistikurma-2(1.28kg), BARI Mistikurma-1(1.62) and BARI Mistikurma-3 (2.11 kg) varieties (1.28 to 2.11 kg) grown at Manikganj. BARI Hybrid Mistikumra-2 produced higher fruit yield 30.00 t ha⁻¹at Mymensingh and 36.56 t ha⁻¹ at Cumilla. Local varieties produced lower yields at Mymensingh (26.22 t ha⁻¹) and Cumilla (26.33 t ha⁻¹). Farmers variety (Lalteer hybrid) gave the maximum yield (32.60 t ha⁻¹) followed by BARI Mistikumra-3 (29.30 t ha⁻¹), BARI Mistikumra-1 (24.30t ha⁻¹) and BARI Mistikumra-2 (20.80 t ha⁻¹) at Manikganj.

Cost and return

Mymensingh: The maximum gross margin (Tk. 110395.00 ha⁻¹) was obtained from BARI Hybrid Mistikumra-2 and minimum in check variety (Tk. 91495.00 ha⁻¹).

Cumilla: Higher gross margin (Tk. 421840.00 ha⁻¹) was obtained from Hybrid Mistikumra-2 than Maxima hybrid (Tk. 278620 ha⁻¹).

Manikganj: Higher gross margin (Tk.273055.00 ha⁻¹) was obtained from Lalteer hybrid followed by BARI Mistikumra-3 (Tk. 236955.00 ha⁻¹), BARI Mistikumra-1 (Tk.176955.00ha⁻¹) and BARI Mistikumra-2 (Tk. 134955.00ha⁻¹).

Disease and pest incidence

At Mymensingh, white fly infestation was controlled spraying with Malataf @ 2 ml L⁻¹ water. Pheromone trap was also set at 12 m distance in the plot to control the fruit fly insect. Fruit fly infestation was observed in the plots at Manikganj. Sex pheromone trap was used to control it. Powdery mildew disease was also observed in the plots.

Farmers' opinion

Farmers of Mymensingh and Cumilla chose BARI Hybrid Mistikumra-2 for its higher yield, colour, sweetness and longer fruiting duration in the field while at Manikganj, farmers preferred BARI Mistikumra-3 due to its medium fruit size and good demand in the market.

Table 2. Yield and yield attributes of sweet gourd varieties at different location during Rabi season of 2020-21.

Locations	Variety	Fruits plant ⁻¹ (no.)	Single fruit wt. (kg)	Fruit yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Mymensingh	BARI Hybrid Mistikumra-2	6.2	2.26	30.00	110395
	Hybrid Mistikumra (Sweety)	5.9	2.41	26.22	91495
	T-value	0.818	-3.135	0.093	
Cumilla	BARI Hybrid Mistikumra-2	4.16	2.33	36.56	421840
	Hybrid Mistikumra (Maxima)	3.91	1.89	26.33	278620
	LSD _(0.05)	0.29	0.49	7.55	
	CV (%)	4.7	13.5	13.68	
Manikganj	BARI Mistikumra-1	4.80	1.62	24.30	176955.00
	BARI Mistikumra-2	4.60	1.28	20.80	134955.00
	BARI Mistikumra-3	4.80	2.11	29.30	236955.00
	Hybrid Mistikumra (Lalteer)	4.40	2.40	32.60	273055.00
	LSD _(0.05)	0.435	0.292	2.963	
	CV (%)	6.80	11.42	8.04	

Price of sweet gourd: Cumilla: Tk. 14 kg⁻¹, Mymensingh: Tk. 5 kg⁻¹, Manikganj: Tk. 12 kg⁻¹

Conclusion

Sweet gourd var. BARI Hybrid Mistikumra-2 and BARI Mistikumra-3 showed better performance regarding yield and economic return. Therefore, large-scale extension of these BARI varieties is required in the study areas.

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ON-FARM TRIAL OF BARI DEVELOPED BITTER GOURD VARIETY

Abstract

The experiment was conducted at Cumilla, Faridpur, Jashore and Rajshahi during the Kharif-II season of 2021 to evaluate the yield performance of BARI Bitter gourd varieties against commercial hybrid varieties as check. BARI Korola-2 and BARI Korola-3 against farmers' variety (Tia hybrid) at Cumilla and Faridpur; BARI Korola-2, BARI Korola-3 against local variety (Goj Korola) at Jashore; BARI Korola-2 and BARI Korola-3 against local variety at Rajshahi were evaluated. The experiment was laid out in RCBD with six dispersed replications. BARI Korola-2 gave the highest yield (17.32 t ha⁻¹) at Rajshahi followed by Jashore (9.15 t ha⁻¹), Faridpur (5.79 t ha⁻¹) and the lowest at Cumilla (5.05 t ha⁻¹). BARI Korola-3 gave 4.12, 7.70 and 8.33 t ha⁻¹ yield in the farmers field at Faridpur, Cumilla and Jashore, respectively. The yield of commercial hybrid (Tia) ranged from 4.82 to 12.11 t ha⁻¹ and BARI varieties performed better at all the tested locations compared to local hybrids. Higher gross margin was also obtained from BARI Bitter gourd varieties.

Introduction

Bitter gourd is one of the most popular vegetable crops in our country cultivated mostly during Kharif season. During the rainy season the market price of this crop remains high but the production area is limited and total production is also low. This declining is probably associated with variety, climatic change, and improper management decreasing soil fertility, deficiency of micronutrient and quality seed

availability during the sowing time. Farmers generally collect seeds of commercial variety from the seed traders. Some advance farmers grow commercial hybrid variety but the seeds are very costly that causes economic loss to the farmers. Horticulture Research Centre of BARI has developed some varieties of Bitter gourd which are supposed to be higher yielder and less susceptible to pest and diseases. These new varieties should be disseminated in the farmers' field. The present study was therefore undertaken to evaluate the performance of BARI Bitter gourd varieties in the farmer's field and to popularize the varieties among the farmers.

Materials and Methods

The experiment was conducted at farmer's field during Kharif-II season of 2020 at Cumilla, Faridpur, Jashore and Rajshahi. The experiment was laid out in RCB design with six dispersed replications. BARI Korola-2 and BARI Korola-3 against local variety (Tia hybrid) at Cumilla and Faridpur; BARI Korola-2, BARI Korola-3 against local variety (Goj Korola) at Jashore; BARI Korola-2 and BARI Korola-3 against local variety at Rajshahi were evaluated. The plot size was 7.5m × 1.25m and spacing was 1.5m × 1.5m. The crop management practices used in different locations is shown in Table 1. Whole amount of cowdung, one-third of urea, one-third of MoP, total amount of TSP, Gypsum, Zinc and Boron were applied one week before transplanting of seedlings. The remaining amount of urea and MoP were applied in two equal splits at 25 and 40 DAP. For controlling pest and disease, Nitro @ 2.0 ml L⁻¹ water, Emitaf @ 0.25 ml L⁻¹, and Pegasus @ 1ml L⁻¹ and Dithane M-45@ 2.5 ml L⁻¹ water were sprayed time to time during the cropping period in different tested locations. Other intercultural operations and plant protection measures were taken as and when required. Data on yield and yield contributing characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Cumilla	09 to 10 June, 2020	15 July to 30 August, 2020	76-40-70-14-2-2-5000
Faridpur	07 to 12 May, 2020	13 to 17 August, 2020	100-40-30-15-1-1-5000
Jashore	02 May, 2020	22 July to 08 September 2020	80- 45-87-25-4-2-5000
Rajshahi	16 April, 2020	10 June to 17 August, 2020	76-32-70-15-4-2-5000

Results and Discussion

The fruit yield and yield characters of Bitter gourd varieties differ statistically among the varieties in different tested locations. BARI Korola-2 gave higher yield at all the tested locations except at Cumilla (43.63 t ha⁻¹) where BARI Korola-3 gave higher yield (7.70 t ha⁻¹) than BARI Korola-2 (5.05 t ha⁻¹). The number of fruits plant⁻¹ among the varieties differ statistically at all the tested locations except at Cumilla (6.90 to 7.85). The maximum number of fruits plant⁻¹ (20.00 to 24.00) was recorded at Jashore followed by Rajshahi (11.42 to 21.61) and Faridpur (9.28 to 12.28). The weight of single fruit of BARI Korola-2 ranged from 43.63g to 80.96g and BARI Korola-3 ranged from 46.78g to 89.80g whereas 58.62 to 100.60 g was recorded in local variety. The highest fruit yield (17.32 t ha⁻¹) from BARI Korola-2 was obtained at Rajshahi followed by Jashore (9.15 t ha⁻¹), Faridpur (5.79 t ha⁻¹) and the lowest at Cumilla (5.05 t ha⁻¹). BARI Korola-3 gave 4.12, 7.70 and 8.33 t ha⁻¹ yield in the farmers field at Faridpur, Cumilla and Jashore, respectively. The yield of commercial hybrid (Tia) ranged from 4.82 to 12.11 t ha⁻¹ and BARI varieties performed better at all the tested locations compared to local hybrids. Higher number of fruits plant⁻¹ and single fruit weight contributed to produce higher yield in BARI varieties.

Cost and return

The economic return was calculated on the basis of yield and prevailing market price of the commodities. The maximum gross margin Tk. 76018, Tk. 293570 and Tk. 219000 ha⁻¹ were obtained from BARI Korola-2 at Faridpur, Jashore and Rajshahi, respectively while BARI Korola-3 gave higher gross margin (Tk. 256500 ha⁻¹) at Cumilla. The minimum gross margin was recorded in local varieties at all the tested locations.

Pest and disease incidence: At Jashore, the crop was slightly infested by fruit fly and sex pheromone trap was used for controlling this insect. At Faridpur, lower leaves of the plant became yellowish during flowering and fruiting stage and move upward infecting the upper leaves. Thus, number of flowers and fruits reduced and size of fruit appeared smaller. Fungicide Autostin @ 2.5 ml L⁻¹ water sprayed three times at 24-26, 35-41 and 53-57 DAT.

Farmers at Faridpur, Jashore and Rajshahi expressed their satisfaction with higher yield of BARI Korola-2 due to its higher yield and market demand whereas farmers at Cumilla choose BARI Korola-3 as this variety gave higher yield and economic return than Tia hybrid and BARI Hybrid Korola-2.

Table 2. Yield and yield contributing characters of Bitter gourd varieties grown at different locations during Kharif season of 2020.

Location	Variety	Fruits plant ⁻¹ (no.)	Single fruit wt. (g)	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Cumilla	BARI Hybrid Korola-2	6.90	43.63	5.05	137250
	BARI Hybrid Korola-3	7.85	89.80	7.70	256500
	Tia Hybrid	7.15	100.60	6.70	211500
	LSD (0.05)	NS	15.38	1.67	
	CV (%)	7.40	4.58	6.01	
Faridpur	BARI Hybrid Korola-2	11.00 b	65.98 a	5.79 a	76018
	BARI Hybrid Korola-3	12.28 a	46.78 b	4.12 c	1318
	Tia Hybrid	9.28 c	65.33 a	4.82 b	32368
	CV (%)	5.92	11.03	5.65	
Jashore	BARI Korola-2	24.40 c	80.60 b	9.15 a	293570
	BARI Korola-3	22.40 b	75.80 c	8.33 bc	244371
	Goj Korola (Local)	20.00 a	74.40 a	8.07 c	228770
	CV (%)	11.42	8.89	5.09	
Rajshahi	BARI Korola-2	17.94	80.96	17.32	219000
	BARI Korola-3	21.61	69.31	15.14	164500
	Local variety	14.54	58.62	12.11	88750
	LSD (0.05)	6.77	4.38	2.76	
	CV (%)	10.16	8.26	9.34	

Farm gate price of Bitter gourd: Cumilla- Tk. 45 kg⁻¹, Faridpur- Tk. 45 kg⁻¹, Jashore- Tk.60 kg⁻¹, and Rajshahi- Tk. 25 kg⁻¹

Conclusion

Considering the yield and economic return, Bitter gourd var. BARI Korola-2 and BARI Korola-3; BARI Hybrid Korola-2 and BARI Hybrid Korola-2 was found to be promising than local variety. Therefore, BARI varieties could be extended in the tested locations.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM ADAPTIVE TRIAL OF BARI DEVELOPED OKRA VARIETY

Abstract

The on-farm trial was conducted at Cumilla during Kharif season of 2020 and Pabna during Kharif season of 2021 to evaluate the performance of BARI Dherosh-1 and BARI Dherosh-2 against local variety as check. The experiment was laid out in RCB design with six dispersed replications. BARI Dherosh-2 produced higher marketable yield 10.10 and 15.10 t ha⁻¹ at Cumilla and Pabna, respectively whereas local variety gave 9.7 and 10.70 t ha⁻¹. BARI Dherosh-2 was resistant to YVMV in the farmers' field at Pabna but 10.1% infestation was recorded at Cumilla compared to local variety (9.7%). Higher gross margin was also obtained from BARI Dherosh-2 at both the tested locations.

Introduction

Okra (*Abelmoschus esculentus*) is an important vegetable crop of Bangladesh. The average yield of this crop is low in Bangladesh compared to other okra producing countries. Lack of high yielding variety and yellow vein mosaic virus (YVMV) is considered as the major limiting factor for Okra production. Farmers generally use local varieties. Yield potentiality of local variety is very poor and susceptible to pest and diseases and provides poor economic return. BARI has released BARI Dherosh-1 and BARI Dherosh-2 those have high yield potentiality and tolerant to yellow vein mosaic virus disease. It needs to evaluate the BARI varieties in the farmers field and to popularize the varieties among the farmers. Therefore, an adaptive trial was undertaken to evaluate the performance of this new variety in different locations and to increase farmers' production and income.

Materials and Methods

The trial was conducted at Cumilla during Kharif season of 2020 and Pabna during Kharif season of 2021. BARI Dherosh-2 and a farmer's variety (Nolok) as check were used at Cumilla but BARI Dherosh-1, BARI Dherosh-2 and a farmer's variety as check were used at Pabna. The experiment was laid out in RCBD with six dispersed replications. The unit plot size was 7m × 6m with spacing of 60cm × 40cm. Crop management practices used in different locations shown in Table 1. Total amount of cowdung, TSP and MoP were applied at the time of final land preparation. The remaining amount of MoP was applied as top dress after 30 days of seed sowing. Urea was applied in three equal splits at 30, 45 and 60 days after sowing. Intercultural operations and plant protection measures were done properly. To control the diseases and insect Dithane M-45 @ 4.5 g L⁻¹, Ridomil Gold @ 2.5 ml L⁻¹ and Admire @ 1 ml L⁻¹, Desis @ 2 ml L⁻¹, Reluthrin 2 ml L⁻¹ were applied during the whole cropping period. Data on yield and yield contributing characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Cumilla	20-29 March, 2020	20 May to 09 July, 2020	70-20-75-0-0-0-5000
Pabna	27 March, 2021	20May to 10 July 2021	74-30-75-0-0-0-5000

Results and Discussion

At Cumilla, yield components such as fruit plant⁻¹ (27.20) and single fruit weight (18 g) contributed to achieve higher yield (10.10t ha⁻¹) in BARI Dherosh-2 than local variety (9.70 t ha⁻¹). At Pabna, BARI Dherosh-2 exhibited significantly higher yield (15.10 t ha⁻¹) due to higher number of fruits plant⁻¹ (24.3) and single fruit weight (15.00 g) compared to local variety that gave lower yield (10.70t ha⁻¹).

Cost and return

Cumilla: The gross margin from okra varieties varied due to variation in fruit yield. Gross margin (Tk. 159200 ha⁻¹) was higher in BARI Dherosh-2 and lower in commercial variety Nolok (Tk. 151200 ha⁻¹).

Pabna: Higher gross margin (Tk. 247630 ha⁻¹) was attained from BARI Dherosh-2 over local variety (Tk. 150170 ha⁻¹).

Pest and disease incidence:

Cumilla: Yellow Mosaic Virus infestation was 10.1% in BARI Dherosh-2 whereas 9.7% in local variety (Nolok).

Pabna: No significant disease and pest infestation was observed.

Farmers Opinion

Cumilla: BARI Dherosh-2 was chosen by the farmers for shape, size, color and less virus infestation compared to commercial variety Nolok.

Pabna: Farmers showed their interest to BARI Dherosh-2 as it exhibited higher yield compared to local variety. They were quite happy to get higher economic return from BARI developed okra variety.

Table 2. Yield and yield components of okra varieties at Cumilla and Pabna during Kharif season of 2020 and 2021.

Location	Varieties	Fruit plant ⁻¹ (no.)	Single fruit wt. (g)	Fruit yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Cumilla	BARI Dherosh-2	27.20	18.00	10.50	159200
	Local variety (Nolok)	23.00	15.50	9.30	151200
	T test (0.05)	*	*	*	
Pabna	BARI Dherosh-1	20.2	15.40	12.80	196590
	BARI Dherosh-2	24.30	15.00	15.10	247630
	Local variety	18.80	13.60	10.70	150170
	LSD (0.05)	1.60	0.49	1.3	
	CV (%)	4.40	1.90	5.6	

Market price of Okra, Cumilla: Tk. 20 kg⁻¹ and Pabna: Tk. 22 kg⁻¹

Conclusion

Okra var. BARI Dherosh-2 is a promising variety regarding yield and economic return than the check variety. Therefore, this variety could be extended in the tested locations.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED WINTER TOMATO VARIETIES

Abstract

The trial was conducted at Manikganj, Tangail, Narsingdi, Rajshahi, Cumilla, Noakhali and Bandarban during rabi season of 2020-21 to evaluate the performance of BARI developed winter Tomato varieties. Eight BARI Tomato varieties viz. BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18, BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 were evaluated against local varieties as check grown in different locations in the study. BARI developed Tomato varieties performed better in different locations compared to local varieties. BARI Tomato-14 produced higher and similar yields in the farmers field at Rajshahi (66.47 t ha⁻¹) and Sauria, Manikganj (59.51 t ha⁻¹). BARI Tomato-15 gave higher average yield 80.05 t ha⁻¹ at three locations of Tangail followed by Rajshahi (70.21 t ha⁻¹). Similarly, higher average yield 80.60 t ha⁻¹ was obtained from BARI Tomato-16 at Tangail, Narsingdi (75.50 t ha⁻¹) and the lowest (59.87 t ha⁻¹) at Rajshahi. BARI Tomato-17 performed better at Narsingdi (84.67 t ha⁻¹) and Satutia, Manikganj (79.72 t ha⁻¹). BARI Tomato-18 provided average 75.30 t ha⁻¹ in three locations of Tangail with the maximum yield at Atia, Tangail (90.06 t ha⁻¹) followed by Narsingdi (70.50 t ha⁻¹), Noakhali (69.45 t ha⁻¹) and the lowest at Rajshahi (55.64 t ha⁻¹). The higher fruit yield was recorded from BARI Tomato-19 (93.56 t ha⁻¹) and BARI Tomato-21 (85.78 t ha⁻¹) in the hill valleys of Bandarban. Local variety produced lower yields (24.12 to 58.84 t ha⁻¹) at all the tested locations except at Bandarban (82.89 t ha⁻¹). Higher gross margin was obtained from BARI winter Tomato varieties in all locations compared to local variety.

Introduction

Tomato (*Solanum lycopersicum*) is the most important vegetables crop in Bangladesh cultivated during the rabi season. It is a good source of vitamins and minerals. This average yield of Tomato is very low compared to other Tomato growing countries of the world. Farmers use the traditional varieties those are low yielding and susceptible to diseases and pests. As a result, yield is decreasing day by day. Horticulture Research Centre of BARI has developed some Tomato varieties which are supposed to be high yielding and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI developed Tomato varieties at different locations and to increase production and economic return of farmers.

Materials and Methods

The experiment was conducted at Manikganj, Tangail, Narsingdi, Rajshahi, Cumilla, Noakhali, and Bandarban during rabi season of 2020-21. BARI Tomato-14, BARI Tomato-17 and against a local variety (Ruma VF) at Manikganj; BARI Tomato-15, BARI Tomato-16 and BARI Tomato-18 at Tangail; BARI Tomato-16, BARI Tomato-17, BARI Tomato-18 and BARI Tomato-19 against a local variety (Surma) at Narsingdi; BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18, BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 at Rajshahi; BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 against a local variety (Ruma VF) at Cumilla; BARI Tomato-17, BARI Tomato-18 and BARI Tomato-20 against a local variety (Ruma VF) at Noakhali; BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 against farmers variety at Bandarban were evaluated. The experiment was laid out in RCB design with six dispersed replications. The unit plot size 5m × 4m and spacing was 60cm × 40cm. Crop management practices used in different locations shown in Table 1. The whole amount of cowdung, TSP, MOP, Gypsum, Zinc sulphate, Boric acid and half of urea were applied during final land preparation. The remaining urea was applied in two equal splits at 30 and 45 days after transplanting. Other intercultural operations were done as and when required. Data on yield and yield attributes were taken and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Manikganj	23 October to 17 November 2019	08 January to 10 February 2020	250-90-125-22-1-1-5000
Tangail	15-23 November 2020	09 February to 10 April 2021	253-90-125-22-5.4-2-5000
Narsingdi	20-22 November 2020	15 February to 15 March 2021	161-44-132-21.6-5.04-2.04-5000
Rajshahi	01 to 03 December, 2020	28 February to 03 April, 2021	253-90-125-22-5.4-2-5000
Cumilla	01 to 03 December, 2020	23 February to 20 April, 2021	210-50-75-0-0-0-5000
Noakhali	6 to 7 December, 2020	26 February to 05 April, 2021	253-90-125-22-5.40-2-5000
Bandarban	16 December, 2020	10 March to 20 April, 2021	250-90-125-22-0-0-5000

Results and Discussion

All BARI developed Tomato varieties performed better in the farmer's field of Tangail, Narsingdi and Rajshahi whereas lower yields were obtained at Ghior, Manikganj. Yield characters such as number of fruits plant⁻¹ and single fruit weight contributed to produce higher yield in different Tomato varieties. The yield of BARI Tomato-14 ranged from 40.38 to 66.47 t ha⁻¹ but higher yield was found at Rajshahi (66.47 t ha⁻¹). BARI Tomato-15 produced higher yield at Atia, Tangail (92.60 t ha⁻¹) followed by Dhanbari-Tangail (78.59 t ha⁻¹), Rajshahi (70.21 t ha⁻¹) and Ghatail, Tangail (68.97 t ha⁻¹). BARI Tomato-16 gave higher and similar yields at Dhanbari (88.81 t ha⁻¹) and Atia, Tangail (88.13 t ha⁻¹) followed by Narsingdi (75.50 t ha⁻¹), Ghatail, Tangail (64.8 t ha⁻¹) and Rajshahi (59.87 t ha⁻¹). The yield of BARI Tomato-17 ranged from 47.90 to 83.17 t ha⁻¹ producing higher yields at Narsingdi (83.17 t ha⁻¹) followed by Sauria, Manikganj (79.72 t ha⁻¹), Noakhali (62.85 t ha⁻¹) and Rajshahi (61.84 t ha⁻¹) but the lowest at Ghior, Manikganj (47.90 t ha⁻¹). BARI Tomato-18 produced higher yields at Atia, Tangail (90.06 t ha⁻¹), Narsingdi (70.50 t ha⁻¹) and Noakhali (69.45 t ha⁻¹) but lower yields were obtained at Ghatail, Tangail (63.46 t ha⁻¹) and Rajshahi (55.64 t ha⁻¹). The yield of BARI Tomato-19 was quite high at Bandarban (93.56 t ha⁻¹) followed by Narsingdi (65.12 t ha⁻¹), Cumilla (53.50 t ha⁻¹) and the lowest at Rajshahi (49.38 t ha⁻¹). BARI Tomato-20 performed the best at Noakhali (74.35 t ha⁻¹) but produced lower yields at Bandarban (43.45 t ha⁻¹), Cumilla (40.70 t ha⁻¹) and Rajshahi (30.20 t ha⁻¹). BARI Tomato-20 gave higher fruit yield (85.78 t ha⁻¹) in the hill valley of Bandarban followed by Cumilla (51.90 t ha⁻¹) and the lowest at Rajshahi (37.74 t ha⁻¹).

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce. Higher gross margin was obtained from BARI developed Tomato varieties than local variety at all the tested locations.

Pest and disease infestation

At Manikganj, Indofil M-45 was sprayed to control root rot disease of seedling and Karate @ 2ml L⁻¹ water was sprayed to control cut worm. Some plants were infected by leaf curl virus and were uprooted from the plot. In Tangail, Narsingdi and Rajshahi, late blight was successfully controlled by applying Ridomil Gold @ 2 g L⁻¹ water and white fly infestation at Tangail was controlled by spraying Karate @ 2ml L⁻¹ water three times each 15 days interval. Confidor @ 2ml L⁻¹ water was sprayed 6 times to control fruit borer in the farmers field at Narsingdi. Virus infestation was observed in the farmers field at Cumilla and it was higher in farmers variety (Ruma VF) (12.4%) but less in BARI varieties (4.0 to 5.10%).

Farmers of Manikganj were interested to grow the BARI Tomato-14 and BARI Tomato-17 for their higher yield, uniform size, attractive color and economic benefit. BARI Tomato-17 was also got popularity among the farmers of Narsingdi due to good shape and higher yield potentiality. Farmers at Rajshahi preferred BARI Tomato-15 due to its attractive color, fruit shape and higher yield as well as good price and demand in the market. Farmer at Tangail expressed their satisfaction on BARI released Tomato varieties for their keeping quality and attractive color and high yield potentiality. Farmers also opined that BARI released Tomato varieties are less susceptible to bacterial wilt and leaf curl virus than existing variety. Farmers of Noakhali liked BARI Tomato-20 but at Bandarban preferred BARI Tomato-21 for profuse bearing habit.

Table 2. Fruit yield and yield attributes of Tomato varieties at different locations during the rabi season of 2020-21.

Location	Variety	Fruits plant ⁻¹ (no)	Single fruit wt. (g)	Fruit yield (t ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Manikganj	Saturia				
	BARI Tomato-14	21.00	95.35	59.51	289685.00
	BARI Tomato-17	18.00	116.67	79.72	451765.00
	Local variety (Ruma VF)	16.00	58.87	35.81	100085.00
	LSD _(0.05)	2.826	10.29	5.602	
	CV (%)	8.91	6.59	5.52	
	Ghior				
	BARI Tomato-14	15.20	91.73	40.38	296977.00
	BARI Tomato-17	17.55	118.42	47.90	372177.00
	Local variety (Ruma VF)	11.15	58.63	24.12	134377.00
	LSD _(0.05)	0.355	15.15	6.322	
	CV (%)	4.86	9.78	9.75	
Tangail	Atia				
	BARI Tomato-15	35.33	73.33	92.60	638500
	BARI Tomato-16	33.07	74.67	88.13	593800
	BARI Tomato-18	34.33	78.33	90.06	613100
	LSD _(0.05)	3.47	5.29	NS	
	CV (%)	5.10	3.50	2.70	
	Ghatail				
	BARI Tomato-15	32.50	63.75	68.97	405338
	BARI Tomato-16	34.50	56.50	64.88	372618
	BARI Tomato-18	36.00	53.00	63.46	361258
	LSD _(0.05)	3.22	18.92	5.27	
	CV (%)	5.10	6.00	3.70	
	Dhanbari				
	BARI Tomato-15	38.83	38.83	78.59	591878
	BARI Tomato-16	39.66	39.66	88.81	694078
	BARI Tomato-18	34.93	34.93	72.39	529878
	LSD _(0.05)	5.17	5.17	9.29	
	CV (%)	6.40	6.40	5.10	

Location	Variety	Fruits plant ⁻¹ (no)	Single fruit wt. (g)	Fruit yield (t ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Narsingdi	BARI Tomato-16	64.1	83.70	75.50	746130
	BARI Tomato-17	40.1	209.34	83.17	850170
	BARI Tomato-18	42.2	122.14	70.50	694130
	BARI Tomato-19	63.22	92.00	65.12	658170
	Local variety (Surma)	42.46	56.00	46.00	374130
	LSD (0.05)	18.72	36.00	12.15	
	CV (%)	20.13	28.12	8.32	
Rajshahi	BARI Tomato-14	18.16	81.61	66.47	422500
	BARI Tomato-15	26.16	69.31	70.21	460400
	BARI Tomato-16	20.83	66.02	59.87	357000
	BARI Tomato-17	12.66	146.49	61.84	376700
	BARI Tomato-18	18.16	75.41	55.64	314700
	BARI Tomato-19	18.17	60.83	47.38	314700
	BARI Tomato-20	22.33	30.6	30.20	60300
	BARI Tomato-21	14.50	61.01	37.74	135700
	LSD (0.05)	5.22	10.81	11.87	
Cumilla	BARI Tomato-19	36.7	58.2	53.5	344500.00
	BARI Tomato-20	51.4	20.3	40.7	296500.00
	BARI Tomato-21	36.9	52.3	51.9	328500.00
	Local variety (Ruma VF)	31.5	57.2	35.6	165500.00
	LSD (0.05)	5.98	6.98	4.95	
	CV (%)	9.98	3.85	12.48	
Noakhali	BARI Tomato-17	23.8	74.4	62.85	441340.00
	BARI Tomato-18	24.5	76.5	69.45	520540.00
	BARI Tomato-20	26.9	78.5	74.35	579340.00
	Local variety (Ruma VF)	24.5	72.6	58.84	393220.00
	LSD (0.05)	2.07	6.61	7.47	
	CV (%)	14.09	11.01	12.07	
Bandarban	BARI Tomato-19	53.40	56.13	93.56	356360.00
	BARI Tomato-20	41.30	26.72	43.45	55700.00
	BARI Tomato-21	39.53	62.37	85.78	309680.00
	Local variety	31.73	78.44	82.89	302340.00
	LSD (0.05)	6.67	3.55	6.50	
	CV (%)	2.67	1.62	4.52	

Market price of Tomato- Manikganj: Saturia: Tk. 8 kg⁻¹ and Ghior: Tk. 10 kg⁻¹, Tangail: TK.10 kg⁻¹, Narsingdi: Tk. 12 kg⁻¹, Rajshahi: Tk.10 kg⁻¹, Cumilla: Tk.10 kg⁻¹, Noakhali: Tk.12 kg⁻¹, Bandarban: Tk.6 kg⁻¹

Conclusion

Considering yield and economics, BARI released different varieties of Tomato performed better in different locations. Therefore, these varieties could be extended in the farmers' field in the tested locations according to yield performance and farmers choice.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON FARM TRIAL OF BARI DEVELOPED SUMMER TOMATO VARIETIES

Abstract

The experiment was conducted at Char-Kumaria in Bhola sadar and at Char-Gumani under Doulatkhan upazila in Bhola district during Kharif season of 2020. Four summer hybrid Tomato varieties viz. BARI Hybrid Tomato-8, BARI Hybrid Tomato-10, BARI Hybrid Tomato-11 and Hitom-2 (Check) were used in the study. The trial was laid out in RCB design with 3 dispersed replications. BARI Hybrid Tomato-10 (25.35 t ha^{-1}) gave 4.32% higher yield than Hitom-2 (24.30 t ha^{-1}). The highest fruit yield (22.35 t ha^{-1}) was obtained from BARI Hybrid Tomato-8 and the lowest in BARI Hybrid Tomato-11 (20.65 t ha^{-1}). Higher gross margin (Tk. 1031500 ha^{-1}) was also obtained from BARI Hybrid Tomato-10.

Introduction

Tomato (*Lycopersicon esculentum* L.) is an important vegetable crop in Bangladesh mostly grown during winter season. The area of Tomato has markedly decreased and production also declining. This declining is probably associated with variety, climatic change, and improper management decreasing soil fertility, deficiency of micronutrient and quality seed availability during the sowing time. Farmers use the traditional old variety, which is low yielder and susceptible to disease. During summer and rainy season in Bangladesh, market price of Tomato remain higher as Tomatoes are imported from different nearby countries. During this period, farmers don't cultivate Tomato due to the unavailability of seeds along with proper production instruction about the hybrid summer Tomato varieties released by BARI. So, the study was undertaken to evaluate the performance of BARI developed hybrid summer Tomato varieties in southern coastal region and to increase production and economic return of the farmers.

Materials and Methods

The adaptive trial was conducted at Char-Kumaria and Char-Gumani in Bhola district during Kharif season of 2020. Four summer hybrid Tomato varieties viz. BARI Hybrid Tomato-8, BARI Hybrid Tomato-10, BARI Hybrid Tomato-11 and Hitom-2 as check were used in the study. The trial was laid out in RCB design with 3 dispersed replications. The plot size was 10 m^2 to 20 m^2 with a spacing $60 \text{ cm} \times 40 \text{ cm}$. Half of cowdung, whole amount of P and half of K were applied during final land preparation. The remaining half of cowdung was applied during pit preparation. The remaining amount of K and total amount of N were top dressed in three equal installments at 15, 25 and 45 days after transplanting. A 50 cm wide channel was made in between two beds to facilitate drainage. The Tomato was started to harvest during 60-65 days after transplanting. Hormone Tomatoton (2%) was sprayed on plants at anthesis stage 30-35 days after transplanting in each tunnel. Intercultural operations and plant protection measures were taken as and when required. Data on different plant characters and yield were collected and analyzed statistically.

Table 1. Crop management practices used in different locations during Kharif season of 2020

Transplanting time	Harvesting time	Fertilizer dose (N-P-K-S-Zn-B-Cowdung kg ha^{-1})
11-19 July, 2020	13 September to 29 October, 2020	98-40-46-18-4-2-5000

Results and Discussion

Significant variation in plant and yield characters was observed among the Tomato varieties. The tallest plant (120cm) was recorded in Hitom-2 Tomato variety followed by BARI Hybrid Tomato-10 (118.4 cm), BARI Hybrid Tomato-11 (113.3 cm) and BARI Hybrid Tomato-8 (106.7 cm). Fruit bearing plant¹ was maximum in BARI Hybrid Tomato-10 (25.60) followed by Hitom-2 (22.5) and BARI Hybrid Tomato-8 (20.7). The minimum number of fruits plant¹ (17.30) was recorded in BARI Hybrid Tomato-11. The largest fruit size was recorded in Hitom-2 (61.3g) followed by BARI Hybrid Tomato-10 (52.5g) and BARI Hybrid Tomato-11 (50.7g) but the smallest in BARI Hybrid Tomato-8 (48.2 g). Fruit maximum fruit yield was obtained from BARI Hybrid Tomato-10 (25.35 t ha^{-1}) and the minimum in BARI Hybrid Tomato-11 (20.65 t ha^{-1}). BARI Hybrid Tomato-8 and Hitom-2 gave fruit yield 22.35 t ha^{-1} and 24.30 t ha^{-1} , respectively.

Cost and return

The highest gross margin was obtained from BARI Hybrid Tomato-10 (Tk. 1031500 ha⁻¹) and the lowest from BARI Hybrid Tomato-11 (Tk.608500 ha⁻¹). The highest BCR (1.82) was obtained from BARI Hybrid Tomato-10.

Disease and pest incidence:

Seedling mortality due to bacterial wilt was observed higher (4.67%) in BARI Hybrid Tomato-8 and lower than 3% in other BARI varieties.

Farmers Opinion

Farmers showed their interest on BARI Hybrid Tomato-10 due to higher yield and larger fruit size. They demanded the seeds of BARI hybrid summer Tomato to cultivate in the next year.

Table 2. Yield and yield contributing characters of hybrid summer Tomato varieties at Bhola during Kharif season of 2020.

Variety	Plant height (cm)	Fruitsplant ⁻¹ (no.)	Single fruit wt. (g)	Yield (tha ⁻¹)
BARI Hybrid Tomato-8	106.7	20.7	48.2	22.35
BARI Hybrid Tomato-10	118.4	25.6	52.5	25.35
BARI Hybrid Tomato-11	113.3	17.3	50.7	20.65
Hitom-2 (Check)	120.6	22.5	61.3	24.30
LSD (0.05)	4.09	6.04	3.70	6.33
CV (%)	4.89	3.37	4.65	5.34

Table 3. Cost and return from summer hybrid Tomato in Bhola during kharif season of 2020

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI Hybrid Tomato-8	2011500	1250000	761500	1.61
BARI Hybrid Tomato-10	2281500	1250000	1031500	1.82
BARI Hybrid Tomato-11	1858500	1250000	608500	1.48
Check (Hitom-2)	2187000	1250000	937000	1.74

Price of summer Tomato: Tk. 90 kg⁻¹

Conclusion

Hybrid Tomato var. BARI Hybrid Tomato-10 was found to be promising in respect of yield and economics for summer season. Therefore, this variety could be suggested to grow in Bhola area during summertime for higher yield and income.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED WINTER HYBRID TOMATO VARIETIES

Abstract

The field experiment was conducted at Tangail and Manikganj during rabi season of 2020-21 to evaluate the performance of BARI winter hybrid Tomato varieties and to popularize the varieties among the farmers. The experiment was laid out in RCB design with six dispersed replications. BARI Hybrid Tomato-5 and BARI Hybrid Tomato-7 against Safol hybrid at Tangail and BARI hybrid Tomato-5 against Lalteer hybrid as check at Manikganj were evaluated in the study. BARI Hybrid Tomato-5 produced the maximum fruit yield 98.00 and 94.00 t ha⁻¹ at Delduar and Modhupur of Tangail, respectively which were 27.27 and 23.68% higher than Safol hybrid grown in the same locations. On the other hand, BARI Hybrid Tomato-5 at Saturia and Ghior upazila of Manikganj produced yields 87.04 and 51.84 t ha⁻¹, respectively which were 8.47 and 3.74% higher than Lalteer hybrid. The fruit yield 77.00 and 76.00 t ha⁻¹ were recorded from BARI Hybrid Tomato-7 at Delduar and Modhupur

of Tangail but farmers variety gave lower yields 77.00 and 76.00 t ha⁻¹, respectively. Higher gross margin was also obtained from BARI Hybrid Tomato varieties compared to farmers variety.

Introduction

Tomato (*Solanum lycopersicum*) is the most important vegetable crop in our country cultivated during winter season. The area of winter hybrid Tomato at the tested locations are low and total production is also low. Farmers use the traditional varieties which is low yielding and susceptible to diseases and pests. As a result, yield is decreasing day by day. This declining is probably associated with variety, climatic change, decreasing soil fertility, deficiency of micronutrient and unavailability of quality seeds during the sowing time and also and improper management. Some advance farmers grow commercial hybrid varieties but the seeds are very costly that causes economic loss of the farmers. Horticulture Research Centre of BARI has developed some winter hybrid Tomato varieties those are supposed to be high yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI winter hybrid Tomato varieties in the farmers' field and to popularize the varieties among the farmers to promote their adoption.

Materials and Methods

The experiment was conducted in farmers' field at FSRD site, Delduar and MLT site, Modhupur of Tangail; Satoria and Ghior upazila of Manikganj district during rabi season of 2020-21. Two BARI developed hybrid Tomato varieties viz. BARI Hybrid Tomato-5 and BARI Hybrid Tomato-7 against Safol hybrid at Tangail and BARI hybrid Tomato-5 against Lalteer hybrid as check at Manikganj were evaluated. The experiment was laid out in RCB design with six dispersed replications. The unit plot size was 5m × 4m with spacing of 60cm × 40cm. Thirty days old seedlings were planted in the main field. Crop management practices used in different locations shown in Table 1. Intercultural operations were done as and when required. Data on yield and yield contributing characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung
Tangail	20 November, 2020	12 February to 30 March, 2021	253-90-125-22-5.4-2-5000
Manikganj	18 October to 05 November, 2020	16 January to 25 February, 2021	250-90-125-22-1-1-5000

Results and Discussion

BARI winter hybrid Tomato varieties performed better than those of local hybrid Tomato varieties cultivated in two locations of Tangail and Manikganj. Yield of BARI Hybrid Tomato-5 ranged from 94.00 to 98.00 t ha⁻¹ in the farmers field at Tangail whereas the yield of the same variety at Manikganj ranged from 51.84 to 87.04 t ha⁻¹. On the other hand, BARI Hybrid Tomato-7 ranged from 86.00 to 88.00 t ha⁻¹ produced at Delduar and Modhupur of Tangail, respectively. Hybrid Tomato-5 produced the maximum fruit yield 98.00 and 94.00 t ha⁻¹ at Delduar and Modhupur of Tangail but the same variety at Satoria and Ghior gave 87.04 and 51.84 t ha⁻¹, respectively. The lowest yield was recorded at Ghior, Manikganj (51.84 t ha⁻¹). BARI Hybrid Tomato-7 at Delduar and Modhupur of Tangail gave fruit yield 77.00 and 76.00 t ha⁻¹, but farmers variety gave lower yields 77.00 and 76.00 t ha⁻¹, respectively. The cumulative effect of yield characters viz. number of fruits plant⁻¹ and weight of single fruit contributed to achieve higher yield in both BARI developed winter hybrid Tomato varieties.

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce. Higher gross margin was obtained from both BARI Hybrid Tomato varieties at both the locations and lower from the farmers varieties.

Pest Infestation

In the farmers field at Tangail, plants were infected by leaf blight and successfully controlled by applying Ridomil Gold @ 2 gL⁻¹ water. White fly infestation was controlled by spraying subicron @ 2mL⁻¹ water. Experimental plots at Manikganj were sprayed with Indofil M-45 to control root rot disease of seedling and Karate @ 2ml L⁻¹ water to control cut worm. Some plants were infected by leaf curl virus and were uprooted from the plot.

Farmers' opinion

Farmers of Tangail were interested to grow BARI Hybrid Tomato varieties for their higher yield, uniform size, attractive color and higher economic return. Farmers opined that keeping quality of BARI varieties were better than locally available hybrid Tomato varieties. They demanded seeds of BARI hybrid varieties for next growing season. Manikganj farmers preferred BARI Hybrid Tomato-5 due to its higher yield, fruit size and attractive color. They commented that seed price of commercial hybrid is too costly that reduced net profit.

Table 2. Fruit yield, yield attributes and gross margin of winter hybrid Tomato varieties at different locations during the rabi season of 2020-21.

Location	Variety	Fruits plant ⁻¹ (no.)	Single fruit weight (g)	Fruit yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Tangail	BARI Hybrid Tomato-5	43.00	72.00	94.00	1723725
	BARI Hybrid Tomato-7	34.00	75.00	86.00	1543885
	Local variety (Safol hybrid)	32.00	54.00	76.00	1333925
	LSD (0.05)	1.52	1.79	5.80	
	CV (%)	5.70	7.30	6.98	
Manikganj (Saturia)	BARI Hybrid Tomato-5	41.42	61.80	87.04	506775.00
	Local variety (Lalteer hybrid)	40.00	59.00	80.24	441125.00
	LSD (0.05)	3.522	5.797	6.78	
	CV (%)	4.92	4.93	4.86	
Manikganj (Ghior)	BARI Hybrid Tomato-5	21.47	70.81	51.84	409077.00
	Local variety (Lalteer hybrid)	25.39	57.89	49.97	360377.00
	LSD (0.05)	5.516	6.658	4.171	
	CV (%)	13.41	4.59	4.67	

Market price of winter hybrid Tomato- Tangail: Tk.20 kg⁻¹ and Manikganj: Saturia-Tk. 8.00 kg⁻¹ and Ghior-10.00 kg⁻¹

Conclusion

Winter hybrid Tomato var. BARI Hybrid Tomato-5 and 7 showed better performance regarding yield potentiality and economic return. Therefore, these varieties could be extended in the farmers' field in the study areas.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED POINTED GOURD VARIETIES IN KUSHTIA

Abstract

An experiment was conducted at MLT site, Chuadanga during 2019-20 in farmer's field to observe the performance of BARI released pointed gourd varieties. Three BARI released pointed gourd varieties viz. BARI Potal-1, BARI Potal-2 and BARI Hybrid Potal-1 were tested against farmer's variety as check. BARI Hybrid Potal-1 gave highest yield (39.70 t ha⁻¹) and the lowest yield was obtained from BARI potol-2 (33.83 t ha⁻¹).

Introduction

Pointed gourd (*Trichosanthes dioica*) is one of the most nutritive vegetables in Bangladesh belong of the family Cucurbitaceae. It is a good source of vitamins and minerals. It is easily digestible; diuretic and laxative invigorate the heart and brain and is useful in disorder of the circulatory system. It was reported that pointed gourd possesses the medicinal property of lowering the total cholesterol and blood sugar (Chandrasekar *et al.*, 1988; Sharma and pant, 1988; Sharma *et al.* 1988). In Bangladesh, is it is cultivated during summer season. The average yield of pointed gourd in Bangladesh is low compared to other countries of the world. This low yield may be due to the cultivation of the low yielding local varieties, incidence of diseases and insects, lack of technical knowledge etc. BARI has developed three-pointed gourd varieties, BARI Poto-1, BARI Poto-2 and BARI hybrid Poto-1 those possesses higher yield. The present study was undertaken to observe the performance of BARI varieties in farmer's field condition and to popularize the varieties among the farmers.

Materials and Methods

The experiment was carried out at the MLT site, Chuadanga during 2019-20 to observe the performance of BARI released pointed gourd varieties in the farmer's field. BARI Poto-1, BARI Poto-2, BARI Hybrid Poto-1 were evaluated against farmer's variety as check. The experiment was laid out in RCB design with six dispersed replications. The unit plot size was 15m x 10m. The land was fertilized with 32-28-50-36-5 kg ha⁻¹ of NPKSZn, respectively along with 5 t ha⁻¹ cowdung. The full amount of fertilizer except N and K was applied at the time of final land preparation. Remaining N and K were applied at 25, 50, 75 and 100 DAS. The vines of pointed gourd were planted on 17 November, 2019 with a spacing of 60 cm x 30 cm. The first harvesting starts on 20 March, 2020. Data on yield and yield attributes were collected from 5 randomly selected plants from each plot. Data on yield and yield contributing characters were recorded and analyzed statistically.

Results and Discussion

Significant variation was observed among the varieties in yield and yield contributing characters. The maximum number of fruits plant⁻¹ (240) was observed in BARI Hybrid Poto-1 followed by local variety (230) and BARI Poto-1 (220) but the lowest (215) in BARI Poto-2. The highest fruit weight (13 gm) was found in BARI Hybrid Poto-1 and the lowest (9.80 gm) in BARI Poto-2. The highest yield (39.70 t ha⁻¹) was obtained from BARI hybrid poto-1 followed by local variety (38.28 t ha⁻¹) and BARI Poto-1 (34.78 t ha⁻¹), The lowest yield was recorded in BARI Poto-2 (33.83t ha⁻¹).

Farmer's opinion

Farmers were pleased to see the yield performance of BARI Hybrid Poto-1 compared to local variety. They have chosen BARI Hybrid Poto-1 due to its higher yield.

Table 1. Yield and yield attributes of BARI Pointed gourd varieties at MLT site, Chuadanga during 2019-20.

Varieties	Fruitplant ⁻¹	Fruit weight (gm)	Yield (tha ⁻¹)
BARI Poto-1	220.00	10.00	34.78
BARI Poto-2	215.00	9.80	33.83
BARI Hybrid Poto-1	240.00	13.00	39.70
Local variety	230.00	12.50	38.28
F-test	NS	NS	*
CV (%)	11.73	10.23	7.58

Conclusion

BARI developed pointed gourd var. BARI Hybrid Poto-1 were more profitable to the farmers and could be extended in the farmers field of Kushtia region.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM ADAPTIVE TRIAL OF BARI DEVELOPED CAPSICUM VARIETIES

Abstract

The trial was conducted at MLT site, Chandina of Cumilla and Saharasti of Chandpur during Rabi season of 2020-21 to evaluate the performance of BARI developed capsicum varieties viz. BARI Capsicum-1 and BARI Capsicum-2 in the farmer's field. Higher fruit yield (11.75 t ha^{-1}) was obtained from BARI Capsicum-2 compared to BARI Capsicum-1 (10.35 t ha^{-1}). The highest gross return (Tk. 822500 ha^{-1}), gross margin (Tk. 702500 ha^{-1}) and BCR (6.85) were also obtained from BARI Capsicum-2.

Introduction

Capsicum (*Capsicum annuum*) is a new winter vegetable grown in Bangladesh. Now a day, this vegetable is gaining popularity among the farmers and consumers due to its higher market price as well as for its nutritive values. The health benefits of capsicum may include relief from stomach issues, back pain, muscle spasms, headaches, skin aging, peptic ulcers, menopausal problems, lower risk of cardiovascular diseases, and diabetes management. It might have anti-inflammatory and analgesic properties, and may also provide relief from pain related to arthritis. They can be an excellent source of vitamins A and C, among other nutrients. Recently BARI has developed high yielding capsicum varieties. Farmers can get higher yield and economic return from these varieties. Therefore, the present experiment was undertaken to popularize and disseminate BARI capsicum varieties among the farmers in the Cumilla region.

Materials and Methods

The experiment was carried out at MLT site, Chandina of Cumilla and Saharasti of Chandpur during Rabi season of 2020-21 to evaluate the performance of BARI Capsicum-1 and BARI Capsicum-2. The trial was laid out in RCB design with three dispersed replications. The unit plot size was $5.0 \text{ m} \times 2.0 \text{ m}$ and spacing was $50\text{cm} \times 40\text{cm}$. Seedlings were transplanted on 14 December 2020. Fertilizer dose was applied @ 115-70-125-47-1.8 kg N-P-K-S-Zn ha^{-1} in the capsicum cultivation. TSP, $1/5^{\text{th}}$ urea and MP, full gypsum and ZnSO_4 were applied during land preparation. Rest $4/5^{\text{th}}$ of Urea and MP were applied as top dress. Irrigation, plant protection measures and other intercultural operations were done as and when required. Harvesting of fruits was started at 22-28 March, 2021 and continued up to 8-11 April, 2021. Data on different plant characters and yield were collected and analyzed statistically.

Results and Discussion

The yield characters such as fruit plant $^{-1}$, fruit length, fruit diameter capsicum varieties did not differ statistically except individual fruit weight. The maximum individual fruit weight (78.40g) was found in BARI Capsicum-2 and minimum in BARI Capsicum-1 (68.65g). The highest fruit yield (11.75 t ha^{-1}) was obtained from BARI Capsicum-2 and the lowest in BARI Capsicum-1 (10.75 t ha^{-1}).

Cost and return:

The gross margin from capsicum varieties varied due to variation in fruit yield. Higher gross margin (Tk. 702500 ha^{-1}) was obtained from BARI Capsicum-2 compared to BARI Capsicum-1 (Tk. 604500 ha^{-1}).

Pest incidence: Plants were infected by leaf blight and root rot disease which were controlled by spraying with Ridomil Gold and Amistar Top @ 2 g L^{-1} water. White fly infestation was controlled by spraying three times with Subicron @ 2 ml L^{-1} water at 15 days interval.

Farmers' opinion

Farmers expressed their satisfaction on BARI Capsicum-2 for its keeping quality and high yield potentiality. They commented that the seeds of BARI Capsicum varieties are not available in the market.

Table 1. Yield and yield contributing characters of BARI released capsicum varieties in Cumilla region during 2020-21

Variety	Fruit plant ⁻¹ (no.)	Ind. Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Capsicum-1	4.50	68.65	7.49	7.00	10.35	604500
BARI Capsicum-2	3.55	78.40	7.23	7.05	11.75	702500
T value	NS	*	NS	NS	NS	
CV (%)	16.15	0.61	0.54	0.78	5.43	

Market price of capsicum: Tk. 70 kg⁻¹

Conclusion

Capsicum var. BARI Capsicum-2 gave higher yield and economic return than BARI Capsicum-1. This was the first-year trial and may be repeated next year for more precise result.

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ON-FARM TRIAL OF BARI BROCCOLI VARIETY IN HILL VALLEYS OF BANDARBAN

Abstract

An on-farm trial was conducted at Bakichara hill valleys of Bandarban sadar and Chaingya of Rowangchhari upazila during the rabi season of 2020-21 to evaluate the performance of BARI Broccoli-1 in farmers' field. A hybrid variety of Broccoli was used as check. The experiment was laid out in RCB design with three dispersed replications. BARI Broccoli-1 took less time to harvest (63 days) than hybrid variety (65 days). BARI Broccoli-1 gave higher single head weight (251.13 g) and yield (11.16 t ha⁻¹) than local variety (229.42 g and 10.20 t ha⁻¹). The highest gross margin (Tk. 343775 ha⁻¹) was found from BARI Broccoli-1 than farmers variety (Tk. 305375 ha⁻¹).

Introduction

Broccoli (*Brassica oleracea* var. *italica*) is a biannual and herbaceous winter vegetable crop in Bangladesh. Broccoli, originated from west Europe has now been distributed in both the sub-tropical and tropical areas like Bangladesh. Cultivation of broccoli, a foreign variety of vegetable, is gaining popularity among the farmers in our country as well as in hilly areas of Bandarban. The vegetable is rich with nutrients such as proteins, vitamin C, and other minerals. In addition, it is also a vegetable that has gained popularity for having qualities to prevent cancer. On the other hand, many farmers are cultivating this seasonal cash crop in the area as they are getting a better market price for their yield compared to many other crops. BARI has released a broccoli variety in Bangladesh. Traditionally farmers have to pay a lot of money for buying hybrid broccoli seeds from market where BARI Broccoli-1 is an open pollinated variety where farmers can take the seeds for the next year. The experiment was undertaken in farmers' field to find out the performance of the variety in hilly area and to know the farmers judgment about the variety regarding yield and economic return over hybrid variety in Bandarban.

Materials and Methods

The trial was conducted in the farmer's field of Vorakhali of Bandarban Sadar upazila and Chaingya of Rowangchhari upazila during Rabi season of 2020-2021 to evaluate the performance of BARI Broccoli-1. A hybrid variety of Broccoli was used as check. The experiment was laid out in RCB design with three dispersed replications. Seeds were sown on seedling tray containing ready cocopeat on 13 October, 2020 and seedlings were transplanted at farmers' field on 18-20 November, 2020. Crop was planted with the spacing 50 cm × 45 cm. The unit plot size was 10m x 8m. The experimental plots were fertilized @120-30-50-15-1.5-2-5000 kg N-P-K-S-Zn ha⁻¹. Total amount of cowdung, TSP, gypsum, zinc sulphate and boric acid were applied in the plot during final land preparation. Urea and MoP were

applied in three equal splits at 15, 30 and 45 days after planting. Irrigations were done as and when required. Three weeding was also done after planting. Ten plants were selected randomly for data collection from each plot. Harvesting was started on 23 January 2021 and completed on 30 January 2021. Data on yield and yield characters were collected analyzed statistically.

Results and Discussion

BARI Broccoli-1 took less time to harvest (62.83 days) than hybrid variety (65.17 days). BARI Broccoli-1 gave higher head length (18.13 cm) and diameter (15.33 cm) than local broccoli variety (10.50 cm and 13.08 cm). BARI Broccoli-1 produced larger head (251.13 g) than local variety (229.42 g). BARI Broccoli-1 produced higher yield (11.16 t ha⁻¹) than local variety (10.20 t ha⁻¹).

Cost and return

The gross margin from broccoli varieties varied due to variation in yield. BARI Broccoli-1 gave higher gross margin (Tk. 343775 ha⁻¹) and BCR (4.35) over local broccoli variety (Tk. 305375 ha⁻¹ and 3.98).

Farmers' opinion

Farmers expressed their satisfaction with higher yield, individual head weight and attractive color of BARI Broccoli-1. Farmers commented that they got higher market price by selling Broccoli than other seasonal vegetables.

Table 1. Yield and yield characters of BARI broccoli variety at Bakichara and Chaingya hill valleys of Bandarban during Rabi season of 2020-21.

Treatment	Days to harvest	Head length (cm)	Head diameter (cm)	Single head wt. (g)	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI Broccoli-1	62.83	18.13	15.33	251.13	11.16	343775	4.35
Local variety (Hybrid Broccoli)	65.17	10.50	13.08	229.42	10.20	305375	3.98
LSD (0.05)	1.37	0.13	0.39	13.48	0.60		
CV (%)	2.62	1.14	3.37	6.87	6.88		

Market Price of Broccoli: Tk. 40 kg⁻¹

Conclusion

Broccoli var. BARI Broccoli-1 performed better in hill valleys of Bandarban and could be recommended for large scale extension.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI DEVELOPED SPONGE GOURD VARIETY

Abstract

An experiment on sponge gourd varieties was conducted at MLT site, Debidwer of Cumilla during Rabi season of 2020-21 to evaluate the performance of BARI Sponge Gourd-1 at farmer's field condition. BARI Dhundol-1 showed higher yield potentiality and gave higher yield (10.22 t ha⁻¹) compared to local variety Raka (8.90 t ha⁻¹). Higher gross margin (Tk. 68300.00 ha⁻¹) was also obtained from BARI Dhundol-1 than commercial variety Raka (Tk. 48500.00 ha⁻¹).

Introduction

Sponge gourd (*Luffa aegyptica*) is one of the most important summer vegetables grown in Bangladesh. It is usually added to various meal recipes for added taste and nutrition. Sponge gourd is rich in vitamin A, which is responsible for promoting vision and integrity of the skin and the mucus membranes.

Sponge gourd contains fiber that helps to speed up digestion and metabolism, eliminate harmful substances like toxins and free radicals, which cause diseases like heart disease and cancer. It also reduces the amount of low-density lipoproteins or bad cholesterol in the bloodstream, preventing gastrointestinal disorders like constipation, diverticulitis, and hemorrhoids. Horticultural Research Center of BARI newly released sponge gourd variety BARI Dhundol-1 having high yield potential. This variety needs to evaluate in the farmer's field. Therefore, the present on farm trial was undertaken to popularize and disseminate BARI sponge gourd variety in the Cumilla region.

Materials and Methods

The on-farm trial was carried out at MLT site, Debidwer of Cumilla during Rabi season of 2020-21 to evaluate the performance of BARI Sponge Gourd-1 at farmer's field condition. A commercial variety (Raka) was used as check in the trial. The unit plot size was 4.0m × 2.5m. Seeds were sown on 20 May, 2020 in pits maintaining a distance of 2.50m × 1.50m. Fertilizer dose was applied @ 106-46-96-6-1.4-0.7-5000 kg N-P-K-S-Zn-B-Cowdung ha⁻¹. Whole amount of Cowdung, 1/3th TSP, 1/5th MoP, full gypsum, ZnSO₄ and boric acid were applied during pit preparation. Total amount of Urea, 2/3 TSP, and 4/5th of MoP was applied as top dress. Irrigation, plant protection measures and other intercultural operations were done as and when required. Harvesting of fruits was started on 17 July, 2020 and continued up to 08 August, 2020. Data on plant characters and yield were collected and analyzed statistically.

Results and Discussion

Higher number of fruits plant⁻¹ (15.00) was observed in BARI Dhundol-1 than the local variety (Raka) produced lower of fruits plant⁻¹ (13.00). The yield characters like fruit length (18.36cm), diameter (4.58cm) and single fruit weight (211g) was lower in BARI Dhundol-1 compared to commercial variety Raka with 18.56cm, 4.72cm and 215g, respectively. Higher number of fruits plant⁻¹ contributed to produce higher yield (10.22 t ha⁻¹) in BARI Dhundol-1 compared to local variety Raka (8.90 t ha⁻¹).

Cost and return

Higher gross margin (Tk. 68300.00 ha⁻¹) was also obtained from BARI Dhundol-1 than farmers variety Raka (Tk. 48500 ha⁻¹).

Table1. Yield and yield attributes of sponge gourd varieties at Debidwer, Cumilla, during Kharif season of 2020.

Variety	Fruit plant ⁻¹ (no.)	Fruit length (cm)	Fruit diameter (cm)	Single fruit weight (g)	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Dhundol-1	15.00	18.36	4.58	211.0	10.22	68300
Local variety (Raka)	13.00	18.56	4.72	215.0	8.90	48500

The price of Sponge gourd: Tk. 15 kg⁻¹

Conclusion

Sponge gourd var. BARI Dhundol-1 showed better performance regarding yield in the study area. Therefore, BARI Dhundol-1 could be recommended to cultivate in large scale in the farmers field at Cumilla.

Acknowledgement: Author is gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

Spices Crops

ON-FARM TRIAL OF BARI RELEASED GARLIC VARIETIES

Abstract

The experiment was conducted at MLT site Bhuapur, Tangail during the rabi season of 2019-20 and 2020-21 and Tungipara, Kashiani, Gopalganj sadar during the rabi season of 2020-21 to introduce BARI released garlic varieties in the area and to increase the economic return of the farmers. The trial was laid out in RCB design with dispersed replications. In Tangail, the highest average bulb yield of 7.87 t ha⁻¹ was obtained from BARI Rashun-4 whereas BARI Rashun-3 gave highest bulb yield (9.75 t ha⁻¹) in Gopalganj. BARI Rashun-1 produced minimum yield in all the location.

Introduction

Garlic (*Allium sativum*) is one of the most popular spices commercially grown in all parts of the country with respect to its production and economic value. Garlic is an integral part of many culinary traditions in Bangladesh. It is an indispensable component in daily life, mostly in kitchen. The crop is used for seasoning in many foods as well as for medicinal and religious purposes also (Hannan and Sorensen, 2001). However, its production and productivity are very low due to many biotic and biotic factors such as lack of high yielding varieties, non-availability of quality seeds, imbalanced fertilizer use, lack of irrigation facilities, lack of proper disease and insect pest management and other agronomic practices, low storability and lack of marketing facilities (Mohamed *et al.*, 2014). Spices Research Centre (SRC) of BARI has developed four new garlic varieties (BARI Rashun-1, BARI Rashun-2, BARI Rashun-3 and BARI Rashun-4) which are high yielder and less susceptible to pest virus and diseases. In Bangladesh, the Char area covers about 0.88 lakh hectares. Adaptability trial of released varieties may be conducted at the char land for introducing garlic varieties and higher yield. Hence the present study was under taken to find out the performance of garlic varieties.

Materials and Methods

The trial was conducted at the farmers' field of Bhuapur, Tangail during the rabi of 2019-2020 and 2020-2021 and Tungipara, Kashiani, Gopalganj sadar during 2020-2021 to introduce the BARI released garlic varieties in the area. Five garlic varieties viz. BARI Rashun-1, BARI Rashun-2, BARI Rashun-3, BARI Rashun-4 and a farmer's variety (check) were used in Tangail whereas four BARI varieties were used in Gopalganj. The unit plot size was 8m x 5m. Crop management practices used in different locations is shown in Table-1. The full amount of P, K & S and 1/3rdN were applied during final land preparation. The remaining 2/3rd urea were applied in two equal installments at 3 and 6 weeks after sowing (DAS). Cloves of garlic were sown in line with 15 cm X 10 cm spacing. Two irrigations were provided at 25 and 45 DAS. One hand weeding was done at 30 DAS. Other necessary management practices were done for the normal growth and development of the crop. Necessary data were collected plot wise and analyzed statistically using Crop Stat analytical package.

Table 1. Crop management practices used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B
Tangail	01 Dec. 2020	31 March – 11 April 2021	100-53-166-20-0-0
Gopalganj	18 - 28 November 2020	20 to 28 March 2021	110-44-75-20-0-0

Results and Discussion

Tangail: Data on plant height (cm), individual bulb weight (g) and yield (t ha⁻¹) are presented in Table 2. The individual bulb weight and yield differed significantly among the varieties. The highest plant height (60.62 cm) was produced by BARI Rashun-4 and the shortest plant (55.27 cm) was observed in BARI Rashun-3. The highest individual bulb weight (11.45 g) was obtained from BARI Rashun-4

which was statistically identical with BARI Rashun-2, BARI Rashun-3 and the lowest individual bulb weight (8.66g) was recorded from farmer's variety. The highest average bulb yield of garlic (7.87 t ha⁻¹) was recorded from BARI Rashun-4 while the lowest yield was recorded in local variety (6.49 t ha⁻¹). Higher bulb yield obtained in BARI Rashun-4 might be due to higher individual bulb weight against the other varieties.

Gopalganj: The highest plant height (68.35 cm) was found in BARI Rashun-3 and lowest (58.01 cm) was found from BARI Rashun-2. The maximum wt. of single bulb (19.25 g) was found in BARI Rashun-3 and minimum wt. (15.23 g) was recorded by BARI Rashun-1. Finally, BARI Rashun-3 gave the highest yield (9.75 t ha⁻¹) might be due to its highest number of cloves and maximum wt. of single bulb than other varieties. At the same time lowest bulb yield (7.41 t ha⁻¹) was found in BARI Rashun-1.

Pest incidence: Leaf blight was successfully controlled by using Rovral @ 2 ml L⁻¹.

Cost and Return

Tangail: In cost and return analysis, the highest gross margin (Tk. 194589 ha⁻¹) was obtained from BARI Rashun-4 (Table 2).

Farmers' opinion

Farmers' of Tangail choose BARI Rashun-4 and BARI Rashun-3 due to their higher yield potentiality as well as economic return. Farmers' of Gopalganj choose BARI Rashun-3 and BARI Rashun-2 due to their higher yield potentiality as well as economic return.

Table 2. Yield and yield attributes of different garlic varieties at different locations.

Location	Variety	Plant height (cm)	Single bulb wt. (g)	Bulb yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Tangail	BARI Rashun-1	58.22	9.28	6.84 Av.	1,43,089 Av.
	BARI Rashun-2	57.48	11.08	7.31 Av.	1,66,589 Av.
	BARI Rashun-3	55.27	11.17	7.54 Av.	1,74,049 Av.
	BARI Rashun-4	60.62	11.45	7.87 Av.	1,94,589 Av.
	Farmers local	58.02	8.66	6.49 Av.	1,25,589 Av.
	LSD (0.05)	7.50	1.51	-	-
	CV (%)	6.90	7.90	-	-
Gopalganj	BARI Rashun-1	60.02	15.23	7.41	-
	BARI Rashun-2	58.01	17.21	9.30	-
	BARI Rashun-3	68.35	19.25	9.75	-
	BARI Rashun-4	61.11	17.11	8.24	-
	LSD (0.05)	9.22	7.39	8.57	-
	CV (%)	7.86	1.74	1.02	-

Conclusion

Garlic var. BARI Rashun-2, BARI Rashun-3 and BARI Rashun-4 gave higher yield as well as higher economic return. Therefore, these garlic varieties could be extended in the farmers field of tested locations.

Acknowledgement: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON FARM TRIAL OF TURMERIC VARIETIES

Abstract

On farm trial of Turmeric varieties were conducted at the farmers' field of Binatti and Satarpur union of Kishoreganj sadar and Karimganj upazila under Kishoreganj district and Rajbari during the rabi season of 2020-21 to find out the suitable Turmeric variety for the area. Two BARI developed Turmeric varieties viz. BARI Halud-4, BARI Halud-5 and farmers variety were tested in Rajbari whereas BARI Halud-4 and one local variety were used in Kishoreganj. The highest yield was found from BARI Halud-4 gave the highest rhizome yield in both the location. The lowest rhizome yield was recorded from local variety in both the location. BARI Halud-4 gave the highest gross return, gross margin followed by other varieties.

Introduction

Turmeric (*Curcuma longa*) is one of the most important spice crops in Bangladesh as well as in south Asia. In Bangladesh, total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Local variety covers the greater portion of Turmeric growing areas in Bangladesh. Farmers traditionally cultivate this low yielding local variety and thus get poor yield. Cultivation of BARI developed high yielding Turmeric varieties have the potentialities to produce higher yield. Therefore, the study was undertaken to find out the suitable variety of Turmeric in the location.

Material and Methods

The experiment was conducted at Kishoreganj and Rajbari during the year of 2020-21 to examine the suitable variety of Turmeric for that area. The experiment was laid out in RCB design with dispersed replications. Varieties were BARI Halud-4 and farmers local in Kishoreganj and BARI Halud-4, BARI Halud-5 and farmers local in Rajbari. The unit plot size was 20m x 10m in Kishoreganj and 8 m x 5 m in Rajbari. The mother rhizomes were planted on 17 November 2020 in Kishoreganj and 23 April – 13 May 2020 in Rajbari maintaining 60cm x 25cm spacing. The recommended fertilize doses were applied @ 101-25-130-17.6-0.5 kg ha⁻¹ N-P-K-S-B in Kishoreganj and 140-40-80-15-3-1.5 kg ha⁻¹ N-P-K-S-Zn-B in the form of urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid, respectively. Half of urea and MoP and all other fertilizers were used at final land preparation. The remaining part of urea and MoP fertilizer was applied at the side of the row in two equal splits at 80-90 DAS and 110-120 DAS, respectively. Two weeding and earthing-up was done after 85 and 115 DAS, respectively. No significant diseases were observed in Turmeric. Mancozeb and Autostin were applied to control leaf blotch and rhizome rot of Turmeric. The crops were harvested on 10 February, 2021 in Kishoreganj and 10-18 January 2021 in Rajbari. Data on yield and yield contributing characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B
Kishoreganj	01 Dec. 2020	31 March – 11 April 2021	100-53-166-20-0-0
Rajbari	18 - 28 November 2020	20 to 28 March 2021	110-44-75-20-0-0

Results and Discussion

Kishoreganj: The highest plant height was found BARI Halud-4 (95.02 cm) and the lowest from local variety (82.43 cm). The highest number of mother rhizome plant⁻¹ and weight of mother rhizome plant⁻¹ was recorded from BARI Halud-4 (3.43 no and 136.1 g) and the lowest from local variety (3.0 no and 55.3 g). The highest weight of rhizome plant⁻¹ was found from BARI Halud-4 (583.3 g) and the lowest weight of rhizomes plant⁻¹ was found from local variety (167.5 g). The highest rhizome yield was found from BARI Halud-4 (28.97 t ha⁻¹) and the lowest from local variety (15.71 t ha⁻¹).

Rajbari: A significant variation was observed among the varieties tested on different parameters of turmeric except weight of mother rhizome m⁻² (Table 2). The highest plant height was observed in

Rajbari local (137.83 cm) and the lowest was in BARI Holud-5 (114.50 cm). Weight of mother rhizome m^{-2} ranged between 361.83 g (BARI Holud-4) to 437.16 g (BARI Holud-5). Statistically the highest rhizome yield was calculated from BARI Holud-4 (28.82 t ha^{-1}) due to obtain highest wt. of finger m^{-2} and the lowest from Rajbari local (21.04 t ha^{-1}). The rhizome yield of BARI Holud-4 was 37% higher over Rajbari local.

Cost and Return

Kishoreganj: The highest gross margin (Tk. 317020 ha^{-1}) was calculated from the variety BARI Halud-4. Local variety gave lower GM (Tk 167500 ha^{-1}). Market price of local variety was higher than BARI Holud-4.

Rajbari: The highest gross margin (Tk. 300205 ha^{-1}) was found from BARI Halud-4 and the lowest gross margin (Tk. 216628 ha^{-1}) was calculated from local variety.

The farmers of Kishoreganj area have chosen BARI Halud-4 for its high yield potentiality and excellent colour. Farmers of the Rajbari showed their keen interest to BARI Holud-4 and BARI Holud-5. BARI Holud-4 had higher yield potentiality (31% higher than BARI Holud-5). BARI Holud-5 was also preferred by farmers due to its deep orange yellow core color and higher market price.

Table 2. Yield and yield attributes of different turmeric varieties at different locations.

Location	Variety	Plant height (cm)	Wt. of rhizome plant ⁻¹ / m^{-2} (g)	Mother rhizome plant ⁻¹ / m^{-2} (no.)	Wt. of mother rhizome plant ⁻¹ / m^{-2} (g)	Yield (t ha^{-1})	Gross margin (Tk. ha^{-1})
Kishoreganj	BARI Halud-4	95.02	583.3	3.43	136.1	28.97	317020
	Local variety	82.43	167.5	3.0	55.3	15.71	167500
	LSD (0.05)	8.82	24.6	1.12	18.6	1.00	-
	CV (%)	2.83	1.86	9.91	5.54	1.23	-
Rajbari	BARI Holud-4	114.50	2881.83	19.67 ab	361.83	28.82	300205
	BARI Holud-5	123.67	2203.00	22.67 a	437.16	22.03	233428
	Rajbari local	137.83	2103.66	18.00 b	390.33	21.04	216628
	CV (%)	5.69	12.45	12.54	25.86	12.44	-

Conclusion

Turmeric var. BARI Holud-4 and BARI Holud-5 gave the higher yield in the farmers field and market price was also high compared to local varieties. Therefore, these turmeric varieties could be extended in the farmers field of tested locations.

Acknowledgement: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON FARM ADAPTIVE TRIAL OF CHILLI VARIETIES IN FARIDPUR

Selim Ahmed and A F M Ruhul Quddus

Abstract

A trial was conducted at the farming System Research and Development (FSRD) site under On-Farm Research Division (OFRD), Faridpur under AEZ-12 during the kharif I season of 2020 to find out the suitable chilli varieties and to increase the chilli production and productivity. It was laid out in RCB design in seven dispersed replications. BARI released chilli variety named BARI Morich-2 was evaluated in the trial against two local cultivars named Sholakundu and Khalkhula. The highest fruit yield was calculated from BARI Morich-2 (7.36 t ha^{-1}) followed by local Sholakundu (7.29 t ha^{-1}) and the lowest fruit yield was found from local Khalkhula (7.05 t ha^{-1}). The highest gross return was obtained from BARI Morich-2 (Tk. 956800 ha^{-1}) due to highest yield. The lowest gross margin (Tk. 706043 ha^{-1}) was calculated from local khalkhula due to the lowest yield.

Introduction

Chilli is one of the major spices crops grown in Bangladesh. Chilli is cultivated in 104858 ha land (both winter and summer) and produced 176000 ton annually. Farmers of Faridpur usually grow local chilli variety which has no uniformity of fruit shape. Yield potentiality of local/traditional variety is also poor and it's susceptible to different diseases and pests. Spices Research Centre of BARI has developed some improved varieties of chilli, which are supposed to be higher yielder and less susceptible to pest and diseases. With this point of view, the present study was undertaken to evaluate the performances of chilli varieties at farmers field for higher yield and economic return.

Materials and Methods

The trial was conducted at farming System Research and Development (FSRD) site under On-Farm Research Division (OFRD), Faridpur under AEZ-12 during the kharif I season of 2020 to find out the suitable chilli varieties and to increase the chilli production and productivity. It was laid out in randomized completed block design (RCBD) in seven dispersed replications. BARI released chilli variety named BARI Morich-2 was evaluated in the trial against two local cultivars named Sholakundu and khalkhula. Unit plot size was 3 m × 2 m. Thirty-five days old seedlings were transplanted in a spacing of 50 cm × 50 cm. Date of transplanting was 17 April-1 May 2020. The crop was fertilized with 130-60-50-15-1.5-1.5 kg ha⁻¹ N-P-K-S-Zn-B in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. Additional 3 t ha⁻¹ organic fertilizer was used. All of organic fert, P, K, S, Zn and B; and half of N was applied as basal during final land preparation. Remaining N was applied as top dress at 25-30 DAT under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Weeding was done two times at 20-25 and 60-65 days after transplanting. After 1st weeding, one irrigation was applied. At 50-55 DAT, earthing up was done. Fungicide named Amister top was sprayed three times at 13-17, 55-65 and 85-89 DAT. Two times miticide named vertimek was sprayed at 75-80 and 90-95 DAT and two times insecticide named Carbofuran (45-50 DAT) and Pegasas (85-90 DAT). Chilli was harvested from 25 June to 28 September 2020. Data on all operations and agronomic parameters were recorded properly and was analyzed statistically with open-source software R 4.0.0 software and the means were separated by DMRT (Gomez and Gomez 1984).

Results and Discussion

All the yield and yield contributing characters except final plant population m⁻², fruit length, fruit breadth, fruit yield plant⁻¹ and fruit yield (t ha⁻¹) showed significant difference among the tested varieties (Table 1). Number of final plant population m⁻² ranged between 3.46 to 3.51. The statistically highest plant height was calculated from BARI Morich-2 (86.63 cm) which was statistically similar with local Sholakundu (83.11 cm). The lowest plant height was observed from local Khalkhula (78.66 cm).

The highest number of fresh fruits per plant was found from local Sholakundu (133.43) followed by local Khalkhula (121). The lowest number of fresh fruits per plant was found from BARI Morich-2 (113.43). The highest (1.72g) and lowest (1.48g) single fruit weight was calculated from local Khalkhula and local Sholakundu, respectively. Fruit length and fruit breadth ranged between 5.25 cm to 5.43cm and 0.82cm to 0.83 cm, respectively. The highest number of seed fruit⁻¹ was found from local Sholakundu (45.63) and lowest from BARI Morich-2 (37.03). Fruit yield plant⁻¹ was recorded from 184 kg to 215 kg. The highest fruit yield was calculated from BARI Morich-2 (7.36 t ha⁻¹) followed by local Sholakundu (7.29 t ha⁻¹) and lowest fruit yield was found from local Khalkhula (7.05 t ha⁻¹). Picking cost of chilli (Tk 9.5 kg⁻¹ of chilli picking) influenced on the cost of production.

The highest gross return was obtained from BARI Morich-2 (Tk. 956800 ha⁻¹) due to the highest yield. The lowest gross margin (Tk. 706043 ha⁻¹) was calculated from local khalkhula due to the lowest yield.

Pest and disease incidence

Few cut worm infestations were observed in the seedling stage and it was controlled by hand picking. Mite & thrips complex was observed at some plants. Insecticides (Vertimek and Pegasus) were sprayed. No other disease or pest infestation was observed during the cropping period.

Farmers' opinion

Farmers were very happy to cultivate BARI Morich-2 for its higher yield. Fruit shape of BARI variety were also uniform that was absent in local varieties. They demanded BARI developed chilli variety seeds available in the local markets.

Table 1. Yield and yield attributes of chilli varieties at Faridpur during kharif 2020

Variety	Final plant population m ⁻² (No.)	Plant height (cm)	Fresh fruits plant ⁻¹ (No.)	Single fruit wt. (g)	Fruit length (cm)	Fruit breadth (cm)	Seed fruit ⁻¹ (No.)	Fruit yield plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
BARI Morich-2	3.46	86.63 a	113.43 b	1.56 b	5.43	0.83	37.03 b	215.00	7.36
Local (Sholakundu)	3.51	83.11 ab	133.43 a	1.48 b	5.25	0.83	45.63 a	209.71	7.29
Local (Khalkhula)	3.47	78.66 b	121.00 ab	1.72 a	5.42	0.82	40.97 ab	184.00	7.05
CV (%)	4.75	4.87	8.749	6.51	8.83	4.07	10.50	13.31	7.92

Table 2. Cost and return of chilli varieties at Faridpur during kharif 2020

Variety	Chilli yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Morich-2	7.36	956800	213402	743398
Local (Sholakundu)	7.29	947700	212737	734963
Local (Khalkhula)	7.05	916500	210457	706043

Price (Tk kg⁻¹): Green chilli (Tk. kg⁻¹): 30-200, selling price: Tk. 13 kg⁻¹

Conclusion

BARI Morich-2 was the best in terms of yield and gross margin. Pilot production program is needed for more familiarity of that variety. Seeds of BARI developed chili variety should be available in the local markets.

Acknowledgement: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ON-FARM TRIAL OF BARI ONION VARIETIES

Abstract

The experiment was carried out at the FSRD site, Faridpur, Kushtia sadar and Gopalganj during the winter season of 2020-21 under farmer's field condition to evaluate the performance of Onion varieties against local cultivar. Two BARI released Onion varieties viz. BARI Piaz-1 and BARI Piaz-4 were evaluated in the trial against local cultivars at all the locations. At Faridpur, the highest bulb yield was calculated from BARI Piaz-4 (22.42 t ha⁻¹) followed by Lalteer king (18.29 t ha⁻¹) and the lowest from BARI Piaz-1 (13.70 t ha⁻¹). At Kushtia, the highest bulb yield was calculated from BARI Piaz-4 (19.37 t ha⁻¹) followed by BARI Piaz-1 (15.75 t ha⁻¹) and the lowest from Local King (15.63 t ha⁻¹). At Gopalganj, the highest bulb yield was calculated from Local variety Red King (18.50 t ha⁻¹) followed by BARI Piaz-4 (17.40 t ha⁻¹) and the lowest from BARI Piaz-1 (12.75 t ha⁻¹).

Introduction

Onion (*Allium cepa* L.) is an important spice crop all over the world. It is used in every home almost daily as a seasoning for a wide variety of dishes. Onion can be consumed raw as well as cooked. It has very good medicinal values and is known the benefit in the prevention and treatment of atherosclerosis, diabetes and coronary heart diseases. It is one of the major spice crops in Bangladesh ranks to first in production 2.1 M ton (BBS 2018) among the spice crops covering 36% of total areas under spices. Bangladesh produces only 10.52 lac tons of Onion against the total requirement of 450 thousand metric tons per year. So, there is an acute shortage of Onion in relation to its requirement. The high demand of Onion can be meet up by increasing area and cultivating high yielding variety. Spices Research Center of BARI has developed three winter Onion varieties which are high yielder and less susceptible to pest and diseases. The present study where be undertaken to evaluate the performance of winter Onion bulb varieties against local cultivar like Taherpuri, Lalteer King.

Materials and Methods

A field trial on Onion bulb was conducted at Faridpur, Kushtia and Gopalganj during the winter season of 2020-21 under farmer's field condition to evaluate the performance of winter Onion bulb varieties against local cultivar. Two BARI released Onion varieties viz. BARI Piaz-1 and BARI Piaz-4 were evaluated in the trial against local cultivars at all the locations. The experiment was laid out in RCBD design with dispersed replications. Crop management practices used in different locations is shown in Table 1. All of P, S, Zn and B, and half of N and K were applied as basal during final land preparation. Remaining N and K will be applied in two equal splits at 25-30 DAT and 45-50 DAT under moist soil condition and mixed thoroughly with the soil. Four times irrigation was done at pre-planting, immediately after sowing, 25 and 40 DAT. Weeding was done twice. Fungicides and insecticides were sprayed accordingly. Other plant protection measures were taken as and when required. Data on yield and yield characters were collected and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Sowing time	Harvesting time	Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B
Faridpur	30 Dec. 2020 to 9 Jan. 2021	24 to 31 March 2021	140-60-60-30-3-1.5
Kushtia	26 Dec. 2020-09 Jan. 2021	28 March-03 April, 21	115-55-125-19.78-1.44-0.85
Gopalganj	28 Dec. 2020 to 4 Jan. 2021	03 to 28 March 2021	110-40-75-22-0-0

Results and Discussion

Faridpur: The plant height ranged from 47.30 cm to 54.60 cm. The highest single bulb wt. was 34.58 g in BARI Piaz-4 and the lowest was in BARI Piaz-1 (19.00g). The highest bulb yield was obtained from BARI Piaz-4 (22.42 t ha⁻¹) due to the highest single bulb weight followed by Lalteer king (18.29 t ha⁻¹) and the lowest was in BARI Piaz-4 (13.70 t ha⁻¹). Larger bulb size contributed to produce higher yield in BARI Piaz-4.

Kushtia Sadar: The plant height was higher in BARI Piaz-4 (38.33 cm) and lowest was in BARI Piaz-1 (33.77). Single bulb weight of BARI Piaz-4 was higher (29.00 g) whereas BARI Piaz-1 produced smaller bulb (22.72 g). Therefore, BARI Piaz-4 gave the highest bulb yield (19.37 t ha⁻¹) followed by BARI Piaz-1 (15.75 t ha⁻¹) and Local cultivar produced the lowest yield (15.67 t ha⁻¹).

Gopalganj: The plant height was higher in Local Red King (56.42 cm) than BARI variety. Single bulb weight of Red King was higher (37.03 g) than BARI varieties. The highest bulb yield was found higher in local variety (18.50 t ha⁻¹) due to the production of larger bulb followed by BARI Piaz-4 (17.40 t ha⁻¹) and the lowest from BARI Piaz-1 (12.75 t ha⁻¹).

Cost and return

Faridpur: The highest gross return (Tk. 6,26,610 ha⁻¹) was obtained from Lalteer king due to highest bulb price and gross margin (Tk. 4,32,574 ha⁻¹) was obtained higher in BARI Piaz-4 due to lower input cost.

Kushtia sadar: The maximum gross return (Tk. 387400 ha⁻¹) and gross margin (Tk. 159730 ha⁻¹) were obtained from BARI Piaz-4 and the lowest in local variety.

Farmer's opinion

Faridpur: Farmers were happy to observe the bulb yield of BARI Piaz-4 and Lalteer king. They have chosen BARI Piaz-4 for higher yield potentiality, shape and size and attractive color. But market price Lalteer king was higher than BARI Piaz-4 as commented by the farmers.

Kushtia: Farmers were happy to observe the bulb yield of BARI Piaz-4. They have chosen BARI Piaz-4 due to its comparatively higher yield.

Gopalganj: Farmers were happy with the yield of local variety (Red King).

Table 2. Yield and yield attributes of different Onion varieties at different locations during the year of 2020-21.

Location	Variety	Plant height (cm)	Single bulb wt. (g)	Bulb yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Faridpur	BARI Piaz-1	48.50	19.00	13.70	2,89,474
	BARI Piaz-4	54.60	34.58	22.42	4,32,574
	Lal teer king	50.25	25.27	18.29	4,31,431
	Local cultivar (Taherpuri)	47.30	20.06	13.86	2,83,758
	LSD (0.05)	2.58	3.14	0.98	-
	CV (%)	3.44	8.97	3.58	-
Kushtia sadar	BARI Piaz-1	33.77	22.72	15.75	87,330
	BARI Piaz-4	38.33	29.00	19.37	1,59,730
	Local variety	38.20	24.97	15.63	84,930
Gopalganj	BARI Piaz-1	51.02	25.71	12.75	-
	BARI Piaz-4	53.52	33.12	17.40	-
	Local cultivar	56.42	37.03	18.50	-

Conclusion

Onion var. BARI Piaz-4 appeared better in the farmers field in respect to yield and gross margin compared to local varieties. Therefore, this variety could be extended in the farmers field of the tested locations.

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Floating Agriculture

INTEGRATED NUTRIENT MANAGEMENT FOR TURNIP ON EX-SITU FLOATING BED WASTE INCORPORATED LAND

Selim Ahmed and A F M Ruhul Quddus

Abstract

A nutrient management trial was conducted at the Aamgram, Sadar, Madaripur during the rabi, 2020-21 to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers. The experiment was laid out in randomized complete block (RCB) design. Four treatments were considered as T_1 (Recommended Fertilizer Dose; RFD) = $N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha⁻¹ (FRG, 2018), T_2 (RFD + Organic) = $T_1 + 8$ t ha⁻¹ decomposed floating bed waste, T_3 (RFD + Organic) = $T_1 + 4$ t ha⁻¹ decomposed floating bed waste and T_4 (Farmer's practice) = $N_{92}P_{56}K_{40}S_{25}Zn_3B_1$ kg ha⁻¹. Combination of chemical fertilizer and floating decomposed waste in T_2 treatment exhibited relatively higher single card weight. The highest card yield (19.66 t ha⁻¹) was obtained from T_2 followed by T_3 . The lowest card yield (16.62 t ha⁻¹) was recorded in farmer's practice (T_4). Maximum gross return (Tk. 196600 ha⁻¹) and gross margin (Tk. 117350 ha⁻¹) were obtained from that treatment where combination of recommended fertilizer dose and 8 t ha⁻¹ decomposed floating bed waste was incorporated in soil.

Introduction

Floating agriculture (locally *vasoman/dhapchash*) is an age-old practice for crop production in the low-lying areas of the south and south-western regions of Bangladesh. Farmers generally grow selected vegetable and spice crops and its seedlings on water hyacinth made floating bed during rainy season. After harvesting of the monsoon crops, the decomposed floating bed is incorporated with the soil at the same place/land (in-situ) or with the soil in other place/land (ex-situ) for cultivation of succeeding winter crops. The local farmers opine that ex-situ incorporation of the organic waste of decomposed floating bed with the soil (where no floating agriculture is practiced) need less amount of chemical fertilizer for winter crop (like potato, cabbage, turnip, broccoli etc.) production. Determination of

optimum fertilizer dose for turnip on ex-situ floating bed incorporated plain land is therefore needed for increasing the yield and economic return of turnip. Thus, minimum use of chemical fertilizers as well as increase the soil fertility through floating agriculture practices in Bangladesh will be possible. The present study was undertaken to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers

Materials and Method

The nutrient management trial was conducted at the Aamgram, Sadar, Madaripur during the rabi, 2020-21 to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers. The experiment was laid out in randomized complete block (RCB) design with two replications. Four treatments were considered as T_1 (Recommended Fertilizer Dose; RFD) = $N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha⁻¹ (FRG, 2018), T_2 (RFD + Organic) = $T_1 + 8$ tha⁻¹ decomposed floating bed waste, T_3 (RFD + Organic) = $T_1 + 4$ tha⁻¹ decomposed floating bed waste and T_4 (Farmer's practice) = $N_{92}P_{56}K_{40}S_{25}Zn_3B_1$ kg ha⁻¹. Recommended fertilizer dose for turnip in 10m²plot was 220 g urea, 300 g DAP, 80 g MP, 135 g gypsum, 8 g zinc sulphate monohydrate and 6 g boric acid. Hybrid variety was used as planting material in the study. The unit plot size was 4.8m x 3.6m. Twenty-five days old seedlings were transplanted on 2-3 December 2020 maintaining 60 cm × 45 cm spacing. All kinds of fertilizers were applied as liquid form in three equal splits at 15, 30 and 50 days after transplanting (DAT). The liquid form of plant nutrients was applied around the crop plants. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. Fertilizers were applied after weeding of the plot. The crop was harvested on 4-6 February 2021 during the study period. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed with excel.

Results and Discussion

Yield attributes and card yield of turnip as influenced by different fertilizer packages during 2020-21 were presented in Table 1. The highest plant height (44.9 cm) was recorded in T_2 where RFD+ 8 tha⁻¹ decomposed floating bed waste was used followed by T_3 (44.6 cm). The lowest plant height (43.0 cm) was recorded in farmer's practice (T_4). Card length was ranged between 9.65 cm (T_4) to 11.25 cm (T_2). The highest card circumference (36.7cm) was obtained from T_2 followed by T_3 (36.3 cm). The lowest card circumference was 34.4 cm which was found from T_4 treatment. The maximum weight of single card (664.10 g) was observed in T_2 followed by T_3 (625.45g). The lowest weight of single card was noted in T_4 (561.2 g). Combination of chemical fertilizer and floating decomposed waste in T_2 treatment exhibited relatively higher single card weight suggested that additional plant nutrients from inorganic and organic sources were needed for optimum card growth and development as compared with other treatments. However, the highest card yield (19.66 t ha⁻¹) was obtained from T_2 followed by T_3 (18.52 t ha⁻¹). The highest card yield was the cumulative effect of card length, card circumference and single card weight. The lowest card yield (16.62 t ha⁻¹) was recorded in T_4 .

Considering economic benefit, maximum gross return (Tk. 196600 ha⁻¹) and gross margin (Tk. 117350 ha⁻¹) were obtained from that treatment where combination of recommended fertilizer dose and 8 t ha⁻¹ decomposed floating bed waste was incorporated in soil. The minimum gross margin (Tk. 95920 ha⁻¹) was observed in farmer's practice.

Farmers' opinion

Farmers are happy to see the result of higher card yield in combination of recommended fertilizer dose and 8 t ha⁻¹ decomposed floating bed waste.

Table 1. Yield attributes and yield of turnip as influenced by fertilizer management packages

Treatments	Plant population m ⁻²	Plant height (cm)	Card length (cm)	Card circumference (cm)	Single card weight (g)	Card yield (t ha ⁻¹)
T ₁ (RFD)	3.70	44.2	10.45	34.6	582.1	17.23
T ₂ (RFD + Organic)	3.70	44.9	11.25	36.7	664.1	19.66
T ₃ (RFD + Organic)	3.70	44.6	10.65	36.3	625.4	18.52
T ₄ (Farmer's practice)	3.70	43.0	9.65	34.4	561.2	16.62

T₁ (Recommended Fertilizer Dose) = N₁₀₁P₆₀K₄₀S₂₅Zn₃B₁ kg ha⁻¹ (FRG, 2018), T₂ (RFD + Organic) = T₁ + 8 t ha⁻¹ decomposed floating bed waste, T₃ (RFD + Organic) = T₁ + 4 t ha⁻¹ decomposed floating bed waste and T₄ (Farmer's practice) = N₉₂P₅₆K₄₀S₂₅Zn₃B₁ kg ha⁻¹

Table 2. Cost and returns analysis of turnip as influenced by fertilizer management package

Treatment	Card yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ (RFD)	17.23	172300	71250	101050
T ₂ (RFD + Organic)	19.66	196600	79250	117350
T ₃ (RFD + Organic)	18.52	185200	75250	109950
T ₄ (Farmer's practice)	16.62	166200	70280	95920

Input price (Tk kg⁻¹): Urea: 16.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc sulphate: 220.00, Boric acid: 220.00, Decomposed floating bed waste: 1.00 Output price (Tk kg⁻¹): Turnip: 10.00

Conclusion

Combination of recommended fertilizer dose and 8 t ha⁻¹ decomposed floating bed waste gave higher yield. It is the result of one year only. For concrete/final decision, the experiment may be repeated in next year.

Acknowledgement: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ADAPTIVE TRIAL OF WINTER HYBRID TOMATO ON FLOATING BED IN MADARIPUR (NON-TIDAL METHOD)

Selim Ahmed and A F M Ruhul Quddus

Abstract

A trial was conducted at Hijalbari under Rajoir upazila of Madaripur during the winter season, 2020-21 to find out the suitable hybrid Tomato variety for cultivation on floating bed and to popularize BARI develop varieties among the neighbor farmers under floating agriculture system in Madaripur areas. Each floating bed was considered as one treatment with RCB design. Three hybrid Tomato varieties (BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid) were selected for this program. The fruits yield (tha⁻¹) was 65.50, 72.85 and 55.10 of BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid variety, respectively.

Introduction

Farmers living in the low-lying areas of Madaripur, Barishal, Gopalganj and Pirojpur districts traditionally grow selected vegetable and spice crops and their seedlings grow on water hyacinth made floating bed during monsoon season. Farmers mainly grow winter hybrid Tomato at plain land as well as floating bed. Farmers use mainly local hybrid Tomato and seedlings of Tomato are also produced on floating bed but these seedlings are used only for crop production under normal land condition in southern region. Sometimes farmer become looser using local hybrid Tomato as a low quality of seed. It can be mentioned that sometimes lands become submerge during monsoon season due to heavy rainfall, which can delay transplanting of Tomato in that season. Cultivation of Tomato on floating bed can escape that problem and will make available of Tomato in the market during the season. BARI has developed some promising hybrid variety of Tomato but no data are yet available to assess the

performance of hybrid Tomato production on floating bed. Considering above all the facts, the experiment was undertaken to evaluate the yielding abilities of selected hybrid Tomato varieties as well as to popularize the floating bed-based hybrid Tomato production under flooded ecosystem.

Materials and Methods

An activity was conducted at Hijalbari under Rajoir upazila of Madaripur district during rabi season, 2020-21 to find out the suitable hybrid Tomato varieties for cultivation on floating bed and to popularize the floating bed-based hybrid Tomato production in Madaripur areas. The work was performed in floating bed and each floating bed was considered as one treatment with RCB design. Three Tomato varieties (BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid variety) were selected for this program. The size of each floating bed was 9.15m x 1.37m. The number of crop row/bed was 2, plant to plant distance was 0.6m X .04m and number of seedling hill⁻¹ was 1, respectively. Uniform size, healthy 30-32 days old seedlings of Tomato were transplanted on 17 December 2020. The fertilizer dose was N₁₆₀P₆₀K₄₀S₂₀Zn₂ and B₁ kg ha⁻¹ and applied in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. All the chemical fertilizers were applied on the floating bed in liquid form and two equal splits at 15 and 35 days after transplanting (DAT). The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated when as necessary. Harvesting was started during 70 to 100 DAT (23 February to 31 March 2021). Data on plant population (m⁻²), fruits plant⁻¹(no.), individual fruit weight (kg) and fruit yield (t ha⁻¹) were recorded and analyzed statistically.

Result and Discussions

Performance of hybrid Tomato were presented in Table 1. Statistically difference was present in yield and yield contributing characters except plant population. The number of fruits plant⁻¹ were 33.6, 40.2 and 32.2 of BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid variety, respectively. The single fruits weight was 46.8g, 43.5g and 41.0g for BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid variety, respectively. The fruits yield (tha⁻¹) was 65.50, 72.85 and 55.10 of BARI Hybrid Tomato-5, BARI Hybrid Tomato -9 and local hybrid variety, respectively. The local variety yield was the lowest among all the planted variety due to all yield attributes showed the lowest value.

Farmers' Opinion

- Farmers were very happy for getting higher yield from BARI variety using floating bed.
- Higher market price and highly demandable to customers due to fresh and insecticide free fruits.
- Fruits ripe quickly after harvest so need keeping quality variety

Table 1. Yield and yield attributes of hybrid Tomato variety grown on floating bed at Hijalbari, Rajoir, Madaripur during 2020-21

Variety	Days to 50% flowering	Final pl. pop (m ⁻²)	No of fruits plant ⁻¹	Single fruit wt. g)	Fruit yield 10 m ² plot ⁻¹ (kg)
BARI Hybrid Tomato-5	61 b	4.17	33.6 b	46.8 a	65.60 b
BARI Hybrid Tomato-9	68 a	4.17	40.2 a	43.5 b	72.85 a
Local Hybrid Tomato	59 b	4.17	32.2 b	41.0 c	55.10 c
CV (%)	6.60	-	8.71	6.05	8.19

Conclusion

From the study, it reveals that floating bed is good way for production of Tomato. BARI develop hybrid Tomato variety performed the best followed by local. Need further verification for conclude decision.

ADAPTIVE TRIAL OF WINTER ONION ON FLOATING BED IN MADARIPUR

Selim Ahmed and A F M Ruhul Quddus

Abstract

The experiment was conducted at Hijalbari under Rajoir upazila of Madaripur during the winter season, 2020-21 to find out the suitable onion variety for cultivation on floating bed and to popularize BARI developed variety among the neighbor farmers under floating agriculture system in Madaripur areas. Each floating bed considered as one treatment (variety) with following RCB design Three onion varieties (BARI Piaz-1, Lal Teer and local variety) were selected for this program. The highest bulb yield (12.07 tha^{-1}) obtained from Lal Teer variety and the second highest was BARI Piaz-1 (10.20 tha^{-1}). The local variety yield (9.31 tha^{-1}) gave the lowest yield among all the planted variety due to all yield attributes showed the lowest value.

Introduction

Farmers living in the low-lying areas of Madaripur, Barishal, Gopalganj and Pirojpur districts traditionally grow selected vegetable and spice crops and their seedlings grow on water hyacinth made floating bed during monsoon season. Farmers mainly grow winter onion at plain land with local variety. Sometimes farmer become looser for using local variety as a low quality of seed. It can be mentioned that sometimes lands become submerge during monsoon season due to heavy rainfall, which can delay transplanting of onion in that season. Cultivation of onion on floating bed can escape that problem and can ensure availability of onion in the household purpose. BARI and some companies have developed onion variety but no data are yet available to assess the performance of onion variety on floating bed. Considering above all the facts, the experiment was undertaken to evaluate the yielding abilities of selected onion varieties as well as to popularize the floating bed-based onion production under flooded ecosystem.

Materials and Methods

An activity was conducted at Hijalbari under Rajoir upazila of Madaripur district during rabi season, 2020-21 to find out the suitable onion variety for cultivation on floating bed and to popularize BARI develop variety among the neighbor farmers under floating agriculture system in Madaripur areas. The work was performed in floating bed and each floating bed considered as one treatment (variety) with following RCB design. Three onion varieties (BARI Piaz-1, Lal Teer and local variety) were selected for this program. The size of each floating bed was 9.15m X 1.37m (30ft long x 4.5ft wide). The number of row/beds was 10, plant to plant distance was 15 cm X 10 cm and 1, respectively. Uniform size, healthy 30-35 days old seedlings of onion were transplanted on 10 January, 2021. The fertilizer dose was $\text{N}_{115}\text{P}_{50}\text{K}_{75}\text{S}_{20}\text{Zn}_2$ and $\text{B}_1 \text{ kg ha}^{-1}$ and applied in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. All the chemical fertilizers were applied on the floating bed in liquid form and two equal splits at 25 and 50 days after transplanting (DAT). The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated when as necessary. Harvesting was started during 76 to 78 DAT (27 to 29 March 2021). Data on yield and yield contributing characters were recorded and analyzed statistically using MSTATC program.

Result and Discussions

Performance of onion variety were presented in Table 1. Statistically difference was present in yield and yield contributing characters. The number of bulb m^{-2} were 61.5, 57.5 and 58.8 of BARI Piaz-1, Lal Teer and local variety, respectively. The single bulb weight were 17.1g, 21.20g and 16.10 g for BARI Piaz-1, Lal Teer and local variety, respectively. The highest bulb yield (12.07 tha^{-1}) obtained from Lal Teer variety and the second highest was BARI Piaz-1 (10.20 tha^{-1}). The local variety yield (9.31 tha^{-1}) gave the lowest yield among all the planted variety due to all yield attributes showed the lowest value.

Farmers' opinion

- Farmers were happy for getting higher yield from Lal Teer and BARI variety using floating bed.
- It was a new idea and alternate way for growing onion

Table 1. Yield and yield attributes of onion variety grown on floating bed at Hijalbari, Rajoir, Madaripur during 2020-21

Variety	Plant height (cm)	No of leaves plant ⁻¹	No of bulb (m ⁻²)	Single bulb wt. (g)	Bulb yield 10 m ² plot ⁻¹ (kg)
BARI Piaz-1	37.3 b	5.90	61.5 a	17.10 a	10.20 b
Lal Teer	39.8 a	6.10	57.5 b	21.20 b	12.07 a
Local	34.3 c	5.80	58.8 b	16.10 c	9.31 c
CV (%)	4.44	4.69	2.58	4.94	5.36

Conclusion

From the study, it reveals that floating bed was a good way for production of onion. BARI develop onion variety performed better than that of local. For further verification needed for next year.

INTERCROPPING OF NON-CREEPERS WITH CREEPER VEGETABLES ON FLOATING BED CUM TRELLIS (NON-TIDAL MODEL)

Selim Ahmed and M Mohiuddin

Abstract

The intercropping-based activity was conducted at Amgram and Hijalbari area under Rajoir upazila of Madaripur district and Kishoreganj sadar and Karimganj upazila under Kishoreganj district during 2020-21 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers for extending floating agriculture system. Four treatments were considered as T_1 = Bottle gourd + Redish, T_2 = Cucumber + Red amaranth, T_3 = Sweet gourd + coriander leaf and T_4 = Yard long bean + spinach at Kishoreganj and T_1 = Bottle gourd + Red amaranth, T_2 = Sweet gourd + Red amaranth, T_3 = Yard long bean + Red amaranth and T_4 = Ash gourd + kangkong. Each floating bed considered as one treatment following RCB design. The highest gross margin (Tk. 2,20,529 ha⁻¹) was obtained from T_1 treatment at Kishoreganj whereas ash gourd (54.60 tha⁻¹) intercropped with kangkong (32 tha⁻¹) combination at Madaripur produced highest yield.

Introduction

In different places of Bangladesh have many water bodies or canals near road side that are connected to River. Water bodies remain unusable specially in monsoon period. Some enthusiastic farmers like farmers of Gopalganj and Kishoreganj grow creeper vegetables on floating bed made of conventional way. But cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lack of wider space on it for proper growth and development of the creeper vegetables. Recently, a technology namely “Floating Bed cum Trellis (non-tidal model)” has been developed for growing creeper vegetables successfully. In this system, seedlings of creeper vegetables are transplanted on floating bed but their growth and development take place on trellis as made between two floating beds. In this system, different non-creeper vegetables could be cultivated as intercrops (Red amaranth, coriander leaves etc.) with creeper vegetables on floating bed without hampering the growth and development of the creeper vegetables. Practices of intercropping would increase the crop productivity and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment was undertaken to evaluate the intercropping performances of different non-creeper with creeper vegetables on “Floating Bed cum Trellis (non-tidal model)” under flooded ecosystem in non- tidal areas.

Materials and Methods

The activities were conducted at Amgram and Hijalbari area under Rajoir upazila of Madaripur district and Kishoreganj sadar and Karimganj upazila under Kishoreganj district during 2020-21 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers of floating agriculture system. The work was conducted in floating bed and each floating bed

considered as one treatment. Treatments and crop varieties were Presented in Table 1. The size of each floating bed was 9.15 m X 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) were 9.15m x 6m (30ft long x 20 ft wide). The two rows of creeper crop were grown on each floating bed maintaining 1.5 m plant to plant distance. The seedlings per hill was 2 for all. Uniform size, healthy 10-12 days old seedlings of creeper plants were selected for transplanting. The intercropped non-creeper vegetables like red amaranth and kangkong were grown in between two rows of creeper vegetables. The agronomic management (date of planting, age of seedling and fertilizer dose) were showed in Table 2. The fertilizer dose (For 10 sqm floating bed area) was different applying on vegetables. All the chemical fertilizers were applied on floating bed in liquid form. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed except Zinc and B fertilizer. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Data on plant population (m^{-2}), fruits plant⁻¹(no), individual fruit weight (kg) and fruit yield ($t\ ha^{-1}$) were recorded. The data on yield and yield attributes were analyzed.

Table 1. Treatment combination for different location

Treatment	Madaripur	Kishoreganj
T ₁	Bottle gourd + Red amaranth	Bottle gourd + Redish
T ₂	Sweet gourd + Red amaranth	Cucumber + Red amaranth
T ₃	Yard long bean + Red amaranth	Sweet gourd + coriander leaf
T ₄	Ash gourd + kangkong	Yard long bean + spinach

Table 2. Agronomic management of creeper and non-creeper vegetables as intercrop grown on floating bed, 2020-21

	Intercropping	Treats	Crops and variety	Planting date	Fertilizer dose (kg. ha ⁻¹)	Harvesting date
Madaripur	Creeper crops	T ₁	Bottle gourd (BARI Lau-3)	01-20 Sep 2020	N ₂₄ P ₂₇ K ₁₅ S ₆ Zn ₁ B ₁	63-100 DAP
		T ₂	Sweet gourd (BARI Mistikumra-2)	01-20 Sep 2020	N ₂₄ P ₂₇ K ₁₅ S ₆ Zn ₁ B ₁	68-103 DAP
		T ₃	Yard long bean (BARI Barbati-1)	29 Aug 2020	N ₂₀ P ₁₆ K ₁₆ S ₃ Zn ₁ B ₁	62-144 DAP
		T ₄	Ash gourd (BARI Chalkumra-1)	01-20 Sep 2020	N ₃₂ P ₁₉ K ₁₂ S ₆ Zn ₁ B ₁	65-103 DAP
	Non-creeper crops	T ₁ , T ₂ & T ₃	Red amaranth (BARI Lalshak-1)	20 Aug-10 Sep 2020	--	26-47 DAP
		T ₄	Kangkong (BARI Gimakalmi-1)	20 Aug-10 Sep 2020	--	13 April 2020
Kishoreganj	Creeper crops	T ₁	Bottle gourd (BARI Lau-3)		53 g urea, 135 g DAP, 30 g potash, 33 g gypsum, 2 g Zinc sulphate, 4 g boric acid	19 Nov. 2020-22 May 2021
		T ₂	Cucumber (Alavi green)		57g urea, 64g DAP, 18g MoP, 28 g gypsum, 2 g Zinc sulphate, 5 g boric acid	19 Nov. 2020-22 May 2021
		T ₃	Sweet gourd (BARI Mistikumra-2)		53g urea, 135g DAP, 30g potash, 33g gypsum, 2g Zinc sulphate, 4g boric acid	Up to 25 June 2021
		T ₄	Yard long bean (BARI Barbati-1)		-	Up to 30 March 2021
	Non-creeper crops	T ₁	Radish (Tasakisan)		-	
		T ₂	Red amaranth (BARI Lalshak-1)		-	
		T ₃	Coriander leaf (Local)		-	
		T ₄	Spinach (Local)			

Result and Discussions

Madaripur: Yield performance of creeper and non-creeper vegetables were presented in Table 3. The single fruit weight was 1.65 kg, 2.14 kg and 1.56 kg for bottle gourd, sweet gourd and ash gourd, respectively. The highest yield was obtained from ash gourd (54.60 t ha⁻¹) intercropped with kangkong (32 t ha⁻¹) and second highest was sweet gourd with red amaranth. The lowest yield was obtained from yard long bean (11.50 t ha⁻¹) and red amaranth (17 t ha⁻¹). It was the lowest among all the planted creeper vegetables due to water hyacinth of floating bed became almost rotten and roots touch the water.

Kishoreganj: Performance of creeper and non-creeper vegetables are presented in table 3. The fruits weight per bed were 42.61 kg, 21.35 kg, 39.46 kg and 10.68 kg for bottle gourd, cucumber, sweet gourd and yard long bean, respectively. The yard long bean yield was the lowest among all the planted creeper vegetables due to water hyacinth of floating bed became almost rotten and roots touch the water as a result a smaller number of yard long bean was harvested. Performance of non-creeper vegetables are presented in table 3. Among the vegetables, Spinach gave the highest yield followed by red amaranth and radish, respectively. In economic point of view, yard long bean and spinach intercropping gave the highest gross margin due to high yield of spinach, good market price and low-cost involvement followed by sweet gourd and coriander intercropping practice.

Farmers' Opinion

Madaripur:

- Yields of all vegetables obtained higher over conventional practice
- Higher demand to customers along with higher market price due to pesticide free production
- Initially invest cost is higher
- Less availability of water hyacinth in dry season as a result repair or refill of floating bed may not possible
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed

Kishoreganj:

- Yields of all vegetables obtained higher over conventional practice
- Higher demand to customers along with higher market price due to pesticide free production
- Initially invest cost is higher
- Less availability of water hyacinth in dry season as a result repair or refill of floating bed may not possible
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed

Table 3. Yield of creeper and non-creeper vegetables grown on floating bed as intercropped during 2020-21

Treatment	Kishoreganj			Madaripur		
	Crop	Yield (t ha ⁻¹)	GM	Treatment	Crop	Yield (t ha ⁻¹)
T ₁	Bottle gourd	33.96	220529	T ₁	Bottle gourd	39.20
	Radish	13.46			Red amaranth	15.00
T ₂	Cucumber	17.02	143654	T ₂	Sweet gourd	46.70
	Red amaranth	14.44			Red amaranth	18.00
T ₃	Sweet gourd	31.45	156648	T ₃	Yard long bean	11.50
	Coriander leaf	2.56			Red amaranth	17.00
T ₄	Yard long bean	8.51	208353	T ₄	Ash gourd	54.60
	Spinach	31.44			Kangkong	32.00

Conclusion

Madaripur: From the study it reveals that floating bed cum trellis (non-tidal model) is a good way for production of creeper vegetables with non-creeper simultaneously. Ash gourd performed better followed by sweet gourd and bottle gourd. Among the non-creeper vegetables, kangkong gave the best performance then red amaranth.

Kishoreganj: It may be concluded that floating bed cum trellis (non-tidal mode) is good way for production of creeper vegetables with non-creeper simultaneously. Bottle gourd performed better followed by sweet gourd and cucumber. Among the non-creeper vegetables, spinach gave the best performance then radish, red amaranth and coriander leaf. For further verification the trial may be repeated in next year.

Acknowledgement: Authors are gratefully acknowledged to the Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Gazipur for providing financial and logistic support.

ADAPTIVE TRIAL OF BARI WINTER BRINJAL VARIETIES ON FLOATING BED

M. Mohiuddin

Abstract

Adaptive trial of BARI winter brinjal varieties was conducted at the Kishoreganj sadar and Karimganj upazila of Kishoreganj district during 2020-21 to examine a suitable brinjal variety for the area. Two BARI developed varieties such as BARI Begun-6 and BARI Begun-10 were tested. The significantly highest yield was found from BARI Begun-10 (38.77 t ha⁻¹) and the lowest from BARI Begun-6 (35.78 t ha⁻¹). From financial analysis, BARI Begun-10 gave the highest gross return (Tk. 387654 ha⁻¹), gross margin (Tk. 219134 ha⁻¹) and benefit cost ratio (2.08) followed by BARI Begun-6.

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed besides, seedlings of brinjal also produced on floating bed. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for brinjal production in this season. Cultivation of brinjal on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected brinjal varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Material and Methods

The experiment was conducted at Kishoreganj sadar and Karimganj upazila of Kishoreganj district during 2020-21 to examine the suitable variety of brinjal on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI Begun-6 and BARI Begun-10. The unit bed size were 9.15m x 1.37m. Seedlings were planted on 05 November 2020 followed by 100 cm x 75 cm spacing. The recommended fertilize doses were applied Urea-47gm, DAP-214g, MoP-48g, Gypsum-24g, Zinc-02g and Boric acid-05g per bed respectively. All the chemical fertilizers will be applied on the floating bed in liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting. The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. This year did not appear any major disease of brinjal. BARI Begun-6 and BARI Begun-10 were started to harvest at 16 February 2021 to April 2021. Data on yield were recorded and presented in the table.

Results and Discussion

BARI Begun-10 gave the highest yield (38.77 t ha⁻¹), gross margin (219134 Tk ha⁻¹) and BCR 2.08 followed by BARI Begun-6.

Farmer's opinion

In between two varieties farmers have chosen the BARI Begun-10 for its high yielding potentiality, market demand and excellent colour.

Table 1. Yield and economic performance of brinjal on floating bed in Kishoreganj during 2020-21

Treatments	Yield (kg/bed)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI Begun-6	44.89	35.78	357767.3	168520	189247.3	1.92
BARI Begun-10	48.64	38.77	387654.3	168520	219134.3	2.08

* TVC includes cost of bed preparation, labour, price of seedlings, fertilizers and insecticides, price: BARI Begun-6 and 10 = 10 tk/kg

Conclusion

It was the results of first year study. To make a final conclusion there is need to repeat the experiment next year.

ADAPTIVE TRIAL OF BARI TOMATO VARIETIES ON FLOATING BED

M. Mohiuddin

Abstract

Adaptive trial of BARI Tomato varieties was conducted at the Kishoreganj sadar and Karimganj upazila of Kishoreganj district during 2020-21 to examine a suitable Tomato variety for the area. Two BARI developed varieties such as BARI Tomato-17 and BARI Tomato-21 were tested. The significantly highest yield was found from BARI Tomato-21 (54.19 t ha⁻¹) and the lowest from BARI Tomato-17 (43.58 t ha⁻¹). From financial analysis, BARI Tomato-21 gave the highest gross return (Tk. 541880 ha⁻¹), gross margin (Tk. 377645 ha⁻¹) and benefit cost ratio (3.08) followed by BARI Tomato-17.

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed. Besides, seedlings of Tomato also produced on floating bed. It can be mentioned that the low-lying lands become submerged during monsoon season due to heavy rainfall, which is not suitable for Tomato production in this season. Cultivation of Tomato on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected Tomato varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Material and Methods

The experiment was conducted at Kishoreganj sadar and Karimganj upazila of Kishoreganj district during 2020-21 to examine the suitable variety of Tomato on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI Tomato-17 and BARI Tomato-21. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 05 November 2020 followed by 60 cm x 40 cm spacing. The recommended fertilizer doses were applied Urea-47g, DAP-214g, MoP-48g, Gypsum-24g, Zinc-02g and Boric acid-05g per bed respectively. All the chemical fertilizers will be applied on the floating bed in liquid form. Urea was applied 3 equal splits at 10, 25 and 40 days after transplanting. MoP was applied in 3 equal splits as basal dose at land preparation time and 25 and 40 days after transplanting. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. This year did not appear any major disease of Tomato. BARI Tomato-17 and BARI Tomato-21 were started to harvest at 20 February 2021 to April 2021. Data on yield were recorded and presented in the table.

Results and Discussion

The highest yield per bed was recorded from BARI Tomato-21 (68.10 kg) and lowest from BARI Tomato-17 (54.68 kg). BARI Tomato-21 gave the highest gross return Tk. 541880 ha⁻¹, gross margin Tk. 377645 ha⁻¹ and BCR 3.08 followed by BARI Tomato-17.

Farmers' opinion

Farmers choose BARI Tomato-21 for its high yield potential, attractive colour and market demand.

Table 1. Yield and economic performance of Tomato on floating bed in Kishoreganj during 2020-21

Treatments	Yield (kg/bed)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI Tomato-17	54.68	43.58	435790	164235	271555	2.48
BARI Tomato-21	68.10	54.19	541880	164235	377645	3.08

Conclusion

In the haor areas like Kishoreganj floating agriculture is disseminating day by day. So, purpose of more dissemination and meet up to vegetable crisis further continuation is needed.

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INTEGRATED FARMING RESEARCH AND DEVELOPMENT FOR LIVELIHOOD IMPROVEMENT IN THE PLAINLAND ECOSYSTEM

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Abstract

Integrated farming is now gaining priority to ensure food, nutrition and income security of resource poor farm households with the rapid increasing of population and declining of agricultural land. The program was undertaken to develop integrated farming technologies, fine tune the technologies generated by NARS institutes, integrate component technologies with efficient use of farm resources and thereby improve family income and livelihoods. The programs were conducted during the year of 2018-19 to 2020-21 at 5 Farming Systems Research and Development (FSRD) Sites viz., Ajoddhapur (Rangpur), Ganggarampur (Pabna), Sholakundu (Faridpur), Atia, Delduar (Tangail) and Tarakandi (Sherpur). A total of fifty-four types of activities were done for maximizing the total productivity using the existing resources of sixty farmers, where twelve from each location comprising of four from each of marginal, small and medium farmers group considering homestead vegetables and fruits, field crops, poultry and livestock, fisheries and off-farm component of farming systems. Over the location, the average vegetables produced per homestead 624 kg after intervention (AI), which was only 167 kg before intervention (BI). The average vegetables consumption during AI was 254 g head⁻¹ day⁻¹, which was 388% higher than BI. The average fruits produced per homestead 500 kg, which was only 279 kg during BI. The average consumption of fruits was also increased (Avg. 83%). The daily nutritional requirements of a family members were supplemented considerably. Animal product from fish, chicken, pigeon, Turkey and livestock also could help to minimize the protein deficiency. A total of 611 fruit trees were brought under pest management and a total of 3811 saplings of different fruits were distributed in different FSRD sites. Women participation (25-80%) in different agricultural activities increased to a great extent that showed some positive effect on gender equity within the family. In field crops component two or three crops-based cropping pattern (CP) could be successfully replaced by three to four crops-based CP. Among them Potato included 4 crop-based CP T. Aus-T. Aman rice-Potato/Sweet gourd and T. Aus-T. Aman-Potato-Mungbean produced higher REY 51.39 and 29.99 t ha⁻¹, respectively. In pilot production program, sole crop Tomato gave maximum gross margin (Tk. 605200 ha⁻¹) at Rangpur than other location. In the livestock component, after deworming and vaccination, the frequency of major diseases of cattle were reduced and attained below 7% and addition of vitamin ADE injection increased the lactation period and yield remarkably. Cattle fattening and calf rearing programs were created interest among the farmer due to remarkable gain of cattle body weight (18-46%). Goat rearing was found promising as low cost required for rearing. In poultry system, Sonali breed, Naked-neck (Garchila) chicken, Khaki Campbell Duck, Turkey bird and pigeon rearing in the homestead area created a good impact among the farm families as a good source of income and child nutrition. Mortality of poultry reduced (70-99%) after vaccination. Moreover, farmyard manure (FYM) production (3050 kg homestead⁻¹) and vermicompost production (320 kg homestead⁻¹) and their utilization, and green fodder production (53 t ha⁻¹) were created a good impact among the farm families. Seasonal fish culture with carp polyculture in seasonal pond was found promising than monoculture. Carp polyculture gave a satisfactory fish yield (avg. 171 kg per 13-decimal size pond) and gross margin (avg. Tk. 12513 per 13-decimal size pond) at farmers' level. From different types of off-farm activities farmers also earned some extra money (avg. gross margin Tk. 5173 household⁻¹). Among the different production components, field crop sector gave maximum gross margin (Tk. 103647-250910 farm⁻¹) but gross margin increased maximum at homestead vegetable production sector (53-646%), where total gross margin increased 59-385% per farm. The activities (seed and seedling collection, production, and distribution/sell) of Local Service Provider (LSP) were found promising for home gardening, vaccination and other activities at FSRD site, Ajoddhapur, Rangpur. Partial integration among the farm components was found as a cost saving technology especially compost pit-based integration activities were found promising.

Keywords: farming system, food security, homestead model, integrated farming, livelihood, plainland.

Introduction

The subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. Integrated farming is a combination of different agricultural activities and a whole farm management system which aims to deliver more sustainable agriculture. Sustainable farm resource management approach to maximize farm productivity, farm resource use efficiency, employment opportunity, farmers' income and nutrition as well as livelihood of the resource poor farm households is an integral part of integrated farming. It is a dynamic approach which can be applied to any farming system around the world. The subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. These resources may be utilized in such a manner that maximize farm productivity, farmers benefit and resource use efficiency in an environmentally sound and sustainable way. Particular emphasis is placed on a holistic management approach looking at the whole farm as cross-linked unit, on the fundamental role and function of agro-ecosystems, on nutrient cycles which are balanced and adapted to the demand of the crops, and on health and welfare of all livestock on the farm. Preserving and enhancing soil fertility, maintaining and improving a diverse environment and the adherence to ethical and social criteria are indispensable basic elements (Boller *et al.*, 2004). As per EISA (European Initiative for Sustainable Development in Agriculture) Integrated Farming Framework includes Organization and Planning, Human and Social Capital, Energy Efficiency, Water Use and Protection, Climate Change and Air Quality, Soil Management, Crop Nutrition, Crop Health and Protection, Animal Husbandry, Health and Welfare, Landscape and Nature Conservation and Waste Management Pollution Control (EISA, 2012). An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirement to farm household while presenting resources base and maintaining a high-level environmental quality (Lal and Millar, 1990). In other words, farming system is a decision-making unit comprising the farm household, cropping and livestock system that transform land, capital and labor into useful products that can be consumed or selling (Fresco and Westphal, 1988). The system specially refers to a group combination of enterprises in which the products and or the by products of one enterprise serve as the inputs for production of other enterprise. However, land topography, soil composition and availability of different inputs along with the environmental factors influence the farmers in choosing different enterprises (Uddin and Takeya, 2005).

A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. Bangladesh Agricultural Research Institute (BARI) is conducting research on different discipline through a number of programs and divisions. Those programs and divisions are generating a good number of technologies including new cultivars/different management techniques/machines etc. for the farmers of Bangladesh. However, before transferring those to extension agencies/ NGOs and farmers they need on-farm verification/test of fine-tuning to fit into the farmers existing socio-agro-economic environments. Moreover, through on-farm trial valuable farmers' feedback is obtained to modify technology or to develop new technology. BARI has given this noble responsibility to OFRD to test those developed on-station technologies directly to the farmer's field. Proper utilization of these resources with improved technologies can ensure higher production and income generation. BARI has developed a number of technologies which can be used for increasing production and income of the farmer. BARI and BRRI have already developed improved cropping pattern with management practices involving 3 or 4 crops. Besides, BFRI and BLRI also developed improved technologies on calf rearing, poultry rearing and high value fish culture. Verification of new technologies, integration of different farming components for livelihood improvement and dissemination of proven technologies developed by NARS institutes on crops, cropping pattern, climate resilient options, resource conservation technologies, plantation crops, homestead production systems, fish, livestock and poultry production as well as other income generating activities were included in this project under plain land ecosystem. Increasing profitability by minimizing resource loss through reuse of wastage of one component as an input of other

components and making integration is getting priority in the program. Thrusts are given on Local Service Provider (LSP) development at the site level for more sustainability of farming systems activities.

Objectives

a) General objectives:

To improve livelihood of rural households through generation and adoption of Farming System Technologies.

b) Specific objectives of BARI Component:

- i) To develop integrated farming technologies to maximize farm productivity with efficient use of farm resources.
- ii) To modify fine tune on station technologies generated by NARS institutes and at different FSRD sites of plain land ecosystems.
- iii) To integrate component technologies (crops, livestock, fisheries, agro-forestry and homestead gardening, etc.) for improving farm productivity.
- iv) To establish linkage with different stakeholders.

Methodology

For the successful implementation of the proposed integrated farming research and development program, the following methods were considered-

Implementing locations

Implementing locations were selected based on climatic, edaphic, social, vegetation and economic conditions of the regions. Two villages were selected for each FSRD site i.e., Ajoddhampur, Rangpur; Ganggarampur, Pabna; Sholakundu, Faridpur; Atia, Delduar, Tangail and Tarakandi, Sherpur.

FSRD site Ajoddhampur, Rangpur:

Two villages named South Ajoddhampur and Jhautary village under Rangpur Sadar upazila of Rangpur district were considered for FSRD activities. Ajoddhampur has a distance of sixteen km from the upazila head quarter and is located at the west side ($25^{\circ}40'$ N latitude and $89^{\circ}10'$ E longitude; AEZ-3).



FSRD site Ganggarampur, Pabna:

In Pabna, Ganggarampur has a distance of eighteen km from the upazila head quarter and is located at the east side ($24^{\circ}03'$ N latitude and $89^{\circ}38'$ E longitude; AEZ-11).



FSRD site Sholakundu, Faridpur:

The Integrated Farming Research and Development for Livelihood Improvement in the Plainland Ecosystem project site named Sholakundu, Kanaipur, Faridpur is located at $23^{\circ}43'$ north latitude and $89^{\circ}28'$ east longitude (AEZ-11 and 12). The site is situated about 10 km south of district head quarter. It spreads over a part of Kanaipur union under Faridpur Sadar upazila.



FSRD site Atia, Tangail:

The FSRD site Atia is situated at the two villages namely Hinganagar and Mahmudpur of Atia union under Delduar Upazila of Tangail district. It is twelve km far away from the district headquarter and is also located at the east side 24°17' N latitude and 89°90' E longitude. Delduar Upazila with an area of 184 sq.km is bounded by Tangail Sadar and Basail upazilas on the north, Nagorpur upazila on the south, Basail and Mirzapur upazilas on the east and Nagorpur and Tangail Sadar on the west. Dholshori river flow at the west side of this Upazila. Communication of the village with upazila headquarter is well and mode of transportation is bus, autorickshaw, motorcycle, bicycle, rickshaw, 3-wheelers etc.



FSRD site Tarakandi, Sherpur:

The Tarakandi, Sherpur FSRD site is located at N 24°58'59.33" to E 90°06'21.62". The area is under Old Bhramaputra Floodplain (AEZ-8 and AEZ-9). Sherpur is bounded by Jamalpur district on the south and west, Mymensingh district on the east, Indian province of Meghalaya on the north. Main rivers are Brahmaputra and Vogad.



Specific Methodology

The integrated farming research and development activities were executed at Plainland ecosystem (FSRD site Ajodhdhapur, Rangpur; Ganggarampur, Pabna; Sholakundu, Faridpur; Atia, Tangail and Tarakandi, Sherpur) during the years of February 2018 to January 2021 to improve livelihood of rural households through generation and adoption of Farming System Technologies especially integrated farming technologies and the technologies generated by NARS institutes. The program was executed in a participatory approach, where critical inputs and technological suggestions were provided by BARI personnel and other commodities were used from farmer's own sources. Based on farmer's traditional practices, their needs and choices, several alternatives of technologies of crops, livestock, fisheries, off-farm activities and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers-marginal, small and medium having major components of farming and sizeable homestead under single ownership were targeted and twelve farm households from two villages were selected at each site (Table 1).

Table 1. Category-wise selected farmers information of different FSRD sites

FSRD site	Categories	No. of Farmer	Av. family size (no.)	Av. crop land size (ha)	Av. homestead area (ha)	Av. pond area (ha)
Ajodhdhapur, Rangpur	Marginal	4	4.5	0.18	0.057	0.032
	Small	4	4.25	0.44	0.058	0.034
	Medium	4	5.25	0.97	0.048	0.054
Ganggarampur, Pabna	Marginal	4	5.0	0.435	0.084	0.03
	Small	4	5.75	0.891	0.126	0.04
	Medium	4	5.5	1.188	0.195	0.04
Sholakundu, Faridpur	Marginal	4	4.50	0.17	0.047	0.028
	Small	4	5.00	0.64	0.103	0.037
	Medium	4	4.25	1.12	0.11	0.06
Atia, Delduar Tangail	Marginal	4	6.5	0.19	0.11	-
	Small	4	4.66	0.58	0.13	0.05
	Medium	4	5.0	1.05	0.16	0.05
Tarakandi, Sherpur	Marginal	1	4.00	0.06	0.06	-
	Small	8	4.38	0.45	0.064	0.048
	Medium	3	5.33	1.12	0.08	0.08

Training program was arranged to buildup farmers capacity and to develop awareness regarding nutrition and crop production. An individual household survey (Benchmark survey) was carried out before starting the project activities. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Year-round vegetable production followed by respective location-wise model in each homestead, fruit tree management and new plantation, crops and cropping system improvement through improve cropping pattern development and promising variety piloting, vaccination of poultry and livestock, rearing of Turkey, poultry, pigeon and calf, green fodder production, fish culture and some off-farm activities were identified as their major potential area.

During the implementation period of project activities, site working group meeting, PRA, base line survey, field visit was done, and field staffs were organized. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. However, season-wise (Rabi= October-March, Kharif I= April-June and Kharif II= July-September) data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing income and expenditure and other socio-economic information were collected and tabulated accordingly.

A. HOMESTEAD PRODUCTION SYSTEM

Before going to implement the program, a benchmark survey was carried out to know the existing agricultural situation for technology intervention of the pilot areas. Twelve different categories farmers were selected on the basis of available resources and potentials for homestead farming and averaged shown here. Each farm families consist of average 5 members. The selected farmers were provided training and suggestion by the FSRD team on year-round vegetables and quick growing fruits production following respective site wise production model. Thereafter, the trained farm families produced vegetables and fruits in their homestead area following respective site-wise model.

A homestead is a farmhouse, together with the land around it. The area under a homestead is a valuable asset for the resource poor farm household and suitable for production of different kinds of vegetables and fruits.

a) Vegetables

Based on farmers' choice and agro-ecological suitability, the vegetables production models of different locations were determined and followed accordingly.

Table 2. Different models for vegetables production in homestead area in different farming system research and development (FSRD) sites under plainland ecosystem

Table 2a. Syedpur model (Modified) (Ajoddhapur, Rangpur)

Niche/space		Year-round homestead vegetables and fruits pattern		
		Rabi (October- March)	Kharif-I (April-June)	Kharif-II (July-September)
1. Open sunny space	Bed 1	Radish	Red amaranth	Kangkong
	Bed 2	Cabbage	Stem amaranth	Merah shak
	Bed 3	Brinjal + Spinach	Red amaranth	Indian spinach
	Bed 4	Tomato + Napashak	Okra	Red amaranth
	Bed 5	Garlic+Leafy coriander	Leafy Jute	Okra
2. Roof		Bottle gourd	Ash gourd	Ash gourd
3. Trellis		Country bean	Sweet gourd/Snake gourd	Sweet gourd
4. Fence		Bitter gourd/Country bean	Yard long bean/Ribbed gourd	Bitter gourd
5. Tree support		Country bean	Potato yam/Sponge gourd	Potato yam/
6. Marshy land		Water taro (Kalakachu), Aroid (Latiraj)		

Niche/space	Year-round homestead vegetables and fruits pattern		
	Rabi (October- March)	Kharif-I (April-June)	Kharif-II (July-September)
7. Backyard	Papaya, Banana, Guava, Mango, Lemon, Sugarcane, Palm, Moringa		
8. Partially shady place	Ginger, Turmeric, Moulavi kachu		
9. House boundary	Papaya, Lemon, Multa etc.		
10. Pond bank	Creeping vegetables, Papaya, Lemon, Napier grass etc.		

Table 2b. Goyeshpur model (Ganggarampur, Pabna)

Niche/space			Cropping patterns		
			Rabi	Kharif-I	Kharif-II
1. Open sunny space	Bed-1	:	Radish	Stem Amaranth	Indian spinach
	Bed-2	:	Cabbage	Brinjal	Red amaranth
	Bed-3	:	Tomato	Spinach	Okra
2. Fence	:	Bitter gourd	Yard long bean	Bitter gourd	
3. Trellis	:	Bottle gourd	Sweet gourd	Sweet gourd	
4. Roof	:	Bottle gourd	Wax gourd	Wax gourd	
5. Tree support	:	Bitter gourd	Ridge gourd	Sponge gourd	
	:	Potato yam	Snake gourd Potato yam	Potato yam	
	:	Country bean	Yard long bean	Yard long bean/Country bean	
	:	Elephant foot yam			
6. Partial shady area	:	Leaf aroid (moulavi kachu)			
	:	Turmeric			
	:	Perennial Chilli			
	:	Panikachu (Latiraj)			
7. Marshy land	:	Papaya (3-5 plant)			
8. Homestead boundary	:	Guava (1-2 plant)			
	:	Lemon (1-2 plant)			
	:	Laizna (1-2 tree)			
9. Back Yard /waste land	:	Banana			
	:				

Table 2c. Ishan Gopalpur model (Sholakundu, Faridpur)

Sl.no	Location		Cropping Pattern
1	Open space	a	Radish-Red amaranth-Indian spinach
		b	Spinach-Tomato-Stem Amaranth
		c	Cabbage-Okra-Okra
		d	Cauliflower -Gimakolmi- Gimakolmi
		e	Broccoli-Red amaranth- Stem Amaranth
		f	Potato-Indian Spinach-Indian Spinach
2	Roof top		Bottle gourd-Ash gourd
3	Trellis		Bottle gourd-Sponge gourd Bottle gourd- Sweet gourd
4	Tree support		Potato yam
5	Partial shady area		Moulavi kachu
6	Marshy Land		Taro
7	Fence		Country bean-Ribbed gourd/ Country bean- Bitter gourd
8	Homestead boundary		Papaya, Guava and Lemon
9	Back Yard/ Waste land		Banana
10	Pond bank		Sweet gourd-Ash gourd/ Country bean- Ribbed gourd

Table 2d. Palima model (Atia, Tangail)

Niche/space		Cropping patterns		
		Rabi	Kharif-I	Kharif-II
1. Open sunny space	Bed 1	Tomato/Radish	Okra	Indian spinach
	Bed 2	Brinjal + Lalshak	Indian spinach	Okra + Lalshak
	Bed 3	Spinach	Gimakalmi	Gimakalmi
	Bed 4	Bush bean	Amaranthus	Indian spinach
2. Trellis		BARI Lau-1/Local	Ash gourd	Sponge gourd
		BARI Lau-2/Local	Bitter gourd	Snake gourd
		Lau	Sweet gourd	Ash gourd
3. Roof		BARI Lau-1/Local	Ash gourd	Ash gourd
		Sweet gourd	Ash gourd	Ash gourd
4. Tree support		Mete Alu	Mete Alu	Mete Alu
		Mete Alu	Mete Alu	Mete Alu
		-	Sponge gourd	Sponge gourd
5. Partial shady area		Ginger	Ginger	Ginger
		Ginger	Ginger	Ginger
6. Pond bank		Napier	Napier	Napier
		Lau	Blackgram	Blackgram
		Arum	Arum	Arum
7. Slightly marshy land		Latiraj	Latiraj	Latiraj

Table 2e. Narekeli model (Tarakandi, Sherpur)

Niche/space		Cropping pattern		
		Rabi	Kharif-I	Kharif-II
1. Open sunny space	Bed 1	Tomato	Indian spinach	Danta
	Bed 2	Lalshak + Cabbage	Kangkong	
	Bed 3	Coriander + Onion	Okra	
	Bed 4	Spinach + Garlic	Chilli	
	Bed 5	Carrot + Bitter gourd	Latiraj kachu	
2. Roof top		Country bean	White gourd	-
3. Trellis		Country bean, Bottle gourd	Yard long bean	-
4. Fence		Bitter gourd	-	-
5. Marshy land		Latiraj kachu		
6. Shady place		Turmeric, Ginger		
7. Boundary		Papaya, Drumstick		
8. Unused tree		Potato yam		

b) Fruits

On the basis of farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied and plantation were done in the homestead area and nearby homestead area. In Rangpur, a sole Dragon fruit orchard and a mixed fruit garden with Mango, Guava and Litchi were established. Mixed fruit garden was also established at Pabna. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program.

B. CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

There were different types of cropping pattern exist in different locations. Among the existing cropping patterns, more prominent cropping pattern were considered for the improvement or replace by alternate profitable cropping pattern. To increase crop productivity, two to three cropping patterns were considered for development at each FSRD site under plainland ecosystem.

Table 3. Activities for improvement or development of cropping pattern under plainland ecosystem.

FSRD sites	Existing cropping pattern	Date of sowing/ transplanting	Date of harvesting	Alternative/improved cropping pattern	Date of sowing / transplanting	Date of harvesting
Ajodhpur, Rangpur	T. Aman (Swarna)- Fallow- Boro (BRRI dhan28)	20-25 July - 25-28 Feb	27-30 Nov - 20-23 Jun	T. Aman (Binadhan-17)- Mustard (BARI Sarisha-14)- Boro (BRRI dhan28)	5-18 Aug. 27 Nov-7 Dec 25 Feb-7 Mar	11-19 Nov 22-27Feb 28Jun-11 Jul
	T. Aman (Swarna)- Potato (BARI Alu-8)- Boro (BRRI dhan28)	5-10 Aug. 1-5 Dec 1-7 Mar	23-30 Nov 24-27 Feb 15-22Jun	T. Aus (BRRI dhan48)- T. Aman (Binadhan-17)- Potato (BARI Alu-25)- Sweet gourd (BARI Hybrid Mistikumra-1)	10-17 May 12-17 Aug. 25-30 Nov 7-12 Dec. (relay)	5-10 Aug. 20-23 Nov 5-9 Feb 7-14 April
Ganggarampur, Pabna	T. Aman (BRRI dhan39)- Mustard (Tori-7)- Boro (Toba)	22-28 Jul 26-30 Nov 25-28 Feb	On going 20-25 Feb 3-7 Jun	T. Aman (Binadhan-17)- Mustard (BARI Sarisha-17)- Boro (BRRI dhan28)	24 July 15 Nov 20 Feb	05 Nov. On going 16 May
	T. Aman (BRRI dhan39)- Lentil (BARI Masur-6)- Sesame (Local)	25-30 July 15-20 Nov 15 Mar	On going 15 Mar 25 Jun	T. Aman (Binadhan-17)- Lentil (BARI Masur-8)- Sesame (BARI Til-4)	30 Jul 10 Nov 9 Mar	8 Nov On going 20 June, 19
Sholakundu, Faridpur	Lentil (Local)- Jute (JRO 524)- T. Aman (BRRI dhan39)	28 Nov to 4 Dec 26 Mar to 5 Apr 30 Jul to 15 Aug.	15-20 Mar- 20-30 Jul- 12-30 Nov	Lentil (BARI Masur-8)- Jute (Rabi-1)- T. Aman (Binadhan-17 /BRRI dhan75)	16-30 Nov 28 Mar 7 Apr 10-15 Aug.	8-24 Mar 1-8 Aug. 17-20 Nov
	Mustard (Tori-7)- Jute (JRO 524)- T. Aman (BRRI dhan39)	9-20 Nov/ 25-30 Nov.- 26 Mar to 5 Apr 20-30 Mar	27 Jan to 6 Feb /10-15 Feb- 20 Jul to 3 Aug. /18-25 Jul. 5-15 Nov./ 25-30 Nov	Mustard (BARI Sarisha-17/18)- Jute (Rabi-1)- T. Aman (Binadhan-17/ BRRI dhan75)	9-20 Nov./ 25-30 Nov.- 26 Mar to 5 Apr./ 20-30 Mar.- 12-18 Aug./ 5-10 Aug.	10-18 Feb/ 5-8 Mar- 28 Jul to 6 Aug./20-27 July- 15-20 Nov.
Atia, Delduar Tangail	Boro (BRRI dhan29)- T. Aman (BR11)- Mustard (Tori-7)	6-15 Feb.- 8-14 Jul- 10-15 Nov.	13-22 Jun- 24-31 Oct- 25-30 Jan	Boro (BRRI dhan29)- T. Aman (BRRI dhan72)- Mustard (BARI Sarisha-14)	10-18 Feb.- 25-31 Jul- 12-16 Nov.	15-24 Jun.- 25-30 Oct- 5-10 Feb.
	Brinjal (Singhnath)- T. Aman (BR11)- Cabbage (Autumn queen)	20-25 Jan.- 14-25 Jul- 15-19 Nov.	10 Mar to 28 Jun- 24-29 Oct 10-20 Feb.	Okra (BARI Dherosh-2)- T. Aman (BRRI dhan72)- Cabbage (Autumn queen)	9-12 Mar. 20-25 Jul.- 10-16 Nov.	20 Apr to 25 Jun 14-20 Oct- 7-17 Feb.
Tarakandi, Sherpur	T. Aman (Hori)- Fallow- Boro (BRRI dhan29)	27 to 29 Jul- Fallow- 25 to 26 Jan	20 to 25 Nov- Fallow- 20 to 30 May	T. Aman (BRRI dhan49)- Potato (BARI Alu-25)- Mungbean (BARI Mung-6)- T. Aus (BRRI dhan48)	18 to 29 Aug.- 18 to 28 Nov- 4 to 9 Mar- 28 May to 02 Jun	10 to 15 Nov- 17 to 20 Feb- 10 to 20 May- 15 to 20 Aug.
	T. Aman (Hori)- Fallow- Boro (BRRI dhan29)	27 to 30 Jul- Fallow- 25 to 27 Jan	24 to 26 Nov- Fallow- 25 to 29 May	T. Aus (BRRI dhan48)- T. Aman (BRRI dhan49)- Motorshuti (BARI Motorshuti-3)- Boro (Hybrid shakka)	25 to 30 May- 20 to 28 Aug.- 21 to 24 Nov- 4 to 17 Feb	13 to 15 Aug.- 10 to 15 Nov- 28 to 30 Jan- 14 to 20 May

b) On-farm verification/production program

Bangladesh Agricultural Research Institute and other NARS Institutes have developed a large number of modern varieties of different crops, which are high yielder as well as short in duration. To identify the suitable crops and varieties, on-farm verification trial was conducted during years of 2018-19 and 2019-20 with different types of crops e.g., Mustard, Potato, Tomato, Wheat, Mungbean, Sesame, Lentil, Barley, Okra, Radish, etc. The identified suitable varieties were brought under production program at each location in the following years. The details of crop management are given in result part.

Table 4. Different operations conducted for production program at different FSRD sites under plainland ecosystem during the years of 2018 to 2020.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Ajoddhapur, Rangpur	Mustard	BARI Sarisha-14	6	1	21-28 Nov.	27-28 Feb.
		BARI Sarisha-18	2	1	20-30 Nov.	7-8 March
	Tomato	BARI Tomato-15	3	0.5	16-18 Nov.	15 Feb-09 March
	Potato	BARI Alu-25	7	1.4	28-30 Nov.	27Feb.-05 March
		BARI Alu-53	5	1	30 Nov-10 Dec	04-10March
Ganggarampur, Pabna	Mustard	BARI Sarisha-17	4	0.5	2-5 Dec.	13-15 March
	Lentil	BARI Masur-8	4	0.5	1-5 Dec.	15-20 March
	Pea	BARI Motor-3	9	1.0	25-28 Nov.	5-10 March
Sholakundu, Faridpur	Mustard	BARI Sarisha-14	3	0.24	8-15 Nov 18	6-12 Feb
		BARI Sarisha-18	3	0.3	30 Nov. -3 Dec.	9-11 Mar
	Wheat	BARI Gom-28	4	0.4	30 Nov. -2 Dec.	24-25 Mar
		BARI Gom-33	3	0.4	30 Nov. -8 Dec.	19-27 Mar
	Mungbean	BARI Mung-6	2	0.16	5 Mar	12-27 May (2 picking)
		BARI Mung-8	3	0.24	1-2 March	9-10 May (1 picking)
	Sesame	BARI Til-4	3	0.24	8-12 Mar	1-3 Jun
		BARI Til-4	4	0.25	19-25 March	15-22 Jun.
	Lentil	BARI Masur-8	3	0.3	28 Nov.-3 Dec.	20-22 Mar
		BARI Masur-8	4	0.25	19 Nov-3 Dec	--
	Onion	BARI Piaj-1	3	0.3	4-14 Jan	24-31 Mar
		BARI Piaj-4	3	0.3	1-10 Jan	24-31 Mar
		BARI Piaj-1	4	0.5	30 Dec 20-10 Jan	--
		BARI Piaj-4	4	0.5	30 Dec 20-10 Jan	--
	Bottle gourd	Hybrid	1	0.06	25 Jul	25 Sep-20 Nov
	Summer Tomato	BARI Hybrid Tomato-11	1	0.012	16 Aug.	7-31 Oct
	Black gram	BARI Mash-3	2	0.2	17 Sep	3 Dec
	Intercropping of Radish + Onion bulb + Red amaranth with Sugarcane	Radish (BARI Mula-1), Onion (BARI Piaj-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	1	0.06	Sugarcane: 28 Oct Radish+Onion+Red amaranth: 1 Nov	Sugarcane: 5-18 Oct Radish: 1-5 Jan Onion: 5-10 Jan Red amaranth: 4-5 Dec
Atia, Delduar, Tangail	Mustard	BARI Sarisha-14	29	5.53	14-24 Nov.	03-11 Feb.
		BARI Sarisha-17	25	3.90	16-24 Nov.	5-12 Feb.
	Barley	BARI Barley-6	8	1.15	20-26 Nov.	15 Feb-09 March
		BARI Barley-7	7	1.11		
	Potato	BARI Alu-41	21	2.92	25Nov.- 04 Dec	20-27 Feb.
Tarakandi, Sherpur	Mustard	BARI Sarisha-14	1	124 dec	03-06 Nov.	21-22 Jan.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/transplanting	Date of harvesting
	Okra	Shakti (Hybrid)	1	15 dec	15-18 March	1-25 May
	Potato	BARI Alu-35 BARI Alu-36 BARI Alu-37 BARI Alu-40 BARI Alu-41	1	124 dec	28-30 Nov.	19-20 Feb.

C. LIVESTOCK COMPONENT

Productivity and profitability of livestock sector mostly depend on farm animal health and maintaining of livestock health is an integral part of integrated farming. Cattle health may be improved through deworming which may make the farmer economically benefitted. More than 10 faeces sample of cattle were selected from different location by the symptomatic parasitic infection and then investigated the parasites through faeces sample analysis for the confirmation. After confirmation of parasitic infestation, the test animal was de-wormed by broad spectrum anthelmintics i.e., Trilev-vet (Livamisole and Triclabendazole) for round worm and liver fluke as per recommendation for the body weight. After deworming, Vitamin A, D and E containing injections were also being injected in cattle. Proper vaccination against four major diseases may reduce the mortality rate of cattle. For this purpose a short FGD was conducted to identify the disease severity and mortality after vaccination. In the vaccinated group Anthrax vaccine, Foot and mouth disease (FMD) vaccine, Blood quarter (BQ) vaccine and Hemorrhagic septicemia (HS) vaccine were injected as per recommended schedule. Cattle fattening and Calf rearing programs were also continued at some areas.

Besides of cattle product, Cowdung is very important by-product for integrated farming and farmers were motivated to use it for preparation of farm Yard manure (FYM) including other homestead wastage instead of using the Cowdung as fuel.

Napier grass was identified as a suitable and profitable green fodder to produce in the homestead and its surrounding areas especially on pond bank. Farmers were advised to apply FYM after every cut of grass. It was introduced among the farmers under the program to produce for feeding their cattle. Some farmers were also selling their produced Napier grass in the market besides of feeding their cattle.

Poultry rearing is a common practice in rural Bangladesh. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level this program was conducted at the farmer's field. A good number of poultry birds were vaccinated during the project period. In the vaccinated group BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague vaccine were used as per recommended schedule. Regular contact was done by the facilitator team for providing necessary suggestions to solve their specific problems. Chick rearing, Pigeon rearing, Duck rearing and Turkey rearing programs were also conducted at some locations.

D. FISHERIES COMPONENT

Improper management is the major hindrance against profitability of fish culture in pond under homestead area. The carp poly culture and monoculture of Tilapia, Pabda, Shing, Tengra etc. programs in perennial and seasonal ponds were undertaken at the FSRD sites with the objectives of increasing farmer's income and removing protein deficiency of rural people. For fish cultivation, weeds and wild fishes were removed from the pond and Lime was given at the rate of 1 kg per decimal as well as prepared for stocking with organic manure (Cowdung) at the rate of 3 kg per decimal. Fingerlings stocking density is mostly depending on fingerlings size, species, pond depth, feed availability etc. However, in poly culture system, Silver carp, Catla, Rui, Mrigal, Common and Mirror carp may form 20–30%, 10–15%, 15–20%, 10–15% and 15–20% respectively maintaining 20-30 fingerlings decimal⁻¹. Fish feed partially collected and supplied by the co-operative farmers whereas Lime and fingerlings were supported from the program. Periodic checking and suggestion were given by the office personnel of the respective FSRD site.

E. OFF-FARM ACTIVITIES

Off-farm (non-farm) income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, pensions, and interest income earned by farm families. Since the last three decades or so, there has been increasing evidence showing that small-holder farm households in developing countries rarely rely on agriculture alone, but often maintain a portfolio of income activities in which off-farm activities are an important component (Barrett *et al.*, 2001).

Some farm families' especially the women were engaged with off-farm activities. Some farmers had small grocery shop and opened at his off-time and also had practice of weaving *Katha* and cloth sewing with machine. Commercially cooking is also practiced in some cases by the men. The women were also engaged in making *Kumra bora*, *Pilo cover*, making handicrafts with rope, plastic ball etc. during their leisure periods and men were engaged with basket making and van/rickshaw pulling.

F. LOCAL SERVICE PROVIDER (LSP)

For the better execution of farming activities and to make them more sustainable, one male and one female Local Service Provider (LSP) was selected from the co-operator farmers. The LSP was selected based on their knowledge level, eagerness, technology understanding and dissemination capability, local and social acceptance, etc.

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Integrated farming consists of several enterprises like home gardening with vegetables and fruits, crops and cropping system, dairying, poultry, fishery, etc. and these enterprises are interrelated. The end product and wastage of one enterprise may use as inputs in another enterprise. Moreover, judicious use of farm resources may reduce production cost and can help to keep clean the environment. In integrated farming, the contribution of one component on other component ('s) is important consideration for sustainable farming.

Results and Discussion

A. HOMESTEAD PRODUCTION SYSTEM

Activity 1. Year-round vegetables and fruits production in homestead area during the years of 2018 to 2021

FSRD Site, Ajoddhapur, Rangpur

Vegetables production: The vegetables cultivation program at homestead area was carried out for three consecutive years at the Farming Systems Research and Development (FSRD) site, Ajoddhapur, Rangpur following the "Syedpur Model" (Table 5a) from February 2018 to January 2021. From the results it was found that Open sunny place contributed more for vegetables production followed by Back Yard and trellis in all the years and the average vegetables production from open sunny place was 257 kg homestead⁻¹year⁻¹ (Table 5b and 5c). From the Table 5a it was observed that the vegetables production was maximum in *Rabi* season (275, 239 and 269 kg homestead⁻¹ in 2018-19, 2019-20 and 2020-21, respectively). The second highest vegetables were obtained in *Kharif-2* season except 2020 and in 2020, the less vegetables are due to damage by severe flood (Table 5a). The total vegetables production was in increasing trend in 2019-20 compared to 2018-19 but in 2020-21, it was decreased due to almost fully damage of *Kharif-2* vegetables by severe flood (Table 5b and 5c). Round the year total vegetable produced 516, 595 and 538 kg homestead⁻¹ in 2018-19, 2019-20 and 2020-21, respectively and it was partially contributed by the total number of available production niches. After intervention of the improved technologies, the average vegetable production was increased 282% compared to before intervention of the program. Using of improved technologies and judicious time management for vegetables production might be enhanced the remarkable increment of vegetable production in homestead area.

Utilization of vegetable: The disposal pattern of different vegetable produced in the homestead area was recorded regularly through the help of the co-operator farmers. The three years average results

indicated that disposal pattern of vegetables varied after intervention (Table 5c). The average vegetable intake per year per 5 members farm family was 407 kg after program intervention and the increment was 303%, whereas intake was only 101 kg per farm family per year before program intervention. The average vegetables intake by a 5 member's farm family was increased remarkably and it was 223 g head⁻¹day⁻¹. After program intervention, the average distribution of vegetable per year was recorded as 44 kg and average sell of vegetable per year was 99 kg. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship and it also helped them to earn more money from more selling of vegetable. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Different types of quick growing fruit trees (Dragon fruit, Papaya, Lemon, Banana etc.) along with other existing fruit trees (Mango, Jackfruit, Coconut, Wood apple etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies, fruits production was increased significantly. Table 5a showed that higher quantity of fruits production was obtained from *Kharif-1* (699, 572, 570 kg homestead⁻¹ in 2018-19, 2019-20 and 2020-21, respectively) season followed by *Kharif-2* (55, 167, and 63 kg homestead⁻¹ in 2018-19, 2019-20 and 2020-21, respectively). The *Rabi* season was lean period, which was more or less the reverse scenario of vegetable production (Table 5a). Minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the average fruits production was increased 110% (Table 5b). The tremendous production of fruits might be due to use of improved technologies including judicious fertilizer management and pest control.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely in three consecutive years. The three years average fruits intake per year per farm family was 358 kg after program intervention, whereas it was only 264 kg before intervention and the 36% increment was mainly due to increment of total production and motivation (Table 5c). After program intervention, the average distribution of fruits per year was recorded as 113 kg and sell of fruits per year was 290 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income: In case of vegetables, after intervention of homestead production system, the income was Tk. 6910, 14140 and 12835 in 2018-19, 2019-20 and 2020, respectively. The average increment of income was 504% at after intervention compared to before intervention (Table 5b).

In case of fruits sector, after program intervention, income per homestead was recorded as Tk. 11933, 19850 and 17375 in 2018-19, 2019-20 and 2020-21, respectively. The income was increased in 2nd year than 1st year but decreased in 3rd year due to damage of fruit trees especially Papaya by flood. The average increment of gross margin was 201% at after intervention compared to before intervention (Table 5c).

Table 5a. Round the year vegetables and fruits production per homestead from different niches of homestead during the years of February 2018 to January 2021 at FSRD site, Ajodhpur Rangpur.

Space		Rabi				Kharif-1				Kharif-2				Total (kg)			
		October- March				April-June				July-September							
		Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.	Feb.2019- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.	Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.	Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.
Open sunny space	Bed-1	45.4	26	27	33	4	13	15	11	12	21	5	13	61.4	60	47	56
	Bed-2	48.5	29	34	37	7	26	19	17	2	4	0	2	57.5	59	53	57
	Bed-3	21	20	22	21	6	23	20	16	7	24	3	11	34	67	45	49
	Bed-4	23.5	32	27	28	5	20	22	16	12	13	0	8	40.5	65	49	52
	Bed-5	0	8	19	9	7	17	18	14	8	23	0	10	15	48	37	33
Roof		21	23	27	24	14	0	10	8	20	16	10	15	55	39	47	47
Trellis		50	33	34	39	15	23	26	21	18	14	5	12	83	70	65	73
Fence		11.2	2	6	6	4	6	8	6	5	0	0	2	20.2	8	14	14
Tree support		11.5	0	7	6	5	0	5	3	4	7	2	4	20.5	7	14	14
Marshy land		14.5	0	2	6	0	3	8	4	11	9	13	11	25.5	12	23	20
Backyard		15.5	27	20	21	12	31	28	24	22	30	10	21	49.5	88	58	65

Space	Rabi				Kharif-1				Kharif-2				Total (kg)			
	October- March				April-June				July-September							
	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2019-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.
Partially shady place	0	19	17	12	11	3	7	7	12	4	2	6	23	26	26	25
House boundary	1	3	7	4	2	4	6	4	4	6	10	7	7	13	23	14
Pond bank	12	17	20	16	5	9	15	10	7	8	2	6	24	34	37	32
Total (vegetable)	275	239	269	261	97	178	207	161	144	179	62	128	516	595	538	550
Fruits	42	55	62	53	699	572	570	614	55	167	63	95	796	794	695	762
Total (vegetables +fruit)	317	294	331	314	796	750	777	774	199	346	125	223	1312	1389	1233	1311

Table 5b. Round the year vegetables and fruits production and income per homestead from different niches of homestead during the years of February 2018 to January 2021 (Comparative data) at FSRD site, Ajoddhapur Rangpur

Niches	Before intervention		After intervention									
			Feb.2018-Jan.2019		Feb.2019-Jan.2020		Feb.2020-Jan.2021		Av.Feb. 2018 to Jan.2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (%)
Open sunny place	0	0	208	2084	299	4580	231	3525	257	3513	257	-
Roof	0	0	55	830	39	780	47	940	47	853	47	-
Trellis	86	1295	83	1335	70	1480	65	1430	86	1548	0	-
Fence	0	0	20	808	8	235	14	420	14	488	14	-
Tree support	0	0	21	308	7	137	14	280	14	242	14	-
Marshy land	0	0	26	510	12	230	23	500	21	413	21	-
Backyard	36	356	50	495	88	5208	58	4100	85	3468	49	-
Partially shady place	22	220	23	230	26	1020	26	1040	26	770	4	-
House boundary	0	0	7	70	13	130	23	230				
Pond bank	0	0	24	240	34	340	37	370				
Total (vegetable)	144	1871	516	6910	595	14140	538	12835	550	11295	282	504
Fruits	363	5438	796	11933	794	19850	695	17375	762	16386	110	201
Total (vegetables +fruit)	507	7309	1312	18842	1389	33990	1233	30210	1312	27681	159	279

Table 5c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of February 2018 to January 2021 at FSRD site, Ajoddhapur Rangpur

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan.2021	Av.Feb. 2018 to Jan.2021	Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan.2021	Av.Feb. 2018 to Jan.2021
Consumption	101	264	396	465	359	407	439	305	331	358
Distribution	28	54	38	35	58	44	145	95	99	113
Selling	15	45	82	95	121	99	212	394	265	290
Total production	144	363	516	595	538	550	796	794	695	762
Gross return (Tk.)	1871	5438	6910	14140	12835	11295	11933	19850	17375	16386
Variable cost (Tk.)	650	1250	2720	2739	2480	2646	3175	3240	3150	3188
Gross margin (Tk.)	1221	4188	4190	11401	10355	8649	8758	16610	14225	13198

FSRD Site, Ganggarampur, Pabna

Vegetable production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Goyeshpur model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, nine niches were utilized in Goyeshpur model. After intervention of the proven and improved technologies in the homestead, vegetables production has increased remarkably. It was observed that

the average vegetables production was 361 kg homestead⁻¹) in *Rabi* season followed by *Kharif-1* (278 kg homestead⁻¹) and *Kharif-2* (271 kg homestead⁻¹) season (Table 6a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-1* season. *Kharif-2* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal drought and sometimes excessive rainfall. After intervention of the improved technologies, vegetables production was increased 129% compared to before intervention of the program (Table 6b). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and optimum management practices.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 6c). The average vegetables intake per year per farm family was 453 kg after program intervention which was 116% higher as compared to the before intervention (210 kg per family per year). Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 248 g head⁻¹ day⁻¹. After program intervention, the average distribution of vegetables per farm per year was recorded 69 kg and sell of vegetables per year was 387kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jack fruit, Coconut, Wood apple, Pummelo etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies in the homestead, fruits production has increased remarkably. Higher quantity of average fruits production per year per farm was found in *Kharif-2* (537 kg homestead⁻¹) followed by *Kharif-1* (410 kg homestead⁻¹) and *Rabi* (277 kg homestead⁻¹) season, which was more or less the reverse scenario of vegetables production (Table 6a). Maximum fruits were produced during *Kharif-2* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety. In this regard, scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits productions were increased 46% compared to before intervention of the program (Table 6b). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 595 kg after program intervention which was 102% higher as compared to before intervention (295 Kg per family per year) mainly due to incremental production (Table 6c). After program intervention, the distribution of fruits per year per family was recorded 207 kg and selling of fruits per year per family was 455 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, and the farmers were also sold their fruits for getting satisfactory cash money.

Income: After program intervention, gross return and gross margin was recorded Tk. 13640 and Tk. 10457 per year per farm from year-round vegetables whereas gross return and gross margin was Tk. 4566 and Tk. 3818 per year per farm was noted before intervention. From the fruits sector, after program intervention, average gross return and gross margin was recorded as Tk. 31016 and Tk. 24280 per farm whereas gross return and gross margin was Tk. 16700 and Tk. 13775 per year per farm was noted before intervention (Table 6c).

Table 6a. Round the year vegetable and fruits production from different niches of homestead during the years of February 2018 to January 2021 at FSRD site, Ganggarampur, Pabna.

Space		Rabi				Kharif-1				Kharif-2				Total (kg)			
		Feb 18-Jan-19	Feb 19-Jan-20	Feb 20-Jan-21	Av.	Feb 18-Jan-19	Feb 19-Dec-20	Feb 20-Jan-21	Av.	Feb 18-Jan-19	Feb 19-Jan-20	Feb 20-Jan-21	Av.	Feb 18-Jan-19	Feb 19-Jan-20	Feb 20-Jan-21	Av.
open	Bed-1	30	43	52	42	22	27	31	27	20	21	25	22	72	91	108	90
sunny	Bed-2	45	47	61	51	25	19	27	24	10	16	14	13	80	82	101	88
space	Bed-3	30	41	49	40	26	22	23	24	12	12	14	13	68	75	86	76
Roof top		40	31	37	36	35	-	1	18	15	-	19	17	90	31	72	64
Trellis		60	56	65	60	17	21	25	21	30	20	30	27	107	97	120	108
Shady place		45	21	32	33	60	23	26	36	50	32	30	37	155	76	88	106
Marshy land		-	-	-	-	40	24	22	29	25	34	25	28	65	59	47	57
Unproductive tree		21	13	17	17	-	9	12	11	10	10	10	10	31	32	39	34
Fence		16	16	14	15	10	14	12	12	10	8	6	8	36	38	32	35
Backyard		18	25	33	25	35	33	41	36	45	54	32	44	98	112	105	105
House boundary		38	48	41	42	45	40	52	46	50	65	60	58	133	153	153	146
Total vegetables		343	341	399	361	315	232	286	278	277	272	264	271	935	845	948	909
Fruits		275	245	312	277	430	395	406	410	545	505	561	537	1250	1145	1279	1225
Total (veg. + fruits)		618	586	711	638	745	627	692	688	822	777	825	808	2185	1990	2227	2134

Table 6b. Round the year vegetables and fruits production from different niches of homestead during the years of February 2018 to January 2021 at FSRD site, Ganggarampur, Pabna.

Niches	Before intervention		After intervention									
			Feb-2018 to Jan-2019		Feb-2019 to Jan-2020		Feb-2020 to Jan-2021		Av. Feb-2018 to Jan-2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)
Open sunny place	-	-	220	3530	248	3852	294	4410	254	3264	-	-
Roof top	25	288	90	2035	31	357	72	1073	64	821	156	185
Trellis	75	862	107	1230	97	1116	120	1792	108	1379	44	60
Shady place	90	1035	155	1783	76	874	88	1312	106	1323	18	27
Marshy place	50	575	65	748	59	678	47	705	57	710	14	23
Unproductive tree	12	138	31	356	32	368	39	585	34	436	183	216
Fence	-	-	36	414	38	437	32	473	35	441	-	-
Backyard	60	690	98	1127	112	1288	105	1575	105	1330	75	93
House boundary	85	978	133	1530	153	1760	153	2295	146	1861	71	90
Total	397	4566	935	10753	845	9717	948	14220	909	11563	129	153
Fruit (Other places)	835	16700	1250	25000	1145	22900	1279	31975	1225	26625	46	59
Total (veg. + fruit)	1232	21266	2185	35753	1990	32617	2227	46195	2134	38188	175	212

Table 6c. Round the year vegetables and fruits production and utilization pattern before and after intervention during the years of February 2018 to January 2021 at FSRD site, Ganggarampur, Pabna.

Description	Before intervention		After intervention					
	Vegetables (kg)	Fruits (kg)	Vegetables (kg)			Fruits (kg)		
			Feb 2018 to Jan 19	Feb 2019 to Jan 20	Feb 2020 to Jan 21	Feb 2018 to Jan 19	Feb 2019 to Jan 20	Feb 2020 to Jan 21
Consumption	210	295	472	450	437	607	550	630
Distribution	37	118	56	70	82	135	175	312
Selling	150	422	407	325	429	508	420	437
Total production	397	835	935	845	948	1250	1145	1279
Gross return (Tk.)	4566	16700	14025	12675	14220	31875	29198	31975
Variable cost (Tk.)	748	2925	3273	2958	3318	6875	6298	7035
Net return (Tk.)	3818	13775	10753	9717	10902	25000	22900	24940

FSRD Site, Sholakundu, Faridpur

Vegetables and fruit production: The vegetables cultivation program at homestead area was carried out at the Farming Systems Research and Development (FSRD) site following Ishan Gopalpur vegetable production model using the available and utilizable production niches of the homestead areas. With the consideration of time and space, the fallow and under-utilized homestead areas were utilized scientifically. In the production system at Sholakundu, Faridpur, nine niches were utilized for 2018 to 2021 (Table 7a). After intervention of improved technologies, vegetables production has increased significantly, and the most remarkable change was observed in case of open space vegetables produced at open sunny place (Table 7a). The first two years, vegetable production was increasing but in the third year (Feb 2020 to Jan 2021), vegetable production was decreased. The total vegetable production was 566 kg, 831 kg, 720 kg per homestead during Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21, respectively (Table 7a). Average increment of vegetables production and income over before intervention was 532 kg and 479%, respectively (Table 7b). Vegetable production in homestead area was enhanced remarkably might be due to effectively use of different production niches, improved technologies and judicious management. Improved management through pruning, pest control, fertilization and irrigation in quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jackfruit, Coconut, Hog plum etc.) were provide after program intervention and as a result, fruits production has increased significantly. The total fruit production was 167 kg, 200 kg, 390 kg per homestead during Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21, respectively. Average increment of fruit production and income over before intervention was 128 kg and 78%, respectively. Using of improved technologies including judicious fertilizer, pest management in fruits production has increased the yield tremendously. Minimum fruits were produced during Rabi season, and it is actually due to less availability of Rabi (winter) fruits species and variety, which needs to introduce more winter fruiting fruit trees like Ber, Guava, Multa etc. In every homestead, a total of 958 kg of fruit and vegetables were produced, and income was Tk. 18885 showing 201% income increment over before intervention (Table 7b).

Utilization of vegetables and fruits: Utilization of homestead produced vegetables in the means of consumption, distribution and sold was recorded regularly with the help of the co-operator farmers. From the results it was found that disposal pattern of vegetables varied (Table 7c). During before intervention, vegetables consumption, distribution and selling was 101 kg, 14 kg and 59 kg, respectively whereas after intervention, utilization pattern was increased remarkably. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent consumption, distribution and sold. Surplus vegetables produced in homestead area helped the farmers' to earn more cash money from more selling of vegetables. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their inter-relationship. After program intervention, the fruits consumption per year per farm family was 71 kg, 155 kg and 225 kg, respectively for Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21. Thus, it is concluded that, consumption ratio was increasing year wise. Average gross margin of after intervention for vegetables and fruits were Tk. 9334 and Tk. 6617, respectively.

Table 7a. Round the year vegetables and fruits production from different niches of homestead during the years of February 2018 to Jan 2021 at the FSRD site, Sholakundu, Faridpur.

Space		Rabi				Kharif-1				Kharif-2				Total (kg)			
		October- March				April-June				July-September							
		Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.	Feb.2019- Jan.2020	Feb.2019- Jan.2020	Feb.20- Jan.2021	Av.	Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.2020- Jan.2021	Av.	Feb.2018- Jan.2019	Feb.2019- Jan.2020	Feb.20- Jan.2021	Av.
Open sunny space	Bed-1	35	60	46	47	12	22	22	19	16	27	24	22	64	109	92	88
	Bed-2	21	51	42	38	21	18	18	19	17	23	25	22	60	92	85	79
	Bed-3	31	39	37	36	11	21	19	17	9	15	24	16	51	75	80	69
	Bed-4	24	37	40	34	13	15	21	16	11	19	20	17	48	71	81	67
	Bed-5	18	36	34	29	12	18	14	15	14	18	19	17	43	72	67	61
	Bed-6	21	31	32	28	15	22	17	18	12	19	21	17	47	72	70	63
Roof top		18	17	8	14	13	8	5	9	10	21	7	13	42	46	20	36

Space	Rabi				Kharif-1				Kharif-2				Total (kg)			
	October- March				April-June				July-September							
	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2019-Jan.2020	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.
Trellis	27	47	38	37	21	23	18	21	16	36	27	26	64	106	83	84
Tree support	1	12	08	7	2	5	4	4	1	9	8	6	4	26	20	17
Shady Place	8	5	06	6	8	7	7	7	8	16	8	11	24	28	21	24
Marshy Land	3	4	04	4	3	6	5	5	5	14	7	9	11	24	16	17
Backyard	11	13	05	10	14	11	3	9	18	20	3	14	43	44	11	33
Homestead Boundary	16	17	18	17	16	11	12	13	13	21	17	17	45	49	47	47
Pond bank	8	9	10	9	6	4	8	6	6	4	9	6	20	17	27	21
Total (vegetable)	243	378	328	316	167	191	173	177	156	262	219	212	566	831	720	706
Fruits	22	38	71	44	107	91	205	134	38	71	114	74	167	200	390	252
Total (veg. +fruit)	432	416	399	416	274	282	378	311	194	333	333	287	733	1031	1110	958

Table 7b. Round the year vegetables and fruits production from different niches of homestead during the years of February 2018 to January 2021 (comparative data) at FSRD site, Sholakundu, Faridpur.

Niches	Before intervention		After intervention									
			Feb.2018-Jan.2019		Feb.2019-Jan.2020		Feb.2020-Dec.2020		Av.Feb. 2018 to Dec. 2020		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (%)
Open sunny place	0	0	313	4457	491	6870	475	8550	426	6626	426	--
Roof top	12	144	42	598	46	828	20	360	36	595	24	313
Trellis	61	732	64	911	106	1908	83	1494	84	1438	23	96
Tree support	0	0	4	57	26	390	20	360	17	269	17	--
Shady Place	11	110	24	342	28	336	21	378	24	352	13	220
Marshy Land	10	100	11	157	24	288	16	288	17	244	7	144
Backyard	18	180	43	612	44	660	11	198	33	490	15	172
Homestead Boundary	47	494	45	641	49	931	47	846	47	806	--	63
Pond bank	15	168	20	285	17	255	27	486	21	342	6	104
Total	174	1928	566	8060	831	12466	720	12960	706	11162	532	479
Fruit (other places)	124	4340	167	5833	200	7000	390	10335	252	7723	128	78
Total	298	6268	733	13893	1031	19466	1110	23295	958	18885	660	201

Table 7c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of February 2018 to January 2021 at FSRD site, Sholakundu, Faridpur.

Description	Before Intervention		After Intervention							
	Vegetable s (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Feb 2018- Jan 2019	Feb 2019- Jan 2020	Feb 2020- Jan 2021	Av. Feb.201 8 to Jan 2021	Feb 2018- Jan 2019	Feb 2019- Jan 2020	Feb 2020- Jan 2021	Av. Feb.201 8 to Jan 2021
Consumption	101	65	324	633	524	494	71	155	225	150
Distribution	14	25	44	51	41	45	34	22	68	41
Selling	59	34	198	147	155	167	62	23	97	61
Total production	174	124	566	831	720	706	167	200	390	252
Gross return (Tk.)	1928	4340	8060	12466	12960	11162	5833	7000	10335	7723
Total Variable cost (Tk.)	276	280	2350	1513	1620	1828	1130	860	1328	1106
Gross margin(Tk.)	1652	4060	5710	10953	11340	9334	4703	6140	9007	6617

Cropping pattern I: Tomato-Chilli/Sweet gourd

Improved cropping pattern: Tomato (BARI Tomato-18) + Lettuce (BARI Lettuce-1)-Chilli (BARI Morich-2)/Sweet gourd (BARI Mistikumra-2) in Dragon fruit orchard

Existing cropping pattern: Tomato (Hybrid)-Chilli (Local)/Sweet gourd (Hybrid) in Dragon fruit orchard

Farmers cultivate sole Tomato but intercropping of Lettuce with BARI developed Tomato might be a good practice. During kharif II season, Sweet gourd was cultivated as a relay crop with Chilli. BARI varieties were used in after intervention package. Before intervention, farmers normally used local or imported hybrid varieties (Table 7d) and their date of sowing was earlier than that of after intervention sowing date. BARI developed varieties were used in after intervention.

Farmers Tomato variety performed better (32.00 t ha⁻¹) due to use of hybrid variety. In the improved cropping pattern, additional 6.40 t ha⁻¹ Lettuce was produced along with 26.20 t ha⁻¹ Tomato (BARI Tomato-8). The yield of Chilli was 6.15 t ha⁻¹ and 6.36 t ha⁻¹ for before and after intervention, respectively. BARI Mistikumra-2 produced 11% higher yield than imported hybrid due to lower fertile flower in before intervention. Whole pattern net return was Tk 964430 ha⁻¹ during after intervention and it was 7% higher than that of before intervention (Table 7e.).

Farmers were interested to cultivate Tomato with Lettuce as intercropping technology and other crops with BARI released varieties in the next year.

Table 7d. Crop managements of vegetables production near by the homestead as cropping pattern during the year of 2019-20 at FSRD site, Sholakundu, Faridpur

Observation	Before Intervention (kg)			After Intervention (kg)		
Season	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Chilli	Sweet gourd	Tomato+Lettuce	Chilli	Sweet gourd
Variety	Hybrid	Local	Hybrid	BARI Tomato-18+BARI Lettuce-1	BARI Morich-2	BARI Mistikumra-2
Date of sowing/ Transplanting	26 Nov 19	4 Apr 20	10 Sep 20	30 Dec 19	20 Apr 20	18 Sep 20
Seed rate ((kg ha ⁻¹))	0.25	0.90	6	0.25+0.20	0.80	6
Spacing	50 cm x 50 cm	60 cm x 50 cm	2.40 m x 2.25 m	60 cm x 40 cm	60 cm x 50 cm	2.4 m x 2 m
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	115-55-75-25-3-2	170-60-60-22-1.8-1.7	100-50-60-0--0	104-45-64-24-2.7-1.3	130-60-50-15-1.5-1.5	100-50-60-0--0
Date of harvesting (range)	Feb-Mar 20	15 June-15 Nov 20	15-30 Nov 20	20 Feb-15 Apr 20 (Tomato) 10-15 Feb 20 (Lettuce)	20 Jun-10 Nov 20	7-30 Nov 20
Field duration(days)	127	241	82	108	205	74
Turned around time (days)	3	Relay	--	10	Relay	--

Table 7e. Yield and economics of vegetables production near by the homestead before and after Intervention during the year of 2019-2020 at FSRD site, Sholakundu, Faridpur

Vegetables	Before Intervention (kg)			After Intervention (kg)			
	Rabi	Kharif-1	Kharif-2	Rabi		Kharif-1	Kharif-2
Crop	Tomato	Chilli	Sweet gourd	Tomato+Lettuce		Chilli	Sweet gourd
Variety	Hybrid	Local	Hybrid	BARI Tomato-18	BARI Lettuce-1	BARI Morich-2	BARI Mistikumra-2
Total production (t ha ⁻¹)	32.00	6.15	10.50	26.20	6.40	6.36	11.62
Gross return (Tk. ha ⁻¹)	384000	738000	210000	314400	128000	763200	232400
TVC (Tk. ha ⁻¹)	213300	159640	60895	237630		173520	62420
Gross margin (Tk. ha ⁻¹)	170700	578360	149105	204770		589680	169980
Whole pattern gross margin (Tk ha ⁻¹)	898165			964430			

Output price (Tk. kg⁻¹): Tomato: 12, Lettuce: 20, Chilli: 120, Sweet gourd: 20

Cropping pattern II: Tomato-Bitter gourd

Improved cropping pattern: Tomato (BARI Tomato-19)-Bitter gourd (BARI Korola-2)

Existing cropping pattern: Tomato (Hybrid)-Bitter gourd (Hybrid)

Before intervention, farmers normally used imported hybrid varieties for Tomato and Bitter gourd cultivation (Table 7f) but BARI developed varieties named BARI Tomato-19 and BARI Korola-2 were used in after intervention. Bitter gourd was harvested up to Kharif II season.

Farmers Tomato variety performed better (62.83.00 t ha⁻¹) due to use of hybrid variety. In the improved cropping pattern, BARI Tomato-19 produced 57.87 t ha⁻¹ yield. The yield of Bitter gourd was 12.28 t ha⁻¹ and 17.84 t ha⁻¹ for before and after intervention, respectively. In hybrid Bitter gourd, plant leaf was infected with diseases. Whole pattern net return was Tk. 927051 ha⁻¹ during after intervention and it was 39% higher than that of before intervention (Table 7g).

Farmers were interested to cultivate vegetable crops with BARI released higher yielding varieties in the next year.

Table 7f. Crop managements of vegetables production near by the homestead as cropping pattern during the year of 2019-20 at FSRD site, Sholakundu, Faridpur.

Observation	Before Intervention (kg)			After Intervention (kg)		
Season	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Bitter gourd	Bitter gourd continued	Tomato	Bitter gourd	Bitter gourd continued
Variety	Hybrid	Hybrid	Hybrid	BARI Tomato-19	BARI Korola-2	BARI Korola-2
Date of sowing/ Transplanting	28 Nov 19	13 May 20	--	3 Dec 19	19 May 20	--
Seed rate ((kg ha ⁻¹))	0.25	8	--	0.25	8	--
Spacing	50 cm x 50 cm	2 m x 1.25 m	--	60 cm x 40 cm	2 m x 1.25 m	--
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	115-55-75-25-3-2	115-50-50-45-3.5-2	--	104-45-64-24-2.7-1.3	100-40-30-15-1-1	--
Date of harvesting (range)	3 Mar-10 Apr 20	14 Jul-17 Sep 20		9 Mar -15 Apr 20	23 Jul-8 Aug.20	
Field duration(days)	127	128		135	143	
Turned around time (days)	32	--		33		

Table 7g. Yield and economics of vegetables production near by the homestead before and after Intervention during the year of 2019-20 at FSRD site, Sholakundu, Faridpur.

Vegetables	Before Intervention (kg)			After Intervention (kg)		
	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Bitter gourd	Bitter gourd continued	Tomato	Bitter gourd	Bitter gourd continued
Variety	Hybrid	Hybrid	--	Tomato (BARI Tomato-19)	Bitter gourd (BARI Korola-2)	Bitter gourd continued
Total production (t ha ⁻¹)	62.83	12.28		57.87	17.84	
Gross return (Tk. ha ⁻¹)	628300	552600		636680	802800	
Total variable cost (Tk. ha ⁻¹)	324395	187428		322995	189434	
Net return (Tk. ha ⁻¹)	303905	365172		313685	613366	
Whole pattern net return (Tk. ha ⁻¹)	669077			927051		

Output price (Tk. kg⁻¹): Tomato: 10, Bitter gourd: 45

FSRD Site, Atia, Tangail

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Palima model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, seven niches were utilized in Palima model. After intervention of the proven and improved technologies in the homestead, vegetables production has increased significantly. It was observed that the average vegetables production was 564 kg homestead⁻¹) in *Rabi* season followed by *Kharif-2* (546 kg homestead⁻¹) and *Kharif-1* (437 kg homestead⁻¹) season (Table 8a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-2* season. *Kharif-1* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal drought. After intervention of the improved technologies, vegetables production was increased 821% compared to before intervention of the program (Table 8b). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and judicious time management.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 8b). The average vegetables intake per year per farm family was 250 kg after program intervention and the increment was 456%, whereas intake was only 45 kg per farm family per year before program intervention. Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 137 g head⁻¹day⁻¹. After program intervention, the distribution of vegetables per year was recorded 32 kg and sell of vegetables per year was 233kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jack fruit, Coconut, Wood apple, Pummelo etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies in the homestead, fruits production has increased significantly. Higher quantity of average fruits production was found in *Kharif-1* (112 kg homestead⁻¹) season followed by *Kharif-2* (87 kg homestead⁻¹) and *Rabi* (82 kg homestead⁻¹) season, which was more or less the reverse scenario of vegetables production (Table 8a). Maximum fruits were produced during *Kharif-1* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits production was increased 47% compared to before intervention of the program (Table 8b). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 59 kg after program intervention, whereas it was only 40 kg before intervention and the 48% increment was mainly due to increment of total production (Table 8a). Average intake of fruits per year per farm family was 59 kg after project intervention whereas it was 40 kg before intervention. After program intervention, the distribution of fruits per year was recorded 11kg and sell of fruits per year was 32 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested in sell for getting some cash money.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 5281 with the average gross return of Tk. 3594 which was only Tk. 536 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 1873 with the average gross margin of Tk. 1438 which was only Tk. 917 before intervention (Table 8c).

Table 8a. Round the year vegetables and fruits production from different niches of homestead during the years of February 2018 to January 2021 at FSRD site, Atia, Tangail.

Space		Rabi				Kharif-1				Kharif-2				Total (kg)			
		October- March				April-June				July-September							
		Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.18-Jan019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Av.
Open sunny space	Bed-1	38	43	13	31	11	14	11	12	23	33	15	24	72	90	39	67
	Bed-2	38	19	6	21	19	29	18	22	27	18	14	20	84	66	38	63
	Bed-3	32	27	7	22	13	31	10	18	19	31	17	22	64	89	34	62
	Bed-4	30	29	0	20	15	25	9	16	24	27	21	24	69	81	30	60
Roof top		0	14	19	11	17	13	6	12	15	18	13	15	32	45	38	38
Trellis		23	48	24	32	28	58	15	34	25	47	15	29	76	153	54	94
Shady Place		11	14	0	8	10	13	6	10	16	18	13	16	37	45	19	34
Marshy Land		15	7	15	12	17	9	3	10	9	11	0	7	41	27	18	29
Unproductive Tree		12	10	11	11	0	0	4	1	15	12	0	9	27	22	15	21
Fence		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Backyard		16	19	24	20	13	14	6	11	17	19	14	17	46	52	44	47
House Boundary		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total (veg.)		215	230	119	188	143	206	88	146	190	234	122	182	548	670	329	516
Fruits		22	36	24	27	20	36	56	37	35	29	23	29	77	101	103	94
Total (veg. + fruit)		237	266	143	215	163	242	144	183	225	263	145	211	625	771	432	609

Table 8b. Round the year vegetables and fruits production from different niches of homestead during February 2018 to January 2021 (Comparative data) at FSRD site, Atia, Tangail

Niches	Before intervention		After intervention									
			Feb.2018-Jan.2019		Feb.2019-Jan.2020		Feb.2020-Jan.2021		Av.Feb. 2018 to Jan. 2021		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)
Open sunny place	24	298	289	2312	326	2608	141	1692	249	2204	225	640
Roof top	21	204	32	320	45	540	38	456	38	439	17	115
Trellis	11	244	76	760	153	1224	54	810	94	931	83	202
Fence	-	-	-	-	-	-	-	-	-	-	-	-
Tree support	0	0	27	270	22	264	15	225	21	256	21	100
Marshy place	0	0	41	328	27	324	18	144	29	265	29	100
Backyard	0	0	46	360	52	624	44	352	47	445	47	100
Partial shady place	0	0	37	740	45	540	19	950	34	743	34	100
Total	56	746	548	5090	670	6124	329	4629	516	5281	460	608
Fruit (other places)	64	1280	77	1540	101	2020	103	2060	94	1873	30	46
Total (veg.+ fruit)	120	2026	625	6014	771	7639	432	6174	609	6609	489	226

Table 8c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of February 2018 to January 2021 at FSRD site, Atia, Tangail

Description	Before Intervention		After Intervention							
			Vegetables (kg)				Fruits (kg)			
	Vegetables (kg)	Fruit (kg)	Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan 2021	Av. Feb. 2018- Dec 2020	Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan 2021	Av. Feb. 2018- Jan 2021
Consumption	45	40	220	360	170	250	47	70	60	59
Distribution	02	5	20	46	31	32	9	7	11	9
Selling	09	19	308	264	128	233	21	24	32	26
Total production	56	64	548	670	329	516	77	101	103	94
Gross return (Tk.)	746	1280	5090	6124	4629	5281	1540	2020	2060	1873
Variable cost (Tk.)	210	363	1390	1980	1690	1687	410	440	456	435
Gross margin (Tk.)	536	917	3700	4144	2939	3594	1130	1580	1604	1438

FSRD Site, Tarakandi, Sherpur

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Narekeli Model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, seven niches were utilized in Narikeli Model. After intervention of the proven and alternate technologies in the homestead, vegetables production has increased significantly. It was observed that the average vegetables production was 242 kg homestead⁻¹) in *Rabi* season followed by *Kharif-1* (105 kg homestead⁻¹) and *Kharif-2* (45 kg homestead⁻¹) season (Table 9a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-1* season. *Kharif-2* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal rainfall. After intervention of the alternate technologies, vegetables production was increased 872% compared to before intervention of the program (Table 9b). The remarkable increment of vegetables production in homestead area might be enhanced by using alternate technologies and judicious time management.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 9c). The average vegetables intake per year per farm family was 123 kg after program intervention and the increment was 583%, whereas intake was only 18 kg per farm family per year before program intervention. Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 67 g head⁻¹day⁻¹. After program intervention, the distribution of vegetables per year was recorded 35 kg and sell of vegetables per year was 183kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana, Coconut, Alubukhara Multa etc.) along with other existing fruit trees (Mango, Jack fruit, Pummelo, etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and alternate technologies in the homestead, fruits production has increased significantly. Higher quantity of average fruits production was found in *Kharif-2* (107 kg homestead⁻¹) season followed by *Kharif-1* (93 kg homestead⁻¹) and *Rabi* (35 kg homestead⁻¹) season, which was more or less the reverse scenario of vegetables production (Table 9a). Maximum fruits were produced during *Kharif-2* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits production was increased 1583% compared to before intervention of the program (Table 9b). Using of alternate technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 65 kg after program intervention, whereas it was only 6 kg before intervention and the 983% increment was mainly due to increase total production (Table 9c). After program intervention, the distribution of fruits per year was recorded 13kg and sell of fruits per year was 91 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 5981 with the average gross margin of Tk. 5042 which was only Tk. 615 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 2525 with the average gross margin of Tk. 2283 which was only Tk. 114 before intervention (Table 9c).

Table 9a. Round the year vegetables and fruits production from different niches of homestead during February 2018 to January 2021 at FSRD site, Tarakandi, Sherpur.

Space		Rabi			Kharif-1			Kharif-2			Total (kg)		
		October- March			April-June			July-September			Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021
		Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021	Feb.2018-Jan.2019	Feb.2019-Jan.2020	Feb.2020-Jan.2021			
Open sunny space	Bed-1	5.8	40.98	14.17	0	12.1	11.39	0	4.46	8.87	5.8	57.54	34.43
	Bed-2	43.0	78.13	36.43	0	21.38	20.21	0	7.67	11.85	43.0	107.18	68.49
	Bed-3	9.47	10.47	1.46	0	18.49	13.34	0	4.26	9.03	9.47	33.22	23.83
	Bed-4	6.10	11.11	9.54	0	3.32	3.28	0	4.59	3.80	6.10	19.02	16.62
	Bed-5	25.50	13.57	11.30	0	10.9	12.08	0	8.33	14.39	25.50	32.8	37.77
Roof		81.00	85	28	0	0	50	0	0	0	81.00	85.00	78
Trellis		30.00	31	40	0	0	15	0	0	0	30.00	31.00	55
Fence		8.00	7	9	0	0	0	0	0	0	8.00	7.00	9
Unused tree		0	3.5	0	0	0	0	0	0	12	0	3.5	12
Marshy land		0	0	0	0	0	8	0	0	0	0	0	8
Backyard		0	4.5	12	0	0	0	0	0	0	0	4.5	12
Shady place		10.00	13	16	0	0	0	0	0	0	10.00	13	16
House boundary		5.00	15	15	0	0	10	0	0	0	5.00	15.00	25
Total (vegetable)		218.87	313.26	192.9	0	66.19	143.3	0	29.31	59.94	218.87	408.8	396.14
Fruits		25.00	25	55	0	46	140	0	34	180	25.00	105	375
Total (veg. +fruit)		348.87	338.26	247.9	0	112.19	283.3	0	63.31	239.94	348.87	513.76	771.14

Table 9b. Round the year vegetables and fruits production from different niches of homestead during the years of February 2018 to January 2021 (Comparative data) at FSRD site, Tarakandi, Sherpur.

Niches	Before intervention		After intervention									
			Feb.2018-Jan.2019		Feb.2019-Jan.2020		Feb.2020-Jan.2021		Av.Feb. 2018 to Jan. 2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (%)
Open sunny place	22	215.00	89.87	879.70	249.76	4960.25	181.14	4528.50	173.59	456.15	151.59	-
Roof	15	150.00	81.00	810.00	85.00	1020.00	78.00	1170.00	81.33	1000.00	66.33	-
Trellis	25	250.00	30.00	300.00	31.00	310.00	55.00	550.00	38.67	386.67	13.67	-
Fence	0	0	8.00	240.00	7.00	210.00	9.00	270.00	8.00	240.00	8.00	-
Unused tree	0	0	0	0	3.50	105.00	12.00	360.00	5.17	155.00	5.17	-
Marshy land	0	0	0	0	0	0	8.00	160.00	2.67	53.33	2.67	-
Backyard	0	0	0	0	4.50	90.00	12.00	240.00	5.50	110.00	5.50	-
Shady place	0	0	10.00	200.00	13.00	260.00	16.00	480.00	13.00	313.33	13.00	-
House boundary	0	0	0	0	15.00	300.00	25.00	500.00	13.33	266.67	13.33	-
Total (vegetable)	62	615.00	218.87	2429.70	408.76	7255.25	396.14	8258.50	341.26	5981.15	279.26	872
Fruits	10	150.00	25.00	375.00	105.00	1575.00	375.00	5625.00	168.33	525.00	158.33	1583
Total (vegetables +fruit)	72	765.00	243.87	2804.70	513.76	8830.25	771.14	13883.50	509.59	5506.15	437.59	1012

Table 9c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of February 2018 to January 2021 at FSRD site, Tarakandi, Sherpur.

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan 2021	Av. Feb. 2018 to Jan. 2021	Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020-Jan 2021	Av. Feb. 2018 to Jan. 2021
Consumption	18	6	76.00	126.00	166.14	122.71	5	39	150	64.67
Distribution	6	0	21.00	55.00	30.00	35.33	4	10	25	13
Selling	38	4	121.87	227.76	200.00	183.21	16	56	200	90.67
Total production	62	10	218.87	408.76	396.14	341.26	25	105	375	168.33
Gross return (Tk.)	615	150	2429.70	7255.25	8258.50	5981.15	375.00	1575.00	5625.00	2525.00
Variable cost (Tk.)	55.00	36.00	5011.00	1103.00	1204.00	939.33	86.00	156.00	485.00	242.33
Gross margin (Tk.)	560.00	114.00	1918.70	6152.25	7054.50	5041.82	289.00	1419.00	5140.00	2282.67

Activity-2: Family labor utilization pattern in homestead production system at different FSRD sites during the years of 2018 to 2021.

Homestead gardening is a sector where all family member can work in a group. Homestead production system gave an opportunity for women employment and empowerment. From the Table 10, it was revealed that women had a good involvement in seed/seedling preparation and planting, intercultural operation, harvesting and marketing of vegetable and fruits. It is revealed that women are coming forward and participating more in income generation system. Hard working i.e., land preparation mostly was done by the men workers. Children were also help the men and women adult workers in the production systems especially in non-hard-working areas. So, it was found that homestead gardening has created a good opportunity to utilize unused labor of women and children properly, which can help to produce more crop and to earn more money by a resource poor farm family.

Table 10. Family labor utilization pattern for homestead vegetables and fruits production at different FSRD sites

Working area	Men (%)					Women (%)					Children (%)				
	Pab	Ran	Far	Tan	Sher	Pab	Ran	Far	Tan	Sher	Pab	Ran	Far	Tan	Sher
Land preparation	40	70	50	63	65	50	25	30	33	25	10	5	20	4	10
Seed/seedling production	25	55	40	66	30	60	40	50	34	50	15	5	10	0	20
Sowing/planting	40	35	40	54	25	55	65	40	39	55	5	0	20	7	20
Intercultural operation	10	25	30	42	45	60	65	50	54	45	30	10	20	4	10
Harvesting	10	25	20	56	20	70	60	50	42	55	20	15	30	2	25
Marketing	30	45	20	76	75	65	55	80	21	20	5	0	00	3	5
Cooking	0	0	00	0	0	100	90	100	99	85	0	10	00	1	15

Pab. = Pabna, Ran.= Rangpur, Far.= Faridpur, Tan. = Tangail, Sher. = Sherpur

Plantation and management of fruit tree:

Activity-3: Establishment of homestead and nearby homestead fruit garden during the years of 2018 to 2020.

FSRD site, Ajoddhapur, Rangpur

Sapling/seedling distribution: To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead and for mother garden e.g., Mango, Litchi, Dragon fruit, etc. The supplied total number of saplings of different fruits plants are shown in Table 11.

Table 11. Distributed of fruit saplings at FSRD site during the years of February 2018 to January 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020 – Jan 2021	Total	
1	Mango	BARI Aam-,3, 4	12	30	10	52	10-25
2	Litchi	BARI Litchi-3	12	5	2	19	15-20
3	Guava	BARI Peyara-2	12	-	2	14	0
4	Multa	BARI Multa-1	12	-	-	12	8
5	Lime	BARI Lebu-1	12	-	-	12	0
6	Papaya	Local	36	-	108	144	8-90
7	Dragon fruit	BARI Dragon Fol-1	4	60	36	100	0
8	Moringa	Year round	24	-	-	24	4
9	Sugarcane	BSRI Akh-42	12	-	-	12	33
10	Palm	Local	100	-	-	100	40

FSRD Site, Ganggarampur, Pabna

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings of BARI developed varieties and locally popular varieties were supplied to homestead e.g., Mango, Litchi Guava, Lemon, Papaya, Sugarcane and Bay leaf. Total number of supplied saplings of different fruit plants was 818. The saplings are in good condition and survival rate ranges from 5-10% (Table 12). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 12. Distributed of fruit saplings at FSRD site, Ganggarampur, Pabna during the years of February 2018 to January 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020 – Jan 2021	Total	
01.	Mango	BARI Aam-4	12	12	0	24	0
		Langra	0	13	16	29	2
		Gopalvogue	0	24	20	44	2
		Khirsha	0	12	20	32	2
02.	Litchi	BARI Litchi-3	12	10	7	29	0
03.	Guava	BARI Peyara-2	20	30	24	74	
04.	Sweet orange	BARI Multa-1	12	0	0	12	0
05.	Lemon	Kagij	12	0	0	12	0
06.	Papaya	Local improved	160	170	150	480	5
07.	Black paper	BSRI Golmorich-1	12	24	10	46	0
08.	Bay leaf	BARI Tejpatha-1	12	10	14	36	10
Total			252	305	261	818	21

FSRD Site, Sholakundu, Faridpur

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Dragon, Multa, Guava, Mango, Papaya, Chuijhal and Sugarcane. Total number of supplied saplings of different fruit plant were 867. The saplings are in good condition and survival rate ranges from 25-100% (Table 13). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 13. Distributed of fruit saplings/spices/Sugarcane at FSRD site during the years of February 2018 to January 2021.

Sl.no.	Types of fruits sapling	Variety	Number				Mortality (%)
			Feb 2018-Jan 2019	Feb 2019-Jan 2020	Feb 2020 – Jan 2021	Total	
1	Dragon fruit	BARI Dragon fruit-1	--	60	--	60	0
2	Multa	BARI Multa-1	--	20	--	20	0
3	Guava	BARI Peara-2	10	20	15	45	0
4	Mango	BARI Aam-4	06	--	15	21	0
		BARI Aam-11	--	--	01	01	
5	Lemon	BARI Lebu-4	--	--	15	15	0
6	Papaya	Red lady	20	20	300	340	10
7	Ber	Kashmiri kul	--	--	15	15	10-12
8	Cuijahl (Piper chaba)	Local	--	50	--	50	75-80
9	Sugarcane	BSRI 41 and 42	50	150	100	300	65-70
	Total		86	320	461	867	--

FSRD Site, Atia, Tangail

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Mango, Litchi, Guava, Sweet orange, Lemon, Papaya, Dragon fruit, Moringa, Sugarcane, Plum, Burmese grape, Aonla, Hogplum, Pomegranate, Coconut and Bay leaf. Total number of supplied saplings of different fruit plant were 632. The saplings are in good condition and survival rate ranges from 75-100% (Table 14). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 14. Distributed of fruit saplings at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			Feb. 2018-Jan. 2019	Feb. 2019-Jan. 2020	Feb. 2020 – Jan. 2021	Total	
01.	Mango	BARI Aam-4	12	0	06	18	16
		BARI Aam-11	0	12	04	16	0
		BARI Aam-3	0	24	10	34	0
02.	Litchi	BARI Litchi-3	12	24	06	42	17
03.	Guava	BARI Peyara-2	12	12	10	34	10
04.	Sweet orange	BARI Multa-1	12	18	12	42	5
05.	Lemon	BARI Lebu-1	12	10	12	34	0
06.	Papaya	Red Lady	36	120	50	206	20
07.	Dragon fruit	BARI Dragon Fol-1	4	10	12	26	0
08.	Moringa	Year Round	24	10	0	34	0
09.	Sugarcane	BSRI Akh-42	12	0	0	12	0
10.	Plum	BARI Alubokhara-1	10	12	05	27	25
11.	Burmese grape	BARI Lotkon-1	0	12	12	24	0
12.	Aonla	BARI Amloki-1	0	12	05	17	9
13.	Hog Plum	BARI Amra-1	0	12	10	22	17
14.	Pomegranate	BARI Dhalim-2	0	10	0	10	10
15.	Coconut	Vietnami Coconut	0	12	0	12	10
16.	Bay leaf	BARI Tejapata-1	0	12	10	22	25
Total			146	322	164	632	-

FSRD Site, Tarakandi, Sherpur

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Mango, Guava, Papaya, Litchi, Lime, Multa, Banana, Alubokhara, Coconut, Sugarcane

etc. Spices seedlings also given for increase of spices production at homestead level. The supplied total number of saplings of different fruits and spices plants are shown in Table 15.

Table 15. Distributed of fruit saplings at FSRD site, Tarakandi, Sherpur during the years of February 2018 to January 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			Feb. 2018-Jan. 2019	Feb. 2019-Jan. 2020	Feb. 2020-Jan. 2021	Total	
1	Mango	BARI Aam-3, 4	24	100	112	236	0
2	Litchi	BARI Litchi-3	12	50	50	112	5
3	Guava	BARI Peyara-2	0	0	24	24	0
4	Multa	BARI Multa-1	12	100	112	224	0
5	Lime	BARI Lebu-4	0	250	250	500	5
6	Papaya	Local	24	-	0	24	10
7	Alubokhara	BARI Alubokhara-1	0	0	24	24	0
8	Coconut	Dwarf variety	0	8	8	16	0
9	Sugarcane	BSRI Akh-42	12	-	-	12	50
10	Banana	BARI Kola-1	0	12	12	24	0

Activity-4: Pest management activities for increasing fruits production in homestead area during the years of 2018 to 2021.

Pest management of fruit tree: Availability of fruit trees in the homestead area is the best source of human nutrition. Although in most cases, it was found that pest is the major hindrance for sufficient edible fruits production, which sometimes discourages the farmers to plantation of fruit trees in homestead area. But very simple technology, two times spray of both insecticide and fungicide, once at just before flower blooming and once at pea size fruit stage, can help for successful fruits production in homestead area. From these views, pesticide spraying activities in safe way were conducted at each FSRD site (Table 16). A total of 611 fruit trees were sprayed with insecticide and pesticide, where maximum fruit trees were Mango (246).

Table 16. Number of fruit trees sprayed for hopper and other pest control at different FSRD sites during the year of 2019-20.

FSRD site	Mango	Guava	Jackfruit	Litchi	Multa	Coconut	Others*
Ganggarampur, Pabna	51	15	20	15	12	7	11
Ajoddhapur, Rangpur	62	9	9	12	12	4	19
Atia, Tangail	40	12	10	12	12	8	14
Tarakandi, Sherpur	45	10	25	11	12	13	15
Sholakundu, Faridpur	48	12	7	12	12	6	17
<i>Total</i>	<i>246</i>	<i>58</i>	<i>71</i>	<i>62</i>	<i>60</i>	<i>38</i>	<i>76</i>

c) Apparent nutrient intake and supplementation: Vegetables and fruits produced in homestead areas are the important sources of human nutrition. Apparent nutrient intake especially protein, iron, carotene, vitamin B and vitamin C by a 5 member's family from year-round vegetables and fruits consumption was estimated (Table 17a). The apparent nutrient supplementation was also calculated on the basis of per head requirement and considering apparent nutrient intake from vegetables and fruits sources (Table 17b). Nutrient intake was varied with different locations. Intake of nutrient was positively correlated with vegetable and fruits consumption and also with production. Among the nutrient's protein intake was increased more than other nutrients but it still needs to supplement from animal source. Iron supplementation was more in Ganggarampur, Pabna (68.96%), which is very crucial nutrient for women. Other nutrients intake and supplementation also increased remarkably especially carotene and vitamin C, which was more or less sufficiently supplemented from homestead vegetables and fruits source after program intervention, and it might be due to more production and relatively more intake through motivational activities.

Table 17a. Apparent nutrient Consumption in a year by a family from homestead vegetables and fruits (before and after intervention) during the year of 2019-20.

FSRD site	Intervention	Protein (g)	Iron (mg)	Carotene (µg)	Vit-B (mg)	Vit-C (mg)
Ganggarampur, Pabna	Before	9108	18687	15227000	611	160516
	After	18036	35240	30152478	1209	317855
Ajoddhapur, Rangpur	Before	6583	13506	11005654	442	116016
	After	13888	27135	23217408	931	244748
Sholakundu, Faridpur	Before	3174	6513	5306836	213	55942
	After	14212	27769	23760153	953	250470
Atia, Tangail	Before	1533	3145	2562960	103	27018
	After	13346	26078	22312834	895	235213
Tarakandi, Sherpur	Before	649	1332	1085489	44	11443
	After	5555	10854	9286963	372	97899

Table 17b. Apparent nutrient supplementation from a homestead produced vegetables and fruits on the basis of per head per day requirement (Av. of five member's family: male 3 and female 2) during the year of 2019-20

FSRD site	Category	Year	Protein (%)	Iron (%)	Vit-A (%)	Vit-B (%)	Vit-C (%)
Ganggarampur, Pabna	Male	Before	9.07	36.56	139.06	27.90	219.88
		After	17.97	68.96	274.86	55.21	435.42
	Female	Before	9.99	36.56	139.06	33.46	219.88
		After	19.77	68.96	274.86	66.25	435.42
Ajoddhapur, Rangpur	Male	Before	6.55	26.42	100.51	20.16	158.92
		After	13.83	53.10	211.64	42.51	335.27
	Female	Before	7.22	26.42	100.51	24.19	158.92
		After	15.22	53.10	211.64	51.01	335.27
Sholakundu, Faridpur	Male	Before	3.16	12.74	48.46	9.72	76.63
		After	14.16	54.34	216.59	43.50	343.11
	Female	Before	3.48	12.74	48.46	11.66	76.63
		After	15.58	54.34	216.59	52.20	343.11
Atia, Tangail	Male	Before	1.53	6.15	23.41	4.70	37.01
		After	13.30	51.03	203.40	40.85	322.21
	Female	Before	1.68	6.15	23.41	5.63	37.01
		After	14.63	51.03	203.40	49.02	322.21
Tarakandi, Sherpur	Male	Before	0.65	2.61	9.91	1.99	15.67
		After	5.53	21.24	84.66	17.00	134.11
	Female	Before	0.71	2.61	9.91	2.39	15.67
		After	6.09	21.24	84.66	20.40	134.11

Note: Standard nutritional demand: Protein (g)- 55(Male), 50 (Fem)., Iron(mg)- 28 (MaleandFem.), Vit A (µg)- 600 (Male andFem)., Vit B (mg)- 1.2 (Male), 1.0(Fem) and Vit C (mg)- 40 (Male and Fem.), Source: AIS, 2017 (Krishi Diary, 2017)

B. CROPS AND CROPPING SYSTEM

I. Improvement of cropping pattern (CP)

FSRD site, Ajoddhapur, Rangpur

Activity 5. Improvement of existing T. Aman-Fallow-Boro cropping pattern at FSRD site, Ajoddhapur, Rangpur during the years of 2018 to 2020.

Existing cropping pattern: T. Aman (Swarna)-Fallow-Boro (BRRI dhan28)

Improved cropping pattern: T. Aman (Binadhan-17)-Mustard (BARI Sarisha-14)-Boro (BRRI dhan28)

The total field duration and turnaround time were 288-305 and 60-77 and 232-241 and 124-133 in improved and existing cropping pattern, respectively. Cost, return and yield performance of the tested pattern (T. Aman rice -Mustard-Boro rice) against existing pattern (T. Aman rice-Fallow- Boro rice)

during Feb. 2018 to December 2020 is presented in Table 18a, 18b, 18c and 18d. In the first year (2018-19), the T Aman rice could be grown only during the project period. In 2019-20, the rice equivalent yield (REY) was 18.53 and 10.81 t ha⁻¹ with the whole pattern gross margin Tk. 98588 and 31540 ha⁻¹ in improved and existing cropping pattern, respectively. In 2020, the rice equivalent yield (REY) was 11.30 and 6.12 t ha⁻¹ with the whole pattern gross margin Tk. 158740 and 59760 ha⁻¹ in improved and existing cropping pattern, respectively. The MBCR in improved cropping pattern was attained 3.14 and 4.23 in 2019-20 and 2020, respectively over existing cropping pattern. The higher REY was obtained from improved cropping pattern due to use of modern variety, inclusion of extra crop Mustard and improve crop management technologies.

Table 18a. Crop managements of improved and existing cropping pattern at FSRD site, Ajoddhapur.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Variety	Binadhan-17	BARI Sarisha-14	BRRI dhan28	Swarna	—	BRRI dhan28
Date of sowing/ Transplanting	05-18 Aug.	29 Nov.-07 Dec.	25 Feb.-07 Mar.	20-25 Jul.	—	25-28 Feb.
Seed rate (kg ha ⁻¹)	30	1	30	35	-	35
Spacing	20 x 15 cm ²	Broadcast	20 x 15 cm ²	20 x 20 cm ²	—	20 x 20 cm ²
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	100-12-30-10-1.5	129-34-45-29-2-2	123-18-71-18-2	92-30-25-11	—	101-26-30-11-CD 3 t
Date of harvesting (range)	11-19 Nov.	22-27 Feb.	28 Jun.-11 Jul.	27-30 Nov.	—	20-24 Jun.
Field duration (days)	89-96	80-85	118-124	113-116	-	119-125
Turned around time (days)	18-24	7-10	26-34	70-85	-	28-31

Table 18b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of 2018-2019.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain Yield (t ha ⁻¹)	4.41	-	-	3.31	-	-
Straw yield (t ha ⁻¹)	4.81	-	-	3.7	-	-
Rice equivalent yield (t ha ⁻¹)	4.73	-	-	3.56	-	-
Whole pattern REY (t ha ⁻¹)	-			-		
Gross return (Tk. ha ⁻¹)	70960	-	-	53350	-	-
Total variable cost (Tk. ha ⁻¹)	46500	-	-	45100	-	-
Gross margin (Tk. ha ⁻¹)	24460	-	-	8250	-	-
Whole pattern GR (Tk. ha ⁻¹)	24460			8250		
MBCR	-			-		

Unit price (Tk. kg⁻¹): Aman rice=12.75, Boro rice=15, Rice straw =1, Mustard=41, Mustard stover=1.

Table 18c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of 2019-2020.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain Yield (t ha ⁻¹)	4.61	1.89	5.63	3.31	-	4.67
Straw yield (t ha ⁻¹)	4.8	2.67	5.78	3.7	-	5.15
Rice equivalent yield (t ha ⁻¹)	5.13	6.32	7.08	4.18	-	6.63
Whole pattern REY (t ha ⁻¹)	18.53			10.81		
Gross return (Tk. ha ⁻¹)	65375	80633	90230	53350	-	84540
Total variable cost (Tk. ha ⁻¹)	45800	29350	62500	45100	-	61250
Gross margin (Tk. ha ⁻¹)	19575	51283	27730	8250	-	23290
Whole pattern GR (Tk. ha ⁻¹)	98588			31540		
MBCR	3.14					

Unit price (Tk. kg⁻¹): Aman rice=12.75, Boro rice=15, Rice straw =1, Mustard=41.25, Mustard stover=1.

Table 18d. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of February to January 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain yield (t ha ⁻¹)	2.53	1.52	5.48	2.1	-	4.67
Straw yield (t ha ⁻¹)	3.09	2.1	4.4	1.87	-	5.15
Rice equivalent yield (t ha ⁻¹)	3.27	2.59	5.44	1.71	-	4.41
Whole pattern REY (t ha ⁻¹)	11.30			6.12		
Gross return (Tk. ha ⁻¹)	81790	64800	136000	42720	-	110290
Total variable cost (Tk. ha ⁻¹)	32000	29350	62500	32000	-	61250
Gross margin (Tk. ha ⁻¹)	49790	35450	73500	10720	-	49040
Whole pattern gross margin (Tk. ha ⁻¹)	158740			59760		
MBCR	4.23					

Unit price (Tk. kg⁻¹): Aman rice=25, Boro rice=20, Rice straw =6, Mustard=41.25, Mustard stover=1.

Activity 6. Development of alternative cropping pattern T. Aus-T. Aman-Potato/Sweet gourd at FSRD site, Ajoddhapur, Rangpur during the years of 2018 to 2020

Existing cropping pattern: T. Aman (Swarna)-Potato (BARI Alu-8)-Boro (BRRI dhan28)

Improved cropping pattern: T. Aus (BRRI dhan48)-T. Aman (Binadhan-17)-Potato (BARI Alu-8)/Sweet gourd (BARI Hybrid Mistikumra-1)

Crop management practices of different crops under cropping pattern-2 are given in Table 19a. The total field duration and turnaround time were 318-330 and 35-47 and 299-309 and 56-66 in improved and existing pattern, respectively. Crop yield and economical performances of the tested pattern (T. Aus-T. Aman-Potato/Sweet gourd) against existing pattern (T. Aman-Potato-Boro) during Feb. 2018 to December 2020 is presented in Table 19a, 19b, 19c and 19d. In the first year (2018-19), the T. Aus and T. Aman rice could be grown only. In 2019-20, the rice equivalent yield (REY) was 51.39 and 24.98 t ha⁻¹ with the whole pattern gross margin Tk. 423064 ha⁻¹ and Tk. 98770 ha⁻¹ in improved and existing cropping pattern, respectively. In 2020, the REY was 24.96 and 14.00 t ha⁻¹ with the whole pattern gross margin Tk. 391730 and 130180 ha⁻¹ in improved and existing cropping pattern, respectively. The MBCR in improved pattern was attained 12.08 over existing pattern. Use of modern variety, inclusion of extra crop T. Aus and replacing Boro with Sweet gourd including improve crop management technologies were triggered the higher REY in improved cropping pattern.

Table 19a. Crop managements of improved and existing cropping pattern at FSRD site, Ajoddhapur Rangpur.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Variety	BRRI dhan48	Binadhan-17	BARI Alu-25	BARI Hybrid Mistikumra-1	Swarna	BARI Alu-13	BRRI dhan28
Date of sowing/ Transplanting	10-17 May	12-17 Aug.	25-30 Nov.	7-12 Dec.	5-10 Aug.	2-5 Dec.	22-27 Feb.
Seed rate ((kg ha ⁻¹))	30	30	2000	5	35	2000	30
Spacing	20 x 15 cm ²	20 x 15 cm ²	60 x 20 cm ²	1.8 x 1.8 cm ²	20 x 20 cm ²	45 x 15 cm ²	20 x 20 cm ²
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	97-20-40-13-3.5	100-12-30-10-1.5	135-25-140-17-3-1.5	0	92-30-25-11	140-30-150-20-3-2	101-26-30-11-CD 3 t
Date of harvesting (range)	5-10 Aug.	20-23 Nov.	05-09 Feb.	07-14 April	23-30 Nov.	14-17 Feb.	20-28 Jun
Field duration (days)	89-91	97-99	72-75	Potato+60-65	109-111	74-77	116-121
Turned around time (days)	7-8	5-7	-	30-33	7-9	8-10	40-46

Table 19b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of 2018-2019.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain yield (t ha ⁻¹)	5.16	4.16	-	-	3.74	-	-
Straw yield (t ha ⁻¹)	5.71	4.61	-	-	4.21	-	-
Rice equivalent yield (t ha ⁻¹)	-	-	-	-	-	-	-
Whole pattern REY (t ha ⁻¹)	-				-		
Gross return (Tk. ha ⁻¹)	83110	67010	-	-	56100	-	-
Total variable cost (Tk. ha ⁻¹)	40500	46250	-	-	42500	-	-
Gross margin (Tk. ha ⁻¹)	42610	20760	-	-	13600	-	-
Whole pattern gross margin (Tk. ha ⁻¹)	63370				13600		
MBCR	-				-		

Unit price (Tk. kg⁻¹): Rice=12.75, Rice straw =1,

Table 19c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of 2019-2020.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain yield (t ha ⁻¹)	4.89	4.58	28.75	35.82	3.74	25.29	5.02
Straw yield (t ha ⁻¹)	5.11	4.67	0	0	4.21	0	5.62
Rice equivalent yield (t ha ⁻¹)	6.15	5.09	18.04	22.11	4.40	13.88	6.69
Whole pattern REY (t ha ⁻¹)	51.39				24.98		
Gross return (Tk. ha ⁻¹)	78460	64851	230000	281903	56100	177030	85340
Total variable cost (Tk. ha ⁻¹)	40550	44600	125000	22000	42500	115950	61250
Gross margin (Tk. ha ⁻¹)	37910	20251	105000	259903	13600	61080	24090
Whole pattern gross margin (Tk. ha ⁻¹)	423064				98770		
MBCR	7.04						

Unit price (Tk. kg⁻¹): Aman rice=12.75, Boro rice=15, Rice straw =1, Potato=10.

Table 19d. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of February to January 2021.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain Yield (t ha ⁻¹)	4.95	2.68	28.63	36.18	2.43	25.29	5.02
Straw yield (t ha ⁻¹)	5.23	2.76	0	0	2.89	0	5.62
Rice equivalent yield (t ha ⁻¹)	5.22	3.34	9.16	7.24	2.15	7.08	4.76
Whole pattern Rice equivalent yield (t ha ⁻¹)	24.96				14		
Gross return (Tk. ha ⁻¹)	130380	83560	229040	180900	53790	177030	119060
Total variable cost (Tk. ha ⁻¹)	40550	44600	125000	22000	42500	115950	61250
Gross margin (Tk. ha ⁻¹)	89830	38960	104040	158900	11290	61080	57810
Whole pattern gross margin (Tk. ha ⁻¹)	391730				130180		
MBCR	12.08						

Unit price (Tk. kg⁻¹): T. Aus=20, Aman rice=25, Boro rice=20, Rice straw =6, Potato=8.**FSRD Site, Ganggarampur, Pabna****Activity-7: Improvement of existing T. Aman-Fallow-Boro rice cropping pattern at FSRD site, Ganggarampur, Pabna during the year of 2019-20.****Existing cropping pattern:** T. Aman rice (BRRI dhan39)-Mustard (Tori-7)-Boro (Local Toba)**Improved cropping pattern:** T. Aman rice (Binadhan-7)-Mustard (BARI Sarisha-17)- Boro (BRRI dhan28)

Different crop management practices are presented in Table 20a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 20b and 20c. In the improved pattern though Tori-7 required at least 7 days less than BARI Sarisha-17 but BARI Sarisha-17 gave higher seed yield (2.25 and 2.0 t ha⁻¹) over Tori-7 (1.05 and 1.02 t ha⁻¹) at the FSRD site, Ganggarampur, Pabna during both the year. The T. Aman variety BRRI dhan39 gave lower yield (4.5 and 4.4 t ha⁻¹) than the Binadhan-17 (5.5 and 5.25 t ha⁻¹). Yield of Boro rice in improved pattern is also higher (5.2 and 5.3 t ha⁻¹) than the existing local Boro rice whose field duration is long too. Mustard yield in improved cropping pattern was increased by above 100%, Boro rice yield increased by 30% and T.Aman rice yield increased by 23%, respectively due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. Rice equivalent yield of improved cropping pattern was 15.84 and 14.55 t ha⁻¹ yr.⁻¹ which was about 45 and 33% higher against existing cropping pattern (10.90 and 10.94 t ha⁻¹yr⁻¹). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 131580 and 195830 ha⁻¹ which was 65% higher than existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 3.60 and 4.75 during two consecutive years which further indicated the superiority to improved cropping pattern over existing pattern.

Table 20a. Crop managements of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Variety	Binadhan-7	BARI Sarisha-17	BRRI dhan28	BRRI dhan39	Tori-7	Local Toba
Date of sowing/ Transplanting	25-30 July	15-20 Nov.	20-25 Feb.	22-28 July	25-30 Nov.	25-28 Feb.
Seed rate (kg ha ⁻¹)	35	7.5	35	45	10	45
Spacing	20 X 15cm	Broadcasting	20 X 15cm	Not properly maintained	Broadcasting	Not properly maintained
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	90-10-35-12-1-0	90-27-32-15-1-1	150-12-55-18-1.3-0	90-10-35-12-1-0	90-27-32-15-1-1	150-12-55-18-1.3-0
Date of harvesting (range)	5-10 Nov.	10-15 Feb.	25-31 May	10-20 Nov.	10-15 Feb.	10-15 June
Field duration(days)	95-100	85-90	95-100	105-110	75-80	105-110
Turned around time (days)	30-35	5-10	10-15	40-45	15-20	12-15

Table 20b. Yield and economic analysis of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna during the year of 2018-2019.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Seed /grain Yield (t ha ⁻¹)	5.50	2.25	5.20	4.50	1.05	4.00
Straw yield (t ha ⁻¹)	6.10	2.85	5.90	5.13	1.70	4.85
Rice equivalent yield (t ha ⁻¹)	5.50	5.14	5.20	4.50	2.4	4.00
Whole pattern Rice equivalent yield (t ha ⁻¹)	15.84			10.90		
Gross return (Tk. ha ⁻¹)	96250	90000	91000	78750	42000	70000
Total variable cost (Tk. ha ⁻¹)	74500	53500	78500	73500	40500	68500
Gross margin (Tk. ha ⁻¹)	21750	36500	12500	5250	1500	1500
Whole pattern gross margin (Tk. ha ⁻¹)	70750			8250		
MBCR	3.6					

Unit price (Tk. kg⁻¹): Boro rice=17.50, T. Aman rice =17.50, Rice straw = 4, Mustard seed =40 and stover=1.00

Table 20c. Yield and economic analysis of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna during the year of 2019-2020.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Seed /grain Yield (t ha ⁻¹)	5.25	2.00	5.30	4.40	1.02	4.50
Straw yield (t ha ⁻¹)	4.75	2.3	4.32	4	1	4.25
Rice equivalent yield (t ha ⁻¹)	5.25	4.00	5.30	4.40	2.04	4.50
Whole pattern Rice equivalent yield (t ha ⁻¹)	14.55			10.94		
Gross return (Tk. ha ⁻¹)	131250	100000	132500	110000	51000	112500
Total variable cost (Tk. ha ⁻¹)	74500	53500	78500	73500	40500	73500
Gross margin (Tk. ha ⁻¹)	56750	46500	54000	36500	10500	39000
Whole pattern gross margin (Tk. ha ⁻¹)	157250			86000		
MBCR	4.75					

Unit price (Tk. kg⁻¹): Boro rice=25.0 T. Aman rice=25.0, Rice straw = 4, Mustard seed = 50 and stover=1.00

Activity 8. Improvement of existing T. Aman-Lentil-Sesame cropping pattern at FSRD site, Ganggarampur, Pabna during the years of 2018 to 2021.

Existing cropping pattern: T. Aman rice (BRRI dhan39)-Lentil (BARI Masur-6)- Sesame (Local)

Improved cropping pattern: T. Aman rice (Binadhan-17)-Lentil (BARI Masur-8)-Sesame (BARI Til-4)

Different crop management practices are presented in Table 21a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 21b and 21c. In the improved pattern BARI Masur-8 gave higher seed yield (1.8 and 1.9 t ha⁻¹) over BARI Masur-6 (1.6 and 1.8 t ha⁻¹) at the FSRD site, Ganggarampur, Pabna during both the year. The T. Aman variety BRRI dhan39 gave lower yield (4.65 and 4.45 t ha⁻¹) than the Binadhan-17 (5.6 and 5.5 t ha⁻¹). Yield of BARI Til-4 in improved pattern is also higher (1.45 and 1.4 t ha⁻¹) than the existing local. Lentil yield in improved cropping pattern was increased by above 10%, T. Aman rice yield increased by 20% and Sesame yield was increased by 15% respectively due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. Rice equivalent yield of improved cropping pattern was 15.57 and 14.00 t ha⁻¹ yr⁻¹ which was about 16 and 12% higher against existing cropping pattern (13.33 and 12.45 t ha⁻¹ yr⁻¹). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 159200 and 236990 ha⁻¹ which was about 36% and 22% higher than existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 4.95 and 4.84 during two consecutive years which further indicated the superiority to improved cropping pattern over existing pattern.

Table 21a. Crop managements of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Variety	Binadhan-17	BARI Masur-8	BRRI Til-4	BRRI dhan39	BARI Masur-6	Local
Date of sowing/Transplanting	22-30 July	20-25 Nov.	20-25 March	22-30 July	01-05 Dec.	15-20 March
Seed rate ((kg ha ⁻¹))	35	40	7.5	45	45	10
Spacing	20 X 15cm	Broadcasting	Broadcasting	Not properly maintained	Broadcasting	Broadcasting
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	90-10-35-12-1-0	18-30-25-18-1-1	78-18-27-20-1	90-10-35-12-1-0	18-30-25-18-1-1	78-18-27-20-1
Date of harvesting (range)	14-20 Nov.	10-15 March	25-30 June	13-20 Nov.	10-15 March	20-25 June
Field duration(days)	105-110	110-115	95-100	105-110	105-110	95-100
Turned around time	25-35	5-10	10-15	22-30	15-20	5-10

Table 21b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna during the year of 2018-2019.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Seed /grain Yield (t ha ⁻¹)	5.60	1.80	1.45	4.65	1.60	1.20
Straw yield (t ha ⁻¹)	5.10	1.60	2.10	4.50	1.50	1.50
Rice equivalent yield (t ha ⁻¹)	5.60	6.66	3.31	4.65	5.94	2.74
Whole pattern REY (t ha ⁻¹)	15.57			13.33		
Gross return (Tk. ha ⁻¹)	98000	117000	58000	81375	104000	48000
Total variable cost (Tk. ha ⁻¹)	71500	36500	34500	70500	32500	31500
Gross margin (Tk. ha ⁻¹)	26500	80500	23500	10875	71500	16500
Whole pattern gross margin (Tk. ha ⁻¹)	130500			98875		
MBCR	4.95					

Unit price (Tk. kg⁻¹): Boro rice=17.50, T. Aman rice=17.50, Rice straw =4.0, Lentil seed =65.0 and stover=2.00, Mustard seed=40.0 and stover=1.00

Table 21c. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Ganggarampur, Pabna during the year of 2019-20.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Seed /grain Yield (t ha ⁻¹)	5.50	1.90	1.40	4.45	1.80	1.30
Straw yield (t ha ⁻¹)	5.25	1.72	2.05	4.41	1.64	1.53
Rice equivalent yield (t ha ⁻¹)	5.50	5.7	2.8	4.45	5.4	2.6
Whole pattern Rice equivalent yield (t ha ⁻¹)	14.00			12.45		
Gross return (Tk. ha ⁻¹)	137500	142500	70000	111250	135000	65000
Total variable cost (Tk. ha ⁻¹)	71500	38500	35500	70500	33500	33500
Gross margin (Tk. ha ⁻¹)	66000	104000	34500	40750	101500	31500
Whole pattern gross margin (Tk. ha ⁻¹)	204500			173750		
MBCR	4.84					

Unit price (Tk. kg⁻¹): Boro rice=25.0, T. Aman rice=25.0, Rice straw =4.0, Lentil seed =75.0 and stover=2.00, Mustard seed=50.0 and stover=1.00

FSRD Site, Sholakundu, Faridpur

Activity-9: Improvement of existing Lentil-Jute-T. Aman cropping pattern at FSRD site, Sholakundu, Faridpur during the years of 2018 to 2021.

Existing cropping pattern: Lentil (Local)- Jute (JRO524)- T. Aman rice (BRRI dhan39)

Improved cropping pattern: Lentil (BARI Masur-8)-Jute (Rabi-1)- T. Aman rice (Binadhan-17/BRRI dhan75)

For improved cropping pattern, BARI Masur-8, Rabi-1 and Binadhan-17 for 2019 and BRRI dhan75 for 2020 were used whereas, local Lentil, JRO-524 (Jute) and BRRI dhan39 were used in existing cropping pattern (Table 22a). Sowing date of Lentil, Jute and T. Aman (transplanting) for improved cropping pattern during both the year was 12 Nov to 30 Dec, 28 March to 7 April and 10 to 15 August, respectively. For both years in improved cropping pattern, field duration was 116-124 days, 123-125 days and 97-99 day for Lentil, Jute and T. Aman, respectively.

The crop yield and return of the improved and existing patterns for both the years are presented in Table 22b and 22c. From those table, it was found that, NARS varieties were performed better than that of farmer's existing varieties. For second year (2019-20), main *pat* (mature Jute) and *baschh pat* (immature Jute) yield were included resulting higher fibre and stick yield. The MBCR of first year (2018-19) and second year (2019-20) was 2.04 and 3.26, respectively. During 2nd year, yield of product and by product

was higher than that of first year resulting higher rice equivalent yield (19.68), whole pattern gross margin (Tk. 531100 ha⁻¹) and MBCR.

The Table 22d showed the average yield and economy of improved and existing cropping pattern for 2018-19 and 2019-20. In the improved pattern, BARI Masur-8 gave higher seed yield (1.71 t ha⁻¹) over local (0.83 t ha⁻¹) at FSRD site, Sholakundu, Faridpur. The Lentil yield in improved pattern was increased by 106% due to application of balance fertilizer, better management practices and also due to inclusion of modern variety. Rabi-1 gave higher fibre yield (2.96 t ha⁻¹) over JRO-524 (2.64 t ha⁻¹). The T. Aman yield in improved cropping pattern was increased by above 12%. The Whole pattern Rice equivalent yield was 18.66 t ha⁻¹ and 14.64 t ha⁻¹, respectively. Whole pattern gross margin was Tk. 170851 ha⁻¹ and Tk. 107034 ha⁻¹ for improved pattern and existing pattern, respectively. The average MBCR was 2.65.

Farmers were interested following improved cropping pattern with BARI Masur-8 for Lentil, Rabi-1 for Jute and BRRI dhan75 for rice production. Binadhan-17 was infected with false smut during pre-mature stage of grain resulting lower yield. They stored seed for next year cultivation.

Table 22a. Crop managements of improved and existing cropping pattern during the years of 2018 to 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Variety	BARI Masur-8	Rabi-1	Binadhan-17/ BRRI dhan75	Local	JRO524	BRRI dhan39
Date of sowing/ Transplanting	16-30 Nov.	28 Mar.-7 Apr	10-15 Aug.	28 Nov.- 4 Dec.	26 Mar. – 5 Apr.	30 July 15 Aug.
Seed rate ((kg ha ⁻¹)	35	6.5	50	40	7	50
Spacing	Broadcast	Broadcast	20 cm x 15 cm	Broadcast	Broadcast	20 cm x 15 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	28-24-14-9-2-1	140-30-25-15-4-2	80-15-35-8-1-0	23-24-25-9-1.8-0.8	95-20-50-0-0-0	45-20-25-18-3-1
Date of harvesting (range)	8-24 Mar	1-8 Aug.	17-20 Nov	15-20 Mar	20-30 Jul	12-30 Nov.
Field duration(days)	117-118 110-114	123-124 123-125	98-100 97-99	119-125 107-108	118-119 117	106-110 105-106
Turned around time (days)	10	13-20	--	4-16	11-16	-

Table 22b. Yield and Economic analysis of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of 2018-2019.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Variety	BARI Masur-8	Rabi-1	Binadhan-17	Local	JRO 524	BRRI dhan39
Seed /grain/fibre yield (t ha ⁻¹)	1.63	2.67	4.11	0.8	2.48	4.00
Stover/straw/stick yield (t ha ⁻¹)	0.78	4.20	5.16	0.53	3.64	5.12
Rice equivalent yield (t ha ⁻¹)	5.26	7.39	4.99	2.61	7.00	4.66
Whole pattern REY (t ha ⁻¹)	17.64			14.26		
Gross return (Tk. ha ⁻¹)	91990	129412	87405	45590	122520	81520
Variable cost (Tk. ha ⁻¹)	45230	122680	66615	42500	107580	55460
Gross margin (Tk. ha ⁻¹)	46760	16732	20790	3090	14940	26060
Total Gross return (Tk. ha ⁻¹)	308807			249630		
Total variable cost (Tk. ha ⁻¹)	234525			205540		
Total gross margin (Tk. ha ⁻¹)	84882			44090		
MBCR	2.04					

Output price (Tk/kg). Lentil: 55.00, Stover: 3.00 rice: 17.50, rice straw: 3.00, Jute fiber: 43.75, Jute stick: 3.00

Table 22c. Yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu during the months of February to December 2020.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute (both main and <i>basch pat</i>)	T. Aman	Lentil	Jute (main pat)	T. Aman
Variety	BARI Masur-8	Rabi-1	BRRI dhan75	Local	JRO 524	BRRI dhan39
Seed /grain/fibre yield (t ha ⁻¹)	1.79	3.26	5.05	0.87	2.81	4.20
Stover/straw/stick yield (t ha ⁻¹)	0.84	5.31	6.51	0.4	4.46	5.46
Rice equivalent yield (t ha ⁻¹)	4.80	8.14	6.74	2.38	7.00	5.65
Whole pattern REY (t ha ⁻¹)	19.68			15.03		
Gross return (Tk. ha ⁻¹)	129500	219680	181920	64275	188975	152600
Variable cost (Tk. ha ⁻¹)	45398	162062	66820	38093	139650	58130
Gross margin (Tk. ha ⁻¹)	84102	57618	115100	26182	49325	94470
Total Gross return (Tk. ha ⁻¹)	531100			405850		
Total variable cost (Tk. ha ⁻¹)	274280			235873		
Total gross margin (Tk. ha ⁻¹)	256820			169977		
MBCR	3.26					

Output price (Tk. kg⁻¹). Improved: Lentil: BARI Masur-8: 70.00, Stover: 5.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00
Existing: Lentil: 72.50, Stover: 3.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00

Table 22d. Average yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu during the years of 2018 to 2020.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Seed/grain/fibre yield (t ha ⁻¹)	1.71	2.96	4.58	0.83	2.64	4.1
Stover/straw/stick yield (t ha ⁻¹)	0.81	4.75	5.83	0.46	4.05	5.29
Rice equivalent yield (t ha ⁻¹)	5.03	7.76	5.86	2.49	7	5.155
Whole pattern REY (t ha ⁻¹)	18.66			14.64		
Gross return (Tk. ha ⁻¹)	110745	174546	134662	54932	155747	117060
Variable cost (Tk.ha ⁻¹)	45314	142371	66717	40296	123615	56795
Gross margin (Tk. ha ⁻¹)	65431	37175	67945	14636	32132	60265
Total Gross return (Tk. ha ⁻¹)	419953			327740		
Total variable cost (Tk. ha ⁻¹)	254402			220706		
Total gross margin (Tk ha ⁻¹)	170851			107034		
MBCR	2.65					

Activity-10: Improvement of existing Mustard-Jute-T. Aman cropping pattern at FSRD site, Sholakundu, Faridpur during the years of 2018 to 2020

Existing cropping pattern: Mustard (Tori-7)-Jute (JRO524)- T. Aman rice (BRRI dhan39)

Improved cropping pattern: Mustard (BARI Sarisha-17/18)- Jute (Rabi-1)-T. Aman rice (Binadhan-17/BRRI dhan75)

For improved cropping pattern, BARI Sarisha-17 for 2018-19 and BARI Sarisha-18 for 2019-20, Rabi-1 and Binadhan-17 for 2019 and BRRI dhan75 for 2020 were used whereas, local Mustard (Tori), JRO 524 (Jute) and BRRI dhan39 were used in existing cropping pattern (Table 23a). Sowing date of Mustard, Jute and T. Aman (transplanting) for improved cropping pattern during both the year was 9 to 30 Nov, 20 Mar to 5 Apr and 10 to 18 Aug., respectively. For both years in improved cropping pattern, field duration was 91-102 days, 120-125 days and 95-103 day for Lentil, Jute and T. Aman, respectively. Field duration of BARI Sarisha-18 was higher than BARI Sarisha-17.

The crop yield and monetary return of the improved and existing patterns for both the years are presented in Table 23b and 23c. From those table, it was found that, NARS varieties were performed better than that of farmer's existing varieties. For second year (2019-20), main *pat* (mature Jute) and *baschh pat* (immature Jute) yield were included for calculating gross return. The MBCR of first year

(2018-19) and second year (2019-20) was 2.04 and 2.37, respectively. During 2nd year, yield of product and by product was higher than that of first year resulting higher rice equivalent yield (18.18), whole pattern gross margin (Tk. 214276 ha⁻¹) and MBCR.

The Table 23d showed the average yield and economy of improved and existing cropping pattern for 2018-19 and 2019-20. In the improved pattern, BARI released Mustard variety gave higher seed yield (1.71 t ha⁻¹) over local (0.91 t ha⁻¹) at FSRD site, Sholakundu, Faridpur. The Mustard yield in improved pattern was increased by 88% due to application of balance fertilizer, better management practices and also due to inclusion of modern variety. Rabi-1 gave higher fibre yield (3.02 t ha⁻¹) over JRO-524 (2.60 t ha⁻¹). The T. Aman yield in improved cropping pattern was increased by above 12%. The Whole pattern Rice equivalent yield was 17.34 t ha⁻¹ and 13.95 t ha⁻¹, respectively. Whole pattern gross margin was Tk. 140331 ha⁻¹ and Tk. 97055 ha⁻¹ for improved pattern and existing pattern, respectively. The average MBCR was 2.25.

Farmers were interested following improved cropping pattern with BARI Sarisha-18 for Mustard, Rabi-1 for Jute and BRRI dhan75 for rice production. Binadhan-17 was infected with false smut during pre-mature stage of grain resulting lower yield. BARI Sarisha-18 produced higher yield than that of BARI Sarisha-17. Farmers who have more family members showed interest to harvest basch pat with main pat (Jute). They stored seed of Mustard and T. Aman for next year cultivation.

Table 23a. Crop managements of improved and existing cropping pattern during the year of 2018 to 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Variety	BARI Sarisha-17/ 18	Rabi-1	Binadhan-17/ BRRI dhan75	Torri	JRO524	BRRI dhan39
Date of sowing/ Transplanting	9-20 Nov /25-30 Nov	26 Mar to 5 Apr / 20-30 Mar	12-18 Aug. / 5-10 Aug.	10-19 Nov / 21-30 Nov	25 Mar-5 Apr /20-30 Mar	25 Jul-10 Aug./ 12-21 Aug.
Seed rate ((kg ha ⁻¹)	35	6.5	50	40	7	50
Spacing	Broadcast	Broadcast	20 cm x 15 cm	Broadcast	Broadcast	20 cm x 15 cm
Fertilizer dose (N-P- K-S-Zn-B kg ha ⁻¹)	120-36-40-15-2- 1	140-30-25-15-4- 2	80-15-35-8-1- 0	92-30-50-9-2- 1	95-20-50-0- 0-0	45-20-25-18- 3-1
Date of harvesting (range)	10-18 Feb/ 5-8 Mar	28 Jul to 6 Aug./ 20-27 Jul	16-20 Nov/ 15-20 Nov	27 Jan-6 Feb/ 10-15 Feb	20 Jul to 3 Aug./ 18-25 Jul	5-15 Nov/ 25-30 Nov
Field duration(days)	91-94/ 100-102	124-125	95-100	79-80	118-121	98-104
Turned around time (days)	43-45/ 14-21	11-14	--	56-57	4-6	--

Table 23b. Yield and Economic analysis of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of 2018-2019

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Variety	BARI Sarisha-17	Rabi-1	Binadhan- 17	Torri	JRO524	BRRI dhan39
Seed/grain/fibre yield (t ha ⁻¹)	1.65	2.73	3.94	0.90	2.36	3.85
Stover/straw/stick yield (t ha ⁻¹)	2.76	4.30	4.85	1.80	3.34	4.10
Rice equivalent yield (t ha ⁻¹)	4.17	7.56	4.77	2.42	6.64	4.55
Whole pattern REY (t ha ⁻¹)	16.50			13.61		
Gross return (Tk. ha ⁻¹)	72900	132338	83500	42300	116220	79670
Variable cost (Tk. ha ⁻¹)	45860	113110	63383	36903	106180	54460
Gross margin (Tk. ha ⁻¹)	27040	19228	20117	5397	10040	25210
Total Gross return (Tk. ha ⁻¹)	288738			238190		
Total variable cost (Tk. ha ⁻¹)	222353			197543		
Total gross margin (Tk. ha ⁻¹)	66385			40647		
MBCR	2.04					

Output price (Tk. kg⁻¹). Mustard: 40.00, stover: 2.50, rice: 17.50, rice straw: 3.00 Jute fiber: 43.75, Jute stick: 3.00

Table 23c. Yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute (both main and <i>basch pat</i>)	T. Aman	Mustard	Jute (Main pat)	T. Aman
Variety	BARI Sarisha-18	Rabi-1	BRRIdhan75	Tori	JRO 524	BRRIdhan39
Seed/grain/fibre yield (t ha ⁻¹)	1.77	3.32	4.97	0.91	2.84	4.12
Stover/straw/stick yield (t ha ⁻¹)	2.78	5.38	6.46	1.66	5.53	5.36
Rice equivalent yield (t ha ⁻¹)	3.26	8.28	6.64	1.70	7.08	5.51
Whole pattern REY (t ha ⁻¹)	18.18			14.29		
Gross return (Tk. ha ⁻¹)	87990	223640	179410	45930	191090	148760
Variable cost (Tk. ha ⁻¹)	48820	162562	65382	34210	141532	56575
Gross margin (Tk. ha ⁻¹)	39170	61078	114028	11720	49558	92185
Total Gross return (Tk. ha ⁻¹)	491040			385780		
Total variable cost (Tk. ha ⁻¹)	276764			232317		
Total gross margin (Tk. ha ⁻¹)	214276			153463		
MBCR	2.37					

Output price (Tk/kg). Improved and existing: Mustard: 45.00, Stover: 3.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00

Table 23d. Average yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of 2018-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Seed/grain/fibre yield (t ha ⁻¹)	1.71	3.02	4.45	0.91	2.60	3.99
Stover/straw/stick yield (t ha ⁻¹)	2.77	4.84	5.65	1.73	4.44	4.73
Rice equivalent yield (t ha ⁻¹)	3.71	7.92	5.70	2.06	6.86	5.03
Whole pattern Rice equivalent yield (t ha ⁻¹)	17.34			13.95		
Gross return (Tk. ha ⁻¹)	80445	177989	131455	44115	153655	114215
Variable cost (Tk. ha ⁻¹)	47340	137836	64382	35556	123856	55517
Gross margin (Tk. ha ⁻¹)	33105	40153	67073	8559	29799	58698
Total Gross return (Tk. ha ⁻¹)	389889			311985		
Total variable cost (Tk. ha ⁻¹)	249558			214930		
Total gross margin (Tk. ha ⁻¹)	140331			97055		
MBCR	2.25					

FSRD Site, Atia, Tangail

Activity-11: Development of alternative cropping pattern at FSRD site, Atia, Tangail during the years of 2018 to 2020.

Existing cropping pattern: Boro (BRRIdhan29)-T. Aman rice (BR11)-Mustard (BARI Sarisha-14)

Improved cropping pattern: Boro (BRRIdhan29)-T. Aman rice (BRRIdhan72)-Mustard (BARI Sarisha-14)

Different crop management practices are presented in Table 24a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 24b and 24c. In the improved cropping pattern, BARI Sarisha-14 gave seed yield 1.79 and 1.75 t ha⁻¹ which was 83 and 59 % higher over the farmers' existing variety Tori-7 (0.98 and 1.10 t ha⁻¹) due to introduce high yielding variety and improved management practices in two consecutive years. BRRIdhan29 produced grain yield 6.49 and 6.56 t ha⁻¹ which gave 5 and 4 % higher yield compared to existing pattern (6.49 and 6.30 t ha⁻¹) might be due to better management practices and balance fertilization. BRRIdhan72 gave higher grain yield (5.42 and 5.36 t ha⁻¹) and farmers' existing variety BR11 produced lower grain yield (4.59 and 4.56 t ha⁻¹) at the FSRD site, Atia, Tangail in two successive years. T. Aman rice variety BRRIdhan72 gave higher yield by 18 and 27 % over BR11 due to better management practices, use balance fertilizer, seedling age and also inclusion of new rice variety. Rice equivalent yield of

improved cropping pattern was 16.84 and 16.75 t ha⁻¹ yr.⁻¹ which was about 25 and 22% higher against existing cropping pattern (13.50 and 13.91 t ha⁻¹ yr.⁻¹) due to introduction of high yielding T. Aman and Mustard variety and improved management practices. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 105335 and 102810 ha⁻¹ which was 62 and 57 % higher against existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 3.60 and 4.49 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 24a. Crop managements of improved and existing cropping pattern at FSRD site, Atia, Tangail

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Variety	BRRI dhan29	BRRI dhan72	BARI Sarisha-14	BRRI dhan29	BR11	Tori-7
Date of sowing/ Transplanting	10-18 Feb.	25-31 Jul	12-16 Nov.	06-15 Feb.	8-14 Jul.	10-15 Nov.
Seed rate ((kg ha ⁻¹))	40	30	6	50	35	8
Spacing (cm)	25×15	25×15	Broadcast	25×15	25×15	Broadcast
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	140-15-45-10-2-0	70-10-40-10-2-0	100-32-40-24-1-1	115-24-50-20-0-0	90-20-40-20-0-0	70-15-17-0-0-0
Date of harvesting	15-24 Jun	25-30 Oct	5-10 Feb.	13-22 Jun	24-31 Oct	25-30 Jan
Field duration(days)	125-126	92-93	85-86	127-128	108-110	76-77
Turned around time (days)	5-8	40-41	15-17	12-14	24-25	15-17

Table 24b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Tangail during the year of 2018-2019

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Seed/grain yield (t ha ⁻¹)	6.49	5.42	1.79	6.19	4.59	0.98
Straw yield (t ha ⁻¹)	5.85	5.30	2.41	6.12	4.87	1.58
Rice equivalent yield (t ha ⁻¹)	6.49	5.42	4.93	6.19	4.59	2.72
Whole pattern REY (t ha ⁻¹)	16.84			13.50		
Gross return (Tk. ha ⁻¹)	109050	97320	74010	105090	78590	40780
Total variable cost (Tk. ha ⁻¹)	77560	55805	41680	76128	51690	31700
Gross margin (Tk. ha ⁻¹)	31490	41515	32330	28962	26900	9080
Whole pattern GR (Tk. ha ⁻¹)	105335			64942		
MBCR	3.60					

Unit price (Tk. kg⁻¹): Boro rice=15, T. Aman rice=16.00, Rice straw =2, Mustard seed =40 and stover=1.00

Table 24c. Yield and Economic analysis of alternate and existing cropping pattern at the FSRD site during the year of 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Seed/grain yield (t ha ⁻¹)	6.56	5.36	1.75	6.30	4.56	1.10
Straw yield (t ha ⁻¹)	5.90	5.30	2.50	5.70	4.85	1.80
Rice equivalent yield (t ha ⁻¹)	6.56	5.36	4.83	6.30	4.56	3.05
Whole pattern REY (t ha ⁻¹)	16.75			13.91		
Gross return (Tk. ha ⁻¹)	110200	96360	72500	105900	82660	45800
Total variable cost (Tk. ha ⁻¹)	78650	56250	41350	77500	52500	36300
Gross margin (Tk. ha ⁻¹)	31550	40110	31150	28400	27600	9500
Whole pattern GR (Tk. ha ⁻¹)	102810			65500		
MBCR	4.49					

Unit price (Tk. kg⁻¹): Boro rice=15, T. Aman rice=16.00, Rice straw =2, Mustard seed =40 and stover=1.00

Activity-12: Development of alternative cropping pattern at FSRD site, Atia, Tangail during the years of 2018 to 2020.

Existing cropping pattern: Brinjal (Singhnath)-T. Aman rice (BR11)-Cabbage (Autumn queen)

Improved cropping pattern: Okra (BARI Derosh-2)-T. Aman rice (BRRI dhan72)- Cabbage (Autumn queen)

Different crop management practices are presented in Table 25a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 25b and 25c. In improved cropping pattern, Cabbage gave head yield 80.55 and 85.50 t ha⁻¹ which was 2.74 and 3.76% higher over the farmers' practice (78.40 and 82.40 t ha⁻¹) due to improved management practices and balance fertilization in two successive years. BARI dherosh-2 produced fruit yield 16.15 and 16.56 t ha⁻¹ and BRRI dhan72 gave higher grain yield (5.34 and 5.30 t ha⁻¹) and farmers' existing variety BR11 produced lower grain yield (4.23 and 4.53 t ha⁻¹) at the FSRD site, Atia, Tangail. T. Aman rice variety BRRI dhan72 gave higher yield by 26 and 17 % over BR11 due to better management practices, use balance fertilizer, seedling age and also inclusion of new rice variety. Rice equivalent yield of improved cropping pattern was 40.62 and 42.21 t ha⁻¹ yr.⁻¹ which was about 27.37 and 20.22% higher against existing cropping pattern (31.89 and 35.11 t ha⁻¹ yr.⁻¹) due to introduction of high yielding T. Aman rice variety and improved management practices. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was also observed that the higher total gross margin Tk. 431160 and 465050 ha⁻¹ was obtained from improved cropping pattern against existing cropping pattern which was 38 and 27% higher over existing pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 6.34 and 6.98 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 25a. Crop management of improved and existing cropping pattern at FSRD site, Atia, Tangail

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Variety	BARI Derosh-2	BRRI dhan72	Autumn queen	Singhnath	BR11	Autumn queen
Date of sowing/ Transplanting	09-12 March	20-25 July	10-16 Nov	20-25 Jan	14-25 July	15-19 Nov
Seed rate (kg ha ⁻¹)	5	40	0.4	0.4	50	0.4
Spacing (cm)	45 cm x 30cm	25cm x15cm	60 cm x 45cm	100 cm x 75cm	25cm x15cm	60 cm x 45cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	70-20-75-0-0-0	70-10-40-10-2	138-40-125-20-0-1	138-50-100-16-0-2	90-20-40-20	118-40-75-0-0-0
Date of harvesting	20 Apr.-25 Jun	14-20 Oct	7-17 Feb	10 Mar-28 Jun	24-29 Oct	10-20 Feb
Field duration(days)	106-110	84-88	88-92	157-161	102-104	85-89
Turned around time (days)	28-32	24-26	24-28	-	14-18	15-19

Table 25b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Delduar, Tangail during the year of 2018-2019

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Card/fruit/grain yield (t ha ⁻¹)	16.15	5.34	80.55	12.90	4.23	78.40
Straw yield (t ha ⁻¹)	-	5.30	-	-	4.20	-
Rice equivalent yield (t ha ⁻¹)	15.14	5.34	20.14	8.06	4.23	19.60
Whole pattern rice equivalent yield (t ha ⁻¹)	40.62			31.89		
Gross return (Tk. ha ⁻¹)	242250	85440	322200	129000	67680	313600
Total variable cost (Tk. ha ⁻¹)	83840	56570	78320	72760	49830	74120
Gross margin (Tk. ha ⁻¹)	158410	28870	243880	56240	17850	239480
Whole pattern gross margin (Tk. ha ⁻¹)	431160			297570		
MBCR	6.34					

Unit Price: Card price = Tk.4.00 kg⁻¹, Brinjal=10.00, Okra= Tk.15 kg⁻¹, T. Aman rice= Tk.16.00 kg⁻¹, Straw= Tk.2.00 kg⁻¹ and stover=1.00

Table 25c. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Delduar, Tangail during the year of 2019-2020

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Card/fruit/grain yield (t ha ⁻¹)	16.56	5.30	85.50	13.30	4.53	82.40
Straw yield (t ha ⁻¹)	-	5.40	-	-	4.80	-
Rice equivalent yield (t ha ⁻¹)	15.53	5.30	21.38	9.98	4.53	20.60
Whole pattern rice equivalent yield (t ha ⁻¹)	42.21			35.11		
Gross return (Tk. ha ⁻¹)	248400	95600	342000	159600	82080	329600
Total variable cost (Tk. ha ⁻¹)	84650	56750	79550	79500	51570	73450
Gross margin (Tk. ha ⁻¹)	163750	38850	262450	80100	30510	256150
Whole pattern gross margin (Tk. ha ⁻¹)	465050			366760		
MBCR	6.98					

Unit Price: Card price =Tk.4.00 kg⁻¹, Brinjal=12.00, Okra= Tk.15 kg⁻¹, T. Aman rice= Tk.16.00 kg⁻¹, Straw= Tk.2.00 kg⁻¹ and stover=1.00

FSRD Site, Tarakandi, Sherpur

Activity-13: Development of alternative cropping pattern at FSRD site, Tarakandi, Sherpur during the years of 2018 to 2020.

Existing cropping pattern: T. Aman (Hori)-Fallow-Boro (BRRI dhan29)

Alternate cropping pattern: T. Aman (BRRI dhan49)-Potato (BARI Alu-25)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan48)

Different crop management practices are presented in Table 26a. Yield and economic performance of alternate cropping pattern against existing pattern are presented in Table 26b and 26c. In the alternate pattern, BARI Alu-25 gave tuber yield (38.7 and 27.67 t ha⁻¹ at 2018-19 and 2019-20) whereas in existing cropping pattern the land remained fallow at the FSRD site, Tarakandi, Sherpur during the year of 2018-21. Inclusion of Mungbean in the pattern increased total production as well as improve soil health as leguminous crop. The variety Hori dhan gave higher yield than the BRRI dhan49 during two consecutive years. Boro rice variety BRRI dhan29 gave yield 5.5 t ha⁻¹ in existing pattern. Alternate cropping pattern gave higher REY (26.8 t ha⁻¹yr⁻¹) than existing pattern (9.21 t ha⁻¹yr⁻¹) in two consecutive years. From two years average, it was observed that the higher total gross margin Tk. 245188 ha⁻¹ was obtained from alternate cropping pattern T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49)-Potato (BARI Alu-25)-Mungbean (BARI Mung-6) against existing cropping pattern T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29) with Tk.75075 ha⁻¹. The marginal benefit cost ratio (MBCR) was obtained 1.93 and 1.84 which indicated the superiority to alternate cropping pattern over existing pattern.

Table 26a. Crop managements of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Improved cropping pattern				Existing cropping pattern		
	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Variety	BRRI dhan49	BARI Alu-25	BARI Mung-6	BRRI dhan48	Hori dhan	-	BRRI dhan29
Date of sowing/ Transplanting	18-29 Aug.	18-28 Nov.	4-9 Mar.	28 May-2 June	27-29 Jul.	-	25-26 Jan.
Seed rate (kg ha ⁻¹)	40	2000	30	40	50	-	40
Spacing	(20 x 15) cm	(60 x 25) cm	Broadcast	(20 x 15) cm	(20 x 15) cm	-	(20 x 15) cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	82-24-35- 11-4-0	150-40- 113-18-2.7- 1	20-15-38-0-0- 0	69-15-38-10- 0-0	90-20-25-0- 0-0	-	130-30-81- 15-0-0-0
Date of harvesting (range)	10-15 Nov.	17-20 Feb.	10-20 May	15-20 Aug.	20-25 Nov.	-	20-30 May
Field duration (days)	85-90	90-95	68-72	80-85	120-125	-	115-125
Turned around time (days)	8-13	17-19	12-18	3-9	53-66	-	33-37

Table 26b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the year of 2019-2020

Observation	Alternate cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Seed/grain yield (t ha ⁻¹)	3.9	27.67	1.08	4.7	4.3	-	5.5
Straw yield (t ha ⁻¹)	4.5	-	-	5.06	5.2	-	4.35
Rice equivalent yield (t ha ⁻¹)	4.16	18.97	3.08	3.78	4.47	-	5.12
Whole pattern Rice equivalent yield (t ha ⁻¹)	29.99				9.59		
Gross return (Tk. ha ⁻¹)	72750	332040	54000	66160	78300	-	89600
Total variable cost (Tk. ha ⁻¹)	49070	173142	31120	50000	50000	-	68350
Gross margin (Tk. ha ⁻¹)	23680	158898	22880	16160	28300	-	21250
Whole pattern gross margin (Tk. ha ⁻¹)	221618				49550		
MBCR	1.93						

Unit price (Tk. kg⁻¹): Aman rice=17.5, T. Aus rice=13.0, Boro Rice= 15.50, Hori dhan=17.0, Mungbean= 50.00, Rice straw =1.0, Potato=12.0

Table 26c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the months of February to December 2020

Observation	Alternate cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Seed/grain yield (t ha ⁻¹)	4.08	27.67	1.08	4.87	4.5	0	5.5
Straw yield (t ha ⁻¹)	4.85	-	-	5.07	5.1	0	4.35
Rice equivalent yield (t ha ⁻¹)	4.27	13.28	2.16	3.90	4.7	0	4.13
Whole pattern Rice equivalent yield (t ha ⁻¹)	23.61				8.83		
Gross return (Tk. ha ⁻¹)	106850	332040	54000	97600	117600	0	103350
Total variable cost (Tk. ha ⁻¹)	55450	173142	31120	62020	52000	0	68350
Gross margin (Tk. ha ⁻¹)	51400	158898	22880	35580	65600	0	35000
Whole pattern gross margin (Tk. ha ⁻¹)	268758				100600		
MBCR	1.84						

Unit price (Tk. kg⁻¹): Aman rice=25, Aus=19, Boro rice=18, Rice straw =1, Potato=12, Mungbean=50.

Activity-14: Development of alternative cropping pattern at FSRD site, Tarakandi, Sherpur during the years of 2018 to 2020

Existing cropping pattern: T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29)

Alternate cropping pattern: T. Aus (BRRI dhan48) – T. Aman (BRRI dhan49)-Motorshuti (BARI Motorshuti-3)-Boro (Hybrid shakka)

Different crop management practices are presented in Table 27a. Yield and economic performance of alternate cropping pattern against existing pattern are presented in Table 27b, 27c and 27d. In the alternate pattern, BARI Motorsuti-3 produced green pod yield (9.3 and 9.2 t ha⁻¹ at 2018-19 and 2019-20) whereas in existing cropping pattern the land remained fallow at the FSRD site, Tarakandi, Sherpur during the year of 2018-21. The variety Hori dhan gave higher yield than the BRRI dhan 49 during two consecutive years. Boro rice variety Hybrid shakka gave higher average yield 6.13t ha⁻¹ in alternate cropping pattern. Alternate cropping pattern gave higher REY (29.4 t ha⁻¹yr⁻¹) than existing pattern (10.0 t ha⁻¹yr⁻¹) in two consecutive years. From two years average, it was observed that the higher total gross margin Tk. 265560 ha⁻¹ was obtained from alternate cropping pattern T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49)-Motorshuti (BARI Motorshuti-3)-Boro (Hybrid shakka) against existing cropping pattern T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29) with Tk. 56490 ha⁻¹. The marginal benefit cost ratio (MBCR) was obtained 1.80 and 2.39 which indicated the superiority to alternate cropping pattern over existing pattern.

Table 27a. Crop managements of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Variety	BRRI dhan48	BRRI dhan49	BARI Motorshuti-3	Hybrid shakka	Hori dhan	-	BRRI dhan29
Date of sowing/ Transplanting	25-30 May	20-28 Aug.	21-24 Nov.	4-17 Feb.	27-30 July	-	25-27 Jan.
Seed rate ((kg ha ⁻¹))	40	40	35	20	50	-	40
Spacing	20 x 15 cm ²	20 x 15 cm ²	25 x 10 cm ²	20 x 15 cm ²	20 x 15 cm ²	-	20 x 15 cm ²
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	69-15-38-10-0-0	82-24-35-11-4-0	46-30-50-0-0-0	100-30-40-10-3.6-0	90-20-25-0-0-0	-	130-30-81-15-0-0-0
Date of harvesting (range)	13-15 Aug.	10-15 Nov.	28-30 Jan.	14-20 May	24-26 Nov.	-	25-29 May
Field duration (days)	80-82	82-85	69-70	93-100	120	-	120-123
Turned around time (days)	10-11	7-13	9-11	7-17	63	-	63-64

Table 27b. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the year of 2018-2019

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Seed/grain yield (t ha ⁻¹)	4.0	3.41	9.3	5.9	4.2	-	5.5
Straw yield (t ha ⁻¹)	5.0	3.66	-	6.1	5.2	-	6.2
Rice equivalent yield (t ha ⁻¹)	4.54	3.81	15.08	6.08	4.65	-	5.72
Whole pattern Rice equivalent yield (t ha ⁻¹)	29.51				10.37		
Gross return (Tk. ha ⁻¹)	84000	70530	279000	112500	86000	-	105900
Total variable cost (Tk. ha ⁻¹)	50745	50070	81500	80500	50000	-	75600
Gross margin (Tk. ha ⁻¹)	33255	20460	197500	32000	36000	-	30300
Whole pattern gross margin (Tk. ha ⁻¹)	283215				66300		
MBCR	1.80				-		

Unit price (Tk. kg⁻¹): T Aus rice=18.50, T. Aman=18.50, Motorshuti= 30.00, Boro= 17.00, Hori dhan= 18.00, Rice straw =2.00.

Table 27c. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the year of 2019-2020

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Seed/grain Yield (t ha ⁻¹)	4.75	3.38	9.2	6.37	4.1	-	5.61
Straw yield (t ha ⁻¹)	5.65	3.81	0	7.18	5.1	-	4.4
Rice equivalent yield (t ha ⁻¹)	3.85	3.60	15.77	6.05	4.39	-	5.22
Whole pattern Rice equivalent yield (t ha ⁻¹)	29.27				9.61		
Gross return (Tk. ha ⁻¹)	67400	62960	276000	105915	74800	-	91355
Total variable cost (Tk. ha ⁻¹)	50745	50070	81500	82056	50000	-	69475
Gross margin (Tk. ha ⁻¹)	16655	12890	194500	23859	24800	-	21880
Whole pattern gross margin (Tk. ha ⁻¹)	247904				46680		
MBCR	2.39						

Unit price (Tk. kg⁻¹): T Aus rice=13, T. Aman=17.5, Motorshuti= 30.00, Boro= 15.50, Hori dhan= 17.00, Rice straw =1.00.

Table 27d. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the months of February to December 2020

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	Boro	T. Aus	T. Aman	Motorshuti	T. Aman	Fallow	Boro
Seed/grain yield (t ha ⁻¹)	6.37	4.6	4.05	-	4.4	-	5.60
Straw yield (t ha ⁻¹)	7.18	5.03	4.86	-	5.1	-	4.4
Rice equivalent yield (t ha ⁻¹)	7.24	5.22	3.34	-	2.15	-	4.76
Whole pattern Rice equivalent yield (t ha ⁻¹)	-				-		
Gross return (Tk. ha ⁻¹)	121840	62430	106110		115100	-	105200
Total variable cost (Tk. ha ⁻¹)	82056	60500	54470	-	52500	-	69475
Gross margin (Tk. ha ⁻¹)	39784	31930	51640	-	62600	-	35725
Whole pattern gross margin (Tk. ha ⁻¹)	-				98325		
MBCR	-						

Unit price (Tk. kg⁻¹): T Aus rice=19, T. Aman=25, Boro= 18, Hori dhan= 25, Rice straw =1.00

II. On-farm verification/Production program

On-farm verification trial

Activity-15: On-farm verification trials with modern varieties of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2018 to 2020

FSRD site, Ajoddhapur, Rangpur

Different crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 28. The results revealed that in case of Mustard, BARI Sarisha-14 (yield 1.50-1.72 t ha⁻¹) and BARI Sarisha-18 (yield 1.51-1.70 t ha⁻¹) was performed better than other varieties and farmers also choose these varieties for next year cultivation. In case of Tomato, BARI Tomato-15 and BARI Tomato-18 both performed better than local variety and farmers were selected these varieties for next year cultivation. In case of Potato, all varieties gave satisfactory yield compared to BARI Alu-8, but farmers choose the BARI Alu-25 and BARI Alu-53 due to the red skin color.

Table 28. Different operations conducted and yield of different crops under on-farm verification trial FSRD site Ajoddhapur, Rangpur during the year of 2018-2019

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (dec.)	Yield (t ha ⁻¹)
Mustard	BARI Sarisha-14	21-28 Nov.	27-28 Feb.	6	12	1.50-1.72
	BARI Sarisha-15	21-28 Nov.	27-28 Feb.	6	12	1.40-1.52
	BARI Sarisha-18	20-30 Nov.	7-8 March	6	12	1.51-1.70
	Tori-7	21-28 Nov.	23-25 Feb.	6	12	0.95-1.06
Tomato	BARI Tomato-15	16-18 Nov.	15Feb-09 March	3	9	76-88
	BARI Tomato-18	16-18 Nov.	15Feb-09 March	3	9	82-86
	Local	16-18 Nov.	15Feb-09 March	3	9	70-75
Potato	BARI Alu-8	28-30 Nov.	27Feb.-05 March	7	7	23.72
	BARI Alu-25	28-30 Nov.	27Feb.-05 March	7	7	29.12-30.96
	BARI Aul-46	28-30 Nov.	27Feb.-05 March	7	7	28.05-32.52
	BARI Aul-53	28-30 Nov.	27Feb.-05 March	7	7	29.53-31.25

FSRD site, Atia, Tangail

Different crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 29. iv. The results revealed that in case of Mustard, BARI Sarisha-14 (yield 1.61 t ha⁻¹) and BARI Sarisha-17 (yield 1.63 t ha⁻¹) was performed better than local varieties and farmers also choose these varieties for next year cultivation. In case of Barley, BARI Barley-6 and BARI Barley-7 both performed better than local variety and farmers were selected these varieties for next year cultivation. In case of Potato, BARI Alu-41 performed better than BARI Alu-7 and BARI Alu-8.

Table 29. Different operations conducted and yield of different crops under on-farm verification trial FSRD site Atia, Tangail during the year of 2018-2019

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (dec.)	Yield (t ha ⁻¹)
Mustard	BARI Sarisha-14	13-20 Nov.	4-11 Feb.	5	20	1.61
	BARI Sarisha-17	13-20 Nov.	3-12 Feb.	5	20	1.63
	Tori-7	13-20 Nov.	27-31 Jan.	5	20	0.99
Barley	BARI Barley-6	22-26 Nov	17-19 March	4	15	2.05
	BARI Barley-7	22-26 Nov	17-19 March	4	15	2.11
	Local	22-26 Nov	12-16 March	4	15	1.39
Potato	BARI Alu-7	24-28 Nov.	20-26 Feb	3	10	28.77
	BARI Alu-8	24-28 Nov.	20-26 Feb	3	10	28.96
	BARI Aul-41	24-28 Nov.	20-26 Feb	3	10	32.54
Wheat	BARI Gom-30	17-20 Nov.	12-15 March	3	60	3.65
	BARI Gom-31					3.80
	BARI Gom-32					3.78
	BARI Gom-33					3.97
Onion	BARI Piaj-1	04-11 Jan	06-15 April	3	60	17.77
	BARI Piaj-4					13.25
	Local					9.58

FSRD site, Tarakandi, Sherpur

Crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 30. The results revealed that incase of Potato, BARI Alu-41 performed better than other varieties.

Table 30. Different operations conducted and yield of Potato under on-farm verification trial FSRD site Tarakandi, Sherpur during the year of 2018-2019

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (ha)	Yield (t ha ⁻¹)
Potato	BARI Alu-35 BARI Alu-36 BARI Alu-37 BARI Alu-40 BARI Alu-41	27.11.2019	19.02.2020- 20.02.2020	01	0.5	40.62

Production program

Activity-16-35: Production a. iv. with modern varieties of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajodhpur, Rangpur

Different crop management, variety used, number of farmers involved in the production program of Mustard, Tomato and Potato is given in Table 31.

Table 31. Different operations conducted for production program at FSRD site Ajoddhapur, Rangpur

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/transplanting	Date of harvesting
Mustard	BARI Sarisha-14	6	1	21-28 Nov.	27-28 Feb.
	BARI Sarisha-18	2	1	20-30 Nov.	7-8 March
Tomato	BARI Tomato-15	3	0.5	16-18 Nov.	15 Feb-09 March
Potato	BARI Alu-25	7	1.4	28-30 Nov.	27Feb.-05 March
	BARI Alu-53	5	1	30 Nov-10 Dec	04-10March

a. Production program of BARI released Mustard variety

The seed yield of Mustard variety BARI Sarisha-14 was 1.75 and 1.50 t ha⁻¹ and the gross margin was calculated Tk. 44138 and 35695 ha⁻¹ in 2018-19 and 2019-20, respectively (Table 32a). BARI Sarisha-18 produced 1.59 t ha⁻¹ seed yield in 2019-20 with the gross margin Tk.40258 ha⁻¹. The average seed yield gross margin of Mustard was 1.61 t ha⁻¹ and Tk. 40030 ha⁻¹, respectively.

Table 32a. Yield of Mustard variety at FSRD site, Ajoddhapur, Rangpur during the years of February 2018 to January 2021.

Year	Variety	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk. ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
				Grain	Straw	Total		
2018-19	BARI Sarisha-14	1.75	1.9	72188	1900	74088	29950	44138
2019-20	BARI Sarisha-14	1.50	1.82	61875	1820	63695	28000	35695
2019-20	BARI Sarisha-18	1.59	2.67	65588	2670	68258	28000	40258
Average	-	1.61	2.13	66550	2130	68680	28650	40030

Market price of output (Tk. Kg⁻¹): Seed=41.25 and Stover =1.00.

b. Production program of BARI released Tomato varieties

BARI Tomato-15 and BARI Tomato-18 seedlings were produced and supplied by the LSP to other farmers, who was bought it at reduced price. The fruit yield of BARI Tomato15 was 88.00 and 76.54 t ha⁻¹ and gross margin was calculated Tk. 662000 and 560400 ha⁻¹ during the year of 2018-19 and 2019-20, respectively (Table 32b). BARI Tomato-18 produced 82.32 t ha⁻¹ fruit yield with gross margin Tk. 618200 ha⁻¹ in 2019-20. The average fruit yield and gross margin were 82.29 t ha⁻¹ and Tk. 613533 ha⁻¹, respectively.

Table 32b. Yield of Tomato variety at FSRD site, Ajoddhapur, Rangpur during the years of February 2018 to January 2021.

Year	Variety	Fruit yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
			Fruit	Straw	Total		
2018-19	BARI Tomato-15	88.00	880000	-	880000	218000	662000
2019-20	BARI Tomato-15	76.54	765400	-	765400	205000	560400
2019-20	BARI Tomato-18	82.32	823200	-	823200	205000	618200
Average	-	82.29	822867	-	822867	209333	613533

Market price of output (Tk. kg⁻¹): Tomato=10.

c. Production program of BARI released Potato varieties

BARI Alu-53 and BARI Alu-25 were produced during the year of 2018-19, 2019-20 and 2020-21. The tuber yield of BARI Alu-53 and BARI Alu-25 were 29.62 and 30.12 t ha⁻¹ and gross margin was calculated Tk. 170200 and 174200 ha⁻¹ in 2018-19 and 2019-20, respectively (Table 32c). The average tuber yield and gross margin were 29.87 t ha⁻¹ and Tk.172200 ha⁻¹, respectively.

Table 32c. Yield of Potato variety at FSRD site, Ajoddhapur, Rangpur during the years of February 2018 to January 2021.

Year	Variety	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
			Tuber	Straw	Total		
2018-19	BARI Alu-53	29.62	296200	-	296200	126000	170200
2019-20	BARI Alu-25	30.12	301200	-	301200	127000	174200
Average	-	29.87	298700	-	298700	126500	172200

Market price of output (Tk. kg⁻¹): Potato=10.

FSRD site, Ganggarampur, Pabna

The production program on Wheat, Garlic, Onion, Mustard, Lentil, Sesame and Turmeric was conducted at FSRD site, Ganggarampur, Pabna during the years of 2018 to 2021. The number of cooperator farmers, area coverage, date of sowing/planting and date of harvesting is presented in Table 33. The variety BARI Gom-28, BARI Rashun-2 and BARI Piaz-2, BARI Sarisha-17, BARI Masur-8 and BARI Halud-4 was used in the production program. The average yield of Wheat was 4.12 t ha⁻¹ with gross margin of Tk. 24000 ha⁻¹. The average yield of Garlic was 8.75 t ha⁻¹ with gross margin of Tk. 96250 ha⁻¹. The average yield of Onion was 12.50 t ha⁻¹ with gross margin of Tk. 6500 ha⁻¹. (Table 34a). The production program of Mustard (var. BARI Sarisha-17), Lentil (var. BARI Masur-8) and Turmeric (var. BARI Halud-4) was conducted during the year of 2019-20 and continuing at rabi season of 2020. The average seed yield of Mustard was 1.95 t ha⁻¹ with gross margin of Tk. 42062 ha⁻¹ (Table 34b). The average seed yield of Lentil was 1.58 t ha⁻¹ with gross margin of Tk. 71500 ha⁻¹ (Table 34c). The average rhizome yield of Turmeric was 14.50 t ha⁻¹ with gross margin of Tk. 119750 ha⁻¹ (Table 34d). The production program of Sesame (var. BARI Til-4) was conducted during the year of 2019-20. The average seed yield of Sesame was 1.5 t ha⁻¹ with gross margin of Tk. 38700 ha⁻¹ (Table 34e).

Table 33. Different operations conducted for production program at FSRD site, Ganggarampur, Pabna during the years of 2018 to 2021.

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ planting	Date of harvesting
Wheat	BARI Gom-28	2	0.5	20-26 Nov	26-28 Mar
Garlic	BARI Roshun-2	2	0.5	25-27 Nov	15-17 Mar
Onion	BARI Piaz-2	1	0.2	22-25 Dec	25-30 Mar
Mustard	BARI Sarisha-17	95	20	25-29 Nov	03-7 Mar
Lentil	BARI Masur-8	30	7	02-6 Dec	15-20 Mar
Sesame	BARI Til-4	12	2.5	15-20 March	01-5 June
Turmeric	BARI Halud-4	3	0.2	22-24 May	28-30 Dec

Table 34a. Performance of Wheat, Garlic and Onion at FSRD site, Ganggarampur, Pabna during the year of 2018-2019.

Crop	Variety	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Cost of Production (t ha ⁻¹)	Gross margin (t ha ⁻¹)
Wheat	BARI Gom-28	4.12	4.45	82500	58500	24000
Garlic	BARI Roshun-2	8.75	-	218750	122500	96250
Onion	BARI Piaz-2	12.50	-	187500	122500	6500

Unit Price (Tk. Kg⁻¹): Wheat grain = 20, Garlic = 25, Onion = 15

Table 34b. Performance of Mustard at FSRD site, Ganggarampur, Pabna during the year of 2019-2020.

Year	Variety	Seed yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Cost of Production (t ha ⁻¹)	Gross margin (t ha ⁻¹)
Feb. 2019 to Jan 2020	BARI Sarisha-17	1.95	95062	53000	42062
Feb. 2020 to Jan. 2021	BARI Sarisha-17	1.92	86400	53200	33200

Unit Price: Mustard = 45

Table 34c. Performance of Lentil at FSRD site, Ganggarampur, Pabna during the year of 2019-2020.

Year	Variety	Yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Cost of Production (t ha ⁻¹)	Gross margin (t ha ⁻¹)
Feb. 2019 to Jan. 2020	BARI Masur-8	1.58	110600	33500	77100
Feb. 2020 to Jan. 2021	BARI Masur-8	1.60	112000	33500	78500

Unit Price: Lentil= 70

Table 34d. Performance of Turmeric at FSRD site, Ganggarampur, Pabna during the year of 2018-2019.

Year	Variety	Yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Cost of Production (t ha ⁻¹)	Gross margin (t ha ⁻¹)
Feb. 2019 to Jan. 2020	BARI Halud-4	14.50	290000	170250	119750
Feb. 2020 to Jan. 2021	BARI Halud-4	14.55	291000	170250	120750

Unit Price: Turmeric=20 Tk. kg⁻¹.

Table 34e. Performance of Sesame at FSRD site, Ganggarampur, Pabna during the year of 2019-20.

Crop	Variety	Grain yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (t ha ⁻¹)
Sesame	BARI Til-4	1.5	77000	38300	38700

FSRD Site, Sholakundu, Faridpur

Different BARI released 15 crop varieties were used for conduction production program during the years of 2018 to 2021. A total of 51 farmer's field including 4.7 ha of land were used (Table 35).

Table 35. Production program conducted during the years of 2018 to 2021

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-14	3	0.24	8-15 Nov 18	6-12 Feb 19
	BARI Sarisha-18	3	0.3	30 Nov. -3 Dec. 19	9-11 Mar. 2020
Wheat	BARI Gom-28	4	0.4	30 Nov. -2 Dec. 18	24-25 Mar 19
	BARI Gom-33	3	0.4	30 Nov. -8 Dec. 19	19-27 Mar 20
Mungbean	BARI Mung-6	2	0.16	5 Mar 19	12-27 May 19 (2 picking)
	BARI Mung-8	3	0.24	1-2 March 2020	9-10 May 2020 (1 picking)
Sesame	BARI Til-4	3	0.24	8-12 Mar 19	1-3 Jun 19
	BARI Til-4	4	0.25	19-25 March 20	15-22 June, 20
Lentil	BARI Masur-8	3	0.3	28 Nov.-3 Dec. 19	20-22 Mar 2020
	BARI Masur-8	4	0.25	19 Nov-3 Dec 20	--
Onion	BARI Piaj-1	3	0.3	4-14 Jan. 2020	24-31 Mar. 2020
	BARI Piaj-4	3	0.3	1-10 Jan. 20	24-31 Mar. 2020
	BARI Piaj-1	4	0.5	30 Dec. 20-10 Jan 21	--
	BARI Piaj-4	4	0.5	30 Dec. 20-10 Jan 21	--
Bottle gourd	Hybrid	1	0.06	25 Jul. 20	25 Sep-20 Nov 20
Summer Tomato	BARI Hybrid Tomato-11	1	0.012	16 Aug. 20	7-31 Oct. 20
Black gram	BARI Mash-3	2	0.2	17 Sep. 20	3 Dec. 20
Intercropping of Radish+Onion bulb+Red amaranth with Sugarcane	Radish (BARI Mula-1), Onion (BARI Piaj-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	1	0.06	Sugarcane: 28 Oct 19 Radish + Onion + Red amaranth: 1 Nov 2019	Sugarcane: 5-18 Oct. 20 Radish: 1-5 Jan. 2020 Onion: 5-10 Jan. 2020 Red amaranth: 4-5 Dec. 2019

Mustard: BARI Sarisha-14 and 18 were used during the year of 2018-19 and 2019-20, respectively. The seed was sown on 8-15 Nov 2018 (BARI Sarisha-14) and 30 Nov -3 Dec 2019 (BARI Sarisha-18). A total of 0.54 ha of land with six farmers were selected. The fertilizers were applied @ 120-36-40-15-2-1 kg of N-P-K-S-Zn-B ha⁻¹. The crop was harvested on 6-12 Feb 2019 and 9-11 Mar 2020. The yield of BARI Sarisha-14 was 1.76 t ha⁻¹ with gross margin Tk. 27070 ha⁻¹ (Table 36a). BARI Sarisha-18 produced 1.71 t ha⁻¹ seed yield with 2.67 t ha⁻¹ stover yield. Gross margin of BARI Sarisha-18 was 35% higher than that of BARI Sarisha-14. Average seed yield, gross return and gross margin was 1.74 t ha⁻¹, Tk. 82080 ha⁻¹ and Tk. 31843 ha⁻¹.

Farmers opined positive to the new variety BARI Sarisha-14 and 18 for its higher seed yield and negligible pest infestation. A good number of seed has been stored by the farmers for growing in the next year. Shattering tendency of seed in BARI Sarisha-18 was observed. Plant height was higher than that of BARI Sarisha-14 resulting lodging.

Wheat: BARI Gom-28 and BARI Gom-33 were used during the year of 2018-19 and 2019-20, respectively. The seed was sown on 30 Nov-2 Dec 2018 (BARI Gom-28) and 30 Nov -8 Dec 2019 (BARI Gom-33). A total of 0.80 ha of land with seven farmers were selected. The fertilizers were applied @ 160-30-60-15-3-1 kg of N-P-K-S-Zn-B ha⁻¹. Two-third of N and full amount of P, K, S, Zn and B were applied as basal during final land preparation. The remaining one-third of N was applied at 20-25 DAS. The crop was irrigated twice (20-25 and 55-65 DAS). Nativo was sprayed at 55-60 DAS and 70-75 DAS. The crop was harvested during 24-25 March 2019 and 19 to 27 March 2020. The grain yield of BARI Gom-28 was 3.81 t ha⁻¹. Gross margin was calculated Tk. 26542 ha⁻¹ (Table 36b). BARI Gom-33 produced 3.95 t ha⁻¹ grain yield. Gross margin of BARI Gom-33 was 7% higher than that of BARI Gom-28. Average grain yield, gross return and gross margin was 3.88 t ha⁻¹, Tk. 88287 ha⁻¹ and Tk. 27474 ha⁻¹.

Farmers' opined that grain color of BARI Gom-33 was attractive and shiny. Plants remain greenish even at the time of mature stage resulting lower lodging. Farmers are happy with that cultivar due to higher yield and blast resistant over their existing varieties.

Mungbean: BARI Mung-6 and BARI Mung-8 were used during the years of 2019 and 2020, respectively. The seed was sown on 5 March 2019 (BARI Mung-6) and 1-2 March 2020 (BARI Mung-8). A total of 0.40 ha of land with five farmers were selected. The fertilizers were applied @ 24-32-24-18-2-1 kg of N-P-K-S-Zn-B ha⁻¹. All fertilizer was applied as basal during final land preparation. One irrigation (29-30 DAS) and one hand weeding (26-28 DAS) were done. The crop was harvested during 12-27 May 2019 with 2 picking and 9 to 10 May 2020 (one picking). The seed yield of BARI Mung-6 was 0.76 t ha⁻¹ with gross margin in Tk. 9988 ha⁻¹ (Table 36c). BARI Mung-8 produced 0.69 t ha⁻¹ seed yield. Gross margin of BARI Mung-8 was 137% higher than that of BARI Mung-6. During 2nd year, seed price was higher @ Tk. 17.50 kg⁻¹ than first year and one picking was happened. Average seed yield, gross return and gross margin was 0.73 t ha⁻¹, Tk. 51350 ha⁻¹ and Tk. 16838 ha⁻¹.

Farmers were happy for getting higher price from BARI Mung-8 because of yellow seed coat color over BARI Mung-6.

Sesame: A production program was conducted with BARI Til-4 at the FSRD site, Faridpur during Kharif I, 2019 and 2020. A total of 0.49 ha of land with seven farmers were selected. The seed was sown on 8-12 March 2019 and 19-25 March 2020. The fertilizers were applied @ 100-40-40-20-3-3 kg of N-P-K-S-Zn-B ha⁻¹. Half N and all amount of P, K, S, Zn and B was applied as basal during final land preparation. Rest N was applied as top dress at 25-27 DAS under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Irrigation and hand weeding were done when as necessary. The crop was harvested during 1-3 Jun 2019 and 15-22 Jun 2020. The seed yield obtained from BARI Til-4 was 1.83 t ha⁻¹ and 1.34 t ha⁻¹ during the year of 2019 and 2020, respectively (Table 36d). Gross margin of BARI Til-4 during 2nd year was Tk. 46093 ha⁻¹ which was lower than that of 1st year gross margin (Tk. 85255 ha⁻¹). This was due to lower seed yield during 2nd year for heavy rainfall at seed formation stage. Average seed yield, gross return and gross margin was 1.59 t ha⁻¹, Tk. 105607 ha⁻¹ and Tk. 65674 ha⁻¹.

Farmers were happy for getting higher yield from BARI Til-4 with higher price. They were disappointed for getting poor yield due to unexpected heavy rainfall was occurred during seed formation stage. Almost all plant was harvested before maturity of seed. Farmers demanded black colored seed variety of Sesame due to Tk.25 kg⁻¹ more selling price of black seed than BARI variety (reddish colored seed)

Lentil: A production program with BARI Masur-8 was conducted during the *rabi* 2019-20 and 2020-21. A total of seven co-operator farmers were considered. A total of 0.55 ha of land was used. The seed was sown on 28 Nov to 3 Dec 2019 and 19 Nov to 3 Dec 2020. The crop was fertilized with 28-24-14-9-2-1 kg of N-P-K-S-Zn-B ha⁻¹ in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate, boric acid, respectively. All fertilizers were applied as basal. Provex and know in (carbendazim) were applied at 22-25 DAS. Amistar top (1 ml litre⁻¹) was applied at 70-75 DAS as preventive measure against Stemphyllium blight disease. BARI Masur-8 was harvested during the year of 20-22 March 2020. Second year Lentil is under vegetative condition. The seed yield obtained from BARI Masur-8 was 1.76 t ha⁻¹ (Table 36e). The gross return and gross margin of BARI Masur-8 was Tk. 127600 ha⁻¹ and Tk. 84370 ha⁻¹. Farmers stored different amount of seeds.

Farmers showed interest to BARI Masur-8 variety because of its higher yield potentiality and enriched iron and zinc. A good number of seed for BARI Masur-8 has been stored by the farmers for growing in the next year.

Onion: A production program of BARI Piaz-1 and BARI Piaz-4 was conducted at the FSRD site, Faridpur during the *rabi* 2019-20 and 2020-21. The program was conducted in about 0.6 ha of land. A total of six farmers were selected. Seedling was transplanted on 1-14 Jan 2020 and for second year, seedling will be transplanted on 30 Dec 2020 to 10 Jan 2021 both the varieties. The crop was fertilized with 140-60-60-30-3-1.5 kg of N-P-K-S-Zn and B ha⁻¹ in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N and K will be applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 25-30 DAT and 50-55 DAT under moist soil condition and mixed thoroughly with the soil. Pesticides named Rovral, Ridomil, Amister top, Confidor, karate were sprayed. Onion varieties were harvested during 24-31 March 2020 (Table 36f). The bulb yield of BARI Piaz-4 (16.22 t ha⁻¹) was 38% higher than that of BARI Piaz-1 (11.76 t ha⁻¹). Gross margin of BARI Piaz-1 and BARI Piaz-4 were Tk. 260335 ha⁻¹ and Tk. 368925 ha⁻¹, respectively.

Farmers opined positively to the BARI Piaz-4 for its higher bulb yield. Next cropping season, they will cultivate BARI Piaz-4 variety covering large area.

Bottle gourd: A production program with imported hybrid was conducted during the *Kharif II* 2020. A total of 0.06 ha of land was used in one farmer's field. The seedling was transplanted on 25 July 2020. The crop was fertilized with 80-45-87-25-4-2-5000 kg of N-P-K-S-Zn -B and Cowdung ha⁻¹. Full amount of Cowdung, P, S, Zn, B and 1/3rd of K was applied during pit preparation at least 7 days before transplanting. N and the remaining K were applied in 4 equal installments at 20, 40, 60 and 80 days after transplanting. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. The Bottle gourd was harvested during 25 Sep to 20 Nov 2020. Fruit yield of Hybrid Bottle gourd was 13.60 t ha⁻¹. The gross return and gross margin were Tk. 231200 ha⁻¹ and Tk. 123200 ha⁻¹, respectively (Table 36g).

Farmers were satisfied with Hybrid variety due to its higher yield, market price and taste.

Summer Tomato: A production program with imported hybrid was conducted during the *kharif II* 2020. A total of 0.012 ha of land was used in one farmer's field. The seedling was transplanted on 16 August 2020. The fertilizer was applied @ 104, 45, 64, 24, 2.7 and 1.3 kg ha⁻¹ as N, P, K, S, Zn and B, respectively. 2 t ha⁻¹ vermicompost was also applied. Four times irrigation was applied at 1, 15, 44 and 74 DAP. Half of organic fertilizer and all of P, S, Zn and B was applied as basal during final land preparation. Remaining organic manure was applied in pits before planting of seedling. One third of N was applied at 15 DAP as ring method. Rest one third N and half of K Soil was applied at 44 and 74 DAP, respectively as ring method. No weeding was done because of providing polymulch. Two times fungicides with Autostin and Ridomilgold at 10 and 20 DAP, respectively. Bio control measures like sex pheromone trap and yellow skicky was applied at 37-39 DAP. Two times insecticides with Imitaf

and Pegasus was applied at 28 and 38 DAP, respectively. The Tomato was harvested during 7-31 Oct 2020. Fruit yield of BARI Hybrid Tomato-11 was 5.50 t ha⁻¹. The gross return and gross margin were Tk. 605000 ha⁻¹ and Tk. 159460 ha⁻¹, respectively (Table 36h).

Farmers' opined that it was first time cultivation with BARI Hybrid Tomato-11 to their life. Farmers became interested to cultivate BARI Hybrid Tomato-11 for its lucrative shape and higher market price.

Blackgram: A production program without ploughing (zero tillage) BARI Mash-3 was done at the FSRD site, Faridpur during the *kharif II* 2020. A total of 02 co-operator farmers were selected having a total of 0.2 ha of land. Seeds were sown during 17 September 2020. All fertilizers were applied @ 20-18-20-10-1.8 N-P-K-S-B kg ha⁻¹ before seed sowing. BARI Mash-3 was harvested during 3rd December 2020. The seed yield obtained from BARI Mash-3 was 1.12 t ha⁻¹ (Table 36i). The gross return and gross margin of BARI Mash-3 was Tk. 67200 ha⁻¹ and Tk. 43050 ha⁻¹.

Farmers showed interest to BARI Mash-3 for its lower cost of production and higher market value. A good amount of seed of BARI Mash-3 has been stored by the farmers for growing in the next year.

Table 36a. Yield and economics of BARI released Mustard variety during the years of February 2018 to January 2020

Year	Variety	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2018-19	BARI Sarisha-14	1.76	2.10	79200	52130	27070
2019-20	BARI Sarisha-18	1.71	2.67	84960	48345	36615
Average	--	1.74	2.39	82080	50237	31843

Average market price of output (Tk.kg⁻¹): Seed: 43.75, Stover: 2.55

Table 36b. Grain yield, cost and return of Wheat at FSRD site during the years of 2018 to 2020

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2018-19	BARI Gom-28	3.81	85725	59183	26542
2019-20	BARI Gom-33	3.95	90850	62444	28406
Average	--	3.88	88287	60813	27474

Average market price of output (Tk.kg⁻¹): Seed: 22.75

Table 36c. Seed yield, cost and return of Mungbean at FSRD site during the year of 2019 to 2020

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2019	BARI Mung-6	0.76	47500	37512	9988
2020	BARI Mung-8	0.69	55200	31512	23688
Average	--	0.73	51350	34512	16838

Average market price of output (Tk.kg⁻¹): Seed: 71.75

Table 36d. Seed yield, cost and return of Sesame at FSRD site during the year of 2019 and 2020

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2019	BARI Til-4	1.83	123630	38375	85255
2020	BARI Til-4	1.34	87585	41492	46093
Average	--	1.59	105607	39933	65674

Average market price of output (Tk.kg⁻¹): Seed: 66.00

Table 36e. Seed yield, cost and return of Lentil at FSRD site during the years of 2019-20 and 2020-21

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2019-20	BARI Masur-8	1.76	123200	43230	79970
2020-21	BARI Masur-8	1.79	125300	43230	82070
Average	--	1.78	124250	43230	81020

Average market price of output (Tk.kg⁻¹): Seed: 70.00

Table 36f. Bulb yield, cost and return of Onion at FSRD site during the years of 2019-20 to 2020-21

Year		Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2019-20	BARI Piaz-1	11.76	411600	151265	260335
	BARI Piaz-4	16.22	527150	158225	368925
2020-21	BARI Piaz-1	11.50	402500	151265	251235
	BARI Piaz-4	16.80	546000	158225	387775
Average	BARI Piaz-1	11.63	407050	151265	255785
	BARI Piaz-4	16.51	536575	158225	378350

Market price of output (Tk.kg⁻¹): Bulb: 35.00 (BARI Piaz-1), 32.50 (BARI Piaz-4)

Table 36g. Fruit yield, cost and return of Bottle gourd at FSRD site during the year of 2020-21

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2020	Hybrid	13.60	231200	108000	123200

Market price of output (Tk.kg⁻¹): Fruit: 17.00

Table 36h. Fruit yield, cost and return of summer Tomato at FSRD site during the year of 2020-21

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2020	BARI Hybrid Tomato-11	5.50	605000	445540	159460

Market price of output (Tk.kg⁻¹): Fruit: 110.00

Table 36i. Seed yield, cost and return of black gram at FSRD site during the year of 2020-21

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2020	BARI Mash-3	1.12	67200	24150	43050

Market price of output (Tk.kg⁻¹): Seed: 60.00

Intercropping of Radish + Onion bulb + Red amaranth with chewing type Sugarcane: A production program of intercropping of Radish + Onion bulb + Red amaranth with chewing type Sugarcane was conducted during the year of 2019-20. A total of 0.06 ha of land was used in one farmer's field. The Sugarcane sett was planted on 28 Oct 2019. Radish, Onion bulb and Red amaranth were sown on 1 Nov 2019. The Sugarcane crop was fertilized with 230-100-750-45-4-2 kg ha⁻¹ N-P-K-S-Zn-B. For Onion sett bulb and Radish production, 50% of recommended dose of Onion (140-60-60-30-3-1.5 kg ha⁻¹ N-P-K-S-Zn-B) and Radish (180-60-80-18-3 kg ha⁻¹ N-P-K-S-Zn) were used. 25% of 100-24-20-9 kg ha⁻¹ N-P-K-S was used for Red amaranth production. Sugarcane was harvested on 5-18 Oct 2020. Radish, Onion and Red amaranth were harvested on 1-5 Jan 2020, 5-10 Jan 2020 and 4-5 Dec 2019, respectively. The yield of Sugarcane, Radish, Onion bulb and Red amaranth was 91.86 t ha⁻¹ (57500 piece), 16.15 t ha⁻¹, 2.85 t ha⁻¹ and 2.25 t ha⁻¹, respectively. The gross return of Sugarcane, Radish, Onion and Red amaranth was Tk. 862500 ha⁻¹, Tk. 80750 ha⁻¹, Tk. 256500 ha⁻¹, Tk. 36000 ha⁻¹. The total gross return and gross margin was Tk. 1235750 ha⁻¹ and Tk. 866012 ha⁻¹ (Table 37).

Farmers showed interest to cultivate chewing type Sugarcane with different vegetables and spices. Intercropping of Onion with Sugarcane was found profitable.

Table 37. Yield, cost and return of different crops at FSRD site during the year of 2019-2020

Year	Variety	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
2019-20	Radish (BARI Mula-1), Onion (BARI Piaz-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	Sugarcane: 91.86 (57500 piece), Radish: 16.15 Onion bulb: 2.85 Red amaranth: 2.25	1235750 (Sugarcane: 862500, Radish: 80750, Onion: 256500, Red amaranth: 36000)	369738	866012

Market price of output (Tk.kg⁻¹): Sugarcane: 15.00 per piece, Radish: 5.00, Onion: 90.00 and Red amaranth: 16.00

FSRD Site, Atia, Tangail

Mustard: The Production program was conducted in the farmer's field of the FSRD site, Atia, Delduar, Tangail during rabi season of 2018-1920, 2019-20 and 2020-2021 for increasing area and production of Mustard. The variety viz. BARI Sarisha-14 and BARI Sarisha-17 were used in this production program. The number of cooperators farmers of BARI Sarisha-14 were 29 covered by 5.53 ha of land

and BARI Sarisha-17 were 25 covered by 3.90 ha of land. The seeds of BARI Sarisha-14 were sown on 14-24 November and BARI Sarisha-17 was 16-24 November at the rate of 6 kg seed ha⁻¹. The crop was harvested during 3-11 February and 5-12 February, respectively (Table 38). The average yield of BARI Sarisha-14 was 1.57 t ha⁻¹ and BARI Sarisha-17 was 1.65 with gross margin in Tk.34114 and Tk. 37531 ha⁻¹, respectively (Table 39a). Rovral 50WP was sprayed twice to control Alternaria leaf blight and white mould diseases. Farmers reacted positively and were satisfied with higher seed yield economic return than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Barley: The Production program was conducted in the farmer's field of the FSRD site, Atia, Delduar, Tangail during rabi season of 2018-19 and 2019-20 for increasing area and production of Mustard. The variety viz. BARI Barley-6 and BARI Barley-7 were used in this production program. The number of cooperators farmers were 15 covered by 2.26 ha of land. The seeds were sown on 20-26 November at the seed rate of 120 kg ha⁻¹. The crop was harvested during 7-14 March (Table 38). The average yield of BARI Barley-6 was 1.97 t ha⁻¹ and BARI Barley-7 was 2.05 with gross margin in Tk.23408 and Tk. 25448 ha⁻¹, respectively (Table 39b). No remarkable pest and disease infestation was observed in the field during the crop period. Farmers showed their interest in new and promising BARI barley varieties due to awn less, higher yield, less disease infection and benefit than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Potato: BARI Alu-41 was cultivated among five farmers covered by 1.40 ha of land to popularize Potato variety among the farmers and increase yield and economic return of the farmers. Seeds were sown on 21-25 November 2019 at the @ 1600 kg ha⁻¹ of seeds and harvested during 17-19 February 2020 (Table 38). For controlling vector admire was sprayed twice and to prevent late of Potato, wilt and other fungal diseases Indofil-M 45 was sprayed 3 times in the field. BARI Alu-41 produced tuber yield 31.57 t ha⁻¹ with gross margin in Tk. 174037 (Table 39c). Farmers showed their interest in new and promising Potato variety due to higher yield, less disease infection and higher benefit than local variety.

Table 38. Different operations conducted for production program at FSRD site, Atia, Tangail during the years of 2018 to 2021

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/transplanting	Date of harvesting
Mustard	BARI Sarisha-14	29	5.53	14-24 Nov.	03-11 February
	BARI Sarisha-17	25	3.90	16-24 Nov.	5-12 February
Barley	BARI Barley-6	8	1.15	20-26 Nov.	15 Feb-09 March
	BARI Barley-7	7	1.11		
Potato	BARI Alu-41	21	2.92	25Nov.- 04 Dec	20- 27Feb.

Table 39a. Yield of Mustard varieties at FSRD site Atia, Tangail during the year of February to January 2021

Year	Variety	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (t ha ⁻¹)	Cost of Production (t ha ⁻¹)	Gross margin (t ha ⁻¹)
Feb. 2018 to Jan 2019	BARI Sarisha-14	1.55	2.32	72070	39402	32668
	BARI Sarisha-17	1.66	2.45	77150	39402	37748
Feb. 2019 to Jan 2020	BARI Sarisha-14	1.59	2.42	73970	38407	35563
	BARI Sarisha-17	1.63	2.37	75720	38407	37313
Feb. 2020 to Jan. 2021	BARI Sarisha-14	1.60	2.45	74450	39402	35048
	BARI Sarisha-17	1.65	2.40	76650	39402	37248
Average	BARI Sarisha-14	1.58	2.40	73497	39070	34426
	BARI Sarisha-17	1.65	2.41	76507	39070	37436

Unit Price: Mustard seed =45 and stover=1.00

Table 39b. Yield of Barley varieties at FSRD site Atia, Tangail during the years of February 2018 to January 2020

Year	Variety	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Feb. 2018 to Jan 2019	BARI Barley-6	1.95	191	50660	30875	19785
	BARI Barley-7	1.98	1.88	51380	30875	20505
Feb. 2019 to Jan 2020	BARI Barley-6	1.99	1.85	51600	24570	27030
	BARI Barley-7	2.12	1.96	54960	24570	30390
Average	BARI Barley-6	1.97	1.88	51130	27723	23408
	BARI Barley-7	2.05	1.92	53170	27723	25448

Barley grain price = Tk. 20.00 kg⁻¹ and Straw price= Tk. 1.00 kg⁻¹

Table 39c. Yield of BARI Alu-41 at FSRD site, Atia, Tangail during the years of February 2019 to January 2021

Year	Variety	Tuber yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Feb. 2019 to Jan 2020	BARI Alu-41	31.57	315700	141663	174037
Feb. 2020 to Jan. 2021	On-going				

Tuber price= Tk. 10.00 kg⁻¹

FSRD Site, Tarakandi, Sherpur

Mustard: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2018-19 for increasing area and production of Mustard. The variety viz. BARI Sarisha-14 was used in this production program. The number of cooperators farmers of BARI Sarisha-14 was 1 covered by 0.5 ha of land. The seeds of BARI Sarisha-14 were sown on 03-06 November. The crop was harvested during 21-22 January (Table 40). The average yield of BARI Sarisha-14 was 1.37 t ha⁻¹ with gross margin in Tk.31510 (Table 41a). Rovral 50WP was sprayed twice to control Alternaria leaf blight and white mould diseases. Farmers opined positively and were satisfied with higher seed yield and economic return than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Okra: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2019-20 for increasing area and production of Okra. The variety viz. Hybrid Shakti was used in this production program. The number of cooperators farmers of Hybrid Shakti was 1 covered by 0.1 ha of land. The seeds of Hybrid Shakti were sown on 15-18 March. Harvesting of Okra started from 1st May and it was continued up to 25th May (Table 40). The average yield of Hybrid Shakti was 28.82 t ha⁻¹ with gross margin in Tk.144590 (Table 41b). Systemic insecticides were sprayed twice at pre fruit setting stage to control white fly and other sucking insects. Farmers were satisfied with higher fruit yield and economic return than local variety.

Potato: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2019-202 for increasing area and production of Potato. The variety viz. BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40 and BARI Alu-41 were used in this production program. The number of cooperators farmers of Potato varieties was 1 and covered 0.5 ha of land. The tuber of Potato was sown on 28-30 November. The crop was harvested during 19-20 February (Table 40). The average tuber yield of Potato was 40.62 t ha⁻¹ with gross margin in Tk .312298 (Table 41c). Dithane-M 45 and Ridomil gold was sprayed to control late blight disease. Farmers were satisfied with higher tuber yield and economic return.

Table 40. Different operations conducted for production program at FSRD site, Tarakandi, Sherpur.

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-14	1	0.5	03-06 Nov.	21-22 Jan.
Okra	Hybrid variety shakti	1	0.1	15-18 March	1-25 May
Potato	BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41	1	0.5	28-30 Nov.	19-20 Feb.

Table 41a. Yield of Mustard variety at FSRD site, Tarakandi, Sherpur during the year of 2018-2019.

Year	Variety	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Grain	Straw	Total		
2018-19	BARI Sarisha-14	1.37	1.81	57540	3620	61160	29650	31510

Market price of output (Tk. Kg⁻¹): Seed=42 and Stover=2.00.

Table 41b. Yield of Okra variety at FSRD site, Tarakandi, Sherpur during the year of 2019-2020.

Year	Variety	Fruit yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Fruit	Straw	Total		
2019-20	Hybrid Shakti	28.82	-	345840	-	345840	201250	144590

Market price of output (Tk. Kg⁻¹): Okra=12.

Table 41c. Yield of Potato variety at FSRD site, Tarakandi, Sherpur during the year of 2019-2020.

Year	Variety	Tuber yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)			Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Tuber	Stover	Total		
2019-20	BARI Alu-35	40.06	-	480720	-	480720	175190	35530
	BARI Alu-36	41.35	-	496200	-	496200	175190	321010
	BARI Alu-37	44.26	-	531120	-	531120	175190	355930
	BARI Alu-40	40.22	-	482640	-	482640	175190	307450
	BARI Alu-41	37.23	-	446760	-	446760	175190	271570
<i>Average</i>	-	40.62	-	487488	-	487488	175190	312298

Market price of output (Tk. Kg⁻¹): Potato=12.

C. LIVESTOCK SYSTEM

I. Vaccination program on Cattle

Activity-36: Effect of vaccination and deworming on cattle at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Number of livestock under vaccination program, name of the vaccine applied to the selected cattle, dates of vaccination are presented in Table 42. In an about 224 numbers of cattle including buffalo, Cow, ox, calf and Goat were vaccinated.

Frequency of diseases was listed among the cooperative farmers. It was found that, before vaccination frequency of different diseases was higher. After vaccination of cattle, all of the disease's frequency reduced (Table 42).

This technology was easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested and adopted this technology as per routine work.

Table 42. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Ajoddhapur, Rangpur during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of livestock Vaccinated		Percentage of disease frequency (%)	
		Cattle	Goat	Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax, PR, FMD	48	2	15-34	4-7
Feb 2019-Jan.2020	Anthrax, PR, BQ, FMD	110	12	15-34	3-4
Feb 2020- Dec.2020	Anthrax, PR, BQ, FMD	62	10	15-34	2-4
<i>Total</i>	<i>Anthrax, PR, BQ, FMD</i>	<i>220</i>	<i>24</i>	<i>15-34</i>	<i>2-7</i>

FSRD site, Ganggarampur, Pabna

Vaccination technology was found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested and adopted this technology as per routine work. Table 43 shows the information on number of cattle under vaccination program, name of the vaccine applied to the selected cattle and dates of vaccination. Total number of livestock brought under vaccination program was 438 at FSRD site, Ganggarampur, Pabna during the years of 2018 to 2021. Percentage of mortality before and after vaccination was recorded among the cooperator farmers. It was found that before vaccination mortality rate of cattle was higher (5-10%). After vaccination of cattle, all of the diseases frequency reduced drastically, and mortality rate was almost nil or around 2-3%.

Table 43. Mortality (%) of livestock before and after vaccination against major disease at FSRD site during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of livestock vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2018 to Jan 2019	Torka	95	-	-	10	0
	FMD	40	-	-	5	0
Feb 2019 to Jan 2020	Anthrax	77	-	-	5	3
	Paraclear	25	-	-	6	3
	FMD	77	-	-	10	2
Feb 2020 to Dec 2020	Anthrax	49	-	-	6	0
	FMD	45	-	-	9	0
Total		438	-	-	-	-

FSRD Site, Sholakundu Faridpur

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 44. Total number of livestock brought under deworming and vaccination program were 300 in FSRD site, Sholakundu, Faridpur. Livestock diseases (Anthrax and FMD) occurred in the selected areas before and after vaccination was recorded cautiously. It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 13-15 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Mortality rate also decreased (0%). Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 44. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site Sholakundu, Faridpur during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of livestock Vaccinated	Percentage of mortality (%)	
		Cattle	Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax	100	15	0
Feb 2019-Jan.2020	Anthrax	100	13	0
Feb 2020- jan.2021	FMD	100	14	0
Total	Anthrax, FMD	300	13-15	0

FSRD Site, Atia, Tangail

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 45. Total number of livestock brought under deworming and vaccination program were 477 in FSRD site, Atia, Tangail.

Livestock diseases (Anthrax and FMD) occurred in the selected areas before and after vaccination was recorded cautiously. It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 9-12 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Mortality rate also decreased (1-4 %). Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 45. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of livestock Vaccinated		Percentage of mortality (%)	
		Cattle		Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax and FMD	80		9-12	1-2
Feb 2019-Jan.2020	Anthrax and FMD	183		9-12	3-4
Feb 2020- Jan.2021	Anthrax and FMD	214		9-12	2-3
Total	Anthrax and FMD	477		9-12	1-4

FSRD Site, Tarakandi, Sherpur

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 46. Total number of livestock brought under deworming and vaccination program were 228 in FSRD site, Tarakandi, Sherpur during the years of 2018 to 2021. It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 10-15 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 46. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Tarakandi, Sherpur during the years of February 2019 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2019-Jan.2020	Torka	100	50	5	10-15	0
Feb 2019- Jan.2020	PPR	65	5	3	5	0
Total	Torka, PPR	165	55	8	-	-

II. Vaccination program on poultry birds

Activity-37: Effect of vaccination on poultry production at different FSRD sites during the years of 2018 to 2021

FSRD site, Ajoddhapur, Rangpur

Poultry vaccination program was performed at FSRD site, Ajoddhapur, Rangpur during February 2018 to December 2020. Four different types of vaccines (BCRDV, RDV, Duck plague and Pigeon Pox) were provided to 1183 birds (Table 47). It is revealed that, mortality rate can be minimized significantly through vaccination. Mortality rate was reduced and went below 6% in maximum cases which can be considered as negligible comparing to the condition before the vaccination program. Application of RDV vaccine has reduced the mortality rate 47% and application of BCRDV vaccine has reduced the mortality rate 72%. Thus, mortality rate was turned down to tolerable level (Table 47).

Table 47. Mortality (%) of poultry **birds** before and after vaccination against major diseases at FSRD site during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of poultry birds Vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV, RDV	398	46	10	-	14-22	3-4
Feb 2019-Jan.2020	BCRDV, RDV	274	47	24	60	14-22	2-6
Feb 2020- Jan.2021	BCRDV, RDV	136	18	50	120	14-22	2-7
Total	BCRDV, RDV	808	111	84	180	14-22	2-7

FSRD Site, Ganggarampur, Pabna

Vaccination program of chicken was conducted at FSRD site, Ganggarampur, Pabna during February 2018 to January 2021. Table 48 shows the information on number of poultry under vaccination program, name of the vaccine applied to the selected chicken and mortality percentage. The numbers of different types of vaccinated poultry were 450, 300, 100 and 150 in case of BCRDV, RDV, FOWL POX and FOWL COLERA respectively during the year 2018-19 while the number of chickens were 310 and 500 in case of BCRDV and RDV respectively during the year 2019-20. Mortality percentage of poultry birds against different diseases was recorded among the cooperative farmers. It was found that before vaccination mortality (%) of poultry birds due to different diseases was higher (15-30%). After vaccination of poultry, all of the diseases reduced drastically, and mortality rate was recorded about 2-6% (Table 48).

Table 48. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Ganggarampur, Pabna during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of poultry birds vaccinated	Percentage of mortality	
		Chicken	Before	After
Feb 2018 to Jan 2019	BCRDV	450	30	5
	RDV	300	20	4
	Fowl pox	100	20	5
	Fowl cholera	150	15	6
Feb 2019 to Jan 2020	BCRDV	310	20	3
	RDV	500	15	2
Total		1810	-	-

FSRD Site, Sholakundu, Faridpur

Vaccination program of chicken and plague was conducted at FSRD site, Sholakundu, Faridpur during February 2018 to December 2020. Name of the vaccines and number of the poultry are given in Table 49. Name of the vaccines used in the program was BCRDV, RDV and Duck plague. Total 1390 poultry birds and 50 Ducks were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (23-30 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (6-15 %) significantly.

Table 49. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV	150	--	30	10
	Duck plague	--	50	25	0
Feb 2019-Jan.2020	BCRDV	315	--	30	8
	RDV	425	--	25	15
Feb 2020-Jan.2021	BCRDV	200	--	25	4
	RDV	300	--	23	6
Total	BCRDV	665	--	28	1-10
	RDV	725	--	24	6-15
	Duck plague	--	50	23-30	0

FSRD Site, Atia, Tangail

Vaccination program of chicken and Duck was conducted at FSRD site, Atia, Tangail during February 2018 to December 2020. Name of the vaccines and number of the poultry are given in Table 50. Name of the vaccines used in the program was BCRDV, RDV, Fowl Pox Fowl cholera and Duck plague. Total 816 poultry birds and 439 Ducks were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (20-24 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (2-5 %) significantly.

Table 50. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Year of vaccination	Disease considered for vaccination	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	211	85	20-24	2-5
Feb 2019-Jan. 2020	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	319	168	20-24	2-4
Feb 2020-Jan. 2021	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	286	186	20-24	3-5
Total	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	816	439	-	2-5

FSRD Site, Tarakandi, Sherpur

Vaccination program of chicken and Duck was conducted at FSRD site, Tarakandi, Sherpur during February 2018 to December 2020. Name of the vaccines and number of the poultry birds are given in Table 51. Name of the vaccines used in the program was BCRDV, RDV and PPR. Total 634 poultry birds were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (25-30 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (5-10 %) significantly.

Table 51. Mortality (%) of poultry **birds** before and after vaccination against major diseases at FSRD site during the years of February 2018 to January 2021

Year of vaccination	Disease considered for vaccination	No. of poultry birds Vaccinated			Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Before intervention	After intervention
Feb. 2018-Jan. 2019	BCRDV, Gamboro	150	30	10	30	8
Feb. 2019-Jan. 2020	BCRDV	200	30	8	25	5
Feb. 2020-Jan. 2021	RDV, Plague	153	53	-	25-30	8-10
Total	BCRDV, RDV, Plague, Gamboro	503	113	18	-	-

III. Improvement of cattle health by deworming

Activity-38: Improvement of dairy cattle health by deworming and vitamin ADE injection at different FSRD sites during the years of 2018 to 2020

FSRD site, Ajoddhapur, Rangpur

Number of livestock under deworming program, and their performances are presented in Table 52. Fifty cattle were dewormed, forty cattle were dewormed with added vitamin ADE and twenty-eight cattle were control (no deworming). It was found that deworming as well as vitamin ADE supplementation have positive effect on body weight and lactation period increment. Lactation period was increased about 10% due to deworming.

Table 52. Average body weight gain, milk production and lactation period after deworming at FSRD site, Ajoddhapur, Rangpur during the years of 2018 to 2021.

Treatment	No. of animal	Av. body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. Lactation yield (litter day ⁻¹)	Av. Lactation period (day)
Controlled Cattle	28	30-40	1	178
Dewormed Cattle	50	70-90	1.75	195
Dewormed+ Vitamin ADE injection treated Cattle	40	70-100	1.8	196

FSRD Site, Ganggarampur, Pabna

Deworming and Vitamin ADE injection have positive effects on cattle health. That's why the co-operator farmers were interested and adopted this technology as per routine work. Table 53 shows the performance of body weight gain, milk production and lactation period after deworming and vitamin ADE injection. It indicates that maximum body weight gain (343-420 g day⁻¹animal⁻¹), milk production (1.5-1.75 L day⁻¹) and lactation period (210-214 day) was obtained from deworming and vitamin ADE injection treated cattle followed by dewormed cattle. Relatively lower performance of the above traits was noted from controlled cattle.

Table 53. Average body weight gain, milk production and lactation period after deworming at FSRD site, during the years of 2018 to 2021.

Treatment	Feb 2018 to Jan 2019				Feb 2019 to Jan 2020				Feb 2020 to Dec 2020			
	No. of animal	Av. body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. lactation yield (litre day ⁻¹)	Av. lactation period (day)	No. of animal	Av. body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. lactation yield (litre day ⁻¹)	Av. lactation period (day)	No. of animal	Av. body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. lactation yield (litre day ⁻¹)	Av. lactation period (day)
Controlled cattle	10	166	0.95	165	6	168	1.1	162	5	220	1.20	-
Dewormed cattle	10	292	1.20	180	6	253	1.39	210	5	310	1.50	-
Dewormed + vitamin ADE injected treated cattle	10	375	1.50	210	6	343	1.60	214	5	420	1.75	-

FSRD Site, Sholakundu, Faridpur

Deworming and Vitamin feeding technologies are encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight gain, milk production and lactation period after deworming and vitamin feeding have been presented in Table 54. It was indicated that maximum body weight gain (110-160 g day⁻¹animal⁻¹), milk production (2.65 L day⁻¹) and lactation period (210 days) was obtained from deworming and vitamin feeding treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 54. Average body weight gain, milk production and lactation period after deworming at FSRD site during the years of 2018 to 2021.

Treatment	No. of animal	Av. Body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. Lactation yield (litre day ⁻¹)	Av. Lactation period (day)
Controlled Cattle	10	85-90	1.55	175
Dewormed Cattle	10	110-125	2.20	188
Dewormed+ Vitamin feeding treated Cattle	10	140-160	2.65	210

FSRD Site, Atia, Tangail

Deworming and Vitamin ADE injection technologies are encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight gain, milk production and lactation period after deworming and vitamin ADE injection have been presented in Table 55. It was indicated that maximum body weight gain (165-175 g day⁻¹ animal⁻¹), milk production (2.55 L day⁻¹) and lactation period (215 days) was obtained from deworming and vitamin ADE injection treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 55. Average body weight gain, milk production and lactation period after deworming at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Treatment	No. of animal	Av. Body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. Lactation yield (litre day ⁻¹)	Av. Lactation period (day)
Controlled Cattle	06	75-80	1.60	170
Dewormed Cattle	06	120-130	2.10	195
Dewormed + Vitamin ADE injection treated Cattle	06	165-175	2.55	215

FSRD Site, Tarakandi, Sherpur

Deworming technology is encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight, milk production and lactation period after deworming has been presented in Table 56. It was indicated that maximum body weight gain (60-75 g day⁻¹ animal⁻¹), milk production (1.5 L day⁻¹) and lactation period (205 days) was obtained from deworming treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 56. Average body weight gain, milk production and lactation period after deworming at FSRD site, Tarakandi, Sherpur during the years of 2018 to 2021

Treatment	No. of animal	Av. Body wt. gain day ⁻¹ animal ⁻¹ (g)	Av. Lactation yield (litter day ⁻¹)	Av. Lactation period (day)
Controlled Cattle	12	25-30	1.2	180
Dewormed Cattle	30	60-75	1.5	205

VI. Cattle fattening

Activity-39: Cattle fattening program at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur Rangpur

Cattle were dewormed and vaccinated under beef fattening program and supplied balance and improve feed. It was found that body weight of cattle under the program, increased rapidly (Table 57). Market value was estimated and found that it was increased on an average 65%.

Table 57. Body weight and market value for beef fattening

Year	No. of breed	Initial body wt. (kg)	Body wt. after 90 days (kg)	Body wt. increase over Initial (%)	Initial value (Tk)	Present value (Tk)	Market value Increment (%)
2018-19	1	56	70	25	22000	32000	45.45
2019-20	3	32	48	50	18000	33000	83.33
2020	2	60	98	63	15000	25000	66.67
Average	2	49	72	46	18333	30000	65.15

FSRD Site, Ganggarampur, Pabna

Beef fattening program was conducted during three consecutive years. Fourteen cooperator farmers were selected for beef fattening program during the years of 2018 to 2021. Cattle were dewormed and vaccinated under beef fattening program and supplied balance and improved feed. It was found that body weight of cattle increased due to fattening program (Table 58). Market value was estimated and found that it was increased around 77-197% as compared initial value of the cattle.

Table 58. Body weight and market value for beef fattening at FSRD site Pabna during the years of 2018 to 2021

Year	Farmer	No. of breed	Initial body wt. (kg)	Body wt. after 180 days (kg)	Body wt. increased over initial (%)	Initial value (Tk.)	Present value (Tk.)	Market value increased (%)
Feb 2018 to Jan 2019	Farmer-1	2	285	415	46	62300	140200	125
	Farmer-2	1	177	297	68	58500	103500	77
	Farmer-3	1	212	342	61	59300	115500	95
Feb 2019 to Jan 2020	Farmer-1	2	301	482	60	60500	160600	165
	Farmer-2	1	255	362	42	52000	125500	141
	Farmer-3	2	10	315	75	56500	112000	98
Feb 2020 to Jan 2021	Farmer-1	1	145	250	72	49600	92500	86
	Farmer-2	2	160	375	134	44000	130500	197
	Farmer-3	2	163	292	79	48500	102300	111

FSRD Site, Atia, Tangail

Calf was dewormed and vaccinated under beef fattening program and supplied balance and improve feed. It was found that body weight of calf under the program, increased rapidly (Table 59). Market value was estimated and found that it was increased by 60%.

Table 59. Body weight and market value for beef fattening at FSRD site, Atia, Tangail during the months of February 2018 to January 2021

Year	No. of breed	Initial body wt. (kg)	Body wt. after 90 days (kg)	Body wt. increase over Initial (%)	Initial value (Tk.)	Present value (Tk.)	Market value Increment (%)
2018-19	1	120	154	28	36000	56000	56
2019-20	1	116	144	24	35000	55000	57
2020-21	1	128	169	32	38000	63000	66
Average	1	121	156	28	36333	58000	60

FSRD Site, Tarakandi Sherpur

The program was started at May 2020 and continued up to January 2021. One bullock was included in this program. Initial body weight of the bullock was 82 kg. After 6 months body weight gained 107 kg due to improved feed management and vaccination as well as increased market price (Table 60).

Table 60. Body weight increased and market value for beef fattening.

Year	No. of breed	Initial body wt. (kg)	Body wt. after 180 days	Body wt. increase over initial (%)	Initial value	Present value	Market value increment (%)
2018-19	-	-	-	-	-	-	-
2019-20	-	-	-	-	-	-	-
2020	1	82	107	30	37000	47500	28
Average	1	82	107	30	37000	47500	28

VI. Calf rearing

Activity-40: Calf rearing program at different FSRD sites during the years of 2018 to 2020.

FSRD Site, Ganggarampur, Pabna

Calf rearing was initiated with six co-operator farmers at FSRD site, Ganggarampur. A total of eight calves were selected for rearing during the year 2019-2021. The information on farmers' name, no. of calf, date of starting of rearing, species of calf, age of calf at starting, initial body weight, feed management, present body weight etc. are presented in Table 61. Age and initial body weight of calf were little differed among the co-operator farmers. However, feed management was done as per consultation with the livestock personnel. The selected calves were gradually gained body weight. The

range of increase in body weight of calf was recorded 50-188 kg. This variation in increase of body weight might be due to differences of calf age, feed intake and nursing.

Table 61. Calf rearing status at FSRD site, Ganggarampur, Pabna during the years of February 2019 to January 2021.

Name of farmers and address	No. of cattle	Species	Date of starting	Age during starting date	Initial weight (kg)	Feb 2019 to Jan 2020		Feb 2020 to Jan 2021	
						Present weight (kg) 29.4.19	Weight increased (kg)	Present weight (kg) 20.12.20	Weight increased (kg)
Md Akul Sordar, Pirpur	1	Songkor	14.11.19	3 months	44	67	23	112	68
Md. Abdul Baki, Pirpur	1	Shawal	14.11.19	5 months	75	112	37	125	50
Md. Jilal, Pirpur	1	Freejian	14.11.19	2 months	46	120	74	234	188
	1	Jursey	14.11.19	8 months	82	144	62	263	181
Md. Altaf, Pirpur	1	Sahiwal	14.11.19	6 months	104	141	37	170	66
	1	Freejian	14.11.19	7 months	95	160	65	192	97
Md. Sadek Ali, Kasarpur	1	Local	14.11.19	8 months	76	138	62	165	89
Md. Abdul Molla, Kasarpur	1	Local	14.11.19	8 months	67	95	28	120	53

VI. Goat rearing

Activity-41: Goat rearing in the farmer's household for increase income of farmers

Goats were supplied 7 farmers at FSRD site, Tarakandi, Sherpur. Each farmer received one female Goat. Average initial body weight of the supplied Goat was 9.5 kg. Survival rate of the supplied Goat was 100%. After 6 months of Goat rearing farmers get on an average gross margin Tk. 2247 (Table 62).

Table 62. Performance of Goat at farmers level at FSRD site, Tarakandi, Sherpur during the years of February 2018 to January 2021.

Description of Items	February 19-January 20	February 20- January 21
Number of farmers	3	4
Number of Goats supplied per farmer	1	1
Date of supplied	November	October
Age of Goat during distribution	13 months	13 months
Initial body wt. Goat ¹ (kg)	10 Kg	9 Kg
Procurement price Goat ¹ (Tk.)	4000/-	3500/-
No of Goat survive	100%	100%
Wt. gained/Goat after 6 months	4 kg	1 kg (after 2 month)
Total number of kids born (Feb. 18- Dec. 20) per farmer	2	1
Total return (Tk.) per farmer	6033/-	5960
Total variable cost (Tk.) per farmer	4000/-	3500/-
Gross margin (Tk.) per farmer	2033/-	2460/-

IX. Turkey bird rearing

Activity-42: Performance of Turkey at farmer's level for egg and meat purpose

FSRD site, Ajoddhapur, Rangpur

Among the twelve cooperators farmers, twelve Turkey birds in 2019-20 and 5 birds in 2020-21 were distributed per household. Table 63 shows no. of Turkey bird survive body weight of initial and after five months. The average body weight gained from those Turkey birds was about 4.65 kg. The average gross margin obtained per family after five months rearing was calculated as Tk. 6700.

Table 63. Average performances of Turkey at farmers' level up at 12 months of rearing at FSRD site during the years of February 2018 to January 2021.

Description of Item	February 2018 – January 2019	February 2019 – January 2020	February 2020 – January 2021	Average
Number of farmers	-	12	12	12
No of birds supplied	-	144	60	102
No of birds survived	-	141	58	99.5
Age of supplied bird (days)	-	45	46	45.5
Initial wt. bird ⁻¹ (kg)	-	0.25	0.3	0.28
Initial value bird ⁻¹ (Tk.)	-	200	200	200
Rearing period (month)	-	5	5	5
Feed supplements bird ⁻¹ day ⁻¹ (g)	-	40	40	40
Feed supplements cost bird ⁻¹ (Tk.)	-	300	300	300
Present wt. bird ⁻¹ (kg)	-	4.75	5.1	4.93
Weight gained bird ⁻¹ (kg)	-	4.5	4.8	4.65
Gross return (Tk. Family ⁻¹)	-	11500	5000	8250
Total cost (Tk. Family ⁻¹)	-	1600	1500	1550
Gross margin (Tk. Family ⁻¹)	-	9900	3500	6700

X. Sonali chicken rearing in the farmer's household

Activity 43: Performance of Sonali chicken at different FSRD sites during the years of 2018 to 2020.

FSRD Site, Ganggarampur, Pabna

The cooperator farmers of FSRD site Ganggarampur, Pabna were interested to rear poultry for meat purpose. Five to twelve farmers were selected for poultry rearing and each farmer was supplied 25 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time and Gumboro vaccine was provided at due time. The family members constructed a small house (5ft x 8ft) with bamboo, tin or wood near their own living house. The initial weight of Sonali breed provided to the cooperator farmer was about 0.6-0.72 kg and average final body obtained from those chickens was about 1 to 1.5 kg. It was found that gross margin per farm was Tk.7800-28700 (Table 64). Farmers showed their interest in rearing Sonali chick because of better production of egg and meat.

Table 64. Performance of Sonali chicken at farmers level for egg and meat purpose during the years of February 2018 to January 2021.

Description of Item	Feb 2018 to Jan 2019	Feb 2019 to Jan 2020	Feb 2020 to Jan 2021	
			1 st package	2 nd package
Number of farmers	12	5	5	3
No. of bird supplied	300	125	125	75
Date of supplied period	1.11.18 to 27.1.19	4.11.19	4.11.19	30.6.20
Initial body weight (kg)	0.6	0.72	0.72	0.70
Procurement price bird ⁻¹ (Tk.)	35	180	180	180
No. of chicken survived	280	21	21	22
Date of delivery egg	-	-	5.1.20 to 20.12.20	10.12.20
Egg production (number)	-	-	5150	240
Consumption	-	-	1320	32
Sale	-	-	3780	204
Distribution	-	-	50	4
Total number of eggs	-	-	5150	240
Performance of bird	-	-	-	-
Weight gained bird ⁻¹ (kg)	1.04	0.380	1.58	1.00

Description of Item	Feb 2018 to Jan 2019	Feb 2019 to Jan 2020	Feb 2020 to Jan 2021	
			1 st package	2 nd package
Consumption	21	-	-	-
Sale	257	-	-	-
Distribution	2	-	-	-
Total number	280	-	-	-
Total income from bird (Tk.)	59200	-	7250	5950
Total variable cost (Tk.)	30500	-	50950	13500
Total return farm ⁻¹ (Egg and Meat)	-	-	58750	8350
Gross margin	28700	-	7800	-5150

FSRD Site, Sholakundu. Faridpur

This program was initiated at the FSRD site, Sholakundu, Faridpur district. Twelve farmers were selected in the village for poultry rearing and each farmer was supplied 10 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time. The family members constructed a small house (5ft X 8ft) with bamboo, tin or wood near their own living house. Twenty (20) kg initial feed, one feed pot and one water pot were supplied to the farmer at the time of chick supply. The birds were also vaccinated timely and treated against different diseases. It was found that initial body weight was 0.69-0.72 kg per bird which after 160-163 days raised to 1.01-1.16 kg, respectively. Number of eggs per bird was given 38-133 and total value of egg per bird was TK. 380-1330. The average consumption of eggs per farm family was 52 during laying period up to 15 December 2020. It was found that total return per farm was Tk.7170-8568 and gross margin was Tk. 4151-4165 (Table 65). Farmers showed their interest in rearing Sonali chick for their growth and number of egg and meat.

Table 65. Average performances of Sonali breed at farmers' level up at 12 months of rearing at FSRD site during the years of February 2018 to January 2021.

Description of Item	Feb 2019 – Jan 2020	Feb 2020 – Dec 2020	Feb 2020 – Dec 2020
Number of farmers	12	12	12
No of birds supplied (3 times)	120	120	120
Date of supplied period	9 Oct 2019	15 Mar 2020	10 Sep 2020
Initial body wt. bird ⁻¹ (kg)	0.69-0.72	0.70	0.66
Procurement price bird ⁻¹ (Tk.)	138	140	148
No of chicken survive farm ⁻¹	4	5	6
Date of delivery egg	18.2.19 to 15.12.20	27.6.2020 – 15.12.2020	-
Egg Production (Number of egg bird⁻¹)	--	76	-
Consumption	346	281	-
Sale	170	85	-
Distribution	16	12	-
Total number of egg farm ⁻¹	532	378	-
Performance of Bird	--	--	-
Weight gained/bird (kg)	1.16	1.01	-
Consumption (kg)	2.25	4.00	-
Sale (kg)	7.00	19.94	-
Distribution (kg)	--	--	-
Total weight (kg)	9.25	23.94	-
Total return farmer ⁻¹ in Tk. (Market value of egg + meat)	7170	8568	-
Total variable cost (Tk.)	3005	4417	-
Gross margin (Tk.)	4165	4151	-

FSRD Site, Atia, Tangail

Rearing of Sonali chicken at farmers household level program was initiated at Mahmudpur and Hinghnagar village of Delduar upazila under Tangail district. Ten farmers were selected in the village

for poultry rearing and each farmer was supplied 10-20 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time and gumboro vaccine was provided at due time. The family members constructed a small house (5ft X 8ft) with bamboo, tin or wood near their own living house. Twenty (20) kg initial feed, one feed pot and one water pot were supplied to the farmer at the time of chick supply. The birds were also vaccinated timely and treated against different diseases. It was found that initial body weight was 0.57-0.58 kg per bird which after 8 months raised to 2.10-2.38 kg, respectively. Number of eggs per bird was given 40-92 and total value of egg per bird was Tk. 400-920. The average consumption of eggs per farm family was 74 during laying period. It was found that total return per farm was Tk. 11967-16929 and gross margin was Tk. 4822-11784 (Table 66). Farmers showed their interest in rearing Sonali chick for their growth and number of egg and meat.

Table 66. Average performances of Sonali breed at farmers' level up to 12 months of rearing at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Description of Item	February 2018 – January 2019	February 2019 – January 2020	February 2020 – January 2021
Number of farmers	10	10	10
No of birds supplied	100	200	100
Date of supplied period	18.10.2018	18.06.2019	12.03.2020
Initial body wt. bird ⁻¹ (kg)	0.57	0.58	0.57
Procurement price bird ⁻¹ (Tk.)	200	180	190
No of chicken survive	92	190	85
Date of delivery egg	23.12.18 to 01.02.19	23.10.19 to 31.01.20	15.09.20 to 15.12.20
Egg Production (Number of egg bird⁻¹)	40	90	92
Consumption	56	128	133
Sale	258	487	591
Distribution	06	15	12
Total number of egg farm ⁻¹	320	630	736
Performance of Bird			
Weight gained bird ⁻¹ (kg)	2.10	2.38	2.12
Consumption	02	02	01
Sale	07	07	07
Distribution	0	0	0
Total number	9	9	8
Total income (Tk.) from bird farm ⁻¹	2064	3896	4728
Total variable cost (Tk.) farm ⁻¹	7145	5145	5318
Total return farm ⁻¹ in Tk. (Market value of egg + meat)	11967	16929	14967
Gross margin (Tk.)	4822	11784	9649

FSRD Site, Tarakandi, Sherpur

Activity-44: Performance of Naked neck (Garchila) chicken at different FSRD sites during the years of 2018 to 2021.

Data related to performance of foamy and naked neck chick at farmers' level presented in Table 67. It indicated that income generation was higher over the local chick rearing practices. Initial average weight of foamy and naked neck chick was recorded as about 670 g which was increased to an average of about 1.6 kg after 6 months of rearing. Average egg production per bird was 86. From cost analysis, gross margin was calculated as 2473 Tk per farm family. Farmers' opined that foamy and naked neck chick rearing in the semi-scavenging system under village condition is economically viable and it can be strongly recommended for large scale extension to the farmers' level.

Table 67. Performance of foamy and naked neck chicken at farmers level at FSRD site, Tarakandi, Sherpur during the years of February 2018 to January 2021.

Description of Items	February 18- January 19 (Foamy)	February 19- January 20	February 20- January 21
Number of farmers	8	12	12
Number of birds supplied per farmer	10	5	5
Date of supplied period	20.09.2018	01.10.2019	01.10.2019
Initial body wt. bird ⁻¹ (kg)	0.65	0.69	0.69
Procurement price chicken ⁻¹ (Tk.)	250/-	220/-	220/-
No. of chicken survive	9	4	39
Wt. gained bird ⁻¹ after 6 months	0.97	0.85	0.96
Total number of chicks born (Feb. 18- Dec. 20) per farmer	0	25	23
Consumption (meat no of hen)	8	8	12
Consumption (egg no)	88	70	28
Sale (meat no of hen)	5	12	26
Sale (egg no)	325	212	72
Distribution (meat no of hen)	0	1	2
Distribution (egg no)	15	18	12
Total income from bird (Tk.) per farmer	6180/-	4122/-	7163/-
Total variable cost (Tk.) per farmer	6000/-	2420/-	1625/-
Gross margin (Tk.) per farmer	180/-	1702/-	5538/-

X. Duck rearing in the farmer's household

Activity 45. Performance of Khaki Campbell Duck at different FSRD sites during the years of 2018 to 2020

FSRD site, Ajoddhapur, Rangpur

Among the twelve, three farmers were reared Duck in their homestead using their pond. The average egg laid by the Duck 120-210 no. month⁻¹household⁻¹ (Table 68). Consumption of egg was 60-65 numbers after starting the Duck rearing. Monthly income was calculated about Tk. 1200-2000 month⁻¹household⁻¹.

Table 68. Performance of improved breeds of Duck (Khaki Campbell) after 6 months of rearing at FSRD Site during the years of February 2018 to January 2021

Name of Farmer	No. of Ducks survived at present	Body wt. after 6 months (kg)	Production of egg month ⁻¹	Consumption of eggs month ⁻¹		No. of egg laid month ⁻¹	Monthly income (Tk.)
				Before	After		
Farid Ali	9	1.1	180	0	60	180	1800
Kismot	10	1.12	200	0	65	200	2000
Keramot Ali	6	1015	120	0	62	120	1200
<i>Average</i>	<i>8</i>	<i>339</i>	<i>167</i>	<i>0</i>	<i>62</i>	<i>167</i>	<i>1670</i>

FSRD Site, Atia, Tangail

The experiment was conducted at Higanagor village of Deduar upazilla in Tangail district during February 2018- December 2020. Eight farmers were selected for Duck rearing. The family members made a small house (7ft X 6ft) with bamboo and tin near their own living house. Each farmer was given 10 Ducks of 4-months old. Average survival rate of Duck was 75% at FSRD site Atia, Tangail during the years of 2018 to 2020 (Table 69). The ratio of male and female was 1:5. Twenty kg of initial feed, one feed pot and one water pot were supplied to initiate the experiment. A group discussion was held about management of Duck rearing before distribution. Rice husk with sand used as litter materials and changed twice every week. The Ducks were kept in the backYard pond during day and kept inside in the house at night. The results showed that Ducks started lying egg after six months of age and average egg production was 25 eggs month⁻¹Duck⁻¹. Each farm family has gained more than 160 eggs from a

month (25 eggs month⁻¹Duck⁻¹). On an average, it was observed that the cooperative farmers sell some eggs and earned Tk. 1680 month⁻¹farm⁻¹ from rearing of Duck. The average consumption of eggs per farm family was 25 after rearing and it was only 12 before rearing. One important thing is that the consumption rate of egg per farm family was increased due to laying egg of their own Ducks. As a result, project objective was achieved due to livelihood improvement of the rural people by Duck rearing.

Table 69. Performance of improved breeds of Duck (Khaki Campbell) after 6 months of rearing at FSRD Site, Atia, Tangail during the years of February 2018 to January 2021

Year of rearing Duck	No. of Farmer	No. of Ducks survived at present	Body wt. after 6 months (kg)	Production of egg monthly ⁻¹ Duck ⁻¹	Consumption of egg month ⁻¹		No. of egg laid month ⁻¹	Monthly income farm ⁻¹ (Tk.)
					Before	After		
Feb 2018-Jan. 2019	04	33	2.95	24	12	20	672	1680
Feb 2019-Jan. 2020	10	100	3.25	26		30	2210	1800
Feb 2020-Jan. 2021	10	92	3.16	24		25	1920	1560
<i>Average</i>	<i>8</i>	<i>75</i>	<i>3.12</i>	<i>24.67</i>	<i>12</i>	<i>25</i>	<i>1601</i>	<i>1680</i>

FSRD Site, Tarakandi, Sherpur

Data related to performance of Grinding breed at farmers' level is presented in Table 70. It was observed that, income generation was higher over the local breed rearing practices. Initial average weight of Ginding breed was recorded as about 750 g which was increased to an average of about 1.69 kg after 6 months of rearing. Average egg production per bird was 72. From cost analysis, gross margin was calculated as 7630 Tk per farm family. The introduction of Ginding breed with scientific management systems performed better over the local breed as well as traditional rearing practices. Egg laying capacity also increased significantly as a consequence of proper feeding and management. Farmers showed their keen interest for rearing of Ginding both meat and egg purpose. They opined that, they had a little knowledge about modern disease and feed management technology. Hence more motivation and awareness build up programs should be taken for greater extension of the technology. Farmers especially women and children expressed satisfaction of Duck rearing by improved rearing system and commercially profitable.

Table 70. Performance of alternate breeds of Duck (Ginding) after 6 months of rearing at FSRD Site, Tarakandi, Sherpur during the years of February 2018 to January 2021.

Name of Farmer	No. of Ducks survived at present	Body wt. after 6 months (kg)	Egg production month ⁻¹	Egg Consumption month ⁻¹		No. of egg laid month ⁻¹	Monthly income (Tk)
				Before rearing	After rearing		
Md. Nurul Islam	9	1.69	102	10	25	102	1020
Md. Nur Islam	8	1.66	104	15	28	104	1040
Md. Tota mia	9	1.68	120	11	33	120	1200
Md. Nasmul Islam	10	1.72	115	18	34	115	1150
<i>Average</i>	<i>9</i>	<i>1.69</i>	<i>110</i>	<i>13.5</i>	<i>30</i>	<i>110</i>	<i>1102.5</i>

XII. Rearing of pigeon at farmers household

Activity-46: Performance of pigeon rearing at different FSRD sites during the years of 2018 to 2020.

FSRD site, Ajoddhapur, Rangpur

Among the twelve cooperators farmers, Pigeons were distributed on-test basis two pairs per household and thereafter four pairs during the year 2019-20. Table 71 shows no. of Pigeon survive, initial body weight, squab production and intake by the household members. Pigeon rearing might be a profitable

business. The average weight per bird during supply was on an average 180 g. The average squab production per family was 54 and intake of squab by the household family was 13. The average income from pigeon rearing was Tk. 1250 household⁻¹.

Table 71. Performance supplied pigeons to different farmers household at FSRD site during the years of February 2018 to January 2021.

Year	No. of Pigeon Family ⁻¹	Average weight (g)	No. of Squab Born	Pigeon died	Squab Intake	Sell	Cash income (Tk.)
2019-20	12	0.16	48	3	12	4	500
2020-21	12	0.20	60	3	14	16	2000
<i>Average</i>	<i>12</i>	<i>0.18</i>	<i>54</i>	<i>3</i>	<i>13</i>	<i>10</i>	<i>1250</i>

FSRD Site, Ganggarampur, Pabna

Every year two farmers were selected for pigeon rearing. Around 16-30 pigeon per farm was selected for rearing. Optimum feed management and other nursing was provided pigeon rearing. The body weight of pigeon provided to the cooperator farmer was about 170-210 g and each family get 20-65 squab per year. It was found that income per family from rearing pigeon was recorded Tk.2160-4440 (Table 72).

Table 72. Performance of pigeons at farmers household at FSRD site, Ganggarampur, Pabna during the years of February 2018 to January 2021

Year	Farmes	No. of pigeon Fmily ⁻¹	Average weight (gm)	No. of Squab born	No. of pigeon died	No. of pigeon Consumed	No. of pigeon Selling	Income (Tk)
Feb 2018 to Jan 2019	Farmer-1	30	180	65	10	20	37	4440
	Farmer-2	30	180	50	12	28	18	2160
Feb 2019 to Jan 2020	Farmer-1	28	170	60	6	18	48	5760
	Farmer-2	28	170	66	5	28	41	5330
Feb 2020 to Jan 2021	Farmer-1	16	210	26	2	14	20	2500
	Farmer-2	20	200	22	2	6	24	3050

FSRD Site, Tarakandi Sherpur

Pigeon were supplied 4 farmers at FSRD site, Tarakandi, Sherpur. Each farmer received 2 pair pigeon. Average weight of the supplied pigeon was 190 g. Average nine pairs of squabs was born of four farmers after six month and the farmers kept them to add another pigeon pair and some of them were sold. Finally, total six pairs of squabs were borned per family. Before intervention the farmers have no pigeon and income. But due to rearing of pigeon, per farmer earned Tk. 1500 (Table 73).

Table 73. Performance supplied pigeons to different farmer's household at FSRD site, Tarakandi, Sherpur during the years of February 2018 to January 2021.

Year	No. of Pigeon Family ⁻¹	Average weight (g)	No. of Squab born	Pigeon died	Squab Intake	Sell	Income (Tk.)
2020-21	2 pair	0.19	9 pair (Av.)	Squab 3 (av.)	3	12	1500

VII. Green fodder production

Activity-47: Performance of green fodder production at household level

FSRD site, Ajoddhapur, Rangpur

The production of Napier grass was 80 and 68 t ha⁻¹ and the average gross margin was calculated Tk. 38000 and 2800 ha⁻¹ in 2019-20) and 2020-21, respectively (Table 74). The average green fodder yield was 74 t ha⁻¹ and average gross margin was Tk. 33000 ha⁻¹. The last year yield was hampered due to flood.

Table 74. Average performances of Napier grass production

Year	No. of harvesting	Green fodder yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
2019-20	17	80	80000	42000	38000
2020-21	14	68	68000	40000	28000
Av.	16	74	74000	41000	33000

FSRD Site, Atia, Tangail

Green fodder production in the homestead or nearby homestead area or road side was found as a promising technology for maintaining farmers own cattle as well as earning a handsome amount of money. On an average, six farmers were produced Napier grass as green fodder at Napier FSRD site, Atia, Tangail during February 2019 to January 2021. The average green fodder yield was 32.22 t ha⁻¹ obtained from 6 times harvest in a year with average gross margin Tk. 38447 ha⁻¹ (Table 75).

Table 75. Average performances of Napier grass production at FSRD site, Atia, Tangail during the years of February 2018 to January 2021.

Year	No. of farmers	No. of harvesting	Green fodder yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Feb. 2019- Jan. 20	05	3	33.90	84750	43390	41360
Feb. 2020-Jan. 21	07	5	30.54	76350	40830	35520
Average.	06	4	32.22	80550	41000	38440

VIII. Compost production

Activity 48. Performance of Farmyard Manure production at different FSRD sites during the years of 2018 to 2020.

FSRD site, Ajodhpur, Rangpur

Farm Yard Manure (FYM): Farm Yard manure was producing by using Cowdung and homestead wastage at the homestead area during the year of February 2018 to January 2021. The average production of FYM per homestead was 3050 kg and the gross margin was equivalent to Tk.5400 homestead⁻¹ (Table 76).

Table 76. Average performances of compost production and utilization

Year	Intervention	Total compost produce (kg homestead ⁻¹)	Use for crop production (kg farmer ⁻¹)	Distribution (kg farmer ⁻¹)	Sell (kg farmer ⁻¹)	Value of total compost produce per year (Tk. Homestead ⁻¹)	TVC (Tk. Homestead ⁻¹)	Gross margin (Tk. homestead ⁻¹)
2019-20	Before	2200	2200	0	0	4400	500	3900
	After	3250	3000	0	250	6500	700	5800
2020-21	Before	2200	2200	0	0	4400	500	3900
	After	2850	2650	0	200	5700	700	5000
Av.	Before	2200	2200	0	0	4400	500	3900
	After	3050	2825	0	225	6100	700	5400

Vermicompost

Activity-49: Performance of vermicompost production at different FSRD sites during the years of 2018 to 2021.

Vermicompost was produced in six farmers homestead area using cement ring. The total vermicompost production was 320 kg homestead⁻¹ (Table 77). Gross margin was calculated Tk. 840 homestead⁻¹ after first time production.

Table 77. Average performances of vermicompost production and utilization

Farmers involve (no.)	No. of ring homestead ⁻¹	Total vermicompost produce (kg homestead ⁻¹)	Use for crop production (kg farmer ⁻¹)	Distribution (kg farmer ⁻¹)	Sell (kg farmer ⁻¹)	Value of produce vermicompost per year (Tk.)	TVC (Tk. homestead ⁻¹)	Gross margin (Tk. homestead ⁻¹)
6	2	320	320	-	-	2240	1400	840

D. FISHERIES SYSTEM

Activity-50: Maximization of farmers' income through monoculture technique

I. Production program of Pabda fish

FSRD site, Ajoddhapur, Rangpur

Pabda fish was cultured in one pond as a test case at FSRD site Ajoddhapur, Rangpur during 2018-19. Information on pond area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 78a. The pond was mostly seasonal, but water was supplemented for a certain duration. The pond was 8 decimals sized with approximately 3 m depth. The results revealed that, in *Pabda* fish culture the survival rate was 85%.

Yield and economic analysis are shown in Table 78b. The yield of fish was obtained 49 kg per pond with the gross margin Tk. 9550 per pond.

Among the total production they consumed, distributed to relatives and sold their products in local market (Table 78bc). It was observed that, farmers sold most of the fish (61%), consumed about 35% and distributed about 4% through their neighbors, relatives and well-wishers of the produced fish. The fish feed price in the market is high, so, farmer was less interested to supplement feed through purchasing from the market. As a result, the yield was relatively low.

Table 78a. Performance *Pabda* fish farming at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019.

No. of pond	Area and depth of pond (decimal)	Amount and number of fries	Av. weight of fry (gm)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
1	08 dec. and 3m	7.6 kg #512	14.84	112	49kg #435	85

Table 78b. Production and Economics of *Pabda* farming at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019.

No. of pond	Total yield (kg pond ⁻¹)	Total cost (Tk pond ⁻¹)	Gross return (Tk pond ⁻¹)	Gross margin (Tk pond ⁻¹)	BCR
1	49	7600	17150	9550	2.26

Table 78c. Utilization pattern of harvested *Pabda* fish at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019.

No. of pond	Total yield (kg pond ⁻¹)	Consumption (kg)	Distribution (kg)	Selling (kg)
1	49	17	2	30

II. Production program of Shing fish

FSRD site, Ajoddhapur, Rangpur

Shing fish was cultured in three ponds as a test case at FSRD site Ajoddhapur, Rangpur during 2018-19. Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 79a. There were three ponds selected for 'Shing' production in seasonal ponds'. The ponds were av. 8.5 decimal sized with av. 3.5 m depth. The results revealed that the av. survival rate was 88%.

Yield, cost and return analysis are shown in Table 79b. The yield of fish was obtained 35.5 kg per pond with the gross margin Tk. 6125 per pond.

Among the total production farmer consumed, distributed to relatives and sold their products in local market (Table 79c). It was observed that, farmers sold most of the fish (65%), consumed about 27% and distributed about 8% through their neighbors, relatives and well-wishers of the produced fish.

Table 79a. Performance of *Shing* fish farming at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019

No. of pond	Area and depth of pond (dec and m)	Amount and number of fries	Average weight of fry (g)	Final average weight and length of fish (g and cm)	Total amount and number of fish	Survival rate (%)
3	8.5dec. and 3.5m	2.9 kg #298	9.73	135g and 19cm	35.5 kg #262	88

Table 79b. Total production and economics of *Shing* fish farming at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019

No. of pond	Total yield (kg pond ⁻¹)	Total cost (Tk. pond ⁻¹)	Gross return (Tk. pond ⁻¹)	Gross margin (Tk. pond ⁻¹)	BCR
3	35.5	6300	12425	6125	1.97

Table 79c. Utilization pattern of harvested *Shing* fish at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019

No. of pond	Total yield (kg pond ⁻¹)	Consumption (kg)	Distribution (kg)	Selling (kg)
3	35.5	9.5	3	23

III. Maximization of farmers' income through *Shing*, *Tengra* and monosex *Telapia* culture

Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate of *Shing* and *Tengra* fish has been shown in Table 80a. There were two ponds selected for each of *Shing* and *Tengra* fish. The average size of the ponds was around 10 decimals with average depth of 1.2 meter. There were three ponds selected for monosex *Telapia*. The sizes of the ponds were av. 9 decimal sized with av. 1.57 m depth. The results revealed that the average survival rate of *Shing* and *Tengra* was around 85% whereas the av. survival rate of monosex *Telapia* was 91%.

Yield and economic analysis are shown in Table 80b. The yield and gross margin of fish varied from pond to pond due to its size. Total yield of *Shing*, *Tengra* and monosex *Telapia* was recorded 45, 36 and 68 kg pond⁻¹ and gross margin was recorded Tk. 9050, Tk. 4700 and Tk 5808 pond⁻¹ respectively. Consumption, distribution, selling, total production, net income and BCR increased due to intervention of new technology (Table 80c and 80d).

Table 80a. Performance *Shing*, *Tengra* and monosex *Telapia* fish at FSRD site Ganggarampur, Pabna during the year of 2018-2019

Fish	Area and depth of pond (decandm)	Amount and number of fries	Av. weight of fry (gm)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
Shing	15 Dec. 1.2 m	14 kg and 1400	10	53	60 kg and 1120	80
	6 Dec. 1.2 m	6 kg and 600		55	30.8 kg and 560	93
Tengra	10 Dec. 1.2 m	5 kg and 1000	5	42	34 kg and 820	82
	10 Dec. 1.2 m	5 kg and 1000		44	38 kg and 865	86
Telapia	15 Dec. 2 m	16 kg and 320	50	385	116 kg and 302	94
	8 Dec. 1.5 m	8 kg and 160		390	56 kg and 145	90
	5 Dec. 1.2 m	5 kg and 100		365	33 kg and 90	90

Table 80b. Production and Economics of Shing, Tengra and Telapia at FSRD site Ganggarampur, Pabna during the year of 2018-2019

Fish	Total yield (kg pond ⁻¹)	Total cost (Tk. pond ⁻¹)	Gross return (Tk. pond ⁻¹)	Gross margin (Tk. pond ⁻¹)	BCR
Shing	45	2200	11250	9050	5.12
Tengra	36	2500	7200	4700	2.88
Telapia	68	2392	8200	5808	3.42

Prize (Tk. kg⁻¹): Shing= 250, Tengra= 200

Table 80c. Utilization pattern of harvested fish at FSRD site Ganggarampur, Pabna

SL No.	Consumption (kg)	Distribution (kg)	Selling (kg)
1. Tengra	5	2	29
2. Shing	6	2	37
3. Telapia	20	8	40

Table 80d. Total fish production, utilization pattern and income before and after intervention at FSRD site during February 2018 to January 2021

Description	Before intervention	After intervention				
		February 2018 to December 2019		Feb 2019 to Jan 2020	Feb 2020 to Jan 2021	Average
Consumption	40	Tengra	5	72	123	75
		Shing	6			
		Tilapia	20			
Distribution	10	Tengra	2	7	12	11
		Shing	2			
		Tilapia	8			
Selling	65	Tengra	29	63	80	115
		Shing	37			
		Tilapia	40			
Total production	115	Tengra	36	142	215	201
		Shing	45			
		Tilapia	68			
Gross return (Tk.)	13225	18450		18460	32250	23053
Total cost (Tk.)	6850	7700		10200	15900	11267
Net return (Tk.)	6375	13750		8260	16350	11786
BCR	1.93	2.4		1.81	2.03	2.05

III. Production program of carp polyculture in seasonal pond

Activity-51: Maximization of farmers' income through carp polyculture technique at different FSRD sites during the years of 2018 to 2020.

FSRD site, Ajoddhapur. Rangpur

Mixed carp polyculture was conducted at 8 ponds during the year 2018-19 and 12 ponds during the year 2019-20 and 2020 of the 12 cooperators farmers' pond. Ponds area, fry amount and weight, final total amount and number of fish, survival rate etc. has been presented in Table 81a. The ponds were av. 13 decimal sized with av. 3.2 m depth. The results revealed that, in polyculture of carp fishes, the survival rate was 80-93%.

Yield, cost and return analysis are shown in Table 81b. The av. yield of fish after intervention was obtained 99 kg per pond with the gross margin Tk. 10208 per pond.

Among the total production they consumed, distributed to relatives and sold their products in local market (Table 81b). It was observed that, farmers sold most of the fish (63%), consumed about 33% and distributed about 4% through their neighbors, relatives, and well-wishers of the produced fish. The farmers were benefitted by carp polyculture system, and they showed further interest for farming of carp polyculture.

Table 81a. Performance of carp polyculture fish farming at FSRD site Ajoddhapur, Rangpur during the years of February 2018 to January 2021

SL No.	Area and depth of pond	Amount and number of fries	Av. weight of fry (gm)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	14 dec. and 3.6m	6-10 kg	30	480	98kg and 204#	85
2019-20	13 dec. and 3m	8-12 kg	35	471	105kg and 223#	93
2020-21	13 dec. and 3m	7-11 kg	28	495	95kg and 192#	80
<i>Average</i>	<i>13 dec. and 3.2m</i>	<i>07-11 kg</i>	<i>31</i>	<i>481</i>	<i>99kg and 206#</i>	<i>86</i>

Table 81b. Total fish production, utilization pattern and income before and after Intervention at FSRD site Ajoddhapur, Rangpur during the years of February 2018 to January 2021

Description	Before Intervention (kg ha ⁻¹)	After Intervention (kg ha ⁻¹)			
		February 2018-January 2019	February 2019-January 2020	February 2020 - January 2021	<i>Average</i>
Consumption	10	24	35	40	33
Distribution	1	3	5	5	4
Selling	24	71	65	50	62
Total production	35	98	105	95	99
Gross return (Tk.)	5250	14700	15750	16625	15692
Total variable cost (Tk.)	1800	5400	5550	5500	5483
Gross margin (Tk.)	3450	9300	10200	11125	10208

FSRD Site, Ganggarampur, Pabna

Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 82. There were five ponds selected for polyculture of carp fishes during the year 2019-20 and 2020. The ponds were av. 10 decimal sized with av. 2.0 m depth. The results revealed that in polyculture of carp fishes the av. survival rate was 91%.

Yield and economic analysis are shown in Table 82. The yield of fish was obtained 142 kg and 215 kg per pond during the year 2019-20 and 2020 with the net return of Tk. 8260 and Tk. 16350 per pond.

Among the total production farmers consumed, distributed to relatives and sold their products in local market (Table 11b). It was observed that, farmers consumed average about 37%, sold about 58% and distributed about 5% to their neighbor's, relatives and well-wishers of the produced fish. The marginal farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 82. Performance of carp polyculture fish farming at FSRD site during the years of February 2018 to January 2021

Sl. No/Year	Area and depth of pond (dec. and m.)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
Feb 2019 to Jan 2020	9 dec. and 2m	37 kg #250	148	747	142 kg #190	92
Feb 2020 to Jan 2021	10 dec. and 2m	55kg #272	202	1113	215 kg #193	90

FSRD Site, Sholakundu, Faridpur

There were four ponds selected for carp polyculture production in perennial ponds. The ponds were average 10 decimal sized with average depth of water was 2.25 m. After 7 days of pond preparation, fingerlings were released in the pond with the acclimatization of pond water. The average initial weight of fry (30.80 g), final average weight (570 g), total amount and number of fry (141 kg and 248) and survival rate (75 %) are shown in Table 83a. Average body weight was increased 1745 % over initial body weight (Table 83b). The results revealed that average yield of fish after intervention was obtained 141 kg per pond which was 59% higher than before intervention with an average gross margin of Tk.

16828 per pond which was 77% higher over before intervention. Among the average production they consumed, distributed to relatives and sell their products in local market. It was observed that, farmers average sold most of the fish (85%), consumed about 13% and distributed about 2% through their neighbors, relatives and well-wishers of the produced fish (Table 83c). The farmers were benefitted by carp polyculture system and they showed their interest in farming of carp polyculture.

Table 83a. Performance of carp polyculture fish farming at FSRD site during the years of February 2018 to January 2021

Year	Area and depth of pond (dec and m)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	10 dec and 2.25	8.48 kg and 353 nos.	24.00	445	111 kg and 251 nos	71
2019-20	10 dec and 2.25	10.50 kg and 318 nos.	33.00	617	148 kg and 243 nos	76
2020-21	10 dec and 2.25	11.50 kg and 320 nos.	35.50	648	164 kg and 250 nos	78
Average	10 dec and 2.25	10.16 kg and 330 nos.	30.80	570	141 kg and 248 nos	75

Table 83b. Average performance of carp polyculture fish farming at FSRD site during the years of February 2018 to January 2021

Breed	Initial size (cm)	Initial wt (g)	Size after 60 days(cm)	Weight after 60 days (g)	Size after 180 days(cm)	Weight after 180 days (g)	Body wt. increase % over initial	Survival rate (%)
Silver carp	14	34	20	165	28	640	1782	75
Catla	12	28	18	140	24	480	1614	
Ruhi	13	30	19	158	28	560	1766	
Mrigel	14	36	20	195	29	690	1816	
Rajputi	10	26	14	136	20	480	1746	
Average	12.60	30.80	18.20	158.80	25.80	570	1745	75

Table 83c. Total fish production, utilization pattern and income before and after Intervention at FSRD site during the years of February 2018 to December 2020

Description	Before Intervention (kg ha ⁻¹)	After Intervention (kg ha ⁻¹)			
		Feb 2018- Jan 2019	Feb 2019- Jan 2020	Feb 2020 – Jan 2021	Average
Consumption	275	415	462	491	456
Distribution	42	63	72	80	72
Selling	1908	2297	3166	3529	2997
Total production	2225	2775	3700	4100	3525
Gross return (Tk.)	311500	402375	555000	631400	529592
Total cost (Tk.)	73917	100960	108930	118310	109400
Net return (Tk.)	237583	301415	446070	513090	420192

FSRD Site, Atia, Tangail

There were four ponds selected for carp polyculture production in seasonal ponds. The ponds were average 22 decimal sized with average depth of water was 1.52 m. After 7 days of pond preparation, fingerlings were released in the pond with the acclimatization of pond water. The average initial weight of fry (6.76 g), final average weight (745 g), total amount and number of fry (793 kg and 1071) and survival rate (77 %) are shown in Table 84a. The results revealed that average yield of fish after intervention was obtained 190 kg per pond which was 52% higher than before intervention with an average gross margin of Tk. 12809 per pond. Among the average production they consumed, distributed to relatives and sell their products in local market. It was observed that, farmers sold most of the fish (48%), consumed about 40% and distributed about 12% through their neighbours, relatives and well-wishers of the produced fish (Table 84b). The farmers were benefitted by carp polyculture system and they showed their interest in farming of carp polyculture.

Table 84a. Performance of carp polyculture fish farming at FSRD site, Atia, Tangail during the years of February 2018 to January 2021

Year	Area and depth of pond	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
Feb 2018-Jan. 2019	22 dec, and 1.5 m	9.0 kg and 1420	6.35	670	750 kg and 1120	79
Feb 2019-Jan.2020	22 dec, and 1.5 m	9.2 kg and 1370	6.71	824	840 kg and 1020	74
Feb 2020-Jan 2021	22 dec, and 1.56 m	10 kg and 1390	7.23	742	790 kg and 1073	77
Average	22 dec, and 1.52 m	9.4 kg and 1393	6.76	745	793kg and 1071	77

Table 84b. Total fish production, utilization pattern and income before and after intervention at FSRD site, Atia, Tangail during the years of February 2018 to January 2021

Description	Before Intervention (kg ha ⁻¹)	After Intervention (kg ha ⁻¹)		
		February 2018-January 2019	February 2019-January 2020	February 2020 - December 2020
Consumption	35	70	90	66
Distribution	12	20	28	17
Selling	78	98	92	90
Total production	1403	2111	2358	1942
Gross return (Tk.)	154375	232210	259380	213620
Total cost (Tk.)	80210	84290	88210	88960
Net return (Tk.)	74165	147920	171170	112345
BCR	1.92	2.75	2.94	2.26

FSRD Site, Tarakandi, Sherpur

The program of carp poly culture in sea ponds was undertaken at the FSRD sites with the objectives of increasing farmer's income and to remove protein deficiency of rural people. Fish fries/fingerlings were given among the four selected farmers of two villages under this program. Periodic checking was done after every 15 days interval to measure the growth and weight of fish. For fish cultivation, weeds and wild fishes were removed from the pond, Lime was given at the rate of 1 kg decimal⁻¹ as well as prepared for stocking with organic manure (Cowdung) at the rate of 3 kg decimal⁻¹ (Table 85a).

Average size of the ponds was 16.75 decimal with 1.5 m depth. The result revealed that average survival rate was 86%. Average yield and number of fish was 291 and 358 kg pond⁻¹, respectively. Total production, consumed, distribution, selling and economic analysis are shown in Table 85b. It was observed that in Tarakandi, Sherpur total production was 4114 kg ha⁻¹ with the gross margin of 264491 Tk. ha⁻¹. The farmers were benefitted by carp polyculture system and they showed interest for farming of carp polyculture.

Table 85a. Performance of carp polyculture fish farming at FSRD site, Tarakandi, Sherpur during the years of February 2018 to January 2021

SL No.	Area and depth of pond (dec and m)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	16.75 dec. and 1.5 m	20-25 kg	86	950	291 kg and 310#	95
2019-20	16.75 dec. and 1.5 m	18-20 kg	79	890	296 kg and 305#	96
2020-21	16.75 dec. and 1.5 m	22-26 kg	91	532	288 kg and 460#	90
Average	16.75 dec. and 1.5 m	-	85	615	291 kg and 358#	86

Table 85b. Total fish production, utilization pattern and income before and after Intervention at FSRD site Tarakandi, Sherpur during the years of February 2018 to January 2021

Description	Before Intervention (kg ha ⁻¹)	After Intervention (kg ha ⁻¹)			
		February 2018- January 2019	February 2019- January 2020	February 2020 - January 2021	Average
Consumption	630	738	720	700	719
Distribution	95	160	150	105	138
Selling	2710	3420	3250	3100	3257
Total production	3435	4318	4120	3905	4114
Gross return (Tk.)	412200	680026	556166	507650	581281
Total variable cost (Tk.)	250000	370370	300000	280000	316790
Gross margin (Tk.)	162200	309656	256166	227650	264491

Average pond size = 16.75 Decimal. Price of fish=130 Tk. kg⁻¹

E. OFF-FARM ACTIVITIES

Activity-52: Maximization of farmers' income through Off-farm activities at different FSRD sites during the years of 2018 to 2020.

FSRD site, Ajoddhapur, Rangpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was started handicrafts making and finally most of the households were practiced handicrafts besides of other off-farm activities.

It was found that after intervention the av. net return increased 89%, with the av. net return of Tk. 6226 (Table 86). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 86. Cost and return of off-farm activities

Activities	Before intervention	After intervention			
		Feb.2018- Jan. 2019	Feb.2019- Jan. 2020	Feb.2020- Jan. 2021	Average
Khata making, Handicrafts etc.	Kantha making, Irrigation, Cooking	Handicrafts, Sewing, Kantha making, Irrigation, Cooking	Handicrafts, Sewing, Kantha making, Irrigation, Cooking	Handicrafts, Sewing, Kantha making, Irrigation, Cooking	Handicrafts, Sewing, Kantha making, Irrigation, Cooking
Production cost	1833	3583	3455	3333	3457
Sale value (Tk.)	5133	10583	9250	9217	9683
Net return (Tk.)	3300	7000	5795	5883	6226

FSRD Site, Ganggarampur, Pabna

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Three households were practiced with off-farm activities such as sewing clothes, making of kumara bora and puffed rice, seedling raising in nursery, preparation of Jam/Jelly/Acher, Tailoring, Mudi shop etc. It was found that some off farm activities exhibited good cash income which contributed livelihood of the resource poor farmers to some extent. After intervention net benefit from off- farm activities were recorded Tk. 5765 farm⁻¹ (Table 87). So, if all households could introduce some off-farm activities, it would be helpful to increase their total farm income which eventually contributes livelihood improvement of the rural household.

Table 87. Cost and return of off-farm activities at FSRD site, Ganggarampur, Pabna during the years of February 2018 to January 2021

Activities	Before intervention			After intervention								
				Feb 2018 to Jan 2019			Feb 2019 to Jan 2020			Feb 2020 to Jan 2021		
	Total income	Cost	Net income	Total income	Cost	Net income	Total income	Cost	Net income	Total income	Cost	Net income
Sewing katha	666	320	346	4000	2000	2000	11000	3500	7500	7650	4500	3150
Puffed rice (Muri vaja)/ Kumra bora	483	230	253	2500	1050	1450	2300	1050	1250	1430	820	610
Seedling nursery	200	50	150	800	200	600	1400	652	750	1740	650	1090
Jam jelly	20	15	5	80	20	60	1620	550	1070	650	290	360
Tailoring	46	20	26	200	60	140	5750	1420	4330	3120	750	2370
Mudi shop	100	50	50	500	200	300	22800	14150	8650	35500	19300	16200
Total	1515	685	830	8080	3530	4550	44870	21322	23550	50090	26310	23780
Average	505	228	277	2693	1176	1517	14956	7107	7850	16697	8770	7927

FSRD Site, Sholakundu, Faridpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Four households were practiced with off-farm activities such as vermicompost production and honey production using honey box. It was found that gross margin of Tk. 4600 obtained after intervention of vermicompost the (Table 88) as well as farmers using this product to their homestead gardening. Honey production just started previous rabi season (2019-20) and farmers hoped profit will come from next rabi season. So, if all households could introduce some off-farm activities which would be helpful to increase total farm income.

Table 88. Cost and return of off-farm activities

Activities	Economy	Before intervention	After intervention		
			Feb.19-Jan. 20	Feb.20- Jan. 21	Total
Vermicompost production	Production cost	--	4100	800	4900
	Sale value (Tk.)	--	5300	4200	9500
	Net return (Tk.)	--	1200	3400	4600
Honey production	Production cost	--	7500	--	7500
	Sale value (Tk.)	--	4200	--	4200
	Net return (Tk.)	--	--	*	--

*Honey box will be used for next year honey production so; net return cannot be included.

FSRD Site, Atia, Tangail

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Two households were practiced with off-farm activities such as hatching eggs by incubator and vermicompost production. It was found that after intervention the gross margin increased 40 % with the gross margin of Tk. 27902 (Table 89). So, if all households could introduce some off-farm activities which would be helpful to increase total farm income.

Table 89. Cost and return of off-farm activities at FSRD site, Atia, Tangail during the years of February 2018 to January 2021

Activities	Before intervention	After intervention			
		Feb.2018-Jan. 2019	Feb.2019-Jan. 2020	Feb.2020- Jan. 2021	Average
Hatching eggs and Vermicompost	Hatching eggs 2160 and vermicompost 1340 kg	Hatching eggs 5760 and vermicompost 2340 kg	Hatching eggs 6480 and Vermicompost 2964kg	Hatching eggs 5040 and Vermicompost 2730kg	Hatching eggs 5760 and Vermicompost 2678kg
Production cost	23300	37275	36675	30928	34959
Sale value (Tk.)	43200	58800	70464	59320	62861
Net return (Tk.)	19900	21525	33789	28392	27902

FSRD Site, Tarakandi, Sherpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. It was found that after intervention the income increased than before

intervention. After intervention average net income was Tk.4500 whereas before intervention only Tk.2000. So, FSRD site team of Tarakandi, Sherpur could introduced some off-farm activities at their projected area, it would be helpful to increase total farm income (Table 90).

Table 90. Cost and return of off-farm activities

Activities	Before intervention	After intervention			
		Feb.2018-Jan. 2019	Feb.2019-Jan. 2020	Feb.2020-Jan. 2021	Average
Kantha making, making Coconut strick etc.	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick
Production cost	11000	12000	9000	9500	10166
Sale value (Tk.)	13000	16000	13000	15000	14666
Net return (Tk.)	2000	4000	4000	5500	4500

Income enhancement

FSRD site, Ajoddhapur, Rangpur

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, Carp polyculture, the resources (land, labor, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. Before intervention of the project, an average per farm gross margin was Tk. 45433 whereas it was Tk. 107512, 209919 and Tk. 220659 during 2018-19, 2019-20 and 2020, respectively after intervention of the project activities (Table 91). The average increment of gross margin after intervention was 150% compared to before intervention.

Table 91. Technologies used and return from different sub-systems of integrated farming systems at FSRD site Ajoddhapur, Rangpur during the years of February 2018 to January 2021

Component	Before intervention (Tk.)			After intervention (Tk.)									Gross margin increased (%)			
	Gross return	Total variable cost	Gross margin	Gross return			Total variable cost			Gross margin			Feb.2018-Jan. 2019	Feb.2019-Jan. 2020	Feb.2020-Jan. 2021	Av.
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Homestead	7308	1900	5408	18842	33990	30210	5895	5979	5630	12947	28011	24580	139	418	354	304
Field crop	54725	43800	10925	110540	222863	226618	66625	92450	89000	43915	130413	137618	302	175	190	222
Livestock	27850	5500	22350	45500	46650	57955	11150	11150	16452	34350	35500	41503	54	51	77	61
Fisheries	5250	1800	3450	14700	15750	16625	5400	5550	5550	9300	10200	11075	170	136	156	154
Off-farm	5133	1833	3300	10583	9250	9217	3583	3455	3333	7000	5795	5883	112	76	78	89
Total	100267	54833	45433	200165	328503	340624	92653	118584	119965	107512	209919	220659	137	150	163	150

FSRD Site, Ganggarampur, Pabna

Integrated farming with holistic approach exhibited remarkable improvement in overall farm productivity and income. By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labor, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return was recorded from the field crop followed by livestock during three consecutive year's which was around 73% and 60% higher over previous intervention status of field crop and livestock, respectively. However, year-round vegetables and fruits in homestead also exhibited remarkably higher economic return which was 63% higher over previous intervention. Regarding increase (%) of different component over previous status, fisheries sector demonstrated maximum increase (412%) in return over previous status followed by off-farm activities (105%) (Table 92).

Table 92. Technologies used and return from different sub-systems of integrated farming systems during the years of January 2018 to January 2021

Component	Before intervention (Tk)			After intervention (Tk)									Gross margin increased (%)			
	Gross return	TVC	Gross margin	Gross return			Total variable cost			Gross margin			Feb. 2018-Jan. 2019	Feb. 2019-Jan. 2020	Feb. 2020-Dec. 2020	Av. of 3 years
				2018-19	2019-20	2020	2018-19	2019-20	2020	2018-19	2019-20	2020				
Homestead	27247	5982	21265	45900	41900	46195	10148	9300	10352	35752	32600	35843	68	53	69	63
Field crop	139500	70300	69200	220700	230500	255500	99500	120000	127300	121200	110500	128200	75	60	85	73
Livestock	125450	62500	62950	201000	172800	233100	79800	81100	144500	121245	91700	88600	93	46	41	60
Fisheries	4350	2500	1850	7050	18460	32250	3230	10200	15900	3820	8260	16350	106	347	783	412
Off-Farm	12500	1250	11250	20380	14956	50090	2750	7107	26310	17630	7850	23780	57	249	111	105
Total	309047	142532	166515	495030	478616	617135	195428	227707	334362	299602	250910	292773	-	-	-	-

FSRD Site, Sholakundu, Faridpur

By integration of year-round vegetables production, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labor, capital) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from the crop sector area which was 204% increased after intervention of technologies. The second highest gross margin increased in homestead that was 186% followed by fisheries (77%). The livestock component and off-farm activities contributed a good amount to increase farm income (Table 93).

Table 93. Technologies used and return from different sub-systems of integrated farming systems at FSRD site Sholakundu, Faridpur during the years of February 2018 to January 2021

Component	Before intervention (Tk.)			After intervention (Tk.) average of three years									% Increased of GM with before intervention			
	GR	TVC	GM	GR			TVC			GM			Feb 18-Jan. 19	Feb. 19-Jan. 20	Feb. 20-Jan. 21	Avr
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Crop sector	123100	95300	27800	163400	198400	223600	102630	110960	118425	60770	87440	105175	119	215	278	204
Homestead	6268	556	5712	13893	19466	23295	2350	2373	2948	11543	17093	20347	102	199	256	186
Livestock	3605	1365	2240	5390	7170	8568	2150	3005	4417	3240	4165	4151	45	86	85	72
Fisheries	12460	2957	9503	16095	22200	25256	4038	4357	4732	12057	17843	20524	27	88	116	77
Off-farm	0	0	0	0	5300	4200	0	4100	800	0	1200	3400	--	--	--	--
Total	145433	100178	45255	198778	252536	284919	111168	124795	131322	87610	127741	153597	94	182	239	172

FSRD Site, Atia, Tangail

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labor, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from the homestead area which was 246% increased after intervention of technologies. The second highest gross margin increased in livestock component that was 81% followed by field crop sector (57%). The fisheries component and off-farm activities contributed a good amount to increase farm income (Table 94).

Table 94. Technologies used and return from different sub-systems of integrated farming systems during the years of January 2018 to January 2021

Component	Before intervention (Tk)			After intervention (Tk)									Gross margin increased (%)			
	Gross return	TVC	Gross margin	Gross return			Total variable cost			Gross margin			Feb. 2018-Jan. 2019	Feb. 2019-Jan. 2020	Feb. 2020-Jan. 2021	Av. of 3 years
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Homestead	2026	573	1453	6630	8144	6689	1800	2420	2146	4830	5724	4543	232	294	213	246
Field crop	53870	35170	18700	66838	70188	58664	36735	40186	30632	30103	30002	28032	61	60	50	57
Livestock	39000	23850	15150	54185	58290	70649	28319	30480	42120	25866	27810	28529	71	84	88	81
Fisheries	16832	7144	9688	20680	23100	21780	7650	8089	8025	13030	15011	13755	35	55	42	44
Off-Farm	43200	23300	19900	58800	70464	59320	37275	36675	30928	21525	33789	28392	08	70	43	40
Total	154928	90037	64891	207133	230186	217102	111779	117850	113851	95354	112336	103251	47	73	59	59

FSRD Site, Tarakandi, Sherpur

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labor, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from crop sector and homestead area which was 633% and 645% increased after intervention of technologies. Before intervention of the project, an average per farm gross margin was Tk. 267204 whereas it was Tk. 699029, 1198889 and 1828537 during the years of 2018-19, 2019-20 and 2020, respectively after intervention of the project activities. The average increment of gross margin after intervention was 1505% compared to before intervention (Table 95).

Table.95. Technologies used and return from different sub-systems of integrated farming systems at FSRD site Tarakandi, Sherpur during the years of February 2018 to December 2020

Component	Before intervention (TK.)			After intervention (Tk.)									Gross margin increased (%)			
	Gross return	Total variable cost	Gross margin	Gross return			Total variable cost			Gross margin			Feb.2018-Jan. 2019	Feb.2019-Jan. 2020	Feb.2020-Dec. 2020	Av.
				2018-19	2019-20	2020	2018-19	2019-20	2020	2018-19	2019-20	2020				
Homestead	1004	510	494	2804	8830	13883	765	4350	9350	2039	4480	4533.50	312	806	818	645
Field crop	334055	237825	96230	832236	1870553	1077978	403245	944143	496922	428991	926410	581056	532	862	504	633
Livestock	11,080	4800	6,280	20580	13093	16787	12000	5260	6989	8580	7833	9798	36	25	56	39
Fisheries	412200	250000	162200	680026	556166	507650	370370	300000	280000	309656	256166	227650	91	58	40	63
Off-farm	7000	5000	2000	16,000	13000	15000	12000	9000	9500	4000	4000	5500	100	100	175	125
Total	765339	498135	267204	1551646	2461542	1616198	76601361	1262753	802761	699029	1198889	828537	1071	1851	1593	1505

F. DEVELOPMENT OF LOCAL SERVICE PROVIDER (LSP)

Activity-53: Development of Local Service Provider at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

One co-operative farmer is acted as male LSP and one is acted as female LSP at the project area. The male LSP produced different types of vegetables and fruits seedling in his own nursery and also collected seeds and seedlings from other source and supplied to the project farmers and remaining part sold to the neighbour other farmers. The beneficiary farmers are return back some parts of their produce (vegetables/fruits/seeds) to the LSP. The female LSP provided training on handicrafts production and sewing by sewing machine to the other female farmers and also discussed with women regarding nutrition and sanitation. These activities were found a suitable practice for the sustainable farming activities. Table 96a shows the activities of male LSP and 96b shows the activities of female LSP.

Table 96a. Activities of male Local Service Provider (LSP) at FSRD site Ajoddhapur, Rangpur during the years of February 2018 to January 2021

Activities/crop	No. of seedling produce		Supply to homestead member (no.)		Sell to other farmer (no.)		Gross return (Tk)		Total variable cost (Tk)		Gross margin (Tk.)		
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	Av.
Bottle gourd	750	700	12	12	13	13	1500	1400	550	550	950	850	900
Bitter gourd	380	450	12	12	9	9	760	900	300	300	460	600	530
Brinjal	5000	4500	12	12	11	11	5000	4500	600	600	4400	3900	4150
Tomato	6000	5400	12	12	16	16	6000	5400	600	600	5400	4800	5100
Cabbage	3000	3200	12	12	11	11	6000	6400	1600	1600	4400	4800	4600
Cauliflower	2500	3000	12	12	7	7	5000	6000	1500	1500	3500	4500	4000
Chilli	5000	4800	12	12	20	20	5000	4800	800	800	4200	4000	4100
Napier cutting	200	250	12	12	0	0	400	500	50	50	350	450	400
Sugarcane seedling	-	50	-	12	-	4	-	250	-	50	-	200	200
Dragon fruit seedling	-	55	-	12	-	10	-	1100	-	165	-	935	935
Total		22405		120		101	29660	31250	6000	6215	23660	25035	24348

Table 96b. Activities of female Local Service Provider (LSP) at FSRD site Ajoddhapur, Rangpur during the years of February 2018 to January 2021

Sl no.	Activities	No. of female trainee
1	Training on handicrafts preparation	15
2	Training on Sewing machine	26

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Activity-54: Feasibility study on integration among different household components at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Several enterprises of a farmer like home gardening with vegetables and fruits, crops and cropping system, dairying, poultry, fishery, etc. are interrelated. The end product and wastage of one enterprise was used as inputs in another enterprise. Moreover, judicious use of farm resources can reduce production cost and can help to keep clean the environment. In integrated farming, the contribution of one component on other component ('s) is important consideration for sustainable farming. Two types of integration were found among the different components of a farm, one is direct integration, and another is indirect integration. The direct integration was conducted through sharing of the product or by product directly with each other and in case of indirect integration, it was happened through sharing money or nutrition or labor with each other. Some examples are given below-

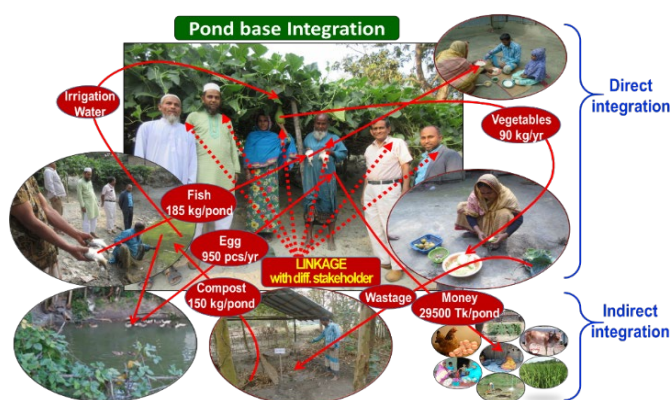


Fig.: Direct and indirect integration based on pond.

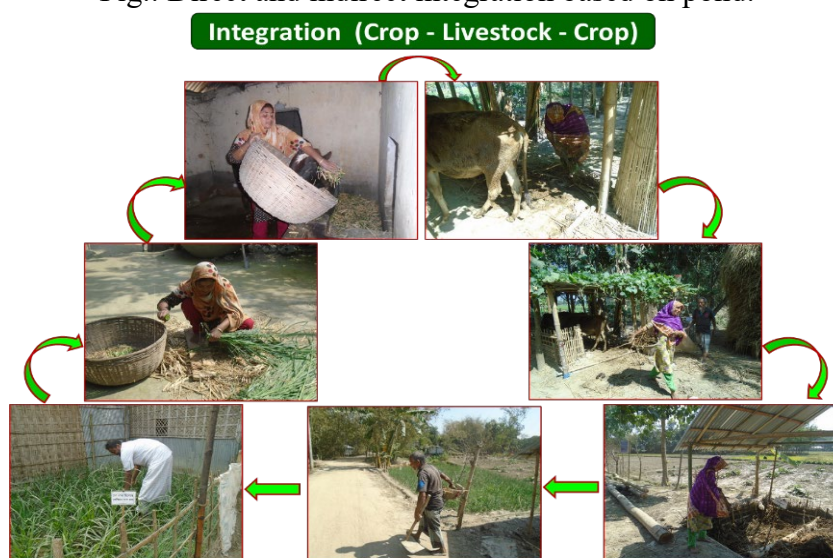


Fig.: Direct integration between crops and livestock.

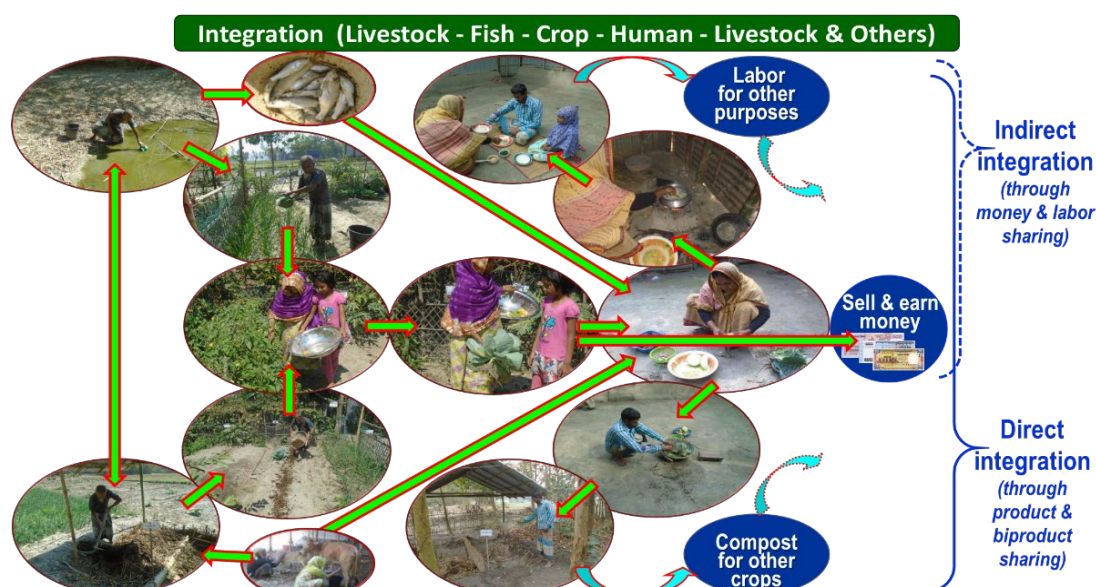


Fig.: Direct and indirect integration among the farm components.

Livelihood improvement (sustainability)

Livelihood improvement is a very complex system and an individual's livelihood involves the capacity to acquire basic necessities in order to satisfy the basic needs. Increasing the capability of sufficient earning, security of nutritional and safe food, medical care, education, assets, acceptable life leading with social status may involve with the livelihood improvement (Table 97). However, the parameters that were considered for the sustainability of livelihood improvement under different FSRD sites are given below.

Table 97. The following information on livelihood improvement parameters (sustainability) have been made after intervention of the project activities at different FSRD sites during the years of February 2018 to January 2021

Sl. No	Area of consideration	Impact created	Indicator to assess the sustainability
1	Income enhancement	Gross margin increased by 59-385%	-Production of vegetables and fruits in homestead area considering time and space properly -Production was done in integrated way to minimize production cost and maximize yield -Used FRG for balanced fertilization of crops (Cereals, Oilseeds, Vegetables etc.) -Used of modern varieties -Innovative technologies -Used fallow land under cultivation - Increased production skill due to training
2	Family nutrition	Improved satisfactorily	-Vegetable intake from homestead source increased 163-1528% -Fruit intake from homestead source increased 16-131% -Fish and poultry meat and egg production and intake increased remarkably -Changed in consumption habit towards vegetables and fruit -Reduced no. of attack and frequency of diseases
3	Soil health	Maintenance/ Increased	-Used of organic matter (FYM, vermicompost, green manure) -Decreased the use of insecticides/chemicals due to use of organic matter and IPM technology

4	Resource use pattern	Increased	-Used homestead (100%) -Introduction of homestead vegetables production model for respective site using 8 to 10 production niches.
5	Technical knowledge	Increased sharply	-Young girls and boys are engaged for implementation of new technologies -Training, field days, LSP activities, fortnightly meeting with field staffs and farming group and exchange of views with different type of peoples.
6	Adaptation innovation	Increase of 60-70%	-New crops, varieties are used -Used of recommended fertilizers -Used of different preservation and curative measures of food and seeds - LSP activities
7	Employment	Increased	-Used of unutilized family labor -Women participation in Agricultural activities (Homestead vegetables, livestock, Duck and poultry rearing, compost making) the new technology and created employment. - Male in female LSP development
8	Micro-environment	Improved	-Household wastes being used for composting and their used in crops -Used of IPM/bio-pesticides saved environment from pollution. -New plantation and increased vegetables contribute to favorable environment
9	Housing	Improved	New house and repairing of house helps in improve living
10	Social status	Improved	-Increased access of better living standard to people -Improved mental strength due to higher income, development of skill on technologies and public conduct.
11	Education	Improved	-Women empowerment especially increased income made them to educate their children for a better future.
12	Women participation	Increased	-Homestead vegetables cultivation -Tree plantation and nursing -Composting -Seed preservation - Homestead mini nursery -Cow, Poultry and Duck rearing -Female LSP development -All these ensured women empowerment

Problems/ Constraints

- Continuous and heavy rainfall in September 2020 caused flood and inundated almost all home garden and damaged Kharif-2 vegetables at Rangpur.
- Vegetables especially bed vegetables were affected partially by poultry though there were fence surrounding the bed.
- Unplanned and unproductive tree species planted in homestead
- Ponds are mostly seasonal and small in size
- Farmers are less interested to supplement fish feed from out source
- Sometimes Turkey fed the seedling and vegetables crop produced in the homestead area, which partially hampered the successful crop establishment.

Farmer's opinion

Integrated farming is a resource saving technology and farmers of different FSRD sites responded positively. They opined that homestead is now the source of fresh vegetables and even during the rainy

season it could provide value able vegetables. The resource poor farmers are interested to adopt integrated farming technique which could provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and shift to other activities. They opine that technologies of different components and critical inputs especially different types of seeds should make available at their level. Their need is to greater access with GO, NGO service provider at the village level. Due to adoption of integrated farming, they are hopeful to maintain their family with farm income. Farmers also opined that LSP system needs to strengthen more.

Conclusion

Generally, most of the homestead area of the farmers was unproductive and unused, female labor was less or unused and vegetables and fruit intake was very low. Farmers did not follow recommended management practices or newly released technologies for crop production, fish culture and livestock production. As a result, existing farming system was not efficient. The integrated farming by reorganization of year round homestead vegetables production, improved cropping pattern, and recommended management practices, De-worming and vaccination program, carp polyculture, off-farm activities etc. have influenced farms income at different site. Integrated farming is a holistic approach and the components of integrated farming like home gardening, cropping system, livestock, fisheries, etc. are found interrelated. The waste of dairy like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle's. The vital indicator for livelihood improvement is increasing income compared to existing condition, which was found increasing trend in the program. So, the proper utilization of farmers' resources could help them in this area. However, for the successful and sustainable integrated farming activities, establishment of a local service provider (LSP) is important at all farming systems research and development sites.

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IMPROVEMENT OF FARM PRODUCTIVITY THROUGH INTERVENTION WITH IMPROVED AGRICULTURAL TECHNOLOGIES IN CHAR LAND ECOSYSTEM

Executive Summary

Charland is one of the most vulnerable ecosystems characterized by a deposit of mud mostly sand as islands within the river, face the flash flood along with other natural disasters due to climate change. The modern agricultural technologies are not properly disseminated in the char land due to scattered, isolated and disconnected transport network. Char areas of Bangladesh are also a hub of hydro meteorological disasters like unpredictable flash flood, seasonal drought, soil erosion and so on. To keep the above issues in the mind, the project activities were identified and prioritized to maximize the farm productivity and farmers benefits with efficient use of famer's existing resources. The activities of the project were initiated from early February 2018 at the FSRD Site, Charkharicha, Mymensingh and FSRD Site, Charpara, Sonatala, Bogura.

Farming system research and development program is an integrated farming approach for sustainable resource management approach to maximize farm productivity, farm resource use efficiency, employment opportunity, farmers' income and nutrition as well as livelihood of the resource poor farm households of char land ecosystem. With rapid increasing population and declining agricultural land, food and nutrition security of resource poor farm households through integrated farming are gaining priority. The integrated farming activities were carried out in Char land ecosystem of Mymensingh and Bogura during the year of 2020-21. The research areas were i) Homestead production system ii) Crops

and cropping system iii) Poultry and livestock production system, iv) Fisheries production system and v) Off-farm activities. All components of integrated farming such as vegetables, fruits, cereal crops, livestock, fish and off-farm activities were brought under improved technological intervention and accordingly income was generated from these components. In Charland ecosystem of Mymensingh and Bogura overall results of homestead production program revealed that intake of vegetables was markedly increased (av485%) by all families included in this system. Average intake of fruits per year was also increased (av 279.50%) after intervention of the technology. Existing fruit tree management and new plantation has created a good impact on farm households. In Charland ecosystem of Mymensingh and Bogura farmers obtained higher yield and economic return from their alternative or improved cropping pattern with high yielding variety (s) and better management approaches. Two improved cropping pattern viz. Mustard-Boro-T. Aus -T. Aman and Wheat-Jute-T. Aman was conducted in FSRD site Char Shyampur, Bogura and Mustard-Boro-T.Aman and Potato-Boro-T.Aman pattern were conducted in FSRD site, Char Kharicha and Char Anondipur, Mymensingh. Newly released high yielding crop varieties were also introduced through on farm validation program where farmers obtained higher crop yields and gross margin. Due to deworming and vaccination program body weight and milk was increased of cattle over pre intervention. Average mortality of poultry declined from 21.20% at pre-intervention to 6.6% at post-intervention conditions. Among the seasonal fish culture carp polyculture gave higher gross margin (av Tk. 11090/pond) which was 451% higher over traditional fish culture at farmers' level. Women participation in agricultural activities increased to a great extent that showed some positive effect on gender equity within the family. The daily nutritional requirements of the family members were supplemented considerably due to increased consumption of vegetables and fruits from the homestead gardening and also from fish, Chicken and livestock production. Active participation of the farmers' and integration of their available resources in planned way has created a positive impact on improving livelihood of resource poor farm household. Finally, it can be concluded that interventions made in different components exerted a visible positive impact in improving farmers' socio-economic condition and livelihood of the char households under both char land ecosystem as well.

Introduction

Integrated farming is a mixture of different agricultural activities and a whole farm management system which aims to deliver more sustainable agriculture. It is a dynamic approach which can be applied to any farming system around the world. Particular emphasis is placed on a holistic management approach looking at the whole farm as cross-linked unit, on the elementary role and function of agro- ecosystem on nutrient cycles which are balanced and adapted to the demand of the crops, and on health and benefit of all livestock on the farm. An integrated farming system consists of a choice of resource-saving practices that aim to achieve acceptable profits and high sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Farming system is a decision-making unit comprising the farm household, cropping and livestock system that transform land, capital and labor into useful products that can be consumed or sold. The system specially refers to a group combination of enterprises in which the products and or the by-products of one enterprise serve as the inputs for production of other enterprise. However, land topography, soil composition and availability of different inputs along with the **environmental factors** influence the farmers in choosing different enterprises.

The subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. These resources may be utilized in such a manner that maximize farm productivity, farmers benefit and resource use efficiency in an environmentally sound and sustainable way. A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. Bangladesh Agricultural Research Institute (BARI) is conducting research through its different crop center, discipline and divisions. Those discipline and divisions are generating a good number of technologies including new cultivars/different management techniques/machines etc. for the farmers of Bangladesh. However, before transferring those to extension agencies/ NGOs and farmers they need on-farm

verification/test of fine-tuning to fit into the farmers existing socio-agro-economic environments. Moreover, through on-farm trial valuable farmers' feedback is obtained to modify technology or to develop new technology. BARI has given this noble responsibility to OFRD to test those developed on-station technologies directly to the farmer's field. Proper utilization of these resources with improved technologies can ensure higher production and income generation. BARI has developed a number of technologies which can be used for increasing production and income of the farmer. Besides of these, some technologies developed by other NARS Institutes on farming systems, which were also verified at different FSRD sites. Department of Agricultural Extension, OFRD, BARI and many NGOs are trying to disseminate these technologies among the farmers. Year-round vegetables and creeper production in homestead, plantation and management of existing trees, livestock and fisheries activities and improvement of different cropping systems were undertaken for livelihood improvement of the farmers in charland ecosystem of Bogura and Mymensingh.

Objectives

1. To generate system-based technologies for charland
2. To optimization of homestead land use for the availability of vegetables and fruits round the year
3. To maximize the farm productivity and efficient utilization of char land areas.
4. To create awareness about modern agriculture technology among the participating farmers.

Methodology

Integrated Farming combines the best of modern tools and technologies with traditional practices according to a given site and situation. In char land ecosystem, Farming System Research and Development were executed in Mymensingh and Bogura with the view to improving of crop production and nutrition, generation of income and livelihood improvement by the integration of farmer's resources. However, for the implementation of the integrated Farming System Research and Development in char land, the following methods were considered-

Location of the Project Site

Site selection has been done on the basis of climatic, edaphic, social, vegetation and economic conditions of the regions. Two villages were selected for each FSRD site i.e. Char Kharicha and char Anondipur, Mymensingh and from Bogura village Boyra and Shyampur were selected. In Mymensingh, two selected villages have a distance of fifteen km from the sadar upazila headquarter and is located Latitude: N24°49' and longitude: E 90°23' (AEZ-9). In Bogura, two villages are located at N 24°05' latitude and E 89°52' longitude and latitude N 24°05' and 89°54' E longitude (AEZ-4).

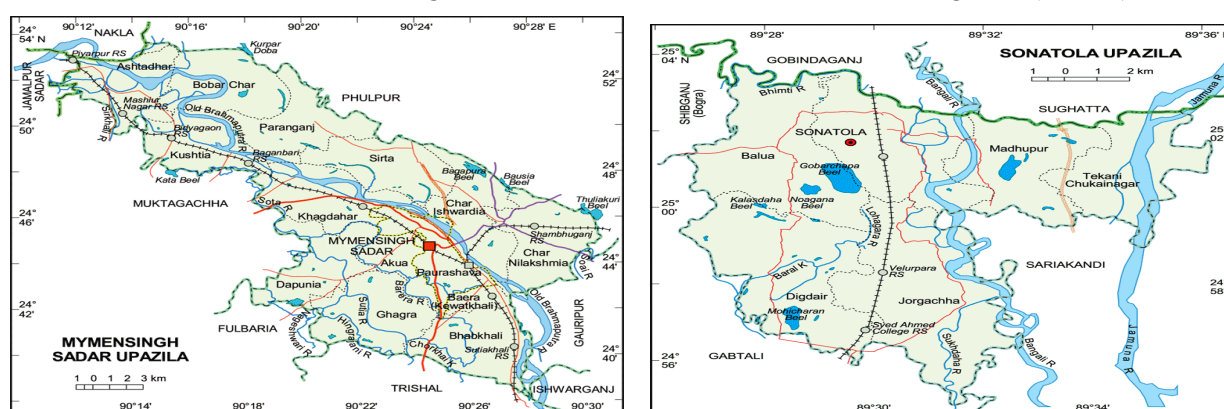


Fig. 1. Map showing the project site under Mymensingh Sadar upazila of Mymensingh and Sonatola upazila of Bogura

Specific Methodology

The integrated farming system research activities in char land were conducted at FSRD site Char Kharicha and Char Anondipur under sadar upazila of Mymensingh district while in Bogura the activities

were conducted in Charpara under Sonatala upazila during the year of 2020-2021. Before initiating the program, several steps were followed such as i) identification of proven/recommended technologies, ii) selection of farmer cooperator, iii) accounting of pre-intervention status, iv) analysis of existing system and selection of technologies for intervention, v) implementation and performance evaluation. On the basis of farmer's traditional practices, their needs and choices, several alternatives of technologies such as crops, livestock, fisheries and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers-landless, marginal and small having major components of farming and sizable homestead under single ownership were targeted and twelve farm households covering from two to three villages were selected. Before going to implement the project activities, a baseline survey of individual households was carried out. Farmers were addressed suitable technology and best ones were selected by them with their need based for livelihood improvement. On-Farm Research Division (OFRD) team facilitated the cooperators for technological support for maximizing the productivity and identified five potential area of intervention.

Training program was arranged to buildup farmers capacity and to develop awareness regarding nutrition and crop production. An individual household survey (Benchmark survey) was carried out before starting the project activities. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Year-round vegetable production followed by respective location-wise model in each homestead, fruit tree management and new plantation, crops and cropping system improvement through improve cropping pattern development and promising variety piloting, vaccination of poultry and livestock, rearing of Turkey, poultry, Pigeon and calf, green fodder production, fish culture and some off-farm activities were identified as their major potential area.

During the implementation period of project activities, site working group meeting, PRA, base line survey, field visit was done and field staffs were organized. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. However, season-wise (Rabi= October-March, Kharif I= April-June and Kharif II= July-September) data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing income and expenditure and other socio-economic information was collected and tabulated accordingly.

A. HOMESTEAD PRODUCTION SYSTEM

A homestead is an area of farmer togetherness with the land around of a farm house. The area under a homestead is a valuable asset of a resource poor farm household which is suitable for vegetables, crops and fruits production. The Fallow and un-utilized homestead areas were brought under cultivation in considering time and space.

On the basis of farmers' choice and agro-ecological suitability, the vegetables production models of different locations were determined and followed accordingly. The recommended seed rate, plant spacing, fertilizer doses and sowing dates were followed for all crops accordingly in all niches. Vegetables from different beds and niches were harvested according to their maturity and the recorded data were converted in to average. The produce values were calculated with the local market price for all crops. The vegetables cultivation program at homestead area was carried out at the FSRD site, Char Kharicha and Char Anondipur, Mymensingh following the "Narekeli Model" including six cooperator farmers from each location during the year 2020. In sunny places, five beds were recommended and the unit plot size 5m×1m was maintained. While in Bogura Goyeshpur model was followed and 12 farm families were involved in the study. In sunny places, five beds were recommended and the unit plot size 5m×1m was maintained.

Table 1a (I-II). Different models for vegetables production in homestead area in different farming system research and development (FSRD) sites under char land ecosystem.

Table 1a.I. *Narekeli* model having eight production units practiced at FSRD site, Mymensingh

Space			Rabi	Kharif-I	Kharif-II
			October-March	April-June	July-September
1	Open sunny space	Bed-1	Tomato *Red amaranth + Red amaranth (BARI Lalshak-1)	Indian spinach (BARI Puishak-1)	Stem amaranth (BARI Data-1)
		Bed-2	Lalshak+cabbage *Radish (BARI Mula-1) + Spinach (BARI Palongshak-1)	Kangkong *Pat shak (Deshi tosha)	Kangkong *Indian spinach (BARI Puishak-1)
		Bed-3	Coriander+onion *Carrot (New Kuroda-35)	Okra *Kangkong (BARI Gimakalmi-1)	
		Bed-4	Spinach+Garlic (BARI Rashun-1)	Chilli *Latirajkachu (BARI Panikachu-1)	
		Bed-5	Carrot + Bitter gourd *Onion (BARI Piaj-1)	*Stem amaranth (BARI Data-1)	*Red amaranth (BARI Lalshak-1)
2	Roof top		Country bean (BARI Sheem-1)	*Sweet gourd (Local cultivar)	-
3	Trellis				
	Trelly-1		Bottle gourd (Hybrid)	*White gourd (BARI Chalkumra-1)	Yard long bean (Local cultivar)
	Trelly-2		Country bean (BARI Sheem-1)	*Bitter gourd (Hybrid)	*Snake gourd (BARI Chichinga-1)
	Trelly-3		Country bean (BARI Sheem-1)	*Sweet gourd (BARI Mistikumra-1)	White gourd (BARI Chalkumra-1)
4	Fence		Bitter gourd (Hybrid)	*Sponge gourd (BARI Dhundol-1)	
5	Marshy land		Latirajkachu (BARI Panikachu-1)		
6	Shady Place		Turmeric, Ginger, *Moulovikachu (Locally collected)		
7	House Boundary		Papaya /Drumstick *Chewing type Sugarcane (Local cultivar)	Papaya /Drumstick *Chewing type Sugarcane (Local cultivar)	Papaya /Drumstick *Chewing type Sugarcane (Local cultivar)
8	Unused tree				
	Creper-1		Potato yam (Local gach alu)	Potato yam (Local gach alu)	Potato yam (Local gach alu)
	Creper-2		*Country bean (BARI Sheem-1)	*Sponge gourd (BARI Dhundol-1)	*Sponge gourd (BARI Dhundol-1)

*Newly introduced crop in the home garden. Text in the parenthesis is the variety name of respective crop

Table 1a. II Goyeshpur model having nine production units practiced at FSRD site, Bogura

Niches		Rabi	Kharif-I	Kharif-II
		October- March	April-June	July-September
1. Open sunny space	Bed-1	Radish (BARI Mula-2)	Stem Amaranth (BARI Danta-1)	Indian spinach (BARI Puishak-1)
	Bed-2	Cabbage/Lalshak (BARI Patakopi-1)	Brinjal/*Corriander (BARI Bt Begun-4)	Indian Spinach (BARI Puishak-1)
	Bed-3	Tomato (BARI Tomato-16/17)	Okra/Gimakolmi (BARI Dherosh-1)	Okra (BARI Dherosh-1)
	Bed-4	*Onion/Lalshak onion (BARI Peyaj-1/4)	Red amaranth (BARI Lalshak-1)	Gimakolmi (BARI Gimakolmi-1)
	Bed 5	*Garlic (BARI Rosun-1/2)	Sweet Gourd *Pat shak (Local)	Red amaranth (BARI Lalshak-1)
2. Rooftop		Bottle gourd/Sweet gourd (BARI Chalkumra-1)	Sweet Gourd/ Ash gourd (BARI Chalkumra-1)	Bottle Gourd/ Ash gourd (BARI Chalkumra-1)

3. Trellis	Bottle gourd (BARI Lau-4/local)	Sweet Gourd/ Ash gourd (BARI Mistikumra-1)	Sweet Gourd/Ash gourd (BARI Mistikumra-1)
4. Shady Place	Turmeric/Ginger/ Olkachu (Local)	Turmeric/Ginger/ Olkachu (Local)	Turmeric/Ginger Olkachu (Local)
5. Marshy Land	Panikachu (Local)	Panikachu (Local)	Panikachu (Local)
6. Unproductive Tree	Country bean (BARI Sheem-1/2)	Bottle gourd (BARI Lau-4/local)	Potato yam (Local)
7. Fence	Yard long bean (Local)/Country bean	Bitter gourd (BARI Korola-1)/Country bean	Sponge gourd/Ridge gourd (Local)
8. Backyard	Banana (Local), Guava (BARI Peyara-2)	Banana, Mango (BARI Aam-3/4), Jackfruit, Drumstick	Banana, Lemon, Moringa (Local)
9. House Boundary	*Dragon fruit (BARI Dragon Phol-1), Papaya/lemon (Local)	*Dragon fruit (BARI Dragon Phol -1), Papaya/lemon (Local)	*Dragon fruit (BARI Dragon Phol -1), Papaya/lemon (Local)

*Newly introduced crop in the home garden. Text in the parenthesis is the variety name of respective crop.

B. CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

i. FSRD site, Mymensingh

This component was implemented by developing cropping pattern and development of crop production by introducing new technologies or varieties. To increase cropping intensity the existing cropping pattern was improved by inclusion of other one or two crops in char land ecosystem. All field operations and management practices were closely monitored and data were recorded and presented in following. However, in FSRD site, Mymensingh three crops based two patterns were improved by incorporation other one crop and their activities were monitored and data was recorded during the year 2019-2020.

ii. FSRD site, Bogura

According to the suitability of the land a four-crop based Mustard – Boro - T. Aus -T. Aman and a three crop-based Wheat-Jute-T. Aman patterns were developed against Mustard – Boro - T. Aman rice and Boro-Fallow-T. Aman rice respectively under medium high land situation at the FSRD site, Char Shyampur, Bogura during 2020 to improve the existing cropping pattern, increase cropping intensity, higher yield and economic return. Transformation of three crops based pattern to four crops and two crops based pattern to three crops by changing suitable varieties of selected crops could contribute to higher system productivity as well as economic return. However, management practices of the cropping patterns are presented in Table 2.

Table 2. Management practices followed in improved and existing pattern cropping at FSRD the site, Bogura during 2020.

Observation	Improved cropping pattern				Existing cropping pattern		
Cropping pattern-I							
Crop	Mustard	Boro	T. aus	T. aman	Mustard	Boro	T. aman
Variety	BARI Sarisha- 14	BRRI Dhan-28	BRRI Dhan-48	BRRI dhan 52	Tori-7	BRRI Dhan-28	Swarna
Date of sowing/ Transplanting	26-10-2019 (relay)	20-01-2020	10-05-2020	14-08-2020	20-10-2019	20-01-2020	29-07-2020
Seed rate (kg ha ⁻¹)	6	40	40	40	8	40	40
Spacing	Broadcast	15-20	15-20	15-20	Broadcast	15-20	15-20
Fertilizer dose (N-P-K-S-Zn-B kg ha-1)	120-70-50-30-3-1	138-21-82-20-4-0	65-11-41-0-0	90-12-53-12-0-0	95-50-40-0-0	125-18-70-15-2-0	102-20-60-16-0-0
Date of harvesting (range)	10-01-2020	08-05-2020	10-08-2020	16-11-2020	10-01-2020	25-04-2020	12-11-2020

Cropping pattern-II						
Crop	Wheat	Jute	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Gom-30	O-9897	BRRI dhan75	BRRI Dhan28	-	Swarna
Date of sowing/ Transplanting	20-11-2019	10-04-2020	5-8-2020	14-01-20	-	21-7-2020
Seed rate (kg ha ⁻¹)	18	7	40	40	-	40
Spacing	Broadcast	15×20	15×20	15×20	-	15×20
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	115-32-45-22-0- 1.5	104-12.5- 38-15-0-0	90-12-53-12-0-0	138-21-82- 20-4-0	-	102-20- 60-16-0-0
Date of harvesting	28-03-2020	27-7-20	10-11-2020	22-04-20	-	6-11-2020

b) On-farm verification

i. FSRD site, Mymensingh

BARI developed different crop varieties viz. BARI Sarisha-14 for Mustard, BARI Alu-25 for Potato, BARI Dherosh-1 for Okra were included in the production program at FSRD site, Mymensingh to popularize those varieties among the farmers of this area and thus improved the existing cropping system of that area. Moreover, local popular variety for Brinjal and Hybrid variety for Papaya and Bottle gourd were also included in the production program. Agronomic activities imposed in crop production program are mentioned in Table 3a.

Table 3a. Management practices, variety, number of farmers, area covered by different crops at FSRD site, Mymensingh during the year of 2020-21.

Name of crops	Variety	Farmers (no)	Area (ha)	Date of sowing	Date of harvesting
Mustard	BARI Sarisha-14	15	3.0	7-21 Nov. 2019	26 Jan to 10 th Dec, 20
Potato	BARI Alu-25	9	1.15	22-26 Nov. 2019	20-25 Feb, 2020
Okra	BARI Dherosh-1	2	0.08	10 Feb. 2020	20 Apr. to 10 June 2020
Papaya	Hybrid papaya	1	0.05	20 Feb. 2020	24 June 2020
Brinjal	Local	1	0.04	14 April 2020	20 June to 25 Sep 2020
Bottle gourd leaf	Hybrid	3	0.12	16 Aug. 2020	20 Sep to 20 Oct 2020

ii. FSRD site, Bogura

Production programs with BARI developed different crops were conducted under farmer's field condition at FSRD site, Bogura to observe their yield performance as well as popularize crop varieties. Production program with HYV of potato (BARI Alu-25 and BARI Alu-36), mustard (BARI Sarisha-14, 17), Sweet potato (BARI Mistialu-8), Wheat (BARI Gom-33), and Maize (BARI Hybrid Maize-16) were conducted in farmers field at the FSRD site, Bogura during the year of 2020-21. Quality seeds, tubers, vines were provided by OFRD, Bogura. In addition to this, fertilizers and pesticides as well as pheromone trap for fall army worm of Maize were given to the farmers to ensure better crop stand. Farmers were advised to follow modern cultivation practices for better yield. Data regarding yield and economic return are given in Table 3b.

Table 3b. Management practices, variety, number of farmers, area covered by different crops at FSRD site, Bogura during the year of 2020-21.

Name of crops	Variety	Farmers (no)	Area (ha)	Date of sowing
Potato	BARI Alu-25, BARI Alu-36	12	1	10-20 Nov, 2020
Mustard	BARI Sarisha-14, 17	40	8	1-15 Nov, 2020
Sweet potato	BARI Mistialu-8	2	0.13	15-16 Nov, 2020
Wheat	BARI Gom-33	6		15-24 Nov, 2020
Maize	BARI Hybrid Maize-16	1	0.12	28 Nov, 2020

C. LIVESTOCK COMPONENT

For improvement of cattle health and control diseases and mortality rate proper vaccination is a key program. Proper vaccination against four major diseases reduces the mortality rate of cattle. In the vaccinated group Anthrax Vaccine, FMD vaccine, BQ vaccine and HS vaccine were injected as per recommended schedule. Poultry rearing are common practices of rural Bangladesh. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level this program was conducted at the farmer's field. A good number of poultry birds were vaccinated during the year of 2020. In the vaccinated group BCRDV, RDV, Fowl pox and Fowl cholera, Duck plague vaccine were used as per recommended schedule. The program with vaccination of cattle and Poultry, Goat rearing, Sonali bird rearing, Duck rearing, beef fattening, artificial insemination is going on as per planning. For implementation of program, both FSRD sites of Char land eco-system has undertaken different types of activities for increasing of farm productivity and increased income of concern farm family. In FSRD site, Char Kharicha and Char Anondipur the program conducted with Goat rearing, Sonali bird rearing, Duck rearing and artificial insemination of cattle during February-December 2020. On the other hand, in FSRD site Charpara, Sonatala, Bogura some activities like beef fattening, sheep and Goat rearing, vaccination of cattle and poultry were conducted for the raising farm productivity and income.

D. FISHERIES COMPONENT

Fish culture in seasonal pond is an income generation and meeting up protein deficiency to rural people also an aesthetic need for some people. Under the project, a program on carp polyculture in seasonal or perennial ponds was undertaken at FSRD site with a view to increase farmers' income and to meet up more protein supply of char land people. During the year of 2020, the activities of mixed carp polyculture system was adopted in FSRD site, Charpara, Sonatala, Bogura. Fish fingerlings were supplied from project site and feed mostly collected and supplied by the co-operative farmers. Recommended management technologies of carp polyculture and necessary suggestions were given by the concern scientific personnel. For fish cultivation, weeds and wild fishes were removed from the pond, lime was given at the rate of 1 kg decimal⁻¹ as well as prepared for stocking with organic manure (Cow dung) at the rate of 3 kg decimal⁻¹.

E. OFF-FARM ACTIVITIES

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was practiced with off-farm activities such as sewing clothes for commercial practice and finally most of the households showed their interest in practicing handicrafts besides of other off-farm activities.

Results and Discussion

Integrated farming consists of several enterprises like home gardening, crops and cropping, dairying, poultry, fishery, etc. and these enterprises are interrelated. Different locations and components-wise findings are discussed below-

A. HOMESTEAD PRODUCTION SYSTEM

i. Location: FSRD site, Mymensingh

1. Year-round vegetables and fruits production in homestead

The available and un-utilizable niches of the homestead area have been brought into cultivation with the recommended model in respective site. The Fallow and under-utilized homestead areas were utilized scientifically considering the time and space.

In year-round vegetable production, *Narekeli* model was followed in the FSRD site, Mymensingh where minimum six niches were utilized and three farmers from both locations of FSRD site, Mymensingh was selected during February to December, 2020. After intervention of the proven and improved technologies in the homestead, vegetable production has increased remarkably and the most remarkable change was observed in case of bed vegetables produced at open sunny place (Table 4a). The average vegetable production of both villages of FSRD site of Mymensingh was maximum (145 kg homestead⁻¹) in *kharif-I* season followed by *kharif-II* (142 kg homestead⁻¹) and rabi season (49 kg homestead⁻¹) (Table 1a). By using all niches total vegetable production was 336 kg homestead⁻¹ during Feb. 2020 - Dec., 2020 which was much higher than that of 63 kg homestead⁻¹ year⁻¹ at before intervention of model and the remarkable increase (742.30%) of vegetable production was observed at Mymensingh (Table 4b) and it might be enhanced by using improved technologies and proper management activities.

After intervention of improved technology, the fruit production was increased remarkably (Table 4b). Higher amount of fruits (400 kg homestead⁻¹) produced in *Kharif-I*. Fruits production in *Rabi* (50 kg homestead⁻¹) and *Kharif-II* (40 kg homestead⁻¹) season was much lower than *Kharif-I* season might be due to less availability of fruits species and variety in Bangladesh. After intervention of proven technology related to fruit tree management, total fruit production was 490 kg homestead⁻¹ during Feb. - Dec., 2020 which was much higher than that of 200 kg homestead⁻¹ at before intervention of model and the remarkable increase (101.70%) of fruit production was observed at Mymensingh (Table 4a and Table 4b). Using of improved technologies including judicious fertilizer management and timely irrigation resulted in increased fruit yield.

Table 4a. Year round vegetables and fruits production from different niches of homestead at FSRD site, Mymensingh during February to December 2020.

Niches	Season Wise Vegetables Production (kg)			Total Production (kg)
	Rabi (Oct - March)	Kharif-1 (April-June)	Kharif-2 (July-Sept.)	
Open sunny space				
Bed-1	9	10	10	29
Bed-2	-	12	12	24
Bed-3	-	13	13	26
Bed-4	-	8	11	19
Bed-5	-	15	12	27
Total	9	58	58	125
Trellis	25	35	20	80
Shady Place	5	20	25	50
Tree support	-	10	15	25
Fence	5	15	12	32
House Boundary	5	7	12	24
Total (vegetable)	49	145	142	336
Fruits	50	400	40	490
Total (vegetables +fruit)	99	545	182	826

Table 4b. Year round vegetables and fruits production and income from different niches of homestead at FSRD site, Mymensingh during Feb.-Dec., 2020.

Niches	Before intervention		After intervention		Increase over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%)	Income (%)
Open sunny place	0	0	125	1875	100	100
Trellis	20	300	80	1200	101.7	101.7
Shady place	10	150	50	750	176.7	176.7
Tree support	10	150	25	375	350.0	350.0
Fence	8	120	32	480	400.0	400.0

Niches	Before intervention		After intervention		Increase over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%g)	Income (%)
House boundary	15	225	24	360	28.9	28.9
Total	63	945	336	5040	742.3	742.3
Fruit(other places)	200	3000	490	7350	101.7	101.7
Total	326	4890	826	12390	186.5	186.5

Utilization of vegetable and fruits: The disposal pattern of different vegetable produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetable varied with two locations of Mymensingh and amount of total vegetable production (Table 4c). The average vegetable intake per farm family during the study period was 70 kg after program intervention. After program intervention the distribution of vegetable was recorded as 16.0 kg and selling of vegetable was 250.0 kg in case of both sites of FSRD site of Mymensingh. However, intake, distribution and sell of vegetables were remarkably higher as compared to before intervention. After intervention increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship. After intervention of program, the farmers consume more vegetables and it increases cash income from more selling of vegetable. The better utilization of homestead area with optimum management by effective farm family labor can be achieved optimum vegetable production and subsequent intake, distribution and sell.

The average fruits intake per farm family during the study period was 150 kg after program intervention. After program intervention the distribution of fruits was recorded as 40.0 kg and selling of fruits was 300.0 kg which was remarkably higher as compared to before intervention.

Income from vegetables and fruits: After intervention of the program, the gross return from vegetables per farm was recorded as Tk. 5040 with the gross margin of Tk 3040. The gross return from fruits was recorded Tk 7350 per farm with gross margin of Tk. 5350. Co-operator farmers are getting benefit due to earning additional cash income from increased production of vegetables and fruits (Table 4c).

Table 4c. Year round vegetables and fruits production and its utilization pattern at before and after intervention during February – December, 2020

Description	Before Intervention		After Intervention	
	Vegetable (kg)	Fruits (kg)	Vegetables (kg)	Fruits (kg)
Consumption	10.00	100	70.00	150.0
Distribution	3.00	20	16.00	40.00
Selling	50.00	80	250.00	300.0
Total production	63.00	200	336.00	490.0
Gross return (Tk.)	945.00	3000	5040.0	7350.
Variable cost (Tk.)	500.00	500	2000.0	2000.
Gross margin return (Tk.)	445.00	2500	3040.0	5350.

2. New plantation and management of fruits trees: On the basis of farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied and plantation was done in the homestead area and near-by homestead area. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program.

3. Other activities

One of the key objectives of this project is to maximize the farm productivity with efficient utilization of farm resources and thus different type of activities were taken considering the farmer's needs and choice as well as on the basis of their existing resources. The activities which were conducted during 2020 are presented in the Table 4d.

Table 4d. Different activities other than vegetables and fruits production in homestead at FSRD site, Mymensingh during the year of 2020.

Location	Activity	No. of Family	Year
FSRD Site. Mymensingh	i. Production of Vermicompost	1	2020
	ii. Establishment of mini orchard	3	2020
	iii. Plantation and Management of fruit trees	12	2020

i. Production of Vermicompost

Vermicompost is an organic fertilizer could be established nearby homestead of a farmer for organic source of fertilizer and safe food production. The vermicompost plant might have been an income generation plant as it is sold for organic fertilizer and as well as selling purpose of worm. For this instant, one farmer was supplied all the materials for establishing a vermicompost plant on 25th Nov, 2020 and establish cost was Tk. 3500. However, their production is still on the pipeline and hopefully output will come after 2/3 month later.

ii. Establishment of mini orchard

Establishment of orchard is a long run process which could be established nearby homestead of a farmer to fulfill the demand of nutrient source as well as alternate income generation. For this purpose, planting materials (i.e. Saplings) were supplied during February to December 2020 to three farmers having 16 decimal land size each for establishing a mini orchard in their respective homestead area in FSRD site, Mymensingh. According to farmers choice two Lotkon (Burmese grape) and one Mango orchard were established nearby the homestead of concern farm family. The variety for Mango was BARI Aam-3, and a local cultivar Lotkon saplings were planted in the orchard. However, survival rate of fruit saplings was still 100 percent and their production is still in the long run of 2/3 years. As the plant will take 1-2 years to fruit bearing different types of vegetables such as Chilli and Red amaranth is now being cultivated as intercrop in the orchard.

iii. Plantation and Management

Forty saplings of mango (var. BARI Aam-3) were supplied to the cooperator farmers in view of increasing fruits production and family nutrition at FSRD site, Mymensingh site during 2020 (Table 4e). The mortality (%) of supplied saplings was 21% probably due to lack of carefulness for management. However, OFRD team are providing technical know how to the households for better growth of the plants.

Table 4e. Distribution of fruit saplings at FSRD site, Mymensingh during February-December, 2020.

Sl. no	Types of fruits sapling	Variety	Number of fruits sapling	Mortality (%)
01	Mango	BARI Aam-3	40	21

iv. Family labor utilization pattern

Homestead production systems create an income generation for woman which is an opportunity for employment and empowerment. It has been observed that woman had a good involvement in intercultural operations, harvesting and a remarkable engagement in cooking. Ninety five per cent women are employed in cooking and 10% of their female children are also engaged in cooking (Table 4f). Most of the hard work such are land preparation, growing of seedling, sowing/transplanting of seedlings, marketing etc. are done by male farmer. Children were also helping the men and women adult workers in the production systems especially in non hard working areas. The data revealed that family labor as women and children can utilize their labor properly and women are coming forward and participated in more income generation activities.

Table 4f. Family labor utilization pattern for homestead vegetable production at FSRD site, Mymensingh during February-December, 2020

Working area	Men (%)	Women (%)	Children (%)
Land preparation	90	10	5
Seed/seedling	90	10	5
Sowing/ planting	85	20	5
Intercultural operations	50	35	5
Harvesting	40	60	15
Marketing	90	0	10
Cooking	0	95	10

ii. Location-II: FSRD Site, Bogura

1. Year-round vegetables and fruits production in homestead

After intervention of the proven and improved technologies in the homestead vegetable production trend during 2020 are presented in the Table 5a. In open sunny space, the average vegetable production of Bogura was maximum in *Rabi* season (87 kg homestead⁻¹year⁻¹) followed by *Kharif-II* (47-64 kg homestead⁻¹ year⁻¹). In *Kharif-I* season the vegetables production was relatively lower (51 kg homestead⁻¹ year⁻¹). Higher vegetables production in *Rabi* season might be due to variety of vegetables produced. By using all niches total vegetable production was 555.04 kg homestead⁻¹ during Feb. 2020 - Dec., 2020 which was much higher than that of 117.39 kg homestead⁻¹ year⁻¹ at before intervention of model and the remarkable increase (305.11%) of vegetable production was observed at Bogura (Table 18) and it might be enhanced by using improved technologies and judicious time management and so far the enhancement of labor utilization pattern.

After intervention of improved technology, the fruit production was increased significantly (Table 5a and Table 5b). Higher amount of fruits (76 kg homestead⁻¹) produced in *Kharif-I* followed by *Kharif-II* (61 kg homestead⁻¹). Minimum fruits production (19 kg homestead⁻¹) was observed in *Rabi* season might be due to less availability of winter fruits species and variety in Bangladesh. After intervention of proven technology related to fruit tree management, total fruit production was 156 kg homestead⁻¹ during Feb. - Dec., 2020 which was much higher than that of 31 kg homestead⁻¹ at before intervention of model and the remarkable increase (403.22%) of fruit production was observed at Bogura (Table 5a and Table 5b). Using of improved technologies including judicious fertilizer management in fruits has increased the fruit yield.

Utilization of vegetable and fruits: The disposal pattern of homestead production was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetable varied with two char areas of Bogura (Table 5c). The vegetable intake per farm family was 282.32 kg after the program intervention during Feb.-Dec., 2020. The distribution of vegetable was recorded as 93.79 kg and selling of vegetable per year was 178.93 kg in both sites of FSRD site of Bogura. However, intake, distribution and sell of vegetables were remarkably higher as compared to before intervention. After intervention increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship. After intervention of program, the farmers consume more vegetables and it increases cash income from more selling of vegetable.

The disposal pattern of different fruits produced under homestead area was recorded timely. The fruits intake per farm family was 94.5 kg after the program intervention which was 509% higher than before intervention. The distribution and selling of fruits was recorded 20 and 41.5 kg which was 400% and 261% higher over before intervention. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income from vegetables and fruits: After intervention of the program, the gross return from vegetables was recorded as Tk. 8326 per farm with the gross margin of Tk. 5496 per farm during Feb.-Dec., 2020 which was remarkably higher over before intervention (Table 5c). From the fruits production

the gross return per farm was recorded as Tk. 6240 with the gross margin of Tk. 4990 per farm which was also remarkably higher than before intervention (Table 5c).

Table 5a. Year-round vegetables and fruits production from different niches of homestead at FSRD site, Bogura during February-December, 2020.

Niches		Season Wise Vegetables and fruit Production (kg)			Total Production (kg)
		Rabi (Oct - March)	Kharif-1 (April-June)	Kharif-2 (July-Sept.)	
Open sunny space	Bed-1	25.5	13	12.3	50.80
	Bed-2	7	7	13.9	27.90
	Bed-3	17	10	11.7	38.70
	Bed-4	14	7	12.7	33.70
	Bed-5	23.5	14	13.4	50.90
Sub-total		87.00	51.00	64.00	202.00
Roof top		82	12	12.2	106.20
Trellis		62.5	12.6	31	106.10
Shady Place		6	3	39	48.00
Marshy land		0	9	4	13.00
Unproductive Tree		5.5	10.5	6	22.00
Fence		3	4	3.1	10.10
Backyard		2.54	5	8.6	16.14
House Boundary		15	5	11.5	31.50
Total (vegetables)		263.54	112.1	179.4	555.04
Total (fruit)		19	76	61	156

Table 5b. Year-round vegetables and fruits production from different niches of homestead during Feb.-Dec., 2020.

Niches	Before intervention		After intervention		Increase over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%g)	Income (%)
Open sunny place	0	0	202.00	3030	100	100
Roof top	55	550	106.20	1593	98.33	144.45
Trellis	42	420	106.10	1592	125.55	183.13
Shady place	1	10	48.00	720	1992.0	2872.0
Marshy land	3	30	13.00	195	292.00	395.33
Unproductive Tree	2.5	25	22.00	330	652.80	849.60
Fence	0	0	10.10	152	100	100
Backyard	6.89	68.9	16.14	242	51.62	101.40
House Boundary	7	70	31.50	473	193.81	292.62
Sub-Total	117.39	1174	555.04	8325	305.11	411.32
Fruit (other places)	31.0	930	156	6240	403.22	281.72
Total	148.39	2104	711.04	14565	285.17	354.03

Table 5c. Year-round vegetables and fruits production and its utilization pattern at before and after intervention during February- December, 2020.

Description	Before Intervention		After Intervention	
	Vegetable (kg)	Fruits (kg)	Vegetables (kg)	Fruits (kg)
Consumption	60.06	15.5	282.32	94.5
Distribution	24.18	4.0	93.79	20
Selling	33.16	11.5	178.93	41.5
Total production	117.4	31	555.04	156
Gross return (Tk.)	1174	930	8326	6240
Variable cost (Tk.)	650	250	2830	1250
Net return (Tk.)	524	680	5496	4990

2. Establishment of mini orchard

A mini orchard for commercial purpose with mango, guava and lemon has been established at FSRD site, Bogura on 3 decimals of land near the homestead of concern farm family during February to December 2020. As fruits are rich source of nutrition like vitamins, minerals, different amino acids; the orchard will provide not only family nutrition but meet handsome cash from selling of fruits to the farm family. Keeping this view in mind, a farmer was provided with 20 Mango, 4 Guava and 16 Lemon saplings on 20th August, 2020 and cost was involved Tk. 4000. The varieties for Mango were BARI Aam-3, BARI Aam-4, BARI Aam-11, for Guava was BARI Peyara-2 and seedless Lemon saplings were planted alongside the border. As the orchard will take 1-2 years to come to production, different vegetables (Tomato, Cauliflower, Cabbage, Indian spinach), spices (Onion) is now being growing the inter plant spaces. The garden yet not in fruiting stage and hopefully production will start after 2/3 years.

3. Plantation of saplings and Management of fruit trees

Fruit trees are the essential elements of a homestead. Though there are some common fruit tree species (Mango, Jackfruit) usually exist around the homestead area but they lack fruit diversity. In order to extend the harvesting period of fruit or make the fruits available throughout year in the homesteads different fruit tree species need to be accommodated there along with management of the existing plants. With the view of increasing fruits production as well as diversity OFRD, Bogura provided different fruit saplings with the financial support of the project for plantation in the farmers homestead areas. Besides new plantation, existing fruit trees was brought under management like irrigation, fertilization, training and pruning, spray against insects and diseases. A total of 382 saplings of different quality fruits varieties were supplied to homestead e. g. Mango, Litchi, Dragon fruit, Dwarf Coconut and quick growing Guava, Lemon was distributed among the farmers. Among the supplied saplings, 1% mango and 1% litchi became died due to transportation shock. As a result of new plantation coupled with management of fruit plants, the fruits production will be increased remarkably in the subsequent years. Details of fruits saplings distribution presented in the Table 5d.

Table 5d. Distribution of fruit saplings at FSRD site, Bogura during Feb.-Dec., 2020

Sl. No.	Types of the fruit saplings	Variety	Sapling number	Mortality (%)
1	Mango	BARI Aam-4	250	1
2	Litchi	China-3	12	1
3	Dwarf Coconut	Exotic	12	0
4	Guava	BARI Peyara-2	60	0
5	Lemon	Seed less	12	0
6	Dragon fruit	BARI Dragon Phol-1	36	0
Total distributed			382	

4. Family labor utilization pattern

Homestead is a unique place where family members involve and share their labor with better understanding among the family members. They usually shared and paid their labor according to the suitability of their own time management to run their farm smoothly in order to improve their daily livelihood. They utilize their family labor in different daily activities throughout the year. The details of family labor utilization presented in the Table 5e. It was observed that men paid their labor mostly on hardworking activities like land preparation, sowing or planting of crops, different intercultural operations, harvesting as well as marketing of produced goods. On an average about 55.71% labor of a farm family came from male (Men) part. Though female were mostly involved in cooking, but they also met their shoulder with their male counterpart to work on different activities as stated above. Around 44.29% female labor was involved to do the different jobs in their own farm. Children of the farm family were also involved as a helping hand to support the family in their leisure period. On an average, 11.71% labor came from children to help the family for land preparation to marketing as well as cooking. After intervention of homestead it suggests that family labor as women and children can utilize their labor properly and women are coming forward and participated in more income generation.

Table 5e. Family labor utilization pattern for homestead activities at FSRD site, Bogura during February-December, 2020.

Working area	Men (%)	Women (%)	Children (%)
Land preparation	60	40	10
Seed/seedling	55	45	15
Sowing/ planting	60	40	7
Intercultural operations	70	30	10
Harvesting	60	40	8
Marketing	85	15	12
Cooking	0	100	20
Average	55.71	44.29	11.71

B. CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

i. Location: FSRD site, Mymensingh

Three crops based two patterns viz. Mustard-Boro-T.Aman and Potato-Boro-T.Aman pattern were improved in FSRD site, Char Kharicha and Char Anondipur, Mymensingh by incorporation other one crop and their activities were monitored and data was recorded during the year 2019-2020.

ii. Location-II: FSRD Site, Bogura

Cropping pattern 1: The yield and economic performance of the tested pattern against the existing pattern are presented in Table 6a. In the improved pattern, BARI Sarisha-14 gave higher seed yield (1.51 t ha^{-1}) over the local Tori-7 (0.96 t ha^{-1}) at the FSRD site, Char Shyampur, Bogura during 2020. Moreover, the crop duration of modern mustard variety BARI Sarisha-14 was expected and did not hamper Boro rice cultivation. In improved pattern, T. Aus rice contributed to 3.78 t ha^{-1} grain yield. Higher rice equivalent yield (REY) was recorded as 16.93 t ha^{-1} from the improved pattern and whereas lower REY (11.44 t ha^{-1}) was noted in existing pattern. Higher rice equivalent yield contributed to the higher gross margin (Tk.169630 ha^{-1}) in improved pattern and lower gross margin (Tk.111900 ha^{-1}) was observed in the existing pattern. In the improved pattern MBCR was recorded as 2.10.

Cropping pattern 2: The yield and economic performance of the tested pattern against the existing pattern are presented in Table 6b. In the improved pattern, BARI Gom-30 gave satisfactory grain yield (3.76 t ha^{-1}) and Jute contributed to the fibre yield of 2.43 t ha^{-1} at the FSRD site, Char Shyampur, Bogura during 2020. The grain yield of T. Aman rice was recorded 4.12 t ha^{-1} in improved pattern. Higher rice equivalent yield (REY) was recorded as 15.35 t ha^{-1} in the improved pattern and lower REY (10.20 t ha^{-1}) was obtained from the existing pattern. Higher rice equivalent yield contributed to the higher gross margin (Tk.188680 ha^{-1}) in improved pattern while lower gross margin (Tk.106630 ha^{-1}) was noted in the existing pattern. Remarkably higher MBCR (4.92) was found in the improved pattern.

Table 6a. Yield and economic return of four crop-based cropping pattern against existing cropping pattern at the FSRD site, Bogura during 2020.

Observation	Improved cropping pattern (Mustard - Boro -T. Aus- T. Aman)				Existing cropping pattern (Mustard-Boro - T. Aman)		
	Mustard	Boro	T. Aus	T. Aman	Mustard	Boro	T. Aman
Seed /grain yield (t ha^{-1})	1.51	4.63	3.78	3.96	0.96	4.24	4.2
Straw yield (t ha^{-1})	1.85	5.25	4.56	4.72	1.23	4.96	5.23
Rice equivalent yield (t ha^{-1})	16.93				11.44		
Gross return (Tk ha^{-1})	62250	103100	84720	88640	39630	94720	94460
Total variable cost (Tk ha^{-1})	29390	52480	42560	44650	24380	50980	41550
Gross margin (Tk ha^{-1})	32860	50620	42160	43990	15250	43740	52910
Whole pattern GM (Tk. ha^{-1})	169630				111900		
MBCR	2.10				-		

Price; Mustard: 40 Tk/kg, Mustard stover: 1.0 Tk/kg and Rice: 20 Tk/kg, Rice straw: 2.0 Tk/kg,

Table 6b. Yield and economic return of three crop-based cropping pattern against existing cropping pattern at FSRD site, Bogura during 2020.

Observation	Alternate cropping pattern			Existing cropping pattern		
	Wheat	Jute	T. Aman	Boro	Fallow	T. Aman
Crop						
Seed /grain Yield (tha ⁻¹)	3.76	2.43	4.12	4.81	-	4.35
Straw/stover yield (tha ⁻¹)	3.12	5.16	4.72	5.06	-	5.42
Rice equivalent yield (t ha ⁻¹)	15.35			10.20		
Gross return (Tk ha ⁻¹)	78320	136980	91840	106320	0	97840
Total variable cost (Tk ha ⁻¹)	34860	38950	44650	50980	0	46550
Gross margin (Tk ha ⁻¹)	43460	98030	47190	55340	0	51290
Whole pattern GM (Tk. ha ⁻¹)	188680			97530		
MBCR	4.92			-		

Price; Wheat: 20 Tk/kg, Jute fibre: 50 Tk/kg, Rice: 20 Tk/kg, Rice straw: 2.0 Tk/kg, Wheat stover: 1.0 Tk/kg, stick: 3 Tk./kg

b) On-farm verification

i. FSRD site, Mymensingh

After intervention of the program the variety and technology of BARI have been disseminated in the concern farmer's field and it was observed that the yield and income were generated enormously. However, the yield, cost and return of different crops have been shown in Table 7a.

Mustard: The BARI Sarisha-14 is a promising variety of mustard all over the country is cultivating. However, in the concern project site the variety gave a good performance and it was 1.64 t ha⁻¹ which is better seed yield than that of national average (1.079 t ha⁻¹). After calculating the gross return, it was obtained Tk.72825 ha⁻¹, total variable cost was Tk. 32913 ha⁻¹ and the calculated gross margin was Tk. 40278 ha⁻¹, respectively. The production and economic return of mustard indicated a better technology in the farmer's field.

Potato: The BARI Alu-25 made a good awareness among the farmer in the farming system research and development site. The BARI released variety is taken over the place of local cultivar which was usually cultivated over there. All input were supplied from the project support and crop was grown up. However, the tuber yield of potato was 26.30 t ha⁻¹. The calculated gross return, the total variable cost and the gross margin were calculated and it was Tk. 303400, Tk. 119434 and Tk. 183966 ha⁻¹, respectively. The economic return indicates that the high yielding BARI released variety of potato cultivation is economically profitable in the farmers' field.

Okra: The BARI released variety BARI Dherosh-2 was conducted in the farmers field with recommended dose of input supplied and observation was done routinely. The data was collected after every harvest and converted the yield with market price and performance was observed. The fruit yield of Okra was 20.00 t ha⁻¹ during the three consecutive years. The gross return was calculated and it was obtained Tk. 264900 ha⁻¹, total variable cost and gross margin were Tk. 57145 and Tk. 207755 ha⁻¹, respectively. The cost and return indicate that this technology is economically profitable.

Papaya: A production technology was followed in the project are of FSRD site, Mymensingh where hybrid variety was followed. Popular hybrid variety and all other technical support were supplied and promising good results were observed in the year 2020. However, the yield was obtained as 35.00 t ha⁻¹ and the calculated gross return was Tk. 525000 ha⁻¹, the total variable cost was Tk. 192750 ha⁻¹ and gross margin was Tk. 332250 ha⁻¹, respectively. This is found economically profitable in the farmers' field.

Brinjal: A locally popular Brinjal variety was cultivated in the farmers' field and the production technologies were provided to the farmers by the OFRD team. The yield was 28.00 t ha⁻¹ in the year, 2020. The calculated gross return was Tk. 560000 ha⁻¹, the total variable cost was Tk. 120000 ha⁻¹ and gross margin was Tk. 440000 ha⁻¹, respectively. The technology is found economically viable in the farmers' field.

Bottle gourd leaf: The production program was conducted with BARI Lau-3 in the farmers' field and the average yield of Bottle gourd during 2020 was 25.00 t ha⁻¹. The gross return, total variable cost and

gross margin were Tk. 324850, Tk. 115000 and Tk. 209850 ha⁻¹, respectively. Farmers accepted this technology due to its economic return.

Farmers' opinion: Farmers are very much impressed having the higher yield of BARI Sarisha-14 and was happy to be easily fitted to Mustard-Boro-T. *Aman* cropping pattern without hampering the *Boro* cultivation. Farmers reacted over the variety very positively and satisfaction with for its high yield. A good number of seed has been stored by the farmers for growing in the next year. High yielding potato variety (BARI developed variety) create an awareness among the farmer for higher yield and hike market price in early marketing but lack of storage facility and fluctuation of market price of tuber exhibit the main constraints for extension of the technology. All the BARI released varieties and technologies make a good impact on the farmers due to their higher yield and economic return, quality and sometimes attractive shape and color. They would follow the technology and grow the crops variety in the coming year and some of them stored higher amount of seeds for the next year cultivation.

Table 7a. Performance of different crops under production program at FSRD site, Mymensingh during February-December, 2020.

Name of crops	Variety	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Mustard	BARI Sarisha-14	1.64	72825	32913	40278
Potato	BARI Alu-25	26.30	303400	119434	183966
Okra	BARI Dherosh-2	20.00	264900	57145	207755
Papaya	Hybrid papaya	35.00	525000	192750	332250
Brinjal	Local	28.00	560000	120000	440000
Bottle gourd leaf	Hybrid	25.00	324850	115000	209850

ii. FSRD site, Bogura

After intervention of the program the performance of BARI developed varieties in farmer's field was evaluated. It was observed that satisfactory yield and economic return were generated due to adoption of the production program. However, the yield, cost and return of different crops have been shown in Table 7b. The yield of potato, mustard, Sweet potato, Wheat and Maize were 28.84, 1.62, 26.34, 3.89, and 8.16 t ha⁻¹. The gross margin of the respective crops was Tk. 171848, Tk. 48740, Tk. 210720, Tk. 38703 and Tk. 66660 ha⁻¹.

Farmer's opinion: Both potato and mustard varieties were higher yielders than the local cultivar and thus farmers are very happy to cultivate those crop varieties in between two rice crops. The variety of Sweet potatoes (BARI Misti Alu-8) was higher yielder than local cultivar and orange-fleshed with better taste. The Wheat varieties were higher yielder as well as rust, blast-resistant, and heat tolerant. The yield of Maize varieties was not up to the mark, moreover, they had a lodging tendency to the storm. Fall army worm is a new threat to Maize cultivation.

Table 7b. Yield and economic return of different crops under production programs at FSRD site, Bogura during the year of 2020-21.

Crops	Crop yield (tha ⁻¹)	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
Potato	28.84	288348	116500	171848
Mustard	1.62	77500	28760	48740
Sweet potato	26.34	263400	52680	210720
Wheat	3.89	77593	38890	38703
Maize	8.16	122400	55740	66660

C. LIVESTOCK COMPONENT

i. FRSD site, Mymensingh

I. Rearing of Duck

During the tenure of February to December, 2020, four Khaki Campbell Ducks were supplied to each of ten farmers and their survival rate was promising and it was almost 100%. After six months of rearing, it was observed that average body weight gained around 1.57 kg and some of the Ducks are being laid to eggs and the average egg laid per month was observed as 47. After intervention of the program the awareness on consumption of egg in farm family has been increased and, on an average, it was observed 49% (Table 8a) which ensure the nutritional balance that means the improvement of livelihood. During the six months average monthly income was recorded Tk. 474 by a family that they expense for their improvement of livelihood. On the other hand, some farm family expresses their good satisfaction on fulfill the aesthetic need and as well as bear the expenditure of their child education.

Table 8a. Performance of Duck rearing after 6 months of distribution at FSRD site, Char Anondipur, Mymensingh during February-December, 2020.

Name of farmers	Ducks supplied (no)	Duck survived (no)	Body wt after 6 months (kg)	Egg laid month ⁻¹ (no)	Egg consumption month ⁻¹ (no)		Monthly income (Tk)
					Before	After	
Md. Abdul Momin	4	4	1.8	50	20	40	500
Md. Abdul Kadir	4	4	1.6	45	30	45	450
Md. Azizul Islam	4	4	1.5	65	40	60	650
Md. Sekandar Ali	4	4	1.6	50	20	30	500
Md. Emdadul Haque	4	4	1.7	60	20	30	600
Md. Fazlur Rahman	4	4	1.6	70	20	25	700
Md. Mostafa Mia	5	4	1.5	29	40	60	290
Md. Kamrul Islam	4	4	1.4	35	25	35	350
Md. Sain Uddin	4	4	1.6	30	15	20	300
Md. Mirash Uddin	4	4	1.4	40	15	20	400

Market price of egg: 40 Tk per 4 pieces

II. Sonali chicken rearing at farmer's level for egg and meat purpose

One of the important sector of livestock production in Bangladesh is poultry for providing eggs and meat. The rural people is rearing the indigenous poultry for eggs and meat and some cases of some additional income but the performance of local hens is genetically poor. From our survey report it was shown that the percentage of egg production of local hens was only 12%. In this context, Sonali breed has much productive and adaptive capacity in village conditions. Keeping these views, the study was under taken during the last February to December 2020 (Table 8b). The birds were attained body weight around 1.6 kg per bird after six months of rearing. The number of egg production per farmer per month was recorded 41 among which farmers consumed 22 eggs and sold 19 eggs per month respectively. The consumption and selling of bird meat was noted 3.0 and 3.0 kg respectively per moth per famer. However, gross margin per farmer from rearing of Sonali chicken was Tk. 1385.

Table 8b. Performance of *Sonali chicken* at household level up to 6 months of rearing at FSRD site, Mymensingh during Feb.2020 – Dec. 2020.

Description of Item	Observation
Number of farmers	11
No of birds supplied (per farmer)	6
Date of supplied period	10 th Aug. 2020
Initial body wt/bird (kg)	0.75
Procurement price/bird (Tk.)	127
No of chicken survive	67%
Date of delivery egg	20 th Nov. 2020
Egg Production/farmer (Number/month)	41
Consumption	22

Description of Item	Observation
Sale	19
Distribution	-
Performance of Bird	
Weight gained/bird (Kg) after six month	1.6
Consumption	3.0 kg
Sale	3.0 kg
Distribution	-
Total income from bird/farmer (Tk.)	1320.00
Total variable cost/farmer (Tk)	300.00
Total return/farmer in Tk. (Market value of Egg + Meat)	1685.00
Gross margin/farmer (Tk)	1385.00

III. Goat rearing in the farmers' household for increase income of farmers

One of the important activities of livestock component is Goat rearing in household to generation of income. For this purpose, four farmers were supplied Goat during the period of February to December, 2020. However, their details are as follows in the Table 8c and production in pipeline.

Table 8c. Performance of Goat rearing at household level at FSRD site, Mymensingh during Feb. 2018-Dec. 2020

Description of Item	Observation
Number of farmers	4
No of Goat supplied per farmers	1
Date of supplied	30 th Nov, 2020
Age of Goat during distribution	1 year 1 month
Initial body wt/Goat (kg)	10
Procurement price/Goat (Tk.)	3000
No of Goat survive (%)	100
Weight gained/Goat (kg) after 1 month	About 0.7 – 0.9

IV. Artificial insemination on cattle

One farmer was suggested to artificial insemination and supplied brahmi AI to two of the cattle and it has been waiting for calf birth. The cattle were inseminated on June 20th, 2020 and the feed for caring the cattle were also supplied by the supervision of OFRD, BARI, Mymensingh. During the last six months the body weight increased as 60 kg (Table 8d).

Table 8d. Performance of artificial insemination after attaining 6 months of growing at FSRD site, Mymensingh during Feb. 2020 – Dec. 2020

Name of farmers	Cattle (no)	Initial body wt (kg)	Body wt after 6 months (kg)	Body wt increased (kg)
Md. Momin Mia	2	115	175	60

ii. FSRD site, Bogura

I. Vaccination of cattle and poultry

The vaccination program of cattle and poultry was conducted at the FSRD site, Bogura during 2020. The results generated under vaccination of cattle are represented in Table 8e. A total of 220 cattle in the FSRD site, Bogura were vaccinated against Anthrax and FMD, 150 Goats and 80 sheep were vaccinated with the PPR vaccine. The frequency of diseases of disease incidence of livestock was recorded from the cooperative farmers. It was observed that after vaccination the mortality rate by foot and mouth disease (FMD) was drastically reduced and it was nil (0%) whereas before conduction of the program mortality rate was 2%. The contact farmer can easily be adopted this technology of vaccination as it is cost-effective, and it can be done as per routine work. The cooperator farmers were very much interested in the vaccination program and admitted that it was a good way to reduce the mortality rate. Vaccination

of cattle improves the health of livestock and handsome cash return to the target farmers. That is why the cooperator farmers were interested and adopted this technology. The cooperator farmers were motivated to this technology expressed their willingness to adopt it in future.

The vaccination of poultry program has created a great awareness to the cooperator farmer and neighborhood of farm families at the concerning FSRD sites. Four types of vaccines as BCRDV, RDV, Fowl Pox, Fowl Cholera, Duck plague were vaccinated in the program (Table 8f). It revealed that the mortality rate can be minimized significantly through vaccination and it declined about 6-7% in most of the cases which can be considered as negligible comparing to the condition before the vaccination program. By the application of the vaccine, average mortality declined from 21.20% at pre-intervention to 6.6% at post-intervention conditions. This type of program is mostly motivated concerned farmers and so far, they would follow to vaccinate the poultry routinely.

Table 8e. Mortality rate (%) of livestock at before vaccination and after vaccination against major diseases at FSRD site, Bogura during February-December, 2020.

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb.-Dec., 2020	Anthrax and FMD, PPR	220	150	80	2	0

Table 8f. Mortality rate (%) of poultry birds before vaccination and after vaccination against major diseases at FSRD site, Bogura during February-December, 2020.

Year of vaccination	Name of the vaccine	Nos. of poultry birds vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb.-Dec., 2020	BCRDV	140	-	-	-	17	7
	RDV	250	-	-	-	16	4
	Fowl Pox	130	-	-	-	25	6
	Fowl Cholera	150	-	-	-	13	6
	Duck plague	-	200			35	10
Total		2429	505	Average		21.20	6.6

II. Sheep and Goat rearing

Initially, 8 farmers provided with sheep till June 2020. Two sheep became dead due to feeding on insecticide sprayed fodder. After June 2020, again six Goats were distributed among the rest six farmers including two who had lost their sheep. The animals were vaccinated and provided with feed. Previously given four adult sheep have given birth to new offspring. One sheep gave 3 kids and the other three gave 6 (each gave 2) offspring. The gross value, rearing cost, and gross margin of the individual farmers were Tk. 6333, 2000, and 4333 per year, respectively (Table 8g).

Table 8g. Performance of sheep/Goat rearing at the household level at FSRD site, Bogura during 2020

Description of Item	Year (2020)
Number of farmers	6
No of sheep/Goat supplied per farmers	1
Date of supplied	16 July, 2020
Age of Goat during distribution	1 year 1 month
Initial body wt./Goat (kg)	5-7
Procurement price/Goat (Tk.)	3800-4200
No of Goat survive (%)	100
Weight gained/Goat (kg) after 6 month	7-8
Total number of kids born (Feb.2018-Dec. 2020) per farmer	5
Gross value (Tk.)/ farmer	6333
Rearing cost (Tk.)/farmer	2000
Gross margin (Tk.)/farmer	4333

III. Beef fattening

The beef fattening program was carried out at the FSRD site, Bogura from February 2020 to December 2020. Details about beef fattening presented in Table 8h. A total of 10 cattle from six farmers' households were selected for fattening. The initial body weight of the selected animal was ranged from 38 kg to 92 kg with an average weight of 56.67 kg. The cattle were provided with supplied food as prescribed by the Department of Livestock Office, Bogura. Besides this, farmers also feed their cattle with their farm-produced crop stubble, grass. After 160 days of rearing, cattle weight increased remarkably ranged from 55 kg to 140 kg with an average increased body weight of 85.67 kg. The average increment of body weight was 50.17%. Initially, the mean value of each cattle was Tk. 51833 which was increased to Tk. 67166 with an average increased value of 29.58%.

Table 8h. Performance of beef fattening at the household level at FSRD site, Bogura during Feb. – Dec. 2020.

Farmer	No. of breed	Initial body wt. (kg)	Body wt. after 160 days (kg)	Wt. increased over Initial (%)	Initial value (Tk)	Present value (Tk)	Increment (%)
Farmers 1	2	92	135	47	78000	103000	32
Farmers 2	1	45	60	33	40000	49000	23
Farmers 3	2	85	140	65	75000	102000	36
Farmers 4	1	40	55	38	37000	48000	30
Farmers 5	1	38	60	58	41000	50000	22
Farmers 6	1	40	64	60	40000	51000	23
Average		56.67	85.67	50.17	51833	67166	29.58

D. FISHERIES COMPONENT

i. FSRD site, Bogura

I. Maximization of farmers' income through carp polyculture technique at low-cost management

There were twelve ponds selected for carp polyculture production in seasonal ponds. The ponds were averagely 12 decimals sized with av. 3.6 m depth and the survival rate of carp fishes were 75-85%. Production and economic return are shown in Table 9a. Around 468% production was increased after the intervention of improved technology of carp polyculture as compared to the previous condition. After the intervention the average yield of fish was obtained 125 kg per pond with an average gross margin of Tk. 11090 per pond and the benefit in terms of gross margin increased to 451% per pond. Among the total production they consumed, distributed to relatives and sold their products in local market. It was observed that, farmers consumed about 57%, about 11.69% was distributed to their neighbors, relatives and well-wishers and sold about 31.23% of the produced fish (Table 9b). The farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

At the pre-intervention stage, farmers paid little or no interest in modern pond management techniques even, they did not know about standard carp polyculture management. After intervention of the program, consumption and distribution were increased to 325% and 181% respectively.

Table 9a. Production and economic return of fish under carp polyculture in seasonal ponds at FSRD site, Bogura during February-December, 2020.

Fish component	Before Intervention	After Intervention	Increased (%)
Production (kg/pond)	22	125	468
Total income (Tk/pond)	2640	16250	515
Variable cost (kg/pond)	630	5160	719
Gross margin (Tk/pond)	2010	11090	451

Table 9b. Utilization pattern of harvested fish under carp polyculture in seasonal ponds at FSRD site, Bogura during February-December, 2020.

Fish component	Before Intervention	After Intervention	Increased (%)
Production (kg/pond)	22	125	468
Consumption (Kg)	16.80	71.35	325
Distribution (Kg)	5.20	14.61	181
Sale (Kg)	0	39.04	100

E. OFF-FARM ACTIVITIES

Location: FSRD site, Bogura

Initially one household was practiced with off-farm activities such as sewing clothes for commercial practice and finally most of the households showed their interest in practicing handicrafts besides of other off-farm activities.

It was found that some off farm activities exhibit good cash income which contribute livelihood of the resource poor farmers to some extent. After intervention average net benefit from off- farm activities was recorded Tk. 6500 farm⁻¹ which was 132.46% higher over before intervention (Table 10). So, if all households could introduce some off-farm activities, it would be helpful to increase their total farm income which eventually contributes livelihood improvement.

Table 10. The economic return of off-farm activities at FSRD site, Bogura during February-December, 2020.

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin increased (%)
	Gross return	Variable cost	Gross margin	Gross return	Variable cost	Gross margin	
Sewing clothes with machine	2500.00	750.00	1750.00	7500.00	2000.00	5500.00	214.28
Irrigation provider	3500.00	1750.00	1750.00	5500.00	2200.00	3300.00	88.57
Fishing	7500.00	2000.00	5500.00	15000.00	4300.00	10700.00	94.54
Average	4500	1500	3000	9333	2833	6500	132.46

Problems/Constraints

- Unavailability of agricultural of inputs viz. quality seeds, fingerlings, and poultry breeds etc.
- Lack of knowledge of cooperator farmer for modern agricultural technologies
- Lack of communication facilities
- Lack of experts for livestock and fisheries program
- Shortage of Scientific personnel in the FSRD sites
- Unplanned and unproductive vegetation in the homestead areas.
- Tedious, laborious and continuous work, needing skills in production techniques of different components.
- Skill of site level staff and the farm family members were not as effective as required for optimum production and accurate information.

Farmers' opinion

The cooperator farmers from FSRD sites responded positively specially for homestead garden as it is a source of fresh vegetables and even it is a source of cash income during rainy season or crisis moment. The resources poor farmers are interested in adopt those technologies which can provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and

shift to other activities. Due to adoption of integrated farming they are hopeful to maintain their family with farm income.

Conclusion

The integrated farming system is a recyclable approach in which bi-product of one enterprise becomes the input of another enterprise thus making efficient use of resources. From the study it was revealed that the components of integrated farming like home gardening, cropping system, dairy, poultry, fishery, etc. are interrelated. The waste of dairy like dung, urine, refuse etc. is used for preparation of FYM, which is an input used in cropping systems. The straw obtained from the crops is used as fodder for cattle and used for mulching for growing crops. Thus, different enterprises of farming systems are highly interconnected. The vital indicator for livelihood improvement is increasing income compared to existing situation, which was successfully obtained from the program. However, integrated farming is a sustainable technology for livelihood improvements of farmers but it needs multi-disciplinary skilled scientific team for more successful integration of technologies. Finally it is needed to screen viable technologies and their greater adoption in farming system research and development sites for sustainable production, income generation and eventual livelihood improvement.

INTEGRATED FARMING FOR IMPROVING LIVELIHOOD OF RESOURCE POOR FARM HOUSEHOLDS IN DROUGHT AND RAINFED ECOSYSTEM

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Abstract

Prolonged drought, high temperatures, uneven distribution of rainfall due to climate change, soil acidity and low soil fertility are major stresses affecting agricultural production in drought and rainfed ecosystem. It needs to manage properly all the resources of poor farm household under integrated approach due to increasing of human population and decreasing of agricultural land. The activities under integrated farming were carried out at Farming Systems Research and Development (FSRD) and Multi-location Testing Sites viz., Basantapur (Rajshahi), Amnura (Chapainawabganj), Chanduria (Rajshahi), Ziaroki (Kushtia) and Kamalbazar (Sylhet) under different station of OFRD, BARI during the year 2019-20 to develop integrated farming technologies, fine tune the technologies generated by NARS institutes, integrate component technologies with efficient use of farm resources and thereby improve family income and livelihoods. The research areas were i) Homestead production system ii) Crops and cropping system iii) Poultry and Livestock production system iv) Fisheries production system and v) Off-farm activities. All components of integrated farming such as vegetables, fruits, cereal crops, livestock, fish and off-farm activities were brought under improved technological intervention and accordingly income was increased from these components. Two villages have been considered under FSRD activities in each site. A total sixty (60) farm households selected considering twelve (12) from each site. On the basis of PRA and base line survey report, farmers need based technologies were intervened among small, marginal and medium sized resource-poor farmers. Year-round homestead vegetables and quick growing fruits production are going on. Some improved cropping patterns have been selected in each site (e.g. Mustard-Boro-T. Aman, Wheat-Sesame-T. Aman and Tomato-Boro-T. Aus; and Lentil-Fallow-T. Aman and Wheat-Mungbean-T. Aman; Lentil-Maize-T. Aman and Mustard (long duration)-T. Aus-T. Aman; Lentil-Sesame-T. Aman and Onion/Sweet gourd-T. Aman; Potato-T. Aus-T. Aman and Mustard-T. Aus-T. Aman rice for FSRD site, Basantapur, Rajshahi; MLT site, Amnura, Chapainawabganj; FSRD site, Shympur, Rajshahi; FSRD site, Kushtia; and FSRD site, Sylhet). Fodder production, De-worming and vaccination program, fish (carp polyculture) culture have been brought under the program. It is revealed that vegetables production increased by 300-500% after project intervention, where intake of vegetables was markedly increased (avg. 200-300%) as compared to before intervention by all families included in this system. Average intake of fruits per year was also increased (Avg. 100-150%) after intervention of the technology as compared to before intervention. Existing fruit tree management and new plantation has created a good impact on farm households. In case of field crops, farmers obtained higher yield and

economic return from their alternative or improved cropping pattern with improve variety(s) and better management approaches. The increment of rice equivalent yield in improve cropping pattern was 50-100% over existing pattern. Newly released high yielding crop varieties were also introduced through on farm validation program. In livestock system, gross margin was increased around 50-100% over pre-intervention due to deworming, vaccination, beef fattening, improve management of diet for cattle and poultry. Mortality of poultry reduced (76-88%) after vaccination. Moreover, farm Yard manure (FYM) production and utilization are continued among the farm families. Green fodder (Napier grass) production is continued on pond bank, road side and fallow space of homestead. Farmers normally did not use their seasonal pond scientifically. The project took them under best management practice. The carp polyculture gave a satisfactory gross margin (Tk. 13000-40000 pond⁻¹) at farmers' level. From off-farm activities, farmers also earned some extra money (Tk. 25000-35000 household⁻¹). Women participation in agricultural activities was observed remarkable that may help to create positive effect on gender equity within the family. Local service provider (LSP) was involved directly in mechanization activities. The LSP gave their service for seeding of crop under conservation agricultural system on custom hiring basis. The results of FSRD activities imply that by implementing the program of integrated farming at FSRD site has created an opportunity to improve livelihood of the resource-poor farmers.

Introduction

Farming system is a unique and reasonable stable management of farming enterprises that a household manages using their own resources. In 1984, Farming system research and development program was initiated in Bangladesh through nine Farming System Research and Development (FSRD) sites of BARI. The farming System program has evolved a number of local specific technologies, which has been widely accepted by the farmers of respective Agro - ecological zones. The drought prone areas are mostly covered in north-western region (high Barind tract of Rajshahi and Chapai Nawabganj; and Kushtia) and rainfed area Sylhet and Bandarban district of Bangladesh. An estimated cultivated area of 5.97 million ha is affected by varying degrees of drought during Rabi, pre-Kharif and Kharif season, of which about 1.22 million ha experience severe to very severe drought mainly in the north-western districts. A combination of high temperature, low and erratic annual rainfall and soil moisture deficiencies are causing drought and rainfed ecosystem and have a devastating impact on agricultural production and threaten small scale farmers. The high Barind tract (HBT) has a distinct physiography of terraced lands. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall. Moreover, no river/water bodies are present within the HBT. Also, vegetation is very low compared to other parts of the country. These situations make the area drought prone along with poor crop productivity. T. Aman-Fallow is the dominant cropping pattern in the HBT. Majority of lands of greater Kushtia is high and medium high land and terminal heat occurs frequently in this region resulted to loss of crops. Again, Sylhet region occupies the eastern part of the country where the rain starts earlier and heavier than any other region. Last 30 years observation late season drought in mid-September to October, coinciding with flowering and grain filling stage of Aman rice, occurs more frequently due mainly to early withdrawal of rainfall. As a result, yield of Aman rice reduce drastically and sometimes damaged completely. The soils are generally heavy silty clay loams and clays with small areas of loam soils. The top soils dry quickly and become hard the end of the rainy season. So, it is not possible to grow up land crops during *Rabi* season. All the drought and rainfed areas have low cropping intensity compared to other part of the country. Though irrigation water is shortage, Boro rice is cultivated in some part of the areas and some lands remain fallow in *Rabi* season. So, low water requiring crops like pluses, oilseed, Wheat and potato given priority to utilize fallow land cultivation in the *Rabi* season. On the other hand, homestead land of these area is mostly unutilized. So, there is an acute shortage of vegetables. There is a scope to cultivate vegetables and fruits in the homestead area and also in the fallow land. Every house has a pond, but they do not cultivate fish in scientifically, hence intervention through modern technology could increase the fish productivity. Most of the cattle are unhealthy due to worm and crisis of feed. Through application of appropriate technology could improve the cattle productivity.

These resources must be utilized in such a manner that maximize farm productivity, farmers benefit and resource use efficiency in an environmentally sound and sustainable way. A holistic approach to

technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/production system and the biophysical and socio-economic environment. Farming system is an inter-linked product and consumption system of a farmer based on all components viz., crop, livestock, fisheries, Agro-forestry etc. The FSRD program is aimed to enhance the efficiency of farm productivity by developing and applying technologies on the household production system. Therefore, the farming system project in drought and rainfed eco-system funded by National Agricultural Technology Project (NATP) Phase-2 coordinated by Bangladesh Agricultural Research Council (BARC) has been undertaken to utilize the present farmers' resources in a better and systematic way, to enlarge the current income level and to determine the effect of integrated farming intervention on total development of a farm family.

Methodology

To integrate farmers' resources with the view of improving production, nutrition, income and livelihood, the activities were carried out five FSRD sites [Basantapur (Rajshahi), Amnura (Chapainawabganj), Chandura (Rajshahi), Ziarokhi (Kushtia) and Kamalbazar (Sylhet)] in drought and rainfed ecosystem during the year 2019-20 funded by NATP Phase-2 to improve livelihood of rural households through generation and adoption of Farming System Technologies especially integrated farming technologies and the technologies generated by NARS institutes. The program was executed in a participatory approach, where critical inputs and technological suggestions were provided by BARI personnel and other commodities were used from farmer's own sources. On the basis of farmer's traditional practices, their needs, choices, several alternatives of technologies of crops, livestock, fisheries and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers- marginal, small and medium having major components of farming and sizeable homestead under single ownership were targeted. Two villages were considered under FSRD activities in each location. A total sixty (60) farm households were selected considering twelve (12) from each site (Table 1).

Table 1. Category-wise selected farmers' information of different FSRD sites.

FSRD site	Categories	No. of Farmer	Av. family size (no.)	Av. crop land size (ha)	Av. homestead area (ha)	Av. pond area (ha)
Basantapur, Rajshahi	Marginal	4	5.00	0.48	0.044	0.020
	Small	4	4.00	0.88	0.050	0.024
	Medium	4	5.75	1.38	0.044	0.052
Amnura, Chapainawabganj	Marginal	4	6.00	0.37	0.032	0.021
	Small	4	4.50	0.87	0.048	0.020
	Medium	4	5.25	1.95	0.074	0.035
Chandura, Rajshahi	Marginal	4	5.60	0.12	0.028	0.028
	Small	4	6.20	0.37	0.040	0.037
	Medium	4	4.00	1.35	0.048	0.06
Ziaroki, Kushtia	Marginal	4	6.5	0.19	0.11	0.025
	Small	4	4.66	0.58	0.13	0.05
	Medium	4	5.0	1.05	0.16	0.05
Kamalbazar, Sylhet	Marginal	1	4.00	0.06	0.06	0.021
	Small	8	4.38	0.45	0.064	0.048
	Medium	3	5.33	1.12	0.08	0.08

Before going to implement the project activities, a PRA was carried out in each site. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Year-round vegetable production followed by respective location-wise model in each homestead, fruit tree management, improving crops

and cropping pattern, beef fattening, vaccination of poultry and livestock, fish culture and some off-farm activities were identified as their major potential area. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. Data on production, farm level utilization, economic return and other socio-economic parameters were recorded, tabulated and integrated accordingly.

A. Homestead Production System

Homestead area is a valuable asset for a resource poor farm household and suitable for production of different kinds of vegetables and fruits. On the basis of farmers' choice and agro-ecological suitability, the vegetables production model for both locations is given in Table 2a to 2c.

On the basis of farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied and plantation were done in the homestead area and nearby homestead area. Some sole fruit orchard with mango and some mixed fruit garden with Mango, Guava and malta were established. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program.

Table 2a. High Barind model for vegetables and fruits production (followed at 3 sites namely Basantapur and Chanduria, Rajshahi, and Amura, Chapainawabganj)

SI No.	Spaces	Cropping patterns		
		Rabi (October-March)	Kharif-I (April-June)	Kharif-II (July-September)
1.	Open sunny land			
	Bed 1	Brinjal+Red amaranth	Kangkong	Kangkong
	Bed 2	Spinach-Spinach	Indian spinach	Red amaranth
	Bed 3	Radish-Red amaranth	Stem amaranth (Katua data)	Green Shak
	Bed 4	Cabbage	Onion	Red amaranth/Jute shak
	Bed 5	Cauliflower-Red amaranth	Okra	Red amaranth/Jute shak
2.	Fence	-	Bitter gourd, Yard long bean	Sponge gourd
3.	Trellis	Country bean, Bottle gourd	Pointed gourd, Snake gourd, ridge gourd	Sponge gourd
4.	Roof	Country bean, Bottle gourd	Sweet gourd, White gourd	White gourd
5.	Tree support	-	White gourd, potato yam, Sponge gourd	Sponge gourd
6.	Partial shady area	Coriander leaf	Turmeric, Aroids	Turmeric, Aroids
7.	Homestead boundary/ back Yard	Plantain banana Papaya Drumstick	Plantain banana Papaya Drumstick	Plantain banana Papaya Drumstick
8.	Pond/ ditch banks and slope	Bottle gourd	Snake gourd, Bitter gourd	-
9.	Others	-	Fodder, chewing Sugarcane	Fodder, chewing Sugarcane

Table 2b. Goyeshpur model (Ziaroki, Kushtia)

Niche/space			Cropping patterns		
			Rabi	Kharif-I	Kharif-II
1. Open sunny space	Bed-1	:	Radish	Stem Amaranth	Indian spinach
	Bed-2	:	Cabbage	Brinjal	Red amaranth
	Bed-3	:	Tomato	Spinach	Okra
2. Fence		:	Bitter gourd	Yard long bean	Bitter gourd
3. Trellis		:	Bottle gourd	Sweet gourd	Sweet gourd
4. Roof		:	Bottle gourd	Wax gourd	Wax gourd
5. Tree support		:	Bitter gourd	Ridge gourd	Sponge gourd
		:	Potato yam	Snake gourd Potato yam	Potato yam
		:	Country bean	Yard long bean	Yard long bean/Country bean

Niche/space		Cropping patterns		
		Rabi	Kharif-I	Kharif-II
6. Partial shady area	:	Elephant foot yam		
	:	Leaf aroid (moulavi kachu)		
	:	Turmeric		
	:	Perennial Chilli		
7. Marshy land	:	Pani kachu (Latiraj)		
8. Homestead boundary	:	Papaya(3-5 plant)		
	:	Guava(1-2 plant)		
	:	Lemon(1-2 plant)		
9. Back Yard /waste land	:	Laizna (1-2 tree)		
	:	Banana		

Table 2c. Golapgonj model (Kamalbazar, Sylhet)

Sl. No.	Niches/space		Year-round homestead vegetables and fruits pattern		
			Rabi (October- March)	Kharif-I (April-June)	Kharif-II (July-September)
1	Open sunny land	Bed-1	Radish/Indian Spinach	Indian Spinach	Kang Kong
		Bed-2	Radish/Tomato	Red amaranth/Okra	Indian Spinach
		Bed-3	Bush bean	Kang Kong	Brinjal
		Bed-4	Dhonia/ Lalshak	Dhonia	Amaranth
2	Cottage roof/top	a	Country bean/Bottle gourd	Ash gourd	-
3	Trellis	b	Country bean/Bottle gourd	Shake gourd	Ridge gourd
4	Fences/Boundary wall	c	Bitter gourd	Bitter gourd	-
5	Non-fruit trees	d	-	Ridge gourd	Ridge gourd
6	Partially shady land	e	Bilati Dhonia	Turmeric/Ginger	Turmeric/Ginger
7	Homestead areas	f	Papaya	Papaya	Papaya
8	Marshy land	Water taro(Kalakachu), Aroid (Latiraj)			
9	Backyard	Papaya, Banana, Guava, Mango, Lemon, Sugarcane, Satkora, malta			

B. Improvement of Cropping Systems

There were different types of cropping pattern exist in different locations. Dominant cropping pattern were considered for the improvment or replace by alternate profitable cropping pattern. To increase crop productivity, two to three cropping patterns were considered for development at each FSRD site under drought and rainfed ecosystem.

Table 3. Activities for improvement or development of cropping pattern under drought and rainfed ecosystem during the year 2019-20

FSRD sites	Existing cropping pattern	Date of sowing/ transplanting	Date of harvesting	Alternative/improved cropping pattern	Date of sowing / transplanting	Date of harvesting
Basantapur, Rajshahi	Boro (BRRI dhan28)-Fallow-T. Aman (Swarna)	18-20 Jan - 25-28 July	1-4 May - 20-25 Nov	T Mustard (BARI Sarisha-17)-Boro (BRRI dhan81)-T. Aman (BRRI Dhan49)	4-7 Nov 9-11 Feb 18-20 July	1-3 Feb 9-12 May 28-30 Oct
	Wheat (BARI Gom-28)-Fallow-T. Aman (Swarna)	1-2 Dec - 25-26 July	3-4 April - 25-27 Nov	Wheat(BARI Gom-30)-Sesame (BRRI Til-4)-T. Aman (BRRI Dhan51)	20-22 Nov 29-30 March 15-20 July	20-23 Mar 20-22 June 10-12 Nov
	Boro (BRRI dhan28) -Fallow-	18-20 Jan - 25-28 July	1-4 May - 20-25 Nov	Tomato (VL-642)-Boro (BRRI dhan81)-T. Aus (BRRI dhan82)	15-20 Sep 5-10 Feb 12-15 June	Dec-Jan 9-12 May 1-5 Sep

FSRD sites	Existing cropping pattern	Date of sowing/ transplanting	Date of harvesting	Alternative/improved cropping pattern	Date of sowing / transplanting	Date of harvesting
	T. Aman (Swarna)					
Amnura, Chapai Nawabganj	Wheat (BARI Gom-28)-Fallow-T. Aman (Swarna)	3-5 Dec - 25-28 July	4-5 April - 20-25 Nov	Wheat (BARI Gom-30)-Mungbean (BARI Mung-6)-T. Aman (BRRI Dhan51)	18-20 Nov 25-28 March 22-26 July	18-22 Mar 05-15 June 12-15 Nov
	Fallow-Fallow-T. Aman rice (Swarna)	- - 23-25 July	- - 20-24 Nov	Lentil (BARI Masur-8)-Fallow-T. Aman (BRRI Dhan51)	20-21 Nov - 15-20 July	08-10 Mar - 5-7 Nov
Chanduria, Rajshahi	Boro (BRRI dhan28)-Fallow-T. Aman (Swarna)	25-28 Feb - 20-25 July	20-23 Jun - 7-10 Nov	Lentil (BARI Masur-8)-Maize (Laltir339)-T. Aman (BRRI dhan87)	20 Nov 05 April 25 July	15 March 15 July 30 Oct
	Boro (BRRI dhan28)-Fallow-T. Aman (Swarna)	25-28 Feb - 20-25 July	20-23 Jun - 7-10 Nov	Mustard (BARI Sarisha-18)-T. Aus (BRRI Dhan82)-T. Aman (BRRI dhan87)	11 Nov 16 March 27 June	21 Feb. 15 June 07 Oct
Ziaroki, Kushtia	Lentil (BARI Masur-6)-Sesame (Local)-T. Aman (BRRI dhan39)	24 Nov 15 March 30 July.	7 March 15 July 03 Nov	Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T. Aman (BRRI dhan75)	23 Nov. 22 March 3-4 Aug.	15 March 16 July 30 Oct
	Onion (Local)-Sweet gourd (Local hybrid)-T. Aman (BRRI dhan39)	5 Dec 20 February 15-15 July.	1 April 15 May-10 8-11 Oct	Onion (BARI Piaz-4)-Sweet gourd (Local hybrid)-T. Aman (BRRI dhan75)	5 Dec 20 February 15-15 July	1 April 15 May-10 June 8-11 Oct
Kamalbazar, Sylhet	Fallow-T. Aus (BRRI dhan26)-T. Aman (BRRI dhan-33)	- 2-5 May 3-7 Aug.	- 25-28 July 5-7 Nov	Potato (BARI Alu-7)-T. Aus (BRRI dhan65)-T. Aman (Bina dhan7)	15-17 Nov 3-5 May 28-30 July	15-17 Feb 23-25 July 28-30 Aug.
	T. Aman (Hori)-Fallow-Boro (BRRI dhan29)	27 to 30 Jul- Fallow- 25 to 27 Jan	24 to 26 Nov- Fallow- 25 to 29 May	T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49)-Motorshuti (BARI Motorshuti-3)-Boro (Hybrid shakka)	25 to 30 May- 20 to 28 Aug.- 21 to 24 Nov- 4 to 17 Feb	13 to 15 Aug.- 10 to 15 Nov- 28 to 30 Jan- 14 to 20 May

C. On-Farm Verification/production program

Bangladesh Agricultural Research Institute and other NARS Institutes have developed a large number of modern varieties of different crops, which are high yielder as well as short in duration. To identify the suitable crops and varieties, on-farm verification trial was conducted during years of 2019-20 with different types of crops. The identified suitable varieties were brought under production program at each location in the following years. The details of crop management are given below.

Table 4. Different operations conducted for production program at different FSRD sites under rainfed ecosystem during the year 2019-20

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Basantapur, Rajshahi	Lentil	BARI Masur-8	6	1.5	20-23 Nov.	12-13 March.
	Chickpea	BARI Chola-5	6	1	16 Nov.	25-30 March
	Tomato	BARI Hybrid Tomato-15	1	0.2	06 July	31 August

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/transplanting	Date of harvesting
	Potato	BARI Alu-7	1	0.25	30 Nov	8 March
		BARI Alu-25				
		BARI Alu-36				
		BARI Alu-41				
		BARI Alu-46				
Amnura, Chapainawabganj	Mustard	BARI Sarisha-14	7	1.5	10-12 Nov	4-5 February
	Chickpea	BARI Chola-5	6	1.5	20-22 Nov.	26-28 March
Chanduria, Rajshahi	Mustard	BARI Sarisha-14	45	38	10-20 Nov	10-17 Feb
		BARI Sarisha-11	6	0.3	30 Nov	14-16 March
		BARI Sarisha-16	6	0.3	30 Nov	14-16 March
		BARI Sarisha-18	6	0.3	30 Nov	14-16 March
	Wheat	BARI Gom-30	8	4.2	20-21 Nov	02-03 March
	Sesame	BARI Til-4	4	1	20 March	25 June
	Lentil	BARI Masur-8	3	0.3	28 Nov.-3 Dec.	20-22 Mar
	Potato	BARI Alu-7	5	0.3	30 Nov	03-04 March
		BARI Alu-37	5	0.3	30 Nov	03-04 March
		BARI Alu-40	5	0.5	30 Nov	03-04 March
Ziaroki, Kushtia	Mustard	BARI Sarisha-14	4	1.02	25-27 Nov.	25-27 Feb.
	Lentil	BARI Masur-8	4	0.91	25-26 Nov.	10-14 March
	Potato	BARI Alu-7	3	0.5	28 Nov	10 Feb
		BARI Alu-25	5	0.5	27 Nov	10 Feb
Kamalbazar, Sylhet	Mustard	BARI Sarisha-14	3	0.24	21-28 Nov.	27-28 Feb
	Wheat	BARI Gom-28	4	0.40	28-30 Nov	24-25 March
	Sunflower	BARI Surjomukhi-2	4	0.45	25-28 Nov.	05-10 March
	Tomato	BARI Tomato-5	-	-	16-18 Nov	10 Feb-15 March
	Potato	BARI Alu-46	-	-	28-30 Nov	07-10 March
	Onion	BARI Piaz-2	-	-	15-25 Nov	15-25 March
	Field pea	BARI Motor-1	-	-	20-22 Nov	10-15 March

D. Livestock component

Cattle health can be improved through deworming which may make the farmer economically benefitted. More than 10 faeces sample of cattle were collected from each location by the symptomatic parasitic infection and then investigated the parasites through faeces sample analysis for the confirmation. After confirmation of parasitic infection, the test animal was de-wormed by broad spectrum anthelmintic i.e. Trilev-vet (Livamisole and Triclabendazole) for round worm and liver fluke as per recommendation for the body weight. Proper vaccination program against four major diseases was conducted to reduce the mortality rate of cattle. In the vaccinated group Anthrax vaccine, Foot and mouth disease (FMD) vaccine, Blood quarter (BQ) vaccine and Hemorrhagic septicemia (HS) vaccine were injected as per recommended schedule. Cattle fattening and Calf rearing programs were also continued at some areas. Besides of cattle product, Cowdung is very important by-product for integrated farming and farmers were motivated to use it for preparation of farm Yard manure (FYM) including other homestead westage instead of using the Cowdung as fuel.

Napier grass was identified as a suitable and profitable green fodder to produce in the homestead and its surrounding areas especially on pond bank. Farmers were advised to apply FYM after every cut of grass. It was introduced among the farmers under the program to produce for feeding their cattle. Some farmers were also selling their produced Napier grass in the market besides of feeding their cattle.

Poultry rearing are common practices of rural Bangladesh. Poultry disease is the main problem faced by the farmers for poultry rearing. Proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level this program was conducted at the farmer's field. A good number of poultry birds were vaccinated during the year 2019-20. In the vaccinated group BCRDV, RDV, Fowl cholera and Duck plague vaccine were used as

per recommended schedule. Regular contact was done by the facilitator team for providing necessary suggestions to solve their specific problems. Each farmer was given 16 chicken bird of 75 days old. The ratio of male and female was 1:9.

E. Fisheries component

Improper management is the major hindrance against profitability of fish culture in pond under homestead area. The carp poly culture programs in ponds were undertaken at the project sites with the objective of increasing farmer's income and to remove protein deficiency of rural people. However, in poly culture system, silver carp, catla, rui, mrigal, common and mirror carp may form 20–30%, 10–15%, 15–20%, 10–15% and 15–20%, respectively maintaining 20–30 fingerlings decimal⁻¹. Fish feed partially collected and supplied by the co-operative farmers whereas lime and fingerlings were supported from the program. Periodic checking and suggestion were given by the office personnel of the respective FSRD site. For fish cultivation, weeds and wild fishes were removed from the ponds. Lime was given at the rate of 1 kg/decimal as well as prepared for stocking with organic manure (Cow dung) at the rate of 3 kg/decimal.

F. Off-Farm Activities

Off-farm (non-farm) income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, pensions, and interest income earned by farm families. Since the last three decades or so, there has been increasing evidence showing that small-holder farm households in developing countries rarely on agriculture alone, but often maintain a portfolio of income activities in which off-farm activities are an important component (Barrett *et al.*, 2001).

Some farm families' especially the women were engaged with off-farm activities. Some farmers had small grocery shop and opened at his off-time and also had practice of weaving *Katha* and cloth sewing with machine. The women were also engaged in making *Kumra bora*, *Pilo cover*, making handicrafts with rope, plastic ball etc. during their leisure periods and men were engaged with basket making and van/rickshaw pulling.

G. Local Service Provider (LSP)

For the better execution of farming activities and to out scale of mechanization, two farmers were selected as Local Service Provider (LSP) from the locality. The LSP was selected based on their knowledge level, eagerness, technology understanding and dissemination capability, local and social acceptance, etc. They were trained up from BARI-FMPE division funded by KGF project.

H. Integration among different components

Integrated farming consists of several enterprises like home gardening with vegetables and fruits, crops and cropping system, dairying, poultry, fishery, etc. and these enterprises are interrelated. The end product and wastage of one enterprise may use as inputs in another enterprise. Moreover, judicious use of farm resources may reduce production cost and can help to keep clean the environment. In integrated farming, the contribution of one component on other component ('s) is important consideration for sustainable farming.

Results and Discussion

Farming system consists of several enterprises like home gardening, cropping system, livestock, fishery, etc. These enterprises are interrelated. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from crops is used as fodder for cattle are highly interrelated. However, different locations and component-wise findings are discussed in underneath.

A. Homestead production system

A homestead is a farmhouse, together with the land around it. The area under a homestead is a valuable asset for the resource poor farm household and suitable for production of different kinds of vegetables

and fruits. Farmers normally grow vegetable unplanned way and mostly trellis crops; and sunny and other places remained fallow. After intervention the program all niches were taken under improved management practice eventually vegetable production significantly increased. Similarly, quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jackfruit, Coconut, etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies in the homestead, fruits production has increased significantly.

Three models were followed for year-round vegetables and fruits production in five sites. The 'Barind model' was followed in three sites of HBT namely, Basantapur, Amnura and Chanduria while 'Goyeshpur model' in Ziaroki and 'Golapgonj model' in Kamalbazar was used. Nine niches were used in the three models. In the sunny place, 5 beds are established in Barind model while it is 3 in Goyeshpur model and 4 in Golapgonj model. The activities under five sites are detailed below-

Vegetable's production and utilization: After intervention of improved technologies, vegetable production has been increased significantly in all the sites (Table 3). The average annual vegetables production considering all sites (633 kg/homestead) was much higher than that of before intervention (105 kg/homestead). Vegetable's production was increased by 502% in after intervention in comparison with before intervention. Among the different niches, open sunny place is the most suitable place that contributed 50% of the total production. However, round the year total vegetables production was maximum at Ziaroki (905 kg/homestead) followed by Basantapur (773 kg/homestead), Chanduria (625 kg/homestead), Amnura (608 kg/homestead) and minimum at Kamal bazar (256 kg/homestead). The average vegetable intake per day per member per farm family was 207 g after program intervention while it was 62 g/day/head before intervention and the increment was 233%. However, after intervention, vegetables consumption was maximum in Basantapur (266 g/day/head) and minimum in Kamal bazar (149 g/day/head). The distribution of vegetable during the study period was ranging from 20 kg to 100 kg and sell of vegetable was 46 kg to 505 kg. Utilization of all niches in homestead area with optimum management by effective farm family labor can be achieved and farmers could earn more gross return (Avr. Tk. 11092/ homestead/year).

Table 3. Round the year vegetables production and utilization pattern in different sites during the year 2019-20

Site	Before intervention					After intervention				
	T. Prod'n (kg)	Cons. (kg)	Dist. (kg)	Sell (kg)	GM (Tk.)	T. Prod'n (kg)	Cons (kg)	Dist. (kg)	Sell (kg)	GM (Tk.)
Basantapur	99	85 (52 g/h/d)	14	0	1745	773	486 (266 g/h/d)	95	192	13945
Amnura	85	68 (42 g/h/d)	17	0	1360	608	422 (231 g/h/d)	65	121	11250
Chanduria	108	72 (44 g/h/d)	14	22	1512	625	373 (227 g/h/d)	74	178	8125
Ziaroki	112	100 (53 g/h/d)	12	0	1240	905	300 (160 g/h/d)	100	505	16100
Kamal bazar	122	117 (91 g/h/d)	5	0	3730	256	190 (149 g/h/d)	20	46	6040
Average	105	88.5 (62 g/h/d)	13	4.5	1917	633	254 (207 g/h/d)	71	208	11092

Fruit production: Higher quantity of average fruits production was found using improved technologies (380 kg/homestead) in compared with farmers practice (140 kg/homestead) (Table 4). Yield increment of fruit was 171% in after intervention and highest amount of fruits per homestead was produced in Kamal bazar (491 kg/homestead) followed by Basantapur (425 kg/homestead) and the lowest one in Ziaroki (200 kg/homestead). Most of the produced during the year was consumed by farm family and it was on an average 232 kg/homestead and selling was only 102 kg/homestead. Higher production of fruits influenced the famers more consumption. After intervention, the average fruit consumption per head per day was 136 g instead of 53 g/h/d in before intervention. However, farmers are more enthuestic selling the fruits than distribution to others. The average gross return from homestead fruit production was Tk. 11256/homestead.

Table 4. Round the year fruits production and utilization pattern in different sites during the year of 2019-20.

Site	Before intervention					After intervention				
	T. Prodn (kg)	Cons. (kg)	Dist. (kg)	Sell (kg)	GM (Tk.) (Tk.)	T. Prodn (kg)	Cons. (kg)	Dist. (kg)	Sell (kg)	GM (Tk.) (Tk.)
Basantaur	135	95 (57 g/h/d)	40	0	2375	425	255 (155g/h/d)	50	120	7450
Amnura	126	90 (49 g/h/d)	36	0	2245	392	235 (128g/h/d)	46	111	6900
Chanduria	181	92 (50 g/h/d)	35	54	2754	390	147 (90 g/h/d)	51	192	12870
Ziaroki	60	15 (10 g/h/d)	10	35	1800	200	200 (110 g/h/d)	0	0	5500
Kamal bazar	200	160 (97 g/h/d)	40	0	9500	491	325 (198 g/h/d)	80	86	23560
Average	140	90 (53 g/h/d)	32	18	3735	380	232 (136 g/h/d)	45	102	11256

Family labor utilization pattern: Homestead production system gave an opportunity for women employment and empowerment. From the Table 5, it was revealed that women had a good involvement in seed/seedling production and planting, intercultural operation, harvesting and marketing of vegetables and fruits. It is revealed that women are coming forward and participating more in income generation system. Hard working activities was mostly done by the men workers. Children also help the men and women in production systems especially in soft-working areas. However, cooking (98%) was done by mainly women little bit exception. Only 2% cooking work was done by men and children where housewife was sick or absent. So, it was found that homestead gardening has created a good opportunity to utilize unused labor of women and children properly.

Table 5. Average family labor utilization pattern of 5 site for homestead vegetables and fruits production

Work area	Men (%)	Women (%)	Children (%)
Land preparation	81	17	2
Seed/seedling production	53	41	6
Sowing/planting	50	43	7
Intercultural operation	37	55	8
Harvesting	27	64	9
Marketing	70	28	2
Cooking	1	98	1

B. Crops and Cropping System

Site: FSRD site, Basantapur, Rajshahi

I. Improvement of cropping pattern

The performance of the improved pattern (IP), Mustard (var. BARI Sarisha-17)-Boro (var. BRRI dhan81) -T. Aman (var. BRRI dhan49) rice against existing pattern (EP), Boro rice-Fallow- T. Aman rice is showed in Table 6. The rice equivalent yield (REY) of IP was 14.07 t ha⁻¹ against 9.64 t ha⁻¹ in EP with the increment was 46% due to introduction of new crop, modern variety and improve crop management. The MBCR of IP was 3.34 over EP. The field duration of IP was 285 days while it was 214 days in EP. The turnaround time between two crops was at least 7 days in improved pattern.

The REY and MBCR of IP, Wheat (BARI Gom-30)-Sesame (BARI Til-4)-T. Aman rice (BRRI dhan51) and EP, Wheat (BARI Gom-28)-Fallow-T. Aman rice (Swarna) is presented in Table 6. The result indicated that the pattern REY in IP was 12.86 t ha⁻¹ while in EP was 9.02. The increment of productivity was 43%. The MBCR in IP was 2.14 over EP.

The improved cropping pattern with Tomato (VL-642)-Boro (BRRI dhan81)-T.Aus (BRRI dhan82) against the existing pattern Boro (BRRI dhan28)-fallow-T. Aman rice (Swarna) was initiated under

high land situation. In the improve pattern, Tomato (VL 642) gave fruit yield 41.46 t ha⁻¹ while in the existing one remain fallow in that time. The result showed that the IP gave higher REY (31.23 t ha⁻¹) than that of EP (10 t ha⁻¹) (Table 6). The improved pattern also gave higher MBCR (3.83) over existing one. (Table 6).

Table 6. Yield and Economic analysis of alternate and existing cropping pattern at Basantapur, Rajshahi during the year of 2019-20.

Parameter	Improved cropping pattern			Existing cropping pattern		
CP-1	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Field duration (days)	90	91	104	94	-	120
REY	14.07			9.64		
GM (Tk. ha ⁻¹)	180720			110480		
MBCR	3.34					
CP-2	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Field duration (days)	122	83	119	123	-	123
REY	12.86			9.02		
GM (Tk. ha ⁻¹)	153735			114610		
MBCR	2.14					
CP-3	Tomato	Boro	T. aus	Boro	Fallow	T. Aman
Field duration (days)	139	91	104	94	-	120
REY	31.23			10		
GM (Tk. ha ⁻¹)	441800			113250		
MBCR	3.83					

Site: Amnura, Chapainawabganj in the Northern HBT

Amnura has less ground water potential. Rainfed T. Aman rice with local variety namely Swarna is the main field crop in the area. In IP, Wheat (BARI Gom-30)-Mungbean (BARI Mung-6)-T. Aman rice (BRRI dhan51) against Wheat (BARI Gom-28)-Fallow-T. Aman rice (Swarna) was carried out where mungbean gave some seed yield as well as brown manure that is helpful for soil management. The result indicated that the pattern REY in IP was 12.81 t ha⁻¹ while in EP was 8.59. The increment of productivity was 49%. The MBCR in IP was 3.82 over EP (Table 7).

The improved cropping pattern, Lentil (BARI Masur-8)-Fallow-T. Aman rice (BRRI dhan51) indicated that the pattern REY in IP was 12.30 t ha⁻¹ while in EP was 4.95. The increment of productivity was substantial and the value was 148%. The MBCR in IP was 3.73 over EP.

Table 7. Yield and Economic analysis of alternate and existing cropping pattern at Amnura, Chapainawabganj during the year of 2019-20.

Parameter	Improved cropping pattern			Existing cropping pattern		
CP-1	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Field duration (days)	120	75	120	122	-	120
REY	12.81			8.59		
GM (Tk. ha ⁻¹)	167320			96220		
MBCR	3.82					
CP-2	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Field duration (days)	110	-	112	-	-	123
REY	12.30			4.95		
GM (Tk. ha ⁻¹)	165500			72050		
MBCR	3.73					

Site: FSRD site, Chanduria, Rajshahi

The agronomic and economic performance of the tested existing pattern is presented in Table 8. Considering CP, the pattern REY was much higher in IP, Lentil (BARI Masur-8)-Maize (Laltir339)-T. Aman (BRRI dhan87) (15.76t ha⁻¹) than EP, Boro (BRRI dhan28)-Fallow-T. Aman (Swarna) (9.04 t ha⁻¹) at the FSRD site, Chanduria, Rajshahi during the year 2019-20. The REY IP was increased by

74% over EP due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. The economic performance followed the similar trend as REY. The gross margin was also higher in IP (Tk. 275495 ha⁻¹) than EP (Tk. 142570 ha⁻¹). The MBCR was 5.48 in IP over EP.

The agronomic and economic performance of the cropping pattern (CP2) are also presented in Table 8. The pattern REY was greater in IP, Mustard (BARI Sarisha-18)-T. Aus (BRRI Dhan82)-T. Aman (BRRI dhan87), (11.82 t ha⁻¹) than that of EP, Boro (BRRI dhan28)-Fallow-T. Aman (Swarna), (9.01 t ha⁻¹) at the FSRD site, Chanduria, Rajshahi during the year 2019-20. The REY IP was increased by 31% over EP due to better management practices and also due to inclusion of modern variety. The economic performance was also better in IP than EP. The gross margin was higher in IP (Tk. 193134 ha⁻¹) than EP (Tk. 139200 ha⁻¹). The MBCR of IP was 3.13 over EP

Table 8. Yield and Economic analysis of alternate and existing cropping pattern at Amnura, Chapainawabganj during the year of 2019-20.

Parameter	Improved cropping pattern			Existing cropping pattern		
CP-1	Lentil	Maize	T. Aman	Fallow	Boro	T. Aman
Field duration (days)	117	102	98	-	117	111
REY	15.76			9.04		
GM (Tk. ha ⁻¹)	275495			142570		
MBCR	5.48					
CP-2	Mustard	T. Aus	T. Aman	Boro	Fallow	T. Aman
Field duration (days)	103	92	102	117	-	111
REY	11.82			9.01		
GM (Tk. ha ⁻¹)	193134			139200		
MBCR	3.13					

Site: FSRD site, Ziaroki, Kushtia

The agronomic and economic performance of the cropping patterns (CP1 and CP2) are presented in Table 9. The pattern REY was greater in IP, Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T. Aman (BRRI dhan75), (13.73 t ha⁻¹) than that of EP, Lentil (BARI Masur-6)-Sesame (Local)-T. Aman (BRRI dhan39), (11.72 t ha⁻¹) at the FSRD site, Ziaroki, Kushtia during the year 2019-20. The REY IP was increased by 17.15% over EP due to better management practices and also due to inclusion of modern variety. The gross margin was higher in IP (Tk. 309708ha⁻¹) than EP (Tk. 250085 ha⁻¹). The MBCR of IP was 1.90 over EP.

The REY of Onion (BARI Piaz-4)-Sweet gourd (Local hybrid)-T. Aman (BRRI dhan75), IP (34.68 t ha⁻¹) was greater than that of Onion (Local)-Sweet gourd (Local hybrid)-T. Aman (BRRI dhan39), EP (26.87 t ha⁻¹) at the FSRD site, Ziaroki, Kushtia during the year 2019-20. The REY in IP was increased by 29% over EP. The gross margin was higher in IP (Tk. 902565 ha⁻¹) than EP (Tk. 705215 ha⁻¹). The MBCR of IP was 2.52 over EP.

Table 9. Yield and Economic analysis of alternate and existing cropping pattern during the year of 2019-20

Parameter	Improved cropping pattern			Existing cropping pattern		
CP-1	Lentil	Sesame	T. Aman	Lentil	Sesame	T.Aman
Field duration (days)	112	114	87	103	120	93
REY	13.73			11.72		
GM (Tk. ha ⁻¹)	309708			250085		
MBCR	1.90					
CP-2	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
Field duration (days)	106	100-120	85-90	106	100-120	85-90
REY	34.68			26.87		
GM (Tk. ha ⁻¹)	902565			705215		
MBCR	2.52					

Site: Kamal bazar, Sylhet

Yield and economic performance of the cropping patterns are presented in Table 10. The improved pattern, Potato (BARI Alu-7)-T. Aus (BRRI dhan65)-T. Aman rice (BRRI dhan57) was tested against Fallow-T. Aus (BRRI dhan26)-T. Aman rice (BRRI dhan33). The REY in IP was 20.73 t ha⁻¹ against EP (7.32 t ha⁻¹). The economic performance was also better in IP than EP. The MBCR of IP was 2.02 over EP.

Considering CP-2, the IP, Mustard (BARI Sarisha-14)-T. Aus (BRRI dhan65)-T. Aman (BRRI dhan57) gave higher REY (10.89 t ha⁻¹) over EP, Mustard (Tori7)-T. Aus (BRRI dhan26)-T. Aman (BRRI dhan-33) (8.78 t ha⁻¹). The gross margin was also higher in IP than that of EP. The MBCR in IP was 5.26 over EP (Table 10).

Table 10. Yield and Economic analysis of alternate and existing cropping pattern at Kamal bazar, Sylhet during the year of 2019-20.

Parameter	Improved cropping pattern			Existing cropping pattern		
CP-1	Potato	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Field duration (days)	90	85	80	-	90	90
REY	20.73			7.32		
MBCR	2.02					
CP-2	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Field duration (days)	85	85	80	75	90	95
REY	10.89			8.78		
MBCR	5.26					

II. Production program

Lentil: BARI Masur-8 was cultivated in three FSRD sites namely Basantapur, Chanduria and Ziaroki. It gave very good seed yield in all locations and ranging from 1.93 to 2.17 t ha⁻¹ where the highest yield was obtained from Ziaroki site (2.17 t ha⁻¹) followed by Banastapur (1.95 t ha⁻¹) and lowest from Chandura sites one (1.93 t ha⁻¹) (Table 11). The gross margin followed similar order as seed yield of lentil and ranging from Tk. 102750 to 134428 ha⁻¹ where Ziaroki site recorded the highest gross margin. Farmer of the all location chose the variety as their high yield potentiality and good market price

Chickpea: BARI Chola-5 is a popular variety in both the Barind sites. The seed yield of Chickpea was 1.52 t ha⁻¹ and 1.55 t ha⁻¹ in Basantapur and Amnura with gross margin Tk. 62700 and 72250 ha⁻¹, respectively (Table 11).

Summer Tomato: This was the first initiative that BARI Hybrid Tomato-8 (summer Tomato) was trying to cultivate at Basantapur in HBT. The grafting seedling was purchased from a commercial nursery "Maxim Agro" located in Bogra. The fruit yield of Tomato was 18.50 t ha⁻¹ with gross margin Tk. 587500 ha⁻¹ (Table 11).

Winter Tomato: The BARI Tomato-5 was cultivated at Kamalbazar, Sylhet. The fruit yield of Tomato was 51.70 t ha⁻¹ with gross margin Tk. 352000 ha⁻¹ (Table 11).

Mustard: BARI Sarisha-14 was cultivated as a production to show the performance among the farmers at Amnura, Chanduria, Ziaroki and Kamal Bazar sites. Seed yield of the variety was ranging from 1.37 to 1.50 t ha⁻¹ where the highest one from Amnura. The maximum gross margin (Tk. 36750 ha⁻¹) was from Amnura and the minimum one from (Tk. 21505 ha⁻¹) (Table 11).

Sesame: BARI Til-4 was cultivated Chanduria site. It is developed by oil seed research center of BARI. It is called '*atsira*'. The BARI Til-4 yielded 1.10 t ha⁻¹ with gross margin Tk. 41000 ha⁻¹ (Table 11).

Sunflower: BARI Surjomukhi-2 was cultivated in Kamalbazar, Sylhet and yielded 2.10 t ha⁻¹ with Tk. 68120 ha⁻¹ gross margin (Table 11).

Onion BARI Piaz-2 was cultivated in Sylhet and yielded 12.00 t ha⁻¹ bulb with Tk. 84000 ha⁻¹ gross margin (Table 11).

Wheat: Wheat was cultivated in two locations namely, Chanduria and Kamalbazar as production program. The BARI Gom-30 was tried in Chanduria site and gave very good grain yield (4.20 t ha^{-1}) with gross margin (Tk 62625 ha^{-1}). In Sylhet, BARI Gom-28 was cultivated to show the performance among the farmers at FSRD site. The variety yielded 2.10 t ha^{-1} with Tk. 40230 ha^{-1} gross margin (Table 11).

Potato: In Sylhet, BARI Alu-46 yielded 32.72 t ha^{-1} tuber with Tk. 299030 ha^{-1} gross margin (Table 11).

Field pea: In Sylhet, the mean seed yield of BARI Motor-1 was 1.42 t ha^{-1} with Tk. 30200 ha^{-1} gross margin (Table 11).

Table 11. Dates of all operations, yield, cost and return of crops in different location during the year of 2019-20.

Variety	Location	Seed yield (t ha^{-1})	GR (Tk ha^{-1})	TC (Tk ha^{-1})	GM (Tk ha^{-1})	BCR
BARI Masur-8	Basantapur	1.95	136500	33750	102750	4.04
	Chanduria	1.93	144750	37700	107050	3.83
	Ziaroki	2.17	176340	41912	134428	3.21
BARI Chola-5	Basantapur	1.52	91200	28500	62700	3.20
	Amnura	1.55	100750	28500	72250	3.53
BARI Hybrid Tomato-8	Basantapur	18.50	1110000	587500	522500	1.88
BARI Tomato-5	Kamal Bazar	51.70	517000	165000	352000	3.13
BARI Sarisha-14	Amnura	1.5	67500	30750	36750	2.19
	Chanduria	1.42	72020	50515	21505	1.42
	Ziaroki	1.46	75260	52065	23195	1.44
	Kamalabazar	1.37	116420	80270	36180	1.45
BARI Til-4	Chanduria	1.1	66000	25000	41000	2.64
BARI Gom-30	Chanduria	4.2	100800	38175	62625	1.61
BARI Gom-28	Kamal Bazar	2.10	73500	33270	40230	2.21
BARI Surjomukhi-2	Kamal Bazar	2.10	96600	45680	50920	2.11
BARI Alu-46	Kamal Bazar	32.72	491580	192550	299030	2.55
BARI Motor-1	Kamal Bazar	1.42	85200	55000	30200	1.55
BARI Piaj-2	Kamal Bazar	12.00	180000	96000	84000	1.88

III. On farm verification

Potato at Basantapur: Normally potato is not cultivated by farmers in Godagari Upazilla due to soil characters. We were trying to validate five popular and latest varieties in Basantapur of Barind area. Among the tested varieties BARI Alu-7 gave the highest tuber yield (26 t ha^{-1}) followed BARI Alu-41 (25.23 t ha^{-1}) and the lowest one in BARI Alu-25 (21 t ha^{-1}) (Table 12).

Potato at Chanduria: An On-farm verification trial with different potato varieties was conducted at FSRD site, Chanduria, Tanore, Rajshahi during the year 2019-20. Among the tested potato varieties, BARI Alu-40 (35.42 t ha^{-1}) gave the highest tuber yield followed by BARI Alu-37 (32.35 t ha^{-1}) and the BARI Alu-7 (31.32 t ha^{-1}) contributed the lowest one (31.32 t ha^{-1}). The gross margin and BCR was similar trend as tuber yield. The BCR was more than 2 for all the tested varieties (Table 12).

Mustard at Chanduria: This verification test was conducted at Chanduria site. Among the tested mustard varieties, the BARI Sarisha-16 (2.04 t ha^{-1}) and BARI Sarisha-11 (2.02 t ha^{-1}) gave similar seed yield (Table 12). The BARI Sarisha-18 that is canola type mustard yielded comparatively lower production (1.91 t ha^{-1}).

Potato at Ziaroki: Potato was harvested on early March at Ziaroki site. Between the tested varieties the BARI Alu-25 gave higher tuber yield (24.40 t ha^{-1}) than BARI Alu-7 (21.78 t ha^{-1}) (Table 12).

Table 12. Dates of all operations, yield, cost and return of Potato during the year of 2019-20.

Location	Crop	Variety	Planting date	Harvesting date	Yield (t ha ⁻¹)
Basantapur	Potato	BARI Alu-7	30 November 2019	8 March 2020	26.00
		BARI Alu-25			21.00
		BARI Alu-36			24.50
		BARI Alu-41			25.23
		BARI Alu-46			24.60
Chanduria	Potato	BARI Alu-7	30 November 2019	03-04 March 2020	31.32
		BARI Alu-37			32.35
		BARI Alu-40			35.42
Ziaroki	Potato	BARI Alu-7	27 November 2019	10 March 2020	21.78
		BARI Alu-25			24.40
Chanduria	Mustard	BARI Sarisha-11	30 November 2019	14-16 March 2020	2.02
		BARI Sarisha-16			2.04
		BARI Sarisha-18			1.91

C. Livestock Component

Livestock component includes management of poultry, cattle and Goat; and preparation of compost.

Vaccination of poultry: Poultry vaccination program was conducted at all the 5 FSRD sites during the year 2019-20. Three different vaccines (BCRDV, RDV, Duck plague) were used to implement the program as per recommended schedules (every three months interval). It is revealed that, mortality rate can be minimized significantly through vaccination. Mortality rate was reduced and went below 5% in maximum cases which can be considered as negligible comparing to the condition before the vaccination program (about 20%). Thus, mortality rate was turned down to tolerable level (Table 13).

Table 13. Number of birds vaccinated and mortality rate before and after vaccination

Location	Name of vaccine	Number of birds vaccinated	Mortality rate (%)	
			Before vaccination	After vaccination
Basantapur	BCRDV	116	22	4
	RDV	282	15	3
	Duck plague	46	14	4
Amnura	BCRDV	106	20	7
	RDV	280	17	6
	Duck plague	50	12	3
Chanduria	BCRDV	109	22	6
	RDV	265	15	2
	Duck plague	47	14	5
Ziaroki	BCRDV	109	22	6
	RDV	265	15	2
	Duck plague	47	14	5
Kamalbazar	BCRDV	100	25	7
	RDV	250	15	2
	Duck plague	200	12	8

Rearing of Sonali Chicken: Sixteen to eighteen Sonali bird including two male was distributed each farm household of all the five sites on the month of February-March 2020. The initial body wt. of each bird was ranging from 0.30 to 0.37 kg. After 6-8 months their body weight was increased significantly and reached at 1.50 to 1.85 kg each bird where the maximum weight gained was recorded at Basantapur and minimum at Kamalbazar. In addition, the hen started to lay egg from the month of June 2020. Eventually farmers' income was also increased. The gross margin was extending from Tk. 13320 to 15800 from rearing of Sonali breed where the maximum gross margin was from Basantapur and the minimum from Kamalbazar (Table 14).

Table 14. Performance of improved breeds (Sonali) after 6-8 months of distribution at FSRD sites, during the year 2019-20

Location	No. of farmers	No. of bird distributed to each farmer	Average initial body wt. (g)	Weight after 6 months (g)	GR from egg and meat (Tk.)	Variable cost (Tk.)	Gross margin (Tk.)
Basantapur	12	18 (Female-16, male-2)	370	1850	18500	2700	15800
Amnura	12	18 (Female-16, male-2)	350	1800	18000	2700	15300
Chanduria	12	18 (Female-16, male-2)	300	1800	17500	2500	15000
Ziaroki	12	18 (Female-16, male-2)	300	1500	17000	2400	14600
Kamalbazar	12	16 (Female-14, male-2)	300	1500	15520	2200	13320

Rearing of pigeon: Pigeon rearing program was initiated in two sites of Barind area namely Basantapur and Amnura (Table 15). Farmers of Amnura site was more interested to rear pigeon. Wheat 6 farmers were involved in the program while 3 farmers in Basantapur site. On an average, each farmer of Amnura had 5 pairs of pigeon whereas it was 3 pairs in Basantapur. The pigeon gave 1 pair of squabs in each 2 months. So, each farmer earned av. Tk. 1600/- and 1600/- in Basantapur and Amnura, respectively during the activities from rearing of pigeon (Table 15).

Table 15. Rearing of pigeon at farmers household at different sites during the year 2019-20

Location	No. of farmers	Av. No. of pigeon/ family	Average initial body wt. (g)	Squab born	Squab died	Squab intake	Squab sold	Gross margin (Tk.)
Basantapur	3	06	400	18	02	10	06	1600
Amnura	6	10	400	30	04	14	12	2600

Vaccination program on cattle:

Vaccination program was done in cattle among the beneficiaries as well as adjacent farmers at all the FSRD sites. Number of livestock under vaccination program, name of the vaccine applied to the selected cattle, and disease incidence are presented in Table 16. In the vaccinated group, Anthrax vaccine, Foot and mouth disease (FMD) vaccine, Black quarter (BQ) vaccine and Hemorrhagic septicemia (HS) vaccine were injected as per recommended schedule. PPR vaccine for Goat was provided only two sites, Basantapur and Amnura. More than 80 numbers of cattle (Cow, ox and calf) were vaccinated in different dates for different diseases. Frequency of diseases was listed among the cooperative farmers. It was found that, before vaccination, the frequency of different diseases was higher. After vaccination of cattle, all of the disease's frequency reduced to below 5%. This technology was easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested and adopted this technology as per routine work.

Table 16. Disease incidence (%) of cattle before and after vaccination

Location	Disease	Number of cattle vaccinated	Disease (%)	
			Before vaccination	After vaccination
Basantapur	Anthrax	85	06	1.5
	BQ	82	18	3
	HS	80	23	4
	FMD	90	25	5
	PPR	100	34	7
Amnura	Anthrax	95	07	2
	BQ	90	20	3
	HS	85	23	4
	FMD	95	25	5
	PPR	105	35	6
Chanduria	Anthrax	77	22	5
	BQ	79	25	5
	HS	80	23	4

Location	Disease	Number of cattle vaccinated	Disease (%)	
			Before vaccination	After vaccination
	FMD	80	21	4
Ziaroki	HS	200	4	0
	FMD	210	16	1
	Anthrax	275	13	2
	BQ	205	11	3
Kamalbazar	Anthrax	55	5	3
	Paraclear	55	6	3
	FMD	55	10	2

Cattle health improvement

Deworming has positive effects on cattle health. That's why the cooperator farmers were interested and adopted this technology as per routine work. Number of livestock under deworming program, and their performances are presented in Table 17. On an average of all sites, eighteen cattle were dewormed against ten. It was found that, after deworming of cattle, lactation yield and lactation period were increased by 50% and 21%, respectively. In addition, gaining of body weight of dewormed cattle 80-90 g/d/cattle instead of 30-50 g/d/cattle in untreated control.

Table 17. Performance of body weight gain, milk production and lactation period after deworming

Treatment	No. of animal	Av. Body wt. gain/day/animal (g)	Av. Lactation yield (litre/day)	Av. Lactation period (day)
Basantapur	06	80-90	1.25	178
Amnura	14	85-95	1.30	182
Chanduria	35	70-90	1.75	195
Ziaroki	3	90-100	2.00	230
Kamalbazar	33	60-80	1.55	182
Treated cattle (Av.)	18	80-90	1.57	193
Controlled cattle (Av.)	10	30-50	1.00	160

Beef fattening: Beef fattening activities was carried out at three FSRD sites except Chanduria and Kamalbazar. Cattle were dewormed and vaccinated under beef fattening program and supplied balance and improve feed. It was found that after 180 days, the body weight of cattle was increased rapidly (Table 18). The weight gained of cattle was extending from 76 to 88% with the average of 80%. Market value was estimated and found that similarly it was also increased by 70%. Beef fattening is profitable technology and some farmers has already taken as business.

Table 18. Body weight and market value (%) for beef fattening.

Location	No. of farmer	No of breed	Initial body wt/beef (kg)	Body wt after 180 days (kg)	Initial value (Tk)	Present value (Tk)	Market value Increment (%)
Basantapur	2	2	85	150	38875	63500	63.34
Amnura	4	2	85	160	38410	66500	73.13
Ziaroki	2	2	75	132	24375	42000	72.30
Average	3	2	82	147	33887	57333	69.35

Compost: Cow dung, crop residue and household wastes were used to produce farm Yard manure at different FSRD sites. Partial supports were provided to the farmers for preparing well compost shade. After project intervention, most of the Cow dung and household wastes are being used for FYM production. It was found that, on an average 1920 kg FYM was produced from each homestead after intervention whereas before intervention it was only 320 kg in Basantapur of Barind area. But for Sylhet it was higher and on an average 2700 kg FYM per homestead after intervention whereas only 800 kg

for before intervention. Fuel wood is an acute problem in HBT and about 80% of Cow dung is used for cooking fuel. So, production of FYM is low in HBT.

Green fodder: Napier grass production was started at farmers land nearby homestead and on the pond bank at different FSRD sites under drought and rain-fed eco-system. It was found that average 40 t/ha green fodders could be produced from a homestead or surrounding areas.

D. Fisheries System

The program of carp polyculture in seasonal ponds was undertaken at all sites with the objectives of increasing farmer's income and to remove protein deficiency of rural people.

Production program of carp polyculture in seasonal pond: Carp polyculture production was conducted in seasonal and perennial pond of project beneficiaries. The ponds were 5-15 decimal sized with 1.5-3.0 m depth. Before intervention the pond was remained fallow or some cultivated fish without using modern technology. But after intervention the pond was used scientifically for pond preparation, maintaining stock density, proper feeding etc. The results revealed that, in polyculture of carp fishes the survival rate was 82-96% (Table 19). After 180 days, yield of fish after intervention was obtained from 110 to 550 kg per pond where the highest production recorded from Ziaroki site mainly due to larger pond size and the lowest one was from Amnura. Similarly gross margin was also varied in different sites and with the highest in Ziaroki (Tk. 40000 per pond). Kamalbazar site recorded the second highest gross margin (Tk. 14700 per pond) and lowest one from Amnura site (Tk. 8700 per pond) (Table 19). Among the total production they consumed, distributed to relatives and sold their products in local market (Table 20). It was revealed that on an average, farmers sold most of the fish (47%), consumed about 44% and distributed about 9% through their neighbors, relatives and well-wishers of the produced fish. The farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 19. Performance of carp polyculture fish farming at different FSRD sites during the year 2019-20

Location	pond depth (m) and stock density (no. dec ⁻¹)	Breed	Initial wt/fingerling (g)	Survival rate (%)	Weight after 180 days (g)	Production (kg pond ⁻¹)	Gross return (Tk)	Total Cost (Tk pond ⁻¹)	Gross margin (Tk pond ⁻¹)
Basantapur	6.5 dec, 1.6 m and 25	Silver carp	208	91	1200	139	16680	5125	11330
		Ruhi	97	87	750				
		Mrigel	93	82	675				
Amnura	5 dec and 1.5 m and 30	Silver carp	170	96	950	110	13200	4500	8700
		Ruhi	95	92	650				
		Mrigel	96	91	670				
Chanduria	6 dec and 1.5 m and 30	Silver carp	50	90	1100	125	21875	10500	11375
		Catla	35	85	1000				
		Ruhi	35	80	900				
		Mrigel	35	82	900				
		Grass carp	42	88	1000				
Ziaroki	15 dec, 3 m and 30	Silver carp	70	85	900	550	55000	15000	40000
		Ruhi	85	80	800				
		Mrigel	70	82	950				
Kamalabazar	8 dec, 1.5 m and 30	Silver carp	70	85	420	230	20700	6000	14700
		Catla	80	80	512				
		Mrigel	70	80	470				

Table 20. Utilization pattern of harvested fish

Location	Total Yield (kg Pond ⁻¹)	Consumption (Kg)	Distribution (Kg)	Sale (Kg)
Basantapur	139	64	10	65
Amnura	110	60	8	42
Chanduria	125	35	9	81
Ziaroki	550	300	50	200
Kamalbazar	230	50	30	150
Average	231	102	21	108

E. Plantation and management

Site: FSRD site, Basantapur, Rajshahi

Sapling/seedling distribution: To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., mango, guava, papaya, malta, Sugarcane, moringa etc. In addition, a mango orchard was established with 40 saplings in crop field. The supplied total number of saplings of different fruits plants are shown in Table 21.

Table 21. Number of fruits and other saplings distributed among the farmers at FSRD site, Basantapur, Rajshahi during the year 2019-20

Sl. No.	Types of the fruit/other saplings (Farmer)	Variety	Number	Survivability (%)
1	Mango	BARI Aam-4	60	95
2	Guava	BARI Peyara-2	24	90
3	Malta	BARI Malta-1	24	90
4	Papaya	BARI Papaya-1	120	80
5	Moringa	Local	60	80
6	Sugarcane	BSRI Akh-42 (Rangbilash)	250	90
7	Establishment of Mango orchard	BARI Aam-4	1 Orchard with 40 saplings	95

Site: MLT site, Amnura, Rajshahi

To fulfilment of nutrition from fruit sector, a number of different fruits saplings were supplied to homestead e.g. mango, guava, papaya, malta, moringa and Sugarcane. The supplied total number of saplings of different fruits plants are shown in Table 22. Furthermore, a mango orchard was established with 70 saplings in crop field. We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 22. Number of fruits and other saplings distributed among the farmers at MLT site, Amnura, Chapainawabganj during the year 2019-20

Sl. No.	Types of the fruit/other saplings (Farmer)	Variety	Number	Survivability (%)
1	Mango	BARI Aam-4	60	95
2	Guava	BARI Peyara-2	24	90
3	Malta	BARI Malta-1	24	90
4	Papaya	BARI Papaya-1	120	80
5	Moringa	Local	60	80
6	Sugarcane	BSRI Akh-42 (Rangbilash)	250	90
7	Establishment of Mango orchard	BARI Aam-4	1 Orchard with 70 saplings	93

Site: FSRD site, Chanduria, Rajshahi

Nine species of fruit sapling were distributed among the target farmers of FSRD site, Chanduria, Rajshahi (Table 23). Total number of saplings was 300 and mortality rate ranged from 2-10%. Chewing type Sugarcane namely BSRI Akh42 (Rangbilash) was distributed among the farmers.

Table 23. Number of fruits and other saplings distributed among the farmers at FSRD site, Chanduria during the year 2019-20

Sl. No.	Types of the fruit/other saplings	Variety	Number	Survivability (%)
1	Mango	BARI Am-4 BARI Am-3 BARI Am-11	180	95
2	Bay Leaves	BARI Tejpata-1	15	98
3	Limon	BARI Lebu-2	15	98
4	Papaya	Hybrid	60	90
5	Dragon fruit	BARI Dragon-1	15	98
6	Pomelo	BARI Batabi Lebu-3	15	98
7	Sugarcane	BSRI Akh-42 (Rangbilash)	186	90

Site: FSRD site, Ziaroki, Kushtia

Ten species of fruit trees was distributed among the selected farmers at FSRD site, Ziaroki, Kushtia. Most of the fruit trees are growing well. The mortality rate was below 5% (Table 24).

Table 24. Number of fruits and other saplings distributed among the farmers during the year 2019-20

Sl. No.	Types of the fruit/other saplings	Variety	Number	Mortality (%)
1	Mango	BARI Aam-4	75	2
2	Litchi	BARI Litchi-3	16	1
3	Guava	Thai-10	103	5
4	Malta	BARI Malta-1	12	0
5	Lime	Thai	4	0
6	Papaya	Shahi	36	3
7	Dragon fruit	BARI Dragon fruit-1	26	0
8	Moringa	--	26	0
9	Sugarcane	BSRI chewing	130	0
10	Ber	Bol shundori	112	0

Site: FSRD site, Kamal Bazar, Sylhet

Eight species of fruit sapling were distributed among the target farmers of FSRD site, Kamalbazar, Sylhet (Table 25). Total number of saplings was 638 and mortality rate ranged from 0-5%. BSRI Akh42, chewing type Sugarcane cultivar, was also distributed among the farmers (Table 25)

Table 25. Number of fruits and other saplings distributed among the farmers at FSRD site, Kamalbazar, Sylhet during the year 2019-20

Sl. No.	Types of the fruit/other saplings	Variety	Number	Mortality (%)
1	Mango	BARI Aam-3	24	2
2	Litchi	BARI Litchi-3	24	5
3	Guava	BARI Payera-2	50	1
4	Malta	BARI Malta-1	210	5
5	Papaya	Local	60	2
6	Satkora	BARI Satkora-1	50	0
7	Jaralebu	BARI Jaralebu-1	160	0
8	Battle nut	Local	60	5
9	Sugarcane	BSRI Akh-42 (Rangbilash)	60	87

F. Off-farm activities

Besides of agricultural production, some farm families' especially the women were engaged with weaving *Katha*, sewing cloths with machine and making different handicrafts with jute rope during their leisure periods. Some farmer had autoriksha, two-wheel tractor and rented them with custom hiring basis. Sometimes, one farmer also sale his labor.

Site: FSRD site, Basantapur, Rajshahi

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household is making dress on custom hiring basis. Initially four households are pulling manual van. After intervention, we sensitized the beneficiaries to transform the vans to power driven. Accordingly, they converted them and income has been increased. It was found that after intervention the av. gross margin increased 85%, with the av. gross margin of Tk. 35362 (Table 25). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 26. Cost and return of off-farm activities

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing cloth	7800	2120	5680	11225	2800	8425	48
Van pulling	38500	6000	32500	82800	20500	62300	91.69
Average	23150	4060	19090	47012	11650	35362	85.23

Site: MLT site, Amnura, Rajshahi

Almost all the household practiced some off-farm activities at Amnura, Chapainawabganj site such as 2-wheel tractor driven, mechanical katha sewing, grocery shop, cattle business, kumra bora and so on. This paper includes the average two categories income. It was found that after intervention the gross margin increased 108%, with the gross margin of Tk. 26000 (Table 26).

Table 26. Cost and return of off-farm activities

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
2WT operator	30000	15000	15000	50000	20000	30000	100
Sewing Katha mechanically	15000	5000	10000	30000	8000	22000	120
Average	22500	10000	12500	40000	14000	26000	108

Site: FSRD site, Chanduria, Rajshahi

Some farmers and their wife are involved with off-farm activities such as Katha sewing, handicraft-bag and mat etc. in the working area. The cost and return are shown in Table 31.

Table 37. Cost and return of off-farm activities

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing machine	3500	800	2700	5500	1500	4000	148
Handicrafts-Bag (Jute rope)	4600	1200	3400	8550	2100	6450	190
Handicrafts-Mat (Jute rope)	2500	500	2000	4500	900	3600	180
Average	3533	833	2700	6183	1500	4683	173

Site: FSRD site, Kamal Bazar, Sylhet

Some farmers are involved in bricks crushing and shuttering. So, they earned very high income. After project activities, on an average the gross margin increased 55%, with the gross margin of Tk. 258500 (Table 38).

Table 38. Cost and return of off-farm activities

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Bricks crushing machine	580000	362000	218000	640000	325000	315000	45
Shuttering	360000	244000	116000	540000	38000	202000	74
Average	470000	303000	167000	590000	331500	258500	55

G. Income enhancement

Site: FSRD site, Basantapur, Rajshahi

By integration of year-round vegetables and fruits production, improved cropping patterns and production technologies, de-worming, vaccination program, cattle fattening and carp polyculture, the resources (land, labor, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. Before intervention of the project, an average per farm gross return and gross margin were Tk. 445815 and Tk. 263530 whereas it was Tk. 729547 and Tk. 432307 after intervention of the project activities (Table 27). The gross margin of a farm was increased by 95% after intervention.

Table 27. Technologies used and return from different sub-systems of a household under integrated farming system at FSRD site

Components	Before intervention (Tk/year)			After intervention (Tk/year)			GM increased (%)
	Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead	4945	825	4120	24570	3175	21395	419
Field crop	385540	162450	225090	562630	228175	334455	49
Livestock	28820	15800	13020	78675	48910	29765	129
Fisheries	3360	1150	2210	16660	5125	11330	412
Off-farm	23150	4060	19090	47012	11650	35362	85
<i>Total</i>	<i>445815</i>	<i>184285</i>	<i>263530</i>	<i>729547</i>	<i>297035</i>	<i>432307</i>	<i>95</i>

Site: MLT site, Amnura, Rajshahi

The results exhibit that after intervention, gross margin (Tk. 417150 per family) of all components increased substantially (111% higher) due to adoption of improved technologies over farmers existing practices (Table 28).

Table 28. Technologies used and return from different sub-systems of a household under integrated farming system at FSRD site

Components	Before intervention (Tk/year)			After intervention (Tk/year)			GM increased (%)
	Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead	4280	675	3605	21040	2890	18150	403
Field crop	283520	115250	168270	507475	174655	332820	98
Livestock	27850	15500	12350	85800	54320	31480	155
Fisheries	2400	1000	1400	13200	4500	8700	521
Off-farm	22500	10000	12500	40000	14000	26000	108
<i>Total</i>	<i>340550</i>	<i>142425</i>	<i>198125</i>	<i>667515</i>	<i>250365</i>	<i>417150</i>	<i>111</i>

Site: FSRD site, Chanduria, Rajshahi

The results revealed that after intervention, the production and economic return (Tk. 219292 per family) of all components increased substantially (169% higher) due to adoption of improved technologies over farmers existing practices (Tk.129955 per family) (Table 41).

Table 41. Technologies used and return from different sub-systems of a household under integrated farming system at FSRD site

Components	Before intervention (Tk/year)			After intervention (Tk/year)			GM increased (%)
	Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead	13775	1628	12147	22900	1976	20924	172
Field crop	146475	73815	72660	242025	126000	116025	63
Livestock	81723	45625	36098	131440	65155	66285	183
Fisheries	10500	4150	6350	21875	10500	11375	179
Off-farm	3533	833	2700	6183	1500	4683	173
<i>Total</i>	256006	126051	129955	424423	205131	219292	169

Site: FSRD site, Ziaroki, Kushtia

From Table 42 it was observed that maximum return recorded from crop sector which was 24% increased after intervention of technologies. The second highest net return was observed in fisheries component and that was 272% followed by livestock components (114%). The lowest net return was found from homestead production system (Tk. 5700). There were no off-farm activities among the target farmers.

Table 42. Technologies used and return from different sub-systems of a household under integrated farming system at FSRD site

Component	Before intervention (Tk/year)			After intervention (Tk/year)			% Increased
	Total income	Cost	Net income	Total income	Cost	Net income	
Crop sector	408300	158215	250085	471970	162262	309708	24
Homestead	2040	1000	1040	13790	8000	5790	457
Livestock	60000	47125	12875	82600	55000	27600	114
Fisheries	27000	10000	17000	86200	23000	63200	272
<i>Total</i>	497340	216340	281000	654560	248262	406298	44.59

Site: FSRD site, Kamal Bazar, Sylhet

Considering whole farm, the increment of gross margin after intervention was 44% over before intervention (Table 43)

Table 43. Technologies used and return from different sub-systems of a household under integrated farming system at FSRD site, Kamalbazar, Sylhet.

Components		Before intervention (Tk/year)			After intervention (Tk/year)			GM increased (%)
		Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead		16880	3650	13230	39700	10100	29600	124
Field crop	CP	165000	123585	55063	335970	203384	146234	166
	PP	1325000	610000	715000	1675060	647770	927290	30
Livestock		11200	9100	2100	15520	10500	5020	139
Fisheries		11250	3500	7750	20700	6000	14700	90
Off-farm		470000	303000	167000	590000	331500	258500	55
<i>Total</i>		1999330	1052835	960143	2676950	1209254	1381344	44

CP: Cropping System; PP: Production Program

H. Integration

Integration is done to recycle resources efficiently. Environmentally sound integration is ensured where livestock dropping and feed waste can be poured directly into the pond to constitute feed for fish and zooplankton. Livestock manure can be used to fertilize grass or other plant growth than can also constitute feed for fish. Vegetables can be irrigated from the fishponds, and their residues and byproducts can be used for feeding livestock. However, most of the manure usually lost up to half its nitrogen content before it became nitrate and was readily available as fertilizer to plants. The quantity

also became inadequate as the population increased, so chemical fertilizers and artificial feeds had to be purchased, eroding the small profits of the small farmers.

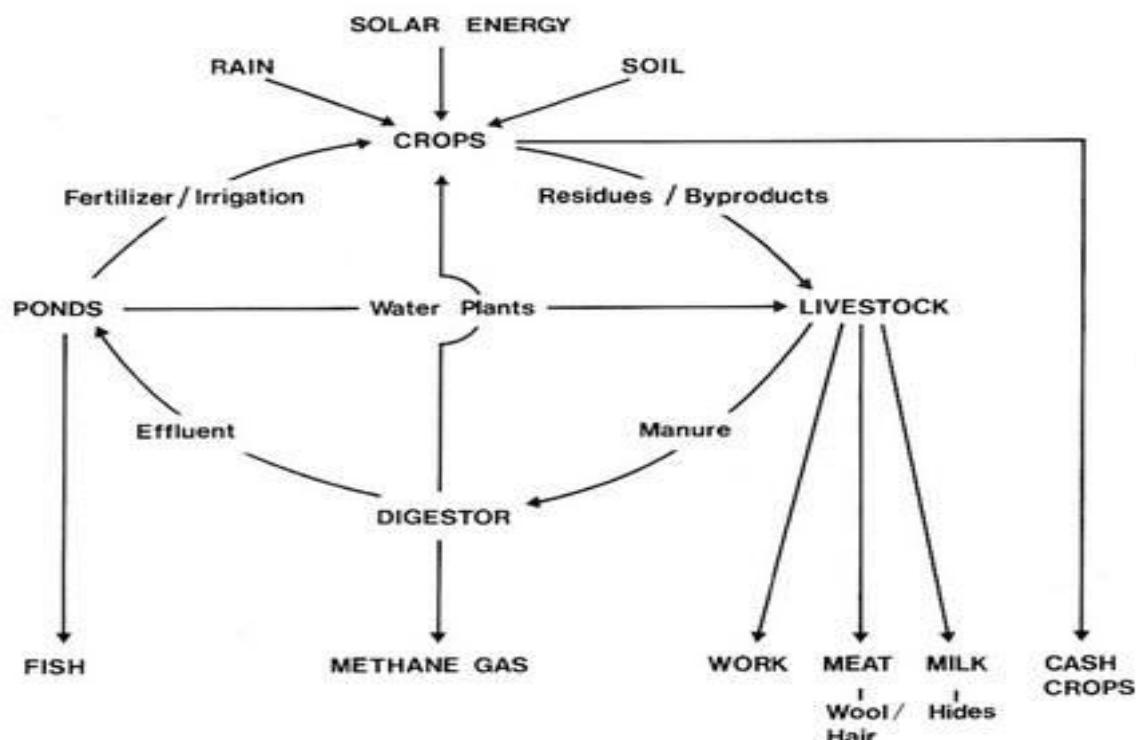


Fig. Flow diagram of integrated farming systems

Farmer's opinion

The resource poor farmers are interested to adopt those technologies which can provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and shift of other activities. Due to adoption of integrated farming, they are hopeful to maintain their family with farm income. The increased productivity, gross margin and nutrition supplementation from the homesteads source made them confident for livelihood improvement.

Impact

- Farmers gathered knowledge about component basis innovative technologies due to which they grow their awareness about integrated farming systems activities for better maintenance of their life.
- Women were specially participated in homestead-based activities like vegetable production, management of fruit trees, poultry rearing, cattle rearing and composting because they were gained up about the relevant technologies.
- In the recent days school girls and children are included in the homestead activities especially vegetable gardening and poultry rearing.
- Farmers were motivated to implement integrated holistic approach because they got cash income from different enterprises.

Limitations of the study

- Scarcity of residual soil moisture particularly in Barind area.
- Homestead activities hampered sometimes due to laborious work and shortage of manpower
- Lack of strong multidisciplinary scientific team to implement the program
- Lack of skillness of site level staffs and the farm family members for optimum production and accurate data collection
- Quality of inputs need to be ensured

Conclusion

An integrated farming system is an eco-friendly approach in which waste of one enterprise becomes the input of another thus making efficient use of resources. From the study it was revealed that the components of farming system like home gardening, cropping system, dairying, poultry, fishery, etc. are interrelated. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle's and cattle are used for different field operations for growing crops. Thus, different enterprises of farming systems are highly interrelated. The vital indicator for livelihood improvement is increasing income compared to existing condition, which was successfully obtained from the program. So, the proper utilization of farmer's resources can help them in this area. However, integrated farming system is a very promising technology for livelihood improvements of farmers but it needs multidisciplinary well experienced strong scientific team for more successful integration of technologies.

CLIMATE RESILIENT FARMING SYSTEMS RESEARCH AND DEVELOPMENT FOR THE COASTAL ECOSYSTEM

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Abstract

Coastal areas of Bangladesh are also a hub of hydro meteorological disasters including cyclones, tidal surges, floods, drought, soil salinity, saline water intrusion, waterlogging, and land subsidence. This has a direct bearing on livelihoods as agriculture provides employment for over 60 percent of the population in Bangladesh and it is a key economic activity for the 40 million inhabitants in the coastal zone. The agricultural system is heavily dependent on environmental factors. In this context, it has become an urgent need to demonstrate modern agricultural technologies through "Integrated farming or Mixed Crop-Livestock System Approach" rather than seasonal or crop specific approach at Coastal areas. The subsistence farms in coastal areas are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. The activities were implemented in two new Farming System Research and Development site (FSRD) located at West Al-Amin, Subarnachar in Noakhali and Jamla, Dumki in Patuakhali where two villages from Subarnachar (Char Wapda and Katabunia) and one village (Jamla) from Dumki Upazilla were selected as target sites. According to the aim, resource poor farmers viz. marginal, small and medium having major components of farming and sizable homestead under single ownership are targeted and twelve farm households from each site covering four farmers from each category were selected. Prior to implement the activities, a baseline survey of individual households was carried out. Based on the potentials, suitable technological options were addressed to the farmers, and accordingly farmers selected suitable technologies were adjusted with their need for livelihood improvement. For developing sustainable cropping patterns on-farm verification trials on cash crop were conducted in both the locations during Rabi season of 2020-2021 cropping year. Besides on-farm trials, Aus crop was established (06 farmers field) with the modern variety such as BRRI dhan48, BRRI dhan82, BRRI dhan83, BRRI dhan85 and Binadhan-19 which was compared with local Hydra variety at Noakhali site. On the other hand, BRRI dhan48 was cultivated at Patuakhali site (05 farmers field). With the aim of improving soil health, eight farmers field were selected for green manuring crops cultivation and eventually, incorporated just before flowering in Noakhali site. High value crops like summer Tomato cultivation were introduced (among 04 farmers) with modern variety of BARI Hybrid Summer Tomato-8. On the other hand, Sorjan method was implemented in Patuakhali. For improvement of cropping pattern, land type-based T. Aman rice varieties (BRRI dhan23, BRRI dhan52 and BRRI dhan87) were cultivated at all farmers field in Noakhali whereas BRRI dhan23, BRRI dhan52, BRRI dhan49 and BRRI dhan76 were cultivated in Patuakhali site. In Noakhali site, three alternate cropping patterns

were introduced such as Groundnut (Dhaka-1)-D./T. Aus (BRRI dhan85)-T. Aman (BRRI dhan87), Proso millet (BARI Cheena-1)-Green manure-T. Aman (BR23) and Soybean (BARI Soybean-6)-T. Aus (BRRI dhan85)-T. Aman (BRRI dhan52). Moreover, Potato (BARI Alu-72)-Mungbean (BARI Mung-6)-T. Aman (BRRI dhan52) and Sunflower (BARI Surjomukhi-2)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan52). For vegetables production, moveable seed bed was introduced for winter vegetables seedling production in Noakhali. Several farmers of Noakhali cultivated Cabbage, cauliflower, broccoli and Tomato in the small-scaled. All farmers in Noakhali site, cultivated onion with a land vary 1 to 1.5 dec. For preservation of high yielding varieties seed, plastic drum (180 kg) along with plastic bag (40 kg) were also distributed among the farmers in both locations. A total of 168 saplings were distributed to enrich agroforestry system with 05 types of fruit trees (Noakhali) whereas 06 types of fruit trees (total 204) were distributed in Patuakhali site. Year-round vegetable production through modified "Atkapalia" Model and "Lebukhali" Model are being practiced among the co-operative farmers. Vaccination of livestock and poultry was done as when necessary for sustaining the production system. Moreover, chick, Duck and pigeon were distributed with the aim of more meat and egg production. Sonali chicken rearing system was followed by the farmers in Patuakhali site whereas in-house pigeon rearing system was practiced by one farmer in Noakhali site. Despite poultry, fodder production was done among six farmers and hydroponic which increased milk production. Furthermore, calf rearing gaining popular in Patuakhali site where farmer could earn 37,000 TK. (average). Nevertheless, vermicompost through ring (Noakhali) and chari (Patuakhali) methods were practiced. To increase farmer's income through aquaculture system, carp poly culture was practiced among the farmers depending on the pond size and other existing frameworks in both the locations. Furthermore, co-operative farmers were encouraged to weaving attractive design Shital Pati in Noakhali site and swing of cloths in Patuakhali site. Continuous follow up evaluation were made by the concerned scientist for sustaining and integrated function of the system.

Introduction

In Asia, some 52.7% of farms are <1.0 ha, with the smallest farm sizes (<0.4 ha) in Bangladesh (Devendra and Thomas, 2002) and number of marginal farms has been increasing from 4.48% in 1996 to 11.20% in 2005 with average size of 0.6 ha (BBS, 2009). In Noakhali (saline char land), with some 80% operational farm holdings are less than one hectare (DAE, Noakhali) which also limits for taken up additional and diversified farming activities. Despite farm sizes, emphasis given to rain-fed T. Aman production with few *Rabi* crops like Soybean, Mungbean, Cowpea, Grass Pea, Groundnut-in some cases risk of crop losses due to heavy rainfall causes early or late season flooding, larger breaks within the monsoon season may cause drought and finally the soil salinity. Recently extreme rainfall that occurred during last couple of year ago (2016) hampered T. Aman seedbed and seedlings. Furthermore, the income from cropping alone is hardly sufficient to sustain the farmer's family in case of small and marginal farmers; those constitute 80.3 per cent of agricultural population with only 36 percent of area operated. On the other hand, an Integrated Farming System (IFS) can ensure the highest standard of food production with the minimum environmental impact with even highly vulnerable climatic conditions with the available resources accessible to farmer. Humans developed agricultural systems that combined crop production with animal husbandry 8 to 10 millennia ago (Allen *et al.*, 2007; Russelle *et al.*, 2007). Research on integrated crop and livestock systems has found to be highly productive and environmentally sustainable (Allen *et al.*, 2005, 2007; Russelle *et al.*, 2007). This productivity often reflects the improved soil structure and fertility, weed suppression and disruption of pest cycles created by diverse crop sequences and the livestock presence (Entz *et al.*, 2002; Mckenzie *et al.*, 1999; Tracy and Davis, 2009). In this aspect, there is scope to linkage mainstream agricultural research intervention for saline area by different research organization (BARI, BRRI, BLRI, BINA, BFRI etc.) with the desirable features of farming system which will help to develop relevant, client-oriented, and location-specific Integrated Farming System. Modification and fine tuning of farmers existing framework and identify suitable enterprise combinations and assess returns and employment opportunities for small, marginal, and medium farmers in the saline char area of Noakhali and Patuakhali which will minimize risks in the changing climatic conditions. Maximizing farm productivity with efficient use of farm resources was the general objective and the succeeding specific objectives were followed for farming systems research and development activities in the costal ecosystem.

- To modify/fine tune on-station technologies generated by NARS institutes at different FSRD sites of coastal ecosystems.
- To integrate component technologies (crops, livestock, fisheries, agro- forestry and homestead gardening, etc.) for improving farm practices, establish linkage with different stakeholders.
- To develop of integrated farming technologies to maximize farm productivity and efficient use of resources.

Approach and Methodology

For the successful implementation of the Climate Resilient Farming Systems Research and Development for the Coastal Ecosystem program, the following methods were considered-

2.1. Site selection: The site selection criteria were - the ecological and physical conditions of the area which representing coastal ecosystem, the biological and economic potential for crop, livestock, and fisheries production systems, and the managerial or logistic conditions for setting up a research base.

2.2. Site description: It includes geographical location, physical, biological, social, and economic conditions, infra-structural condition, existing farming systems, resource situation, general problems etc. The information necessary to describe the site were collected through two-week interactive type of informal survey, secondary sources such as block level SAAO data book, BBS census data etc. and information shared interview with local government members, progressive farmers, and NGO personnel.

2.3. Identification of problems: Identification of the problems was done through two-week interactive type of informal survey, review of secondary data and direct discussion with farmers (50), (20) key informants and (18 from each village) members of farm households as well as meetings (02) with of SRDI and extension personnel, NGOs personnel, scientists, and personal observations etc.

2.4. Prioritization of problems: The research teams further analyse and studies the opportunities and problems in order to prioritizes the research and extension needs in consultation with the client farmers on the basis of the availability of technology, available resources of the farmers, climate change induced hazards, previous experiences of respected personnel of OFRD, Noakhali and OFRD, BARI, Patuakhali.

2.5. Preparation of research and development program: Research and development programs have been formulated against prioritized problems taking into consideration of available resources and previous experiences of the respected scientist and scientific assistant of OFRD, BARI, Noakhali and Patuakhali.

2.6. Discussion on the program: The programs were discussed at the institutional level. At the institutional level, the research programs were discussed at the Research Team meeting headed by Coordinator and Associate Coordinator from BARC, CSO of OFRD from BARI and Concerned Scientists from Noakhali and Patuakhali and targeted farmers from intervention sites.

2.7. Recommendation of the program: Site level program were developed through participatory planning workshop of each site. Then the programs were approved through a day-long meeting with the stakeholders.

2.8. Selection of co-operator farmers: Three categories of famer's viz. marginal, small, and medium were selected from two villages of each site. Four farmers from each category were selected based on resources like homestead, crop land, agroforestry, pond, and livestock subsectors.

2.9. Resources inventory of co-operator farmers: Based on the methodology, initial desk review of the PRA report and discussion with FSRD team a detailed existing farming systems analysis framework was developed around key areas of inquiry. Finally, structured questionnaire was developed based on a quantitative perspective where extension, substitution, expansion, and general questions were included for understanding the actual conditions which was trapped into the farmers mind with their day-to-day farming systems.

2.10. Program execution: The programs have been executed at the farm level with the active participation of FSRD team in collaboration with other NARS institutes. All the programs are managed

by the farmers themselves in their farm with the supply of some additional inputs by FSRD team as free of cost, subsidized rate or with full cost depending upon the type of trials.

2.11. Identification of recommendation domain: Recommendation domain for a particular technology has been identified depending upon the physical, biological, social, and economic requirements of technology.

2.12. Technology selection for development program: Technologies have been selected based on farmer's choice, preference, and resources as well as extension providers.

2.13. Dissemination of FSR technology: Dissemination of technologies was made through-

2.13.1. Year-round vegetables production system at homestead and adjacent lands to homestead

a) Year-Round Vegetables and Quick Growing Fruit Production in Homestead: Homestead area is an asset for the resource poor farm household and suitable for production of different kinds of vegetables and fruits. Based on farmers' choice and agro-ecological suitability, the vegetables production models of “Atkapalia Model” and “Lebukhali Model” are being modified and followed.

Table 2.13.1.1. “Modified Atkapalia Model” followed for year-round homestead vegetable production at FSRD site, West Al-Amin, Subarnachar, Noakhali

Niches/Spaces		Year-round homestead vegetable patterns		
		<i>Rabi</i>	<i>Kharif I</i>	<i>Kharif II</i>
Open sunny spaces	Bed-1	Cauliflower	Brinjal-Gimakolmi	Brinjal-Gimakolmi
	Bed-2	Broccoli	Okra	Okra
	Bed-3	Cabbage	Amaranth / Indian Spinach	Indian Spinach
	Bed-4	Brinjal + Red amaranth	Muki Kachu	Muki Kachu
	Bed-5	Tomato + Radish	Patshak/Indian spinach	Patshak/Indian Spinach
Around the boundary of the open space		Khoi bhutta/Black cumin/Safflower/Marigold		
Homestead garden fence		Yard long bean/Bitter gourd/Summer Country bean		
Entrance of house		Potato Yam /Bitter gourd		
Roof top		Bottle gourd - Ash gourd/Indian spinach		
Pond banks/Trellis		Country bean/Bottle gourd/Sweet gourd/Bitter gourd, Bamboo, Pigeon pea, Neem		
Unproductive Tree support		Potato Yam/ Snake gourd/Ribbed gourd		
Partial shady area		Ginger/Turmeric		
Marshy land		Panikachu		
Homestead boundary		Naga morich, Papaya, Elephant foot Yam, Coconut, Betelnut, Banana, Neem		
Backyard/waste land		Elephant foot Yam, Papaya, Drumstick, Malta, Banana, Neem, Muki kachu		

Table 2.13.1.2. “Modified Lebukhali Model” followed for year-round homestead vegetable production at FSRD site, Jamla, Dumki. Patuakhali

Niches/spaces		Year-round homestead vegetable pattern		
		<i>Rabi</i>	<i>Kharif I</i>	<i>Kharif II</i>
Open sunny space	Bed-1	Tomato + Spinach	Indian Spinach	
	Bed-2	Brinjal + Red amaranth	Kangkong	
	Bed-3	Nolkhol + Coriander leaf	Stem Amaranth	Okra
	Bed-4	Cauliflower + Spinach	Okra	Red amaranth
	Bed-5	Radish + Red amaranth	Stem Amaranth	Red amaranth
Trellis		-	-	Ribbed gourd /Snake gourd
Non-fruit trees		-	Sponge gourd/Yam	Sponge gourd/Yam
Pond/ditch slope		Bottle gourd/Sweet gourd	Bitter gourd	
Nearby homestead		Tomato+ Red amaranth	Bottle gourd	

b) Agro-forestry system: Well-planned agroforestry system was quite impossible in the locality. Under such situation, the unproductive and naturally grown fruit trees were cut down and pit were prepared

for supplied saplings. For planting BARI Malta-1, pit was prepared by rising the land where in some cases one meter and others 0.5 meter high from ground level with 1 to 1.5-meter width. Papaya and Drumstick plant were planted in the base of the house and homestead boundary to protect the saplings from the wind as well as waterlogging condition. One (01) farmer from small categories in Noakhali, had been modified his ten decimals of land near homestead for planting BARI Malta-1 (total 10 plants) and raised the boundary for planting BARI Mango-11 (03 plants), BARI Mango-4 (02 plants), and Green lady papaya variety (04 plants). Finally, the inter space (1 dec) of the orchard outer side (near village road) was used to produce chili seedlings during *Rabi* season. Moreover, onion (02 dec), Tomato (02 dec) and cauliflower (02 dec) were cultivated. On the other hand, dry Water hyacinth was used as mulch during dry season. Besides mulch, one small hole at the end of the plastic container (Five liters) filled with water was hanged by stick near the saplings (Mango) base for supplying water during dry season which was filled again as became empty. Fertilizer was applied based on fruit trees age that prescribed by Krishi Projukti Hatboi, 2018. Some farmers (one from small and other from marginal categories farm) in Noakhali, made one foot high and 2 feet wide pit near the base of the unproductive trees and cultivated ridge gourd and Snake gourd.

Table 2.13.1.3. Management Practices of different kinds of crops production in orchard as agroforestry system at FSRD site, Noakhali during the year of 2020-21.

Crops and Variety	Seedling's age (days)	Management factors			
		Spacing (cm)	Transplanting date	Fertilizer doses (N-P-K-S-Zn kg/ha)	Last Harvesting Date
Chilli* (Debgiri)	24 to 30	Broadcasted (last week of Oct 20) and raised seedlings were sold (last week of Nov. to first week of Dec.2020)			
Tomato (BARI Tomato-14, BARI Tomato-15)	24-26	60X40	12 Nov. 20	138-40-110-16-1.8	19 Feb. 21
Onion (BARI Paj-1)	40 to 42	15X10	20 Dec. 20	110-44-75-20-0	30 Mar. 21
Cauliflower (Snow White)	24 to 26	60X45	15 Nov. 20	100-53-166-20-0	02 Feb. 21

Moreover, potato yam was distributed among all the farmers in the FSRD sites. In addition, chewing type Sugarcane was distributed among the farmers at FSRD site, Jamla, Dumki under Patuakhali district. Coconut is common fruit in coastal region. Almost in every homestead have three to seven (03 to 07) coconut trees. Generally, farmers earned considerable amount of money by selling tender and mature coconut situated in their homestead areas. Farmers are getting frustrated due to rat infestation that causing destroyed tender coconuts in every year. Under such situation, sheet metal rat guard technique was undertaken at FSRD site in Jamla, Dumki, Patuakhali during November, 2020. For this activity, thirty (30) fruit bearing coconut plants under eight (08) farmers were selected. Before setting up the metal sheet, the plants were cleaned, shoots of nearby plants were removed to make six (06) feet free space around each coconut plant. Finally, it was ensured that there was no rodent in the selected plants. Afterwards, three (03) feet wide metal sheet was banded around the trunk (the circumference of the plants and along with extra two inches) at above 06 feet from base of the coconut plant. Each metal sheet costs only TK. 200 to 250 only.

c) Summer Tomato Production in the highlands adjacent to homestead at FSRD site, Noakhali: Summer Tomato was cultivated among four (04) farmers (two from medium, one from small and one from marginal group) during *Kharif* season of 2020 where the unit plot size was three (03) decimals. Despite lands, BARI Hybrid Summer Tomato-8 was used as planting materials in all cases. Fertilizer was applied based on Fertilizer Recommendation Guide (FRG), 2018. The agronomic data were presented in the tabular format (Table 2.13.1.4.).

Table 2.13.1.4. Agronomic practices of Summer Tomato Production at FSRD site, Subarnachar, Noakhali during *Kharif* season of 2020

Tomato Varieties	Seedling age (Days)	Spacing (cm)	Date of Transplanting	Fertilizer doses (N-P-K-S-Zn Kg/ha)	Date of Harvesting
BARI Hybrid Summer Tomato-8	24 to 26	60 X 40	24 to 26 June 2020	210-105-150-13-2.7	08 Aug. to 12 Oct 2020

d) Movable seedbed for winter vegetables seedlings Production in the highlands adjacent to homestead at FSRD site, Subarnachar, Noakhali: After intervention, probably farmers have been more intending to cultivate vegetables on their high lands or modified land adjacent to homestead than ever before. Meanwhile, lack of early seedlings and supply of quality seedlings had proven as the major constraints for winter vegetables production in the coastal saline areas of Noakhali during defining recommendation domain. In addition, farmers incapacitated to install permanent structure for seedlings production due to versatile uses of accessible small-scaled high lands, land ownership pattern diversifying (sharecropper or tenant farmers), delaying cessation of the monsoonal rainfall and water stagnancy during late *Kharif II* season. Such ecosystem, often called for contemporaneous kind of seedlings production unit that should be portable or moveable. Afterwards, the scientist of Noakhali site with close supervision of the CSO, OFRD has developed a seedbed. Finally, it was established as demonstration at field conditions by the concerned scientist during September, 2019 which was replicated in the following year. In this year (2020), two seedbeds were established and compared with the traditional seedbeds used elsewhere at Subarnachar upazilla. Initially last year, only Tomato seedlings were produced in such type of seedbed whereas four types of crops such as cabbage, cauliflower, broccoli, and Tomato were selected for seedlings production. Moreover, cabbage and cauliflower seedlings were established in first seedbed during last week of September, 2020 and total amount of seeds required were 35 gm (Cabbage-10 g, Cauliflower-20 g and Tomato-5g). In case of second seedbed, Cabbage (10 g), cauliflower (10 g), broccoli (10 g) and Tomato (5 g) were used to raise seedlings during 27 September, 2020. The quality seedlings (age 20 to 22 days) were distributed among the cooperative and non-cooperative farmers during field day and major portion was marketed by the respective farmer. The description of the movable or potable seedbed was given below-

Table 2.13.1.5. Description of movable seedbed established at medium high land adjacent to homestead areas at FSRD site, Noakhali during late *Kharif II* season of 2020

Materials used	Description of the seedbed
• Bamboo (27 feet long and 2 pcs) • Muli bamboo (9 feet long and 6 pcs) • Net (5 feet width and 10 feet long with 4"X4" mash) • Polyethene (5 feet width and 10 feet long and 80 to 100 mm) • Rope, Nail etc. • Vermicompost (20 Kg) • Coco dust (80 Kg) • Straw (50 Kg) • Jute bag • Fungicide (Provax 200 WP) • Seeds (Respected crops) • Insecticides (for sucking types of insects) • Root promoting hormone (Rooton)	The seedbed was established in a sunny place where north-south opened alignment was used to minimizing shade and for keeping cool from extra heating through better air circulation. It was four (05) ft wide and eight (8) ft long. Initially, four-bamboo lath (5.5 ft long) was installed in the outer four side of the measured seedbed. Then, the two bamboo laths (six feet) were installed in such a way that each bamboo lath (six feet) was arrayed in the middle position of the two-bamboo lath (5.5 ft) in breadth direction. Also, the lower part of all bamboo laths was buried (0.5 ft) at below the ground. Afterwards, three light bamboo laths (9 ft) were used to keep the structure strong and rigid. In this case, upper ends of two bamboo laths (5.5 ft long) were tied up together by rope with both ends of each nine feet long bamboo lath for connected one-another. Similarly, other bamboo laths (two 5.5 ft and two 6 ft) were tied up with rest of the two nine ft long bamboo laths. Finally, boat-roof shaped roof was prepared where net (6 ft width and 10 ft long with 4"X4" mash) was tied up together with all possible place of the roof by rope. Afterwards, a flat base was prepared (above 2 ft from the ground level) by splitting portion of the bamboo. The distance of the flat base from roof was 3 feet from the corner and 3.5 ft from the middle of roof. After that the flat base was covered by 6 ft width and 8 ft long Polythene sheet (thickness 05 Mils) for constraining any sort of outflow or external damage. Preparation of seedbed media was given below- • Composed or wet straw (20 Kg) was distributed just above the plastic covered flat base for heaping up two inches layer. Before using the straw, fungicide or Trichoderma containing organic pesticides should be applied. • Afterwards, composed coco-dust (20 Kg) and vermicompost (15 Kg) was thoroughly mixed up. Major portion (30 Kg) of this mixture was broadcasted all over the straw layer randomly with the help of the hand. The mixture layer was kept 4 to 5 inch in height and the surface was leveled by the piece of flat wood (8 inches long and 6 inches wide). • Then, Provex 200 WP (2 gm per liter water) was applied for controlling soil borne pathogen. After two days of applying Provex, root promoting

Materials used	Description of the seedbed
	hormone (Rooton @ 15 gm) was broadcasted equally. At last, seeds (treated by Provax 200 WP) were sowed in solid line where rows (row-to-row distance two inch) were oriented in north-south direction.

e) Vegetable and species production in highlands and other places adjacent to homestead at FSRD site, Noakhali: After cultivation of summer Tomato, the existing structure were used to produce early winter season vegetable production in the year among all the farmers. In this case, Cole crops such as cauliflower, cabbage and broccoli were planted under the shade during 20 to 23 October 2020. It is notable that, winter vegetable production in this area started from last week of November to mid-December, depends on the rainfalls. In such cases, seedlings produced from moveable seedbed were used for planting. Moreover, five (05) farmers showed their interest to cultivate winter vegetables in their adjacent lands to homestead (2020-2021). More farmers are willing to grow vegetables because of supply of quality seedlings from moveable seedbed and rainfall stop after first week of November 2020. Fertilizer was applied based on Fertilizer Recommendation Guide (FRG), 2018.

Table 2.13.1.6. Winter vegetables production at FSRD site, Subarnachar, Noakhali during *Rabi* and *Kharif* season of 2020-2021

Crops and varieties	Place of cultivation	Seedling's age (days)	Spacing (cm)	Date of transplanting	Date of Harvesting
Cabbage (Atlas 70), Cauliflower (Snow white), Broccoli (Premium)	Under the shade of summer Tomato	24 to 26	Cole crops: 60 cm X 45 cm Tomato: 60 cm X 40 cm	19-24 Oct2020	22 to 29 Dec. 2020
Cabbage (Atlas 70), Cauliflower (Snow white), Tomato (BARI Tomato-21)	Modified land near homestead	25 to 27		29 to 31 Oct2020	12 to 19 Jan. 21 (Cole crops) 15 Jan. to 19 Feb. 21 (Tomato)
Bitter gourd (Tia)	Using the shade as trellis	18 to 22	Pit was made 1.5 m interval	22 Jan.2021	28 Feb. to 8 Apr. 2021
Snake gourd (BARI Chichinga-1)				15 Apr. 2021	Last week of Jun. 2021

One farmer modified low land (adjacent to the homestead) for vegetables production which was used to grow T. Aman (most of the time damaged due to high rainfall during maturation time) and remained fallow during *Rabi* season due to high moisture. "Sorjan method" was partially followed for modification of the land.

Table 2.13.1.7. Cropping scheme for modified land of farmer at FSRD Site, Noakhali

On the top of high bed	Vegetables	<i>Rabi</i>	Tomato/ Chilli/Onion
		<i>Kharif I</i>	Stem Amaranth/Okra/Brinjal/Indian Spinach
		<i>Kharif II</i>	Stem Amaranth/Okra/Brinjal/Indian Spinach
	Fruits		Papaya/Mango/Malta/Guava/Drumstick
On rim and slopes of the high beds	Vegetables	<i>Rabi</i>	Bottle gourd/Country bean
		<i>Kharif I</i>	Bitter gourd/Ash gourd
		<i>Kharif II</i>	Snake gourd/Bottle gourd/ Summer Country bean

Moreover, two (02) farmers were cultivating creeper vegetables by utilizing roadside fallow areas (average 02.40 dec) adjacent to their homestead. Under such condition, sack method and raised pit method were followed. In sack method, the plastic sacks (02 ft long and 1.5 ft breadth with 2.5 ft circumference) were filled with soil, sands and vermicompost/FYM at the 1:1:1 ratio. Although, the sacks were filled with above mentioned mixture but at the center there was a column of broken bricks which allowed the water to pass to all parts of the sack for growing plants from the sides as well as the top. On the other hand, particular portion of lands were raised enough (03 to 04 ft) to avoid water stagnation condition for preparing pit (1.5-meter interval). Furthermore, FYM/vermicompost/composed Water hyacinth were placed at the top of the raised portion for establishing creeper vegetables seedlings. Trellis was made to support the vegetables. During the *Rabi* season, Bottle gourd was transplanted on 22 November, 2020. Twenty (20) days old seedlings of Bitter gourd were transplanted on 17 February, 2021 for *Kharif* season production.

All the farmers were encouraged for onion production in their lands located near the homestead areas by supplying seedlings and bulbs of BARI Piaj-1. It was also suggested that the land would be at least one (01) dec. In such land areas, more than 2500 seedlings could be planted by following 15 cm X 10 cm spacing. The average land size was 1.3 dec and transplanting was done on 20 to 24 December, 2020 where the seedlings age was 42 to 46 days. Most of the cases, harvesting was completed within first week of April, 2021.

f) Vegetable production nearby homestead at FSRD site, Patuakhali: Most of the medium and small farmer of the FSRD site, Jamla, Dumki, Patuakhali has some places nearby homestead. They use these spaces in Sorjan and Raised bed vegetable production round the year or for a season only.

Sorjan System of Vegetable Cultivation: “Modified Sorjan model” was constructed with a piece of land having 12 m long and 11 m width which depends on farmers existing lands and resources. Alternate rows of ridges and furrows were constructed. The beds were high enough, so that the upland crops will not be flooded. During the preparation of the beds, at first 10-15cm of the soil from the top was scratched which latter piled at the edge of the field. After preparation of the beds, the soil was placed on the top of the beds to make the beds at least 1m (3 feet) high. A trench in between two beds was about 10 feet X 6 feet X 4 feet. Thus, three (3) beds and simultaneously 02 trenches were prepared. Moreover, the slopes of the beds were levelled by the spade. Size of the beds was varied according to the size of the field and the level of monsoon flooding. The top of the high beds was at least 2 feet or 60 cm above the flood level and 15 feet wide. Selection of crops depends on the size of Sorjan, farmers preference and demand of the local market. Crops found most suitable and profitable in the region are listed below-

Table 2.13.1.8. Cropping scheme for Sorjan system at FSRD Site, Patuakhali

On the top of high bed	a) Vegetables	Knolkhol, Red amaranth, Coriander, Country bean, Yard long bean,
	b) Fruits	Papaya, Lemons, Melons, Watermelon
On rim and slops of the high beds	Vegetables	Bottle gourd, Sweet gourd
Sink/furrows	Seasonal fish	

Furthermore, a farmer having lands for constructing Sorjan beds during March 2019 then BARI Lau-4 seeds were planted during April in the beds. Afterwards, Sweet gourd was planted during September and Red amaranth during November, 2020. The total size of the plot was 0.12 ha. Previously this land was used for T. Aman rice cultivation. Seeds of different vegetables and fertilizers were supplied to the farmers. Intercultural operation and management practices were done by the farmers following recommended practices prescribed by Krishi Projukti Hatboi, 2018.

Table 2.13.1.9. Agronomic practices for different *Rabi* and *Kharif* vegetables production in Sorjan bed

Management factors	Kharif	Rabi
Crops	Bottle gourd	Sweet gourd + Red amaranth
Variety	BARI Lau-4	Bengal Sweet+ BARI Lalshak-1
Sowing/ Transplanting date	3 rd week of April	2 nd week of September + 1 st Week of November
Harvesting date	August to October	December-January and December

Raised Bed System of Vegetable Cultivation: In this system, constructing ridges with one (01) m wide and two (02) m furrow in between two (02) ridges which resulted 35 ridges (100 m long) per hectare. Pits for the respected crops were prepared at two (02) m apart on the top of the ridges where trellis were needed to support the crop and fruits. After harvesting of the raised bed crops, ridges could be easily labeled for next crops production. Cucurbit crop was grown in *Kharif* whereas Red amaranth, Coriander leaf and Nolkhol were produced in *Rabi* season in raised bed system among medium and small farmers.

2.13.2. Crops sector

a) On-Farm Verification Trials: Improved varieties of different *Rabi* season crops had evaluated during the year of 2020-21. cropping season where the data collection processes were conformed to the following guidelines:

- Agronomic data required from each trial identified carefully.

- All data recorded in a permanent field book kept.
- Observations and opinions of the farmers noted for increased knowledge of the farming system and changes in research emphasis.

Different crops were harvested when the crops became in physiological maturity stage. One square meter quadrats used to sample the three places selected randomly from the middle area of each plot to avoid border effects. Nearby farmers' managed plots were taken in consideration to compare the yield of the HYVs with locally grown varieties. Economic analysis was done according to the crops.

Table 2.13.2.1. Different On-Farm Verification Trials at selected farmers field at FSRD site, Patuakhali under coastal ecosystem during *Rabi* season of 2020-21

Farm Categories, No. and Av. Plot size (dec)	Name of the Crops	Varieties	Sowing method	Date of sowing	Date of harvesting
04 Medium-30 dec	Groundnut	BARI Chinabadam-8	Line: 30 cm X 15 cm	14 January, 2021	12 May, 2021
05 Small-22 dec					
01 Medium- 35 dec	Maize	BHM-9	Line: 60 cm X 20 cm	15 January, 2021	12 to 14 May, 2020
01 Small-30dec					
04 Medium-30 dec	Sunflower	BARI Surjamukhi-2	Line: 50 cm X 25 cm	02 to 06 January 2021	14 to 17 April, 2021
05 Small-30 dec					
02 Small-80 dec	Mung bean	BARI Mung-6 BARI Mung- 8	Line: 25 cm X 2-3 cm By BPTOS	21 January 2021	21 to 22 April, 2021
03 Medium-120 dec					
02 Medium-33 dec	Grass pea	BARI Khesari-2	Relay with T. Aman	20 November, 2020	13 March, 2021
02 Small-40 dec					
02 Marginal-35dec	Cowpea	BARI Cowpea-1	Line: 40 cm X 10 cm by PTOS	16 January, 2021	02 April, 2021
03 Small-30 dec					
01 Small-30 dec	Chilli	BARI Morich-1	Line: 50 cm X 40 cm	20 December, 2020	13 to 27 April, 2021
01 Medium-36 dec					

Table 2.13.2.2. Different On-Farm Verification Trials at selected farmers field at FSRD site, Noakhali under coastal ecosystem during *Rabi* season of 2020-21

Farm Categories (No.) and Av. Plot size (dec)	Name of the Crops	Varieties	Sowing method	Date of sowing	Date of harvesting
03 Marginal-6 dec	Potato	BARI Alu-72	Line: 60cm × 25cm Using Water hyacinth as mulch	12 to 17 December 2020	11 to 17 March, 2021
04 Small-12 dec					
03 Medium-14 dec					
03 Marginal-15 dec	Ground nut	Dhaka-1	Line: 30 cm X 15 cm	5 to 8 January 2021	27 to 29 April, 2021
03 Small-23 dec					
03 Medium-20dec					
03 Medium-180 dec	Soybean	BARI Soybean-5	Line: 25 cm X 2-3 cm By BPTOS	7 to 17 January 2021	14 to 22 April, 2021
04 Small-120 dec					
03 Marginal-100 dec					
03 Marginal-20 dec	Mungbean	BARI Mung-6	Line: 25 cm X 2-3 cm By BPTOS	26 January to 2 February, 2021	5 to 9 March, 2021
02 Small-45 dec					
02 Medium-60dec					
03 Marginal-20 dec	Cowpea	BARI Felon-1	Line: 25 cm X 2-3 cm By BPTOS	15 to 17 January 2021	11 to 19 May, 2021
02 Small-40 dec					
02 Medium-50dec					
02 Medium-125 dec	Sunflower	BARI Surjomuki-3	Line: 50 cm X 25 cm	8 to 17 January 2021	4 to 12 May, 2021
01 Marginal-20 dec					
02 Small-20 dec	Proso millet	BARI Cheena-1	Broadcasting	7 to 10 January 2021	02 to 05 April, 2021
01 Medium-50dec					
01 Medium-70dec	Mustard	BARI Sharisha-14	Broadcasting	30 December 2021	12 March, 2021

b) Integrated Plant Nutrition System and Use of Sex pheromone in Watermelon cultivation: Plant Nutrition System (Faisal *et al.*, 2011) and Integrated Pest Management approaches such as Sex Pheromone trap for Cucurbit fruit fly, collection and destruction of rotten fruits, yellow and white sticky trap for piercing and sucking type insect, Biopesticides (Ecomec, Biotrine) for mites and other sucking type insects, Biofungicide (Bio-darma) for soil born fungus were applied in watermelon production

during 2020-2021 at farmers' fields in FSRD site, Subarnachar, Noakhali. Moreover, average cultivating areas were correspondingly decreased, and farmers moved to other cash crops cultivation such as soybean, Mungbean and Cowpea. However, seedlings were produced through using polybag (4"X5") for the better crop production in such conditions. In the last year of the project (2020), only five farmers decided to grow watermelon and the seedlings were raised through polybag (04 farmers) and seedlings tray (01 farmer).

Table 2.13.2.3. Management practices followed by the cooperative farmers in watermelon production at FSRD site, Subarnachar, Noakhali during the year of 2020-21.

Varieties	IPNS for HYG (N-P-K-S-Zn-B Kg ha ⁻¹ + Cowdung tha ⁻¹)	Sowing/ Transplanting date	Date of establishing pheromone trap	Date of Harvesting
Glory, Sugar Baby, Jumbo, Sweet Jumbo, Glory Jumbo	61-29-11-8.7- 1.2-1.2-8	15 December 2020**	8-9 January 2021**	26 March to 11 April, 2021
		8 to 15 January 2020	4 to 10 February, 2021	15 to 25 April, 2021

*Seed was directing sowing on the pit.

** one medium farmer producing seedlings using seedling trays.

c) Participatory Variety Selection (PVS) of Aus Rice: During *Kharif I* season (2020) Participatory Variety Selection (PVS) trials of Aus rice was conducted at FSRD site, Noakhali. On the other hand, farmers of FSRD site, Patuakhali usually do not cultivate Aus rice. The following are the steps followed in general for the entire Researcher-led On-farm Participatory Variety Selection trial at FSRD site, Subarnachar, Noakhali.

- **Selection of treatments:** The numbers of the treatments depend on the amount of particular crop varieties/ lines/cultivar seeds available from BRRI and BINA.
- **Experimental design:** The randomized complete block design (RCBD) was used. The basic unit of replication was a participating farmer at different sites.
- **Plot size:** The plot size was varied according to the available lands of the respected farmers.
- **Field operations:** All field operations were done according to “Adhunik Dhaner Chash (18th Ed.)”.

Table 2.13.2.4. Crop management practices in the Researcher-led Participatory Variety Selection (RPVS) Trials at on-farm condition during *Kharif* season of 2020

Location	Farm Categories and No.	Av. Plot size (dec)	Treatments	Sowing Date	Fertilizers dose (N-P-K-S-Zn Kgha ⁻¹)	Date of harvesting
Noakhali	Marginal (03)	65 dec	BR26, BRRI dhan48, BRRI dhan83, BRRI dhan85, Binadhan-19, Hydra	19 to 25 May, 2020	69-11-38-7- 1.9	6 to 15 August, 2020
	Small (02)	100 dec				
	Medium (01)	150 dec				
Patuakhali	Medium (02)	50 dec	BRRI dhan48	15 to 20 May, 2020	61-14-34-6-2	14 to 16 August, 2020
	Small (03)	67 dec				

d) Production Program of Green Manuring Crops (Noakhali): *Sesbania rostrata* was used as green manuring crops among eight (08) farmers field.

Table 2.13.2.5. Agronomic practices of green manuring crop at FSRD site during *Kharif* season, 2021

Farm Categories	Number of Farmers	Average plot size (dec)	Seed rate (Kgha ⁻¹)	Sowing Date	Date of incorporation
Marginal	01	50	50	20 to 22 May, 2021	12 to 18 July, 2021
Small	03				
Medium	04				

e) Land based T. Aman varieties production for sustainable cropping patterns: Farmers usually cultivated Sharna and BRRI dhan40 in Noakhali whereas farmers of Patuakhali cultivated Sadamota, Swarna, etc. where they obtained lower level of yield due to poor management practices. On the other hand, suitability of the land for the varieties were entirely ignored by the farmers.

Table 2.13.2.6. Agronomic practices of T. Aman production at FSRD site, Noakhali during *Kharif II* season

Varieties	Farm Categories (No.)	Av. Plot size (dec)	Date of transplanting	Date of harvesting
BR23	Marginal (01)	75 dec	20 to 24 August, 2020	14 to 19 December, 2020
	Small (02)	110 dec		
	Medium (01)	80 dec		
BRRI dhan52	Marginal (03) *	95 dec	18 to 20 August, 2020	8 to 14 December 2020
	Small (03)	113 dec		
	Medium (04)	124 dec		
BRRI dhan87	Medium (03)	92 dec	18 to 20 August, 2020	24 to 27 November, 2020
	Small (01)	50 dec		

*One marginal farmer rent in 51 dec

Table 2.13.2.7. Agronomic practices of T. Aman production at FSRD site, Patuakhali during *Kharif II* season of 2020

Varieties	Farm Categories (No.)	Av. Plot size (dec)	Date of transplanting	Date of harvesting
BR23	Small (04)	140 dec	20 to 23 August	18 to 21 December
BRRI dhan52	Marginal (02)	90 dec		
BRRI dhan76	Medium (02)	100 dec	22 to 24 August	9 to 12 December
BRRI dhan49	Medium (02)	62 dec	21 to 25 August	18 to 23 December

f) Quality seed production of Soybean in *Kharif II* season: Trail was conducted at FSRD site, Noakhali during late *Kharif II* season of 2020 (three farmers) and 2020-2021 (three farmers). All fertilizers were applied during final land preparation as 50% of the recommended doses (Kg ha^{-1} of N-P-K-S-Zn-B) and Bio-fertilizer (*BARI RGM-901*) at the rate of 1.2 Kg ha^{-1} .

Table 2.13.2.8. Agronomic practices followed in Quality seed production of Soybean during late *Kharif II* season for upcoming *Rabi* season at FSRD site, West Al-Amin, Noakhali

Av. Plot size (dec)	Seed rate (Kg ha^{-1})	Fertilizers doses (N-P-K-S-Zn-B-Mg Kg ha^{-1})	Spacing (cm)	Date of sowing	Date of Harvesting
19	55	12-20-22-5-2.4-1.3-5	Line: 40 cm X 5 cm	25 August, 2020	15 December 2020

g) Cropping Pattern:

Existing CP: Groundnut (Dhaka-1) – Fallow - T. Aman (Sharna)

Improved CP: Groundnut (Dhaka-1)-T. Aus (Binadhan-19)-T. Aman (BRRI dhan87)

Replication: Three dispersed farmers were treated as replication.

Unit plot size: 20 dec for each of existing and improved cropping pattern

Analysis: Yield of each crop was converted to rice REY for comparing the system productivity.

Table 2.13.2.9. Crop managements of improved and existing cropping pattern at FSRD site, West Al-Amin Subarnachar, Noakhali

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Groundnut	T. Aus	T. Aman	Groundnut	Fallow	T. Aman
Variety	Dhaka-1	Binadhan-19	BRRIdhan87	Dhaka-1	-	Sharna
Date sowing/ Transplanting	22-24/12/20	18-22/5/20	18-19/8/20	22-24/12/20		16-22/8/20
Seed rate ((Kg ha ⁻¹))	110	40	40	120	-	42
Spacing (cm)	30×15	20×15	25×15	Randomly	-	Randomly
Fertilizer dose (N-P-K-S-Zn-B Kg ha ⁻¹)	12-32-42-54-0-2	69-11-38-7-1.9-0	69-22-24-5-4-0	20-25-15-0-0-0	-	80-18-20-0-0-0
Date of harvesting	18-22/4/21	8-11/8/20	23-25/11/20	19-23/4/21		5-9/12/20

Existing CP: Soybean (Shohag)-Fallow-T. Aman (Sharna/BRRIdhan52)

Improved CP: Soybean (BARI Soybean-6)-T. Aus (BRRIdhan85)-T. Aman (BRRIdhan52)

Replication: Three dispersed farmers were treated as replication.

Unit plot size: 20 dec for each of existing and improved cropping pattern

Analysis: Yield of each crop was converted to rice REY for comparing the system productivity.

Table 2.13.2.10. Crop managements of improved and existing cropping pattern at FSRD site, West Al-Amin Subarnachar, Noakhali

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Soybean	T. Aus	T. Aman	Soybean	Fallow	T. Aman
Variety	BARI Soybean-6	BRRIdhan85	BRRIdhan52	Shohag	-	Sharna
Date sowing/ Transplanting	5-12/01/21	22-25/5/20	24-29/8/20	8-12/01/21		20-25/8/20
Seed rate ((Kg ha ⁻¹))	45	40	40	55	-	42
Spacing (cm)	25×2	20×15	25×15	Broadcasting	-	Randomly
Fertilizer dose (N-P-K-S-Zn-B Kg ha ⁻¹)	12-20-22-5-24-1.3	69-11-38-7-1.9-0	69-22-24-5-4-0	20-15-10-0-0-0	-	80-18-20-0-0-0
Date of harvesting	13-17/4/21			15-18/4/21		10-13/12/20

Improved CP: Proso millet (BARI Cheena-1) - Green manure - T. Aman (BR23)

Existing CP: Fallow - Fallow - T. Aman (Sharna)

Replication: Three dispersed farmers were treated as replication.

Unit plot size: 20 dec for each of existing and improved cropping pattern

Analysis: Yield of each crop was converted to rice REY for comparing the system productivity.

Table 2.13.2.11. Crop managements of improved and existing cropping pattern at FSRD site, West Al-Amin Subarnachar, Noakhali

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Proso Millet	Green Manure	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Cheena-1	<i>Sesbania rostrata</i>	BR23	-	-	Sharna
Transplanting/ sowing Date	3-5/01/21	18-19/4/20	23-25/8/20	-	-	20-22/8/20
Seed rate ((Kg ha ⁻¹))	20	38	40	-	-	42
Date of incorporation	-	9-15/6/20	-	-	-	-
Spacing (cm)	Broadcasted	Broadcasted	25×15	-	-	Randomly
Fertilizer dose (N-P-K-S-Zn Kg ha ⁻¹)	54-24-32-10-1	-	80-19-33-9-4	-	-	80-18-20-0-0
Date of harvesting	29-31/3/21	-	17-23/12/20	-	-	11-14/12/20

Improved CP: Potato (BARI Alu-72) - T. Aus (BARI Mung-6) -T. Aman (BRRI dhan49)

Existing CP: Mungbean (BARI Mung-6) - Fallow - T. Aman (Moulata)

Replication: Three dispersed farmers were treated as replication.

Unit plot size: 10 dec for each of existing and improved cropping pattern

Analysis: Yield of each crop was converted to rice REY for comparing the system productivity.

Table 2.13.2.12. Crop managements of improved and existing cropping pattern at FSRD site, Patuakhali

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Mungbean	Fallow	T. Aman	Potato	Mungbean	T. Aman
Variety	BARI Mung-6	-	Moulata	BARI Alu-73	BARI Mung-6	BRRI dhan52
Transplanting/ sowing Date	25/1/21		26/8/20	16/12/21	01/3/20	25/8/20
Seed rate ((Kg ha ⁻¹))	40	-	50	1800	40	40
Spacing (cm)	30×cont.	-	Random	60×25	30×cont.	20×20
Fertilizer dose (N-P-K-S-Zn Kg ha ⁻¹)	22-28-22-10-1.8-1	-	110-30-40	150-45-110-16-2.8-1	22-28-22-10-1.8-1	80-28-45-11-3.5-1
Irrigation (DAS)	-	-	-	25 and 45	-	-
Date of harvesting	20-15/4/21	-	20/12/20	26/02/20	10-15/5/20	09/12/20

Improved CP: Sunflower (BARI Surjomukhi-2)- T. Aus (BRRI dhan48)-T. Aman (BRRI dhan52)

Existing CP: Grass pea (Local)-Fallow - T. Aman (Moulata)

Replication: Three dispersed farmers were treated as replication.

Unit plot size: 10 dec for each of existing and improved cropping pattern

Analysis: Yield of each crop was converted to rice REY for comparing the system productivity.

Table 2.13.2.13. Crop managements of improved and existing cropping pattern at FSRD site, Patuakhali

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Grass pea	Fallow	T. Aman	Sunflower	T. Aus	T. Aman
Variety	Local	Fallow	Moulata	BARI Surjomukhi-2	BRRI dhan48	BRRI dhan52
Transplanting/ sowing Date	10/11/20		8/9/20	5/01/21	02/6/20	13/9/20
Seed rate ((Kg ha ⁻¹))	25	-	50	13	40	40
Spacing (cm)	Continuous	-	Randomly	50×25	20×15	25×15
Fertilizer dose (N-P-K-S-Zn-B Kg ha ⁻¹)	13-8-15-0-0	-	110-40-60-25	90-30-75-30-5-5	70-18-36-10-10	90-20-45-10-10
Date of harvesting	24/3/21		26/12/20	13/04/20	06/9/20	29/12/20

h) Distribution of Plastic drum for seed preservation (Noakhali): Most of the farmers of coastal areas of Noakhali enabled to store seeds of crops due to economic conditions. Moreover, some farmers (medium group) farmers kept the seeds for next season in their household by traditional storage structures like Dole, Berh, Gola, Kuthi, Gunny bag, Motka, etc. These structures are not so durable and functional in providing optimum storage conditions. Keeping in mind, plastic drum along with plastic bags were distributed among the participatory farmers.

i) Introduction of BARI Power Tiller Operated Seeder (PTOS): Mungbean and Sunflower are two emerging crops of southern region. January is the optimum sowing time of these two crops. But January and upwards soil moisture dry out rapidly due to gradual increase of evaporation. So, a vast area has to till in short period. To overcome these situations mechanized sowing of Mungbean and sunflower was introduced among the co-operative farmers of FSRD site, Jamla. Power Tiller Operated Seeder (PTOS)

were used to sow the Mungbean and sunflower seeds. In case of sunflower, bird reaping at maturity stage and head threshing activities are very tedious job. For overcome this limitation, bird reaping device and sunflower thresher was supplied to the farmers that reduces losses of sunflowers. In case of Noakhali, PTOS machine was used to sow soybean, Mungbean and Cowpea in all the on-farm trials and cropping pattern experiments.

2.13.3. Livestock Sector

a) Vaccination program for cattle, Goats, and chickens at FSRD site: Cattle health may be improved through deworming which may make the farmer economically benefitted. More than 7 faeces sample of cattle were selected from different location by the symptomatic parasitic infection and then investigated the parasites through faeces sample analysis for the confirmation. After confirmation of parasitic infestation, the test animal was de-wormed for round worm and liver fluke as per recommendation for the body weight by respected personnel from DLS, Subarnachar, Noakhali and DLS, Dumki, Patuakhali. In the vaccinated group Anthrax Vaccine, FMD vaccine and PPR vaccine were injected as per recommended schedule.

Poultry disease is the main problem faced by the selected farmers in the target areas. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level was conducted at both the FSRD sites under coastal ecosystem. A good number of poultry birds were vaccinated during the project period. In the vaccinated group BCRDV, RDV, Fowl pox Fowl cholera vaccine for chicken; Duck plague and Duck cholera for Duck and pigeon pox vaccine were used as per recommended schedule. Regular contact was done by the facilitator team for providing necessary suggestions to solve their specific problems.

b) Establishment of different kinds of housing for livestock and Poultry: Housing is another problem related to poultry and livestock rearing which was identified during resources inventory survey. Form the result of the report, pigeons, chicken, and Goat rearing housing system were developed and distributed among the mentioned categories (medium, small and marginal).

Table 2.13.3.1. Size of modern housing established at selected farmers homestead areas for livestock and poultry at FSRD site, Subarnachar in Noakhali district

Name of the livestock and poultry	Name of materials used	Size of housing	
		Height	Breadth
Goat	Tin, Plastic Net, Wood	10 feet	6 feet
Pigeon	Wood and Net	16 inches	18 inches
Chicken	Tin, Plastic Net, Wood	6 feet	4 feet

c) Rearing of cattle at FSRD sites under coastal ecosystem: Some farmers engaged in Cow rearing for milk production and most of the produced were intake by the family member and sold a portion to income some extra money. Five farmers fatten their cattle.

d) Poultry Distribution and rearing through supplementary feed and housing management

Poultry Distribution: Almost every participatory household family in both locations keep small flocks of indigenous domestic fowl and Ducks under a backYard management system although indigenous poultry are poor producers of eggs and meat. There has no systematic breeding program and close inbreeding occurs among indigenous stocks. Moreover, to meet the increasing demand of meat new and non-traditional poultry were distributed among the farmers at both the FSRD sites.

Poultry rearing: Systematic rearing system such as feed management, housing management, egg hatching mud pot and vaccination program for chickens and Ducks were done according to plan of activities at both the location for enhanced meat and egg production. In Noakhali site, multistoried hen house was developed where chicks were kept in the upper chamber, mid-aged chicks were kept in the middle chamber and the egg laying and roster were kept in the lower chamber of separated places. Moreover, brooding hen was reserved in the house. Different ages Duck was kept in different chamber.

e) Small-scale pigeon rearing in farmer's household:

Noakhali: In-house pigeon rearing system was introduced in one marginal farmer where five developed pigeon houses (two pair can be kept in one house) was hanged six feet from the floor of empty house. In this case, adult breeding pair was kept in confined area of the room and let them fly within it. Regular two times group feeding with balanced diet was provided for their physical and mental health. Egg laying mud pot with soft cloth was used. Feed was supplied in front of loft in a clean pot during morning 8.00 and evening 6.00 o'clock and after seven days of hatching a mid-2.00 pm extra feeding was provided. Moreover, Oyster shell was always provided as a source of calcium. Clean water pot was provided in front of loft and changed within 24 hours. After 16 to 17 days, the squabs separated from the pigeon pair and feed them by hand until desire body weight gain for selling. Multistoried hen house was developed where chicks kept in the upper chamber and mid aged chicks were kept in the middle chamber whereas the egg laying, and rooster were kept in the lower chamber. Moreover, brooding hen was reserved in the house. Different ages Duck was kept in different chamber.

Patuakhali: The activity was undertaken at the FSRD site Jamla, Dumki, Patuakhali during 2020. Twenty-four pairs of adult pigeon were distributed to 12 farmers (Two pairs to each farmer) during February to June 2020. Local breeds of pigeons were collected from the local market. The routine works of vaccination was followed regularly and natural feeds were fed. Egg, squab production and body weight gain was monitored regularly. Technical supports (feeding and watering management, vaccination etc.) and advice were also given to the farmers. Necessary treatments were also provided as per requirement.

f) Fodder production for cattle at FSRD site, Subarnachar, Noakhali: Fodder production is the main limitation for sustainable livestock production in the saline coastal ecosystem including project intervention area. Under the umbrella of the project, six (06) farmers from different categories (two medium, two small and two marginal farmer) were selected for fodder cultivation and the selected fodder crops are Napier, Sorghum. The average plot size was five (05) dec per farmer. The fertilizers doses were 90-36-45 Kg ha⁻¹ of N-P-K for Napier grass and 94-56-37 Kg ha⁻¹ for Sorghum. Moreover, another three (03) farmers (one from each group) were selected for Phak Chong grass cultivation, and 100 cuttings were distributed among them.

g) Small-scale Vermicompost production at FSRD sites under coastal ecosystem

Noakhali: Ten farmers were primarily selected for small scale Vermicompost production. Two farmers have no livestock, and they are encouraged for produce kitchen waste compost production. Vermicomposting was done in ring method. The ring was made of cement and the size of the rings was 80 cm diameter and 20 cm in height. In outer side of the ring there is a small ring for keeping water which act as barrier and will protect earthworms from ants and other insects. The Cowdung was collected from the shed and left it under the sun (4 to 5 days) with covered by jute bag for partial decompose. Finally, 400 *Eisenia fetida* earthworms added to the ring. The ring was covered with a gunny bag to protect the earthworms from light as earthworms like to feed and stay in a dark light. For protecting from rain and sun, shed made of tin and bamboo was provided among the farmers. The partial decomposed Cowdung in the ring was checked in every 1 to 2 days for water. If needed, some water was added in it from the above of gunny bag. After introduction of earthworms, first lot of Vermicompost was ready after certain times and collected for total production.

Patuakhali: Vermi-compost is an organic fertilizer used to increase soil fertility. This fertilizer can be used in all types of crop fields. Vermi-compost increases the water holding capacity of the soil and increases ventilation. The microbiological functions of the soil increase. As a result, the fertility of the soil increases. The activity was started 2-4 November 2020. Four farmers were included in this activity. To produce Vermicompost 4 feet long, 3 feet wide and 2 feet deep a "Chari" (Sand, brick cobblestone and cement made pot), 250-300 earthworms/pot were supplied to the farmers. A tin shade was also prepared by each farmer and the Chari was placed in it. Then 70 Kg stale rotten Cowdung was kept in Chari and 250 to 300 alive earthworms released in it. To keep the earthworms alive and active, water cannot be given too much in the "Chari", nor can the water be dried again. After a period, the Cowdung was look like tea powder. Then Vermicompost was carefully removed from the "Chari" and run it through a sieve. The earthworms must be re-used for composting by separating the manure.

2.13.4. Fisheries Sector

Maximization of farmer's income through carp poly culture technique at low-cost management in perennial pond: Carp poly culture technology is one sustainable technique which impressed the farmers because of various fish species stays there. In both FSRD sites, carp poly culture system had been applied in three culture period. In Patuakhali site, out of twelve farmers, six farmers have seven effective and culture-able ponds. In Noakhali site, 12 ponds of 12 farmer had been taken for carp poly culture system.

During different three culture period, for pond preparation, partial dikes repairing were completed in both site, Aquatic weed, and undesirable fishes were removed by using man labor and netting in both FSRD. Before three days of fingerlings stocking liming was completed with the rate of 1Kg/dec pond area in both sites. After liming, chemical fertilizers were applied with the rate of urea 200g/dec, TSP 100g/dec, MoP 100g per dec with the rate of 1 Kg-3Kg/dec organic manure for improving primary productivity of pond (Plankton growing). Fingerling's stocking density depends on the sizes of fingerlings.

Sampling: It was done after 15 days of regular intervals to check up fish health, to measure growth rate and to know the feed rate for different pond for both sites. At least five fishes were caught by cast net in each sampling in every fish culture year. The weight was taken by precision weighting balance (measuring range from minimum 1 g to maximum 1Kg) and length was taken by measuring scale.

Harvesting: Partial harvesting was done only for farmers interest in different time for a culture period of each pond. After 7 to 8 months in carp poly culture final harvesting was completed of each pond in both FSRD sites. Different information was recorded into the pond registrars in Patuakhali and Noakhali.

2.13.5. Off-Farm Activities

Schumannianthus dichotoma is popular cultivated species with local names in different regions of Bangladesh, such as Patipata and Pati-jung in Chittagong, Mostak in Noakhali, Pat-bat and Murta in Sylhet and Tangail and Paitrabon in Barishal (Rashid *et al.* 1993; Islam 2005). In Noakhali, a traditional bed mat locally called *Pati (Shitalpati)* was made from *Schumannianthus dichotoma* plant grown at the edges of pond bank under partial shade and prefers clay or clay-loam soil with high moisture. Usually, eight (08) farm families have good numbers of Mostak plants at pond banks where less or no agronomic management practices were observed. Generally, the plant stems are 3-5 m long, and basal diameter is 2-5 cm but in the target farmers' areas it was less than 2 m in height and 1.5 to 2 cm diameter. For this reason, some management practices were undertaken such as fertilizer management and tied up of dichotomously branched stems (4 to 5) to protect from broken due to wind etc. Moreover, different types of color were provided, and an informal training were conducted on the design of pati making.

2.13.5. Follow-up evaluation: Follow-up evaluations are continuously done through continuous monitoring for farming systems, cropping systems and the farmers existing technology. Reasons of change were also monitored along with the farm environment.

Results and Discussion

3.1. Year-round vegetables production system at homestead and adjacent lands to homestead

a) Year-Round Vegetables and Quick Growing Fruit Production in Homestead:

Noakhali: Small category of the farmers is more versatile for niches utilization (06 niches) followed by medium category (05 niches) and marginal farmers are less than four (04) niches. After intervention, farmers from all categories were able to utilize all the niches that fitted on the farmer existing resources. It was evident that the highest amounts of vegetables (502 Kg/year) were produced by the medium farmer followed by small (368 Kg/year) and marginal (303 Kg/year). Moreover, vegetable production was maximum during *Rabi* season in all categories of farmer and production was below 50% in other two season compared to *Rabi* season. Vegetable's production in *Kharif I* season was limited due to high temperature and lack of irrigation facility and sometimes sudden hailstorms. On the other hand, vegetable production in *Kharif II* season was damaged due to high rainfall. In case of medium category,

Kharif II season (123 Kg) was more productive than *Kharif I* season (105.67 Kg). On the other hand, vegetables production was slightly higher in *Kharif I* season compared to *Kharif II* season in both marginal and small categories might be due to inclusion of Okra and Brinjal and other leaf vegetables.

In case of fruit production, all categories have coconut, betel nut and mango plants in their homestead and production was low. However, a few of them have papaya, banana (local) and lemon plants. Quick growing fruit trees such as papaya and drumstick were provided among the beneficiaries depend on the space of the planting saplings. When the three groups of beneficiaries were compared, the households belong to the medium category households produced more fruits (Table 3.1.1.). The fruit production in small category was comparatively higher due to less unproductive trees in the homestead areas which offered to utilize more niches for papaya plantation.

Table 3.1.1. Year-round vegetables and fruits production from different niches in distinct categories of farm households at FSRD site, Noakhali under coastal ecosystem.

Farm category	Spaces		Rabi	Kharif I	Kharif II	AI total production (Kg)	BI total production (Kg)
Marginal (Av. of 04 farmers)	Open Sunny Space	Bed-01	16	7	3	26	129
		Bed-02	18	9	9	36	
		Bed-03	21	10	11	42	
		Bed-04	14	8	8	30	
		Bed-05	19	19	0	38	
	Roof		0	5	3	8	0
	Trellis		12	10	12	34	0
	Shady space		7	0	4	11	0
	Marshy land		0	5	15	20	0
	Unproductive tree		0	10	8	18	0
	Fence		0	2	5	7	0
	Backyard		9	8	5	22	14
	House boundary		7	4	0	11	4
	Total (vegetable)		123	97	83	303	147
	Fruits*		21	39	44	104	50
	Total (Vegetables +Fruits)		144	136	127	407	197
Small (Av. of 04 farmers)	Open Sunny Space	Bed-01	22	8	11	41	140
		Bed-02	16	24	8	48	
		Bed-03	16	17	11	44	
		Bed-04	18	12	3	33	
		Bed-05	14	9	5	28	
	Roof		0	0	10	10	7
	Trellis		16	19	10	45	25
	Shady space		7	5	3	10	0
	Marshy land		0	17	4	26	14
	Unproductive tree		4	9	8	21	0
	Fence		7	2	5	14	0
	Backyard		12	7	9	28	23
	House boundary		12	0	8	20	9
	Total (vegetable)		144	129	95	368	218
	Fruits*		41	64	62	167	89
	Total (Vegetables +Fruits)		185	193	157	535	307
Medium (Av. of 04 farmers)	Open Sunny Space	Bed-01	19	13	8	59	210
		Bed-02	20	17	18	54	
		Bed-03	18	8	24	58	
		Bed-04	19	19	14	62	
		Bed-05	7	22	5	68	
	Roof		0	0	0	0	0
	Trellis		16	23	26	65	28
	Shady space		8	12	7	27	15
	Marshy land		7	6	2	15	0

Farm category	Spaces	Rabi	Kharif I	Kharif II	AI total production (Kg)	BI total production (Kg)
	Unproductive tree	0	3	16	19	0
	Fence	6	8	15	29	0
	Backyard	16	12	7	35	33
	House boundary	0	8	3	11	20
	Total (vegetable)	136	151	145	502	306
	Fruits*	45	67	73	185	105
	Total (Vegetables +Fruits)	181	218	218	617	411

Note: AI= After intervention, BI= Before intervention; *Production from betelnut not included here.

Table 3.1.2. Year-round homestead vegetables and fruits production from different niches along with yearly income from different categories of farmers homestead at FSRD site, Noakhali under coastal ecosystem.

Farm Category	Niches	Before intervention		After intervention		Increment over before intervention	
		Production (Kg)	Income (TK.)	Production (Kg)	Income (TK.)	Production (Kg)	Income (%)
Marginal (Av. of 04 farmers)	Open sunny place	129	235	172	720	33.33	206.38
	Roof top	0	0	8	0	-	-
	Trellis	0	0	34	400	-	-
	Shady place	0	0	11	215	-	-
	Marshy place	0	0	20	150	-	-
	Unproductive place	0	0	18	110	-	-
	Fence	0	0	7	100	-	-
	Backyard	14	150	22	250	57.14	66.67
	House boundary	4	50	11	135	175	170
	Total (Vegetables)	147	435	303	2080	106.12	378.16
	Fruits (other places) *	31	1100	48	1280	54.84	16.36
	Total (Vegetables +Fruits)	178	1535	351	2970	97.19	93.49
Small (Av. of 04 farmers)	Open sunny place	140	300	194	1280	38.57	326.67
	Roof top	7	0	10	120	42.86	-
	Trellis	25	150	45	370	80	146.67
	Shady place	0	0	10	350	-	-
	Marshy place	14	30	26	120	85.71	300
	Unproductive place	0	0	21	90	-	-
	Fence	0	0	14	70	-	-
	Backyard	23	150	28	230	21.74	53.33
	House boundary	9	90	20	100	122.22	11.11
	Total (Vegetables)	218	720	368	2730	68.81	279.17
	Fruits (other places) *	60	1500	89	1795	48.33	19.67
	Total (Vegetables +Fruits)	278	2220	457	4525	64.39	103.83
Medium (Av. of 04 farmers)	Open sunny place	210	740	301	1150	43.33	55.41
	Roof top	0	0	0	0	-	-
	Trellis	28	345	65	510	132.14	47.83
	Shady place	15	130	27	280	80	115.38
	Marshy place	0	0	15	90	-	-
	Unproductive place	0	0	12	80	-	-
	Fence	0	0	22	100	-	-
	Backyard	33	260	35	270	6.06	3.85
	House boundary	20	150	25	210	25	40
	Total (Vegetables)	306	1625	502	2690	64.05	65.54
	Fruits (other places) *	64	1600	103	2055	60.94	18.44
	Total (Vegetables +Fruits)	370	3225	605	4745	63.51	47.13

*Production and income from betelnut included here.

After intervention, vegetables and fruit production were increased as well as income in all categories of farmers. However, farmers existing niches might not be applicable to the “Modified Atkapalia Model”

framework which indicated all the niches were not suitable for all the farmers or even in the same category of the farm households. The model will be fully applicable by means of close supervision including the researchers and extension workers in the newly or partially established farm households at the char areas under coastal ecosystem. Eventually, the resources variations were mirrored from the average vegetables production to average production in each niche across the categories or in the same category. Nevertheless, the most productive unit was open sunny places and minimum in roof top within all farm categories. The average increment over before intervention regarding to production (106.12 Kg) and income (378.16%) was highest in marginal category of farm (Table 3.1.2.) through the average production of vegetables was lower than other categories. Moreover, the lowest increment was found from medium category of farm which might be due to less gap of production in between before and after intervention in case of most productive areas. In case of fruit production, the average fruit production was almost similar between medium and small categories, but the average income increment over before intervention was highest (60.94 Kg) in medium category (Table 3.1.2.). Despite fruits production, income increment in fruits was low due to income of betelnut was included in before intervention income parameter. Finally, the total increment of vegetables and fruits production (97.19 Kg) was observed as highest in marginal category of farm followed by small (64.39 Kg). Despite production, vegetables and fruits combined highest (103.83%) income increment over before intervention was noted in small category.

The quantities of vegetables and fruits consumption, distribution and selling by households in all categories of farmers were significantly increased from before intervention of the “Modified Atkapalia Model”. The consumption Pictures of homestead garden produce represent a daily per capita consumption of vegetables and fruits of 146.5 g for marginal group, 165 g for the small group, and 224 g for the medium households. On an average, Bangladeshi people consume a total of 126 g of vegetables and fruit per capita per day which is far below the minimum recommended daily consumption of 400 g of vegetables and fruits. Moreover, all groups of farmers consumed more than 60% and sold more than 22% of their total vegetables production. From vegetables, the highest total income (TK. 8740 per year) and net income (TK. 5709 per year) were obtained from homestead at medium farmers followed by small farm which was TK. 6640 and TK. 4670 per year per homestead, respectively. In case of fruits, similar trend was observed (Table 3.1.3).

Table 3.1.3. Year-round vegetables and fruits utilization pattern before and after intervention among different categories of farmers at FSRD site, Noakhali under coastal ecosystem.

Farm Category	Description	Before Intervention		After Intervention	
		Vegetables (Kg)	Fruits (Kg)	Vegetables (Kg)	Fruits (Kg)
Marginal (Av. of 04 farmers)	Consumption	108	50	203	84
	Distribution	17	10	25	14
	Selling	22	53	75	54
	Total production	147	115	303	152
	Gross return (TK.)	1771	2615	5140	2825
	Variable cost (TK.)	485	370	1489	875
	Net return (TK.)	1286	1630	3651	1950
Small (Av. of 04 farmers)	Consumption	149	63	226	104
	Distribution	23	16	34	53
	Selling	46	70	108	99
	Total production	218	149	368	256
	Gross return (TK.)	2922	3846	6640	3965
	Variable cost (TK.)	1029	370	1970	1200
	Net return (TK.)	1893	1805	4670	2765
Medium (Av. of 04 farmers)	Consumption	211	80	311	119
	Distribution	32	22	58	44
	Selling	63	67	133	125
	Total production	306	169	502	288
	Gross return (TK.)	3640	4015	8740	4745
	Variable cost (TK.)	1225	490	3031	1280
	Net return (TK.)	2415	2260	5709	3465

Patuakhali: After intervention vegetables and fruits production among five different niches was increased. Vegetable production was maximum during *Rabi* season followed by *Kharif II* season across

all categories of farmers (Table 3.1.4.). Open sunny spaces were the most productive niches whereas pond/ditch slope gave remarkable yield in all groups of farmers. In case of small and medium categories of farm adjacent highlands near homestead plays a vital role for producing vegetables throughout the year. In case of marginal farmers fruits production increased slightly whereas the growth of fruits production in small and medium was quite sharp. Total vegetables and fruit production increased 3 to 4 folds across the farm categories.

Table 3.1.4. Year-round vegetables and fruits production from different niches in different categories of farm households at FSRD site, Jamla, Dumki, Patuakhali under coastal ecosystem.

Farm Category	Spaces		Rabi	Kharif-I	Kharif-II	AI total production (Kg)	BI total production (Kg)
Marginal (Av. of 04 farmers)	Open sunny place	Bed 1	10	4	8	22	10
		Bed 2	13	3	12	28	
		Bed 3	12	6	10	28	
		Bed 4	8	4	10	22	
		Bed 5	9	8	11	28	
	Trellis		7	1	10	18	15
	Non-fruit trees		4	5	5	14	12
	Pond/ditch slope		21	12	9	42	35
	Place nearby homestead		0	0	0	0	0
	Total (Vegetables)		84	43	75	202	62
	Fruit		0	42	0	42	18
	Total (vegetable+ Fruits)		84	75	75	244	80
Small (Av. of 04 farmers)	Open sunny place	Bed 1	12	14	16	42	20
		Bed 2	14	10	11	35	
		Bed 3	17	9	14	40	
		Bed 4	15	12	10	37	
		Bed 5	10	11	14	35	
	Trellis		2	4	20	26	26
	Non-fruit trees		4	2	11	17	16
	Pond/ditch slope		74	32	55	161	42
	Place nearby homestead		57	82	36	175	28
	Total (Vegetables)		205	176	187	568	132
	Fruit		0	63	12	75	22
	Total (vegetable+ Fruits)		205	239	199	643	154
Medium (Av. of 04 farmers)	Open sunny place	Bed 1	10	6	11	27	16
		Bed 2	11	5	8	24	
		Bed 3	10	3	7	20	
		Bed 4	8	2	7	17	
		Bed 5	11	7	5	23	
	Trellis		12	5	15	32	22
	Non-fruit trees		7	4	3	14	14
	Pond/ditch slope		87	0	15	102	45
	Place nearby homestead		62	17	78	157	65
	Total (Vegetables)		218	49	149	416	162
	Fruit		5	82	18	105	20
	Total (vegetable+ Fruits)		223	131	167	521	182

Vegetable and fruit production increased 55% for Marginal, 185% for small and 125% for medium farmers over before intervention of modified Lebukhali model at FSRD site, Jamla, Dumki, Patuakhali (Table 3.1.4. and Table 3.1.5.).

Homestead vegetable production as well as consumption, distribution and selling increased after intervention. Consumption, distribution and selling of vegetables increased about 41%, 0%, 53% for marginal farmer, 121%, 37%, 205% for small farmer and 100%, 40%, 136% for medium farmer respectively over before intervention in FSRD site Jamla, Dumki, Patuakhali (Table 3.1.6.)

Table 3.1.5. Year-round homestead vegetables and fruits production from different niches along with yearly income from different categories of farmers at FSRD site, Patuakhali under coastal ecosystem

Farm Categories	Spaces	Before intervention		After intervention		Income Increment over before intervention (%)
		Production (Kg)	Income (TK.)	Production (Kg)	Income (TK.)	
Marginal (Av. of 04 farmers)	Open sunny place	10	200	128	2560	1180
	Trellis	15	300	18	340	13
	Non-fruit trees	12	240	14	280	17
	Pond/ditch slope	35	700	42	840	20
	Total (Veg)	72	1440	202	4040	181
	Fruit	18	720	31	1240	72
	Total (vegetable+ Fruits)	90	2160	233	5280	144
Small (Av. of 04 farmers)	Open sunny place	20	400	189	3780	845
	Trellis	26	520	26	520	0
	Non-fruit trees	16	320	17	340	6
	Pond/ditch slope	42	840	161	3220	283
	Place nearby homestead	28	560	175	3500	525
	Total (Veg)	132	2640	568	11360	330
	Fruit	22	880	55	2200	150
	Total (vegetable+ Fruits)	154	3520	623	13560	285
Medium (Av. of 04 farmers)	Open sunny place	16	320	111	2220	594
	Trellis	22	440	32	640	45
	Non-fruit trees	14	280	14	280	0
	Pond/ditch slope	45	900	102	2040	127
	Place nearby homestead	65	1300	157	3140	142
	Total (Veg)	162	3240	416	8320	157
	Fruit	20	800	71	2840	255
	Total (vegetable+ Fruits)	182	4040	487	11160	176

Table 3.1.6. Year-round vegetables and fruits utilization pattern before and after intervention among different categories of farmers at FSRD site, Patuakhali under coastal ecosystem.

Farm Category	Description	Before Intervention		After Intervention	
		Vegetables (Kg)	Fruits (Kg)	Vegetables (Kg)	Fruits (Kg)
Marginal (Av. of 04 farmers)	Consumption	25	6	41	12
	Distribution	0	0	0	0
	Selling	47	12	161	19
	Total production	72	18	202	31
	Gross return (TK.)	1440	720	4040	1240
	Variable cost (TK.)	375	0	572	410
	Net return (TK.)	1065	720	3468	830
Small (Av. of 04 farmers)	Consumption	45	7	121	18
	Distribution	12	0	37	2
	Selling	75	15	410	35
	Total production	132	22	568	55
	Gross return (TK.)	2640	880	11360	2200
	Variable cost (TK.)	500	200	1050	567
	Net return (TK.)	2140	680	10310	1633
Medium (Av. of 04 farmers)	Consumption	62	15	124	28
	Distribution	15	5	21	8
	Selling	83	0	271	35
	Total production	162	20	416	71
	Gross return (TK.)	3240	800	8320	2840
	Variable cost (TK.)	500	250	967	600
	Net return (TK.)	2740	550	7353	2240

Family Labour utilization at both the FSRD sites under coastal ecosystem: It has been observed from the Labour utilization pattern of both FSRD site that woman had a good involvement in

intercultural operations, harvesting and a remarkable engagement in cooking. Hundred percent women are employed in cooking in Noakhali whereas in Patuakhali site, 95% women and 5% children are also engaged in cooking (Table 11.37.). Land preparation and fencing was done by male person of the household whereas seed/seedling, sowing and harvesting was also done by them. Most interestingly, marketing was done mainly by male and children of the household where the income mainly goes to the women of the household.

Table 3.1.7. Family labor utilization pattern for homestead vegetable production at FSRD sites of Noakhali and Patuakhali district under coastal ecosystem

Working area	FSRD site, Noakhali			FSRD site, Patuakhali		
	Men (%)	Women (%)	Children (%)	Men (%)	Women (%)	Children (%)
Land preparation	75	15	10	70	25	5
Seed/seedling	35	55	10	25	60	15
Sowing/planting	35	50	15	20	60	20
Fencing	85	10	5	70	15	15
Intercultural operations	35	55	10	30	60	10
Harvesting	15	75	10	20	60	20
Marketing	75	5	20	65	10	25
Cooking	-	100	-	-	95	5

b) Summer Tomato Production in the highlands adjacent to homestead at FSRD site, Noakhali: More than eleven lacs (TK. 11,19,544 ha⁻¹) taka per ha was obtained as gross margin from summer Tomato cultivation, though the initial setting up cost was also high (TK. 10,23,356 ha⁻¹). So far, it could be possible to reduce the cost since the shade subsequently could be used in various extended way such as protection against heavy rainfall for early winter vegetables cultivation, trellis for summer creeper vegetables cultivation and early winter vegetables seedlings production, etc. Moreover, effective management of the shade may be provided a realistic way to use the shade for several years to produce summer Tomato or other high value crops. Because of high economic return from summer Tomato production, medium category farmers manifested their massive interest to expand summer Tomato cultivation areas. However, supply system of improved and quality seeds of summer Tomato varieties during sowing time was felt as significant impediment which may be interrupt them for further expansion.

Table 3.1.8. Average Yield of Summer Tomato variety at selected farmers field adjacent to homestead at FSRD site, Noakhali during *Kharif* season of 2020

Variety	Mean Yield (t ha ⁻¹)	Gross Return (TK. ha ⁻¹)	Total Variable Cost (TK. ha ⁻¹)	Gross Margin (TK. ha ⁻¹)
BARI Hybrid Summer Tomato-8	22.81 (max.=24.87, mini. =20.55)	21,42,900/-	10,23,356/-	11,19,544/-

Note: Price of Summer Tomato = TK. 90 Kg⁻¹

d) Movable seedbed for winter vegetables seedlings Production in the highlands adjacent to homestead at FSRD site, Noakhali: In case of such seedbed, from the seedbed preparation to produce marketable seedlings a total of 35 to 40 days were required. In terms of economic viewpoint, farmers were enabled to attain more than ten thousand taka from each seedbed (08 ft long and 05 ft wide). For attaining feasible income from the seedbed mostly depends on some issues such as appropriate time of seedbed establishment, client choice, diversified crops type with improved varieties, market value of the crop, and weather conditions of that locality. Under the coastal ecosystem, the optimum time for seedbed establishment is on the last week of September. The economic analysis of seedbed for vegetables seedlings was given below-

Table 3.1.9. Economic return from Movable seedbed established at selected farmer field of FSRD site, Subarnachar Upazila, Noakhali during late *Kharif II* season of 2019 and 2020

Sl. No.	Expenditure items	TVC (TK.)	Seedlings (No.)	GR (TK.)	GM (TK.)
1	30 ft long 2 pcs Bamboo (@ TK. 250 per pcs)	500/-	Cabbage-2467pcs Cauliflower-2367 pcs Broccoli-2390 pcs Tomato-683 pcs	14238/-	10283/-
2	15 ft long and 13 pcs Muli bamboo (@ TK. 30 per pcs)	390/-			
3	6.6 ft width and 10 ft long with 4"X4" mash Net (@ TK. 160 per 6.6 ftX32.8ft)	50/-			
4	6 ft width and 10 ft long with thickness 08 Mills (0.008 inches) Polythene sheet-3.5 Yard (@ TK. 45 per Yard) 6 ft width and 8 ft long Polythene with thickness 05 Mills (0.005 inches) - 3Yard (@ TK. 40 per Yard)	265/-			
5	250 g Rope (@ TK. 100 per Kg), 6 ft width and 9 ft long Jute gunny cover (@ TK. 25 per Yard)	175/-			
6	Seeds of cabbage (10 g), cauliflower (10 g), broccoli (10 g) and Tomato (5 g)	1265/-			
7	Vermicompost (15 Kg @ TK. 20 per Kg), Straw (50 Kg @ TK. 2 per Kg), Coco dust (20 Kg @ TK. 10 per Kg), Fungicide (Provax 200 WP @ TK. 130 per 10 g), Bioderma (20 g @ TK. 500 per Kg) and Root hormone (15 g @ TK. 120 per Kg)	810/-			
8	Labour (1 person one day)	500/-			
Total cost		3955/-	7880 pcs		

*Price of seedling (pcs per TK.): Cauliflower and Broccoli =2 TK. per pcs; Cabbage and Tomato = TK.1.5 per pcs

*GR=Gross Return, TVC=Total Variable Cost, GM=Gross Margin

e) Vegetable and species production in other places adjacent to homestead at FSRD site, Noakhali:

After harvesting of the summer Tomato, farmers cultivated winter vegetables and the gross margin was higher than the normal winter vegetables as farmers produced it earlier than as usual. Highest gross margin was obtained from the plot were cabbage, cauliflower and broccoli were cultivated during *Rabi* season.

Table 3.1.10. Winter vegetables production under the shade of summer Tomato and other places near homestead at FSRD site, Subarnachar, Noakhali during the year of 2020-21.

Season	Crops	Place of cultivation	Av. Whole plot Yield (Kg)	GR (TK. ha ⁻¹)	TVC (TK. ha ⁻¹)	GM (TK. ha ⁻¹)
Rabi	Cabbage, Cauliflower, Broccoli (Av. plot size 3 dec)	Under the shade of previously grown summer Tomato	417	6,86660/-	1,72,970/-	5,13,690/-
	Cabbage, Cauliflower, Tomato (Av. plot size 2.5 dec)	Modified land near homestead	Cole crops = 351 Tomato = 82	6,49,500/-	1,85,860/-	4,63,640/-
Kharif	Bitter gourd (Av. plot size 3 dec)	Using the shade as trellis	216	2,66,760/-	57,852/-	2,08,908/-
	Snake gourd (Av. plot size 3 dec)		192	3,16,160/-	61,360/-	2,54,800/-

Price (TK. per Kg): Cole crops (under shade) = TK.20; Cole crops (adjacent land) = TK.15; Tomato= TK. 15; Bitter gourd = TK.15, Snake gourd = TK. 20.; GR=Gross Return, TVC=Total Variable Cost, GM=Gross Margin

It was assumed that one family (five family members) can meet up their family demand for five to six months from the onion that was produced in the adjacent lands to homestead.

Table 3.1.11. Winter onion production adjacent lands to homestead at FSRD site, Noakhali

Farm Categories	Crops and Varieties	Average Plot size (dec)	Average Yield per plot (Kg)	Yield (t ha ⁻¹)
Marginal	Onion (BARI Piaj-1)	1.20	37	7.63
Small		1.42	40	6.88
Medium		2	62	7.69

f) Vegetable production nearby homestead at FSRD site, Patuakhali:

Vegetable production in Sorjan bed and raised bed: During April-December 2020 total production was 195 Kg and earned TK. 7800 (Table 3.1.12.). Similarly, a farmer earned TK. 5850 producing Kangkong and Panikachu in raised bed during this period (Table 3.1.13.)

Table 3.1.12. Vegetable production in Sorjan at selected farmer of FSRD site, Jamla, Patuakhali

Crops	Production (Kg)	Intake (Kg)	Distribution (Kg)	Sell (Kg)	Income (TK.)
Bottle gourd	195	56	14	125	7800

Table 3.1.13. Vegetable Production in raised bed at selected farmer of FSRD site, Jamla Patuakhali

Crops	Production (Kg)	Intake (Kg)	Distribution (Kg)	Sell (Kg)	Income (TK.)
Kangkong	105	45	-	60	5850
Panikachu	90	65	-	25	

3.2. Crop Sector

a) On-Farm Verification Trials: Yield and economic returns of on-farm verification trials conducted at different categories of farmers field under FSRD site, West Al-Amin, Subarnachar, Noakhali were presented as follows:

Table 3.2.1. Average yield and economic analysis of different *Rabi* crops in On-farm verification trials conducted among selected farmers' fields at FSRD site of Noakhali

Crops	Varieties	Mean Yield (t ha ⁻¹)		Gross Return (TK. ha ⁻¹)	Total Variable Cost (TK. ha ⁻¹)	Gross Margin (TK. ha ⁻¹)
		Trial field	Farmer's field			
Potato	BARI Alu-72 (With mulch)	13.10	-	1,31,000/-	76500/-	54500/-
Ground nut	Dhaka-1	1.20	1.12	72,000/-	42378/-	29622/-
Sunflower	BARI Surjomuki-3	1.21	-	48,400/-	27264/-	21136/-
Proso millet	BARI Cheena-1	0.95	-	38,000/-	14289/-	23721/-
Mustard	BARI Sharisha-14	0.76	-	30,400/-	14780/-	15620/-

Farmgate Selling Price (TK. per Kg): Groundnut=60; Sunflower=40, Proso millet=40, Potato=10, and Mustard=40

Potato: Scarcity of quality irrigation water, short winter season and unavailability of land for planting potato in appropriate time is the major constraints to produce potato. However, farmers are interested to grow potato as their subsistence nature of farming. Water hyacinth (*Eichhornia crassipes*) is considered as the best mulching materials in this region as it is grown profusely in abundant stagnant water bodies. After planting tubers, the plot was covered by the Water hyacinth (@ 68 t ha⁻¹). The average tuber yield of potato was 13.10 t ha⁻¹. Along with all the on-farm verification trials highest gross margin (TK. 54,500 ha⁻¹) was observed in potato production with Water hyacinth mulch. However, this production system required large amount of Water hyacinth which may not be available for all categories of farmers. This type of system should be practiced in this locality in small scale rather than large scale to meet up family demand.

Mustard: It is the main edible oil crop in Bangladesh. It ranks top in respect of area and production among the oil crops grown in this country. In the coastal areas, area and production of mustard was very low because of late harvest of T. Aman, late monsoon, and some cases of excess moisture in the soil. Short duration BARI Sharisha-14 was selected as the variety is almost self-compatible type which helps to produce considerable yield at adverse weather condition during flowering stage. Short duration. The variety gave better seed yield (760 Kg ha⁻¹) than that of nation average (650 Kg ha⁻¹) in Noakhali location. The gross margin was the lowest (TK.15620 ha⁻¹) among all the on-farm verification trials conducted at the FSRD site, Noakhali.

Proso millet: In moderate to strong saline soils which remained fallow during *Rabi* season before intervention, crops varieties such as BARI Cheena-1 found more promising compared to BARI Sharisha-14, BARI Khesari-2 and BARI Gom-25 cultivation. Moreover, this trial was conducted in the

highly saline soil condition and more than 950 Kg ha⁻¹ yield might be possible to produce from slightly to moderately saline soil areas with low input as well as production cost (Table 3.2.1.).

Groundnut: Groundnut is one of the few *Rabi* crops had been traditionally growing in the coastal chars of Bangladesh. In the recent years, coastal region receives high rainfall during early monsoon and groundnut fields remain under water at the time of harvest. These seem to make farmers hesitant to grow it unless the price expectation is good. In case of Noakhali Dhaka-1 was chosen due to short duration whereas BARI Chinabadam-8 was selected for Patuakhali region due to higher yield with moderate duration. The average seed yield of BARI Chinabadam-8 was 2.80 t ha⁻¹ which represented the second highest gross margin (TK.76,600 ha⁻¹) over all the on-farm verification trials conducted at Patuakhali site. On the other hand, the average pod yield of Dhaka-1 was 1.20 t ha⁻¹ which provided a considerable gross margin (TK.29,622 ha⁻¹) during the *Rabi* season of 2020-2021.

Yield and economic returns of on-farm verification trials conducted at different categories of farmers field under FSRD site, Jamla, Dumki, Patuakhali were presented as follows:

Table 3.2.2. Average yield and economic analysis of different *Rabi* crops in On-farm verification trials conducted among selected farmers' fields at FSRD site of Patuakhali

Crops	Varieties	Mean Yield (t ha ⁻¹)		Gross Return (TK. ha ⁻¹)	Total Variable Cost (TK. ha ⁻¹)	Gross Margin (TK. ha ⁻¹)
		Trial field	Farmer's field			
Maize	BARI Hybrid Maize-9	8.30	7.80 (Hybrid)	175500	90000	85500
Chilli	BARI Morich-1	1.90	0.95 (local)	114000	54600	59400
Groundnut	BARI Chinabadam-8	2.80	1.46 (Dhaka-1)	168000	63200	76600
Cowpea	BARI Felon-1	1.82	1.10	80000	24055	55945
Grass pea	BARI Khesari-2	1.58	0.97 (Local)	36800	19430	17370

Farmgate selling Price (TK. per Kg): Maize=22.50, Chilli=60, Groundnut=60, Cowpea=50, Grass pea=40,

Maize: The popularity of Maize and area under production are increasing rapidly in Patuakhali region because of its diversified uses, increasing demand from poultry industry, higher nutritive value, higher per hectare yield and net benefit than other cereals. The grain yield of BARI Hybrid Maize-9 was 8.30 t ha⁻¹. In case of all the verification trials at FSRD site of Patuakhali, the highest gross margin (TK.85500 ha⁻¹) was found from BARI Hybrid Maize-9 due to its higher yield potentiality (Table 3.2.2.).

Grass pea: Grass pea ranks first among the pulses in respect of area and production in Bangladesh. In southern belt, grass pea is generally grown as relay crop with T. Aman without fertilizers. Due to salinity tolerant capability BARI Khesari-2 were selected in both the location. In Patuakhali site, BARI Khesari-2 gave 1.58 0.92 t ha⁻¹ along with TK. 17370 ha⁻¹ as gross margin.

Chilli: In Patuakhali site, one farmer from marginal group was engaged in Chilli cultivation where local variety were used along with improved agronomic practices. The yield was 1.90 t ha⁻¹ and the gross margin was ranked as third comparing to other on-farm verification trials gross margin (Table 3.2.2.).

Soybean: Among oilseeds in Bangladesh, in fiscal year (FY) 2016-17, soybeans are the fourth ranked crop in terms of total planted area at 9.82% of total oilseed planted area. The lion shares of the soybean cultivating areas located in greater Noakhali region where more than eighty (80) percent farmers adopting Shohag variety which was released in 1992. In the course of time BARI developed three varieties such as BARI Soybean-5, BARI Soybean-6 and BARI Soybean-7 which is planted by some 5 to 10 percent of soybean farmers. Moreover, FM and PHED division, BARI developed Power tiller operated seeder for sowing different kinds of *Rabi* crops. PTOS performs three functions i.e., ploughing, seeding in rows, and laddering, simultaneously which reduced land preparation cost and reduced seeds rate as compared with traditional practices. In both the locations, farmers practiced broadcasting method for sowing of oil seed and pulses crop which costs less, but ultimate income is also less due to higher intercultural operation costs and lower grain yields (Table 3.2.3.). In this year, line sowing method were practiced in the trials and the average yield was 1.97 tha⁻¹ (Table 3.2.3). On the other hand, PTOS were used during the year of 2020-21. for sowing in BARI Soybean-6 variety, yielded 2.06 t ha⁻¹ where

sowing cost was reduced about TK.2000 ha⁻¹ and gross margin increased averagely 19% over broadcasting and line sowing methods (Table 3.2.3).

Table 3.2.3. Performance of Power Tiller Operated Seeder in different crops production at different FSRD sites under coastal ecosystem

Location	Crop	Area (ha) and Farmers No.	Yield (t ha ⁻¹)		Sowing cost (TK. ha ⁻¹)		Gross Return (TK. ha ⁻¹)		Gross Margin (TK. ha ⁻¹)	
			PTOS	FP	PTOS	FP	PTOS	FP	PTOS	FP
Patuakhali	Mungbean	3.34 (08)	1.52	1.19 (B)	5613	9880(B)	76000	59500	70387	49620
	Sunflower	01 (6)	1.78	1.25 (L)		17290(L)	89000	62500	88437	45210
Noakhali	Soybean	5.73(08)	2.06	1.68 (B)	6516	7459(B)	61800	50400	55284	42941
				1.97(L)		9360(L)		59100		49740
	Mungbean	1.82 (06)	1.12	0.86 (B)	8120	8570(B)	67200	51600	59800	43030
	Cowpea	1.70 (07)	0.98	0.76 (B)	8185	7450 (B)	49000	38000	41550	30550

Price (TK. per Kg): **Noakhali**- Soybean=30, Mungbean=60, Cowpea=50; **Patuakhali**- Mungbean=50, Sunflower=50 *Picture in the parentheses are farmers' number; PTOS=Power Tiller Operated Seeder, FP=Farmers Practice, B= Broadcasting method, L=Line sowing method by hand

Mungbean: The southern coastal belt is a major Mungbean growing areas of Bangladesh. The high yielding and short duration BARI Mung-6 was cultivated among the cooperative farmers in both locations. During *Rabi* season of 2020-21, PTOS was used in both the location for sowing purposes where 1.12 and 1.52 t ha⁻¹ was found from BARI Mung-6 cultivation in Noakhali and Patuakhali, respectively. In Patuakhali, sowing by PTOS reduced about Tk.8000 ha⁻¹ sowing cost and averagely 69% gross margin increased over broadcasting and line sowing method observed in the on-farm verification trial (Table 3.2.3.). Though sowing cost reduced minimum in PTOS method in Noakhali site, but 39% gross margin increased over traditional broadcasting method observed during the trial period of 2020-21 (Table 3.2.3.).

Cowpea: Cowpea is one of the most preferred crops and a valuable component in the farming systems of most resource poor rural households in the coastal areas of Bangladesh. Farmers usually cultivated it in limited scale for household consumption and sold additional yield. In both the location, BARI Felon-1 was selected as planting material where line sowing was done along with recommended fertilizer doses. In case of Patuakhali, it produced 1.82 per hectare and farmers earned TK. 55945 ha⁻¹. Alternatively, farmers of Noakhali broadcasted Cowpea in the less fertile soils. During the *Rabi* season of 2019-20, Cowpea was sown in line sowing methods whereas PTOS was used to sow Cowpea in the following year. In that year, seed yield of Cowpea was increased about 30% which offered an additional TK.11000 ha⁻¹ (Table 3.2.3.).

Sunflower: In Bangladesh, attempts of sunflower cultivation have been initiated and area of production is increasing. Now it is being grown in 16 districts of Bangladesh and the average production is about 1.2 t ha⁻¹. There is a great scope for growing sunflower after harvest of T. Aman rice, because it is considered as moderately salt and drought tolerant crop. In case of Noakhali, the average seed yield was 1.21 t ha⁻¹ and farmers earned less money by investing more production cost. Moreover, number of unfilled seeds per head or high sterility was observed due to late sowing which reflected in selling price. On the other hand, farmers of Patuakhali, practiced Hybrid sunflower cultivation more than 12 years and the crop have usual marketing facility. During *Rabi* season of 2020-21, BARI Surjomuki-2 was planted by PTOS. In this year 40% yield increased compared to farmers practices. Additionally, 68% reduction in sowing cost was recorded.

b) Controlling of Cucurbit fruit fly in watermelon by using Sex Pheromone: Watermelon are being cultivated as cash crops where most of the farmers did not apply balance fertilizer. Moreover, farmers applied too much insecticide for controlling fruit fly. For this reason, previous experimental result on IPNS system and IPM approaches was practiced among the cooperative farmer's field. In this perspective, watermelon yield of co-operative farmers was compared with the yield of adjacent farmers field for motivating farmers of the locality. Integrated Plant Nutrition System (IPNS) resulted lower use of inorganic fertilizers, eventually helped to improved soil health. On the other hand, Integrated Pest Management (IPM) combination brought down the infestation rate of *Bactrocera cucurbitae* which facilitated to reduced deformed shape fruits within the fields with increased the quality harvested

marketable fruits. Moreover, bio-pesticides along with sticky traps helped to withdrawal insecticide spray frequencies and cost of production reduced more than Tk.15000 to 20,000 ha⁻¹.

Table 3.2.4. Comparison of yield and economic performance of watermelon production under different cultivation practices done by farmers at FSRD site, Subarnachar, Noakhali during the year of 2020-21.

Cultivation Practices	Av. Yield (t ha ⁻¹)	Fruit fly infestation (%)	Gross Return (TK. ha ⁻¹)	Total Variable Cost (TK. ha ⁻¹)	Gross Margin (TK. ha ⁻¹)
IPNS system +IPM system	26.51	≤ 7	265100/-	110422/-	154678/-
Adjacent farmers practices (Injudicious use of chemical fertilizers along with 20 to 25 times insecticides spray)	22.94	≥20	2,29,400/-	143780/-	85620/-

Price (TK. per Kg): Watermelon=10 *GR=Gross Return, TVC=Total Variable Cost, GM=Gross Margin

c) Quality seed production of Soybean in *Kharif II* season: Quality seed of soybean for upcoming *Rabi* season was possible to produce during *Kharif II* season by applying with 50% recommended dose (12-20-22-5-2.4-1.3-5 Kg ha⁻¹ of N-P-K-S-Zn-B) + 1.2 Kg ha⁻¹ of BARI *RGm-901* bio fertilizer. The average yield of was 1.63 t ha⁻¹ where total variable cost was 41,523 TK. ha⁻¹ and average gross return was 1,20,977 TK. ha⁻¹(Table 3.2.5). The quality of the seed was increased as produced seeds had higher percentages of normal seedlings in the germination test compared to last year *Rabi* season seeds which preserved by the farmers.

Table 3.2.5. Yield and cost-return analysis of *Kharif II* season Soybean seed production for *Rabi* season at FSRD site, Subarnachar, Noakhali during *Kharif II* season of 2020

Fertilizer doses	Seed yield (t ha ⁻¹)	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
50 % recommended dose + 1.2 Kg ha ⁻¹ Bio-fertilizer	1.63	163000/-	40,387/-	122613/-

Input and output price per Kg: Soybean seed selling price (for *Rabi* crops) = 100/- (2019), Soybean seed purchasing price = 60/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Zinc Sulphate= 120/-. Boron= 140/-, Bio-fertilizer = 100/-

d) PVS trials on Aus Rice (Noakhali) and production program of Aus rice (Patuakhali): Generally, co-operative farmers from both the location cultivated T. Aman in *Kharif II* season and other cash crops during *Rabi* season. During *Kharif I* season lands remain fallow due to proper knowledge on modern rice crops. In Noakhali, highest yield (4.18 t ha⁻¹) was obtained from BRRI dhan85 followed by Binadhan19 (3.92 t ha⁻¹). Modern varieties should be incorporated with the cropping system instead of BRRI dhan48 as it was short which was not suitable for the low land. In Patuakhali, the average yield of BRRI dhan48 was 3.56 t ha⁻¹.

Table 3.2.6. Average Yield of different Aus rice varieties at selected farmers of FSRD site, Subarnachar, Noakhali and FSRD site, Jamla, Patuakhali during *Kharif* season of 2020-2021

Location	Varieties	Mean Yield (t ha ⁻¹)	Farmers Preference	Final Ranking
Noakhali	BR26	3.57	5	6
	BRRI dhan48	3.73	3	5
	BRRI dhan82	3.78	6	4
	BRRI dhan83	3.83	4	3
	BRRI dhan85	4.18	2	1
	Binadhan19	3.92	1	2
	Hydra	2.39	7	7
location	Variety	Yield (t ha ⁻¹)		
Patuakhali	BRRI dhan48	3.56		

e) Production Program of Green Manuring Crops (Noakhali): Green manuring with *Sesbania* was done and assume that continuously cultivation in four or five seasons improves the permeability and

helps to reclaim soil salinity. In addition, green manuring crops cultivation should be practiced in all co-operative farmers field where D. Aus/T. Aus cultivation will not possible.

f) Land based T. Aman varieties production for sustainable cropping patterns: In Noakhali, BRRI dhan52 gave highest yield (4.57 t ha^{-1}) whereas second highest yield (4.34 t ha^{-1}) was obtained from BRRI dhan87. The lowest yield (3.96 t ha^{-1}) was obtained from BR23. In this site, farmers usually cultivate shorna and BRRI dhan52 with less fertilizer management as well as ignoring the land suitability of the variety. For example, BRRI dhan87 is suitable for slightly high land. Moreover, BRRI dhan87 is short duration compared to other varieties. In case of Patuakhali, highest yield (4.71 t ha^{-1}) was found from BRRI dhan52 whereas farmers prefer BR11 and BR23 as water level in the field was high during the season.

Table 3.2.7. Average Yield of different T. Aman rice varieties at selected farmers of FSRD site, Subarnachar, Noakhali and FSRD site, Jamla, Patuakhali during *Kharif II* season of 2020-21

Location	Varieties	Co-operative Farmers	Varieties	Adjacent Farmers
		Mean Yield (t ha^{-1})		Mean Yield (t ha^{-1})
Patuakhali	BR11	3.32	Moulata	2.8
	BR23	4.01	Moulata	3.11
	BRRI dhan52	4.71	BRRI dhan52	3.95
Noakhali	BRRI dhan87	4.34	BRRI dhan52	3.78
	BR23	3.96		
	BRRI dhan52	4.57	Swarna	3.89

g) Improvement of cropping pattern:

Noakhali: Three improved cropping pattern was describing below-

Existing CP: Groundnut (Dhaka-1)-Fallow-T. Aman (Sharna)

Improved CP: Groundnut (Dhaka-1)-T. Aus (Binadhan-19)-T. Aman (BRRI dhan87)

In improved cropping pattern, groundnut yield (1.07 t ha^{-1}) was higher than the existing cropping pattern might be optimum use of fertilizers and optimum plant population. Moreover, inclusion of modern Aus rice variety into the cropping pattern also provided more economic return compared to existing cropping pattern. Despite Aus rice, farmers were used to cultivate Swarna variety in T. Aman season without maintaining proper spacing as well as proper fertilizers doses which lower down the yield. Moreover, the field duration of Swarna variety is higher than BRRI dhan-87 which created a larger barrier for planting groundnut in appropriate time. On the other hand, early rainfall might be caused severe damage to groundnut which needed early sowing. However, BRRI dhan-87 is suitable for well drainage field as compared to Swarna. This type of cropping pattern is suitable for the lands which located near canal or slightly higher than medium high land. Additionally, heavy rainfall during late December and early January is completely unfavorable to fit this improved cropping pattern in such locality. From the cost return analysis, improved cropping pattern performed better than the existing cropping pattern (Table 3.2.8.). The MBCR was found 1.68 which indicated the superiority of the three crops pattern over farmers' two crops cropping pattern.

Table 3.2.8. Yield and Economic analysis of Improved and existing cropping pattern at the FSRD site, Subarnachar, Noakhali during the year of 2020-21.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Groundnut	T. Aus	T. Aman	Groundnut	Fallow	T. Aman
Seed /Grain Yield (t ha ⁻¹)	1.07	3.72	4.25	0.95	-	4.09
Stover/ Straw yield (t ha ⁻¹)	2.10	4.43	4.84	2.03	-	4.99
Rice equivalent yield (t ha ⁻¹)	3.30	4.45	4.73	2.95	-	4.58
Whole pattern Rice equivalent yield (t ha ⁻¹)	12.48			7.54		
Gross Return (TK. ha ⁻¹)	66000	89140	94580	59030	-	91670
Total Variable Cost (TK. ha ⁻¹)	32378	52018	63167	29792	-	58690
Gross Margin (TK. ha ⁻¹)	33622	37122	31413	29238		32980
Whole Pattern Gross Margin (TK. ha ⁻¹)	102157			62218		
Marginal Benefit Cost Ration (MBCR)	1.68					

Input and output price per Kg: Groundnut selling price = 60/-, Paddy selling price = 20/-, Straw=2/-, Stover=1/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Zinc Sulphate= 120/-, Labour = 500/- per day

Farmer's opinioned that cultivation of Aus rice is possible within their existing cropping pattern and it will be helpful for them to increase the economic return. Moreover, they also expressed that rainfall and landowner demands are the main factor to adopting such type of cropping pattern. It is notable that some year heavy rainfall occurred during *Rabi* season and there is no or enough rainfall for planting Aus rice during *Kharif* season. Moreover, lack of irrigation during dry month is another problem for planting Aus rice.

Existing CP: Soybean (Shohag)-Fallow-T. Aman (Sharna/BRRI dhan52)

Improved CP: Soybean (BARI Soybean-6)-T. Aus (BRRI dhan85)-T. Aman (BRRI dhan52)

Under the improved cropping pattern, the modern variety of soybean was introduced by replacing the low yielding Shohag variety. Moreover, medium highland (87%) is the dominant land type at the target villages (Noakhali), where flooding depth ranges from 0.3-0.9 meter and soil salinity range from slightly to moderately saline. Under the above-mentioned conditions, the improved cropping pattern Soybean-T. Aus-T. Aman trials were conducted during the year of 2020-21. cropping season. In the cropping pattern, T. Aman variety was changed due to impurity of the seeds. Moreover, farmers used to cultivate *Mamun Swarna* variety which have somewhat lodging prone if transplanted in low laying areas and it was observed throughout the intervened areas during Cyclone 'Bulbul'. The result of the cropping pattern trials indicated that the yield of T. Aman in improved practice was slightly higher than of conventional pattern (Table 3.2.9.). This may be due to better management practice in improved pattern as well as suitability of the variety according to the land and soil types. In improved pattern, T. Aus (BRRI dhan85) produced grain yield of 3.93 t ha⁻¹ and BARI Soybean-6 produced 31% more yield over existing Shohag variety. Moreover, replacing of soybean variety in *Rabi* season and inclusion of T. Aus in *Kharif I* season in the existing cropping pattern increased rice equivalent yield (REY) by 73% compared to farmers' existing cropping pattern.

Table 3.2.9. Yield and Economic analysis of Improved and existing cropping pattern at the FSRD site, Subarnachar, Noakhali during the year of 2020-21.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Soybean	T. Aus	T. Aman	Soybean	Fallow	T. Aman
Seed/Grain Yield (t ha ⁻¹)	2.11	3.93	4.14	1.61	-	4.10
Stover/ Straw Yield (t ha ⁻¹)	2.52	4.68	4.97	2.12	-	4.97
Rice equivalent yield (t ha ⁻¹)	3.29	4.28	4.64	2.51	-	4.59
Whole pattern Rice equivalent yield (t ha ⁻¹)	12.20			7.10		
Gross Return (TK. ha ⁻¹)	65670	87950	92730	50265	-	91830
Total Variable Cost (TK. ha ⁻¹)	24275	53220	63167	18740	-	58690
Gross Margin (TK. ha ⁻¹)	41395	34730	29563	31525		33140
Whole Pattern Gross Margin (TK. ha ⁻¹)	105688			64665		
Marginal Benefit Cost Ration (MBCR)	1.65					

Input and output price per Kg: Soybean selling price = 30/-, Paddy selling price = 20/-, Straw=2/-, Stover=1/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Zinc Sulphate= 120/-, Labour = 500/- per day

From the economic point of view, the improved cropping pattern showed its superiority over farmers' pattern during both the trial periods. In improved pattern, the whole pattern gross margin was TK.105688 ha⁻¹ which was more than 63% higher over farmers' existing pattern (Table 3.2.9.). The higher gross margin of the improved pattern was achieved mainly higher yield advantages of soybean crop and inclusion of T. Aus rice. The marginal benefit cost ratio (MBCR) was found 1.65 which indicated the superiority of the improved pattern over the farmers' pattern. The MBCR was comparatively low due to higher total variable cost for producing additional crop and management practices needed for soybean variety.

Existing CP: Fallow - Fallow - T. Aman (Sharna)

Alternate CP: Proso millet (BARI Cheena-1) - Green manure - T. Aman (BR23)

In the char areas of Noakhali region, soil salinity increases progressively through capillary movement and reaches peak in around Mid-March to April, at the beginning of the pre-monsoon season (8.5 to 14.0 dS m^{-1}) which diminishes with the onset of monsoon (1.5 to 4.2 dS m^{-1}) and allow farmers to grow T. Aman (Sattar, 2002). During *Rabi* season the land remains fallow due to salinity, scarcity of quality irrigable water and irrigation facilities, poor knowledge about integration and inadequate salt tolerant varieties etc. in Subarnachar upazilla where the intervened site located. The predominant cropping pattern is Fallow-Fallow-T. Aman (42 %), although double cropping (Fallow-T. Aman -*Rabi* crops) is practiced in some areas. Additionally, Proso millet can escape the adverse effect of salinity due to its short duration (85-90 days). Moreover, it can be grown in less fertile soil with minimum inputs which needed to further be testing, Soil salinity was low during crop establishment periods, and it was below 2 dS m^{-1} across all the replications. However, soil salinity was low in West Al-Amin site whereas soil salinity was high at Katabunia site throughout the growing season and peaks up near about 10 dS m^{-1} during harvesting period of Proso millet. In improved cropping pattern, by incorporation of Proso millet as salinity escape crops an extra 1.57 t ha^{-1} yield was obtained. Contrary, at the same time the land remains fallow due to high salinity progression during mid-February to March in the existing cropping pattern. Moreover, inclusion of green manuring crop reduced the amount of nitrogen fertilizer for succeeding crop and soil salinity assumes to decrease in the next year due to land coverage during *Kharif I* season. Inclusion of Proso millet in *Rabi* season in alternate cropping pattern (7.42 $\text{t ha}^{-1}\text{yr}^{-1}$) increased REY about 69% compared to farmers practiced.

Table 3.2.10. Performance of alternate and existing cropping pattern at FSRD site, West Al-Amin, Subarnachar, Noakhali during the year of 2020-21.

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Proso millet	Green manure	T. Aman	Fallow	Fallow	T. Aman
Grain Yield (t ha ⁻¹)	1.57	-	4.08	-	-	3.90
Straw yield (t ha ⁻¹)	1.87	-	4.91	-	-	5.04
Rice equivalent yield (t ha ⁻¹)	2.84	-	4.58	-	-	4.40
Whole pattern Rice equivalent yield (t ha ⁻¹)	7.42			4.40		
Gross Return (TK. ha ⁻¹)	56820	-	90520	-	-	87970
Total Variable Cost (TK. ha ⁻¹)	18650	5700	59890	-	-	58570
Gross Margin (TK. ha ⁻¹)	38170	-	30630			29400
Whole Pattern Gross Margin (TK. ha ⁻¹)	64000			29400		
Marginal Benefit Cost Ration (MBCR)	2.31					

Input and output price per Kg: Proso millet selling price = 35/-, Paddy selling price = 20/-, Rice Straw=2/-, Millet Straw=1/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Labour = 500/- per day

From the economic point of view, Proso millet- Green manure crop-T. Aman cropping pattern provided TK.64000 ha^{-1} as whole pattern gross margin which was 118% higher than the existing cropping pattern. In addition, the marginal benefit ratio was 2.31 obtained from improve cropping pattern.

Patuakhali: Two improved cropping patterns were describing below-

Existing Cropping Pattern: Mungbean (BARI Mung-6) - Fallow - T. Aman (Moulata)

Improved CP: Potato (BARI Alu-72) - T. Aus (BARI Mung-6) - T. Aman (BRRI dhan49)

Table 3.2.11. Performance of improved and existing cropping pattern at FSRD site, Patuakhali (2020-21)

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	Mungbean	T. Aman	Mungbean	Fallow	T. Aman
Grain Yield (t ha^{-1})	20.73	1.25	4.41	1.52	-	3.16
Straw yield (t ha^{-1})	-	-	4.04	-	-	4.00
Rice equivalent yield (t ha^{-1})	10.37	3.44	4.81	4.18	-	3.56
Whole pattern Rice equivalent yield (t ha^{-1})	18.62			7.74		
Gross Return (TK. ha^{-1})	207400	68750	92140	83600	-	67100

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	Mungbean	T. Aman	Mungbean	Fallow	T. Aman
Total Variable Cost (TK. ha ⁻¹)	73472	30600	45640	30600	-	41950
Gross Margin (TK. ha ⁻¹)	133928	38150	30630	53000		25150
Whole Pattern Gross Margin (TK. ha ⁻¹)	202708			78150		
Marginal Benefit Cost Ration (MBCR)	2.59					

Input and output price per Kg: Potato selling price = 10/-, Mungbean selling price = 55/-, Paddy selling price = 20/-, Rice Straw-2/-, Urea=16/-, TSP= 22/-, MoP=15/-, Gypsum=12/-, Labour = 500/- per day

In developed pattern, incorporation of potato before Mungbean gave an extra yield of 21.6 tha⁻¹ whereas Mungbean yield was decreased about 280 Kg ha⁻¹ than the existing cropping pattern. Moreover, during the *kharif* season the land was occupied by Mungbean whereas in existing pattern the land was remain fallow during *Rabi* season (Table 3.2.11.). In case of T. Aman, about 47% yield increased due to incorporation of modern variety along with balance fertilizer, appropriate seedling rate and age and other management practices. Moreover, the higher total gross margin TK. 2,02,708 ha⁻¹ and BCR 2.59 was obtained from the improve cropping pattern.

Existing CP: Grass pea (Local)-Fallow - T. Aman (Moulata)

Improved CP: Sunflower (BARI Surjomukhi-2)- T. Aus (BRRI dhan48)-T. Aman (BRRI dhan52)

In developed pattern, by replacing of Grass pea by sunflower and incorporation of Aus rice in existing pattern Rice Equivalent Yield increased about 139% as Grass pea replacing by sunflower increased gross return TK. 57,500 and Aus incorporation added extra gross return of TK.80,400. The whole pattern GM increased TK.85,750 over existing pattern that contributed to make more marginal benefit over marginal cost.

Table 3.2.12. Performance of improved and existing cropping pattern at FSRD site, Patuakhali (2020-21)

Observation	Developed cropping pattern			Existing cropping pattern		
Crop	Sunflower	T. Aus	T. Aman	Grass pea	Fallow	T. Aman
Grain Yield (t ha ⁻¹)	1.81	4.02	4.64	0.75	-	3.43
Stover/Straw Yield (t ha ⁻¹)	-	4.51	3.82	1.46	-	4.12
Rice equivalent yield (t ha ⁻¹)	4.53	4.47	5.02	2.01	-	3.85
Whole pattern Rice equivalent yield (t ha ⁻¹)	14.02			5.86		
Gross Return (TK. ha ⁻¹)	90500	80400	96620	33000	-	72715
Total Variable Cost (TK. ha ⁻¹)	53600	41180	41680	17400	-	43025
Gross Margin (TK. ha ⁻¹)	36900	39220	54940	15600	-	29690
Whole Pattern Gross Margin (TK. ha ⁻¹)	131040			45290		
Marginal Benefit Cost Ration (MBCR)	2.13					

Input and output price per Kg: Sunflower selling price = 50/-, Grass pea-selling price = 50/-, Paddy selling price = 20/-, Urea=16/-, TSP= 22/- MoP=15/-, Gypsum=12/-, Zinc Sulphate= 110/-, Labour = 500/- per day.

h) Distribution of plastic drum (Noakhali): A total of 12 with 180 Kg capacity high quality plastic drum along with 40 Kg plastic bag (03 for each farmer) were distributed to preserve high yielding varieties seed. The co-operative farmers were motivated to preserved seeds of BARI Mung-6, BARI surjamukhi-2, BARI Soybean-6, BARI Khasari-2, BARI Cheena-1, BARI Felon-1 and vegetable seeds.

Table 3.2.13. Produced and preserved seed of different crops at FSRD sites

Location	Crop	Farmers involved (no)	Preserved (Kg)
Patuakhali	Mungbean	08	400
	Sunflower	6	140
	Indian spinach	01	03
Noakhali	Mungbean	02	100
	Soybean	03	210
	Cowpea	01	60
	Grass pea	01	50

i) Saplings distributions: In Noakhali, each farmer received six (06) types of fruit saplings and the average number of samplings per farmer was fourteen (14). The survival rate was almost 90 percent except papaya that was 88 percent. In Patuakhali, each farmer received five types of fruit saplings and the average number of samplings per farmer was 18. The survival rate of coconut was 100% and the survival rate of dragon and Malta were 85% whereas the survival rate of mango and guava was 90%.

Table 3.2.14. Name of the varieties of supplied saplings among the co-operative farmers at FSRD sites, Noakhali and Patuakhali

Location	Varieties of the saplings		No. of Saplings	Survival rate (%)
Noakhali	Mango	BARI Mango-11	02 from each variety for each farmer	90
		BARI Mango-4		95
	Malta	BARI Malta-1	02 for each farmer	95
	Guava	BARI Peyara-4	02 for each farmer	92
	Papaya	Red lady	04 for each farmer	88
	Drumstick	Year-round variety	01 for each farmer	98
		Hybrid variety	01 for each farmer	90
Patuakhali	Mango	BARI Mango-4	03 for each farmer	90
	Coconut	BARI Narical-2	04 for each farmer	100
	Dragon fruit	BARI Dragon-1	04 for each farmer	85
	Guava	BARI Peyara-4	02 for each farmer	90
	Malta	BARI Malta-1	04 for each farmer	85

3.3. Livestock and poultry

a) Housing for livestock and poultry (Noakhali): In the intervened area, proper housing is one of the major constraints for sustainable and economically profitable rearing of livestock and poultry, without its poultry (especially chicks and pullets) become easy prey to other wild animals and birds along with state of stolen by the thief. Some model, housing systems were developed with the help of DLS personnel for livestock and poultry which was distributed among the cooperative farmers.

b) De-worming and vaccination of co-operative farmers Cattles at both the FSRD sites:

Noakhali: It was found that before vaccination, frequency of different disease was not so much high. After vaccination of cattle, Goat and buffalo disease frequency and mortality rate reduced (Table 3.3.1.). Farmers were interested to continue vaccination, but it was very difficult to continue the program without local service provider. Although, there is a LSP in the Katabunia village, but the difference in vaccination time of different cattle was difficult to maintain.

Table 3.3.1. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Noakhali during the year of 2020-21.

Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
	Cattle	Goat	Buffalo	Before intervention	After intervention
Anthrax	82	-	-	05	00
Foot and Mouth	82	-	-	02	02
PPR	-	42	-	05	02

Number and name of the cattle owned by the cooperative farmers were selected for deworming program (Table 3.3.1.). Second dose of deworming was given 35-40 days interval as per body weight of the cattle recommended by concerned personnel of DLS, Subarnachar, Noakhali. In Noakhali, ten (10) farmers out of 12 farmers engaged in cattle rearing and most of them have indigenous breed with average milk yield per lactation is below 290 lit before intervention and it increased more than 100 lit. Milk production increased might be due to better veterinary services, deworming and feed management, especially supply of green fodder during dry season. On the other hand, two farmers (one marginal and one small farm) engaged Goat rearing and supplementary feeding management was introduced.

Table 3.3.2. Income and utilization pattern of milk from milch Cow rearing system at FSRD site, Noakhali during the year of 2020-21.

Average Milk production (lit)	Utilization pattern				Income from selling cattle (Tk.)
	Consumption (lit)	Distribution (lit)	Sold (lit)	Income (Tk.)	
395 (average no. of Cow 1.5)	192	15	188	11280/-	19800/-

*Price of milk per liter = 60/-

Patuakhali: For improvement of cattle health and control diseases and mortality rate proper vaccination is a key program. Farmers would be economically benefitted through de-worming of cattle because improvement of its health. De-worming and vaccination program was carried out at the FSRD sites, Jamla, Dumki, Patuakhali throughout the project period. Thirty cattle including 03 milking Cows owned by the cooperative farmers were selected for de-worming and vaccination (Table 3.3.3.). Second dose of de-worming was given 35-40 days interval as per body weight of the cattle recommended by concerned personnel of ULO, Dumki, Patuakhali. After de-worming the cattle their milking rate per day and body weight gaining were observed promisingly. However, it was observed that de-worming is an easy process to adopt with minimum cost. The gaining body weight of dewormed milch Cow was observed as 40 g/day/Cow whose average lactation yield was increased up to 0.75 lit/day over the controlled (Table 3.3.4.). It was also observed that among the vaccinated cattale no anthrax disease was found whereas incidence of foot and mouth disease was only 01% that is 88% lower than before of vaccination (Table 3.3.5.).

Table 3.3.3. Livestock covered by de-worming and vaccination program at FSRD site, Patuakhali

Livestock Type	De-worming	Name of the Vaccination
Cattle	30	Anthrax (30), Foot and Mouth (30)

Table 3.3.4. Average Body weight and average lactation yield increased by de-worming at FSRD site Jamla, Dumki, Patuakhali during the year of 2020-21.

Treatment	Animal (no)	Average Body wt. gain/day/animal(g)	Average Lactation yield (lit/day)	Av. Lactation period(day)
Controlled Cattle	03	70	1.5	180
De-wormed Cattle	03	110	2.25	205

Table 3.3.5. Effect of cattle vaccination at FSRD site, Jamla, Dumki, Patuakhali

Diseases	Before vaccination (%)	After vaccination (%)
Anthrax	05	0
Foot and Mouth	09	01

c)Vaccination of poultry both the FSRD sites:

Noakhali: Different types of Vaccination were done for controlling diseases of chicken, Duck and pigeon as per schedule suggested by respected personnel of DLS, Subarnachar, Noakhali (Table 3.3.6.). The actual pathogen responsible for disease was not identified before and after vaccination due to lack of lab facility at the locality. In case of chicken, mortality was observed after vaccination might be due to diseases other than vaccinated diseases included parasitic infections, chronic respiratory disease and colibacillosis etc. Similarly, mortality in Duck and pigeon might be due to other infectious diseases of the respected poultry.

Table 3.3.6. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Subarnachar, Noakhali under coastal ecosystem during the year of 2020-21.

Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
	Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
BCRDV	155	-	-	-	23.38	2.43
RDV	530	-	-	-		
Fowl Pox	480	-	-	-		
Fowl Cholera	457	-	-	-		
Duck plague	-	264	-	-	18.48	2.11

Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
	Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Duck Cholera	-	312	-	-		
Pigeon Pox	-	-	170	-	7.69	2.40

Patuakhali: The vaccination of poultry program has created a great awareness to the co-operative farmers and neighborhood farm families the site. It revealed that, mortality rate can be minimized significantly through vaccination. By the vaccination of BCRDV, RDV, Fowl Pox and Duck plague mortality rate was reduced 93%, 91%, 87% and 90%, respectively. After vaccination of poultry, all of the diseases frequency reduced drastically, and mortality rate dropped below 8% (Table 3.3.7.).

Table 3.3.7. Number of birds vaccinated and mortality rate before and after vaccination at FSRD site, Jamla, Dumki, Patuakhali under coastal ecosystem during the year of 2020-21.

Name of poultry	Name of vaccine	No. of bird vaccinated	Mortality before Vaccination (%)	Mortality after Vaccination (%)	Mortality reduces (%)
Chicken	BCRDV	85	60	4	93
	RDV	100	80	7	91
	FOWL POX	150	45	6	87
Duck	Duck plague	180	80	8	90

Moreover, systematic rearing system such as feed and housing management, egg hatching mud pot and vaccination of poultry assisted participatory farmers to attain additional income by means of increased flock size, enhanced meat, and egg production.

Table 3.3.8. Present conditions and income of supplied and owned poultry (native chicken and Duck) among the participatory farmers at FSRD sites under coastal ecosystem

Location	Farm Category	Bird and Egg sold (TK. Farm ⁻¹)	Bird and egg consumed (TK. Farm ⁻¹)	Value of the present stock (TK. Farm ⁻¹)	Gross Return (TK. Farm ⁻¹)	Variable Cost (TK. Farm ⁻¹)	Gross Margin (TK. Farm ⁻¹)
Noakhali	Marginal	1970	1890	6780	10640	1870	8770
	Small	2490	2385	9630	14505	2280	12225
	Medium	3595	3220	14570	21385	3045	18340
Patuakhali	Average	3150	2895	16590	22635	3720	18915

d) Sonali chicken rearing (Patuakhali): The average initial body weight of Sonali chicks was 62-72g during distribution periods among the participatory farmers. Final body weight was 1.98 Kg after six months from which average total return per farmer was TK. 20873. Average gross margin per farmer was TK. 11,253 respectively (Table.3.3.9.).

Table 3.3.9. Average performances of Sonali chicken at farmers' level in Patuakhali

Description of Item	Production and income related information
Number of farmers	12
No of birds supplied per farmers	10
Initial body wt./bird (g)	72
Procurement price/bird (TK.)	20
No of chicken survive/farmer	8
Weight gained/bird (Kg) after 6 months	1.98
Egg Production (Number)	363
Consumption	56
Sale	125
Distribution	0
Hatch	172
Damage	10
Total income from chick rearing (TK.)	20873
Total variable cost (TK.)	9620
Gross margin (TK.)	11253

e) Small-scale pigeon rearing in farmer's household

Noakhali: One marginal farmer was practicing the in-house pigeon rearing system and earned roughly TK.1860 per month. Besides in house pigeon rearing, almost all households are being practicing pigeon rearing and the average flock size was 4 pair. Moreover, most of the production was consumed by the household members and few of them seldom sold the squab to meet up unexpected cost. Another marginal farmer reared 12 pair of pigeon in semi-intensive method and earned above TK.900 per month.

Table 3.3.10. Monthly basis Income from in-house pigeon rearing by co-operative farmer at FSRD site, Noakhali during the year of 2020-21.

Initial stock (Pair)	Present stock (Pair)	Squab production (Pair month ⁻¹)	Feed and medicine cost (TK. month ⁻¹)	Consumption (Pair month ⁻¹)	Distribution (Pair month ⁻¹)	Value of present stock (Tk.)	Selling (TK. month ⁻¹)
06 pair	27 pair	19 pair	2015/-	2.5 pair	01 pair	16200/-	3875/-

*One pair squab price = 250/-

Patuakhali: In four-month, squab production was 08 pair per farm of which 03 pair was stocked. Per farm squab consumption was 02 pair and sold 03 pair for 04 months. Squab stocking as well as selling increased their income. Consumption of squab also increased their nutrition. Pigeon rearing provides additional income of TK. 3000 per farm by squab stocking and selling.

Table 3.3.11. Average per farm Income from small-scale pigeon rearing in household level at FSRD site, Patuakhali during the year of 2020-21.

Initial stock (Pair)	Present stock (Pair)	Consumption (Pair month ⁻¹)	Distribution (Pair month ⁻¹)	Squab sell (Pair month ⁻¹)	Value of present stock (Tk.)	Income from selling (Tk.)
02	05	02	0	03	3000/-	600

*One pair squab price = 200/-

f) Calf rearing (Patuakhali): Five co-operative farmers were engaged in calf rearing. They bought calf from local market which was latter kept at the Yard or household premises. They mainly used locally available fodder and residue of homestead for rearing calf. During Eid-Ul-Adha, such type of cattle demand was much higher than those comes from other areas. By this approach, farmers earned substantial money (TK. 37,850) that facilitated them to enjoy the Eid-Ul-Adha festival.

Table 3.3.12. Income from calf rearing by the co-operative farmers at FSRD site, Patuakhali during the year of 2020-21.

Name of Farmers	Total calf	Rearing cost (TK.)	Gross Income (TK.)	Gross Return (TK.)
Abdul Mannan Khan	02	28500	76000	47,500
Anwar Hossain Mrida	02	36000	81000	45,000
Manik Hawlader	01	12400	35000	22,600
Paresh Chandra	02	32000	87000	55,000
Kabir Hossain	01	9500	28000	19,000
Average income				37,820

g) Fodder production (Noakhali): Fodder contains a major protein of daily ration of milch animals and therefore, cultivation of nutritious and high yielding variety fodder is inevitable. In the intervention dimension, two types of fodder were produced and harvesting of green fodders was done according to the nature of the fodder crops. In case of Napier grass, green fodder was collected three times (Table 3.3.13.) and yield was highest during 2nd time harvesting.

Table 3.3.13. Production of Fodder at FSRD site, West Al-Amin, Subarnachar, Noakhali during the year of 2020-21.

No. of Farmers	Average area	Date of cutting sowing/ Seed sowing	Fodder harvesting (Days)	Fodder yield (t ha ⁻¹)
06	02 dec (wastelands near homestead)	25 November to 07 December,2020 (Napier)	32-35 DAS	5.29
			65-67 DAS	8.13
			95-98 DAS	7.72

h) Small-scale Vermicompost production

Noakhali: Initially, one hundred forty to forty-eight kilograms of partially decomposed Cowdung were used in the ring to produce Vermicompost. For producing first time Vermicompost, the *Eisenia fetida* earthworms took 65 to 72 days. Time differences for first Vermicompost collection was observed due to each farmer's conditions, management, and number of alive earthworms after release. However, as the earthworms multiply overtime, the production time of Vermicompost declined. As a result, during the next cycle, Vermicompost was produced within 37 to 41 days (Table 3.3.14.). The highest production was found from the first-time collection and the lowest from the third time collection. Before collecting Vermicompost, the materials were sieved for collecting earthworms and eggs of the worms for the next cycle. Average production from each ring was approximately 43.25 Kg. Most of the farmers used Vermicompost for vegetables production and two farmers used it for watermelon production.

Table 3.3.14. Production cycle of Vermicompost produced in ring method at FSRD site, Noakhali

Vermicompost collection (days)	Production (Kg per ring)
First collection 65 to 72	47
Second collection (37 to 41)	44
Third collection (28 to 34)	40
Fourth collection (25 to 27)	42

Table 3.3.15. Vermicompost production and utilization at different FSRD sites under coastal ecosystem

Location	Av. Production (Kg per farmer)	Av. utilization (Kg per Farmer)	Av. sell (Kg per Farmer)
Noakhali	43.25	38	5.25
Patuakhali	53.75	44	9.75

3.4. Fisheries Sector

Maximization of farmer's income through carp poly culture technique at low-cost management in perennial ponds: In Patuakhali pond size varied from 2 dec to 20 dec and average depth varied from 1 m to 1.5m round the year. Stocking density were 36 to 38 fingerlings for one decimal pond area. In contrast, pond size varied from 05 dec to 35 dec, average depth was from 1.3m to 2m, stocking density was 35 fingerlings per dec in Noakhali FSRD site. Besides ponds area, survival rate ranged from 72.22% to 79.95% in and 85% to 95% at FSRD site, Patuakhali Noakhali, respectively.

Table 3.4.1. Performance of carp poly culture in per decimal pond area at both FSRD sites under coastal ecosystem during the year of 2020-21.

Location	Farm category (No.)	Av. area (dec) and Av. depth of pond (m)	Average Initial wt. (Kg and No.)	Av. weight of fingerlings (g)	Av. final wt. (Kg and No.)	Survival rate (%)
Patuakhali	Marginal	15 dec and 1.4 m	1.31Kg (37)	30 g	12.07 Kg (27)	72.97%
	Small	4 dec and 1.12 m	1.08 Kg (36)	30 g	11.82 Kg (26)	72.22%
	Medium	12 dec and 1.35 m	1.29 Kg (38)	30 g	15.08 Kg (30)	79.95%
Noakhali	Marginal	9.78 dec and 1.37 m	1.20 Kg (35)	15 g	10.5 Kg (30)	85%
	Small	19 dec and 1.8 m	1.20 Kg (35)	15 g	12.0 Kg (33)	95%
	Medium	30 dec and 1.9 m	1.20 Kg (35)	15 g	16.0 Kg (33)	95%

Major part of the total production was consumed by the farm families whereas a modest amount of the production was sold and distributed. The consumption rate and selling were observed highest in medium farm across the locations (Table 3.4.2.).

Table 3.4.2. Fish production and utilization pattern in both the FSRD sites under coastal ecosystem

Location	Farm category	Total production (kg)	Consumption (Kg)	Distribution (Kg)	Sold (Kg)
Patuakhali	Marginal	543	543	-	-
	Small	177	177	-	-
	Medium	1080	650	-	380
Noakhali	Marginal	924	630	-	294
	Small	2736	2052	-	684
	Medium	4320	2635	62	1623

In Patuakhali site during the culture period, highest gross income (TK.162000) and net income (TK. 88350) per cultured pond was observed in the medium category of farmers (Table 3.4.2.) where BCR ranged from 1.20 to 1.59 across the farm categories. Corresponding trends were observed in Noakhali site and the BCR ranged from 1.07 to 1.76 (Table 3.4.3.).

Table 3.4.3. Economic Analysis of carp poly culture in perennial ponds at both the FSRD sites under coastal ecosystem during the year of 2020-21.

Location	Farm Category	Total production (kg)	Gross Return (TK. per Pond)	Total variable cost (TK. per Pond)	Gross Margin (TK. per Pond)	BCR
Patuakhali	Marginal	543	81450/-	34103/-	47347/-	1.39
	Small	177	26550/-	10252/-	16298/-	1.59
	Medium	1080	162000/-	73656/-	88350/-	1.20
Noakhali	Marginal	924	138600/-	87020/-	71680/-	1.07
	Small	2736	410400/-	254700/-	155700/-	1.61
	Medium	4320	648000/-	367,500/-	280500/-	1.76

Yet, farmers of both FSRD site were very impressed with the performance of carp poly culture. The neighbor farmers showed their keen interest to take the carp poly culture system in their ponds.

3.5. Off-Farm Activities

Usually, they use cutting for propagation whereas after motivation they started to use rhizomes as propagating materials. Moreover, tie of 6 to 7 dichotomously branched stems together protect from wind and resulted long stem whereas application of fertilizer helped to produce diameter of the stem 2.5 cm above, allowed farmers to collect seven or eight thin strips from the bark of the single pati pata plant.

The important fact is the pati is a major source of livelihood of the women. Moreover, farmers easily can made 7 feet long and 5 feet wide pati by practices the following management. Two to three persons can weave a pati within a month with decorative design. Depending on the quality and size a Shitol Pati costs one thousand taka to five thousand taka.

Table 3.5.2. Comparison of Cost and return parameters on off-farm activities at FSRD site, Noakhali

Before intervention			After intervention			Gross Margin increased over before intervention (%)
Gross Return (TK.)	Total variable cost (TK.)	Gross Margin (TK.)	Gross Return (TK.)	Total variable cost (TK.)	Gross Margin (TK.)	
4200	1980	2220	11550	4120	7430	235

Summary

For developing sustainable cropping patterns on-farm verification trials on cash crop were conducted in both the locations during *Rabi* season of 2020-21 cropping year. Besides on-farm trials, Aus rice crop was established among farmers (in each location) with the modern variety such as BRRI dhan48, BRRI dhan82, BRRI dhan83, BRRI dhan85 and Binadhan-19. With the aim of improving soil health, several farmers' fields were selected for green manuring crop cultivation and eventually, incorporated just before flowering in Noakhali site. High value crops like summer Tomato cultivation were introduced among farmers with modern variety of BARI Hybrid Summer Tomato-8. On the other hand, Sorjan method was implemented in Patuakhali site. For improvement of cropping pattern, land type-based T. Aman rice varieties (BRRI dhan23, BRRI dhan52 and BRRI dhan87) were cultivated in farmers field across the locations. In both the location, some improved and alternate cropping pattern were introduced such as Groundnut (Dhaka-1)- D./T. Aus (Binadhan-19) - T. Aman (BRRI dhan87), Proso millet (BARI Cheena-1) - Green manure - T. Aman (BR23), Potato (BARI Alu-72) - Mungbean (BARI Mung-6) -T. Aman (BRRI dhan49) and Sunflower (BARI Surjomukhi-2) - T. Aus (BRRI dhan48) -T. Aman (BRRI dhan52). Moveable seed was introduced for winter vegetables seedling production in Noakhali site. Several farmers of Noakhali cultivated Cabbage, cauliflower, broccoli and Tomato in the small-scaled. Surprising all farmers willing to cultivate onion and eventually all of them started to cultivate with a land varied from 1.2 to 2 dec. For preservation of high yielding varieties seed, plastic drum (180 Kg) along with plastic bag (40 Kg) were also distributed in the farmers of Noakhali. A total of 168 saplings were distributed to enrich agroforestry system with 06 types of fruit trees (Noakhali). Year-round vegetable production through modified "Atkapalia" Model and modified "Lebukhali" Model are being practiced among the co-operative farmers. Vaccination of livestock and poultry was done as when necessary for sustaining the production system. Moreover, chick, Duck, turkey, titir and pigeon were distributed with the aim of more meat production. Sonali chicken and small-scale pigeon rearing were gaining popular among the farmers due to economic return as well as source of protein. Despite poultry, some farmers engaged in calf rearing system for selling during Eid-Ul-Adha. Moreover, fodder cultivation was carried out in the wastelands near homestead in Noakhali site to meet up green fodder shortage during dry season. For the purpose of increase farmer's income through aquaculture system, carp poly culture technique at low-cost management in perennial ponds were implemented in the co-operative farmers pond across the locations. Furthermore, co-operative farmers were encouraged to follow agronomic management for the pati pata plant inhabited in their pond banks or other partially shady places and providing attractive design for weaving Shital Pati at FSRD site in Noakhali under coastal ecosystem. Continuous follow up evaluation were made by the concerned scientists to fruitful the objectives of the intervention though sometimes movement was restricted due to Covid-19 pandemic.

FLOATING AGRICULTURE BASED INTEGRATED FARMING RESEARCH AND DEVELOPMENT FOR LIVELIHOOD IMPROVEMENT OF FARMER

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Executive Summary

Integrated farming is termed as integrated resource management. Sustainable local natural resource management in the submerged areas through floating agriculture based integrated farming practices may be a good option for improving livelihood and coping up with the climate change situation. From these views, the program was undertaken to generate floating agriculture based modern and appropriate technologies, to develop the management technologies of different crops under floating agriculture system, and thereby to increase the yield and economic return of floating agriculture through vegetables, spices, forage, livestock, fisheries and homestead gardening under integrated approach. The research and development activities under floating agriculture based integrated farming were carried out in 5 locations of low-lying areas of southern Bangladesh (Tungipara, Gopalganj sadar and Kotalipara upazilla under Gopalganj district; Nazirpur upazilla under Pirojpur district; and Mollahat upazilla under Bagerhat district) during the year of 2017-18 to 2020-21.

A total of nineteen types of activities were done for maximizing the total productivity using the existing resources of 120 farmers (60 farmers under OFRD, BARI and 60 farmers under Palli-Bangla Unnayan Shahojogita Sangstha -PBUSS). Among them 12 farmers from each location comprising of 6 from each of marginal and small farmers group considering floating agriculture and mainland crops, homestead vegetables and fruits, poultry and livestock, fisheries and off-farm component under OFRD, BARI. All components were brought under improved technological intervention and accordingly incomes were increased from these components. The average waterlogged land size per farmer was 27, 25, 24, 15 and 15 decimals in Nazirpur, Gopalganj Sadar, Tungipara, Kotalipara, and Mollahat, respectively. In waterlogged land, floating agriculture based a total of 9 types research and development activities were conducted focusing screening of vegetables, spices, and forage; standardization of bed size; nutrient management; agronomic management; pest and disease control etc.

In *kharif* season of 2020-'21 four vegetable crops viz. Bottle gourd, Bitter gourd, Sweet gourd and Okra were cultivated in floating bed and in *rabi* season of 2020-'21 Broccoli, Cabbage, Cauliflower and Knolkhol were cultivated to observe their suitability and profitability. The experiment was conducted on Water hyacinth based floating bed at Tungipara and Kotalipara under Gopalganj district; Nazirpur under Pirojpur district and Mollahat, Bagerhat. Among these vegetables, Bottle gourd gave highest BCR at each location and it were 1.76 in Tungipara, Gopalganj; 1.72 in Kotalipara, Gopalganj; 1.85 in Nazirpur, Pirojpur and 1.91 in Mollahat, Bagerhat. In *rabi* season of 2020-21, four vegetable crops (viz. Broccoli, Cabbage, Cauliflower and Knolkhol) were cultivated at same bed of same area to observe their suitability and profitability. Among the vegetables cauliflower gave highest BCR in each trial area and it was 1.81 76 in Tungipara, Gopalganj; 1.71 in Kotalipara, Gopalganj and 1.85 in Nazirpur, Pirojpur. At the same season the lowest BCR was recorded from cauliflower and it were 1.25 in Tungipara, Gopalganj; 1.13 in Kotalipara, Gopalganj; 1.22 in Nazirpur, Pirojpur.

The experiment was carried out on Water hyacinth based floating bed at Kotalipara and Tungipara under Gopalganj district; Nazirpur under Pirojpur district and Mollahat, Bagerhat during the year of 2020-21. Under this experiment three turmeric varieties were used to evaluate their performance in floating bed viz. BARI Holud-3, BARI Holud-5 and local. In case of Kotalipara and Tungipara under Gopalganj district and Nazirpur under Pirojpur BARI Holud-5 gave highest yield and it were 155 kg, 176 kg and 160 kg/bed, respectively. Also the highest BCR were found from the same variety it were 2.28, 2.46 and 2.35, respectively. In case of Mollahat, Bagerhat the same variety BARI Holud-5 gave highest yield and BCR which were 135/bed and 1.99, respectively.

An experiment was carried out to develop new cropping pattern at Kondorpogati, Kotalipara and Tungipara in Gopalganj and at Nazirpur in Pirojpur district during the year of 2020-'21. The aim of the study was to find out the suitable cropping pattern over the existing one. The cropping pattern *Boro*-Floating bed-fallow introduced against traditional cropping pattern fallow-Floating bed-fallow. The

highest gross margin and BCR was obtained from improve pattern which were 339195.33 taka and 1.48, respectively while from the existing cropping pattern gross margin and BCR were found 214500 and 1.36, respectively.

The experiment was carried out at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur and Mollahat in Bagerhat district during the *rabi* and *kharif* season of 2020-21. The aim of the experiment was to evaluate the performance of sowing and transplanting method in vegetable crops on floating agriculture. Bottle gourd was cultivated under this experiment. The highest yield/bed 212.2 kg, 236.2 kg were found from transplanting method at *rabi* and *kharif* season, respectively also highest BCR 1.42 and 1.67 were found at *rabi* and *kharif* season from the same method while from sowing method yield 170.7kg, BCR 1.42 were found at *rabi* season and yield 199.9kg and BCR 1.67 were found at *kharif* season.

The experiment was carried out on Water hyacinth based floating bed at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur during *kharif* season of 2020-21. The aim of the study was to observe the response of vegetables to macro- and micronutrient. Okra (variety-chyanika) was taken as vegetable crop. Four fertilizer doses were taken as treatment viz. $T_1 = \text{N-P-K-S-Zn-B: 75-21-15-5-1-0.5 kg/ha}$, $T_2 = 75\%$ of T_1 , $T_3 = 50\%$ of T_1 and $T_4 = \text{Farmers' practice}$. The highest mean yield (68.3 kg/bed), gross margin (820 Tk./bed) and BCR (1.45) were recorded from the bed where N-P-K-S-Zn-B were applied @ 75-21-15-5-1-0.5 kg/ha while the lowest yield (53.3 kg/ha), gross margin (255.00 Tk./bed) and BCR 1.14 were found from farmers' practice where no fertilizer was applied.

Four intercropping system viz. Bottle gourd + Red amaranth, Sweet gourd + Red amaranth, Cucumber + Red amaranth and Bitter gourd + Red amaranth were taken to test the suitability for intercrop in floating agriculture. The experiment was conducted at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur and Mollahat, Bagerhat during 2020-21. Among the four intercropping, Bottle gourd + Red amaranth found suitable in regards of its profitability. The highest mean gross margin (Tk. 1205/bed) and BCR (1.63) were calculated from Bottle gourd+ Red amaranth intercropping while the lowest gross margin (Tk.-90/bed) and BCR (0.95) were recorded from Cucumber+ Red amaranth intercropping.

Bottle gourd and Country bean seedling were grown on Water hyacinth made floating bed at Nazirpur, Pirojpur during the year of 2020-21. The highest gross margin (Tk.8000/bed) and BCR (2.33) found from Bottle gourd seedling bed whereas 6000/- gross margin and 2.00 BCR was found from Country bean seedling bed.

In the mainland, the research and development activities were conducted using the residue (compost) of floating bed. Winter vegetables viz. Broccoli, Cauliflower, Knolkhol, Cabbage, Red amaranth and Spinach were cultivated by using residue of floating bed at Tungipara and Kotalipara in Gopalganj district and Nazirpur, Pirojpur to observe their suitability and profitability. Among the vegetables, cauliflower gave the highest mean gross margin (618400.00/ha) and BCR (3.30) which followed by Broccoli with gross margin 396300.00/ha and BCR 2.48. At the same time the lowest gross margin (Tk. 83300) and BCR (1.69) were recorded from Red amaranth

Tilapia fish culture in cage (size: 20ft x 10ft x 6ft) besides of floating bed in waterlogged area was found promising and 75.25, 752.10, 76.27 and 79.00 kg fish/cage were produced in Tungipara, Kotalipara, Nazirpur and Mollahat, respectively. Besides of cage fish culture, open water also a good source of natural fish.

Five types of activities are going on in the livestock component. In case of floating system, Duck was reared by the farmers and for this regard five Ducklings were supplied to each farmer at all locations and after rearing five months the monthly income was calculated 115 Tk./Duck.

In case of homestead area, after deworming and vaccination of cattle, the frequency of major diseases e.g. Anthrax, FMD, PPR, BQ etc. were reduced to below 10%. In poultry system, Sonali chicken and pigeon rearing in homestead created a good impact as a good source of income and child nutrition. Mortality of poultry reduced (50-85%) after vaccination. Average compost produced from Water hyacinth based floating bed ranged 20.10-36.18 t/farmer under floating system and farm-Yard manure produced (1900 kg/homestead/yr) in compost pit in homestead area were found promising.

The average homestead size was 13, 11, 10, 12 and 12 decimals in Nazirpur, Gopalganj Sadar, Tungipara, Kotalipara, and Mollahat, respectively. In homestead component, four types of activities were done with year-round vegetables and fruits production, new plantation, and fruit tree management. The average vegetables produced per homestead in rabi 828 kg and kharif 540 kg after intervention (AI), which was only 143 kg before intervention (BI). The average vegetables consumption during AI was 196 g/head/day, which was 239% higher than BI. Fruit tree management has created a good impact and a total of 235 fruit trees were brought under pest management and a total of 720 saplings of different fruits were distributed in different locations.

Women participation in agricultural activities increased to a great extent that showed some positive effect on gender equity within the family. From different types of off-farm activities (e.g. Pati weaving with Hoglapata, Diar making with bamboo, Kantha sewing etc.), farmers also earned some extra money (avg. gross margin Tk. 7200/household). On an average, the gross margin of a household from different components was increased 68.22%. Integration among the farm components especially floating agriculture-based integration activities are going on. However, the possibility to develop floating agriculture based integrated farming technology would undoubtedly open up opportunities to raise farm income, livelihood and food security in poor people who can benefit of locally available materials and by-products to run sustainable farming.

Introduction

Bangladesh is an agro-based country. Agriculture is the backbone of Bangladesh. About 65% of the total population lives in the village. Their livelihood is very poor. Agriculture in Bangladesh is characterized by intensive crop production, mainly rice, vegetable, Jute etc. Vegetable production is very low in Bangladesh compared to Thailand, Japan, China, Korea etc. There are several factors behind it of them depletion of organic matter, submerged soils, water logging, in sufficient high land, no available cold storage, imbalance use of fertilizer, high doses of pesticide, intensive cropping, without inclusion of legume crops in rotation, nutrient leaching with monsoon rain, lack of knowledge of new inputs and technique. So, production of vegetable can be increased by replenishment of soil organic matter, well drainage, changing of cropping pattern and application of advanced technology.

Bangladesh is one of the most vulnerable countries of the world due to the impacts of climate change. In southern region, the major consequences of climate change are: sea level rise, floods, salinity intrusion, disasters like cyclones (*SIDR*, *Aila*, *Mahasen* etc.) and tidal surge. The National Aeronautics and Space Administration (NASA) of the United States has recently reported that sea levels of one meter or more might be unavoidable in the next 100-200 years that may cause inundation of 15% more area of Bangladesh particularly the low-lying area of the country (Daily star, 2015). Intergovernmental Panel on Climate Change earlier predicted that about 17% of the country's landmass could be inundated with a one meter rise in sea levels in Bangladesh (IPCC and UNFP, 2014). The harmful impacts of climate change may intensify these situations in future and would create great challenges for sustainable crop production and food security.

Climate variability is changing the rainfall and hydrogeological patterns in deltaic, sub-tropical countries, like Bangladesh. This would consequently cause extended flooding and waterlogged conditions more frequently. Floating garden offers additional arable space under such adverse conditions. Different types of vegetables and spices can be grown on these floating beds to meet the needs of people living in the wetlands. In addition, these beds provide space to raise seedlings of rice and vegetables. As a result, farmers can get ready with the seedlings of winter crops and get on with agriculture as soon as flood water recedes from farmlands.

The low-lying areas of the southern region remain fallow for long period (generally June-December) particularly in monsoon season due to flooding/submergence. In winter season, some farmers cultivate only *Boro* rice under *Boro rice*-Fallow-Fallow cropping pattern in southern areas (DAE, 2014). Moreover, salinity intrusion had increased by 27% (0.223 million ha) from 1973 to 2009 in coastal areas caused severe yield reduction or even crop failure (SRDI, 2010). The livelihoods of local people are leading a miserable life as most of them are struggling against poverty and malnutrition. Therefore, development of climate smart and/or innovative agricultural technologies (commodity and non-

commodity) is essential for sustaining the crop productivity towards improving the food security of the vulnerable people particularly in the flood prone and submerged southern areas of Bangladesh.

The indigenous floating agriculture practices are designed mainly based on farmers' traditional techniques and knowledge but only application of traditional knowledge cannot produce the potential yield and profitability due to different biotic and abiotic constraints. The local farmers produce vegetable and spice crops as well as their seedlings of locally available cultivars that provide almost poor yields. Low yielding varieties cultivated with poor agronomic practices (in terms of sowing/planting method, nutrient management, irrigation, mulching, crop husbandry, weeding, insect pest and disease, rodent control etc.) on floating garden reduce the yield and profitability of the crops remarkably. The farmers of this area are not habituated to cultivate forage as fodder for cattle. Not only that they are not practiced deworming, vaccination for livestock improvement, homestead gardening for nutrition and also fisheries cultivation. Fisheries cultivation is another part of livelihood improvement but in those areas they are not practiced due to lack of availability of pond. We want to introduce fish cultivation through cage culture like; Tilapia, Pabda and Tangra. Nevertheless, unavailability of natural resources (e.g. Water hyacinth, *topapana* etc.) due to salinity intrusion, haphazard use of natural resources, lack of quality seeds and lack of farmers' knowledge further deteriorate the crop yields. To increase the crop productivity, it will be needed to improve the indigenous floating agriculture system through introducing modern technologies into production system. Practices of floating agriculture based modern technologies can remarkably increase the crop production as well as income generation particularly of the millions of flood affected farm households in Bangladesh.

The agricultural sector will face significant yield reduction and thus food- grain self-sufficiency will be at risk in future. The area is acutely vegetables deficit; malnutrition is widespread among the landless, marginal and small categories of farmers. Thus, homestead vegetables production can play a vital role in reducing malnutrition and create job opportunity for women. Every farm has a floating bed for seedling production and vegetable cultivation, but fish is not generally cultivated, hence intervention through modern technology could increase fish productivity through fish cage culture at waterlogged area and income of the farmers. Most of the cattle's are poor healthy due to worm and poor feeding. Through application of appropriate technology and creating awareness, productivity of this sector can also be improved. BARI, BFRI and BLRI have already developed some promising technologies of crops, livestock and fisheries which need to test and validate in the project area.

Considering the above-mentioned facts, a floating agriculture based integrated farming research and development program was undertaken in the view to increase the production of vegetables, spices, forage, livestock and fisheries through applying modern technologies.

Objectives

a) General objectives:

To improve livelihood of rural householders through generation and adaptation of floating agricultural based Farming System Technologies.

b) Specific objectives:

1. To generate floating agriculture based modern and appropriate technologies.
2. To develop quality seedling production and their management technologies of different crops (vegetables, spices, forage etc.) under floating agriculture system.
3. To increase the yield and economic return of floating agriculture through vegetables, spices, forage, livestock, fisheries and homestead gardening under integrated approach and adaptive capacity of the farmers/stakeholders through training, field day and other motivational activities.

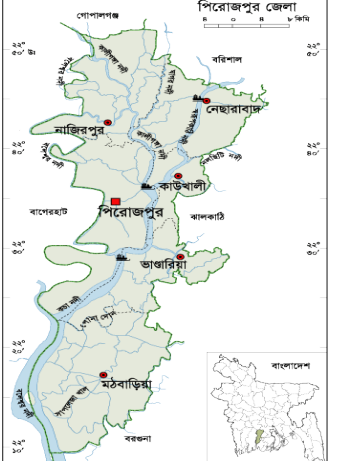
Methodology

The Floating agriculture based integrated farming research and development programs were executed at Floating ecosystem in southern belt of Bangladesh with the coordination between Bangladesh Agricultural Research Institute (BARI) and Palli-Bangla Unnayan Shahojogita Sangstha (PBUSS). For the successful implementation of the proposed integrated farming research and development program, the following methods were considered-

Location of the Project Site

The project activities were carried out in a participatory approach in the farmer's field under vulnerable eco-system in perennially waterlogged and flood prone areas of 5 Upazilas i.e. Nazirpur, Gopalganj Sadar, Kotalipara, Tungipara and Mollahat under 3 districts.

Districts	Upazilla	AEZ
Pirojpur	Nazirpur	AEZ 12, 14
Gopalganj	Gopalganj Sadar	AEZ 10, 12, 14
	Tungipara	AEZ 10, 12, 14
	Kotalipara	AEZ 12, 14
Bagerhat	Mollahat	AEZ 13, 14

		
Location of project site at Tungipara, Kotalipara, Gopalganj sadar under floating agriculture ecosystem	Location of project site at Nazirpur, Pirojpur under floating agriculture ecosystem	Location of project site at Mollahat, Bagerhat under floating agriculture ecosystem

Specific Methodology

The floating agriculture-based activities were executed at Floating eco-system during 2017-18 to 2020-21 to improve the indigenous floating agriculture system for livelihood improvement by generating modern technologies on floating agriculture and integrating farm resources. The project activities were carried out in a participatory approach in the farmer's field at 5 Upazilas i.e. Nazirpur, Gopalganj Sadar, Kotalipara, Tungipara and Mollahat. The land area of project site of each upazilla were maintained 12 farmers with 10-15 decimal of each farmer, where 6 farmers were small, and 6 farmers were marginal. A total of 120 farmers to be engaged and among them 60 farmers under OFRD, BARI and 60 farmers under PBUSS. Existing cropping pattern data were collected from farmers own practiced plot. Based on farmer's traditional practices, their needs and choices, several alternatives of technologies of crops, livestock, fisheries, off-farm activities, and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers-marginal and small having major components of farming including waterlogged land, dry land, sizeable homestead under single ownership were targeted and twelve farm households from each Upazilla were selected (Table I).

Table I. Selected farmer's information of different locations

FSRD site	No. of Farmer	Av. family size (no./farm)	Av. Waterlogged land size /farmer (deci)	Av. dry land size /farmer (deci)	Av. homestead area /farmer (deci)
Nazirpur, Pirojpur	12	4.67	27	184.33	13
Gopalganj Sadar	12	5.52	25	212.15	11
Tungipara, Gopalganj	12	5.75	24	220.25	10
Kotalipara, Gopalganj	12	5.61	15	215.31	12
Mollahat, Bagerhat	12	4.95	15	149.94	12
Average	12	5.30	21.20	196.40	11.60

Training program was arranged to buildup farmers capacity and to develop awareness regarding nutrition and crop production. A baseline survey was carried out before starting the project activities to document some baseline information, to know the present status of different crop production practiced by the farmers and also to explore the constraints and opportunities of the sample farmers for further expansion. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Floating bed and trellis, and dryland based crops and cropping system improvement through vegetables, spices, rice and fodder crop production and management, vaccination of poultry and livestock, rearing of poultry, pigeon and calf, fish culture in cage and open water, year round vegetables production in homestead, fruit tree management and new plantation and some off-farm activities were identified as their major potential area. The OFRD, BARI and PBUSS team facilitated the cooperators for technological intervention to maximize the productivity of the components. In conducting on-farm trials at dispersed locations, standard methodologies have followed (Zandstra, 1978). Data on environmental conditions, soil and hydrological conditions conforming growing of vegetables, pulses and forage, especially in the floating bed, varietal performance in terms of yield and yield attributing performance of improved technologies and farmers' reaction and overall impact on production etc. have been recorded. At the end of the project period, an independent impact assessment will be conducted. Data collected from different experiments have subjected to statistical analyses following statistical package MSTAT (C) and treatment means have compared with DMRT. However, component-wise methodologies were as follows-

A. CROPS AND CROPPING SYSTEM

The research program has planned and prioritized based on farmers' needs and local problems over the indigenous floating agriculture practices to generate of floating agriculture based modern/innovative technologies. In this respect, several research and development program have designed and executed on the following areas. Different types of vegetables and field crops were produced in floating bed, trellis, water succeeding land and dry land. Bed vegetables, spices and fodder crops were produced in year-round and seasonal floating bed where creeper vegetables were produced on trellis following variety screening, crop, fertilizer and pest management. Cropping pattern development, fertilizer management related research and development activities were conducted in water succeeding land and dry land. Different activities-wise details methodologies are given in the following part.

B. FISHERIES:

In general, farmers do not provide any management for fish culture in their waterlogged area, just harvest the naturally produced fish. The monoculture of Tilapia in cage fish culture system was introduced in the water body near the floating bed area with the objectives of increasing farmer's income and removing protein deficiency of rural people. Five fish cage (size: 20 × 10 × 6 feet) were provided for each of 12 household in each site. Twenty kg of monosex Tilapia fingerlings were release in each

cage. Besides of natural fish, about 100 kg of monosex Tilapia fingerlings were released in the open water body at each site.

C. LIVESTOCK

Livestock is an integral part of integrated farming and its productivity and profitability mostly depend on farm animal health. Cattle health may be improved through deworming which may make the farmer economically benefitted. After deworming, Vitamin A, D and E containing injections were also being injected in cattle. Proper vaccination against major diseases may reduce the mortality rate of cattle. For this purpose a short FGD was conducted to identify the disease severity and mortality after vaccination. In the vaccinated group Anthrax vaccine, Foot and mouth disease (FMD) vaccine were injected as per recommended schedule. Cattle fattening and Calf rearing programs were also continued at some areas. High yielding fodder crops have been adapted at farm level. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate a good number of poultry birds were vaccinated with BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague vaccine during the project period. Duck was provided to the farmers to rear in the waterlogged area under floating system. Besides, chick and pigeon rearing in homestead area have been strengthened with the help of department of Livestock.

D. COMPOSTING:

In case of floating system, the floating bed prepared with Water hyacinth is a good source of compost. After completed of crop production on floating bed, the decomposed Water hyacinth mud cum compost was used as organic manure in main land crops and homestead crops production. In case of homestead, besides of cattle product, Cowdung is very important by-product for integrated farming and farmers were motivated to use it for preparation of farm Yard manure (FYM) including other homestead wasteage instead of using the Cowdung as fuel.

E. HOME GARDEN:

Home garden is an area of land, individually owned, surrounding a house, and usually planted with a mixture of perennials and annuals. To establish homestead farming twelve households were selected based on their available resources and potentials at each location. The area under a homestead is a valuable asset for the resource poor farm household and suitable for production of different kinds of vegetables and fruits.

Vegetables: Based on farmers' choice and agro-ecological suitability, the vegetables production activities were done in different niches as bellow-

Table II. Round the year vegetables production at homestead area

Niche/space		Year-round homestead vegetables pattern		
		Rabi	Kharif-I	Kharif-II
1. Open sunny space	Bed 1	Red amaranth	Okra	Green amaranth
	Bed 2	Spinach	Indian spinach	Red amaranth
	Bed 3	Radish	Stem amaranth	Cucumber
	Bed 4	Seedling	Knolkhol	Knolkhol
	Bed 5	Batishak	Leafy Jute	Red amaranth
2. Fence		Country bean	Yard long bean	Yard long bean
3. Trellis		Bottle gourd/ Sweet gourd/ Country bean	Sweet gourd/Snake gourd/Ridge gourd/ Sponge gourd/Ash gourd	Sweet gourd
4. Tree support		Country bean	Sponge gourd	Sponge gourd
5. Backyard		Banana	Banana	Banana

Fruits: Based on farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied, and plantation were done in the homestead area and near by homestead area. Besides seven fruit seedlings like mango (var. BARI Aam-4, BARI Aam-11), Guava (var. BARI

Peyara-2), Sapota (var. BARI Sofeda-1), Malta (var. BARI Malta-1) and lemon (var. BARI Lebu-2) were supplied to each farmer. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program.

F. OFF-FARM ACTIVITIES:

The portion of farm household income obtained from off the farm is referred as Off-farm (non-farm) income. Off-farm activities are an important component for extra income generation. Some farm families' especially the women were engaged with off-farm activities. Mat (*Pati*) making with Hoglapata is a good source of extra income. Besides of this, sewing cloths, weaving *Katha* were practiced during their leisure periods and some men were engaged with Diar making with bamboo, rickshaw/van pulling etc.

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Floating agriculture based Integrated farming consists of several enterprises like crops and cropping system in floating bed and mainland, cattle and poultry, fishery, home gardening with vegetables and fruits, etc. and these enterprises are interrelated. The end product and wastage of one enterprise may use as inputs in another enterprise. Moreover, judicious use of farm resources may reduce production cost and can help to keep clean the environment. In integrated farming, the contribution of one component on other component ('s) is important consideration for sustainable farming. The main sector floating agriculture is interrelated with associate sector through sharing of compost, water, money energy etc.

Results and Discussion

Component of Floating Model: The low-lying areas of the southern region of Bangladesh remain fallow for long period (generally June-December) particularly in monsoon season due to flooding/submergence. The livelihoods of local people are leading a miserable life as most of them are struggling against poverty and malnutrition. From these views some initiatives were taken considering the existing resources of the local farmers. Effort was given to improve their agricultural and non-agricultural productivity under different components, i.e. Crops and cropping system (Floating bed of waterlogged land and main land), Fisheries (Cage culture and open water), Livestock (poultry in floating system and homestead area and cattle in homestead area), Composting (Floating system and homestead area), Home garden (Vegetables and fruits), and Off-farm activities. Component-wise research and development activities are discussed below-

A. CROPS AND CROPPING SYSTEM

1) Crops in floating system: The water-logged and low-lying areas are valuable assets for cultivation of high value crops in the Water hyacinth made floating bed and on trellis. The water body area besides of floating bed also may be the source of some vegetables.

a) Crop production in floating bed: In the floating bed, there were some research and development activities on vegetables, spices crops, fodder crops, and also on crop management and protection.

a1) Vegetables in floating bed: Different types of research and development activities on vegetables were conducted in floating bed focusing screening of vegetables, crop management considering nutrient and planting system, crop protection against pest and disease, floating bed standardization etc.

Activity 1: Screening and selection of different vegetables crops/varieties for floating agriculture system

Abstract: In *kharif* season of 2020-'21 four vegetable crops viz. Bottle gourd, Bitter gourd, Sweet gourd and Okra were cultivated in floating bed and in *rabi* season of 2020-'21 Broccoli, Cabbage, Cauliflower and Knolkhol were cultivated to observe their suitability and profitability. The experiment was conducted on Water hyacinth based floating bed at Tungipara and Kotalipara under Gopalganj district; Nazirpur under Pirojpur district and Mollahat, Bagerhat. Among these vegetables, Bottle gourd gave highest BCR at each location and it were 1.76 in Tungipara, Gopalganj; 1.72 in Kotalipara,

Gopalganj; 1.85 in Nazirpur, Pirojpur and 1.91 in Mollahat, Bagerhat. In *rabi* season of 2020-21, four vegetable crops (viz. Broccoli, Cabbage, Cauliflower and Knolkhol) were cultivated at same bed of same area to observe their suitability and profitability. Among the vegetables cauliflower gave highest BCR in each trial area and it was 1.81 76 in Tungipara, Gopalganj; 1.71 in Kotalipara, Gopalganj and 1.85 in Nazirpur, Pirojpur. At the same season the lowest BCR was recorded from cauliflower and it were 1.25 in Tungipara, Gopalganj; 1.13 in Kotalipara, Gopalganj; 1.22 in Nazirpur, Pirojpur.

Introduction: Vegetables are important part of healthy eating and provide a source of many nutrients, including potassium, fiber, folate (folic acid) and vitamins A, E and C. For each person is required to take 250g vegetables per day to get vitamins and minerals. Vegetables are mainly grown on high and medium high lands. But farmers living in the low-lying areas traditionally grow selected vegetables on Water hyacinth made floating bed during monsoon season. Under floating bed agriculture system, the farmers cultivate only a few numbers of vegetable crops. But the floating bed crops should be diversified to make profitable of the traditional floating agriculture practices. In this respect, adaptation of vegetables can be introduced in floating agriculture system. Therefore an experiment was undertaken with Indian spinach, Sweet gourd, Bottle gourd, Yard long bean, Cucumber, Okra and Bitter gourds for suitability on floating bed.

Materials and Methods: The experiment was carried out on Water hyacinth based floating bed at Tungipara and Kotalipara under Gopalganj district; Nazirpur under Pirojpur district and Mollahat, Bagerhat Ghatbila, Mollahat, Bagerhat during *rabi* and *kharif* season of 2020-'21. The size of each bed was 9.15m (30 feet) x 1.37m (4.5 feet). In *kharif* season four vegetables viz. Bottle gourd, Bitter gourd, Sweet gourd, Okra and in *robi* season four viz. Bottle gourd, Bitter gourd, Sweet gourd, Indian spinach, Sponge gourd and Cucumber were cultivated at floating bed. The sowing and transplanting date was 17/11/2020-02/12/2020 in *rabi* season and in *kharif* season on 25/07/2020-04/08/2020. The harvesting date were 25/01/2021-7/03/2021 in *rabi* season and 12/08/2020-07/11/2020 in *kharif* season in respect of different crop. In *kharif* season Bottle gourd, Bitter gourd, Sweet gourd and Okra were transplanted with the spacing of 2mx1m, 1mx1m, 2mx2m and 50 cm x25 cm. In *rabi* season Broccoli, Cabbage, Cauliflower and Knolkhol were transplanted at 60cmx40cm spacing. Diammonium 584 phosphate (DAP) was applied in liquid form @ 100g/L⁻¹ water. All kinds of intercultural operations were done as and when necessary. During the crop growing period insect and disease were controlled by applying bio pesticide. The cultivated crops with their varieties, sowing/planting date and harvesting date were given below:

Table 1: Crop, varieties, sowing/planting and harvesting date of different crops at different locations in *Kharif* season of 2020-'21 under floating agriculture system

Location	Crop	Variety	Date of sowing/planting	Date of harvesting
Tungipara, Gopalganj	Bottle gourd	BARI Lau-4	04/08/2020	27/09/2020-30/10/2020
	Bitter gourd	Tia	04/08/2020	02/10/2020-28/10/2020
	Sweet gourd	Sweety	04/08/2020	13/10/2019-03/11/2020
	Okra	Chyanika	25/07/2020	12/08/2020-07/11/2020
Kotalipara, Gopalganj	Bottle gourd	BARI Lau-4	04/08/2020	27/09/2020-30/10/2020
	Bitter gourd	Tia	04/08/2020	02/10/2020-28/10/2020
	Sweet gourd	Sweety	04/08/2020	13/10/2019-03/11/2020
	Okra	Chyanika	25/07/2020	12/08/2020-07/11/2020
Nazirpur, Pirojpur	Bottle gourd	BARI Lau-4	04/08/2020	27/09/2020-30/10/2020
	Bitter gourd	Tia	04/08/2020	02/10/2020-28/10/2020
	Sweet gourd	Sweety	04/08/2020	13/10/2019-03/11/2020
	Okra	Chyanika	25/07/2020	12/08/2020-07/11/2020
Mollahat, Bagerhat	Bottle gourd	BARI Lau-4	04/08/2020	27/09/2020-30/10/2020
	Bitter gourd	Tia	04/08/2020	02/10/2020-28/10/2020
	Sweet gourd	Sweety	04/08/2020	13/10/2019-03/11/2020
	Okra	Chyanika	25/07/2020	12/08/2020-07/11/2020
Range sowing/ transplanting date	-	-	25/07/2020-04/08/2020	12/08/2020-07/11/2020

Table 2: Crop, varieties, sowing/planting and harvesting date of different crops at different locations in *rabi* season of 2020-`21 under floating agriculture system

Location	Crop	Variety	Date of sowing/planting	Date of harvesting
Tungipara, Gopalganj	Broccoli	Green Carpet	17/11/2020	25/01/2021-07/02/2021
	Cauliflower	Snow box	17/11/2020	15/01/2021-30/01/2021
	Cabbage	Atlast-70	17/11/2020	23/02/2021-5/03/2021
	Knolkhol	Challenger	17/11/2020	07/02/2021-15/02/2021
Kotalipara, Gopalganj	Broccoli	Green Carpet	28/11/2020	05/02/2021-17/02/2021
	Cauliflower	Snow box	28/11/2020	17/02/2021-25/02/2021
	Cabbage	Atlast-70	28/11/2020	25/02/2021-03/03/2021
	Knolkhol	Challenger	28/11/2020	15/02/2021-07/03/2021
Nazirpur, Pirojpur	Broccoli	Green Carpet	02/12/2020	28/01/2021-13/02/2021
	Cauliflower	Snow box	02/12/2020	28/01/2021-12/02/2021
	Cabbage	Atlast-70	02/12/2020	25/02/2021-10/03/2021
	Knolkhol	Challenger	02/12/2020	18/02/2021-03/03/2021
Range sowing/ transplanting date	-	-	17/11/2020-02/12/2020	25/01/2021-7/03/2021

Results: In *kharif* season during 2020-`21 there were a significant difference was found in respect of yield and BCR (Table-3). There are four vegetable crops viz. Bottle gourd, Bitter gourd, Sweet gourd and Okra were tested in *kharif* season under this experiment. Among these vegetables, Bottle gourd gave highest BCR at each location and it were 1.76 in Tungipara, Gopalganj; 1.72 in Kotalipara, Gopalganj; 1.85 in Nazirpur, Pirojpur and 1.91 in Mollahat, Bagerhat. At the same time the lowest BCR was recorded from Bitter gourd and it were 0.87 in Tungipara, Gopalganj; 0.91 in Kotalipara, Gopalganj; 0.97 in Nazirpur, Pirojpur and 1.01 in Mollahat, Bagerhat.

Table 3. Yield and profitability of different crops at different locations in *Kharif* season of 2020-`21 under floating agriculture system

Locations	Crop	Yield (kg/bed)	Gross income (Tk/bed)	Total variable cost (Tk/bed)	Gross margin	BCR
Tungipara, Gopalganj	Bottle gourd	159	3180	1800	1380	1.76
	Bitter gourd	45	1575	1800	-225	0.87
	Sweet gourd	67	2010	1800	210	1.11
	Okra	72	2520	1800	720	1.40
Kotalipara, Gopalganj	Bottle gourd	155	3100	1800	1300	1.72
	Bitter gourd	47	1645	1800	-155	0.91
	Sweet gourd	69	2070	1800	270	1.15
	Okra	70	2450	1800	650	1.36
Nazirpur, Pirojpur	Bottle gourd	167	3340	1800	1540	1.85
	Bitter gourd	50	1750	1800	-50	0.97
	Sweet gourd	62	1860	1800	60	1.03
	Okra	68	2380	1800	580	1.32
Ghatbila, Mollahat, Bagerhat	Bottle gourd	172	3440	1800	1640	1.91
	Bitter gourd	52	1820	1800	20	1.01
	Sweet gourd	71	2130	1800	330	1.18
	Okra	72	2520	1800	720	1.40

Price (Tk/kg): Price (Tk/kg): Bottle gourd-20/-, Bitter gourd-35/-, Sweet gourd-30/- and Okra-35/-
Cost per bed (Tk/season): 1800/-

In *rabi* season 2020-`21, there were a significant difference was found among the tested vegetables (Broccoli, Cabbage, Cauliflower and Knolkhol) in respect of yield and BCR (Table-4). Among the

vegetables cauliflower gave highest BCR in each trial area and it was 1.81 76 in Tungipara, Gopalganj; 1.71 in Kotalipara, Gopalganj and 1.85 in Nazirpur, Pirojpur. At the same season the lowest BCR was recorded from cauliflower and it were 1.25 in Tungipara, Gopalganj; 1.13 in Kotalipara, Gopalganj; 1.22 in Nazirpur, Pirojpur.

Table 4. Yield and profitability of different crops at different locations in *rabi* season of 2020-`21 under floating agriculture system

Locations	Crop	Yield (kg/bed)	Gross income (Tk/bed)	Total variable cost (Tk/bed)	Gross margin	BCR
Tungipara, Gopalganj	Broccoli	55	2750	1800	800	1.25
	Cauliflower	75	2250	1800	450	1.81
	Cabbage	130	3250	1800	1450	1.72
	Knolkhol	155	3100	1800	1300	1.33
Kotalipara, Gopalganj	Broccoli	120	2400	1800	600	1.13
	Cauliflower	68	2040	1800	240	1.71
	Cabbage	123	3075	1800	1275	1.59
	Knolkhol	143	2860	1800	1060	1.27
Nazirpur, Pirojpur	Broccoli	114	2280	1800	480	1.22
	Cauliflower	73	2190	1800	390	1.85
	Cabbage	133	3325	1800	1525	1.48
	Knolkhol	145	2660	1800	860	1.22

Price (Tk/kg): price (kg/Tk) Broccoli =30/- Cauliflower = 25/- Cabbage =20/- Knolkhol= 20/-
Cost per bed (Tk): 1800/-

Conclusion: In *kharif* season of 2020-`21 Bottle gourd and in *rabi* season cauliflower gave highest profitability.

Farmers' opinion: Farmers are showed their interested to grow Bottle gourd in *kharif* season and cauliflower in *rabi* season on floating bed because of its higher profitability.

Activity 2. Performance of different turmeric varieties on floating agriculture system

Abstract: The experiment was carried out on Water hyacinth based floating bed at Kotalipara and Tungipara under Gopalganj district; Nazirpur under Pirojpur district and Mollahat, Bagerhat during the year of 2020-21. Under this experiment three turmeric varieties were used to evaluate their performance in floating bed viz. BARI Holud-3, BARI Holud-5 and local. In case of Kotalipara and Tungipara under Gopalganj district and Nazirpur under Pirojpur BARI Holud-5 gave highest yield and it were 155 kg, 176 kg and 160 kg/bed, respectively. Also the highest BCR were found from the same variety it were 2.28, 2.46 and 2.35, respectively. In case of Mollahat, Bagerhat the same variety BARI Holud-5 gave highest yield and BCR which were 135/bed and 1.99, respectively.

Introduction: Farmers living in the low-lying areas of Barisal, Gopalganj and Pirojpur districts traditionally grow selected vegetables and spice crops and their seedling on Water hyacinth made floating bed during monsoon season. As spice crop, only turmeric's grown on floating bed. The farmers generally produce the local variety of turmeric on floating bed. Bangladesh Agricultural Research Institute (BARI) has developed a good number of high yielding varieties of turmeric. However, BARI developed some turmeric varieties are yet not to be tested on floating bed. Therefore, the experiment has been undertaken to find out the suitable varieties of turmeric and to introduce chili varieties on floating bed condition.

Materials and Methods: The experiment was carried out on Water hyacinth based floating bed at Kotalipara and Tungipara under Gopalganj district; Nazirpur under Pirojpur and Mollahat under Bagehot district during the year of 2020-21. The size of bed was 9.15m x1.37m. BARI developed two turmeric varieties viz. BARI Holud-3, BARI Holud-5 and local were taken as treatment in the study. Rhizome of the turmeric varieties were sown on 14-30 July, 2020 in Gopalganj and 15-23 July, 2020 in Bagerhat with the spacing of 30cmx25cm. No insect pest was observed during the crop growing

period. All kinds of intercultural operations were done as and when necessary. The harvested date were 14-18 March 2021 in different locations.

Results and Discussion: Turmeric varieties like BARI Holud-3, BARI Holud-5 and local turmeric were grown on floating bed to find out the suitable turmeric variety (ies) in floating agriculture. In case of Kotalipara and Tungipara under Gopalganj and Nazirpur under Pirojpur district BARI Holud-5 gave highest yield it were 155 kg/bed, 167 kg/bed and 160 kg/bed, respectively where lowest yield were found local turmeric and it were 90 kg/bed, 93kg/bed and 84kg/bed, respectively (Table-1). The Highest Benefit Cost Ratio (2.28, 2.24 and 2.35, respectively) were also found in BARI Holud-5 and the lowest (1.32, 1.37 and 1.23, respectively) were found in local turmeric (Table-1). In case of Mollahat, Bagerhat the same trend was found in results, the highest yield (135 kg/bed) and BCR (1.99) were found from BARI Holud-5 (Table-2).

Table 1. Yield and profitability of different turmeric varieties grown on floating bed at Kotalipara and Tungipara under Gopalganj district and Nazirpur, Pirojpur during the year of 2020-'21

Location	Crop	Variety	Yield (kg/bed)	Gross income (Tk/bed)	Total cost (Tk/bed)	BCR
Kotalipara, Gopalganj	Turmeric	BARI Holud-3	145	7250	3400	2.13
		BARI Holud-5	155	7750	3400	2.28
		Local	90	4500	3400	1.32
Tungipara, Gopalganj	Termaric	BARI Holud-3	150	7500	3400	2.21
		BARI Holud-5	167	8350	3400	2.46
		local	93	4650	3400	1.37
Nazirpur, Pirojpur		BARI Holud-3	130	6500	3400	1.91
		BARI Holud-5	160	8000	3400	2.35
		local	84	4200	3400	1.23

Cost: Bed cost= 2800; Seed (5 kg) = 300; others cost (Tk/bed) = 300 and Price (tk/kg): Turmeric-50.

Table 2. Yield and profitability of different turmeric varieties grown on floating bed at Mollahat, Bagerhat during the year of 2020-21.

Crop	Variety	Yield (Kg/bed)	Gross return (Tk./bed)	Total cost (Tk./bed)	BCR
Turmeric	BARI Halud-3	120	6000	3400	1.76
	BARI Halud-5	135	6750	3400	1.99
	Local	79	3950	3400	1.16

Conclusion: Turmeric var. BARI Holud-5 gave higher yield at Tungipara and Kotalipara in Gopalganj; Nazirpur in Pirojpur and Mollahat in Bagerhat district.

Farmers' opinion: Farmers of Tungipara and Kotalipara in Gopalganj; Nazirpur under Pirojpur and Mollahat, Bagerhat district chose BARI Holud-5 for its higher yield and lucrative color.

Activity 3. Development of alternate cropping pattern through Boro-floating bed (Okra) -fallow against fallow-floating bed (Okra)-fallow

Abstract: An experiment was carried out to develop new cropping pattern at Kondorpogati, Kotalipara and Tungipara in Gopalganj and at Nazirpur in Pirojpur district during the year of 2020-'21. The aim of the study was to find out the suitable cropping pattern over the existing one. The cropping pattern *Boro-Floating bed-fallow* introduced against traditional cropping pattern *fallow-Floating bed-fallow*. The highest gross margin was obtained from improve pattern which were 339195 taka, while from the existing cropping pattern.

Materials and Methods: The experiment was conducted at Kotalipara and Tungipara in Gopalganj and Nazirpur in Pirojpur district during the year of 2020-21. Okra (Choyonika) were taken as test a crops in

existing cropping pattern where floating bed size was 9.15m x1.37m. In case of, alternate cropping pattern in *kharif* season Okra was cultivated in floating bed then in *Boro* season, SL-08 rice was cultivated in same land. Okra was transplanted from 25/07/2020 to 04/08/2020 and *Boro* rice was transplanted from 10-15 December 2020 in different locations. The harvested date of Okra was 12/08/2020-07/11/2020 and the rice was 25/04/2021 to 30/04/2021.

Results: There was a significant difference was found in existing and alternate cropping pattern in respect of yield and economics. In case of existing cropping pattern the average gross margin was found Tk. 214500 ha⁻¹ whereas from alternate cropping pattern the average gross margin was found Tk. 339195 ha⁻¹ (Table-2).

Table 1. Yield and economics of Fallow-Floating bed (Okra)-Fallow cropping pattern

Locations	Yield (kg/bed)	Yield (t/ha)	Gross income (Tk/ha)	Total variable cost (Tk/ha)	Gross margin
Tungipara, Gopalganj	72	23.76	831600	594000	237600
Kotalipara, Gopalganj	70	23.10	808500	594000	214500
Nazirpur, Pirojpur	68	22.44	785400	594000	191400
Average	70	23.1	808500	594000	214500

Price (Tk/kg): 35 Tk. Cost per bed (Tk/season): 1800/-

Table 2. Yield and economics of Boro-Floating bed (Okra) –Fallow cropping pattern

Location	Yield rice (t/ha)	Yield Okra (t/ha)	Total rice equivalent yield (t/ha)	Gross income (Tk/ha.)	Total cost variable (Tk/ha)	Gross margin (Tk/ha)	BCR
Tungipara, Gopalganj	9.68	23.76	42.94	1073500	706138	367362	1.52
Kotalipara, Gopalganj	9.50	23.10	41.84	1046000	706138	339862	1.48
Nazirpur, Pirojpur	9.25	22.44	40.66	1016500	706138	310362	1.44
Average	9.48	23.10	41.81	1045333.33	706138	339195.33	1.48

Price (Tk/ton): Rice-25000/- , Cost: (112138+594000) =706138

Conclusion: The introduced cropping pattern gave more benefit over the traditional cropping pattern to the farmers. The farmers obtained reasonable grain yield of Boro rice.

Farmers' opinion: Farmers are impressed with new cropping pattern, Boro-floating agriculture-fallow because they obtained more than one crop in the same field.

Activity 4. Improvement of agronomic management for vegetable crops through sowing and transplanting method

Abstract: The experiment was carried out at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur and Mollahat in Bagerhat district during the *rabi* and *kharif* season of 2020-21. The aim of the experiment was to evaluate the performance of sowing and transplanting method in vegetable crops on floating agriculture. Bottle gourd was cultivated under this experiment. The highest yield/bed 212.2 kg, 236.2 kg were found from transplanting method at *rabi* and *kharif* season, respectively also highest BCR 1.42 and 1.67 were found at *rabi* and *kharif* season from the same method while from sowing method yield 170.7kg, BCR 1.42 were found at *rabi* season and yield 199.9kg and BCR 1.67 were found at *kharif* season.

Introduction: Vegetables are important part of healthy eating and provide a source of many nutrients, including potassium, fiber, folate (folic acid) and vitamins A, E and C. Potassium may help to maintain healthy blood pressure. Dietary fiber from vegetables helps reduce blood cholesterol levels and lower risk of heart disease. Folate helps to body form healthy red blood cells. For this each person is required

to take 250g vegetables per day to get vitamins and minerals. Vegetables are mainly grown on high and medium high lands. But farmers living in the low-lying areas traditionally grow selected vegetables on Water hyacinth made floating bed during monsoon season. Under floating bed agriculture system, the farmers cultivate only a few numbers of vegetable crops. Farmers in this area normally grow vegetables specially gourd crops by direct sowing of seeds on floating bed. In this method they got low yield of the crops. But transplanting of the gourd crops have potentiality to give more yield. In this context the experiment was undertaken to find out the suitable planting method for higher yield.

Materials and Methods: The experiment was conducted on Water hyacinth based floating bed at Ghatbila, Mollahat, Bagerhat during rabi and kharif season in 2020-21. The size of each bed was 9.15mx 1.37m. Bottle gourd (variety-Tafsi) was taken as test plant under this experiment. Seeds and seedlings of the tested plants were sown and transplanted with the spacing of 2mx2m. Diammonium phosphate (DAP) was applied in liquid form @ 100g/L-1 water. All kinds of intercultural operations were done as and when necessary. During the crop growing period aphid, ants and caterpillars infestation were observed and these were controlled applying ektara, furadan 3G, mortar with the recommended dose, respectively. In case of disease, leaf spot and leaf rot were recorded and it was managed by spraying Tilt 250 EC @ 0.05ml/L-1. Date of sowing and harvesting at different season in different seasons are given in tabular form in below:

Table 1: The planting method and date of sowing, harvesting during the *kharif* season of 2020-21.

Name of locations	Planting method	Date of sowing / planting	Date of Harvesting
Tungipara, Gopalganj	Sowing	16/07/20	25/09/2020-22/10/2020
	Transplanting	„	30/09/2020-03/10/2020
Kotalipara, Gopalganj	Sowing	16/07/20	20/09/2020-18/10/2020
	Transplanting	„	02/10/2020-30/10/2020
Nazirpur, Pirojpur	Sowing	16/07/20	20/09/2020-18/10/2020
	Transplanting	„	25/09/2020-30/10/2020
Mollahat, Bagerhat	Sowing	10/07/20	20/09/2020-18/10/2020
	Transplanting	„	30/09/2020-30/10/2020
Range	-	10/07/20-16/07/20	20/09/2020-30/10/2020

Table 2: The planting method and date of sowing, harvesting during the *rabi* season of 2020-21.

Name of locations	Planting method	Date of sowing / planting	Date of Harvesting
Tungipara, Gopalganj	Sowing	23/11/18	15/02/2020-02/04/2020
	Transplanting	„	05/03/2020-23/04/2020
Kotalipara, Gopalganj	Sowing	23/11/18	10/02/2020-10/04/2020
	Transplanting	„	28/02/2020-30/04/2020
Nazirpur, Pirojpur	Sowing	23/11/18	13/02/2020-08/04/2020
	Transplanting	„	05/03/2020-23/04/2020
Mollahat, Bagerhat	Sowing	27/11/18	10/02/2020-10/04/2020
	Transplanting	„	03/03/2020-30/04/2020
Range	-	23/11/18-	15/02/2020-30/04/2020

Results: Two planting methods viz. sowing and transplanting were taken as treatment to find out the suitable one for Bottle gourd production on floating bed in *rabi* and *kharif* season during the year of 2020-21. There was a significant different found in respect yield, gross return and BCR. In kharif season of 2020-21 the highest mean yield, gross return and BCR were recorded from transplanting method and its were 212.20 kg, Tk. 3183.7 and 1.77, respectively at the same season its were found 170.7 kg, 2561.2 tk and 1.42 from sowing method (table-3). The same trend of results were observed in *rabi* season, the highest mean yield, gross return and BCR were also recorded from transplanting method and its were 236.2 kg, 3543.0 tk and 1.97, respectively while the lowest yield, gross return and BCR 199.9, Tk.2998.8 and 1.67 recorded from sowing method (able-4).

Table 3. Yield and profitability of different planting method of Bottle gourd in floating agriculture system at different locations in *kharif* season during 2020 -21.

Name of Locations	Yield (kg/bed)		Gross return (Tk./bed)		Total variable cost (Tk./bed)		Gross margin (Tk./bed)		BCR	
	S	T	S	T	S	T	S	T	S	T
Tungipara, Gopalganj	218	172.5	3270	2587.5	1800	1800	1470	787.5	1.82	1.44
Kotalipara, Gopalganj	201	165.5	3015	2482.5	1800	1800	1215	682.5	1.68	1.38
Nazirpur, Pirojpur	220	182.5	3300	2737.5	1800	1800	1500	937.5	1.83	1.52
Mollahat, Bagerhat	210	162.5	3150	2437.5	1800	1800	1350	637.5	1.75	1.35
Average	212.2	170.7	3183.7	2561.2	1800.0	1800.00	1383.7	761.2	1.77	1.42

*S=Sowing T=Transplanting, Price (Kg/tk): Bottle gourd 15/-; Cost per bed (Tk): 1800/-

Table 4. Yield and profitability of different planting method of Bottle gourd in floating agriculture system at different locations in *rabi* season during 2020-21.

Name of Locations	Yield (kg/bed)		Gross return (Tk./bed)		Total variable cost (Tk./bed)		Gross margin (Tk./bed)		BCR	
	S.	T.	S.	T.	S.	T.	S.	T.	S.	T.
Tungipara, Gopalganj	247.8	188.7	3717.0	2830.5	1800.0	1800.0	1917.0	1030.5	2.07	1.57
Kotalipara, Gopalganj	230.0	193.5	3450.0	2902.5	1800.0	1800.0	1650.0	1102.5	1.92	1.61
Nazirpur, Pirojpur	240.0	210.0	3600.0	3150.0	1800.0	1800.0	1800.0	1350.0	2.00	1.75
Mollahat, Bagerhat	227.0	207.5	3405.0	3112.5	1800.0	1800.0	1605.0	1312.5	1.89	1.73
Average	236.2	199.9	3543.0	2998.8	1800.0	1800.0	1743.0	1198.8	1.97	1.67

*S=Sowing T=Transplanting, Price (Kg/tk) : Bottle gourd 15/-; Cost per bed (Tk): 1800/-

Conclusion: Between sowing and transplanted of Bottle gourd, transplanting method showed better performance in respect of yield and profitability.

Farmers' opinion: Between two methods of planting, transplanting methods seems to better in respect of yield and profitability.

Activity 5. Integrated nutrient management of Okra under floating agriculture

Abstract: The experiment was carried out on Water hyacinth based floating bed at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur during *kharif* season of 2020-`21. The aim of the study was to observe the response of vegetables to macro- and micronutrient. Okra (variety-chyanika) was taken as vegetable crop. Four fertilizer doses were taken as treatment viz. T₁= N-P-K-S-Zn-B: 75-21-15-5-1-0.5 kg/ha, T₂= 75% of T₁, T₃= 50% of T₁ and T₄= Farmers' practice. The highest mean yield (68.3 kg/bed), gross margin (820 tk/bed) and BCR (1.45) were recorded from the bed where N-P-K-S-Zn-B were applied @ 75-21-15-5-1-0.5 kg/ha while the lowest yield (53.3 kg/ha), gross margin (255.00 tk/bed) and BCR 1.14 were found from farmers' practice where no fertilizer was applied.

Introduction: The farmers living in low-lying areas like Barisal, Pirojpur, Gopalganj and Bagerhat cultivate selected vegetables and spice crops on Water hyacinth made floating bed during monsoon. The traditional floating beds are built up with various types of local materials such as Water hyacinth, topapana and dulalilata (Islam and Atkins, 2007). The Water hyacinth contains smaller proportion of macronutrients (nitrogen 1.16%, phosphorus 0.09%, potassium 0.13%, calcium 1.02%, magnesium 0.15% and sulphur 0.69%)and trace amount of micronutrient (iron 1.57%, zinc 0.09% and copper 0.01%). Regarding the physical properties of Water hyacinth plants, the pH is somewhat acidic (pH 5.80) and water holding capacity is approximately 50% (Lekshmi and Viveka, 2011). But the nutrient content in Water hyacinth made floating bed is not enough to grow vegetables properly. It is evident that sometimes vegetables grown on floating bed show different nutrient deficiency symptom which

hamper the complete their life cycle. But research work has not yet been conducted to develop floating agriculture based nutrient management package for Okra. In this respect, the research has been undertaken to develop nutrient management package for Okra on Water hyacinth made floating bed.

Material and Methods: The experiment was carried out on Water hyacinth based floating bed at Ghatbila, Mollahat, Bagerhat during rabi season of 2020-'21. Nutrient element based four treatments viz. T_1 = N-P-K-S-Zn-B:75-21-15-5-1-0.5 kg/ha, T_2 = 75% of T_1 , T_3 = 50% of T_1 and T_4 = Farmers' practice (without fertilizer application) were applied to observe the response of the crop. The size of each bed was 9.15mx 1.37m. Okra (var. Chyanika) was taken as test plant. Seeds of Okra was sown on 20/07/2020-27/07/2020 with spacing of 30cmx25cm. All kinds of intercultural operations were done as and when necessary. During the crop growing period aphid, ants and caterpillars infestation were observed and these were controlled by using bio pesticide. The crop harvested from 12/08/2020 to 19/11/2020. The bed preparation cost is counted at half for one season.

Results and discussion: Fruit yield of Okra was influenced by different treatments presented in Table 1. The highest mean yield (68.3 kg/bed), gross margin (820 tk/bed) and BCR (1.45) were recorded from the bed where N-P-K-S-Zn-B were applied @ 75-21-15-5-1-0.5 kg/ha it followed by T_2 treatment. The lowest yield (53.3 kg/ha), gross margin (255.00 tk/bed) and BCR 1.14 were found from farmers' practice where no fertilizer was applied. Highest yield received from T_1 was due to its higher dose of fertilizer application where T_4 gave the lowest yield and it was because of did not apply any fertilizer. From this results, it is evident that yield increases with the increases of fertilizers.

Table 1. Yield and profitability influenced by different doses of fertilizers at different locations during the year of 2020-21.

Location	Yield Kg/bed				Gross return (Tk/bed)				Variable Cost (pre/bed)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Tungipara, Gopalganj	75	70	66	62	3000	2800	2640	2480	1810	1808	1806	1800
Kotalipara, Gopalganj	68	61	56	51	2720	2440	2240	2040	1810	1808	1806	1800
Nazirpur, Gopalganj	62	56	52	47	2170	1960	1820	1645	1810	1808	1806	1800
Mean	68.3	62.3	58.0	53.3	2630.0	2400.0	2233.3	2055	1810	1808	1806	1800

T_1 = N-P-K-S-Zn-B : 75-21-15-5-1-0.5 kg/ha, T_2 = 75% of T_1 , T_3 = 50% of T_1 and T_4 = Farmers' practice
Price: Okra-Tk. 35/kg; Cost/ bed:1800/-; Fertilizer cost T_1 =8/-, T_2 =6/-, and T_3 =4/- and T_4 =0.00/-.

Table 1 (Continued). Mean yield and profitability influenced by different doses of fertilizers at different locations during the year of 2020-21.

Location	Cross margin (Tk/bed)				BCR			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Tungipara	1190	992	834	680	1.66	1.55	1.46	1.38
Kotalipara	910	632	434	240	1.50	1.35	1.24	1.13
Nazirpur	360	152	14	-155	1.20	1.08	1.01	0.91
Average	820.00	592.00	427.33	255.00	1.45	1.33	1.24	1.14

T_1 = N-P-K-S-Zn-B : 75-21-15-5-1-0.5 kg/ha, T_2 = 75% of T_1 , T_3 = 50% of T_1 and T_4 = Farmers' practice
Price: Okra-Tk. 35/kg; Cost/ bed:1800/-; Fertilizer cost T_1 =8/-, T_2 =6/-, and T_3 =4/- and T_4 = 0.00/-.

Conclusion: Considering yield of Okra it could be concluded that T_1 (N-P-K-S-Zn-B:75-21-15-5-1-0.5 kg/ha) is the optimum dose for Okra cultivation in floating bed. Fruit yield was increased with the increased of both macro- and micronutrients.

Farmers' opinion: Results showed that crop yield increased with the increase of fertilizers where, N-P-K-S-Zn-B:75-21-15-5-1-0.5 kg/ha gave the highest yield and farmers opined that they would follow this fertilizer package for grow vegetables on floating bed.

Activity 6. Performance of trellis vegetables with intercrop of leafy vegetables on floating bed

Abstract: Four intercropping system viz. Bottle gourd + Red amaranth, Sweet gourd + Red amaranth, Cucumber + Red amaranth and Bitter gourd + Red amaranth were taken to test the suitability for intercrop in floating agriculture. The experiment was conducted at Kotalipara and Tungipara in Gopalganj, Nazirpur in Pirojpur and Mollahat, Bagerhat during 2020-'21. Among the four intercropping, Bottle gourd + Red amaranth found suitable in regards of its profitability. The highest mean gross margin (Tk 1205/bed) and BCR (1.63) were calculated from Bottle gourd+ Red amaranth intercropping while the lowest gross margin (Tk.-90/bed) and BCR (0.95) were recorded from Cucumber+ Red amaranth intercropping.

Introduction: Floating agriculture is a practice to grow crops especially vegetables for the utilization of water logging area. It is a conventional practice in southern part of Bangladesh where most of the land remains waterlogged for longer period of time. Different vegetable crops (Cucumber, Bottle gourd, Bitter gourd, Tomato, Brinjal, Snake gourd, Yard long bean etc.) are grown on floating bed under submerged ecosystem and it is a promising alternative method of vegetable production to meet the food security in the southern part of the country. Even though floating agriculture is an old practice but no research has been conducted on intercropping of vegetables. Vegetables which described above are sown and/or transplanted maintaining a certain spacing. But there is a scope to introduce short duration leafy vegetables to grow between spacing of the vegetables techniques of vertical expansion of crop production. It increases total productivity per unit area than sole cropping. Therefore, the present study was undertaken to observe the performance of intercropping against the conventional sole vegetable cultivation.

Materials and Methods: The experiment was carried out on Water hyacinth based floating bed at Ghatbila, Mollahat, Bagerhat during the 2018. The size of each bed was 9.15mx 1.37m. Five intercrop viz. Bottle gourd + Red amaranth, Sweet gourd + Red amaranth, Cucumber + Red amaranth and Bitter gourd + Red amaranth were tested in this study. Seeds and seedlings of the tested plants were sown and planted from 23/08/2020 to 26/08/2020. Bottle gourd, Sweet gourd, Cucumber, Bitter gourd and Yard long bean were transplanted with the spacing of 2mx1m, 2mx1m, 1mx1m, 1mx1m, 1mx1m, respectively and seeds of Red amaranth was broadcasted between spacing of two rows. Diammonium phosphate (DAP) was applied in liquid form @ 100g/L-1 water for all vegetables except Red amaranth. All kinds of intercultural operations were done as and when necessary. During the crop growing period aphid, ants and caterpillars infestation were observed and these were controlled by applying ektara, furadan 3G and mortar, respectively. In case of disease, leaf spot and leaf rot were recorded and it was managed by spraying know in @ 2mL/L-1. However, crops with their varieties, sowing/planting and harvesting date were given below in tabular form.

Table 1. Crop with their varieties, sowing/planting and harvesting date at different locations during the cropping season 2020-'21

Location	Treatments	Variety	Date of sowing/ planting	Harvesting date
Tungipara, Gopalganj	Bottle gourd+ Red amaranth	Modumoti+ BARI Lalshak-1	25/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 28/10/2020-23/12/2021
	Sweet gourd+ Red amaranth	BARI Sweet gourd-2+ BARI Lalshak-1	25/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-25/12/2021
	Bitter gourd+ Red amaranth	Tia + BARI Lalshak-1	25/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-22/12/2020
	Cucumber+ Red amaranth	Green line + BARI Lalshak-1	25/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 25/10/2020-23/12/2021
	Bottle gourd+ Red amaranth	Modumoti+ BARI Lalshak-1	26/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 22/10/2020-23/12/2021

Location	Treatments	Variety	Date of sowing/ planting	Harvesting date
Kotalipara, Gopalganj	Sweet gourd+ Red amaranth	BARI Sweet gourd- 2+Lalshak-1	26/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-25/12/2021
	Bitter gourd+ Red amaranth	Tia + BARI Lalshak-1	26/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-22/12/2020
	Cucumber+ Red amaranth	Green line+ BARI Lalshak-1	26/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 25/10/2020-23/12/2021
Nazirpur, Pirojpur	Bottle gourd+ Red amaranth	Modumoti+ BARI Lalshak-1	23/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 28/10/2020-23/12/2021
	Sweet gourd+ Red amaranth	BARI Sweet gourd- 2+Lalshak-1	23/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-25/12/2021
	Bitter gourd+ Red amaranth	Tia + BARI Lalshak-1	23/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-22/12/2020
	Cucumber+ Red amaranth	Green line + BARI Lalshak-1	23/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 25/10/2020-23/12/2021
Mollahat, Bagerhat	Bottle gourd+ Red amaranth	Modumoti+ BARI Lalshak-1	24/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 28/10/2020-23/12/2021
	Sweet gourd+ Red amaranth	BARI Sweet gourd- 2+Lalshak-1	24/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-25/12/2021
	Bitter gourd+ Red amaranth	Tia + BARI Lalshak-1	24/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 30/10/2020-22/12/2020
	Cucumber+ Red amaranth	Green line + BARI Lalshak-1	24/08/2020	Red amaranth: 25/09/2020-30/09/2020 Bottle gourd: 25/10/2020-23/12/2021

Results and discussion: Four trellis vegetables were evaluated to observe their suitability and profitability with intercrop of Red amaranth in Water hyacinth made floating bed. Yield and profitability of the crops are presented (Table 2). Among the four intercropping Bottle gourd found + Red amaranth suitable its yield and profitability. The highest mean gross margin (Tk.1205 tk/bed) as well as BCR (1.63) was calculated from Bottle gourd and Red amaranth intercropping it followed by Cucumber+ Red amaranth intercropping which gross margin and BCR were 967.5 tk/bed and 1.51, respectively. The highest mean gross margin and BCR were found from Bottle gourd and Red amaranth intercropping might be due to higher yield of Bottle gourd. The lowest gross margin (Tk -90/bed) and BCR (0.95) was recorded from Bitter gourd + Red amaranth intercropping.

Table 2. Mean yield and profitability of the different trellis vegetables intercropped with Red amaranth in floating bed at different locations during *Kharif* 2020 -'21

Treatments	Locations	Yield (kg/bed)		Gross return (Tk/bed)	TVC (Tk/bed)	GM (Tk/bed)	BCR
		Trellis Vegetables	Red amaranth				
Bottle gourd+ Red amaranth	Tungipara	165	53	3270	1900	1370	1.721
	Kotalipara	150	48	2970	1900	1070	1.563
	Nazirpur	155	44	2985	1900	1085	1.571
	Bagerhat	170	43	3195	1900	1295	1.682
	Mean	160	47	3105	1900	1205	1.634
Sweet gourd+ Red amaranth	Tungipara	120	47	3105	1900	1205	1.634
	Kotalipara	125	43	2520	1900	620	1.326
	Nazirpur	123	45	2520	1900	620	1.326
	Bagerhat	138	48	2790	1900	890	1.468
	Mean	126.5	45.75	2733.75	1900	833.7	1.439

Bitter gourd+ Red amaranth	Tungipara	47	53	1735	1900	-165	0.913
	Kotalipara	52	48	1760	1900	-140	0.926
	Nazirpur	49	58	1850	1900	-50	0.974
	Bagerhat	55	53	1895	1900	-5	0.997
	Mean	50.75	53	1810	1900	-90	0.953
Cucumber+ Red amaranth	Tungipara	108	55	2985	1900	1085	1.571
	Kotalipara	115	43	2945	1900	1045	1.550
	Nazirpur	107	45	2815	1900	915	1.482
	Bagerhat	104	43	2725	1900	825	1.434
	Mean	104	43	2867.5	1900	967.5	1.51

Cost/bed: 1900/-

Price (Tk/kg): Bottle gourd-15, Sweet gourd-20, Cucumber 15, Bitter gourd 20, Red amaranth 15. Cost: Bamboo-Tk. 900/bed and Labour=Tk. 1000/bed

Conclusion: Among the four intercropping system, Red amaranth with Bottle gourd was more suitable in the context of the yield and profitability.

Farmers' opinion: Farmers and their neighbor's choose Bottle gourd+ Red amaranth intercrop for its best performance in respect of gross margin with BCR.

Activity 7. Performance of different seedling production in floating bed

Abstract: Bottle gourd and Country bean seedling were grown on Water hyacinth made floating bed at Nazirpur, Pirojpur during the year of 2020-21. The highest gross margin (Tk.8000/bed) and BCR (2.33) found from Bottle gourd seedling bed whereas 6000/- gross margin and 2.00 BCR was found from Country bean seedling bed.

Materials and method: The experiment was carried out on Water hyacinth based floating bed at Nazirpur, Pirojpur during the year of 2020-21. The size of each floating bed was 60 feet x 4.5 feet. Two vegetables viz. Bottle gourd and Country bean were taken as test crops. Seeds of the tested crops were sown in 3 time from 15 September to 12 December 2020. All kinds of intercultural operations were done as and when necessary.

Result: Both crops were suitable with regards to their growth and economic return (Table 1). The highest gross margin (Tk. 8000/bed) and highest benefit cost ratio (2.33) was calculated from Bottle gourd seedling. It was because of its higher market price. The lowest gross margin (Tk. 6000/bed) and BCR (2.00) was recorded from Country bean may be due to its lower market price.

Table 1. Seedling no. and profitability of Bottle gourd and Country bean at Nazirpur, Pirojpur during the year of 2020-'21

Location	Name of the Crop	No. of grown Seedling/bed in season	TVC	Gross return	Gross margin	BCR
Tungipara , Gopalganj	Bottle gourd	700x4=2800	6000	14000	8000	2.33
	Country bean	1000x4=4000	6000	12000	6000	2.00

Market price of seedling: Bottle gourd 5tk/seedling at Bagerhat and 4/- at Gopalganj and Bean 4 tk /seedling.

Conclusion: Above the result it concluded that, seedling production is very profitable on floating bed. SO, the farmers and their neighbor showed their interest to production of seedling on floating bed.

Activity 8. Performance of different vegetables with residue of floating bed in dry land.

Abstract: Winter vegetables viz. Broccoli, Cauliflower, Knolkhol, Cabbage, Red amaranth and Spinach were cultivated by using residue of floating bed at Tungipara and Kotalipara in Gopalganj district and Nazirpur, Pirojpur to observe their suitability and profitability. Among the vegetables, cauliflower gave the highest mean gross margin (618400.00/ha) and BCR (3.30) which followed by

Broccoli with gross margin 396300.00/ha and BCR 2.48. At the same time the lowest gross margin (83300 tk) and BCR (1.69) were recorded from Red amaranth.

Introduction: In Gopalganj and some parts of Pirojpur district, farmers like to grow vegetables on floating bed during rainy season as the low lying area of land become inundated by water on that time. This practice help them to utilize the fallow land and with cash flow. In winter season they also cultivate vegetables in dry land but if they use the residue of floating bed that have been used for crop production during rainy season, the production of winter vegetable will be higher and will help the farmers with more cash as the residue work as a bio fertilizer which make the soil more fertile with various nutrients.

Materials and Methods: The cultivation program was carried out in dry land at Kotalipara, Tungipara under Gopalganj district and at Nazirpur under Pirojpur district during the year of 2020-'21. Different vegetables like Broccoli, Cabbage, Cauliflower, Kolkhol, Red amaranth and Spinach were cultivated altogether in same piece of land using the residue of floating bed. Intercultural operation and pest management was done where and when necessary. Date of sowing/ transplanting and harvesting and crop variety was given below in table-1.

Table 1. Crop with their varieties, sowing/planting and harvesting date of different locations during the *rabi* season 2020-'21

Locations	Crop	Varieties	Date of sowing/ planting	date of harvesting
Tungipara, Gopalganj	Broccoli	Green Carpet	20/11/2020- 30/11/2020	02/01/21-17/03/21
	Cabbage	Atlas-70		
	Cauliflower	Snow white		
	Knolkhol	Challenger		
	Red amaranth	BARI Lalshak-1		
	Spinach	BARI Palongsak-1		
Kotalipara, Gopalganj	Broccoli	Green Carpet	20/11/2020- 5/12/2020	20/01/21-25/03/21
	Cabbage	Atlas-70		
	Cauliflower	Snow white		
	knolkhol	Challenger		
	Red amaranth	BARI Lalshak-1		
	Spinach	BARI Palongsak-1		
Nazirpur, Pirojpur	Broccoli	Green Carpet	20/11/2020- 5/12/2020	5/01/21-25/03/21
	Cabbage	Atlas-70		
	Cauliflower	Snow white		
	Knolkhol	Challenger		
	Red amaranth	BARI Lalshak-1		
	Spinach	BARI Palongsak-1		

Results and Discussion: There were a difference found among the cultivated vegetable in respect of yield, gross margin and BCR (Table-2). The yield of Broccoli, Cabbage, Cauliflower, Knolkhol, Spinach, and Red amaranth were 22.16 t/ha, 30.59 t/ha, 29.56 t/ha, 28.57 t/ha, 13.55 t/ha and 18.08 t/ha, respectively. The highest gross margin (618400 tk./ha) and BCR (3.30) were obtained from cauliflower while the lowest gross margin (38300 tk./ha) and BCR (1.69) were obtained with Red amaranth.

Table 2. Mean yield and profitability of the different winter vegetables cultivated by using floating bed residue in dry land during the *rabi* season of 2020 -'21

Treatments	Production areas	Yield (t/ha)	Gross return (Tk/ha.)	TVC (Tk/ha.)	Gross margin (Tk/ha.)	BCR
Broccoli	Tungipara	23.2	696000	268500	427500	2.59
	Kotalipara	22.1	663000	268500	394500	2.47
	Nazirpur	21.18	635400	268500	366900	2.37
	Mean	22.16	664800	268500	396300	2.48
Cabbage	Tungipara	30.4	608000	268500	339500	2.26
	Kotalipara	32.12	642400	268500	373900	2.39

Treatments	Production areas	Yield (t/ha)	Gross return (Tk/ha.)	TVC (Tk/ha.)	Gross margin (Tk/ha.)	BCR
Cauliflower	Nazirpur	29.24	584800	268500	316300	2.18
	Mean	30.59	611733.33	268500.0	343233.33	2.28
	Tungipara	31.16	934800	268500	666300	3.48
	Kotalipara	28.25	847500	268500	579000	3.16
	Nazirpur	29.28	878400	268500	609900	3.27
Knolkhol	Mean	29.56	886900.0	268500.0	618400.00	3.30
	Tungipara	30.25	605000	268500	336500	2.25
	Kotalipara	27.18	543600	268500	275100	2.02
	Nazirpur	28.28	565600	268500	297100	2.11
	Mean	28.57	571400.00	268500.00	302900.00	2.13
Red amaranth	Tungipara	13.68	205200	120000	85200	1.71
	Kotalipara	12.49	187350	120000	67350	1.56
	Nazirpur	14.49	217350	120000	97350	1.81
	Mean	13.55	203300.00	120000.0	83300.00	1.69
	Tungipara	16.48	197760	120000	77760	1.65
Spinach	Kotalipara	18.08	216960	120000	96960	1.81
	Nazirpur	19.48	233760	120000	113760	1.95
	Mean	18.01	216160.00	120000.0	96160.00	1.80

Price (Tk/kg): Broccoli=30, Cabbage=20, Cauliflower = 25, Kolkhol =15, Red amaranth = 15 and Spinach = 12.

Production cost of Broccoli, Cabbage, Cauliflower and Knolkhol : Labor (tk/ha) = 190000/-, Fertilizer= 30000/- Pesticide (tk/ha) = 20000,

Seed (tk/ha): Broccoli-28500, Cabbage = 16625, Cauliflower = 28500, Knolkhol = 11475

Production cost of red amaranth and spinach: Labour -90000, Fertilizer= 10000/- Seed (tk/ha)- Red amaranth= 10000 /-, Spinach=10000/-.

Conclusion: Cultivation of cauliflower and broccoli with residue of floating bed in dry land is better because of its highest yield and gross return.

Farmers' opinion: Farmers of all locations showed their interest to cultivate cauliflower and broccoli with residue of floating bed in dry land due to its higher profit than others vegetables.

Activity 9: Performance of fish production in open water body

About 200 kg fingerlings of Tilapia fish were released in open water body at each location. Besides of limited released Tilapia fish there were also existing vast natural fish like Climbing fish, Catfish, Snakehead murrel, Spotted Snakehead, Eel, etc., which was partial source of fish for consumption and sell in the market.

Table 1. Yield and profitability of fish produced naturally in open water

Types of natural fish	Total amount of released Tilapia fish fingerlings (Kg)	Amount of harvested fish (kg/dec)	Gross Return (Tk./dec)	TVC	Gross Margin
Climbing fish (Koi mash), Catfish, Snakehead murrel, Spotted Snakehead, Eel, etc.	950	2.5	900	No-cost	900

C. LIVESTOCK

1) Livestock in floating system: The water around the floating bed and open places is the suitable place for Duck rearing.

a) Duck rearing: Farmers were encouraged to rear Duck using the water resource and for this regard Ducklings were provide to the cooperative farmers.

Activity 10: Duck rearing under floating system

Among twelve cooperator farmers at each location under 5 upazilla were provided with Ducks according to their accommodation facilities. The provided Ducks were mostly reared depending on their waterlogged area. Table-10 shows the average number of Duck survive, body weight after eight months, monthly egg production and monthly income per farmer per location. The average body weight obtained from those Ducks was about 1.75 kg. The monthly income obtained from egg per household per bird was calculated and it was about Tk. 115 (Table 1).

Table 10. Average performance of improved breeds of Duck per location under floating system

No. of farmer involved	Total No. of birds supplied	No. of Ducks survive	Rearing period (up to reporting)	Initial body weight/Duck (g)	Body wt. after rearing period/Duck (kg)	No of egg laid/month/Duck	Monthly income (Tk/Duck)	Monthly income (Tk/household)
12	60	55	5 months	95	1.75	12	115	500

2) Livestock in homestead: Farmers are used to rear cattle and poultry in their homestead area. But in generally they do not take care them properly especially vaccination.

a) Vaccination and de-worming program on cattle: Vaccination and de-worming program was conducted with Cow, buffalo, Goat etc.

Activity 11: Vaccination and de-worming program on cattle

Vaccination and de worming technologies were done for adopt with minimum cost involvement in 2018-19, 2019-20 and 2020-21. That's why the cooperator farmers were interested and adopted this technology as per routine work. The information on number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and dates of vaccination are presented in Table 1. A good number of cattle were dewormed under deworming program such as 206, 68, 80, 154 and 125 were dewormed during the program in Gopalganj, Tungipara, Kotalipara, Nazirpur and Mollahat, respectively. The names of vaccine under vaccination program are also given in Table 1. The number of different types of vaccinated livestock are as 600, 250, 300, 600 and 120 during the program in Gopalganj, Tungipara, Kotalipara, Nazirpur and Mollahat, respectively. Frequency of diseases was listed among the livestock of cooperative farmers. It is found that, before de-worming and vaccination frequency of different diseases was higher. After deworming and vaccination of cattle, all of the diseases frequency reduced remarkably (Table 2).

Table 11a: Deworming and vaccination activities livestock under livestock program during the year of 2020-21

Location	De worming of cattle (No.)	Vaccination of cattle (No.)	Name of vaccination
Tungipara	140	140	FMD, PPR, HS, BQ
Kotalipara	100	100	Do
Gopalganj sadar	120	120	Do
Nazirpur	150	150	Do
Mollahat	125	125	Do

Table 11b. Livestock diseases occurred in the study area (before and after vaccination)

Location	Before vaccination (%)						After vaccination (%)					
	Anthra x	FMD	Choler a	PPR	HS	BQ	Anthra x	FMD	Choler a	PPR	HS	BQ
Gopalganj sadar	5	15	5	20	2	3	1	×	2	7	0	1
Tungipara	5	12	5	22	3	4	1	×	3	6	0	2
Kotalipara	5	10	6	12	3	5	2	1	2	6	0	1
Nazirpur	8	15	4	22	5	4	1	2	3	5	0	2
Mollahat	6	12	5	22	3	4	1	×	3	4	0	2

b) Vaccination of poultry: Vaccination program was conducted with hen, Duck, pigeon etc.

Activity 12: Vaccination program of poultry

Poultry vaccination program was performed at Gopalganj sadar, Tungipara, Kotalipara and Nazirpur (Table 22a). Three different vaccines (BCRDV, RDV and Duck plague) were used to implement the program. It is revealed from the conducted program results that, mortality rate can be minimized significantly through vaccination. Mortality rate went below 12% in maximum cases which can be considered as negligible comparing to the condition before the vaccination program.

Table 12. Number of vaccinated birds and mortality rate before and after vaccination at different locations during the year of 2020-21.

Name of the Vaccine	Vaccinated Sites	No. of birds vaccinated	Mortality before vaccination (%)	% Mortality after vaccination	Mortality reduce (%)
BCRDV (Chicken)	Tungipara, Gopalganj	350	20	5	75.00
	Kotalipara, Gopalganj	250	20	5	75.00
	Sadar, Gopalganj	280	20	5	75.00
	Nazirpur, Pirojpur	250	25	5	80.00
	Mollahat, Bagerhat	200	20	4	80.00
	Average	266	21	4.8	77.00
RDV (for Hen)	Tungipara, Gopalganj	250	22	3	86.36
	Kotalipara, Gopalganj	200	200	3	88.00
	Sadar, Gopalganj	250	25	5	80.00
	Nazirpur, Pirojpur	200	20	3	85.00
	Mollahat, Bagerhat	80	25	2	92.00
	Average	196	58.4	3.2	86.27
Duck plague (for Duck)	Tungipara, Gopalganj	250	20	5	80.00
	Kotalipara, Gopalganj	250	25	5	80.00
	Sadar, Gopalganj	280	25	5	80.00
	Nazirpur, Pirojpur	300	25	5	80.00
	Mollahat, Bagerhat	250	22	5	77.27
	Average	266	23.4	5	79.45

c) Hen rearing: Sonali breed hen was supplied to the cooperative farmers for rearing in semi-scavenging system.

Activity 13: Poultry rearing at homestead level

A total of 600 chickens were distributed among the 60 farmers of five upazila in three districts (Tungipara, Kotalipara, and Gopalganj Sadar, Gopalganj; Mollahat, Bagerhat and Nazirpur, Pirojpur). Each farm household received 10 chicks. Table 13 shows the average body weight at initial and after six months. The average body weight obtained from those chicks was about 1.60 kg with the average gross margin Tk. 1730 per farmer.

Table 13. Average performance of improved breeds of chicken per location at homestead area

Activities	Gopalganj sadar	Tungipara	Kotalipara	Nazirpur
Breed	Sonali	Sonali	Sonali	Sonali
Rearing period (up to reporting)	07/02/2019	06/02/2019	07/02/2019	10/02/2019
Number of farmers	12	12	12	12
No of birds supplied	120	120	120	120
Date of supplied period	07/02/19	06/02/2019	07/02/2019	10/02/2019
Initial wt/bird (kg)	500gm	500gm	500gm	500gm
Initial value /bird(Tk.)	180/-	180/-	180/-	180/-
Date of delivery egg	17/06/2019	10/06/2019	20/06/2019	25/06/19
Feed Supplements bird/day (g.)	100gm	100gm	100gm	100gm
Feed Supplements cost /bird/day(Tk.)	5/-	5/-	5/-	5/-
No of egg/ bird	170/-	180/-	180/-	175/-
Total value of egg/bird (Tk.)	13600/-	14400/-	14400/-	1400/-
Present wt/bird (kg)	1.60	1.50	1.70	1.60
Weight gained / bird (kg)	3.10	2.80	2.80	3.00
Cost/farmer in Tk.(Feed cost/farm)	15250	15250	15250	15250
Total variable cost (Tk)	17050/-	17050/-	17050/-	15050/-
Total return/farmer in Tk. (Market value of egg+ Meat)	18560	18600	19160	18800
Gross margin (Tk.)	1510	1550	2110	1750

d) Pigeon rearing: Pigeon was supplied to the cooperative farmers for rearing in homestead area for some extra income.

Activity 14: Pigeon rearing at homestead level

A total of 600 chick was distributed among the 60 farmers of five upazila in three districts (Tungipara, Kotalipara, and Gopalganj Sadar, Gopalganj; Mollahat, Bagerhat and Nazirpur, Pirojpur). Each farm household received 10 chicks.

D. COMPOSTING

1) Compost of floating bed: Floating bed is prepared with Water hyacinth, which is an excellent source of compost.

Activity 15: Compost production under floating system

The residue of Water hyacinth made floating bed is a good source of compost. It is a valuable resource for field crop production as organic manure. In different sites, the compost is now used for crop production as its production increased. Previously, farmers do not prepare floating bed in all their waterlogged area, but now they are practiced to make floating bed with Water hyacinth to produce vegetables, which is the main reason for increasing compost production. Semi dry compost produced

per farmer ranged 4.02 to 10.24 t/farmer, where maximum produced in Nazirpur and minimum at Mollahat (Table 15). The compost production increased 242 to 400% over the location.

Table 15. Av. performances of compost production from floating bed of a farmer at different locations

Location	Av. waterlogged land/farmer (dec.)	Av. Floating bed/farmer (no.)	Av. semi dry compost produced/farmer after intervention (ton)	Av. semi dry compost produced/farmer before intervention (ton)	Av. composed production increased (%)
Nazirpur	27	50	36.18	10.24	253
Gopalganj Sadar	25	45	33.50	6.70	400
Tungipara	24	43	32.16	7.43	332
Kotalipara	15	27	20.10	5.88	242
Mollahat	15	27	20.10	4.02	400

2) Farm Yard Manure (FYM): Household wastage, which is negligible to most of the farm household, is a valuable resource for homestead and field crop production through preparing as manure. Farm Yard manure produced in well managed compost pit was found very important nutrient source for crop production especially for homestead vegetables and fruits production.

Activity 16: Performance of farm Yard manure production at homestead level

Previously, most of the Cowdung was used as fuel and very few was used for farm Yard manure production, whereas after project intervention, most of the Cowdung and household wastage are using for FYM production. It was found that on an average 1850 kg FYM was produced per homestead after program intervention where it was only 1200 kg before intervention (Table 26a). It may also help to keep clean the environment of the homestead area and to produce relatively safe vegetables.

Table 16. Av. performances of FYM production from a homestead per year over the location

Total compost produce (kg/homestead/yr)			Use for crop production (kg/farmer/yr)		Distribution (kg/farmer/yr)	
Before intervention	After intervention	Increased (%)	Before intervention	After intervention	Before intervention	After intervention
1200	1850	54	950	1850	0	0

E. HOME GARDEN

1) Vegetable's production system: The area under a homestead is a valuable asset for the resource poor farm household and suitable for production of different kinds of vegetables.

Activity 17: Round the year vegetables production at homestead area

Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetable. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, about five niches were utilized for vegetables production round the year (Table II). After intervention of the proven and improved technologies in the homestead, vegetable production has increased significantly, and the most remarkable change was observed in case of bed vegetables produced at open sunny place (Table 27a). It was observed that the average vegetable production of all sites was maximum (151 kg/homestead) in *Rabi* season followed by *Kharif-2* (102 kg/homestead) and *Kharif-1* (98 kg/homestead) season (Table 27a). Individual site wise results showed that maximum vegetables were produced during *Rabi* season at all sites. *Kharif-1* season was found a dull season for vegetable production at all sites. However, round the year total vegetable produced maximum at Tungipara (428 kg/homestead) followed by Gopalganj sadar (356

kg/homestead) and minimum at Kotalipara (280 kg/homestead). After intervention of the improved technologies, vegetable production was increased maximum at Tungipara (229%) and minimum at Kotalipara (94%) compared to before intervention of the program (Table 27a). The remarkable increment of vegetable production in homestead area might be enhanced by using more production niches, improved technologies and judicious time management.

Table 17a. Season-wise vegetables production in kg per homestead at different location

Location	Year-round homestead vegetables production (Kg/homestead)			Total vegetables production (Kg/homestead)		Production increased (%)
	Rabi	Kharif-1	Kharif-2	AI	BI	
Nazirpur	148	96	100	344	160	115
Gopalganj Sadar	153	100	103	356	145	146
Tungipara	184	120	124	428	130	229
Kotalipara	120	78	81	280	144	94
Mollhat	148	96	100	344	135	155
Average	151	98	102	350	143	145

Utilization of vegetable: The disposal pattern of different vegetable produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetable varied with different locations and amount of total vegetable production (Table 27b). The average vegetable intake per year per farm family was 172 kg after program intervention and the increment was 139%, whereas intake was only 73 kg per farm family per year before program intervention from homestead source. Individual site wise intake of vegetables per year per farm family was 150, 180, 200, 140 and 190 kg after project intervention, whereas it was 80, 70, 75, 74 and 65 kg before intervention in case of Nazirpur, Gopalganj sadar, Tungipara, Kotalipara and Mollahat, respectively. Vegetables intake by a member of 5 member's farm family was increased remarkably and the vegetable intake per head was on an average 82, 99, 110, 77 and 104 g/head/day in case of Nazirpur, Gopalganj sadar, Tungipara, Kotalipara and Mollahat, respectively. Per head vegetable intake increased maximum at Mollahat (192%) and minimum at Nazirpur (88%). After program intervention, the distribution of vegetable per year was recorded as 40, 42, 50, 45 and 50 kg and sell of vegetable per year was 154, 134, 178, 95 and 104 kg in case of Nazirpur, Gopalganj sadar, Tungipara, Kotalipara and Mollahat, respectively. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables (Table 27b). The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Table 17b: Homestead vegetable production and utilization pattern (Before and after intervention)

Location	Total production (Kg)		Disposal pattern of vegetables (kg/homestead/year)						Consumption increase (%)	Cash income from sell only (Tk.)
			Consumption (g/head/day)		Distribution		Selling			
	BI	AI	BI	AI	BI	AI	BI	AI		
Nazirpur	160	344	80 (44)	150 (82)	20	40	60	154	88	1200
Gopalganj Sadar	145	356	70 (38)	180 (99)	15	42	60	134	157	1200
Tungipara	130	428	75 (41)	200 (110)	25	50	30	178	167	600
Kotalipara	144	280	74 (41)	140 (77)	26	45	44	95	89	880
Mollhat	135	344	65 (36)	190 (104)	35	50	35	104	192	700
Average	143	350	73 (40)	172 (94)	24	45	46	133	139	920

Note: BI= Before intervention, AI= After intervention.

Income: After program intervention, from the vegetable production, the gross return per farm was recorded as Tk. 6880, 7120, 8560, 5600 and 6880 at Nazirpur, Gopalganj sadar, Tungipara, Kotalipara and Mollahat, respectively with the average gross return of Tk. 7008, where it was only Tk. 2856 before intervention (Table 27c). The gross margin attained from vegetable sector after program intervention as Tk. 5340, 5790, 7180, 4120 and 5355 at Nazirpur, Gopalganj sadar, Tungipara, Kotalipara and Mollahat, respectively with the average gross margin of Tk. 5557 and the average increment of 142%.

Table 17c: Cost and return analysis of vegetables production in a homestead per year at different location (before and after intervention)

Location	Before intervention (Tk)			After intervention (Tk)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Nazirpur	3200	670	2530	6880	1540	5340	111
Gopalganj Sadar	2900	455	2445	7120	1330	5790	137
Tungipara	2600	475	2125	8560	1380	7180	238
Kotalipara	2880	650	2230	5600	1480	4120	85
Mollahat	2700	550	2150	6880	1525	5355	149
Average	2856	560	2296	7008	1451	5557	142

Note: GR = gross return; TVC = total variable cost; GM = gross margin

2) Fruits production system: The area under a homestead is a valuable asset for the resource poor farm household and suitable for production of different kinds of fruits.

a) Homestead fruits: Fruits produced in the homestead area is an easy and nutritious source for household members.

ACTIVITY 18: ROUND THE YEAR FRUITS PRODUCTION AT HOMESTEAD AREA

Improved management through pruning, pest control, fertilization and irrigation in quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Coconut, Wood apple etc.) were provide after program intervention and as a result, fruits production has increased significantly. Different kinds of fruits sapling were distributed among the farmers of different sites (Table 28a) to increase fruits production, fruits diversification and also to increase nutrient consumption from fruits sector. A number of different quality fruits saplings were supplied to homestead e.g. mango, guava, sapota, malta, lemon etc.

Table 18a. Number of fruit saplings distributed among the cooperative farmers under homestead program

	Mango	Guava	Sapota	Malta	Lemon	Others*
Variety	BARI Aam-3 and 4	BARI Peyara-2	BARI Sofeda-1	BARI Malta-1	BARI Lebu-2	-
No. of sapling supplied	120	60	60	60	60	-

b) Pest management of fruit tree: Availability of fruit trees in the homestead area is the best source of human nutrition. Although in most cases, it was found that pest is the major hindrance for sufficient edible fruits production, which sometimes discourages the farmers to plantation of fruit trees in homestead area. But very simple technology, two times spray of both insecticide and fungicide, once at just before flower blooming and once at pea size fruit stage, can help for successful fruits production in homestead area. From these views, pesticide spraying activities in safe way were conducted at each site. A total of 227 fruit trees were sprayed with insecticide and pesticide, where maximum fruit trees were coconut (127).

Table 18b. Number of fruit trees sprayed for hopper and other pest control at all locations.

Mango	Guava	Malta	Coconut	Others*
62	15	12	127	11

F. OFF-FARM ACTIVITIES

Activity 19: Off-farm activities at household level

Among the different site, only at Mollahat, Bagerhat had the program under cooperative farmer. It was found that after intervention of the pati weaving with Hoglapata, Diar making with bamboo, Kantha sewing etc. technology, the income increased 80%, with the gross margin of Tk. 7100 (Table 29a). So, if all sites could introduce some off-farm activities at their projected area, it would be helpful to increase total farm income, which will be helpful to increase total income and livelihood.

Table 19. Cost and return of off-farm activities at Mollahat, Bagherhat

Location	Before intervention (Tk)			After intervention (Tk)			GM increased (%)
	GR	TC	GM	GR	TC	GM	
Mollahat	6100	2150	3950	12050	4950	7100	80

Note: GR = gross return; TC = total cost; GM = gross margin

G. Integration among different sectors and components

Integrated farming consists of several enterprises like cropping system in floating bed and mainland, poultry, fishery, dairying, home gardening, composting etc. and these enterprises are interrelated. The end product and wastes of one enterprise are used as inputs in others. The residue of Water hyacinth made floating bed is a good source of compost, which is used for crop production in the mainland. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle's, which are used for different field operations for growing crops. The water of waterlogged area used for crop production in floating bed as well as fish production, where the compost of floating bed helps to produce phytoplankton in water as a fish feed. Thus, different enterprises of farming systems are highly interrelated.

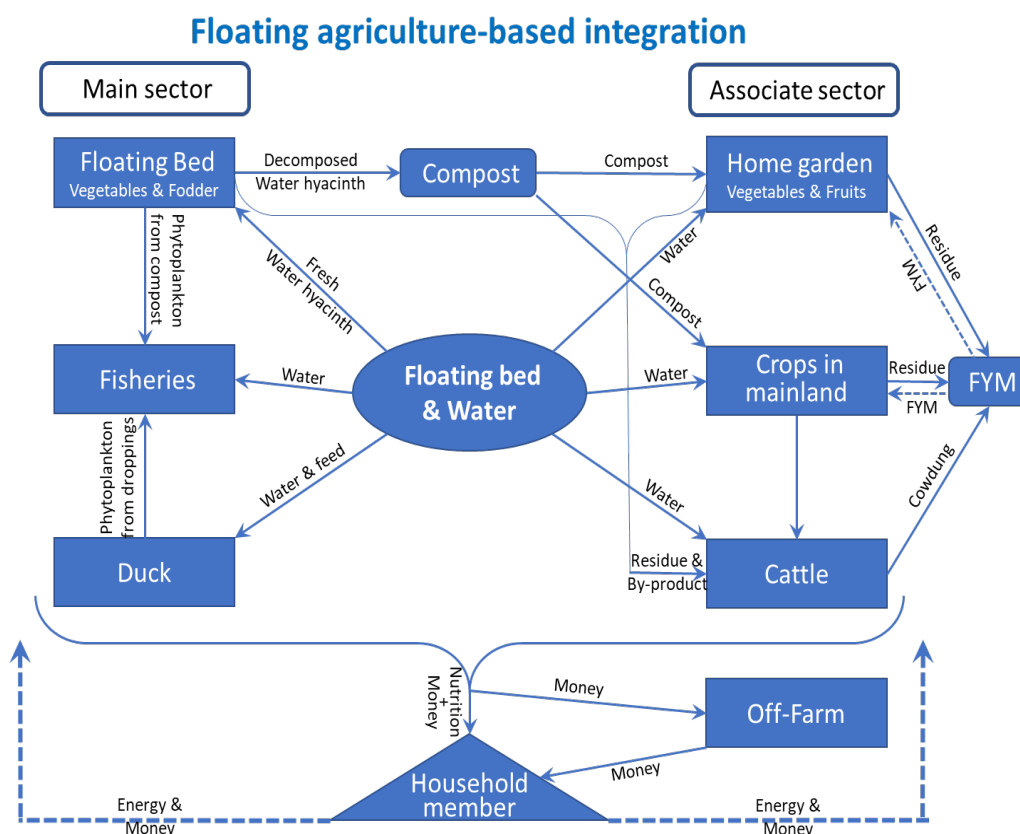


Fig 1: Integration among different sectors and components under floating agriculture system

H. INCOME ENHANCEMENT

By integrating of improved cropping patterns and production technologies in floating bed and mainland, year-round vegetables and fruits production, HYV seeds, de-worming, vaccination program and monosex tilapia fish cultivation, the resources (land, labor, capital, etc) of the farmers have used optimally and therefore farmer's income and livelihood have been increased. Gross margin was varied in different sites. Before intervention of the project, an average per farm gross margin was Tk. 151334 whereas it was Tk. 254575 after intervention of the project activities (Table 20).

Table 20. Technologies used and average return from different sub-systems of a small household under floating based integrated farming

Components	Before Intervention (Tk)			After Intervention (Tk)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Floating bed and trellis and rice land	109840	43200	66640	206984	82000	124984	87.55
Main field Crop (Dry land)	100188	53560	46628	114752	52928	61824	32.59
Homestead (Vegetables and Fruits)	6476	1610	4866	11758	3316	8442	73.49
Livestock in floating system	0	0	0	2475	1000	1475	100.00
Livestock in homestead	25100	5850	19250	46200	11200	35000	81.82
Fisheries (Cage and open water)	10000	0	10000	40850	25100	15750	57.50
Off-Farm	6100	2150	3950	12050	4950	7100	79.75
Total	257704	106370	151334	435069	180494	254575	68.22

Farmer's opinion

Improved management system with different high yielding vegetables, spices, and fodder crops created a great impact on the farmers at the project area. The resource poor farmers are interested to adopt those technologies which can provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and shift to other activities. Due to adoption of floating agriculture based integrated farming, they are hopeful to maintain their family with farm income. The increased productivity, gross margin and nutrition supplementation from the homestead source made them confident for livelihood improvement.

Conclusion

Floating agriculture based integrated farming is an eco-friendly approach in which waste of one enterprise becomes the input of another thus making efficient use of resources. It was revealed that the different components of floating agriculture based integrated farming like cropping patterns and production technologies in floating bed and mainland, year round vegetables and fruits production, HYV seeds, de-worming, vaccination program and mono-sex tilapia fish cultivation etc. are interrelated. The residue of Water hyacinth made floating bed is a good source of compost, which is used for crop production in the mainland. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. Floating agriculture showed competitive advantages to soil-based agriculture. Improved tolerance to salt, easier management that excludes irrigation tasks, better pest control than conventional farming and productivity in flood prone areas make floating agriculture an interesting option to reduce the impact of climate change. In addition, the cost-free organic fertilization in aquaculture water could sensitively increase farm productivity by improving both fish and vegetable production. Thus, different enterprises of farming systems are highly interrelated. The vital indicator for livelihood improvement is increasing income compared to existing condition, which was successfully obtained from the program. So, the proper utilization of farmers' resources can help them in this area.

PRODUCTIVITY, PROFITABILITY AND OPPORTUNITY OF LENTIL PRODUCTION IN RAJSHAHI DISTRICT OF BANGLADESH

Dr. MD. Mazharul Anwar

Abstract

A survey was undertaken on lentil producers in the two upazilas (Paba and Godagari) of Rajshahi district to know the socio-economic characteristics, input use, costs, returns problems and opportunities of lentil production. Total eighty lentil producers where forty from Paba Upazila and forty from Godagari Upazila of Rajshahi District were selected using random sampling technique. There is little variation in the age of householders of the two upazilas. Among the sample farmers, highest percentage of the farmers education was in secondary level whereas the lowest in illiterate level. Average farm sizes of the sample farmers were 0.56 hectare. Labour, Seed, Urea, TSP, DAP, MP, Boric Acid, Gypsum, Pesticide, Irrigation are the main inputs for lentil production. Most of the farmers used family labour in lentil production. At the times of harvesting and threshing sometimes farmers used higher labour. BARI released lentil varieties adopt in the two upazilas of Rajshahi district and recently released variety (BARI Masure-8) covered most of the area of the sample farmers. Per hectare gross return and gross margin on full cost basis were Tk. 124400, and Tk 46916, respectively whereas gross margin of variable cost and cash cost basis were Tk 100965 and Tk 103128. Variable and cash cost basis gross margin were much higher compared to full cost basis due to higher land cost (opportunity cost of land). Similarly benefit cost ratios were higher in variable cost and cash cost basis compared to full cost basis. Most of the farmers reported that root rot disease at growing stage was the main problems of the farmer followed by not available of HYV/quality seed at sowing time, lack of technological knowledge of HYV lentil production, low product price at harvesting period and not found power tiller or tractor in proper time. Again, HYV lentil provide higher yield as well as more profitable. So, lentil areas (acreage) are increasing in the Rajshahi regions. In the conclusion it can be said that lentil is not only technically feasible but also economically viable in Rajshahi region. More efforts should be made to transfer HYV lentil varieties among the farmers.

Introduction

Pulse crops are important for the people of Bangladesh. It plays a vital role in the Bangladesh diet as a cheap source of protein. Eight kinds of pulses, such as lentil, mungbean, blackgram, grasspea, chickpea, cowpea, filed pea and pigeon pea are grown in Bangladesh. Pulses cultivation cover 2.22% of the total cultivated land in Bangladesh (BBS,2019). Among the pulses, lentil (*lens culinaris*) commonly known as “masur” is a popular pulse crop in Bangladesh and occupied 40.23% cultivation of pulse crops (BBS,2019). It contains more protein than any other agricultural produce, and is nearer to animal flesh in food value for which it is often called poor man’s meat. Lentil is a winter pulse of temperate and subtropical region. Its contribution to pulse production of the world is 2.4%. Being legume, lentil is restorative in nature and its seed contains average 25.7% protein, which is almost three times higher than that of cereals (Erskine and Witcombe, 1984) and 59% carbohydrate. The per capita pulses consumption required for balance diet as given by FAO is 15 gm. Lentil ranks first among the pulses in terms of area (40%) and consumer preferences. The country is deficit in meeting her lentil demand. So, local markets are also being influenced by import quantity and prices. Different markets are there at different levels of distribution process. So, local markets with domestic products may not be much integrated as import markets which also influence price formation. As the markets were (monthly) segmented, price policy if any, for lentil improvement should be considered regionally for the effectiveness of such policies. Efforts need to be taken for market developments throughout the country. Pulses are vital components in diversification of Bangladesh’s predominantly rice-based cropping system. Lentil is the highest most important pulse crop in terms of area (142510 ha) and production (175384 MT) and ranks the highest in consumer preference and total consumption (BBS, 2019). Lentil seed is a rich source of protein and several essential micronutrients (Fe, Zn, β -carotene). The area and production of lentil indicates the major lentil cultivated areas in Bangladesh. BARI lentil varieties were occupied 98 % of lentil cultivated lands (Rahman et al, 2012). BARI has developed a good number of high yielding varieties which preferred by farmers in different parts of Bangladesh. Therefore, the present study was undertaken with the following specific objectives.

- i. To assess socio economic characteristics of the study farmers.
- ii. To analyze the input use, cost and returns of lentil production.
- iii. To know the farmers perceptions, disposal pattern, problems, and opportunities of lentil

Materials and Methods

Study area: Selection of the study area is an important step and largely depends upon objectives or purpose of the study. According to Yang (1962) the area in which a farm survey is to be made depends on the particular purpose of the survey and the possible cooperation of the farmers. Two Upazilas under Rajshahi District were selected one from Barind Area (AEZ 26) and another from plain land area (AEZ 11).

Data: The study accounting data of 80 farms were collected from two Upazilas of Rajshahi District for lentil producing farmers by using Random Sampling Technique method.

Sample Size: The study accounting data of 80 farms and the data were collected from two Upazilas of Rajshahi for identifying socioeconomic characteristics, productivity, profitability, problems and opportunities of lentil production. At first, a list of all farms from the two represented villages was prepared and out of 80 farms 40 from Paba Upazila and 40 from Godagari Upazila of Rajshahi District were selected using random sampling technique.

Processing, Analysis and Presentation of Data: After collection of data, each interview schedule was verified for the sake of consistency and completeness. Editing was done before putting the data in the computer. Summarization, careful scrutiny and necessary summary tables have been made from the data. Tabular techniques have been used for analysis, interpretation and presentation of data to fulfill the objectives of the study.

Analytical Techniques

The variable costs used in the analysis were the costs of land preparation, fertilizers, insecticides, irrigation, harvesting and cleaning etc. These variable costs were determined based on information provided by local farmers of the respective areas. Fixed costs are those costs which do not change with change in the volume and type of production, such as land rental value, and interest on operational cost. Land rental value was the rental cost for lentil production based on information provided by local farmers. The land rental cost was assigned according to the duration of the crop (4 months). Interest on operating capital (IOC) was calculated using the following equation: $IOC = TVC \cdot i \cdot t / (100 \cdot 12)$ (Alam et al. 2017)

where,

TVC = total variable cost investment;

i = annual interest rate (9%, the current Bank interest rate in Bangladesh);

and t = length of the crop production period in months (as above).

The total cost in lentil production was calculated as the sum of variable cost and fixed costs. Gross return was calculated from the amount of harvested ($t \text{ ha}^{-1}$) and their farm gate prices. Gross margin was calculated as the difference between gross return and total variable cost.

Results and Discussion

Year Wise Area under Pulse Crop

Year wise area (acreage) under all pulse crops (lentil, grass pea, field pea, mungbean, chickpea, black gram etc) and individual lentil area in the two Upazilas of Rajshahi district have been shown in the Table 1. After analyzing the data, it was estimated standard deviation and growth rate. The data of standard deviation were larger that indicate the data points can spread far from the mean. Standard deviation measures the spread of a data distribution. The more spread out a data distribution is, the greater its standard deviation. Growth rates refer to the percentage change of a specific variable within a specific time period. In Table 1, it was found that the growth rate of area (25.81 was for paba and 41 was for Godagari) under lentil production was higher compared to the area (16.27 was for paba and 10.72 was for Godagari) under all pulse crops, which indicates the percentage increase of lentil area (acreage) was higher compared to percentage increase of all pulse crops area (acreage).

Table 1: Year Wise Area (ha) under Pulse Crop in Paba and Godagari Upazila of Rajshahi District

Year	Area under Pulse Crop in Rajshahi	Paba Upazila		Godagari Upazila	
		Area under Pulse	Area under Lentil	Area under Pulse	Area under lentil
2008-09	19503	1369	395	4491	251
2009-10	22550	1703	638	4968	275
2010-11	29543	3807	1094	4473	364
2011-12	40575	2816	1020	3305	444
2012-13	33301	4628	2627	6297	1704
2013-14	36352	4756	2687	6423	1500
2014-15	35476	5486	3782	5801	2312
2015-16	34072	5598	3843	6615	3079
2016-17	41609	6964	5173	10414	7845
2017-18	36580	7117	5023	10411	7656
2018-19	38689	7069	5037	10862	9475
Standard Deviation	7043.43	2059.68	1848.90	2651.32	3458.63
Growth rate	5.54	16.27	25.81	10.72	41

Socio-Economic Characteristics

There is little variation in the age of households of the two upazilas of the farmer. In case of farming, age, literacy and farm size have important impact on decision making processes. The younger farmers have more technically efficiency than the older farmers and a younger farmer can easily adopt new technology and thereby increase his efficiency (Battese & Coelli, 1995).

Level of education of the sample farmers have been divided into four groups, illiterate, PSC (Primary school certificate), up to SSC (secondary school certificate), HSC (higher secondary school certificate and above). Among the four levels, highest percentage of the farmers was in secondary level whereas the lowest in illiterate level (Table 2).

Main occupation of the farmers were agriculture, service and business, and highest percentage of the sample farmers came from Agriculture followed by business and service (Table 2).

Average farm sizes of the sample farmers were 0.56 hectare where farm size of the farmers of paba Upazila was 0.52 hectare and Godagari Upazila it was 0.59 hectare.

Table 2. Distribution of Farmers by Various Socio-Economic Characteristics

Characters	Paba	Godagari	All Average
1. Farmers Age (year)	43	39	41
2. Education (%):			
Illiterate	7	5	6
Primary	32	28	30
Secondary	38	45	41
Higher secondary school certificate and above	23	22	23
Total	100	100	100
3. Main Occupation (%):			
Agriculture	65	72	69
Service	15	12	13
Business	20	16	18
Total	100	100	100
4. Land Ownership (ha/farm):			
Own Cultivated Land	0.43	0.46	0.45
Rented in/Lease in land	0.13	0.16	0.15
Rented out/Lease out land	0.04	0.03	0.04
Farm Size	0.52	0.59	0.56
Lentil area	0.18	0.21	0.20

Planting and Harvesting Time

Planting and harvesting times are the very important for crop cultivation. Optimum planting date has becomes a prime importance for higher crop production. Early or late planting dates on lentil causes an array of morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development and such changes may lead to a drastic reduction in yield. We have got five categories of planting time of the sample farmers which are October 23 – 30, November 1 – 7, November 8 – 15, November 16 – 25 and November 25 – 30. Most of the sample of Paba Upazila, farmers used planting November 8 – 15 whereas in Godagori Upazila most of the farmers used planting time November 16 – 25 categories Table 2). Again, In the study area farmers harvested lentil from last week of February to third week of March. But most of the farmers harvested lentil 1st and 2nd week of March of the two upazilas (Table 3).

Table 3. Distribution of Farmers by Planting and Harvesting Time of Lentil at Paba and Godagari

Planting and Harvesting time (month)	Paba		Godagari	
	No. of farmer	Percent of total	No. of farmer	Percent of total
Planting:				
October 23 – 30	4	10	2	5
November 1 – 7	9	23	6	15
November 8 – 15	17	43	12	30
November 16 – 25	8	20	17	43
November 25 – 30	2	5	3	8
Total	40	100	40	100
Harvesting:				
February 25-30	5	13	3	8
March 1-7	18	45	16	40
March 8-15	13	33	18	45
March 16-22	4	10	5	8
Total	40	100	40	100

Input Use of Lentil Production

The backbone of any agricultural revolution is access of farmers to modern agricultural inputs. These agricultural inputs range from improved seeds, fertilizers and crop protection chemicals to machinery, irrigation and knowledge. Seeds are critical to successful crop production and inevitably, farm productivity and profitability. Fertilizer supplies nutrients to the soil that are essential for growth. Increased use of fertilizer and improved seeds are partially credited with the large increases in agricultural productivity. Crop protection chemicals (pesticides, herbicides, insecticides and fungicides) control weed species, harmful insects and plant diseases that afflict crops. Finally, technical knowledge and machinery enhance human labor effectiveness and increase farm productivity.

Labour, Seed, Urea, TSP, DAP, MP, Boric Acid, Gypsum, Pesticide, Irrigation are the main inputs for lentil production. Most of the farmers used family labour in lentil production. At the times of harvesting and threshing sometimes farmers used higher labour. In Paba Upazila, most of the farmer used seed from their own sources whereas in Godagari they many farmers purchased their seed from BADC (Table 4).

Table 4. Average input Use in Lentil Production

Inputs	Paba	Godagari	All Average
Human labour (man-day/ha):			
Family	38	32	35
Hired	11	19	15
Total	49	51	50
Tillage (Number):			
Family			
Hired	2	2	2
Total	2	2	2
Seed (kg/ha):			
Owned	28	17	22.5
Purchased	25	38	31.5
Total	53	55	54
Fertilizers (kg/ha):			
Urea	33	31	32
TSP	39	34	36.5
DAP	15	17	16
MP	37	32	34.5
Gypsum	35	30	32.5
Boric Acid	6.5	6	6.25

Cost and Return of Lentil Production

Profitability of an agricultural enterprise is dependent on two economic components: a) total revenue earned from the sale of agricultural crops and b) the cost structure of production. The agricultural producer competes in a market environment that economist describe as a perfectly competitive market. This market structure has the unique feature, where the grain producer has no influence over price (e.g., price per bushel of corn). Thus, total revenue (TR) is defined as $P \times Q$, where P is the price of the product and Q is the level of output produced (bushels per acre). Cost of production refers to the total cost incurred by a farming to produce a specific quantity of a product or crop. Production costs may include things such as labor, input other materials, etc. In this study, three types of cost calculated which were full cost, variable cost and cash cost. The first and most important step is to identify full costs of a crop production and the next step is to classify costs into variable and cash cost. Average per hectare full cost, variable cost and cash costs of lentil production were Tk 77484, Tk 23435 and Tk 21272, respectively (Table 5)

Gross return of each technology was calculated by multiplying the yield with their unit price. Gross margin (GM) is the difference between gross return (GR) and total variable cost (TVC). Per hectare gross return and gross margin on full cost basis were Tk. 124400, and Tk 46916, respectively (Table 5) whereas gross margin of variable cost and cash cost basis were Tk 100965 and Tk 103128. Variable and cash cost basis gross margin were much higher compared to full cost basis due to higher land cost (opportunity cost of land). Similarly benefit cost ratios were higher in variable cost and cash cost basis compared to full cost basis (Table 6).

Table 5. Average Cost of Production of Lentil

Items	Cost (Tk/ha)		
	Paba	Godagari	All Average
Human labour:			
Family	12350	10240	11295
Hired	3575	6080	4827
Total	15925	16320	16122
Mechanical power:			
Family			
Hired	4125	5625	4875
Total	4125	5625	4875

Items	Cost (Tk/ha)		
	Paba	Godagari	All Average
Seed:			
Owned	2660	1666	2163
Purchased	2375	3724	3049
Total	5035	5390	5212
Fertilizers:			
Urea	528	496	512
TSP	858	748	803
DAP	225	255	240
MP	555	480	517.5
Gypsum	350	300	325
Boric Acide	1300	1200	1250
Total	3816	3479	3647.5
Irrigation (purchased)	1312	1875	1593
Insecticides, pesticides and weedicides (purchased)	3187	3375	3281
Interest on operating capital @ 8%	490	644	567
Opportunity cost of land	43125	41250	42187
Gross Cost:			
Full cost	77015	77958	77484
Variable cost	21050	25824	23435
Cash cost	18390	24158	21272

Table 6. Average Yield and Profitability of Lentil Production

Items	Paba	Godagari	All Average
Yield:			
Product (kg/ha)	1830	1620	1725
Price rate (Tk/kg)	68	68	68
Gross Return (Tk/ha):	124440	110160	117300
Product			
By-product (Taka)	6850	7350	7100
Total	131290	117510	124400
Gross Cost (Tk/ha):			
Full cost	77015	77958	77484
Variable cost	21050	25824	23435
Cash cost	18390	24158	21272
Gross margin (Tk/ha):			
Full cost basis	54275	39552	46916
Variable cost basis	110240	91686	100965
Cash cost basis	112900	93352	103128
Benefit Cost Ratio:			
Full cost basis	1.70	1.51	1.61
Variable cost basis	6.24	4.55	5.31
Cash cost basis	7.14	4.86	5.85

Variety Wise Area and Yield

Varietal selection is one of the earliest and most important decisions a lentil grower makes every season. A grower must live with this single decision all year long, from emergence to marketing. The variety decision will begin to establish profit potential before a seed is ever planted. Again, high yielding variety produces higher yield as well as higher production which give higher benefit of the farmers. Here BARI released lentil varieties adopt in the two upazilas of Rajshahi district and recently released variety (BARI Masure-8) covered most of the area of the sample farmers (Table 7).

Table 7. Variety Wise Average Area and Yield of Lentil Sample of the Farmers

Variety	Area (ha)		Yield (Kg/ha)	
	Paba	Godagari	Paba	Godagari
BARI Masure-3, BARI Masure-4, BARI Masure-5	0.8	1.1	1460	1210
BARI Masure-6	2.2	2.3	1780	1520
BARI Masure-8	4.2	5	2250	2130

Per Farm Lentil Production and Disposal

Increasing trends of lentil production also increases its consumption per person as well as per family. Among the sample farmers, average per farm lentil production, sale, gift and keep as seed were 11.36, 71, 7.03 and 10.61 percent, respectively (Table 8).

Table 8. Per Farm Average Production and Disposal Pattern of Lentil

Item	Paba		Godagari		All Average	
	Qty (kg)	Percent	Qty (kg)	Percent	Qty (kg)	Percent
Consumption	44	13.37	32	9.41	38	11.36
Sale	225	68.39	250	73.53	238	71.00
Gift	22	6.69	25	7.35	24	7.03
Seed	38	11.55	33	9.71	36	10.61
Total	329	100	340	100	335	100

Problems and Opportunities for Sustainable Production Lentil

Farmers faced some problems for cultivating lentil in the study area. Out of the problems, 6 major problems have been described in the Tables 9. Farmers were asked about the problems and they answered their problems. These problems summarized and showed in the Table 9. They mentioned that affects of root rot disease at growing stage was the main problems of the farmer followed by not available of HYV/quality seed at sowing time, weeds are considered a major problem facing lentil production, lack of technological knowledge of HYV lentil production, low product price at harvesting period and not found power tiller or tractor in proper time. Again, farmers were asked about the opportunities of cultivating lentil and they answered many opportunities. These opportunities summarized and showed in the Table 10. Lentil can easily produce between two crops. So, lentil areas (acreage) are increasing in the Rajshahi regions. All the sample farmers replied lentil cultivation increase soil fertility, provide higher return, low cost needs for its production and thereby provide more returns (Table 10). Farmer's opinions about sustainable production of lentil were supply of HYV seed, supply of fertilizers and other inputs in real price and need for training regarding improved cultivation technology (Table 11).

Table 9. Distribution of Farmers by Problems Faced by them in the Production and Marketing of Lentil

Problems	Rank of the problems		
	Paba	Godagari	All
1. Not available of HYV/quality seed at sowing time	2	2	2
2. Affects root rot disease at growing stage	1	1	1
3. Lack of technological knowledge of HYV lentil production	4	4	4
4. More weed infestation in lentil production	3	3	3
5. Low product price at harvesting period	5	5	5
6. Not found power tiller or tractor in proper time	6	6	6

Table 10. Distribution of farmers by reasons of cultivating lentil

Reasons	Percent of farmers		
	Paba	Godagari	All
1. Easily it can Produce between two crops	90	70	80
2. More Profitable	95	90	92
3. Provide higher yield	90	80	85
4. Increase soil fertility	100	100	100
5. Create employment opportunity of female labour	65	80	72
6. Low cost of production	100	100	100

Table 11. Distribution of Farmers by their Perception for Sustainable Production of Lentil

Opinion	Percent of farmers		
	Paba	Godagari	All
1. Supply of HYV seed	95	100	98
2. Supply of fertilizers and other inputs in real price	90	95	93
3. Need for training regarding improved cultivation technology	100	100	100

Conclusion

Inadequate use of inputs impedes the effectiveness of other inputs which causes low yield. So, farmers must learn proper use of inputs in time. They should follow recommended practices accurately. The gross margin and benefit cost ratio of BARI lentil cultivation were positive and encouraging to the farmers. This message should be circulated among the growers through various media. Many of the sample farmers did not get desired yield for ignoring the recommended use of inputs. So, formal and hand-on training and demonstration on modern method of producing BARI lentil should be imparted to the farmers. Therefore, More efforts should be made to transfer HYV lentil varieties among the farmers.

ADOPTION AND PROFITABILITY OF CHILLI VARIETIES IN SOME SELECTED AREAS OF BANGLADESH

N. Akter and M. Mohiuddin

Abstract

The study assessed the adoption and profitability of Chilli variety at farm level. Mymensingh and Kishoreganj were selected for data collection. Data were collected from 100 randomly selected Chilli farmers of which 60 from Kishoreganj area and 40 from Mymensingh area. The findings revealed that among the respondent of Kishoreganj, only 13% farmers are using BARI Chilli varieties but no farmers found in Mymensingh areas. The levels of adoption of most crop management technologies were found to be low. Higher level of adoption was observed in ploughing and medium level of adoption was observed in planting time. Chilli production was found profitable in the study locations, where per hectare net return was Tk. 95672.58 and BCR was 1.53. Though the farmers get profit, they had to face some problems. Lack of knowledge, lack of information about BARI Chilli varieties, unavailability of BARI Chilli varieties seed, capital shortage, lack of farmers association and crop insurance, poor transportation and communication system, lack of market monitoring authority were major barrier for the Chilli producers. These problems should be addressed properly to make this crop more profitable.

Introduction

Chilli is an important spice crop of Bangladesh and widely grown both in winter and summer seasons. Cultivated area of Chilli under both Rabi and Kharif season in Bangladesh is about 2, 40,000 acres of land with a production of 1, 58, 000 metric ton (BBS, 2020). Chilli is used in green and dried forms. It is especially liked for its pungency, spicy taste and the appealing color, it adds to the food (Mathukrishnan *et al.*, 1993). Chilies can thus be seen as an important commodity favored by consumers which meets their household needs (Amaral *et al.* 2019). It is used as pickles, sauces and other beverages (Purseglove *et al.*, 1991). Additionally, chilies are used as raw material in the chili processing and medicine or herbal medicine industries and cosmetics (Mariyono, 2016). In general, chilies contain many nutrients and vitamins, including calories, protein, fat, carbohydrates, calcium, vitamin A, vitamin B1, and vitamin C (Karyani *et al.* 2020). Chilli in dry conduction usually has more merchandize value in Bangladesh. The demand for chili consumption tends to increase due to the population growth, increased income and the increase in the types of processed products using chili as one of their ingredients.

Realizing the importance and demand of Chilli, Bangladesh government has given emphasis on research and extension of these crops. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) started research for developing improved varieties. These

national institutes have so far released a good number of improved varieties along with management technologies. The department of Agricultural Extension (DAE) has been involved in developmental programs for the technology transfer of this crop. Although these technologies have been found to be suitable for farmers, for various unknown reasons, a large number of farmers throughout the country are still reluctant to adopt these improved varieties that need to be evaluated properly. Farmers are replacing local varieties with improved varieties of Chilli. But still its economic profitability and adoption status have not been evaluated. The present study aims to assess the rate of adoption of BARI varieties and profitability of Chilli in the study areas.

Table 1. Area, production and yield of Chilli in Bangladesh

Year	Total (Area '000, Acres)	Total (Production '000, M. tons)	Yield (kg/acre)
2009-10	215	110	507
2010-11	240	141	587
2011-12	240	126	525
2012-13	231	102	442
2013-14	22	110	495
2014-15	227	123	541
2015-16	252	130	515
2016-17	256	137	535
2017-18	250	141	786
2018-19	239	149	625
2019-20	239	158	658.22

Source: BBS, 2020

Objectives

1. To know the status of adoption of BARI Chilli varieties and their management technologies at farm level;
2. To estimate the cost and return of cultivating Chili at farm level;
3. To identify the problems of chili cultivation; and
4. To make some recommendations for higher adoption of BARI chili varieties.

Materials and Methods

The present study was conducted in purposively selected Nikli upazila of Kishoreganj and Mymensingh sadar upazila of Mymensingh districts. Data were collected during February to June in the year of 2021. Two villages were selected from each upazila based on the intensive cultivation of the Chilli in consultation with the department of agricultural extension and OFRD of BARI. At first, a list of all Chilli growers was collected from each area and then a total of 100 Chilli growers taking 60 from Kishoreganj area and 40 from Mymensingh area were selected randomly from the lists for the study. Data were collected by the researchers using pretested interview schedule. The collected data were summarized and analyzed by tabular methods using average, percentage, ratios, etc.

Analytical Technique

Adoption level was categorized into three: (70-100%) as high, (50-69) as medium and <50% as low level adoption (Mohiuddin and Sarker, 2019; Hajonget *al.*, 2018). The collected data were coded, edited, summarized, tabulated and analyzed to fulfill the objectives of the study.

The profitability was estimated using gross return, gross margin, net return and benefit cost ratio analysis. Both fixed cost and variable cost were calculated of Chilli cultivation. Land use cost was calculated on the basis of per year existing lease value of land.

Gross return: Gross return (GR) was calculated by multiplying the total volume of output of an enterprise by the average price in the harvesting period. The following equation was used to estimate GR.

$$GR_i = \sum_{i=1}^n Q_i P_i$$

Where,

GR_i = Gross return from i^{th} product ($tkha^{-1}$)

Q_i = Quantity of the i^{th} product (kg)

P_i = Average price of the i^{th} product (tk)

$i = 1, 2, 3, \dots, n$

Gross margin: Gross margin has given an estimate of the difference between total return and variable costs.

That is,

$$GM = TR - VC$$

Where,

GM = Gross margin

TR = Total return

VC = Variable cost

Net return: Net return analysis considered fixed cost, cost of land rent, interest on operating capital etc. Net return was calculated by deducting all costs (variable and fixed) from gross return. To determine the net return the following equation was used in the present study:

$$\Pi = P_Y Y - \sum_{i=1}^n (P_{xi} X_i) - TFC$$

Where,

Π = Net return ($Tkha^{-1}$)

P_Y = Per unit price of the product (Tk/kg)

Y = Quantity of the production per hectare (kg)

P_{xi} = Per unit price of i^{th} inputs (Tk)

X_i = Quantity of the i^{th} inputs per hectare (kg)

TFC = Total fixed cost (Tk)

$i = 1, 2, 3, \dots, n$ (number of inputs)

In this study, cost and return analysis were done on both variable and total cost basis. To achieve the objective of the study a simple tabular analysis was accomplished. The following profit equation was developed to assess the profitability of Chilli

$$\Pi = \text{Gross return} - (\text{Variable cost} + \text{Fixed cost})$$

Here,

Π = Profit per hectare

Gross return = Total production $\times$ per unit price

Variable costs includes cost of human labour, cost of land preparation, cost of insecticide, cost of irrigation, cost of seed, cost of urea, cost of TSP, cost of MP, cost of boron, cost of Gypsum and interest on operating capital. On the other hand, fixed cost was the family labour and land use cost for Chilli.

Benefit cost ratio (BCR): The BCR is a relative measure, which is used to compare benefit per unit of cost. The BCR was estimated as a ratio of gross returns and gross costs. The formula of calculating BCR (undiscounted) is shown below:

$$\text{Benefit cost ratio} = \frac{\text{Gross benefit}}{\text{Gross cost}}$$

Result and Discussion

Adoption of Chilli varieties

An attempt was made to assess the level of adoption in terms of percent of farmers adopted different Chilli variety at farm level. The level of adoption of Chilli variety was mostly depended on the dissemination process used by BARI in association with the DAE. The scientist of BARI have developed and disseminated 4 Chilli varieties to the farmers since 2001. Study found that among the respondents of Kishoreganj area only 13% farmers cultivate BARI morich-1. The study revealed that most of the farmers cultivate hybrid Chilli varieties such as Fire hot(current), Hot master, Fire force and local variety such as Balizuri and Bindu. Farmers of Mymensingh area did not adopt BARI Chilli varieties. Farmers informed that they do not know about BARI Chilli varieties and seed of the BARI Chilli varieties is not available to the farmers.

Adoption of Crop management Technology

The existing level of technology employed in the production of Chilli and their adoption level are presented in Table 2a. Land preparation includes ploughing, laddering and other operations needed to make the soil suitable for sowing seed. On an average, more than 75% farmers ploughed their land 4-5 times which is recommended for Chilli cultivation. Based on the percent of respondent farmers, land preparation secured the high level of adoption. The sowing of Chilli was started from the 3rd week of August and continued up to the 4th week of October. The sowing time of seed was medium adoption. Study found that, farmers of Mymensingh area follow line sowing method where farmers of Kishoreganj follow broadcasting method of seed sowing. The Chilli farmers in the study areas irrigated their land with the help of shallow tube well. On an average, 68% farmers of Kishoreganj irrigated their land 3 to 4 times where 77% of the farmers in Mymensingh irrigated their land above five times which is the over recommended for Chilli cultivation. Based on the percent of respondent farmers, irrigation secured the medium and low level of adoption in Kishoreganj and Mymensingh, respectively. On the other hand, all fertilizer such as Urea, TSP and MoP was highly used by farmer but low level of adoptions that means farmer used more these fertilizer of their recommended dose in both locations (Table 2b). In case of Gypsum and boron fertilizers, the adoption levels were found to be high in Kishoreganj and low in Mymensingh area.

Production cost of Chilli

Variable cost

Human labor shared a large portion of total cost of Chilli production. It requires several operations such as land preparation, seed sowing, planting, weeding, fertilizing, harvesting etc.; and was computed in terms of person days. Both women and men laborer worked in the Chilli production. In pricing, the labor no discrimination was made between the family and the hired labor. In the study area, women labors were used during the harvesting periods. Per hectare cost of human labor was calculated at Tk. 72117.83 and Tk. 86700 in Kishoreganj and Mymensingh, respectively (Table 5). Power tiller is the time and labor-saving modern technology for land preparation. All of the farmers use power tiller in preparing land. Cost of land preparation was estimated at Tk. 8068.26 and Tk. 11227 per hectare in Kishoreganj and Mymensingh, respectively which was 5 percent of the total cost of Chilli production. Purchased seed of Chilli is used. Per hectare cost of seeds for Chilli production was found to be 4 and 9 percent of the total production cost in Kishoreganj and Mymensingh, respectively. Usually, farmers used cowdung as organic fertilizer in their Chilli production. The average per hectare cost of organic fertilizer was calculated at Tk. 6574.54 and Tk. 8750 in Kishoreganj and Mymensingh, respectively which represents 4 percent of the total cost. Different kinds of inorganic fertilizers were used to increase yield of Chilli. Study found that farmers of Mymensingh area didn't use any gypsum in their Chilli field though they use less amount of others fertilizer than the Kishoreganj areas. The average cost of inorganic fertilizer per hectare was calculated at Tk. 28740.04 and Tk. 23010.7 in Kishoreganj and Mymensingh, respectively. The cost of irrigation water was estimated at Tk. 9859.23 and Tk. 18861 per hectare in Kishoreganj and Mymensingh which constituted 6.29 and 8.86 percent of the total cost, respectively. Chilli growers used various insecticides and pesticides. Cost of insecticides per hectare

was calculated at Tk. 11418.96 and Tk. 26540 which covered 7.28 and 12.46 percent of total cost in Kishoreganj and Mymensingh, respectively (Table 5).

Fixed cost

Fixed costs that do not vary or change during the period of production. Land use cost was estimated based on cash rental value of land per hectare. It was estimated for the cropping period of one year as per the prevailing rate in the study area. This amount was calculated at Tk. 11570 and Tk.14970 which covered more than 7% of the total cost in both Kishoreganj and Mymensingh, respectively. Family labour is considered as fixed cost item also. Cost of family labour per hectare was estimated at Tk. 23256 and Tk. 38260 in Kishoreganj and Mymensingh, respectively. Interest on operating capital was determined by including all cost incurred on various operations in the process of cultivation of Chilli not considering those for which interest was already calculated. As regards the production of Chilli, interest on operating capital was calculated at Tk. 2245.75 and Tk. 2925.41 per hectare which constituted to more than one percent of total cost.

Total cost

The total cost is composed of total variable costs and total fixed cost. To get the average per hectare cost of all the resources used in the production process of Chilli by the farmers the previous mentioned costs have been summed up in the Table 5. The total cost of Chilli production per hectare was estimated at Tk. 156861.85 and 212922.41 in Kishoreganj and Mymensingh, respectively.

Gross return

The average yield of Chilli per hectare was found to be 8253.50 kg and its respective value was calculated at Tk. 248010 and Tk. 313120 in Kishoreganj and Mymensingh, respectively (Table 6). From the study it was observed that price of Chilli varies from month to month. In December and January price of Chilli was found highest. It may be noted here that the price of Chilli was reported to be Tk. 34 per kg which was the average farm gate price in the study area.

Gross margin

Per hectare gross margin was obtained by subtracting variable costs from gross return. Average gross margin per hectare was found to be Tk. 123164.95 in Chilli production.

Net return

Net return was calculated by subtracting Total cost from gross return. Net return was estimated at Tk. 95672.58 per hectare of Chilli cultivation. From Table 6, it was clear that Chilli production is profitable for the farmers in the study area.

Benefit cost ratio

This study found that average per hectare BCR of Chilli was 1.53 which means for one taka investment give return 1.53 taka.

Constraints of Chilli farmers

The challenges of Chilli farmers were facing in the study areas are shown in Table 7. Most of the farmers were facing the problem of lack of knowledge about high yielding variety and its cultivation process. Farmers were misleading by the seed dealer. In the time of variety choice farmers were fully depends on the opinion of dealers. Eighty seven percent farmers were facing the problem of lack of information about BARI Chilli varieties. Main problem in the study area was non availability of BARI Chilli varieties seed. Farmers were also facing the problem of lack of labor availability. One of the important problems of chili production is the insect and disease infestation. About seventy eight percent respondents reported about the problem of lack of operating capital and not getting any credit support during the production period of Chilli. Lack of farmers association and crop insurance problems were also crucial for the Chilli producers. About eighty two percent farmers were facing the problem of lack of public and private sector extension services in the remote areas like haor and chars. According to seventy-two percent farmers, Chilli market is controlled by some dominant traders who used to cheat

them while buying produce from them and lack of proper market monitoring authority was the main reason behind that.

Table 2a. Percent of cultivation of different Chilli varieties found in the study areas

Name of variety	Percent of the respondents		All
	Kishoreganj	Mymensingh	
Nodaira	10	-	5
BARI Morich-1	13	-	6.5
Fire hot (current)	7	37	22
Fire force	7	17	12
Fire white	-	15	7.5
Hot master	25	7	16
Tarkata	-	5	2.5
Bizli	5	5	5
Laltir 1701	-	3	1.5
Zilik	-	5	2.5
Bindu	15	3	9
Balizuri	18	3	10.5
	100	100	100

Source: Field survey, 2021

Table 2b. Percent of adoption of crop management technologies in Chilli cultivation

Technology	Kishoreganj		Mymensingh	
	Percent of adoption	Adoption level	Percent of adoption	Adoption level
1.No. of ploughing				
Up to 3	25		18	
* 4-5	75	High	76	High
6-8			6	
2. Planting time(week)				
3rd Augt.-2ndSep.	24		37	
*3rd Sep.-3rd Oct.	67	Medium	57	Medium
4th Oct.	9		6	
3. Seed rate (kgha^{-1})				
Up to 1	16		93	
*1-1.5	63	Medium	7	Low
Above 1.5	21		-	
4. No. of irrigation				
1-2	27		-	
*3-4 times	68	Medium	23	Low
Above 4 times	5		77	
5. Urea (kgha^{-1})				
Up to 179	10		42	
*180-210	38	Low	31	Low
Above 210	52		27	
6.TSP (kgha^{-1})				
Up to 279	13		53	
*280-330	22	Low	26	Low
Above 330	65		21	
7. MoP (kgha^{-1})				
Up to 179	11		23	
*180-200	29	Low	15	Low
Above 200	60		62	
8. Gypsum (kgha^{-1})				
Up to 100	18			
*101-110	71	High		Absent
Above 110	11			
9. Zinc Sulfate (kgha^{-1})				
Upto 10	88		8	

Technology	Kishoreganj		Mymensingh	
	Percent of adoption	Adoption level	Percent of adoption	Adoption level
*10-12	12	Low	14	Low
Above 12			78	
10. Boric acid (kg ha⁻¹)				
Up to 7	09		53	
*7-10	91	High	36	Low
Above 10	-		7	

Source: Field survey, 2021

Table 3. Name of insecticides/pesticides used in Chilli production in the study areas

Name of the insecticides/pesticides	Percentage of the farmers
Imitaf	90
Confidor	55
Otostin	45
Mancozeb	53
Ridomil Gold	85
Vertimec	60
Vittaku	30
Thiovit	53
Endophil	23
Sumisidin	20
Sunvit	30
Admire	23

Table 4. Per hectare use of chemical fertilizers in study area

Name of fertilizer	Quantity (Kg ha ⁻¹)		Cost (Tk ha ⁻¹)	
	Kishoreganj	Mymensingh	Kishoreganj	Mymensingh
Urea	311	190.53	5598	3048.48
TSP	362	306.36	7964	6739.92
MoP	225	174.44	3375	2616.6
DAP	210	169.28	5250	4232
Gypsum	113	-	3390	
Zinc sulfate	8.25	26.23	1568.72	4983.7
Boron	7.90	6.95	1594.32	1390
Total		-	28740.04	23010.7

Source: Field survey, 2021

Table 5. Per hectare total cost of green Chilli production in study area

Cost items	Cost (Tk. ha ⁻¹)		% of Total cost	
	Kishoreganj	Mymensingh	Kishoreganj	Mymensingh
A. Variable cost				
Hired Labor	48861.83	48340	31.15	22.70
Land preparation	8068.26	11227	5.14	5.27
Seed	6250.24	19939	3.98	9.36
Organic fertilizer	6574.54	8750	4.19	4.11
Inorganic fertilizer	28740.04	23010.7	18.32	10.81
Irrigation	9859.23	18861	6.29	8.86
Insecticides & Pesticides	11418.96	26540	7.28	12.46
Total Variable cost	119773.1	156667.7	76.36	73.57
B. Fixed cost				
Family labour	23256	38360	14.83	18.01
Operating capital interest	2245.75	2925.41	1.43	1.37
Cost of land use	11587	14970	7.39	7.03
Total Fixed Cost	37088.75	56255.41	23.64	26.42
Total Cost (A+B)	156861.85	212922.41	100.00	100.00

Source: Field survey, 2021

Table 6. Costs and returns of Chilli production in study area

Particulars	Cost and return		All
	Kishoreganj	Mymensingh	
Yield(Kg ha ⁻¹)	8267.00	8240.00	8253.50
Price(Tk/Kg)	30.00	38.00	34.00
Gross return (Tkha ⁻¹)	248010	313120	280565.00
Total variable cost (Tkha ⁻¹)	119773.1	156667	138220.05
Total Cost (Tk ha ⁻¹)	156861.85	212922	184891.93
Gross margin (Tkha ⁻¹)	128236.90	118093	123164.95
Net return (Tkha ⁻¹)	91148.15	100197	95672.58
BCR(Over total cost)	1.58	1.47	1.53
Cost of green Chilli (Tk./kg)	18.97	25.84	22.41

Source: Field survey, 2021

Table 7. Production, socio-economic and marketing constraints faced by the farmers

Reported constraints	Percent of farmers
Production constraints	
Lack of Knowledge about high yielding variety and production technology	70
Lack of information about BARI Chilli varieties	87
Unavailability of BARI Chilli varieties seed at the time of seed sowing	99
Scarcity of labour	53
High infestation of insect and disease	61
Socio-Economic constraints	
Lack of crop insurance	72
Lack of operating capital/Agricultural Credit	78
Lack of farmer's association	69
Lack of public and private sector extension services in the remote areas like chars	82
Marketing constraints	
Lack of market monitoring authority	68
Lack of market information	63
Poor transportation & communication system	78

Source: Field survey, 2021

Conclusion and Recommendation

The study assessed the adoption and profitability of Chilli variety in two selected districts of Bangladesh. Chili production in the study areas was found profitable, where per hectare net return was Tk. 95672.58 Though the farmers get profit, they had to face some barriers. The finding revealed that local and hybrid varieties seed of Chilli are available but BARI released varieties of Chilli are not available at farm level. Based on the study findings, the following recommendations are given below:

- The seed of the BARI Chilli varieties with other critical inputs should be made locally available to the farmers at proper time. For this reason, the government should encourage BADC and private seed companies for producing BARI Chilli varieties seed and supply these at reasonable price to the farmers.
- Regular training on Chilli cultivation should be conducted by the DAE in association with BARI to inform the farmer about BARI Chilli varieties.
- Necessary financial assistance and others facilities for production of Chilli need to be made available in the region.
- Roads and communication system should be improved so that medium of transportation can move easily and promptly.
- Government should try to help farmers by ensuring a fair price of Chilli. Farmers will increase their production if they know that there is a guaranteed price and market.
- Market monitoring authority should come forward to take proper actions against the dominant traders.
- Initiatives should be taken to form farmer association where the farmers can easily share the problems and ideas to each other.

STUDY ON PRODUCTION AND MARKETING OF SEAWEED IN COX'S BAZAR

M Akhtar Hossain

Abstract

The survey was conducted at Nuniar chara and Charpara of sadar upazila under Cox's Bazar district during February-March 2021 to examine the profitability level of seaweeds cultivation, to know the existing marketing channel of seaweeds, to identify constraints in seaweeds production and marketing and to derive some policy implications for seaweeds production and marketing. Based on higher concentration of seaweed production, Cox's Bazar was selected purposively for the survey. Two local markets namely Bandarban Sadar and Cox's Bazar were also purposively selected for data collection. The participant involved in production and marketing were farmers, faria/bepari, wholesaler and retailer. Primary data were collected during February-March 2021 with pre-designed questionnaire by face to face interview. Total cost, profit and benefit cost ratio, marketing channels, different intermediaries such as faria/bepari, wholesalers and retailers were investigated. The results showed that, the highest marketing cost was found Tk. 950 for wholesaler followed by faria/bepari Tk.600 and retailer Tk. 530 per mond respectively. The highest net marketing margin was found from retailer Tk. 820 per mond followed by faria/bepari Tk. 360 and wholesaler Tk. 270 per mond. The major problem in the seaweeds industry of Bangladesh include poor communication and transportation facilities, higher labor wage and marketing cost, lack of information on seaweeds cultivation, lack of technology, socio-economic constraints and shortage of skilled manpower for seaweed production, harvesting and marketing facilities. Farmers received low price for seaweed due to presence of number of intermediaries and long distance from seaweed production unit to sale point. Different type of tolls as municipality tax, market tax etc. caused lower return to the farmers. In order to overcome these problems, farmers may be encouraged to enhance the capacity building and awareness, to gather knowledge and technologies and techniques on commercially seaweeds production for industrial use, processing and develop marketing facilities in the study area.

Introduction

Seaweed is a Marine alga that is generally classified as a plant. It is a primitive type of plant lacking true roots stems and leaves (Robinson 1980) Seaweed farming is highly developed in many countries of Japan, China, Korea, the Philippines, Malaysia, Indonesia, Thailand (Ohno,2004). According to FAO (2003) the estimated amount of global seaweed production is 6 million ton per annum value of which is around 5 million US dollars. The contribution of cultured seaweed is 15% of the total global aquaculture volume or nearly five percent of total volume of world fisheries production. East and Southeast Asian countries contributes almost 99% cultured production, with half of the production (about 3 million ton) is supplied by China. Presently, commercial production of seaweed through culture is by and large limited to Japan, China, Republic of Korea Taiwan and the Philippine. Robinson (1980) reported that most seaweed species are red (6000 species) brown (2000 species) and green (1200 species). Red seaweed are mainly used for agar production, Carrageenan production, functional food, medicine preparation. Brown Seaweed are used for alginate production, food, fertilizers, medicine functional food industry and green seaweed are used as human food.

In Bangladesh naturally growing seaweed are found St. Martin Island. This Island is in the south most land of Bangladesh. A total of 205 species of seaweed are listed in Bangladesh. Ten species of seaweed so far been recorded for commercial value (Ahmed and Taparhudee, 2005). These include 3 species of seaweeds two species of Brown seaweed and five species of red seaweed. The study of seaweeds resources is a very recent activity in Bangladesh and complete information and statistics in this regard is not available at this stage. The taxonomic and ecological study of seaweeds and other algae has however, been reasonably completed. In Bangladesh, seaweeds or marine macro algae grow abundantly in restricted areas like the rocky coast of the Saint Martin Island and Inani beach, Cox's Bazar and a few on Mangrove trees along the coast of Sundarban. Islam (1976) reported 133 seaweeds species and later Prof. Abdul Aziz (2015) in collaboration with Prof. Islam added 73 species to the list making it a total of 205(98 species belonged to red, 48 to green and 59 to brown). As many as 52 species have economic values, as food and industrial products of everyday use (Aziz, 2015).

Approximately 15 metric ton of seaweeds (all species) were produced in Bangladesh in 1989 (Giasuddin, 1989). The total production was consumed in the country. Bangladesh is not importing seaweeds directly, but imported in product form like agar. In 1987 the country imported 2 tons of agar from Japan and South Korea. Seaweeds culture methods are not yet to be developed in the country. Nothing is being produced by culture. The approximate area of natural seaweeds bed is 10 square kilometers. In terms of area about 50 square kilometer of seashore could be utilized for culture.

A project on Adaptive Trials on Seaweed Cultivation titled “Capacity Building for Conducting Adaptive Trials on Seaweed Cultivation in Coastal Areas” started from 1st January 2016 and ended will be on September 2021 at Cox Bazar funded by Krishi Gobeshona Foundation under Ministry of Agriculture (MOA). The leading agency is Bangladesh Agricultural Research Council and Bangladesh Agricultural Research Institute is directly involved with the research activities in this project. One step seed production (Preira and Yarish 2008) is followed for growing the seaweed in this project. The farming on cultivation of seaweeds are being carried out primarily in the ‘nursery pond’ (land based system) using only one step seed production method which require healthy seaweeds. Seeds for Seaweed farming is being produced by one step (directly using cut pieces and tie with the ropes) and multi-step (inducing spore release by a particular seaweed in laboratory and allowing spore to grow on rope and net) method (Redmond *et. al*, 2014). Healthy seaweeds *Hypnea* species collected from the St. Martine Island are cut into pieces and cut pieces are inserted quickly at 10 to 15 cm gap into the 15 to 25 meter long, 1-1.5 cm diameter synthetic ropes/strings. This study was conducted at Nuniar chara of Cox's Bazar sadar in open sea water along Moheshkhali channel. The seaweeds are found to grow satisfactorily in the rope and it is about 1 meter long within a month.

Bangladesh has a coastal zone of 480 km coastline and 25000 sq. km of coastal area with a huge population, supporting a variety of land use practices. This coastal area with sandy and muddy beaches estuaries and mangrove swamps provide substrate and habitat for various seaweed cultivation (Mahmood *et al*, 1997). The coastal belt of Bangladesh extends over 76 upazila where large number of people depends on their livelihood on fishing, fishery exploitation and other associated activities (Firoza Ahmed, 1997). However the seaweed industry in Bangladesh is an initial stage and it is not widespread due to socio economic and technological constants. People in Bangladesh are still not aware of the seaweeds potential. The demand for seaweeds industries in Bangladesh is great but the present production from natural habitat is very low.

Abundant seaweeds resources are seen in the inter-tidal and sub-tidal regions. These resources have a great potential for the development of seaweed-based industries in Bangladesh. In addition, conservation of natural seaweeds beds is one of the important advantages of seaweed culture in Bangladesh. As seaweeds cultivation requires low inputs and provides good return and can employ many people, therefore, seaweeds culture could be a good industry for coastal communities of Bangladesh.

Seaweed culture can be an alternative income source for coastal fishermen, improving new high yield potential varieties of seaweeds, quality production, distribution and marketing, establish local seaweeds market system as well as find the new international market. If farmers get additional production using new potential seaweed, can sell the produce to the market and can earn extra money. Also it will facilitate additional employment of rural people and thus reduce poverty from the country.

Objectives to the study

- i. To examine the profitability level of seaweeds cultivation
- ii. To know the existing marketing channel of seaweeds
- iii. To identify constraints in seaweeds production and marketing
- iv. To derive some policy implications for seaweeds production and marketing

Material and Method

This study was confined to Nuniar chara and Charpara of sadar upazila under Cox's Bazar district which contributes significantly to the total production of seaweed. Based on higher concentration of seaweed production, Cox's Bazar was selected purposively for the survey. Two local markets namely Bandarban

Sadar and Cox's Bazar were also purposively selected for data collection. The participant involved in production and marketing in the study area were farmers, faria/bepari, wholesaler and retailer. As the population size was not readily available, the farmers and intermediaries were selected considering availability at the first sight; the selected samples included 30 farmers. Primary data were collected during the month of February-March, 2021 with pre-designed questionnaire by face to face interview.

The intermediaries involved in seaweed marketing

Faria/bepari: They were the small traders who had no fixed establishment and staff. They purchased seaweed from the farmers at the farm gate or in the local market and sold them to wholesaler in Bandarban market and partly to retailer. They also dealt in other agricultural commodities. They did their business independently with self-finance.

Wholesaler: They were relatively large traders having fixed establishment in the market and permanent staff. They purchased large portion of seaweed from farmers or faria/bepari. Generally, the largest share of their purchased was sold to Bandarban market some times in Myanmar and a small amount to retailer at the local market.

Retailer: They were the last link in the channel of seaweed marketing. In the study area, they had small permanent or temporary shops located at Bandarban Sadar Bazar, Bandarban. They purchased seaweed from wholesaler, faria/bepari and farmers and sold it to the ultimate consumer. The tribal people were the seaweed consumer. Most of them were also involved in trading of commodities like pulses, oil or different types of necessary things.

Analytical tools: The data collected from different farmers and marketing functionaries were edited and summarized. Descriptive statistics were used to summarize the data and presented in tabular form showing cost, return and profitability of seaweed production. Cost items included establishment of seaweed, planting, harvesting. Profitability was calculated separately using cash cost and full cost concept. In the full cost calculation, land rent was not possible for inclusion because share cropping or leasing arrangement of land was not practiced in the area. Marketing cost and marketing margin of seaweed were also estimated for this study.

Results and Discussion

Profitability of seaweed production: The cost and return of seaweed production in Cox's Bazar were presented in table 1. The average yield of seaweed was calculated 10.83 ton per hectare on the other hand the average gross return was calculated Tk. 649800 per hectare. Interest on operating capital had been considered at 10 percent for one year amount Tk.39520. The average production cost was estimated Tk. 395200 and total cost of production was Tk. 434720 per hectare. The average net return was found Tk. 215080 per hectare. The benefit cost ration was found 1.49 which indicated profitability of seaweed production in farmers' level.

Disposal pattern of seaweed: The disposal pattern was identified as own consumption, sales, neighbor, relatives and wastage. It was revealed that out of total seaweed production, about 92 percent production was sold to marketing intermediaries, 2 percent was used for family consumption, 1 percent was distributed to relatives and neighbor and rest 4 percent was wastage (Table-2).

Marketing channel of seaweed: Farmers, faria/bepari, wholesaler, retailer and consumers were identified as marketing intermediaries in the study area. Farmer-Faria/bepari-Wholesaler-Retailer-Consumer channel and Farmer-Faria/bepari-Retailer-Consumer channel were identified by the help of sample farmers in the study area. About 83 percent farmers sold their product by the Farmer-Faria/bepari-Wholesaler-Retailer- Consumer channel and rest 17 percent farmers used Farmer-Faria/bepari-Retailer- Consumer channel for selling their seaweed products in the study area (Table-3).

Marketing cost of seaweed incurred by the farmers: Marketing costs represent the cost of performing various marketing functions needed to transfer a commodity from the place of production to the ultimate consumer. Marketing cost incurred by the various market participants was presented in table-4. Total marketing cost was found highest for wholesaler Tk. 950 who sold seaweeds in Bandarban market and it was lowest for Faria/bepari Tk.600 per mond who sold the product in Cox's Bazar. The marketing cost was found Tk.530 per mond who sold seaweed to consumers. Among the different cost items of

the intermediaries, transportation was the highest cost item followed by labor wage and person expenses. On the other hand the lowest cost item was found as wastage Tk. 50 per mond of seaweed during transportation for faria/bepari and wholesaler Tk. 80 per mond. The highest marketing cost was found Tk. 950 for wholesaler followed by faria/bepari Tk.600 and retailer Tk. 530 per mond respectively.

Marketing margin of seaweed: Marketing margin was calculated by deducting the purchase price from sale price of seaweed and the net marketing margin was calculated by deducting marketing cost from gross marketing margin of seaweed. The gross marketing margin of faria/bepari, wholesaler and retailer were estimated Tk.1060, Tk.950 and Tk. 530 per mond, respectively. The highest net marketing margin was found from retailer Tk. 820 per mond followed by faria/bepari Tk. 360 and wholesaler Tk. 270 per mond, respectively in the study area (Table-5).

Problem faced by the seaweed farmers: In the study area, the sample farmers were asked for acute problem, they expressed their opinion related to marketing and production as follows.

Marketing related problems: About 94 percent sample farmers reported that poor communication and transportation facilities was the major problem for marketing seaweed from production spot to sale point followed by higher labor wage and marketing cost about 92 percent as well as low selling price of seaweed about 89 percent to the farmers. About 85 percent farmers stated that dominance of market intermediaries and shortage of operating capital was also the problem to them. About 68 to 82 percent farmers were facing the marketing problems as dominance of market intermediaries, shortage of operating capital, absence of storage facilities, long distance between production and marketing spot, lack of changing food habit, lack of adequate market information and lack of formation of farmers group in the study area.

Production related problems: Farmers in the coastal area collected seaweeds which was naturally produced in the seashore. On the other hand some farmers cultivated seaweed from October to March with the help of research personnel. About 95 percent sample farmers opined that seaweed could not cultivated round the year due to modern technology and natural environment. The second most acute problem was naturally grown weeds in seaweed production area to 92 percent farmers. About 85 to 90 percent farmers expressed that bad weather in seaweed cultivation, lack of availability of good quality healthy seed and heavy current with muddy water tore the float in seaweed field were also the problems to them. About 80 percent farmers reported that shortage of skilled manpower was an important problem. About 78 percent farmers mentioned that lack of publicity and advertisement was an obstacle for increasing seaweed utilization in regular diet. About 72 percent farmers stated that low quality of seaweed produced during improper postharvest handling. Finally, about 65 percent farmers explored that lack of capacity building and awareness on seaweed also a short coming to boost up seaweed production and enhanced marketing development in the study area (Table-6).

Table-1: Per hectare cost and return of seaweed in Cox's Bazar, 2021

Items	Amount
Yield of seaweed (Fresh-kg)	10830
Farm gate price (Tk/kg)	60
Gross Return(Tk/ha)	649800
Production cost (Tk/ha) [Float, Rope, Bamboo, Labor etc.]	395200
Int. on operating capital@10%	39520
Total cost of production(Tk/ha)	434720
Net return (Tk/ha)	215080
Benefit cost ratio (BCR)	1.49

Source: Field survey, 2021

Table-2: Disposal pattern of seaweed in Cox's Bazar, 2021

Item	Utilization of seaweed (%)
Own consumption	2
Sale	92
Neighbor	1
Relatives	1
Wastage	4

Source: Field survey, 2021

Table-3: Marketing channel identified by the sample farmers in Cox's Bazar, 2021

Marketing channel	Farmers responded (%)
Farmer-Faria/bepari-Wholesaler-Retailer- Consumer	83
Farmer-Faria/bepari-Retailer- Consumer	17

Source: Field survey, 2021

Table-4: Marketing cost of seaweed incurred by the intermediaries in Cox's Bazar,2021

Cost items	Marketing cost (Tk/mond)		
	Faria/bepari	Wholesaler	Retailer
Transportation	200 (33)	300 (32)	100 (19)
Loading/unloading	0	100 (11)	100 (19)
Wage	150 (25)	200 (21)	100 (19)
Waste	50 (8)	50 (5)	80 (15)
Market tolls	100 (17)	100 (11)	50 (9)
Person expenses	100 (17)	200 (21)	100 (19)
Total	600 (100)	950 (100)	530 (100)

Figures in the parenthesis indicate percentage of total marketing cost

Source: Field survey, 2021

Table-5: Marketing margin of seaweed for different intermediaries in Cox's Bazar,2021

Particulars	Marketing margin (Tk/mond)		
	Faria/bepari	Wholesaler	Retailer
a) Purchase price	3860	4690	4280
b) Sale price	4820	5910	5630
c) Gross margin (b-a)	1060	1220	1350
d) Marketing cost	600	950	530
e) Net margin (c-d)	360	270	820

Source: Field survey, 2021

Table-6: Problem faced by the sample farmers during seaweed production and marketing in Cox's Bazar, 2021

Problems	Farmers responded (%)
<i>Marketing related problems:</i>	
i. Poor communication and transportation facilities	94
ii. Higher labor wage and marketing cost	92
iii. Low selling price of seaweed	89
iv. Dominance of market intermediaries	85
v. Shortage of operating capital	85
vi. Absence of storage facilities	82
vii. Long distance between production and marketing spot	80
viii. Lack of changing food habit	75
ix. Lack of adequate market information	73
x. Lack of formation of farmers group	68
<i>Production related problems:</i>	
i. Seaweed could not cultivated round the year	95
ii. Naturally grown weeds in seaweed production area	92
iii. Bad weather in seaweed cultivation	90
iv. Lack of availability of good quality healthy seed	89
v. Heavy current with muddy water tore float in seaweed field	85
vi. Lack of technology and socioeconomic constraints	81
vii. Shortage of skilled manpower	80
viii. Lack of publicity and advertisement for increasing seaweed utilization in regular diet.	78
ix. Low quality due to improper postharvest handling	72
x. Lack of capacity building and awareness on seaweed	65

Source: Field survey, 2021

Conclusion

Introduction of seaweeds culture in the country's coastal areas could be alternative options for the People's source of income. Many edible seaweeds species are available on the coastal in Bangladesh. Where thousands of the people live along the coastal zone, people can use seaweeds as one of the vital source of good nutrition. The efforts in seaweeds cultivation and its utilization through product and process development could help in meeting the food and nutritional security of Bangladeshi population as well as earning foreign currency.

At present seaweed are only harvested by gathering from natural stock. In comparison to the production these has very little value from the economic point of utilization. The seaweeds consumed locally both as fresh and as dried for human food as well as animal feed, and only the people in the localities where seaweeds are collected and produced. No formal marketing system has evolved till now. There is no culture based production and processing industry in our country.

The major problem in the seaweeds industry of Bangladesh include poor communication and transportation facilities, higher labor wage and marketing cost, lack of information on seaweeds cultivation, lack of technology, socio-economic constants and shortage of skilled manpower for seaweed production, harvesting and marketing facilities. Farmers received low price for seaweed due to presence of number of intermediaries and long distance from seaweed production unit to sale point. Different type of tolls as municipality tax, market tax etc. caused lower return to the farmers. Bargaining power of the seaweed farmers may be improved by forming group- marketing system. In order to overcome these problems, farmers may be encouraged to enhance the capacity building and awareness, to gather knowledge and technologies and techniques on commercially seaweeds production for producing agar as for industrial use, processing and develop marketing facilities in the seaweed production area. Finally, research, extension, marketing department and local government should come forward with different program so that higher economic return as well as better utilization of natural resources in Cox's Bazar and other coastal areas may be ensured.

Mature Technologies

1	Name of Technology	:	Development of four crops based cropping pattern Potato/Sweet Gourd-Jute-T.Aman			
2	Name of the Organization	:	Bangladesh Agricultural Research Institute (BARI)			
3	Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701			
4	Location of application	:	Medium high to high land of Rangpur regions with similar soils of AEZ-3			
5	Key characteristics of the technology		• The long gap period between potato harvesting to jute sowing can be used successfully by relay cultivating of sweet gourd with potato. • Relay cultivation of sweet gourd with potato with no additional fertilizer can give extra cash to the farmers. • Rice equivalent yield (REY) 39.37 t ha⁻¹ in the improved cropping pattern whereas in the existing was 21.47 t ha⁻¹. • Gross margin increased 136% in improved cropping pattern compared to existing pattern.			
6.	Year of experimentation		2017-18 to 2019-20			
7	Production guideline					
	Crop		Potato	Sweet gourd	Jute	T. Aman
	Variety		BARI Alu-25	BARI Hybrid Mistikumra-1	O-795	Binadhan-17
	Spacing (cm)		60 × 25	180 × 200	Broadcast	20 ×15
	Sowing/Transplanting date		3 rd to 4 th week of Nov.	Last week of Nov. to 1 st week of Dec.	2 nd to 3 rd week of April	1 st to 2 nd week of August
	Fertilizer rate (N-P-K-S-Zn-B-cowdung Kg ha ⁻¹)		135-30-110-22-2-1-5000	0-0-0-0-0-0-0	90-6-50-160-0-0-0	90-6-33-4-1-0-0
	Fertilizer application		Half of N and all P,K,S, Zn, B were applied at final land preparation as basal and rest of N was applied at 30-35 days after planting	No additional fertilizer is required for sweet gourd	All P,K,S were applied as basal and N were applied as two equal split of 25 and 55 DAS.	All P,K,S,Zn were applied as basal at final land preparation and N was applied at three equal split of 15, 30 and 45 DAT
	Harvesting time		15-18 Feb.	01-06 April	19-24 July	04-10 Nov.
	Field duration (days)	:	86	Potato: 86 days+48 days	100	90
	Turnaround time (days)		14	Relay	9	18
	Yield (t ha ⁻¹)		27.14	33.12	3.17	4.62
	REY (t ha ⁻¹)		39.37			
8	Risk involvement in adopting the technology		No risk involvement			
9	Impact on environment	:	No harmful effects on environment			
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet, leaflet, TV or radio talk etc.			
11	Expected outcome		Total productivity can be increased			
12	Socio economic aspects Considering the whole pattern	:	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)		Gross margin (Tk.ha ⁻¹)
			866190	275011		591179
13	Recommendation	:	Potato/sweet gourd-Jute-T.aman is an easy setting cropping pattern. Again, in this area potato and vegetables cultivation is very easy and provides higher return. Besides the jute can help to improve soil fertility. Therefore, Potato/sweet gourd-jute-T.aman may be recommended to extend in medium to high land of AEZ-3.			

1	Name of Technology	:	Development of four crops based cropping pattern RADISH–Potato–Maize–T. Aman			
2	Name of the Organization	:	Bangladesh Agricultural Research Institute (BARI)			
3	Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701			
4	Location of application	:	Medium high to high land of Rangpur and Gaibandha regions with similar soils of AEZ-3			
5	Key characteristics of the technology		- Timely and relatively early planting of T. Aman rice gives an opportunity to produce leafy radish before potato planting, which is very high value crop due to early production. - After harvesting of potato, maize can be produced within March to early July and thereafter T. Aman can be planted during mid-July. - Rice equivalent yield (REY) increased 47% in the improved cropping pattern. - Gross margin increased 70% in improved cropping pattern compared to existing pattern.			
6.	Year of experimentation		2017-18 to 2019-20			
7	Production guideline					
	Crop		Radish (Leafy)	Potato	Maize	T. Aman
	Variety		BARI Mula-3	BARI Alu-25	Mirakkel	Binadhan-17
	Spacing (cm)		Broadcast	60 × 25	60 × 20	20 ×15
	Sowing/Transplanting date		3 rd to 4 th week of Oct.	1 st week of Dec.	1st week of March	2 nd to 3 rd week of July
	Fertilizer rate (N-P-K-S-Zn-B-cowdung Kg ha ⁻¹)		92-20-75-0-0-0-0	135-20-90-10-0-1.5-0	135-16-31-18-2-0-0	90-6-33-4-1-0-0
	Fertilizer application		All fertilizers were applied as basal.	Half of N and all P,K,S, Zn, B were applied at final land preparation as basal and rest of N was applied at 30-35 days after planting	One third of N and other all fertilizers were applied as basal and rest of N were applied as two equal split of 25 and 50 DAS.	All P,K,S,Zn were applied as basal at final land preparation and N was applied at three equal split of 15, 30 and 45 DAT
	Harvesting time		Late Nov.	Late Feb.	1 st week of July	Mid-Oct.
	Field duration (days)	:	35-40	87	123	88
	Turnaround time (days)		11	5	7	9
	Yield (t ha ⁻¹)		5.61	28.50	10.80	5.50
8	Risk involvement in adopting the technology		No risk involvement			
9	Impact on environment	:	No harmful effects on environment			
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet, leaflet, TV or radio talk etc.			
11	Expected outcome		Total productivity and profitability can be increased			
12	Socio economic aspects considering the whole pattern	:	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)		Gross margin (Tk.ha ⁻¹)
		770900	267470		503430	
13	Recommendation	:	Radish-Potato-Maize-T.aman is an easy setting cropping pattern. This cropping pattern was more productive and profitable and it could be suggested for large scale production in medium to high land of Rangpur region under AEZ-3.			

1.	Name of Technology	: Effect of different fertilizer management on the performance of BARI Bt Brinjal		
2.	Name of organization	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	Rangpur region with similar soils of AEZ-3		
5.	Key characteristics of the technology	• BARI Bt Begun-4 as a Brinjal fruit and shoot borer (BSFB) resistant variety was used. • Soil test based fertilizer (STB) was verified with different combination of chemical fertilizer. STB fertilizer with 50% additional NPK (splitting 5 times) gave maximum fruit yield (41.80 t ha⁻¹) and farmers practice produced minimum fruit yield (31.46 t ha⁻¹). • Gross margin increased by 40% over farmers' practice		
6.	Year of experimentation	2017-18 to 2019-20		
7.	Production guideline			
	Crop	Brinjal		
	Variety	BARI Bt Begun-4		
	Spacing	100cm × 80cm		
	Sowing date	Mid October to Mid November		
	Transplanting date	Mid September-Mid October		
	Harvesting time	January to April		
	Fertilizer dose (N-P-K-S-Zn-B-Cowdung, kg ha ⁻¹)	194-36-86-14-2-1-5000		
	Fertilizer application	Full amount of cowdung, half of urea, TSP and MoP and full dose of other fertilizers were applied as basal and rest half of urea, TSP and MoP were applied in five splits at 15 days interval starting from 1 st flowering.		
	Yield (t ha ⁻¹)	40.84-42.70		
8.	Risk involvement in adopting the technology	No risk involvement. However, it is necessary to plant 1 row of non-Bt Brinjal at the border of Brinjal field.		
9.	Impact on environment	No harmful effects on environment		
10.	Procedure of transfer	Block demonstration, farmers training, field day, booklet/ leaflet, radio talk, etc.		
11.	Expected outcome	Productivity, profitability will be increased by more than 40%.		
12.	Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		627050	92407	534643
13.	Recommendation	The fertilizer package can be recommended for Bt Brinjal (BARI Bt Begun-4) production in AEZ-3 and the similar area. It is noted that the additional NPK fertilizers should be applied in 5 split application especially just after every time of fruit harvest (about 15 days interval starting from 1 st flowering). Recommended fertilizer dose 194-36-86-14-2-1-5000 kg N-P-K-S-Zn-B-Cowdung ha ⁻¹). It is necessary to plant 1 row of non-Bt Brinjal at the border of Brinjal field.		

1.	Name of Technology	:	Effect of sowing time on leafy coriander production		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Rangpur region with similar soils of AEZ-3		
5.	Key characteristics of the technology	:	- Three coriander varieties viz, BARI Dhania-1, BARI Dhania-2 and local with twenty-four sowing dates, 15 days' interval started from 15 October were tested. - Fresh leaves yield was maximum in BARI Dhania-2 (3.91 t ha⁻¹) and minimum in BARI Dhania-1 (2.85 t ha⁻¹) - First November sowing dates produced maximum leaves yield (5.93 t ha⁻¹) and the poor yielder sowing time was 15 March (1.37 t ha⁻¹) though the other hot and rainy month (April to mid-September) could not grow the coriander crop. - Though the yield was relatively low, but the gross margin was higher in 15 February (297300 Tk. ha⁻¹), 15 September (224200 Tk. ha⁻¹), 01 March (210900 Tk. ha⁻¹) due to higher market price.		
6	Year of experimentation	:	2018-19 to 2019-20		
7.	Production guideline	:			
	Crop	:	Coriander		
	Variety	:	BARI Dhania-2		
	Spacing	:	15cm × continuous		
	Sowing date	:	Sowing for maximum yield: 1 st week of November Sowing for profitable yield: February to March and September		
	Sowing method	:	Seed should be soaked 24 hours with water for priming		
	Harvesting time	:	30 to 40 days after sowing		
	Fertilizer dose (N-P-K-Cowdung, kg ha ⁻¹)	:	70-22-45-5000		
	Fertilizer application	:	Full amount of all fertilizers and cowdung were applied as basal.		
	Yield (t ha ⁻¹)	:	3.91-5.93		
8.	Risk involvement in adopting the technology	:	No risk involvement.		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/ leaflet, radio talk, etc.		
11.	Expected outcome	:	Profitability will be increased by more than 38-95%.		
12.	Socio-economic aspects		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	01 Nov. sown		189760	37620	152140
	15 Feb. sown		334800	37500	297300
	01 March sown		248400	37500	210900
	15 Sep. sown		263000	38800	224200
13.	Recommendation	:	The coriander variety BARI Dhania-2 can be recommended for growing as green leaves purpose with the sowing time in February to March and September for more profitability.		

1.	Name of Technology	:	Sustainable integrated farming through local service provider (LSP)				
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)				
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701				
4.	Location of application	:	Homestead based farming in the villages of Rangpur and all over the country				
5.	Key characteristics of the technology	:	- Integrated farming is now gaining priority to ensure food, nutrition and income security of resource poor farm households with the rapid increasing of population and declining of agricultural land. With the fragmentation of a farm family, the number of farm household is increasing and occupying the agricultural land. - There are about twenty crore homesteads in Bangladesh, which need to bring under year-round vegetables and fruits production system following BARI developed homestead models for ensuring food security. - The BARI developed location specific homestead models are very effective, but the limitation is availability of timely and very small amount of different kinds of seeds for a home garden against sustainability. Besides of it, proper vaccination of scattered reared livestock and fish culture in homestead area is another issue against sustainability. - A local service provider (LSP) can supply small amount of different seeds package, seedling and sapling to the neighbor farmers with the exchange of their product or money. Vaccination of poultry and livestock and service for fisheries also can be provided by the LSP with the exchange of money. On the other hand, for income enhancing and empowerment of women, a female LSP may work, who can serve for the female especially for the off-farm activities.				
6	Year of experimentation	:	2017-18 to 2019-20				
7.	Description	:	One co-operative farmer is acted as male LSP and one is acted as female LSP at an area. The male LSP produced different types of vegetables and fruits seedling in his own nursery and also collected seeds and seedlings from other source and supplied to the project farmers and remaining part sold to the neighbor other farmers. The beneficiary farmers are returned back some parts of their produce (vegetables/fruits/seeds) to the LSP. The LSP also provide vaccine to livestock especially for chicken, duck, pigeon and goat. The female LSP provided training on handicrafts production and sewing by sewing machine to the other female farmers and also discussed with women regarding nutrition and sanitation. These activities were found a suitable practice for the sustainable farming activities.				
	Area		Vegetables	Fruits	Livestock	Fisheries	Off-farm
	Responsible LSP		Male LSP	Male LSP	Male LSP	Male LSP	Female LSP
	Activities		Seed and seedling production, collection, supply, and exchange receive.	Seed and seedling production, collection, supply, and exchange receive.	Deworming, vaccination, and exchange receive.	Fish fingerlings collection, properly release, take care and exchange receive.	Motivation, practical training, and marketing.
	Materials		Seedling-cauliflower, cabbage, tomato, brinjal, chilli, moringa, napier grass etc.	Seedling-Sugarcane, papaya, mango, litchi, guava, lemon, malta, coconut, pomelo, banana, dragon fruit etc.	Cattle, goat, sheep, buffalo, chicken, duck, pigeon etc.	Monoculture of pabda, tangra, tilapia, shing etc. and carp polyculture.	Making of handicrafts, basket, kantha and cloth sewing, pickles etc.
8.	Risk involvement in adopting the technology	:	No risk involvement.				
9.	Impact on environment	:	No harmful effects on environment				
10	Procedure of transfer	:	Stakeholder training, exchange visit, booklet/ leaflet, radio talk, etc.				
11	Expected outcome	:	Sustainable home gardening and integrated farming will be established.				
12.	Socio-economic aspects						
	Male LSP		-Seedling raising (no./year)= 22405; Cost (Tk./year)= 6215; Net profit (Tk./year)=24348. -Seed supply (no./year)= 10 types; Cost (Tk./year)= 5000; Net profit (Tk./year)=3250. -Vaccine provide (no./year)= 520; Net profit (Tk./year)=1040.				
	Female LSP		-Training provides on handicraft production= 15 person. -Training provides on cloth sewing by sewing machine= 26 person.				
13.	Recommendation	:	One male LSP needs to develop for the source of homegarden and other agricultural inputs and one female LSP needs to develop for promotion of off-farm activities among the women in a locality.				

1.	Name of Technology	:	Development of alternative cropping pattern Lentil-Maize-T.Aman against the existing Lentil-Jute-T.Aman rice cropping pattern in Rajshahi region		
2.	Name of organization	:	Bangladesh Agricultural Research Institute		
3.	Contract division	:	CSO, ON-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Paba, Rajshahi under AEZ 11		
5.	Key characteristics of the technology	:	- The newly introduced crop in the farmers cropping pattern was Maize (BARI Hybrid Maize-16) in rabi season. - Field duration of crop sequence was 317 days in the improved cropping pattern whereas 335 days in the existing cropping pattern. - Rice equivalent yield (REY) 22.79 t ha⁻¹ was in the improved cropping pattern whereas in the existing cropping pattern 21.67 t ha⁻¹ yr⁻¹ was recorded. - Gross margin increased by 13.26% over existing pattern.		
6.	Year of experimentation	:	2018-2020		
7.	Production guideline	:			
	Crop	:	Lentil	Maize	T.Aman rice
	Variety	:	BARI Masur-8	BARI Hybrid Maize-16	BRRI dhan 87
	Spacing (cm)	:	Broadcast	60 x 20	20 x 15
	Sowing/Transplanting date	:	2 nd week of November	3 rd week of March	2 nd week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	18-30-25-18-1-1	152-52-74-26-2.5-1.2	90-10-25-12-1-0
	Fertilizer application method	:	Full dose of fertilizer should be applied as basal	Full dose of PKS and 'one third N to be applied as basal and rest of N should be applied in 2 equal splits as to dress at 20 and 40 DAT	Full dose of PKS Zn to be applied as basal and N should be applied in 3 equal splits as to dress at 10, 30 and 45 DAT
	Date of Harvesting	:	2 nd week of March	2 nd week of July	1 st week of November
	Yield (t ha ⁻¹)	:	2.07	7.02	5.18
	Intercultural Operation	:	Intercultural operation should be necessary to support the normal growth of the crops		
	Field duration (days)	:	115	110	92
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity can be increased.		
12.	Socio-economic aspects	:	Considering the whole pattern		
			Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
			370412	216939	153473
13.	Recommendation	:	Improved cropping pattern Lentil-Maize-T.Aman rice was more productive and it could be suggested for large scale production in medium high land of Paba, Rajshahi.		

1.	Name of Technology	:	Development of alternative cropping pattern Garlic relaying with Brinjal -T.Aman against the existing Garlic-Maize-T.Aman rice cropping pattern in Rajshahi region		
2.	Name of organization	:	Bangladesh Agricultural Research Institute		
3.	Contract division	:	CSO, ON-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Shibpur, Rajshahi under AEZ 11		
5.	Key characteristics of the technology	:	- The newly introduced crop in the farmers cropping pattern was Brinjal (BARI Begun-10) in <i>kharif</i> season. - Field duration of crop sequence was 316 days in the improved cropping pattern whereas 340 days in the existing cropping pattern. - Rice equivalent yield (REY) 87.32 t ha⁻¹ was in the improved cropping pattern whereas in the existing cropping pattern 58.50 t ha⁻¹ yr⁻¹ was recorded. Gross margin increased by 67.11% over existing pattern.		
6.	Year of experimentation	:	2018-2020		
7.	Production guideline	:			
	Crop	:	Garlic	Brinjal	T.Aman
	Variety	:	BARI Rashun-4	BARI Begun-10	BRRRI dhan 87
	Spacing (cm)	:	10 x 8	100 x 80	20 x 15
	Sowing/Transplanting date	:	2 nd week of November	3 rd week of January	1 st week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	125-55-170-34-2.5-3	140-40-100-16-0-0	90-10-25-12-1-0
	Fertilizer application method	:	Full dose of PSZnB and half dose of NK to be applied as basal. Rest of NK should be applied in 2 equal splits as to dress at 25 and 50 DAP	Full dose of SZn and half dose of P should be applied during final land preparation. rest of P and one third K should be applied in pit before 7 days of planting. N and rest of K should be applied in 5 equal splits as to dress at 15 DAT, initial stage of flowering stage, initial stage of fruiting stage and two times during harvesting period.	Full dose of PKSZn to be applied as basal and N should be applied in 3 equal splits as to dress at 10, 30 and 45 DAT
	Date of Harvesting	:	2 nd week of March	up to 3 rd week of June	3 rd week of October
	Yield (t ha ⁻¹)	:	9.03	33.27	4.73
	Intercultural Operation	:	Intercultural operation should be necessary to support the normal growth of the crops		
	Field duration (days)	:	130	146	92
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity can be increased.		
12.	Socio-economic aspects	:	Considering the whole pattern		
		:	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
		:	1402484	480369	922115
13.	Recommendation	:	Improved cropping pattern Garlic/Brinjal-T.Aman rice was more productive and it could be suggested for large scale production in medium high land of Shibpur, Rajshahi.		

Sl. no.	Name of Technology	Potato-Danta-T.Aus-T.Aman rice: A highly productive cropping pattern for Narsingdi region.			
1	Name of the Organization	Bangladesh Agricultural Research Institute			
2	Contract division	On-Farm Research Division, BARI, Narsingdi			
3	Location of application	Farmers field at Shibpur			
4	Key characteristic of the technology	• Inclusion of Potato and danta in Boro rice period which increases cropping intensity and total productivity. • Vegetable-vegetable-Rice-Rice cropping pattern is more profitable than existing cropping pattern Rice-Rice-vegetable. • Improved cropping pattern increased rice equivalent yield by 29.97% over the existing pattern.			
5	Year of the experiment	Rabi season of 2018, 2019 and 2020			
6	Crop	Potato	Danta	T. Aus	T. Aman
	Varieties	BARI Alu-40	BARI danta-1	BRRI dhan-48	BINA dhan-7
	Spacing	60cm×25cm	Broadcast	25cm×15cm	25cm×15cm
	Sowing date /time	2 nd week of November	3 rd week of February	Last week of April	Last week of July
	Fertilizer doses N-P-K-S-Zn-B kg/ha	161-44-132-22-5-2	86-50-42-16-0-0	73-20-24-10-0-0	65-32-34-22-2.7-0
	Fertilizer application method	Two third of N and full amount of other fertilizers should be applied during final land preparation. The remaining N to be applied at the time of 30 days after sowing.	Full dose of NPKS should be applied as basal.	Full amount of PKS should be applied as basal and N to be applied in three equal spikits at 10,30,45 DAT.	Full amount of PKSZ should be applied as basal and N to be applied in three equal splits at 10,30,45 DAT
	Date of harvesting	2 nd week of February	2 nd week of April	3 rd week of July	3 rd week of October
	Yield (t/ha)	39.39	26.4	4.3	4.54
	Intercultural operation	Irrigation, Pest management and other intercultural operations to be done as and when necessary.			
7	Field duration (days)	95	55	82	80
8	Risk involvement in adopting the technology	No risk in adoption or dissemination of the technology			
9	Impact on environment	No harmful effects on environment			
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.			
11	Expected outcome	Increased yield, improved soil health			
12	Socio- economic aspects	Considering higher yield obtaining treatments			
		Gross return (Tk/ha)	Total variable cost (Tk/ha)		Gross margin (Tk/ha)
		9,08,370.00	2,65,990.00		6,42,380.00
13	Recommendation	The improved cropping pattern Vegetable-vegetable-Rice-Rice is recommended to use in place of existing cropping pattern Rice-Rice-vegetable in Narsingdi region and similar areas of AEZ 9.			

Sl. no.	Name of Technology	Bottle gourd-Snack gourd-Country bean-Cucumber: An improved Vegetable based cropping pattern for Narsingdi region.			
1	Name of the Organization	Bangladesh Agricultural Research Institute			
2	Contract division	On-Farm Research Division, BARI, Narsingdi			
3	Location of application	Farmers field at Shibpur, Monohardi and Belabo			
4	Key characteristic of the technology	- Improved cropping pattern increased cropping intensity and total productivity. - Improved cropping pattern is more profitable than existing cropping pattern. - Generates good cash income as well as improves the livelihood of the people.			
5	Year of the experiment	Rabi season of 2018, 2019 and 2020			
6	Crop	Bottle gourd	Snack gourd	Country bean	Cucumber
	Varieties	BARI Lau-4	BARI Chichinga1	BRRI Shim-48	Local
	Spacing	2m×2m	1.5m×1.5m	1.5m×1.5m	1m×1m
	Sowing date /time	4 th week of October	1 st week of March	3 rd week of April	2 nd week of August
	Fertilizer doses N-P-K-S-Zn-B kg/ha	55-32-60-14-1.4-0	80-35-75-18-4-1.7	23-18-30-0-0-0	45-30-50-0-0-0
	Fertilizer application method	Half of cowdung, P, K and all of S and Zn should be applied at final land preparation. Remaining cowdung and p should be applied before 7 days in manda. All of N and remaining K should be applied four equal splits.	All ofcowdung, P, S, Zn, B and two third K should be applied at final land preparation. All of N and remaining K should be applied four equal splits 10,30,50,70DAT	All of cowdung, should be applied at final land preparation. Half of N, K and all of P applied before 7 days in manda. Remaining N and K should be applied 30DAT.	All of cowdung, P and half of K should be applied at final land preparation. All of N and remaining K should be applied three equal splits 10,30,50. DAT
	Date of harvesting	Last week of January	2 nd week of April	1 st week of August	2 nd or 3 rd week of October
	Yield (t/ha)	47.2	18.82	15.2	12.44
	Intercultural operation	Irrigation, Pest management and other intercultural operations to be done as and when necessary.			
7	Field duration (days)	90-100	60-70	95-110	55-65
8	Risk involvement in adopting the technology	No risk in adoption or dissemination of the technology. Ensures family nutrition and food security.			
9	Impact on environment	No harmful effects on environment			
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.			
11	Expected outcome	Increased yield, improved soil health			
12	Socio- economic aspects	Considering higher yield obtaining treatments			
		Gross return (Tk/ha)	Total variable cost (Tk/ha)		Gross margin (Tk/ha)
		16,29,200.00	2,75,000.00		13,54,200.00
13	Recommendation	The improved cropping pattern Bottle gourd-Snack gourd-Country bean-Cucumber is recommended to use in place of existing cropping pattern Bitter gourd- Country bean in Narsingdi region and similar areas of AEZ 9.			

Sl. no.	Name of Technology	Effect of Irrigation on Sweet potato in char land of Jamalpur		
1	Name of the Organization	Bangladesh Agricultural Research Institute (BARI)		
2	Contract division	CSO, On-Farm Research Division, BARI, Gazipur 1701		
3	Location of application	Mymensingh region with similar soils of AEZ 8 and 9		
4	Key characteristic of the technology	• Sweet potato cultivation is suitable in this region of its extensive adaptability in char areas. • Water is the most important component of growing plants which help nutrients uptake properly. • Optimum irrigation can play vital role for plant growth as well as yield.		
5	Year of the experiment	2019-2020 & 2020-2021		
6	Crop	Sweet potato		
	Varieties	BARI Mistialu-8		
	Spacing	60cm x 30cm		
	Planting date /time	1 st week of November		
	Fertilizer doses N-P-K kg/ha	70-25-85 kg/ha N-P-K with 5 t/ha cowdung		
	Fertilizer application method	Half of N and all other fertilizers were applied at final land preparation. Remaining N was top dressed in two equal splits at 35 and 65 DAT		
	Date of harvesting	Mid March		
	Yield (t/ha)	34.95 (One irrigation after 50 days of planting)		
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops		
7	Field duration (days)	120 to 130 Days		
8	Risk involvement in adopting the technology	Heavy rainfall may damage the crop or may increase diseases severity at later stage		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.		
11	Expected outcome	Increased yield		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		593480	131870	461610
13	Recommendation	One irrigation after 50 days of planting increased yield		

Sl. no.	Name of Technology	Development of fertilizer package for chili production in char areas of Gaibandha		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Gaibandha		
3	Location of application	Saghata, Gaibandha or with similar soils of AEZ 7		
4	Key characteristic of the technology	- Farmers in char areas are growing chilies but not followed proper fertilizer dose, resulted poor yield. - Application of $N_{107}P_{33}K_{51}S_8Zn_2B_{1.5}$ kg ha⁻¹ for chili cultivation in char areas can maximize the yield and better economic return.		
5	Year of the experiment	Rabi season of 2019-20 and 2020-21		
6	Crop	Chili		
	Varieties	BARI Morich-3		
	Spacing	50 cm x 50 cm		
	Sowing date /time	15 September-10 October		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	$N_{107}P_{33}K_{51}S_8Zn_2B_{1.5}$ kg ha ⁻¹		
	Fertilizer application method	Full dose of P, S, Zn, and 1/4 th of K were applied during final land preparation. The remaining 3/4 th K and full dose of N were divided into 3 equal split and applied 25, 50, and 75 days after transplanting (DAT).		
	Date of harvesting	25 November- 20 March		
	Yield (t/ha)	12.47		
	Intercultural operation	Two to three weeding with four irrigations.		
7	Field duration (days)	180 to 195 Days		
8	Risk involvement in adopting the technology	Sudden flood may damage the crop		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11	Expected outcome	Optimum fertilizer dose determination for chili in char areas of Gaibandha		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		373950	130103	243847
13	Recommendation	Application of $N_{107}P_{33}K_{51}S_8Zn_2B_{1.5}$ kg ha ⁻¹ may be recommended for chili production in the char areas of Gaibandha.		

Sl. no.	Name of Technology	Development of suitable zinc fertilizer dose for maize production in char areas of Gaibandha		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Gaibandha		
3	Location of application	Saghata, Gaibandha or with similar soils of AEZ 7		
4	Key characteristic of the technology	• Soil zinc status is incredibly low in char areas of Gaibandha. • Application of Zn 6 kg ha⁻¹ with other fertilizer can be maximize maize production in char areas of Gaibandha.		
5	Year of the experiment	Rabi season of 2019-20 and 2020-21		
6	Crop	Maize		
	Varieties	BHM-9		
	Spacing	60 cm x 25 cm		
	Sowing date /time	5-30 November		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	N ₂₅₀ P ₄₈ K ₈₀ S ₂₈ Zn ₆ B ₁ kg ha ⁻¹		
	Fertilizer application method	One-third of N and all of P, K, S, Zn and B were applied during final land preparation. Remaining N was applied in two equal splits as top dressing in maize at 8-10 leaf stage (30-35 DAS) and at tasseling stage (60-65 DAS).		
	Date of harvesting	1-20 April		
	Yield (t/ha)	10.40		
	Intercultural operation	One weeding at 30-35 DAS with six to seven irrigations.		
7	Field duration (days)	145 to 150 Days		
8	Risk involvement in adopting the technology	Sudden flood may damage the crop		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11	Expected outcome	Proper zinc fertilizer dose estimated for maize production in char areas of Gaibandha		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		208000	92964	115036
13	Recommendation	Application of N ₂₅₀ P ₄₈ K ₈₀ S ₂₈ Zn ₆ B ₁ kg ha ⁻¹ may be recommended for maize production in the char areas of Gaibandha.		

Sl. no.	Name of Technology	Performance of mixed cropping in char areas of Gaibandha		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Gaibandha		
3	Location of application	Saghata, Gaibandha or with similar soils of AEZ 7		
4	Key characteristic of the technology	- In char areas of Gaibandha, farmers usually practiced mixed cropping of different crops without appropriate seed ratio. - Chile equivalent yield (29.9 ton / ha) can be obtained by cultivating 30 per cent Bt brinjal, 40 per cent radish and 30 per cent coriander mixed with 100 per cent chili in Gaibandha char area.		
5	Year of the experiment	Rabi season of 2019-20 and 2020-21		
6	Crop	Chilli, Brinjal, Radish and Coriander		
	Varieties	BARI Morich-3, BARI Bt. Begun-4, BARI Mula-1 and BARI Dhania-1		
	Spacing	Broadcasting (Mixed)		
	Sowing date /time	15 September-15 October		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	N ₁₄₂ P ₅₈ K ₆₁ S ₁₈ Zn ₃ B ₂ kg ha ⁻¹		
	Fertilizer application method	Full dose of P, S, Zn, and 1/4 th of K was applied during final land preparation. The remaining 3/4 th K and full dose of N were divided into 3 equal split and applied 25, 50, and 75 days after sowing.		
	Date of harvesting	Radish-15 Oct- 15 Nov., Coriander leaf-20 Oct.-20 Nov, Chili- 25 November- 20 Mar, Bt brinjal-10 December-20 March.		
	Yield (t/ha)	Chili: 10.0-10.5, Bt. brinjal: 16.0-17.0, Radish: 10-10.5, Coriander leaf: 2.4-2.5		
	Intercultural operation	One weeding at 30-35 DAS with four to six irrigations.		
7	Field duration (days)	175 to 190 Days		
8	Risk involvement in adopting the technology	Sudden flood may damage the crop		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11	Expected outcome	Determined of optimum seed ratio for mixed cropping in char areas		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		897000	114300	782700
13	Recommendation	100% chili with 30% Bt. brinjal, 40% radish and 30% coriander may be recommended for mixed cropping in the char areas of Gaibandha.		

SL	Name of Technology	:	Development of alternate cropping pattern Mustard-Mungbean-T. Aman rice against Mustard-Fallow-T. Aman rice cropping pattern under AEZ 20 and 22		
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)		
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701		
3	Location of application	:	Madhobpur, Hobigonj with similar soils of AEZ 20 and 22		
4	Key characteristics of the technology	:	• In Sylhet region a vast area remains fallow from December to May due to late transplanting of rainfed T. Aus rice and delay in harvesting of T. Aman rice in the existing cropping pattern. As a result farmers can't grow rabi crops in due time. • A short duration mungbean crop can be grown in this fallow period. • Inclusion of high yielding variety of mungbean in existing Fallow - T. Aus- T. Aman rice cropping pattern increases cropping intensity and improves soil health. • The improved cropping pattern provides rice equivalent yield of 8.23 t ha⁻¹.		
5	Year of experiment	:	2016-2019		
6	Crop	:	Mustard	Mungbean	T. Aman
	Variety	:	BARI Sarisha-14	MARI Mug-6	BARI dhan57
	Spacing	:	Broadcast	Broadcast	Line
	Sowing/transplanting date	:	25-28 Nov	13-15 March	27-29 July
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	138-36-50-33-2.5	23-17-17-0-0	79-14-49-0-0
	Fertilizer application method	:	Basal and top dressed	Vassal	Top dressed
	Date of Harvesting	:	21-25 February	20 May	10-15 November
	Yield (t ha ⁻¹)	:	1.14	0.93	4.34
	Intercultural operation	:	Weeding was done for mungbean and T.aman rice		
7	Field duration (days)	:	85-90	57-60	95-100
8	Risk involvement in adopting the technology	:	No risk involvement		
9	Impact on environment	:	No harmful effects on environment		
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.		
11	Expected outcome	:	Economically profitable Mustard-Mungbean-T. Aman rice cropping system to be developed for increasing cropping intensity.		
12	Socio-economic aspects	:	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	Mustard	:	81200	16700	64500
	Mungbean	:	83700	23775	59925
	T. Aman	:	97650	42680	54970
13	Recommendation	:	The result of experimentation indication that the pattern Mustard-Mungbean- T. Aman rice is economically profitable rather than existing cropping pattern.		

SL	Name of Technology	:	Development of alternate cropping pattern Mustard-T. Aus-T. Aman rice against Fallow-T. Aus-T. Aman rice cropping pattern under AEZ 20		
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)		
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701		
3	Location of application	:	Moulvibazar and Sylhet districts with similar soils of AEZ 20		
4	Key characteristics of the technology	:	• Inclusion of high yielding mustard variety after harvesting of T. Aman rice in the cropping pattern Fallow-T. Aus-T. Aman rice. • Improved cropping pattern increases rice equivalent yield by 45% over farmers existing pattern. • Improved pattern increases production efficiency and provides higher economic return.		
5	Year of experiment	:	2016-2019		
6	Crop	:	Mustard	T. Aus	T. Aman
	Variety	:	BARI Sarisha-14	BARI dhan65	BARI dhan57
	Spacing	:	Broadcast	20 cm x 15 cm	20 cm x 15 cm
	Sowing/transplanting date	:	20-25 Nov.	10-15 May	05-10 Aug.
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	200-15-70-120-4	85-15-47-0-0	79-14-49-0-0
	Fertilizer application method	:	Basal and top dressed	Top dressed	Top dressed
	Date of Harvesting	:	20-28 Feb.	10-15 Aug.	20-25 Nov.
	Yield (t ha ⁻¹)	:	1.08	3.43	4.40
	Intercultural operation	:	Weeding was done for rice		
7	Field duration (days)	:	95-100	75-80	90-95
8	Risk involvement in adopting the technology	:	No risk involvement		
9	Impact on environment	:	No harmful effects on environment		
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.		
11	Expected outcome	:	Economically viable cropping pattern (Mustard-T. Aus-T. Aman rice) will be developed.		
12	Socio-economic aspects	:	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	Mustard	:	43200	16700	26500
	T. Aus	:	68600	39624	28976
	T. Aman	:	99000	42680	56320
13	Recommendation	:	Mustard-T. Aus-T. Aman rice cropping system is more productive, sustainable and remunerative for medium high land under Eastern Surma Kushiara Floodplain (AEZ 20). So, farmers of commanding area could follow Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan65)-T. Aman rice (var. BRRI dhan57) cropping pattern for higher productivity and profitability as well as mustard straw can be utilized as fuel instead of cow dung.		

SL	Name of Technology	:	Intercropping of short duration vegetables with Sweet Potato in Sylhet region			
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)			
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701			
3	Location of application	:	Sylhet, Moulvibazer and Hobigonj districts with similar soils of AEZ 20			
4	Key characteristics of the technology	:	• Sweet potato is a long durated crops (150-180 days). Short durated vegetable can be intercropped in between two rows of sweet potato. • Early harvest of vegetables within 1st week of December provides higher income. • Increases total productivity and income.			
5	Year of experiment	:	2019-2020			
6	Crop	:	Sweet potato 100% + Mustard green 100%		Sweet potato + red amaranth + leaf amaranth + mustard + Base crop (sweet potato sole)	
	Variety	:	BARI Mishti Alu-12 + mustard green (local cultivar)		BARI Mishti Alu-12 + BARI Red Amaranth-1 + BARI Leaf Amaranth-1 + Mustard (local cultivar)	
	Spacing	:	60 cm × 30 cm		Broadcast method	
	Sowing/transplanting date	:	14-16 November			
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	129-34-130-12.8-4.3-1.4			
	Fertilizer application method	:	Basal and top dressed			
	Date of Harvesting	:	Sweet potato: 25-30 March		Companion crops: 15-20, December	
	Yield (t ha ⁻¹)	:	41.75			
	Intercultural operation	:	Fertilizer application followed by earthling up and irrigation was done 40-60 day after transplant			
7	Field duration (days)	:	150-180 for sweet potato		35-40 for companion crops	
8	Risk involvement in adopting the technology	:	No risk involvement			
9	Impact on environment	:	No harmful effects on environment			
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.			
11	Expected outcome	:	Suitable intercrop combination will be developed.			
12	Socio-economic aspects	:	Gross return (t ha ⁻¹)	Total cost (t ha ⁻¹)	Gross margin (t ha ⁻¹)	BCR
	Sweet Potato+ red amaranth	:	472800	131500	341300	3.60
	Sweet Potato + leaf amaranth	:	507600	131200	376400	3.87
	Sweet Potato + mustard green	:	625950	130450	495500	4.80
	Sweet Potato + mustard	:	527550	129580	397970	4.07
	Base crop (sweet potato sole)	:	459000	128700	330300	3.57
13	Recommendation	:	The total productivity along with crop diversification can be possible through intercropping system. It is also found more profitable than the sole cropping and risk of mono cropping can be reduced by intercropping. Though all intercrop combinations were suitable as compared to sole crop, but sweet potato 100% + mustard green (Lai shak) 100% combination was more productive and profitable in respect of sweet potato equivalent yield (42 t ha ⁻¹) and monetary return.			

SL	Name of Technology	:	Intercropping of brinjal with amaranth, mustard green and coriander in Sylhet region			
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)			
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701			
3	Location of application	:	Moulvibazer district with similar soils of AEZ 20			
4	Key characteristics of the technology	:	• Brinjal is a long duration crop. Short duration vegetable and spices can be grown in between rows of brinjal. • Early harvest of vegetables within 1st week of January provides higher income. • Increases total productivity and income.			
5	Year of experiment	:	2018-2020			
6	Crop	:	Brinjal 100% + Mustard green 100%		Brinjal 100% + red amaranth + leaf amaranth + Coriander + Base crop (Brinjal)	
	Variety	:	BARI Bt Begun-1 + mustard green (local cultivar)		BARI Bt Begun-1 + BARI Red Amaranth-1 + BARI Leaf Amaranth-1 + BARI Donia-1	
	Spacing	:	100 cm × 70 cm		Broadcast method	
	Sowing/transplanting date	:	5-7 December			
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	50-100-15-2-0-5			
	Fertilizer application method	:	Basal and top dressed			
	Date of Harvesting	:	Brinjal: 5-10 February		Companion crops: 5-10 January	
	Yield (t ha ⁻¹)	:	32.94			
	Intercultural operation	:	Weeding and irrigation was done at 80-160 days after transplant.			
7	Field duration (days)	:	Brinjal 150-180 days		Companion crops 35-40 days	
8	Risk involvement in adopting the technology	:	No risk involvement			
9	Impact on environment	:	No harmful effects on environment			
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.			
11	Expected outcome	:	Suitable intercrop combination to be selected for higher economic profit.			
12	Socio-economic aspects	:	Gross return (t ha ⁻¹)	Total cost (t ha ⁻¹)	Net return (t ha ⁻¹)	BCR
	Brinjal+ red amaranth	:	278400	152650	125750	1.82
	Brinjal + leaf amaranth	:	289950	152550	137400	1.90
	Brinjal + Coriander	:	268350	152550	115800	1.76
	Brinjal + mustard green	:	498100	152300	341800	3.24
	Base crop (Brinjal)	:	199800	150550	49250	1.33
13	Recommendation	:	The companion crop: mustard green cultivation with brinjal is most suitable and profitable than sole brinjal. Therefore it may be recommended for large scale production in Sylhet area.			

SL	Name of Technology	:	Performance of Maize in zero tillage at before and after harvest of Transplanted Aman rice				
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)				
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701				
3	Location of application	:	Moulvibazar district with similar soils of AEZ 20				
4	Key characteristics of the technology	:	- Maize seed to be sown 20 November before harvesting of T. Aman rice to utilize residual soil moisture. - Maize relay with T. Aman rice provides higher economic benefit. - System can be reduce the environmental hazard.				
5	Year of experiment	:	2017-2019				
6	Crop	:	Maize				
	Variety	:	BARI Hybrid Maize-9/ locally popular maize hybrids				
	Spacing	:	60 cm x 25 cm				
	Sowing/transplanting date	:	20 November				
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	290-62-100-44-5-1				
	Fertilizer application method	:	Basal and top dressed				
	Date of Harvesting	:	15-17 April				
	Yield (t ha ⁻¹)	:	12.19				
	Intercultural operation	:	Three irrigation were applied at 50, 60 and 120 DAS				
7	Field duration (days)	:	110-120				
8	Risk involvement in adopting the technology	:	No risk involvement				
9	Impact on environment	:	No harmful effects on environment				
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.				
11	Expected outcome	:	Suitable sowing date of maize as relay with T. Aman rice to be selected.				
12	Socio-economic aspects	:	Treatments	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	Benefit cost ratio (BCR)
		:	T ₁	174445	96250	78195	1.81
		:	T ₂	230095	96250	133845	2.39
		:	T ₃	168850	94700	74150	1.78
		:	T ₄	163940	94700	69240	1.73
		:	T ₁ : 10 November as relay with T. Aman rice, T ₂ : 20 November as relay with T. Aman rice, T ₃ : 30 November in T. Aman harvested fallow land and T ₄ : 10 December in T. Aman harvested fallow land.				
13	Recommendation	:	The result showed that maize could be grown as a relay with T. Aman rice on 20 November for achieving the maximum grain yield and economic profit with benefit cost ratio (2.39).				

S L	Name of Technology	:	On-farm adaptation of some oil seed crops under acidic soil of Sylhet region in Bangladesh					
1	Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)					
2	Contact division	:	On-Farm Research Division, BARI, Gazipur 1701					
3	Location of application	:	Sylhet region with similar soils of AEZ 20					
4	Key characteristics of the technology	:	• In Sylhet region most of the land remains fallow during rabi season after harvesting of T. Aman rice (December to May). • Oil seed crops can be grown successfully during this fallow period. • BARI released high yielding varieties of oil seed crops can maximize yield and economic return					
5	Year of experiment	:	2017-2019					
6	Crop	:	Mustard	Soybean	Groundnut	Sesame	Linseed	Sunflower
	Variety	:	BARI Sarisha-16	BARI Soybean-6	BARI Chinabadam-9	BARI Til-4	Local cultivar	BARI Surjomukhi-2
	Spacing	:	Broadcast	Broadcast	40cm x 15 cm	Broadcast	Broadcast	50cm x 30cm
	Sowing/transplanting date	:	20-25 Nov	15-18 Dec	2-5 Nov	15-18 Mar	20-25 Nov	15-20 Nov
	Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	:	90-27-32-10-1.0-0.5	23-30-50-15-1.0	25-160-85-300-10	60-30-40-18-2-0.5	31-13-20-8	90-35-75-25-1.0-0.5
	Fertilizer application method	:	Top dressed	Basal	Basal	Top dressed	Top dressed	Basal and top dressed
	Date of Harvesting	:	18-25 Feb.	5-10 Apr	5-7 Mar	12-15 Jun	13-15 Mar	25-28 Feb.
	Yield (t ha ⁻¹)	:	1.23	1.36	1.57	1.15	0.94	2.03
	Intercultural operation	:	Earthling up, weeding and irrigation was done as an when necessary.					
7	Field duration (days)	:	100-110	100-110	130-140	85-90	100-115	95-100
8	Risk involvement in adopting the technology	:	No risk involvement					
9	Impact on environment	:	No harmful effects on environment					
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.					
11	Expected outcome	:	Suitable crop varieties of oil seed crops to be selected for Sylhet region.					
12	Socio-economic aspects	:	Variety		Gross return (t ha ⁻¹)	Total variable cost (t ha ⁻¹)	Gross margin return (t ha ⁻¹)	
		BARI Sarisha-16		67650	35250	32400		
		BARI Soybean-6		36720	25524	11196		
		BARI Chinabadam-9		94200	58200	36000		
		BARI Til-4		40250	18960	21290		
		Local cultivar		61100	19750	41350		
		BARI Surjomukhi-2		81200	54780	26420		
13	Recommendation	:	The results of the trials conducted for two consecutive years revealed that mustard var. BARI Sarisha-16; soybean var. BARI Soybean-6; groundnut var. BARI Chinabadam-9; sesame var. BARI Til-4; Linseed var. Local cultivar and sunflower var. BARI Surjomukhi-2 performed better under the soil and climatic conditions of Sylhet region.					

Sl. no.	Name of Technology	Integrated Nutrient Management on Sunflower in southern region		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Patuakhali		
3	Location of application	Amtoli, Barguna region with similar soils of AEZ 13		
4	Key characteristic of the technology	• Sunflower cultivation is suitable in this region of its extensive adaptability and it is a good substitute when it is difficult to cultivate other oil crops due to climate change, increasing soil salinity in the coastal areas • Integrated nutrient management practices applied for sunflower can contribute to sustainable growth of yield and quality, influence plant health and reduce environmental risks. • Use of organic manures with optimum rate of fertilizers under intensive farming system increased the turnover of nutrients in the soil plant system.		
5	Year of the experiment	Rabi season of 2018, 2019 and 2020		
6	Crop	Sunflower		
	Varieties	BARI Sunflower-2		
	Spacing	60cm x 25cm		
	Sowing date /time	last week of December to 1 st week of January		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	96-34-19-7kg/ha N-P-K-S with 1.5 t/ha vermi-compost		
	Fertilizer application method	The full amount of vermicompost, TSP, MoP, Gypsum, Boric acid and half of urea would be applied as basal at final land preparation. The rest amount of urea would be applied 45 days after sowing.		
	Date of harvesting	15-20 April		
	Yield (t/ha)	2.29		
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops		
7	Field duration (days)	100 to 120 Days		
8	Risk involvement in adopting the technology	Heavy rainfall may damage the crop or may increase diseases severity		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.		
11	Expected outcome	Balanced growth of the plants, increased yield, improved soil health		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		114500	84000	30500
13	Recommendation	IPNS based 96-34-19-7kg/ha N-P-K-S with 1.5 t/ha vermi-compost may be recommended for sunflower production in southern region.		

1.	Name of Technology	:	Effect of Nutrient Management on the Quality Seed Yield of Groundnut		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Ghatail (AEZ-28), Tangail with similar soils of AEZ-28		
5.	Key characteristics of the technology	:	• Soil test based fertilizer with 15% extra NPK of STB dose (77-32-100-40-0.80-0.80 kg NPKSZnB ha⁻¹) gave the highest pod yield and quality seeds compared to others treatment combination • Yield, germination and vigor index increased by 75, 15 and 33%, respectively in STB fertilizer dose over farmers' practice. • Gross margin increased by 58 % in STB than farmers' practice.		
6.	Year of experimentation	:	2017 and 2018		
7.	Production guideline	:			
	Crop	:	Groundnut		
	Variety	:	BARI Chinabadam-8		
	Spacing (cm)	:	30 × 15		
	Sowing date	:	Last week of July		
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	77-32-100-40-0.80-0.80		
	Fertilizer application	:	Half of N and the entire amount of P, K, S, Zn and B were applied during final land preparation. Rest of the N was applied as top dressing at flowering stage		
	Harvesting time	:	Mid December		
	Pod yield (t ha ⁻¹)	:	1.96		
	Intercultural Operation	:	Intercultural operations and plant protections should be done to support the normal growth of the crop		
	Field duration (days)	:	150-155		
8.	Risk involvement in adopting the technology	:	Too much rainfall during sowing time it may hampers to delay sowing		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, providing training and information to DAE personnel and farmers, field day, booklet/ leaflet etc.		
11.	Expected outcome	:	Soil test based fertilizer with 15% extra NPK of STB dose seems promising for groundnut seed production for upcoming Rabi season regarding yield, seed quality and economic return.		
12.	Socio-economic aspects	:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	156800.00	69283.00	87517.00
13.	Recommendation	:	Soil test based fertilizer with 15% extra NPK of STB (77-32-100-40-0.80-0.80 kg ha ⁻¹ of NPKSZnB) fertilizer management package can be suggested for groundnut cultivation in Kharif-II season under AEZ-28 for higher yield, quality seed production and economic return.		

1	Name of Technology	:	Effect of Seedling Age and Transplanting Time on the Yield of Bt Brinjal		
2	Name of Organization	:	Bangladesh Agricultural Research Institute (BARI)		
3	Contract Division	:	On-Farm Research Division, BARI, Gazipur-1701		
4	Location of application	:	Tangail region with similar soils of AEZ 8 and 9		
5	Key characteristics of the technology	:	• The highest yield and gross margin were obtained from 35 days seedling with 15 October transplanted plants. • Fruit yield increased by 5% over 25 days old seedlings • Gross margin was higher than other treatments		
6	Year of experimentation	:	2017-20		
7	Production guideline	:			
	Crop		Brinjal		
	Variety	:	BARI Bt Begun-2		
	Spacing (cm)		100 × 80		
	Sowing date	:	Mid October		
	Fertilizer dose (NPKSZnB kg ha ⁻¹)	:	139- 40-100-18-1.7-3.58 with 33 and 21 kg ha ⁻¹ of Furadan and Bleaching powder +10 t ha ⁻¹ cow dung		
	Fertilizer application	:	Bleaching powder was applied 10-15 days before final land preparation. The entire amount of cow dung, P, S, B, Zn, Furadan and one third amount of K were applied during final land preparation. The remaining K was applied in four equal splits after each harvest of fruits at the time of nitrogen fertilizer application. Nitrogenous fertilizer was applied in four equal splits at 15-20 days after transplanting, flowering stage, fruiting stage and continuous fruiting stage followed by irrigation.		
	Harvesting time	:	January and continuous to Mid-April		
	Yield (t ha ⁻¹)		40.51		
	Intercultural Operation	:	Intercultural operations and plant protections should be done to support the normal growth of the crop		
	Field duration (days)	:	170-180		
8	Risk involvement in adopting the technology	:	Fusarium wilt, Phomopsis blight, Bacterial wilt may hampered the crop		
9	Impact on environment	:	No harmful effects on environment		
10	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet and leaflet etc.		
11	Expected outcome	:	Thirty five (35) days seedling with 15 October transplanted plants for the maximum production of BARI Bt Begun-2		
12	Socio economic aspects	:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
			729180.00	156118.00	573062.00
13	Recommendation	:	BARI Bt Begun-2 can be suggested to 15 October transplanted with 35 days aged seedling for the higher fruit yield and economic return in Tangail region.		

1.	Name of Technology	:	Intercropping of Onion and Garlic With Chilli in Charland Ecosystem in Tangail		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Charland of Tangail region with similar soils of AEZ-8		
5.	Key characteristics of the technology	:	• Intercropping onion with chilli is a profitable and promising Technology in Tangail region • Two rows of onion in between two rows of chilli gave maximum chilli equivalent yield • This technology produced 17.01 t ha⁻¹green chilli equivalent yield • Gross margin was 12% higher than sole chilli (farmers' practice)		
6.	Year of experimentation	:	2016-18		
7.	Production guideline	:			
	Crop	:	Chilli	Onion	Garlic
	Variety	:	BARI Morich-2	BARI Piaj-1	BARI Rashun-1
	Planting method	:	Chilli (100%) + 2 rows of onion in between two rows of chilli		
	Spacing (cm)	:	50 × 50	15×10	15×10
	Sowing/planting date	:	3rd week of November		
	Fertilizer dose (NPKSB kg ha ⁻¹)	:	96-60-100-20-1.36		
	Fertilizer application method	:	Half of nitrogen and full amount of P K S and B fertilizers were applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. Remaining half of N fertilizer was applied in the three equal splits at 25, 50 and 75 days after transplanting.		
	Harvesting time	:	2 nd week of April to 3 rd week of May	Last week of March	2 nd week of April
	Yield (t ha ⁻¹)	:	11.54 (Green chilli)	5.81 (bulb of onion)	
	Intercultural Operation	:	Intercultural operations should be necessary to support the normal growth of the crops		
	Field duration (days)	:	190-200	135-140	135-140
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and cropping intensity can be increased		
12.	Socio-economic aspects	:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		595175.00	92090.00	503085.00	
13	Recommendation	:	Two rows of onion in between two rows of chilli was more productive and economically profitable for charland ecosystem of Tangail (AEZ-8).		

1.	Name of Technology	:	Fertilizer Dose on Sesame in Charland Condition		
2.	Name of the organization	:	Bangladesh Agricultural Research Institute		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of Application	:	MLT site, Bhuapur under AEZ-8		
5.	Key characteristics of the technology	:	Soil test-based fertilizer (107-39-32-17-3.6-0.6 kg ha ⁻¹ N-P-K-S-Zn-B) gave the highest seed yield (1.31 t ha ⁻¹) which was at par with based on IPNS basis fertilizer (37-20-16-13-2-1). Soil test-based fertilizer management practice gave 57.83% higher yield of BARI Til-4 than farmers practice.		
6	Year of experimentation	:	2016-18		
7.	Production guideline	:			
	Crop	:	Sesame		
	Variety	:	BARI Til-4		
	Spacing	:	Continuous sowing with line to line spacing 30 cm		
	Sowing date	:	1 st week of April		
	Fertilizer dose (NPKSZnB kg ha ⁻¹)	:	107-39-32-17-3.6-0.6		
	Fertilizer application	:	Half of nitrogen and full quantity of P K S Zn B were applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively and rest of nitrogen was applied as top dress at flower initiation stage (25 days after sowing).		
	Harvesting date	:	Last week of June to 1 st week of July		
	Seed yield (t ha ⁻¹)	:	1.31		
	Intercultural Operation	:	Intercultural operations should be necessary to support the normal growth of the crops		
	Field duration (days)	:	85-90		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day booklet/ leaflet, radio talk, etc.		
11.	Expected outcome	:	Higher yield of sesame could be achieved by using soil test-based fertilizer management package		
12.	Socio-economic aspects	:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	BARI Til-4	:	65500	31708.62	27637.64
13.	Recommendation	:	It may be suggested that soil test-based fertilizer dose (107-39-32-17-3.6-0.6 kg ha ⁻¹ NPKSZnB) would be more productive and remunerative for sesame cultivation in the charland areas of Bhuapur, Tangail .		

1.	Name of Technology	:	Development of Alternate Cropping Pattern Potato-Boro-T.Aus- T. Aman Rice in Tangail region			
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)			
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701			
4.	Location of application	:	Dhanbari, Tangail region with similar soils of AEZ- 9 and 8			
5.	Key characteristics of the technology	:	• The newly introduced crop in the farmers cropping pattern was potato (BARI Alu-41) in <i>rabi</i> season • A short duration T. Aman rice variety BRRI dhan62 was also introduced for timely sowing of potato crop • Rice equivalent yield (REY) 37.40 t ha⁻¹ yr⁻¹ was in the improved cropping pattern whereas in the existing pattern (Potato-Boro-T. Aman rice) was recorded 26.07 t ha⁻¹ yr⁻¹ • Gross margin increased by 75% over existing pattern • MBCR 2.96 which indicate the improved cropping pattern is more remunerative than existing pattern			
6.	Year of experimentation	:	2017-18 and 2018-19			
7.	Production guideline	:				
	Crop	:	Potato	Boro rice	T. Aus rice	T. Aman rice
	Variety	:	BARI Alu-41	BRRI dhan28	BRRI dhan48	BRRI dhan62
	Spacing (cm)	:	60 cm × 25 cm	20 cm× 15 cm	20 cm× 15 cm	20 cm× 15 cm
	Sowing/Transplanting date	:	2 nd week of November	2 nd week of February	3rd week of May	2 nd week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	156-42-118-18-3-1	140-20-60-20-2-0	70-10-38-7-1-0	70-15-36-8-2.5-0
	Fertilizer application method	:	All P, S, Zn and B and half of N and K should be applied as basal during final land preparation. Remaining half of N and K should be applied as side dressing at 30-35 days after planting during earthing up operation.	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.
	Date of Harvesting	:	1 st week of Feb.	2 nd week of May	Last week of July	Last week of October
	Yield (t ha ⁻¹)	:	34.61	5.77	4.18	4.38
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops			
	Field duration (days)	:	86	89	78	77
8.	Risk involvement in adopting the technology	:	No risk involvement			
9.	Impact on environment	:	No harmful effects on environment			
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.			
11.	Expected outcome	:	Total productivity and cropping intensity can be increased			
12.	Socio-economic aspects	:	Considering the whole pattern			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	
		:	593490	319551	273939	
13.	Recommendation	:	Improved cropping pattern Potato-Boro-T. Aus-T. Aman rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Tangail region with similar soils of AEZ 9 and 8.			

1.	Name of Technology	:	Development of Alternate Cropping Pattern T. Aus- T. Aman/ Blackgram- Boro Rice in Tangail region			
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)			
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701			
4.	Location of application	:	Mizapur, Tangail region with similar soils of AEZ 9 and 8			
5.	Key characteristics of the technology	:	• The newly introduced crop in the farmers cropping pattern was Blackgram (BARI Mash-3) relay with T. Aman in <i>rabi</i> season • A short duration T. Aman rice variety BRRI dhan62 was also introduced for timely sowing of blackgram crop • Rice equivalent yield (REY) 19.99 t ha⁻¹yr⁻¹ was in the improved cropping pattern whereas in the existing pattern (T. Aus- T. Aman-Boro rice) was recorded 14.50 t ha⁻¹yr⁻¹ • Gross margin increased by 77% over existing pattern • MBCR 2.88 which indicate the improved cropping pattern is more remunerative than existing pattern			
6.	Year of experimentation	:	2017-18 and 2018-19			
7.	Production guideline	:				
	Crop	:	T.Aus rice	T. Aman rice	Blackgram	Boro rice
	Variety	:	BRRI dhan48	BRRI dhan62	BARI Mash-3	BRRI dhan28
	Spacing (cm)	:	20 cm× 15 cm	20 cm× 15 cm	Broadcast	20 cm× 15 cm
	Sowing/Transplanting date	:	Last week of May	3 rd week of August	Last week of October	1 st week of February
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	70-10-38-7-1-0	70-15-36-8-2.5-0	20-16-20-8-0-1.5	140-20-60-20-2-0
	Fertilizer application method	:	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.	All fertilizers should be applied as basal during final land preparation.	All of P, K, S, and Zn fertilizers should be applied as basal during final land preparation. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation stage.
	Date of Harvesting	:	2 nd week of August	2 nd week of November	2 nd week of January	2 nd week of May
	Yield (t ha ⁻¹)	:	4.28	4.39	1.48	5.88
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops			
	Field duration (days)	:	78	79	75	95
8.	Risk involvement in adopting the technology	:	No risk involvement			
9.	Impact on environment	:	No harmful effects on environment			
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.			
11.	Expected outcome	:	Total productivity and cropping intensity can be increased			
12.	Socio-economic aspects	:	Considering the whole pattern			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	
		:	333710	203678	135032	
13.	Recommendation	:	Improved cropping pattern T. Aus-T. Aman/Blackgram-Boro rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Tangail region with similar soils of AEZ 9 and 8.			

1.	Name of Technology	:	Development of Alternate Cropping Pattern Mustard-Boro-T. Aman Rice in Tangail Region		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Tangail region with similar soils of AEZ- 9 and 8		
5.	Key characteristics of the technology	:	- The newly introduced crop in the farmers cropping pattern was BARI Sarisha-14 in <i>rabi</i> season - A short duration T. Aman rice variety BRRI dhan72 was also introduced for timely sowing of mustard crop - Rice equivalent yield (REY) 15.98 $\text{tha}^{-1}\text{yr}^{-1}$ was in the improved cropping pattern whereas in the existing pattern was recorded 12.88 $\text{t ha}^{-1}\text{yr}^{-1}$ - Gross margin increased by 65% over existing pattern		
6.	Year of experimentation	:	2017-18 and 2018-19		
7.	Production guideline	:			
	Crop	:	Mustard	Boro rice	T. Aman rice
	Variety	:	BARI Sarisha-14	BRRI dhan29	BRRI dhan72
	Spacing (cm)	:	Broadcast	20 cm $\times$ 15 cm	20 cm $\times$ 15 cm
	Sowing/Transplanting date	:	2 nd week of November	2 nd week of February	2 nd week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	:	100-32-40-24-1-1	140-15-45-10-2-0	70-10-40-10-2-0
	Fertilizer application method	:	All P, K, S, Zn and B and half of N should be applied as basal during final land preparation. Remaining half of N should be applied as top dressed before flower initiation.	All P, K, S, and Zn fertilizers should be applied as basal. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation.	All P, K, S, and Zn fertilizers should be applied as basal. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation.
	Date of Harvesting	:	1 st week of Feb.	1 st week of June	Last week of October
	Yield (t ha^{-1})	:	1.75	6.56	5.36
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
	Field duration (days)	:	82	117	77
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and cropping intensity can be increased		
12.	Socio-economic aspects	:	Considering the whole pattern		
		:	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
		:	299660	186520	113140
13.	Recommendation	:	Improved cropping pattern Mustard-Boro-T. Aman rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Tangail region with similar soils of AEZ 9 and 8.		

1.	Name of Technology	:	Development of Alternate Cropping Pattern Cabbage-Okra-T. Aman rice in Tangail region		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Tangail region with similar soils of AEZ 9 and 8		
5.	Key characteristics of the technology	:	- The newly introduced crop in the farmers cropping pattern was okra (BARI derosh-2) in Kharif season - A short duration T. Aman rice variety BRRI dhan72 was also introduced for timely sowing of cabbage. - Rice equivalent yield (REY) 41.81 t ha⁻¹yr⁻¹ was in the improved cropping pattern whereas in the existing pattern (Cabbage-Brinjal- T. Aman rice) was recorded 32.96 t ha⁻¹yr⁻¹ - Gross margin increased by 17% over existing pattern		
6.	Year of experimentation	:	2017-18 and 2018-19		
7.	Production guideline	:			
	Crop	:	Cabbage	Okra	T. Aman rice
	Variety	:	Atum Queen	BARI Derosh-2	BRRI dhan72
	Spacing (cm)	:	60 cm× 45 cm	45 cm× 30 cm	20 cm× 15 cm
	Sowing/Transplanting date	:	2 nd week of November	2 nd week of March	1 st week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	138-40-125-20-1-1	70-20-75-0-0-0	70-10-40-10-2-0
	Fertilizer application method	:	Except N, all P, S, Zn, B and half of K fertilizers should be applied as basal during final land preparation. N and rest half of K should be applied in 3 equal splits, at 15, 30 and 60 days after transplanting in ring method.	All P, K, S, Zn, B and one fourth of N fertilizers should be applied as basal during final land preparation. Rest three fourth of N should be applied in 3 equal splits, at 20, 40 and 60 days after sowing .	All P, K, S, and Zn fertilizers should be applied as basal. N should be applied in 3 equal splits, the 1 st one as immediately after seedling establishment, the 2 nd one at early tillering stage and 3 rd one at 5-7 days before panicle initiation.
	Date of Harvesting	:	2 nd week of February	2 nd week of April 3 rd week of June	Last week of October
	Yield (t ha ⁻¹)	:	83	17	5.25
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
	Field duration (days)	:	92	96	78
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and cropping intensity can be increased		
12.	Socio-economic aspects	:	Considering the whole pattern		
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	6,82,810/-	2,19,590/-	4,63,220/-
13.	Recommendation	:	Improved cropping pattern Cabbage-Okra-T. Aman rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Tangail region with similar soils of AEZ 9 and 8.		

1.	Name of Technology	:	Recommendation of Fertilizer Dose and Variety on the Yield of Chili at Charland of Tangail		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Bhuapur, Tangail region with similar soils of AEZ-8		
5.	Key characteristics of the technology	:	• New crop variety of chili (BARI Morich-2) introduced among the farmers • Green chili yield was increased about 46% by using soil test based fertilizer dose and BARI Morich-2 compare to farmers existing practice • Gross margin increased by 59% over farmers existing practice		
6.	Year of experimentation	:	2018-19 and 2019-20		
7.	Production guideline	:			
	Crop	:	Chili		
	Variety	:	BARI Morich-2		
	Spacing	:	50 cm x 50 cm		
	Sowing/Transplanting date	:	First to second week of November , 30-35 days old seedling for transplanting		
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	147-51-93-8-1		
	Fertilizer application method	:	Full dose of P, S, Zn, and 1/4 th of K were applied during final land preparation. The remaining 3/4 th K and full dose of N were divided into 3 equal split and applied 25, 50, and 70 days after transplanting.		
	Date of Harvesting	:	March to May		
	Yield (t ha ⁻¹)	:	12.83		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and cropping intensity can be increased		
12.	Socio-economic aspects	:	Considering the whole pattern		
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	577350	105918	471432
13.	Recommendation	:	Soil test-based fertilizer management package (147-51-93-8-1 NPKSZnB kg ha ⁻¹) with BARI Morich-2 may be recommended for chili in the charland of Bhuapur, Tangail for higher yield and economic return.		

1.	Name of Technology	:	Recommendation Of Fertilizer Dose on Black Cumin at Charland of Tangail		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Bhuapur, Tangail region with similar soils of AEZ-8		
5.	Key characteristics of the technology	:	• New crop variety of black cumin (BARI Kalozira-1) introduced among the farmers • Seed yield was increased about 126% by using soil test based fertilizer dose compare to farmers existing practice • Gross margin increased by 326% over farmers existing practice		
6.	Year of experimentation	:	2017-18 and 2018-19		
7.	Production guideline	:			
	Crop	:	Black cumin		
	Variety	:	BARI Kalozira-1		
	Spacing	:	Continuous line sowing with 15 cm line to line distance		
	Sowing/Transplanting date	:	Seeds sown first to second week of November		
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	78-33-15-9-3-1		
	Fertilizer application method	:	Half N, P, K were applied during final land preparation. The remaining ½ N was applied 40 days after sowing.		
	Date of Harvesting	:	April		
	Yield (kg ha ⁻¹)	:	0.95		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and cropping intensity can be increased		
12.	Socio-economic aspects	:	Considering the whole pattern		
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	142500	43050	99450
13.	Recommendation	:	Soil test-based fertilizer management package (78-33-15-9-3-1 NPKSZnB kg ha ⁻¹)) with BARI Kaligira-1 should be recommended for black cumin cultivation for the charland of Bhuapur, Tangail under AEZ#8 for higher yield and economic return.		

1.	Name of Technology	:	Cultivation of Capsicum is a Profitable Technology in Tangail Region		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Atia, Delduar, Tangail		
5.	Key characteristics of the technology	:	• New varieties of capsicum (BARI Misti Morich-1 and BARI Misti Morich-2) were introduced among the farmers. • Fruit yield increased up to 12% over the available imported cultivars • Gross margin increased by 24% over existing cultivars		
6.	Year of experimentation	:	2018-19 and 2019-20		
7.	Production guideline	:			
	Crop	:	Capsicum		
	Variety	:	BARI Misti Morich-1, BARI Misti Morich-2 and available imported cultivar of capsicum		
	Spacing	:	45 cm × 45cm		
	Sowing/Transplanting date	:	First week of November		
	Fertilizer dose (N-P-K-S-Zn kg ha ⁻¹)	:	115-69-125-17-1.7		
	Fertilizer application method	:	Full amount of cow dung (5 t ha ⁻¹) and P, half amount of N, K and entire amount of S were applied during final land preparation. The remaining N and K were applied in 3 equal installments of 21, 35 and 50 days after transplanting.		
	Date of Harvesting	:	January to February		
	Yield (t ha ⁻¹)	:	18.21 (BARI Misti Morich-2)		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Productivity and economic return may be increased		
12.	Socio-economic aspects	:			
			Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
			2913600	1251125	1662475
13.	Recommendation	:	BARI Misti Morich-2 may be recommended for large scale production in Delduar, Tangail for better yield and economic return.		

1.	Name of Technology	:	Cultivation of Gladiolus Flower is a Profitable Technology at Tangail		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
4.	Location of application	:	Atia, Delduar, Tangail		
5.	Key characteristics of the technology	:	• New varieties of flower were introduced among the farmers. • Production of flower may uplift the socio-economic condition of the farmers		
6.	Year of experimentation	:	2018-19 and 2019-20		
7.	Production guideline	:			
	Crop	:	Gladiolus		
	Variety	:	BARI Gladiolus-3, BARI Gladiolus-4, and BARI Gladiolus-5		
	Spacing	:	25 cm × 15 cm		
	Sowing/Transplanting date	:	Second week of November		
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	138-75-150-18-3-2 + CD 5000		
	Fertilizer application method	:	Entire quantity of cowdung, P, K, S, Zn, and B were applied during the final land preparation. Urea was applied in two equal installments of 25 and 50 days after emergence.		
	Date of Harvesting	:	January to February		
	Yield (no. spike ha ⁻¹)	:	185000 (BARI Gladiolus-4)		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Productivity and economic return may be increased		
12.	Socio-economic aspects	:			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	1666000	903669	762331
13.	Recommendation	:	BARI Gladiolus-4 may be recommended as extension message for cultivation in large area in Tangail region.		

1.	Name of Technology	:	Effect of Different Planting Time on Yield of BARI Released Gladiolus Varieties		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur-1701		
4.	Location of application	:	Atia, Delduar, Tangail		
5.	Key characteristics of the technology	:	• Optimum planting time and suitable variety of gladiolus has been identified for Delduar, Tangail region • Production of flower has uplifted the socio-economic condition of the farmers		
6.	Year of experimentation	:	2019-20 and 2020-21		
7.	Production guideline	:			
	Crop	:	Gladiolus		
	Variety	:	BARI Gladiolus-3, BARI Gladiolus-4, and BARI Gladiolus-5		
	Spacing	:	25 cm × 15 cm		
	Sowing/Transplanting date	:	15 October, 30 October and 15 November		
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	138-75-150-18-3-2 + CD 5000		
	Fertilizer application method	:	Entire quantity of cowdung, P, K, S, Zn, and B were applied during the final land preparation. Urea was applied in two equal installments of 25 and 50 days after emergence.		
	Date of Harvesting	:	January to February		
	Yield (no. spike ha ⁻¹)	:	194000 (BARI Gladiolus-3 sown at 15 October)		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Productivity and economic return may be increased		
12.	Socio-economic aspects	:			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	970000	272355	697645
13.	Recommendation	:	BARI Gladiolus-3 sown at 15 October may be recommended as extension message for cultivation in large area in Tangail region.		

1.	Name of Technology	:	Mixed Cropping of Linseed With Groundnut at Varying Plant Population at Charland Ecosystem		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur-1701		
4.	Location of application	:	Bhuapur, Tangail region with similar soils of AEZ-8		
5.	Key characteristics of the technology	:	• Most suitable ratio of groundnut (100%) and linseed (45%) in mixed cropping has been identified • Groundnut equivalent yield was increased about 24% compare to sole groundnut cultivation • Gross margin increased by 30% over sole groundnut cultivation		
6.	Year of experimentation	:	2016-17 and 2017-18		
7.	Production guideline	:			
	Crop	:	Black cumin and linseed		
	Variety	:	BARI Chinabadam-8 and Nila		
	Spacing	:	Groundnut: 30 cm x 15 cm, linseed: Broadcast		
	Sowing/Transplanting date	:	Both groundnut and linseed seeds were sown first week of November		
	Fertilizer dose (N-P-K-S-B kg ha ⁻¹)	:	21-36-25-10-0.4+ CD 5000		
	Fertilizer application method	:	Half of nitrogen and full amount of PKSB were applied at the time of final land preparation. Remaining N was top dressed at flowering stage.		
	Date of Harvesting	:	Linseed: Last week of February, Groundnut: First week of April		
	Groundnut equivalent yield (t ha ⁻¹)	:	2.93		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and maximum utilization of land can be increased		
12.	Socio-economic aspects	:			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	143400	49423	93977
13.	Recommendation	:	Groundnut (100%) with linseed (45%) mixed cropping should be recommended for the charland of Bhuapur, Tangail under AEZ#8 for higher yield and economic return.		

1.	Name of Technology	:	Intercropping of Mukhikachu and Papaya with Pineapple		
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur-1701		
4.	Location of application	:	Modhupur, Tangail region with similar soils of AEZ-28		
5.	Key characteristics of the technology	:	• Most suitable intercropping combination with pineapple (Pineapple + Mukhikachu + Papaya) has been identified • Pineapple equivalent yield was increased about 40% compare to sole pineapple cultivation • Gross margin increased by 48% over sole pineapple cultivation		
6.	Year of experimentation	:	2015-17 and 2018-20		
7.	Production guideline	:			
	Crop	:	Pineapple (100%), mukhikachu (40%) and papaya (66%)		
	Variety	:	Giant Q, Bilashi and Sahi		
	Spacing	:	Pineapple: 50 cm distance between two rows of pineapple and 100 cm distance between two paired row, Mukhikachu: Plant to plant 40 cm and row to row 3 m (Single row), Papaya: plant to plant 2 m and row to row 3 m (Single row)		
	Sowing/Transplanting date	:	Pineapple: Third week of February, Mukhikachu: Third week of May, Papaya: Third week of May		
	Fertilizer dose (N-P-K-S-B kg ha ⁻¹)	:	Pineapple: 225-85-150-30-1.5 + CD 5000 Mukhikachu: 31-27-103-0-0 + CD 5000 Papaya: 114-82-16-0-11 + CD 5000		
	Fertilizer application method	:	Pineapple: n was applied in three equal splits at 20, 60, 90 days after planting. The PKSzn and Cowdung were applied at final land preparation. Mukhikachu and papaya: All fertilizers were applied in pit.		
	Date of Harvesting	:	Pineapple: second week of July to third week of October, Mukhikachu: Third to last week of November, Papaya: Last week of October to First week of April		
	Pineapple equivalent yield (t ha ⁻¹)	:	59.00		
	Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
8.	Risk involvement in adopting the technology	:	No risk involvement		
9.	Impact on environment	:	No harmful effects on environment		
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
11.	Expected outcome	:	Total productivity and maximum utilization of land can be increased		
12.	Socio-economic aspects	:			
		:	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		:	663750	344363	319387
13.	Recommendation	:	Pineapple (100%) with mukhikachu (40%) and papaya (66%) intercropping should be recommended Modhupur, Tangail under AEZ#28 for higher yield and economic return.		

1.	Name of Technology	:	Effect of Different Planting System of Chilli in the Char Areas of Kishoreganj district								
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)								
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701								
4.	Location of application	:	Kishoreganj Sadar and Hossainpur upazilla with similar soils of AEZ-8 and 9								
5.	Key characteristics of the technology	:	- Farmer’s get more yield in continuous seed showing double row method than transplanting in double row and broadcasting methods - Continuous sowing in double row method plants gets more space for natural and nutrients sources and inter species competition is low than other treatments - Continuous seed showing in double row method gives the highest yield (7.21 t/ha) which is 12% higher than the transplanting in double row and 28% higher than the broadcasting method - Gross margin increased by 17% over transplanting in double row and 71% over the broadcasting method								
6.	Year of experimentation	:	2017-2020								
7.	Production guideline	:									
	Treatments	:	T ₁ (Broadcasting)		T ₂ (Continuous sowing in double row)		T ₃ (Transplanting in double row)				
	Variety	:	Nodaria (Local)		Nodaria (Local)		Nodaria (Local)				
	Spacing (cm)	:	Broadcasting		Continuous sowing		25cm x 20cm				
	Sowing/Transplanting date	:	09 to 19 October		09 to 19 October		10 to 15 October				
	Fertilizer dose (N-P-K -B kg ha-1)	:	97-66-100-.85		97-66-100-.85		97-66-100-.85				
	Fertilizer application method	:	One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAS.		One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAS.		One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAT.				
	Date of Harvesting	:	10 Feb. to 25 April		16 Feb. to 10 May		14 Feb. to 12 May				
	Field duration (Days)	:	190		200		188				
	Yield (t/ha)	:	6.45		7.21		5.74				
	Intercultural Operation	:	In chilli cultivation two weeding should be done at 25 and 45 DAS. Three to four irrigation is needed at crop demand for proper flower initiation. Two spray of vertimac done to control insects and pest.								
8.	Impact on environment	:	No harmful effects on environment								
9.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.								
10.	Expected outcome	:	Total productivity can be increased								
11.	Socio-economic aspects	:	Considering all the treatments								
			Gross return (Tk/ha)			TVC (Tk/ha)			Gross margin (Tk/ha)		
			T ₁	T ₂	T ₃	T ₁	T ₂	T ₃	T ₁	T ₂	T ₃
			160375	180250	142875	71385	76050	78510	88990	104200	64365
12.	Recommendation	:	Among the three treatments farmers are vary much encouraged to grow chilli with continuous sowing in double row, as intercultural operation and harvesting is easier and yield is high in this method.								

T₁ = Broadcasting (Farmer's practice), T₂ = Continuous sowing in double row and T₃ = Transplanting in double row

1.	Name of Technology	:	Development of two crops based Potato-Boro rice -Fallow cropping pattern against Fallow-Boro rice -Fallow cropping pattern in haor area of Kishoreganj					
2.	Organization	:	Bangladesh Agricultural Research Institute (BARI)					
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701					
4.	Location	:	Nikli upazilla, Kishoreganj region with similar soils of AEZ-19					
5.	Key characteristics of the technology	:	• The newly introduced crop in the farmers cropping pattern was potato (BARI Alu-8) in rabi season • Rice equivalent yield of Potato-Boro-Fallow pattern (21.89 t/ha) was found 215% higher than the sole boro rice (6.96 t/ha) cultivation • Higher gross margin (224510 Tk/ha) achieved by Potato-Boro-Fallow cropping pattern which was 265% higher than the sole boro rice cultivation • MBCR of Potato-Boro-Fallow cropping pattern was 2.20 which indicated the superiority of potato based cropping pattern over sole boro rice					
6.	Duration	:	2018-2020					
7.	Production guideline	:	Potato-Boro rice-Fallow			Fallow-Boro rice-Fallow		
	Crop Variety	:	Potato BARI Alu-8	Boro rice BRRI dhan29	Boro rice BRRI dhan29			
	Spacing (cm)	:	60cm x 25cm	25cm x15cm	25cm x15cm			
	Sowing/Transplanting	:	04 to 22 November	19 Jan.-04 February	25 December-10 January			
	Fertilizer dose (kg/ha) (N-P-K-S-Zn-B)	:	152-42-125-20-04-02	140-18-53-08-03-02	140-18-53-08-03-02			
	Fertilizer application method	:	Half N and all PKS Zn and B were applied as basal at final land preparation. Rest of N should be applied 30-35 DAS.	One third N and full dose of other fertilizers be applied at final land preparation. Rest one third N should be applied at 20-25 DAT and rest one third N should be applied 5-7 days before panicle initiation.	One third N and full dose of other fertilizers be applied at final land preparation. Rest one third N should be applied at 20-25 DAT and rest one third N should be applied 5-7 days before panicle initiation.			
	Date of Harvesting	:	10 January-04 February	22 April-15 May	13-20 April			
	Field duration (Days)	:	78-90	94-101	110-117			
	Yield (T/ha)	:	24.17	6.62	6.43			
	Intercultural Operation	:	In potato cultivation two weeding and two earthing up should be done 15 and 35 DAS. Two to three irrigation is needed at 20 and 45 DAS for proper tuber formation. In case of Rice cultivation two weeding and top dressed of urea should be done and 10 to 15 cm water should be retain in the field.					
9.	Impact on environment	:	No harmful effects on environment					
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.					
11.	Expected outcome	:	Total productivity and cropping intensity can be increased					
12.	Socio-economic aspects	:	Considering the whole pattern					
			Gross return (Tk/ha)		Total variable cost (Tk/ha)		Gross margin (Tk/ha)	
			Potato-Boro rice - Fallow	Fallow-Boro rice -Fallow	Potato-Boro rice - Fallow	Fallow-Boro rice -Fallow	Potato-Boro rice - Fallow	Fallow-Boro rice -Fallow
			437747	138867	213237	77346	224510	61521
13.	Recommendation	:	Improved cropping pattern Potato-Boro-Fallow was more productive and remunerative and it could be suggested for large scale production in upper catena of Haor areas.					

1.	Name of Technology	:	Development of two crops based Mustard-Boro rice-Fallow cropping pattern against Fallow-Boro rice-Fallow cropping pattern in upper catena of haor area			
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)			
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701			
4.	Location of application	:	Nikli upazilla, Kishoreganj region with similar soils of AEZ-19			
5.	Key characteristics of the technology	:	• Short duration mustard variety (BARI Sharisha-17) was introduced in the haor areas • Rice equivalent yield of Mustard-Boro-Fallow cropping pattern (11.27 t/ha) which is 62% higher than the sole boro rice (6.96 t/ha) cultivation • Higher gross margin achieved by Mustard-Boro-Fallow cropping pattern (104582 Tk/ha) which is 91% higher than the sole boro rice cultivation • MBCR of Mustard-Boro-Fallow cropping pattern is 2.91 which indicate the superiority of mustard based cropping pattern over sole boro rice			
6.	Year of experimentation	:	2018-2020			
7.	Production guideline	:	Mustard-Boro rice-Fallow		Fallow-Boro rice-Fallow	
	Crop	:	Mustard		Boro rice	
	Variety	:	BARI Sharisha-17		BRRI dhan29	
	Spacing (cm)	:	Broadcast		25cm x15cm	
	Sowing/Transplanting date	:	24 October-03 November		19 January-04 February	
	Fertilizer dose per hectare (N-P-K-S-Zn-B kg)	:	115-32-40-25-2-2		140-18-53-08-03-02	
	Fertilizer application method	:	Half of N and full dose of PKS and Zn to be applied as basal and rest of N should be applied at the time of flowering		One third N and full dose of other fertilizers be applied at final land preparation. Rest one third N should be applied at 20-25 DAT and rest one third N should be applied 5-7 days before panicle initiation.	
	Date of Harvesting	:	10 January-04 February		25 April-15 May	
	Field duration (Days)	:	78-90		96-101	
	Yield (t ha-1)	:	1.74		6.5	
	Intercultural Operation	:	In case of Rice cultivation two weeding and top dressed of urea should be done and 10 to 15 cm water should be retained in the field. For Mustard cultivation, one irrigation was done and Rovral was sprayed at 60-65 DAS.			
9.	Impact on environment	:	No harmful effects on environment			
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.			
11.	Expected outcome	:	Total productivity and cropping intensity can be increased			
12.	Socio-economic aspects	:	Considering the whole pattern			
			Gross return (Tk/ha)		Total variable cost (Tk/ha)	
			Mustard-Boro rice-Fallow	Fallow-Boro rice-Fallow	Mustard – Boro rice-Fallow	Fallow-Boro rice-Fallow
			214668	138867	110086	84013
					Gross margin (Tk/ha)	
					Mustard-Boro rice-Fallow	Fallow-Boro rice-Fallow
					104582	54854
13.	Recommendation	:	Improved cropping pattern Mustard-Boro rice-Fallow was more productive and remunerative and it could be suggested for large scale production in upper catena of Haor areas.			

1.	Name of Technology	:	Effect of Detopping on Grain and Fodder Yield of Maize in Haor Areas of Kishoreganj								
2.	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)								
3.	Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701								
4.	Location of application	:	Nikli upazilla, Kishoreganj District with similar soils of AEZ-9								
5.	Key characteristics of the technology	:	• The newly introduced forced maturity technique (Detopping of maize after silking) farmer's get more time for Boro and jute cultivation than traditional farmer's practice • Detopping of maize enhance maturity (save around 10 to 15 days) and thus save the crop from early flash flood in the haor areas • Though farmer's practice (without detopping) give highest yield (10.31 t/ha) but it gets longest life duration (140 days), that creates a big problem with latter Boro rice and Jute cultivation • In addition detopping technique give a huge amount of fresh fodder yield (6.04 t/ha), which serves as a good source of food for cattle at lean season • Gross margin (98485 tk/ha) and MBCR (2.29) is highest at farmer's practice (No detopping)								
6.	Year of experimentation	:	2018-2020								
7.	Production guideline	:									
Treatments		:	T ₁ (Detopping at 25 days after pollination)		T ₂ (Detopping at 35 days after pollination)		T ₃ (No detopping)				
Variety		:	BARI Hybrid Maize-9		BARI Hybrid Maize-9		BARI Hybrid Maize-9				
Spacing (cm)		:	60 cm x 25 cm		60 cm x 25 cm		60 cm x 25 cm				
Sowing/Transplanting date		:	24 to 30 October		24 to 30 October		24 to 30 October				
Fertilizer dose (N-P-K-S-Z _n -B kg/ ha		:	244-50-110-29-3.6-1.2		244-50-110-29-3.6-1.2		244-50-110-29-3.6-1.2				
Fertilizer application method		:	One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used		One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used		One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used				
Date of Harvesting		:	26 Feb. to 06 March		02 to 11 Mach		10 to 25 Mach				
Field duration (Days)		:	126		131		142				
Yield (t ha-1)		:	8.8		9.91		10.31				
Intercultural Operation		:	In maize cultivation two earthing up along with weeding should be done at 25 and 60 DAS. Four irrigation is needed at crop demand for proper kernel development. Two spray of Carate and Virtako was done to control <i>Spodoptera letura</i> .								
9.	Impact on environment	:	No harmful effects on environment								
10.	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.								
11.	Expected outcome	:	Total crop duration is shorter and farmer's can easily cultivate next crop like jute and total productivity and cropping intensity can be increased								
12.	Socio-economic aspects	:	Considering all the treatments								
			Gross return (Tk. ha-1)		Total variable cost (Tk. ha-1)			Gross margin (Tk. ha-1)			
			T ₁	T ₂	T ₃	T ₁	T ₂	T ₃	T ₁	T ₂	T ₃
13.	Recommendation	:	159453	180026	174460	82695	82695	75975	76758	96858	98485
			Among the three treatments farmers are vary much encouraged to cultivate maize with detopping techniques, as they get good quality fodder and enough time for next crop (Jute), So this technology should be extended in the upper catena of haor areas.								

Sl. no.	Name of Technology	Development of four crop-based cropping pattern Field Pea-Boro-T. Aus- T. Aman rice in Pabna region			
1.	Name of organization	Bangladesh Agricultural Research Institute			
2.	Contract division	On-Farm Research Division, BARI, Gazipur			
3.	Location of application	Pabna Sadar and Atghoria upazila with similar soils of AEZ 11			
4.	Key characteristics of the technology	• The turn around time can be minimized about 85-90 days by practicing four crop production in a year. • Rice equivalent yield (REY) 34.43 t ha⁻¹ yr⁻¹ was obtained from four crop-based cropping pattern which is about 51% higher than existing pattern. • Gross margin increased by 57% over existing pattern.			
5.	Year of activities	Two cropping patterns during 2017-18 and 2018-19			
6.	Production guideline				
	Crop	Field Pea	Boro	T. Aus	T. Aman
	Variety	BARI Motor-3	BRRi Dhan28	BRRi Dhan48	Binadhan-17
	Spacing	Broadcast (Relay)	20cm x 15 cm	20cm x 15 cm	20cm x 15 cm
	Sowing/Transplanting date/time	Last week of October	1 st week of February	2 nd week of May	2 nd week of August
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	40-25-20-10-1.5-1	150-20-65-18-1.3-0	75-10-25-9-0.6-0	90-10-35-12-1-0
	Fertilizer application method	Half N and all PKS ZnB should be applied after harvesting of T. Aman and half of N applied during flower initiation stage	Full dose of PKS Zn to be applied as basal and N should be applied in 2 equal splits as to dress at 15 and 35 days after transplanting of seedlings.		
	Date of harvesting	Last week of January	1 st week of May	1 st week of August	1 st week of November
	Yield (t ha ⁻¹)	5.24 (fresh pod)	6.14	5.07	5.48
	REY (t ha ⁻¹ year ⁻¹)	34.43			
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops			
7.	Field duration (Days)	88	90	85	87
8.	Risk involvement in adopting the technology	Excessive drought may damage the crop			
9.	Impact on environment	No harmful effects on environment			
10.	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.			
11.	Expected outcome	Total productivity and cropping intensity can be increased			
12.	Socio-economics	Considering the whole pattern			
		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)		Gross margin (Tk. ha ⁻¹)
		628348	230548		397780
13.	Recommendation	Four crop-based cropping pattern Field Pea-Boro-T. Aus-T. Aman rice is more productive and profitable. It could be suggested for large scale dissemination in medium high land of Pabna and Siraijani.			

Sl. no.	Name of technology	Development of fertilizer management package for onion				
1.	Name of organization	Bangladesh Agricultural Research Institute				
2.	Contract division	On-Farm Research Division, BARI, Gazipur				
3.	Location of application	Pabna Sadar, Santhia and Sujanagar upazila with similar soils of AEZ 11				
4.	Key characteristics of the technology	• Application of recommended fertilizer (RF) + 1.5 t ha⁻¹ ash and RF+ 2 t ha⁻¹ poultry manure (PM) exhibits around 10-13% higher bulb yield of onion over farmers practice. • Maximum gross return and gross margin was obtained from RF + 1.5 t ha⁻¹ ash followed by RF+ 2 t ha⁻¹ PM. • Gross margin increased nearly 17% by RF + 1.5 t ha⁻¹ ash over existing pattern.				
5.	Year of activities	Rabi season of 2018, 2019 and 2020				
6.	Crop	Onion				
	Variety	BARI Piaj-1				
	Spacing	10 cm x 5 cm				
	Transplanting date	10-15 December				
	Treatments	RD (FRG' 2018)	RD + Extra 25% NPKS	RD + 1.5 t ha ⁻¹ Ash	RD+ 2 t ha ⁻¹ PM	Farmers practice
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	RD: 105-45-60-10-1.5-1.0				104-52-120-27-3-1.5
	Fertilizer application method	1/3 N, 1/2 K and full dose of P, S, Zn and B were applied as basal and rest N and K should be applied in 2 equal splits as to dress at 25 and 50 days after transplanting of seedlings.				
	Date of harvesting	20-25 March				
	Yield (t ha ⁻¹)	17.90	18.22	19.84	18.54	17.53
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops				
7.	Field duration (days)	90 to 100 Days				
8.	Risk involvement in adopting the technology	Heavy rainfall may damage the crop or may increase diseases severity				
9.	Impact on environment	No harmful effects on environment				
10.	Procedure of transfer	Block demonstration, Farmer's training, Field day, booklet/leaflet etc.				
11.	Expected outcome	Total productivity can be increased				
12.	Socio-economic aspect	Considering higher yield obtaining treatments				
		Treatments		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		RD + 1.5 t ha ⁻¹ Ash		694400	143712	550688
		RD+ 2 t ha ⁻¹ PM		648900	144212	504688
13.	Recommendation	Application of RF + 1.5 t ha ⁻¹ Ash and RF+ 2 t ha ⁻¹ poultry manure (PM) in soil reveal better fertilizer management package for onion production regarding yield and economic return. This nutrient package can be recommended for onion cultivation in similar extrapolation areas.				

Sl. no.	Name of Technology	Mustard-Boro- T.aman is a profitable cropping pattern in Pabna region		
1.	Name of organization	Bangladesh Agricultural Research Institute		
2.	Contract division	On-Farm Research Division, BARI, Gazipur		
3.	Location of application	Pabna region with similar soils of AEZ 11		
4.	Key characteristics of the technology	• In the improved pattern the yield of Mustard, Boro and T.aman rice can be increased by 100, 30 and 23% respectively over traditional variety. • Rice equivalent yield (REY) 15.2 t ha⁻¹ yr⁻¹ was obtained from three crop-based cropping pattern which is about 45% higher than existing pattern. • Increase crop intensity and productivity and famers' economic return.		
5.	Year of activities	Three cropping patterns during 2017-18 to 2019-20		
6.	Production guideline			
	Crop	Mustard	Boro	T. Aman
	Variety	BARI Sarisha-17	BRRI Dhan28	Binadhan-17
	Spacing	Broadcast	20cm x 15 cm	20cm x 15 cm
	Sowing/Transplanting date/time	15-20 November	15-20 February	25-31 July
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	90-27-33-15.2-1-1	150-20-65-18-1.3-0	90-10-35-12-1-0
	Fertilizer application method	Half N and all PKS Zn B should be applied as basal and half of N applied during flower initiation stage	Full dose of PKS Zn to be applied as basal and N should be applied in 2 equal splits as to dress at 15 and 35 days after transplanting of seedlings.	
	Date of harvesting	5-15 February	20-30 May	20-25 October
	Yield (t ha ⁻¹)	2.13	5.25	5.38
	REY (t ha ⁻¹ year ⁻¹)	15.2		
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops		
7.	Field duration (Days)	80-85	90-95	90-95
8.	Risk involvement in adopting the technology	Excessive drought may damage the crop		
9.	Impact on environment	No harmful effects on environment		
10.	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11.	Expected outcome	Total productivity and cropping intensity can be increased		
12.	Socio-economics	Considering the whole pattern		
		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		382450	209500	172950
13.	Recommendation	The cropping pattern Mustard-Boro-T. Aman rice is more productive and profitable. It could be suggested for large scale dissemination in Pabna region.		

Sl. no.	Name of Technology	Three cop based Lentil-Sesame- T. aman is an improved cropping pattern in Pabna region		
1.	Name of organization	Bangladesh Agricultural Research Institute		
2.	Contract division	On-Farm Research Division, BARI, Gazipur		
3.	Location of application	Pabna region with similar soils of AEZ 11		
4.	Key characteristics of the technology	• In the improved pattern the yield of Lentil, Sesame and T.aman rice can be increased by 9, 14 and 22% respectively over traditional variety. • Rice equivalent yield (REY) 14.8 t ha⁻¹ yr⁻¹ was obtained from three crop-based cropping pattern which is about 14% higher than existing pattern. • Increase crop intensity and productivity and famers' economic return.		
5.	Year of activities	Three cropping patterns during 2017-18 to 2019-20		
6.	Production guideline			
	Crop	Lentil	Sesame	T. Aman
	Variety	BARI Mashur-8	BARI Til-4	Binadhan-7
	Spacing	Broadcast	Broadcast	20cm x 15 cm
	Sowing/Transplanting date/time	15-25 November	15-20 March	25-31 July
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	18-30-25-18-1-1	78-18-27.5-20-1-0	90-10-35-12-1-0
	Fertilizer application method	Half N and all PKS ZnB should be applied as basal and half of N should be applied during 25-30 DAS.	Half N and all PKS ZnB should be applied as basal and half of N should be applied during 25-30 DAS.	Full dose of PKS Zn to be applied as basal and N should be applied in 2 equal splits as to dress at 15 and 35 days after transplanting of seedlings.
	Date of harvesting	5-15 March	20-30 June	1-5 November
	Yield (t ha ⁻¹)	1.85	1.43	5.55
	REY (t ha ⁻¹ year ⁻¹)	14.8		
	Intercultural operation	Intercultural operation should be necessary to support the normal growth of the crops		
7.	Field duration (Days)	110-115	95-100	95-100
8.	Risk involvement in adopting the technology	Excessive drought may damage the crop		
9.	Impact on environment	No harmful effects on environment		
10.	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11.	Expected outcome	Total productivity and cropping intensity can be increased		
12.	Socio-economics	Considering the whole pattern		
		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		370000	164000	206000
13.	Recommendation	The cropping pattern Lentil-Sesame-T. Aman rice is more productive and profitable. It could be suggested for large scale dissemination in Pabna region.		

Sl. no.	Name of Technology	Lentil varieties as relay crop with B. Aman rice		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Cumilla		
3	Location of application	Muradnagar, Cumilla region with similar soils of AEZ 19		
4	Key characteristic of the technology	• There was a strong varietal influence of relay cropping on crop growth and seed yield of lentil. • Among the varieties, BARI Mashur-8 showed the best results in terms of plant population, plant height, number & weight of pods and number of seeds plant⁻¹ resulting in the highest seed yield of 2.1 t ha⁻¹. • Though total cost was the same, BARI Mashur-8 showed the higher benefit over BARI Mashur-6, BARI Mashur-9 and local Mashur due to yield differences.		
5	Year of the experiment	Rabi season of 2019 and 2020		
6	Crop	Lentil		
	Varieties	BARI Mashur-8		
	Spacing	Broadcasting		
	Sowing date /time	Third to Last week of November 9-10 days before harvesting of B. Aman (Local B Amon variety: Puichon).		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	21-18-17.5-1.19 kg/ha N-P-K-B		
	Fertilizer application method	The full amount of TSP, MoP and Boric acid would be applied as basal by broadcasting at the time of one day before seed sowing. The full amount of urea was top dressed in the lentil field at 20 days after germination.		
	Date of harvesting	16-18 March		
	Yield (t/ha)	2.1		
	Intercultural operation	Intercultural operations like weeding, thinning and plant protection measures should be necessary to support the normal growth of the crops		
7	Field duration (days)	110 to 115 Days		
8	Risk involvement in adopting the technology	Heavy rainfall may damage the crop or may increase diseases severity		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmer's training, Field Day, booklet/leaflet etc.		
11	Expected outcome	Suitable variety of lentil as relay cropping system has find out, increased yield, improved soil health		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		126000.00	25908.00	100092.00
13	Recommendation	Considering yield and yield attributes, it may be concluded that BARI Mashur-8 is more suitable for relayed with B. Aman rice considering productivity and profitability.		

Sl. no.	Name of Technology	Mustard varieties as relay crop with B. Aman rice		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Cumilla		
3	Location of application	Muradnagar, Cumilla & Haziganj, Chandpur with similar soils of AEZ 19		
4	Key characteristic of the technology	- There was a strong varietal influence of relay cropping on crop growth and seed yield of Mustard. - The variety BARI Sarisha-17 was superior in respect of plant height and seeds pod⁻¹. So, the yield was also higher in BARI Sarisha-17 (1.7 t ha⁻¹). - From cost & return analysis, it was revealed that BARI Sarisha-17 gave the higher gross return (110500.00 Tk. ha⁻¹) and gross margin (92000.00 Tk. ha⁻¹) over the other varieties and produced 740 kg ha⁻¹ higher yield than Tori-7.		
5	Year of the experiment	Rabi season of 2019 and 2020		
6	Crop	Mustard		
	Varieties	BARI Sarisha-17		
	Spacing	Broadcasting		
	Sowing date /time	Third to Last week of November 9-10 days before harvesting of B. Aman (Local variety: Puichon).		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	18.43, 16, 20, 7, 1.43 and 1.36 kg N-P-K-S-Zn-B ha ⁻¹ , respectively.		
	Fertilizer application method	2/3rd Urea and all the fertilizers of entire amount were applied by broadcasting at the time of one day before seed sowing and rest 1/3rd Urea was applied as top dress at 30 days after broadcasting (BARI, 2014).		
	Date of harvesting	15-20 February]		
	Yield (t/ha)	1.7		
	Intercultural operation	Intercultural operations like weeding, thinning should be necessary to support the normal growth of the crops		
7	Field duration (days)	80 to 85 Days		
8	Risk involvement in adopting the technology	Heavy rainfall and continuous foggy weather may damage the crop or may increase diseases severity		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.		
11	Expected outcome	Suitable variety of Mustard as relay cropping system has find out, increased yield, improved soil health		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		110500.00	18500.00	92000.00
13	Recommendation	Considering yield and yield attributes, it may be concluded that BARI Sarisha-17 is more suitable for relayed with B. Aman rice considering productivity and profitability.		

Sl. no.	Name of Technology	Fertilizer Management Packages for Soybean Production In Chandpur		
1	Name of the Organization	Bangladesh Agricultural Research Institute		
2	Contract division	On-Farm Research Division, BARI, Cumilla		
3	Location of application	Sadar, Haimchar and Faridganj of Chandpur with similar soils of AEZ 19		
4	Key characteristic of the technology	- Plant height (92.27cm) was the highest in BARI recommended dose treatment. Numerically branch plant⁻¹, pods plant⁻¹ were also the highest in BARI rec. dose treatment. - From the economic analysis, we found that gross return and gross margin were also the highest in BARI rec. dose treatment followed by STB dose & farmers practice treatment.		
5	Year of the experiment	Rabi season of 2019 and 2020		
6	Crop	Soybean		
	Varieties	BARI Soybean-6		
	Spacing	Continuously in lines at 30 cm spacing		
	Sowing date /time	2nd week of January		
	Fertilizer doses N-P-K-S-Zn-B kg/ha	BARI rec. dose: N, P, K, S and B @ 23.6, 30.8, 51.3, 14.92 and 1.40 Kg ha ⁻¹ , respectively		
	Fertilizer application method	All the fertilizers were applied during final land preparation.		
	Date of harvesting	20-22 April		
	Yield (t/ha)	2.47		
	Intercultural operation	Intercultural operations like weeding, thinning should be necessary to support the normal growth of the crops		
7	Field duration (days)	98-100 Days		
8	Risk involvement in adopting the technology	Heavy rainfall and continuous foggy weather may damage the crop or may increase diseases severity		
9	Impact on environment	No harmful effects on environment		
10	Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.		
11	Expected outcome	Suitable fertilizer management packages for soybean production has find out, increased yield, improved soil health		
12	Socio- economic aspects	Considering higher yield obtaining treatments		
		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)
		98882.00	45000.00	53882.00
13	Recommendation	It may be concluded that BARI rec. dose fertilizer treatment offer high yielder and more profitable than farmers practice and STB treatment.		

1	Name of Technology	:	Intercropping jute leaf with mukhikachu and sponge gourd under mango based agroforestry system				
2	Name of organization	:	Bangladesh Agricultural Research Institute (BARI)				
3	Contact division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701				
4	Location of application	:	Comilla region and similar soils of AEZ 19				
5	Key characteristics of the technology	:	Young mango orchard, mukhikachu, sponge gourd, jute leaf were used to get maximum benefit from agroforestry system.				
6	Production guideline	:					
	Crop	:	Mango as upper storey crop, mukhikachu and bottle gourd as lower storey crop and jute leaf as intercrop in all plots during 1-6 year old mango plants				
	Variety	:	Mango- BARI Am-3. Vegetables varieties were BARI Mukhikachu-2 for mukhikachu and BARI Lau-4 for bottle gourd were used as under storey crop. Binapatshak-1 was used as inter crop				
	Spacing	:	Line sowing, pit sowing and broadcast method				
	Sowing date	:	2 nd week of March				
	Harvesting time	:	Jute leaf : First-last week of May, Bottle gourd- 1 st week of May to 2 nd week of July and Mukhikachu- last week of September				
	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	:	Soil test based fertilizer dose for mukhikachu and bottle gourd were used				
	Fertilizer application	:	Half of the Urea and MP and whole amount of other fertilizers were applied during final land preparation. Rest MP was applied 20-25 days after seedling emergence. Urea was applied in two equal split 20-25 and 40-50days after emergence				
	Yield (t ha ⁻¹)	:	Mukhikachu, bottlee gourd, mango and jute leaf were: 15.13, 14.90, 1.8 and 9.5 t ha ⁻¹ respectively				
7	Risk involvement in adopting the technology	:	No risk involvement				
8	Impact on environment	:	No harmful effects on environment				
9	Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.				
10	Expected outcome	:	Total productivity and profitability could be increased by intercropping and agroforestry system				
11	Socio-economic aspects	:	Variety	Mango Equiva lent Yield (t ha ⁻¹)	Gross return (Th Tk. ha ⁻¹)	Net return (Th Tk. ha ⁻¹)	BCR
			Mukhika chu	14.74	737.22	623.05	6.45
			Bottle gourd	10.18	508.87	386.71	4.17
12	Recommendation	:	Mukhikachu and bottle gourd showed better performance with maximum economic return in agroforestry system.				

1.	Name of Technology	: Optimization of okra spacing and sowing dates in the south-western saline soils of Bangladesh				
2.	Name of organization	Bangladesh Agricultural Research Institute (BARI)				
3.	Contract division	On-Farm Research Division, Daulatpur, Khulna				
4.	Location of application	Khulna				
5.	Key characteristics of the technology	- Suitable for lands which become ‘joe’ condition during Decemeber and First week of January - Optimum spacing is 45 cm X 10-20 cm - No irrigation is needed immediately after sowing - Irrigation and top dress fertilizer is needed during flowering - Due to closer plant spacings, number of total plants per hectare is higher, hence total yield becomes higher.				
6	Year of experimentation	2019-20, 2020-21				
7.	Production guideline					
	Crop	Okra				
	Variety	BARI Dherosh-2				
	Spacing	40 cm X 10 cm	40 cm X 20 cm			
	Sowing date	Last week of December to 1 st week of January				
	Harvesting time	February to April				
	Fertilizer dose	Cowdung @4 t ha ⁻¹ , urea-TSP-MoP @ 150-100-150 kg ha ⁻¹				
	Fertilizer application	All of the organic manure and TSP were applied at basal and urea and MoP were applied in three splits @75, 25, 25 kg ha-1 on 30 DAS, 50 DAS and 80 days after sowing				
	Yield (t ha ⁻¹)	7.07-7.38				
8.	Risk involvement in adopting the technology	Late T. Aman harvest may delay sowing and sudden heavy rainfall may damage the crop				
9.	Impact on environment	No harmful effects on environment				
10.	Procedure of transfer	Pilot Production Program (PPP), farmers training, field day, booklet/ leaflet, radio talk, etc.				
11.	Expected outcome	Crop intensification and productivity will be increased by utilizing fallow lands as well as farmers income will be increased due to higher price from off-season okra				
12.	Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR	
		1,80,625	534643	90,125	1.99	
13.	Recommendation	Suitable for coastal saline soil where T. Aman is harvested within first half of December and has irrigation facilities				

1.	Name of Technology	:	Upscaling of zero tillage potato with mulch in coastal saline area of Bangladesh			
2.	Name of organization		Bangladesh Agricultural Research Institute (BARI)			
3.	Contract division		On-Farm Research Division, Daulatpur, Khulna			
4.	Location of application		Khulna			
5.	Key characteristics of the technology		• Suitable for coastal saline soil where T. Aman is harvested within Decemeber • Land should be soft however, no mud is attached upon walking with bare foot. • 40-50 g seed potato (either whole or cut) can be sown into the mud by pressing with hand. • Before sowing seeds can be treated with 3% boric acid or Provex-200 wp for 10-15 minutes and dried in air • Spacing should be 40 cm X 20 cm • After sowing seeds should be covered first with compost then rice straw at 15-20 cm thick • After 30-35 days a light irrigation with top dress fertilizer should be applied			
6	Year of experimentation		Rabi, 2017-18, 2018-19, 2019-20 and 2020-21			
7.	Production guideline					
	Crop		Potato			
	Variety		BARI Alu-72, BARI Alu-73, BARI Alu-78			
	Spacing		40 cm X 20 cm			
	Sowing date		2 nd week of December to end of December			
	Transplanting date		-----			
	Harvesting time		Mid March			
	Fertilizer dose		300-200-250-100-10-8 kg urea, TSP, MoP, Gypsum, Zinc Sulphate, Boron and 8-10 ton Cowdung ha ⁻¹			
	Fertilizer application		Half urea and half potash and full dose of other elements and cowdung should be applied at basal and rest urea and potash should be applied at 30-35 DAS			
	Yield (t ha ⁻¹)		18-20			
8.	Risk involvement in adopting the technology		Heavy rainfall during sowing and immediately after sowing may hamper crop establishment			
9.	Impact on environment		No harmful effects on environment			
10.	Procedure of transfer		Pilot Production Program (PPP), farmers training, field day, booklet/ leaflet, radio talk, etc.			
11.	Expected outcome		Crop intensification and productivity will be increased by utilizing fallow lands as well as farmers income will be increased			
12.	Socio-economic aspects		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
			2,00,000	1,40,000	60,000	1.43
13.	Recommendation		Suitable for coastal saline soils where T. Aman is harvested within December and have at least one irrigation facility			

1	Name of Technology	: Development of alternate cropping pattern through Garden pea-Boro- T. Aman against Fallow- Boro- T. Aman			
2	Name of the Organization	: Bangladesh Agricultural Research Institute			
3	Contract Division	: On-Farm Research Division, BARI, Khulna			
4	Location of application	: MLT site, Satkhira			
5	Key characteristics of the technology	• Total rice equivalent yield incised 15.93 t/ha. • NBCR improved by this practice 1.76			
6	Year of experimentation	2017-'18, 2018-'19, 2019-'20			
7	Production guideline				
8	Crop	Gardenpea	Boro	T. Aman	
	Variety	BARI Motorshuti-3	BRRI dhan-28	Binadhan-7	
	Spacing (cm)	30 cm row	20 cm x 15 cm	20 cm x 15 cm	
	Date of Sowing	1 st week of December	2 nd week of February	2 st week of August	
	Harvesting time	1 st week of February	Last week of April	Last week of November	
9	Fertilizer rate (NPKSZn B kg ha ⁻¹)	46.08-30-50-9.09-0-0	138.25-19.60-82.5-20.55-4.32-0	167-62-84-56-7.5-0	
	Fertilizer application method	Basal & top dress	Basal and top dress	Basal & top dress	
	Yield (t ha ⁻¹)	15.78	7.07	5.82	
	Rice equivalent yield (t ha ⁻¹ yr ⁻¹)	28.71			
10	Risk involvement in adopting the technology	Unfavorable climatic condition for Gardenpea			
11	Impact on environment	: No harmful effects on environment			
12	Procedure of transfer	: Pilot Production Program (PPP), farmers training, field day, booklet, Leaflet, TV or radio talk etc.			
13	Expected outcome	: Total productivity can be increased			
14	Socio economic aspects Considering the whole cropping pattern	Gross return (Tk. ha ⁻¹)	Variable cost (only fertilizer cost) (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
		563417	264589	298828	1.76
15	Recommendation	Gardenpea-Boro-T.aman could be extend under cultivation in this practice.			

1	Name of Technology	: Development of four crop based cropping pattern Mustard-Boro/Jute- T. Aman			
2	Name of the Organization	: Bangladesh Agricultural Research Institute			
3	Contract Division	: On-Farm Research Division, BARI, Khulna			
4	Location of application	: MLT site, Satkhira			
5	Key characteristics of the technology	• Total rice equivalent yield incised 20.24 t/ha. • NBCR improved by this practice 4.08			
6	Year of experimentation	2017-'18, 2018-'19, 2019-'20			
7	Production guideline				
8	Crop	Mustard	Boro	Jute	T. Aman
	Variety	BARI Sarisha-14	BRRI dhan-28	GJO-524	Binadhan-7
	Spacing (cm)	30 cm row	20 x15	20 x15	20 x15
	Date of Sowing	Last week of November	2 nd week of January	Last week of April	2 nd week of july
	Harvesting time	2 st week of February	2 st week of May	Last week of August	Last week of November
9	Fertilizer rate (NPKSZn B kg ha ⁻¹)	90-27-60-15-5-2-0	138-20-83-21-4-0	200-50-90-45-10-0	167-62-84-56-7.5-0
	Fertilizer application method	Basal	Basal & top dress	basa \$ top dress	basal & top dress
	Yield (t ha ⁻¹)	1.52	6.00	3.56	5.2
	Rice equivalent yield (t ha ⁻¹ yr ⁻¹)	38.09			
10	Risk involvement in adopting the technology	Unfavorable climatic condition for mustard			
11	Impact on environment	: No harmful effects on environment			
12	Procedure of transfer	: Pilot Production Program (PPP), farmers training, field day, booklet, Leaflet, TV or radio talk etc.			
13	Expected outcome	: Total productivity can be increased			
14	Socio economic aspects Considering the whole cropping pattern	Gross return (Tk. ha ⁻¹)	Variable cost (only fertilizer cost) (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
		753243	333730	562180	4.08
15	Recommendation	Mustard-Boro/Jute-T.Aman could be extend under cultivation in this practice.			

ON-FARM TRIAL OF BARI RELEASED BT BRINJAL VARIETIES IN BANGLADESH

Abstract

The field trial was conducted at 56 farmers field of 19 districts in Bangladesh such as Bhola, Borguna, Brahmanbaria, Cox's bazar, Cumilla, Chandpur, Faridpur, Jhenaidah, Khulna, Kushtia, Kishoreganj, Manikganj, Mymensingh, Noakhali, Patuakhali, Rajshahi, Rangpur, Satkhira and Sherpur during 2020-2021 to observe the performance of transgenic BARI Bt brinjal varieties at the farmers' field. Tested three BARI Bt brinjal varieties performed better against non Bt counterparts, reduced brinjal shoot and fruit borer (BSFB) infestation produced maximum healthy fruit and offered higher gross margin in all locations. These varieties showed maximum 0-4.33% shoot, 0-5.11% fruit infestation by number, 0-7.00% fruit infestation by weight and 19.26-41.26 t ha⁻¹ yield against 3.20-45.30% shoot, 6.30-56.85% fruit by number, 5.67-49.60% fruit infestation by weight and 12.60-27.80 t ha⁻¹ yield in non-Bt counterparts. Among the 19 districts, field trial under 14 districts totally free from BSFB infestation.

Introduction

Brinjal (*Solanum melongena*) is one of the most important and popular vegetables in Bangladesh that grown widely round the year. The crop is damaged severely by the notorious insect called brinjal shoot and fruit borer (BSFB) and the damage ranges from 30-70% depending upon the locality and edaphic conditions. To address this problem, farmers in major brinjal growing areas in the country spray chemical insecticides every alternate day and ranges from 60-180 times per growing season. The practice is unacceptable and unhealthy to consumers, farmers, and the environment. Bt-brinjal is a transgenic brinjal developed by inserting a crystal protein gene (*CryIAC*) from the soil bacterium, *Bacillus thuringiensis* into various brinjal cultivars and these plants are found to be resistance against BSFB. Bangladesh is the first country in the world to approve the commercial cultivation of four Bt-brinjal varieties viz. BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4 on October 30, 2013 by Bangladesh Agricultural Research Institute (BARI). Previous experiments conducted at different stations of BARI indicate that Bt varieties reduce the BSFB infestation, number of insecticide applications and improve yield. The present study was undertaken to evaluate the performance of the varieties under the farmers' field condition and to popularize the varieties among the farmers to promote their adoption in different areas of Bangladesh.

Materials and Methods

The trial was conducted in 56 farmers' field of 19 districts such as Bagerhat, Bandarban, Bhola, Bogura, Brahmanbaria, Cox's bazar, Cumilla, Chandpur, Faridpur, Khulna, Kushtia, Kishoreganj, Manikganj, Mymensingh, Narsingdi, Noakhali, Patuakhali, Rangpur, Satkhira and Sherpur during 2020-21 to observe the performance of four Bt-brinjal varieties viz. BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4. Unit plot area was 16.5 decimal with the spacing of 100 cm × 80 cm. The crop was sowing at 10 October, 2020-27 January, 2021 and its harvested date was 02 February-19 June, 2021. Two rows of non Bt counterpart of respective Bt varieties were planted as the border crops (refuse). Stable bleaching powder was applied 20 days before transplanting @ 21 kg ha⁻¹ for preventive measure against bacterial wilt. The fertilizers were used @ 138-40-100-18-1.7-3.6 kg ha⁻¹ NPKSBZn and Cowdung 10 tha⁻¹. One-third MP and rest fertilizers except urea were applied during final land preparation. Remaining two-third MP was divided into three split and applied at 20 DAP, at flowering and fruiting stage. Urea was applied in four equal installments at 20 DAP, at flowering, fruiting and continuous fruiting stage. Plant protection measures for other pest were taken in some severely infested plots; Furadan applied @ 33 kg ha⁻¹ during transplanting, Imidacloprid, Difenthruron, Azadiractin, Pagasus etc. were sprayed to control sucking pests as and when necessary. Similarly, Bavistin @ 2ml L⁻¹ water was sprayed in 2-3 times to control Fusarium wilt and Tilt @ 0.5ml L⁻¹ was sprayed in 1-2 times to control Phomopsis blight infested plots. Epilachna beetle was controlled by destroying egg mass and larva, pupa & adult by hand picking. Other intercultural operations were done as and when necessary. Ten plants were selected randomly from each plot to record plant height, individual fruit weight, length & breadth of fruit, number of total & infested fruit plant⁻¹. Yield data was calculated based on total plots. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Table 1. Varieties used in different locations with transplanting and harvesting date during 2020-21

Location	No. of trial	Varieties	Sowing time	Harvesting time
Bhola (Sadar & Daulatkhan)	02	BARI Bt Begun-2 and BARI Bt Begun-4 with non Bt counterparts	15 Dec. 20 to 27 January 2021	15 March- 26 May 2021
Cumilla, Chandpur & Brahmanbaria,	06	BARI Bt Begun-2 and BARI Bt Begun-4 with non Bt counterparts	22-30 Dec.2020	28 February-08 May 2021
Cox'sbazar	05	BARI Bt Begun-4 with non Bt counterparts	December15-25, 2020	15 March-10 June, 2021
Faridpur	02	BARI Bt Begun-4 with non Bt counterparts	20 November 2020	5 Mar to 6 Apr, 2021
Jhenaidah	01	BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4 with non Bt counterparts	15 Nov. – 10 Dec.2020	10 March to 20 May 2021
Kishoreganj	03	BARI Bt Begun-3, BARI Bt Begun-4 with non Bt counterparts	24-26 November 2020	1 Mar to 16 Apr, 2021
Khulna (Koyra)	02	BARI Bt Begun-4 with non Bt counterparts	01 Nov. 2020	2 February to 25 April 2021
Kushtia	04	BARI Bt Begun-4 with non Bt counterparts	15-20 November, 2020	10 February to 30 May 2021
Manikganj	02	BARI Bt Begun-3, BARI Bt Begun-4 with non Bt counterparts	25 November- 15 December 2020	23 March-24 May 2021
Mymensingh	10	BARI Bt Begun-4 with non Bt counterparts	24 Nov, 2020	28 Feb. to 19 June 2021
Noakhali	04	BARI Bt Begun-4 with non Bt counterparts	10 October to 6 November, 2020	05 February to 21 April, 2021
Patuakhali, Borguna	05	BARI Bt Begun-2 with non Bt counterparts	08-27 December 2020	06 February-9 June 2021
Rajshahi	03	BARI Bt Begun-4 with non Bt counterparts	06-20 October 2020	25 Dec. 20 to 10 Jan 2021
Rangpur	03	BARI Bt Begun-4 with non Bt counterparts	25-27 Nov. 2020	19 Feb. –10 May 2021
Satkhira	02	BARI Bt Begun-4 with non Bt counterparts	06 Dec, 2020	2 February to 24 April 2021
Sherpur	02	BARI Bt Begun-4 with non Bt counterparts	19 Nov. 2020	8 March-27 April, 2021
20	56	BARI Bt Begun-2 and BARI Bt Begun-3, BARI Bt Begun-4 with non Bt counterparts	10 October 2020 - 27 January, 2021	02 February -19 June 2021

* Non Bt counterparts of the varieties were also planted as border crops

Results and Discussion

Performance of BARI Bt Begun-2: BARI Bt Begun-2 was cultivated in three districts. The mean yield of BARI Bt Begun-2 was 23.32 ton per hectare with a range of 21.87-24.76 ton per hectare over the 3 locations. The higher marketable fruit yield of brinjal was recorded from Patuakhali and Borguna (24.76 t ha⁻¹). The lower yield was recorded from Bhola (21.87 t ha⁻¹). BSFB infestation in shoot ranged 0.4-0.80 percent and in the fruit (by no.) 1.20-5.00 percent as well as infestation (by wt.) varied 1.40-7.00 percent in BARI Bt Begun-2. The non-Bt counterpart of the variety BARI Begun-4 (Kazla) was infected by BSFB both in shoot and fruit and infestation observed on an average 31.72 percent shoot and 40.48 percent fruit (by no.) along with 30.05 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 15.54 ton per hectare (Table 2).

Performance of BARI Bt Begun-3: BARI Bt Begun-3 was cultivated in two districts. The mean yield of BARI Bt Begun-3 was 25.11 ton per hectare with a range of 22.40-27.82 ton per hectare. The higher marketable fruit yield of BARI Bt Begun-3 was recorded from Kishoreganj (27.82 t ha⁻¹). The lower yield was recorded from Manikganj (22.40 t ha⁻¹). The BSFB infestation in shoot, fruit (by no.) and fruit (by wt.) was 0 percent in BARI Bt Begun-3. On the other hand 3.20-15.00 percent shoot and 6.30-20.00 percent fruit (by no.) as well as 8.25-22.23 percent fruit (by wt.) infestation in non-Bt counterpart BARI Begun-5 (Nayantara). The average yield of BARI Begun-5 (Nayantara) was 15.99 ton per hectare (Table 3).

Performance of BARI Bt Begun-4: Comparatively better yield performance was observed in BARI Bt Begun-4 across the country. It was cultivated in 16 districts. The mean yield of BARI Bt Begun-4 was 31.74 ton per hectare with a range of 18.43 to 41.29 ton per. The higher marketable fruit yield of BARI Bt Begun-4 was recorded from Noakhali (41.29 t ha⁻¹) followed by Mymensingh (38.70 t ha⁻¹). The lower yield was recorded from Bhola (18.43 t ha⁻¹) followed by Kustia (19.26 t ha⁻¹). The BSFB infestation in shoot ranged from 1.22 to 4.33 percent and in fruit (by no.) range from 0 to 5.11 percent along with infestation in fruit (by wt.) varied 0 to 6.02 percent in BARI Bt Begun-4. non-Bt counterpart of the variety BARI Begun-6 was infected by BSFB both in shoot and fruit on an average 24.74 percent shoot and 36.28 percent fruit (by no.) along with 25.94 percent (by wt.) were infected by BSFB and obtained marketable yield of 19.09 ton per hectare in case of non-Bt-brinjal variety (Table 4).

Non target Pest incidence: Different sucking pests (Jassid, Whitefly, Thrips, Aphid, Flea beetle, Red mite, Epilacna beetle etc.) and diseases (*Fusarium* wilt, *Phomopsis* blight, Bacterial wilt, Little leaf etc.) were observed in some locations (Table 5). These pests and diseases were controlled by appropriate management approaches.

Farmers' Opinion

- As the fruits of Bt-brinjal varieties are almost free from BSFB infestation, no sorting is required.
- Production cost becomes lower in Bt varieties since no application of insecticides against BSFB is required. Higher gross margin obtained due to BSFB free fresh healthy fruits.
- Many farmers who have visited Bt-brinjal plots demanded seeds for cultivation.
- BSFB free smooth and good-looking fruit created an excellent feelings and curiosity among the farmers.

Table 2. Performance of BARI Bt Begun-2 over location during 2020-21

Location	BSFB infestation (%)						Fruit yield (t ha ⁻¹)	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt
Bhola	0.80	35.50	1.20	42.60	1.40	41.30	21.87	15.14
Patuakhali, Borguna	04	27.94	05	38.35	07.00	18.80	24.76	15.93
Range	0.4- 0.80	27.94- 35.50	1.20- 5.00	38.35- 42.60	1.40- 7.00	18.80- 41.30	21.87-24.76	15.14-15.93
Mean	2.4	31.72	3.1	40.48	4.2	30.05	23.315	15.54

Table 3. Performance of BARI Bt Begun-3 over location during 2020-21

Location	BSFB infestation (%)						Fruit yield (t ha ⁻¹)	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-Bt	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt
Kishoreganj	0	15.00	0	20.00	0	22.23	27.82	19.38
Manikganj	0	3.20	0	6.30	0	8.25	22.40	12.60
Range	0	3.20-15.00	0	6.30-20.00	0	8.25-22.23	22.40-27.82	12.60-19.38
Mean	0	9.1	0	13.15	0	15.24	25.11	15.99

Table 4. Performance of BARI Bt Begun-4 over location during 2020-21

Location	BSFB infestation (%)						Fruit yield (t ha ⁻¹)	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt
Bhola	1.20	34.60	0.60	38.30	0.70	45.80	18.43	13.22
Cumilla, Chandpur & Brahmanbaria	0	25.56	0	35.45	0	16.45	32.00	19.60
Cox'sbazar	0	21.45	0	31.75	0	22.35	32.10	20.85
Faridpur	4.33	33.67	5.11	35.80	6.02	35.76	28.52	15.23
Kishoreganj	0	15.00	0	20.00	0	11.16	38.43	19.38
Khulna	0	24.37	0	41.34	0	21.00	38.20	26.43
Kustia	0	24.60	0	29.80	0	22.50	19.26	18.75
Manikganj	0	3.20	0	6.30	0	5.67	31.34	12.60
Mymensingh	0	22.30	0	27.90	0	18.26	38.70	18.17
Noakhali	0	29.20	3.15	56.85	2.75	49.60	41.29	16.85
Rangpur	0	26.60	0.80	33.50	1.00	21.00	29.70	19.60
Rajshahi	0	45.30	0.04	50.10	-	-	28.20	13.00
Satkhira	0	17.30	0	53.30	0	31.82	37.25	27.88
Sherpur	0	19.90	0	41.00	0	32.40	30.95	25.67
Range	1.22-4.33	3.2-45.3	0-5.11	6.3-56.85	0-6.02	5.67-41.29	18.13-41.29	12.60-27.88
Mean	0.40	24.74	0.69	36.28	0.81	25.94	31.74	19.09

Table 5. Major disease and insect infestation observed in Bt Brinjal field during 2020-21

Treatment	Major diseases	Insect infestation	Insecticide sprayed	Fungicide sprayed	No of spray	
BARI Bt Begun-4	Wilt, Little leaf (15-20%), Phomopsis blight	Flee beetle, white fly, thrips, red mite	Pegasus, Imitaf	Provex	Insecticide	Fungicide
BARI Begun-6 (Non Bt)					2	1

Conclusion

BARI Bt Begun varieties performed better over their non Bt counterparts in respect of BSFB infestation and yield in all locations of the country. Among the 19 districts, field trial under 14 districts totally free from BSFB infestation. Maximum gross margin was obtained from BARI Bt Begun varieties over non Bt counterparts. This technology is highly effective against the target insect pest, Brinjal shoot and fruit borer. But sporadic infestation of other non-target sucking pests, like white fly, thrips, jassid, aphid, flea beetle, red mite, Epilacna beetle etc. and diseases (bacterial wilt, *fusarium* wilt, phomopsis blight, little leaf etc.) was observed in some locations. For large scale demonstration, more awareness should be developed for the cooperative farmers about the Bt technology and management of the non-target insect-mite pests & diseases.

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Production Program

PILOT PRODUCTION OF WHEAT VARIETIES IN DIFFERENT LOCATIONS OF BANGLADESH

Pilot production program of Wheat were executed with the variety of BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-32 and BARI Gom-33 during the *Rabi* of season of 2020-21 at farmers' field condition of different locations (Table 1). The seeds were treated with Provex @ 3g kg⁻¹ seed. Seeds were sown @ 120 kg ha⁻¹ maintaining line at 20 cm. The lands were fertilized as per BARI recommended dose i.e., 110-22-60-15-4-1, N-P-K-S-Zn-B kg ha⁻¹. Two-third of N and all of the other nutrients were applied as basal during final land preparation and one- third of N was top-dressed after first irrigation i.e., 20-day after sowing (DAS). Irrigations were done twice at 20 DAS and 45 DAS. Affinity, a weedicide was sprayed after 5 days of 1st irrigation to control the broadleaf weed.

Results: Among the varieties, BARI Gom-33 produced the highest grain yield (4.80 t ha⁻¹) at Gaibandha followed by the same variety (4.15 t ha⁻¹) in Mymensingh. The lowest grain yield (3.01 t ha⁻¹) was obtained from BARI Gom-28 in Mymensingh.

Farmers' opinion: Farmers from two the locations preferred all the new varieties for their highest yield except for BARI Gom-28. They also opined that this variety is susceptible to disease. They have stored seeds of wheat for growing in next season. Farmers in all the charland areas preferred BARI Gom-33 for its high yield potentials in char land condition than the rest two varieties; BARI Gom-29, BARI Gom-30.

Table 1. Crop management and yield performance of Wheat during the *Rabi* season of 2020-21

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Grain yield (t ha ⁻¹)
Mymensingh	BARI Gom-28	1	0.04	26 -27 Nov 2020	10-18 Mar 2021	3.01
	BARI Gom-30	2	0.06			3.80
	BARI Gom-32	3	0.06			3.74
	BARI Gom-33	2	0.06			4.15
Faridpur	BARI Gom-33	20	0.08	25 Nov – 4 Dec. 2020	18-26 Mar. 2021	3.81
	BARI Gom-28	11	0.06			3.27
Gaibandha	BARI Gom-29	6	1.21	15Nov-5 Dec. 2020	25 Feb.-25 Mar. 2021	4.00
	BARI Gom-30	13	1.32			4.05
	BARI Gom-33	5	0.81			4.80
Bogura	BARI Gom-30	1	0.73	18Nov. 2020	16 Mar. 2021	3.48
Total (Farmer and area)		64	4.43	Average yield		3.81

PILOT PRODUCTION OF HYBRID MAIZE VARIETIES IN DIFFERENT LOCATIONS OF BANGLADESH

Production program of BARI Hybrid Maize varieties was piloted at the farmers' field of in Cumilla, Gaibandha, Rangpur, Bogura and Sylhet district during the *Rabi* season of 2020-21. BARI Hybrid Maize-9, BARI Hybrid Maize-12, BARI Hybrid Maize-13, Hybrid Maize-16 and Hybrid Maize-17 were used in this pilot production platform. The total area under this program was 13.26 ha and 91 farmers have participated. The seeds were sown on 20 November to 5 December 2020 in the farmers' field. Cowdung and plant nutrients (N, P, K, S, Zn and B) were applied in the form of Urea, TSP, Muriate of potash, gypsum, Zinc sulphate, and Boric acid at the rate of 5 t ha⁻¹, 250, 55, 110, 40, 5 and 1.5 kg ha⁻¹, respectively. The one-third of urea and all other fertilizers and manure were applied during final land preparation. The rest amount of urea was applied in two equal splits at knee-high stage (40-45 DAS -1st top dress) and before flowering (2nd top dress). Irrigation was done two times during the crop period. Weeding was done 2 times to maintain the proper hygienic condition of the crop. The crop was harvested from 20 Apr.-5 May 2021.

Results: Maize varieties (BARI Hybrid Maize-16) gave the highest grain yield (13.90 t ha^{-1}) in Cumilla and followed by BARI Hybrid Maize-12 (11.31 t ha^{-1}) in Rangpur followed by BARI Hybrid Maize-17 (11.25 t ha^{-1}) yield in Gaibandha. On the contrary, BARI Hybrid Maize-13 gave the lowest grain yield (8.50 t ha^{-1}) in Sylhet. The overall yield performance of all studied varieties was comparatively low in Sylhet considering their potential yield. The probable causes for its low yield may be due to inadequate irrigation facilities and its application by the farmers on time. The lowest gross margin of Tk. 57710 ha^{-1} in Bogura from BARI Hybrid Maize-9 and the highest was from BARI Hybrid Maize-16 in Cumilla (Tk. 232250 ha^{-1})

Farmers' opinion: Farmers preferred BHM-16 due to shorter in height. Seeds of BARI Hybrid Maize should be available in the local market during the production period. The main problem of BARI Hybrid Maize-9 is taller than other commercial hybrids. Farmers in the char areas showed their interest in cultivating BARI Hybrid Maize in future if the seeds will be available for the growers in the field level.

Table 1. Yield, cost, and return analysis of BARI Hybrid Maize during the *Rabi* season of 2020-21

Location	Variety	No. of farmers	Area (ha)	Grain yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Cumilla	BARI Hybrid Maize- 16	8	0.81	13.90	278000	45750	232250
	Don-111	6	0.20	9.90	198000	45750	152250
Gaibandha	BARI Hybrid Maize- 9	8	1.47	8.90	178000	64500	113500
	BARI Hybrid Maize-16	9	1.60	11.13	222600	64500	158100
	BARI Hybrid Maize-17	21	3.34	11.25	225000	64500	160500
Rangpur	BARI Hybrid Maize- 9	4	1.17	11.10	166500	65000	101500
	BARI Hybrid Maize- 12	1	0.27	11.31	169650	65000	104650
	BARI Hybrid Maize- 17	4	0.67	11.04	165600	65000	100600
Bogura	BARI Hybrid Maize- 9	12	2.00	10.21	153150	95440	57710
	BARI Hybrid Maize- 16	6	1.33	10.35	155250	95440	59810
Sylhet	BARI Hybrid Maize- 9	6	0.20	10.40	218000	88334	119664
	BARI Hybrid Maize- 13	6	0.20	8.50	170000	88334	81666
Total (Farmer and area)		91	13.26	-	-	-	-
Average (Grain yield, GR, TVC and GM)		-	-	10.67	191646	70629	120183

Price of input and output (Tk. Kg^{-1}): Maize grain =Tk. 15-20.00 kg

PILOT PRODUCTION OF BARLEY VARIETIES IN DIFFERENT CHAR LAND AREAS

The production program with BARI released Barley varieties, viz. BARI Barley-6 and BARI Barley-7 were executed in the Charland of Gaibandha, and Bogura during the year of 2020-21. Seeds were sown during 1-8 Dec 2020. The crop was fertilized with N, P, K, S, Zn, and B @ 80-30-50-10-3-1 kg ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulfate monohydrate, and boric acid, respectively. Two third of N and the full amount of P, K, S, Zn, and B was applied as basal during final land preparation. The remaining one-third of N was applied at 23 days after sowing (DAS) as a top dress followed by irrigation. The crop was irrigated twice. The crop was harvested on 24 March=8 April 2021. Data on seed yield was recorded from an area of 40 m^2 from the whole plot avoiding borderline from each side of the unit plot at the time of harvesting. The collected data were averaged and converted into ton per hectare and presented in Table 1.

Results: Results reveal that grain yield of Barley varieties were ranged from 2.15 to 2.50 t ha^{-1} where the highest yield was obtained from BARI Barley-6 at Bogura (2.50 t ha^{-1}) followed by BARI Barley-6 in Gaibandha (2.41 t ha^{-1}). The lowest grain yield was obtained from BARI Barley-7 in Gaibandha (2.15 t ha^{-1}). The overall yield performance of all studied varieties BARI Barley-6 was found suitable to grow in charland conditions as they are tolerant to drought conditions. The highest gross margin was obtained from BARI Barley-6 (Tk. 59700 ha^{-1}) in Gaibandha due to higher market price with supplementary local demands.

Farmer's opinion: Farmers in the char lands showed their interest in cultivating BARI released Barley varieties, BARI Barley-6 and 7 for its higher yield potentials in charland condition than the locally grown barley cultivar and ensured marketing. To keep the continuation of barley cultivation trial farmers stored their seed from the trial plots.

Table 1. Yield and economic return of BARI Barley varieties in different Charlands during the year of 2020-21.

Locations	Variety	No. of farmers	Area (ha.)	Average grain yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Gaibandha	BARI Barley-6	4	1.21	2.41	96400	36700	59700
	BARI Barley-7	3	0.40	2.15	86000	36700	49300
Bogura	BARI Barley-6	1	0.12	2.50	100000	54760	45240
Total (Farmer no and Area)		8	1.73	-	-	-	-
Average (Grain yield, GR, TVC and GM)				2.4	94133	42720	51413

Price range (Tk kg⁻¹): 40.00 of Barley

PILOT PRODUCTION OF BARI RELEASED FOXTAIL MILLET VARIETY IN THE CHAR LAND AREAS

A total of 119 trials were conducted at charland in the four Upazilla's (Fulchhari, Gaibandha Sadar and Saghata) of Gaibandha and Sariakandi of Bogura with BARI released drought and heat tolerant foxtail millet variety, BARI Kaon-2 (High yielding, short stature, and 7-10 days earlier in heading than Local kaon variety) and BARI Kaon-4. Total 535 Kg seeds of BARI Kaon-2 and BARI kaon-4 were distributed among 119 farmers in charland areas of the 4 chars Upazilla's in Gaibandha and Bogura to cultivate 537 bigha (17721 dec) of charlands and seed rate was 1.0 kg/bigha. Plantings started on 21 December 2020 and continued up to 25 January 2021. Soil test basis (STB) fertilizer doses were applied, and standard intercultural management practices were followed in the trial plots. Harvesting of the 119 trial plots started on 1 May 2021 and continued up to 10 May 2021.

Yield (t ha⁻¹) of BARI Kaon-2 at char lands of Gaibandha and Bogura was ranged from 1.96 to 3.00 t ha⁻¹ in with an average value of 2.42 t ha⁻¹ which was higher (39%) than the farmers locally grown foxtail millet (Kaon). Again, the yield of the BARI Kaon-4 was ranged from 2.12-2.40 t ha⁻¹, with an average value of 2.26 t ha⁻¹ which was higher (50%) than the local cultivar. From these 119 trial plots, a total of 168,429 kg quality Kaon was produced. Out of these produce, 730 kg seeds of BARI Kaon-2 and 4 were collected and stored for next year use. (Table 1).

The cost and return analysis presented in the Table 1, showed that higher production contributed to the higher gross return. The highest gross margin was found Tk. 79,250 ha⁻¹ accounted from BARI Kaon-2 in Gaibandha and the lowest gross margin Tk. 69,275 / ha from Bogura with the same BARI Kaon-2 variety. The average cultivation cost was Tk. 26500 ha⁻¹ in Gaibandha and Tk. 29925/ ha in Bogura.

Farmers' opinion: Farmers in all the charland areas were more interested in cultivating high yielding BARI Kaon-2 and BARI Kaon-4 because of the higher production than local variety, good price and ensured market. 10 to 15 days early along with synchronous maturity in BARI Kaon-2, helped in uniform harvest of the crop.

Table 1. Yield and economic performance of BARI Kaon-2 and 4 at different char land under OFRD, BARI, Gaibandha and Bogura in 2020-21

Location	Variety	Yield (Farmer's variety) (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
			Min	Max	Av.			
Gaibandha	BARI Kaon-2	1.50	2.20	2.50	2.35	105750	26500	79250
	BARI Kaon-4	1.50	2.12	2.40	2.26	101700	26500	75200
Bogura	BARI Kaon-2	1.98	1.96	3.00	2.48	99200	29925	69275
	Average	1.66	2.09	2.63	2.36	102217	27642	74575

Market price (Tk/kg): 45 in Gaibandha and 40 in Bogura

PILOT PRODUCTION OF BARI RELEASED PROSO-MILLET VARIETIES IN THE CHAR LAND AREAS

A total of 10 trials were conducted at charland in the three Upazilla's (Gaibandha Sadar and Saghata of Gaibandha and Chilmari of Kurigram districts) with BARI released drought and heat tolerant Proso-millet variety, BARI Cheena-1. Total 30 Kg seeds of BARI Cheena-1 were distributed among 10 to cultivate 14 bigha (465 dec) of charlands and seed rate was 2.0 kg/bigha. Plantings started on 15 December 2020 and continued up to 25 December 2020. Soil test basis (STB) fertilizer doses were applied, and standard intercultural management practices were followed in the trial plots. Harvesting of the 10 trial plots started on 1 March 2021 and continued up to 28 March 2021.

Yield (ton ha⁻¹) of BARI Cheena-1 at char lands were ranged from 2.20 to 2.60 t ha⁻¹ in Gaibandha with an average value of 2.35 t ha⁻¹ which was higher (56.66%) than the farmers locally grown Proso-millet variety. Again, in Kurigram, the yield of the BARI Cheena-1 was ranged from 1.08-1.22 t ha⁻¹, with an average value of 1.15 t ha⁻¹ which was higher (64.28%) than the local cheena cultivar. From these 10 trial plots, a total of 3622 kg quality Cheena was produced. Out of these produces, 160 kg Cheena seed was collected and stored for next year use. (Table 1).

The cost and return analysis presented in the Table 1, showed that higher production contributed to the higher gross return. The higher gross margin was found Tk. 137300 ha⁻¹ accounted from BARI Cheena-1 in Gaibandha whereas in Chilmari Kurigram it was Tk. 40621 ha⁻¹. The average Gross return, cultivation cost and gross margin were Tk, 122500 ha⁻¹; Tk. 33539 ha⁻¹ and Tk. 88,960 ha⁻¹, respectively.

Farmers' opinion: BARI Cheena-1 cultivation in the charland day by day increasing because of the higher production than local variety, good price and ensured market.

Table 1. Yield and economic performance of BARI Cheena-1 variety at different char land under OFRD, BARI, Gaibandha and Rangpur in 2020-21

Location	Variety	Yield (Farmer's variety) (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
			Min	Max	Av.			
Gaibandha	BARI Cheena-1	1.50	2.20	2.60	2.35	164500	27200	137300
Rangpur		0.70	1.08	1.22	1.15	80500	39879	40621
Average		1.10	1.64	1.91	1.75	122500	33539	88960

Market price (Tk/kg): 70 in Gaibandha, and Rangpur

PILOT PRODUCTION OF MUSTARD VARIETIES IN DIFFERENT LOCATIONS ACROSS THE COUNTRY

The pilot production programs were carried out at 15 locations (Pabna, Mymensingh, Manikganj, Tangail, Faridpur, Sylhet, Sherpur, Cumilla, Bhola, Kishoreganj, Kushtia, Gaibandha, Bogura, Rajshahi, and Rangpur of Bangladesh during the *Rabi* season of 2020-21 (Table 1). BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18 were used in different locations in the pilot production program. Quality seeds of the different BARI released Mustard varieties were distributed among 1122 Mustard growers throughout the country which in production covered around 194.05 ha of land. The seeds were broadcasted @ 8.0 kg ha⁻¹. Half of N and all other fertilizers were applied during final land preparation. The rest of N was top-dressed at 33 days after sowing (DAS) followed by irrigation. For controlling the *Alternaria* leaf spot, Rovral was spraying twice at the rate of 0.2 percent at 10 days interval from 45 DAS. For controlling aphid Malathion and Rison were sprayed @ 0.3 percent. At the maturity stage, data on yield was collected accordingly.

Results: Location wise variety, number of farmers involved, area covered, and seed yield is presented in Table 1. All the varieties of Mustard in different locations gave better seed yield than that of the national average (650 kg ha⁻¹). However, among the short duration tested Mustard varieties (BARI Sarisha-18) the highest seed yield (2.38 t ha⁻¹) was found in Kushtia. On the other hand, short-duration variety BARI Sarisha-14 performed well over the locations and yielded ranged from 1.35 to 1.64 t ha⁻¹

¹. However, another short-duration variety BARI Sarisha-17 also performed better all over the locations and yield ranged from 1.38- 2.07 t ha⁻¹. BARI Sarisha-18 gave the highest seed yield in Kushtia (2.38 t ha⁻¹) though the variety took more duration for its maturity.

Farmers' opinion: Farmers are interested to cultivate BARI Sarisha-14 and BARI Sarisha-17, the reason being impressed to have the higher yield of BARI Sarisha-14 and 17 within a shorter period (average of 85 days) and these variety can easily be fitted in the Mustard-Boro-T. *Aman* cropping pattern without hampering the *Boro* cultivation. Farmers in the Rangpur, Gaibandha, Shyampur Rajshahi, and Faridpur location impressed on seed yield BARI Sarisha-18, and it took more days to attain maturity which can be fitted in Mustard- Jute- T. *Aman* cropping pattern.

Table 1. Performance of Mustard varieties in different locations during the year of 2020-21.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Seed yield (t ha ⁻¹)
Pabna	BARI Sarisha-17	20	3.12	20 Nov– 6 Dec 2020	21 Feb. -5 Mar 2021	2.07
	BARI Sarisha-18	8	1.00	15-20 Nov 2020	5-10 Mar 2021	2.14
Mymensingh	BARI Sarisha-14	26	7.68	08-12 Nov, 2020	02-8 Feb, 2021	1.35
	BARI Sarisha-17	08	2.94	15-18 Nov, 2020	10-12 Feb, 2021	1.59
Manikganj	BARI Sarisha-14	48	12.8	6-18 Nov. 2020	16 Feb. – 14 Mar. 2021	1.45
	BARI Sarisha-17	42	12.00			1.68
Tangail	BARI Sarisha-14	130	18.80	10-21 Nov, 2020	1-12 Feb. 2021	1.56
	BARI Sarisha-17					1.68
Faridpur	BARI Sarisha-18	14	1.85	7-26 Nov. 2019	16 Feb - 23 Mar 2021	1.79
Sylhet	BARI Sarisha-14	10	1.0	15-20 Nov. 2020	15- 20 Feb 2021	1.44
	BARI Sarisha-17	10	1.0			1.38
	BARI Sarisha-18	10	1.0			1.43
Sherpur	BARI Sarisha-14	70	10	4-5 Nov. 2020	23-25 Jan. 2021	1.64
Cumilla	BARI Sarisha-14	4	0.40	24-30 Nov 2020	15 Jan.-22 Feb 2021	1.56
	BARI Sarisha-17	12	1.54			1.68
	BARI Sarisha-18	3	0.40			1.95
Bhola	BARI Sarisha-14	10	1.25	25 Nov to 15 Dec 2020	15 Feb- 05 Mar 2021	1.41
Kishoreganj	BARI Sarisha-14	40	8.10	14-20 Nov. 2020	7.-10 Feb 2020	1.54
	BARI Sarisha-17	50	12.15			1.50
Kushtia	BARI Sarisha-18	35	5.00	10-22 Nov 2020	10 Feb -23 Mar 2021	2.38
Gaibandha	BARI Sarisha-14	50	13.01	15-20 Nov 2020	10-20 Feb. 2021	1.39
	BARI Sarisha-17	10	0.8			1.49
Bogura	BARI Sarisha-14	4	0.53	19-21 Nov 2020	5 Feb-1 Mar. 2021	1.45
	BARI Sarisha-17	12	1.6			1.47
Shyampur, Rajshahi	BARI Sarisha-14	20	3.00	25-30 Nov. 2020	18 Feb.- 12 Mar. 2021	1.41
	BARI Sarisha-18	25	1.00			1.82
Rangpur	BARI Sarisha-14	438	70.43	06-28 Nov 2020	10 Feb-6 Mar. 2021	1.50
	BARI Sarisha-18	13	1.65			1.65
Total		1122	194.05	Average yield		1.62

PILOT PRODUCTION OF GROUNDNUT VARIETIES IN DIFFERENT CHAR LAND AREAS

The production program of BARI Groundnut varieties was conducted in the Charland of Manikganj, Faridpur, Tangail, Gaibandha, and Rangpur district. The production program was demonstrated in 46 farmer's field in 7.2 ha of land. The quality seed of the BARI released Groundnut was collected from the Oil Seed Research Centre of BARI, Gazipur. The pilot production field was fertilized with N-P-K-S-Zn-B-cow dung @ 12-17-45-32-2-1.8-5000 kg ha⁻¹ in the form of urea, triple superphosphate, muriate of potash and gypsum, Zinc sulphate, Boric acid, respectively. Half of the urea and all TSP, MoP, Gypsum, Zinc sulphate, and Boron were applied during final land preparation. The remaining half of

urea was applied at 45 DAS during the flowering stage of the crop. Seeds of Groundnut were sown in line maintaining 30cm x 15cm spacing. The seed rate was 100 kg ha⁻¹ with a shell. The seeds were sown on 12 November 2020 to 20 January 2021. The plot was weeded twice and one light irrigation was given in the field. Other plant protection measures were taken as and when required. Nitro @ 2 ml L⁻¹ was sprayed to control insects. The crop was harvested from 25 April to 11 June 2020. Data on yield (in large plot area) was recorded and presented. The crop was infested with leaf-eating insects and Nirto @ 2 ml L⁻¹ was sprayed to control insects. Leaf rust disease was controlled spraying with Contaf @ 2ml L⁻¹ water. No other disease or pest incidence was observed in the experimental plots.

Results: The yield of BARI released Chinabadam varieties were ranged from 1.72 to 2.42 t. ha⁻¹ where the highest yield was obtained from BARI Chinabadam-9 (2.42 t ha⁻¹) in Manikganj but the same variety was giving lowest yield at Bhola (1.72 t ha⁻¹). The local variety Dhaka-1, was the lowest yielder (1.25 t ha⁻¹). Considering the locations. The highest gross return Tk. 193600 and Gross margin Tk. 124525 ha⁻¹ was recorded from BARI Chinabadam-9 in Manikganj. (Table 1).

Farmers' opinion: The farmers opined that the seed size of BARI Groundnut varieties (BARI Chinabadam-8, 9 and 10) is bigger than farmers' variety (Dhaka-1).

Table 1: Yield, cost and return analysis of Groundnut during the *Rabi* season of 2020-21.

Locations	Treatments	No. of Farmers	Area (ha)	Seed yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
Manikganj	BARI Chenadadam-8	01	0.20	2.37	189600	69075	120525
	BARI Chinabadam-9	01	0.20	2.42	193600	69075	124525
Faridpur	BARI Chinabadam-10	01	0.14	2.30	161000	84698	76302
	Dhaka-1	02	0.60	1.25	81200	61200	20050
Tangail	BARI Chinabadam-9	16	2.66	2.01	119400	67200	52,200
Gaibandha	BARI Chinabadam-8	15	2.13	2.35	188000	52200	135800
Rangpur	BARI Chinabadam-9	9	1.17	2.16	172800	78279	94521
Bhola	BARI Chinabadam-9	1	0.10	1.72	137600	78279	59321
Total (No. of farmers and Area)		46	7.2		-	-	-
Average (GR, TVC and GM)		-	-		155400	70001	85406

Cost of foundation seed @Tk.100.00 kg⁻¹ and price of BARI Badam-8 @ Tk. 60.00 kg⁻¹
 Market price (Tk/kg): OFRD, Rangpur Tk. 80 kg⁻¹ and OFRD Gaibandha Tk. 60 kg⁻¹.

PILOT PRODUCTION OF SESAME IN THE CHAR LANDS OF DIFFERENT LOCATIONS

The production program of BARI Sesame variety was conducted in the Charland of Manikganj and Cumilla district during the *Kharif-I* season of 2020 in the farmers' field under rainfed condition. BARI Til-4 was demonstrated in ten (5) farmer's field in 3.73 ha of land. The quality Sesame seed was collected from Oilseed Research Centre of BARI, Gazipur. The experimental block was fertilized with N-P-K-S-Zn-B-cowdung @ 55-30-25-20-2-1.70 kg ha⁻¹ in the form of urea, triple super phosphate, muriate of potash and gypsum, zinc sulphate, boric acid, respectively. Half of urea and all TSP, MoP, Gypsum, Zinc, and Boron was applied during final land preparation. The remaining half of urea was top-dressed at 30 days after sowing (DAS) during the flowering stage of the crop. Seeds of BARI Til-4 were sown as broadcast @ 5.5 kg ha⁻¹ on 20 April 2020. The crop was sprayed with Darsban @ 2 ml L⁻¹ water to control cutworm and other leaf feeder insects to support the normal growth of the plant. Plant protection measures were taken as and when required. The crop was harvested from 05 to 15 July 2021. Data on yield was recorded and converted into t. ha⁻¹.

Results: The yield of BARI Til-4 was 1.46 t ha⁻¹ at Manikganj and 1.45 t ha⁻¹ in Cumilla.

Farmers' opinion: The farmers opined that the seed yield of BARI Til-4 is much higher than the local variety. The color of the seed in BARI Til-4 is reddish-brown. But the market price of black colored seed is higher than the reddish seed of BARI Til-4. Due to higher seed yield farmers were interested to cultivate BARI Til-4 in the next season.

Table 1: No. of farmer, area covered, date of sowing, harvesting, and yield of BARI Til-4 at Charland Manikganj and Faridpur during *Kharif-I* season of 2021.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Grain yield (t ha ⁻¹)
Manikganj	BARI Til-4	2	0.4	20-23 April, 2020	05 to 10 July, 2021	1.46
Cumilla	BARI Til-4	3	1.21	20 -25April, 2020	05 to 15 July, 2021	1.45

PILOT PRODUCTION OF LINSEED IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program was conducted at Noakhali and Cumilla during the *Rabi* season of 2020-2021 under farmers' field conditions to popularize BARI high yielding Linseed variety among the farmers. BARI Tishi-1(Neela) and BARI Tishi-2 was distributed among 20 farmers and having a total of 14.79 ha. The seeds were sown from 24 November to 23 December 2020 as a broadcasting method. The land was fertilized with 60-20-32-12 kg of N-P-K-S kg ha⁻¹. All the fertilizers were applied as basal dose during final land preparation. Plant protection measures and different intercultural activities were done as and when needed. Harvesting was done from 16 March to 5 April 2021. Mean yield data of farmers plots were recorded and compared with the local variety. Seed rate of linseed was 7.5 kg ha⁻¹ and seeds were sown as relay method on 27 November to 01 December, 2020 before 10 days harvesting of T. Aman rice at Cumilla.

Results: The obtained result showed that Noakhali the performance of BARI Tishi-1 was much satisfactory compared to the local variety (Table 1). The average field crop duration was varied 99 to 105 days in BARI Tishi-1 which was 11 to 16 days earlier than that of the local variety (114 days) in Noakhali and Rangpur. The highest seed yield was found 1.24 t ha⁻¹ at Cumilla and the variety was BARI Tishi-2 which relay with T. Aman rice. The cost and return analysis, the highest gross margin was found in Tk. 103500 ha⁻¹ in Cumilla due to a higher market price and as well as for higher yield.

Farmers' opinion: Farmers in Noakhali, Cumilla and Rangpur are interested to cultivate the BARI Tishi-1 and BARI Tishi-2 because higher yield potential.

Table 1. Yield, cost, and return analysis of BARI Tishi during the *Rabi* season of 2020-2021.

Locations	Varieties	Farmers (no.)	Total area (ha)	Avg. crop duration (days)	Seed yield (t ha ⁻¹)	Gross Return (t ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Noakhali	BARI Tishi-1	11	12.15	99 -104	0.667	40020	14776	25244
	Local	4	2.00	113 - 115	0.543	32580	14776	17804
Cumilla	BARI Tishi-2	2	0.32	110	1.24	124000	20500	103500
Rangpur	Neela	3	0.32	100-105	1.08	70200	36357	33843
Total	-	20	14.79	-	-	-	-	-
Average	-	-	-	110	0.88	66700	21602	45097

Price of Linseed per kg = Tk. 50 (for all the variety) at Noakhali and Tk. 100 kg⁻¹ at Cumilla

PILOT PRODUCTION OF SOYBEAN VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program was conducted in the farmer's field in Cumilla, Noakhali and Bhola during the *Rabi* season of 2020-2021. BARI Soybean-6 was used as planting materials. The crop was fertilized with 25, 35, 55, and 18 kg ha⁻¹ of N, P, K, and S, respectively. All fertilizers except urea were applied during final land preparation as a basal dose. Seeds were sown from 14 January to 12 February 2020 by using BARI Power Tiller Operated Seeder (PTOS) for maintaining proper line spacing. Four-line seeding was possible at a time by using PTOS keeping 30 cm x 5 cm spacing. Different intercultural

operations and plant protection measures were taken as and when necessary to raise healthy crops. Harvesting was done from 25 April to 10 May 2021. Data on the yield of soybean variety and field capacity of machine recorded and presented as tabular form.

Results: Yield of soybean varieties across locations were ranged from 1.36 to 2.31 t ha⁻¹, where the highest was obtained from BARI Soybean-6 in Cumilla. The calculated gross return (Tk. 92377 ha⁻¹), total variable cost (Tk. 30000 ha⁻¹), and gross margin (Tk. 62377 ha⁻¹) were recorded from BARI Soybean-6 in Cumilla. Again in Noakhali, the average yield of BARI Soybean-6 was recorded 1.71 t ha⁻¹ which offered a gross margin of Tk. 54035 ha⁻¹. In the case of the conventional line sowing method, the total variable cost (Tk. 29390 ha⁻¹) was higher than the PTOS method (Tk. 25210 ha⁻¹) due to more labour essential for sowing time. However, the yield in the PTOS method was slightly higher than the conventional line sowing might be more plant population or uniform seeds placement. Furthermore, with BARI PTOS farmers could complete the sowing by plowing the soil at the same which also relaxes the soil compactness, as a result, soil aeration increased and favorable to nodulation.

Farmer's opinion: BARI Soybean-6 along with BARI PTOS is highly accepted by the farmers as it offers higher yield as well as economic return compared to local variety and conventional line sowing method in Noakhali. Most of the farmers in Cumilla and Mymensingh are fascinated to cultivate BARI Soybean-5 because of its higher yield potentiality and better market price.

Table 1. Yield, cost, and return analysis of BARI Soybean during *Rabi* season of 2020-21

Location	Variety	Method	No. of farmer	Area (ha)	Seed yield (t ha ⁻¹)	GR (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)
Noakhali	BARI Soybean-6	Convention	10	0.68	1.36	61515	29390	32125
		PTOS	3	0.25	1.71	79245	25210	54035
Cumilla	BARI Soybean-6	Convention	30	9.93	2.31	92377	30000	62377
Bhola	BARI Soybean-6	Convention	6	0.20	1.68	67200	30000	67200
Total (Farmer no. and area)			49	11				
Average (Seed yield, GR, TVC and GM)					1.77	75084	28650	53934

Market price of Soybean Tk. 40. kg⁻¹ at Cumilla

PILOT PRODUCTION OF SUNFLOWER VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The pilot production program was implemented in Cumilla, Kishoreganj, Faridpur, Patuakhali, Borguna, Barisal, Pirojpur, Bhola, Sylhet, Rangpur, Gaibandha district during the *Rabi* season of 2020-21 to display the performance of sunflower varieties under farmer's field condition. BARI developed Sunflower variety BARI Surjamukhi-2 and BARI Surjamukhi-3 was used in this program. The trial plot was plowed by the tiller with four passes then followed by laddering. Chemical fertilizer was applied @ 100-30-60-20-1.5 kg ha⁻¹ N, P, K, S, and B in the form of Urea, TSP, Mop, Gypsum, Boric acid in the field. Half of Urea and full doses of all other fertilizers were applied during final land preparation. The rest amount of Urea was top-dressed at 25 and 45 days after sowing. Seeds were sown on 30 November -17 December 2020 with a spacing of 50 cm × 25 cm, respectively. The seeds were treated with Provax-200 at the rate of 2.5 mg Kg⁻¹ of seeds. To control caterpillar (*Admair* and *Cortan Plus*) Nitro 505 EC at the rate of 2ml L⁻¹ was sprayed twice at the flowering and grain filling stage. For controlling blight and root rot diseases of sunflower Autostin 72 Wp and Rovral -50 WP (@ 1 mg L⁻¹ of water) was sprayed after diseases appeared. The crops were harvested 1-24 March 2021. Data on yield was recorded and presented as t ha⁻¹.

Results: The days to maturity were more or less similar in the case of both varieties. The seed yield of BARI Surjamukhi-2 and BARI Surjamukhi-3 were ranged from 1.06 to 2.21 t ha⁻¹. The seed yield was higher in BARI Surjamukhi -3 than BARI Surjamukhi -2. The overall yield performance of Sunflower varieties across locations was comparatively low in Borguna, Barisal, Bhola and Rangpur considering the potential yield of sunflower. The probable causes for its low yield may be due to unfilled grain of the sunflower, severe bird attacks, unknown management practices, root and stem rot diseases,

difficulties in threshing and human theft as a new crop in that area. The highest gross return (Tk. 148400 ha⁻¹) and gross margin (Tk. 77100 ha⁻¹) were accounted from BARI Surjomukhi-3 in Sylhet and Cumilla, respectively.

Farmer's opinion:

1. Farmers were very much impressed on sunflowers as a new crop in their traditional cropping pattern Rabi- Fallow-T. *Aman*.
2. They were satisfied to see the yield performance of BARI Surjomukhi-2 and BARI Surjomukhi-3 at the farm level. But, some kind of problem to sell their seed because the market channel of Surjomukhi was not established yet.
3. Farmers preferred BARI Surjomukhi-3 due to its short height, uniform big- head.
4. The sunflower was considered a good source of honey collection.

Farmers in the coastal belt (Patuakhali, Borguna, Barisal, Pirojpur, Bhola) opined that as a new crop they are facing problems in sunflower production are like unknown management practice with difficulties in threshing

Table 1. Seed yield and yield contributing characters of BARI Surjomukhi varieties at a different location during the *Rabi* season of 2020-21.

Locations	Varieties/lines	Farmers No.	Area (ha.)	Days to maturity	Seed yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
Cumilla	BARI Surjomukhi-2	6	1.09	101	1.97	98500	33400	65100
	BARI Surjomukhi-3	6	0.12	98	2.21	110500	33400	77100
Kishoreganj	BARI Surjomukhi-3	6	0.20	103	1.56	54600	25200	29400
Faridpur	BARI Surjomukhi-3	6	1.25	120	1.68	126000	85050	40950
Patuakhali	BARI Surjomukhi-2	56	8.0	90-100	1.67	68470	33400	35070
Borguna	BARI Surjomukhi-2	18	3.3	90-101	1.35	55350	33400	21950
Barisal	BARI Surjomukhi-2	6	1.6	90-102	1.06	43460	33400	10060
Pirojpur	BARI Surjomukhi-2	7	1.6	90-101	1.91	78310	33400	44910
Bhola	BARI Surjomukhi-2	37	5.46	90-101	1.42	58220	33400	24820
	BARI Surjomukhi-3	6	0.20	100	1.90	133000	85255	47745
Sylhet	BARI Surjomukhi-3	6	0.20	100	2.12	148400	86300	62100
Rangpur	BARI Surjomukhi-2	11	1.51	90-100	1.58	110600	45935	64665
Gaibandha	BARI Surjomukhi-2	5	0.67	90-100	1.75	105500	47200	58300
Total (Farmer no. and Land area)		176	25.2	-	-	-	-	-
Average (Days maturity, Seed yield, GR, TVC and GM)				102	1.71	91608	46826	44782

Market price: Sunflower Tk. 50 kg⁻¹ in Cumilla, Price of sunflower = Tk. 35 kg⁻¹ Kishoreganj. Price of sunflower seed at Sylhet: Tk. 46 kg⁻¹. Rangpur Tk. 70 Kg⁻¹, Gaibandha Tk. 60 Kg⁻¹

PILOT PRODUCTION OF LENTIL VARIETIES IN DIFFERENT CHAR LAND AREAS

The production program was implemented in Noakhali, Bogura, Gaibandha, and Faridpur district during the *Rabi* season of 2020-2021. Quality seeds of BARI Masur-8 with inorganic fertilizers and pesticides were supplied to the farmers in the Charland's to promote the large-scale production with BARI released Lentil varieties. Seeds were sown on 11 November to 14 December 2020. Fertilizers were applied @ 20.73-17- 17.5-9.42-1.02 kg ha⁻¹ NPKS and B, respectively. All fertilizers were applied as basal during final land preparation. Irrigation was done at one time at 33 DAS. One wedding was done in the Lentil field. The crop was sprayed by Provex-200 and Rovral for controlling footrot and Stemphylium blight diseases, respectively. The crop was sprayed by Tafgor @ 2ml L⁻¹ to control aphid at 74 DAS. The crop was harvested on 25 Feb.-06 March 2021. Yield and other data were recorded.

Results: The yield of Lentil varieties across locations were ranged from 1.27 to 2.06 t ha⁻¹, where the highest (2.06 t ha⁻¹) was obtained from BARI Masur-8 in Faridpur and the lowest yield (1.27 t ha⁻¹) recorded in Noakhali in the same variety.

Farmers' opinion: Lentil growers in the Charlands were satisfied to get the higher seed yield from BARI Masur-8 as the variety resistant to *Stemphylium* blight and it offers a higher yield and more net return than local Lentil cultivar.

Table 1. Number of farmers involved, area covered, and seed yield of BARI Masur-8 Lentil variety in different locations during the year of 2020-21.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Seed yield (t ha ⁻¹)
Noakhali	BARI Masur-8	2	2.00	11 Nov.-14 Dec. 2020	25 Feb.-06 March 2021	1.27
Bogura	BARI Masur-8	8	1.07			1.66
Gaibandha	BARI Masur-8	32	8.68			1.83
Faridpur	BARI Masur-8	14	2.0			2.06
Total (Farmer no. and area)		56	13.75		Average	1.71

PILOT PRODUCTION OF CHICKPEA VARIETIES IN DIFFERENT CHAR LAND AREAS OF FARMERS FIELD

The production program of Chickpea was piloted at the Faridpur and Rangpur during the *Rabi* 2020-21 to popularize BARI Chola-5, BARI Chola-9 and BARI Chola-10 among the farmers. Seeds were sown from 14 November - 6 December 2020 irrespective of farmers. Fertilizers were applied @ 32-28-24-18-2-1.5 kg ha⁻¹ as the source of N, P, K, S, Zn, and B were applied in the form of urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum, Zinc sulphate monohydrate, and boric acid, respectively in the field. All the fertilizers were applied during final land preparation. One-time irrigation was provided immediately after sowing. Insecticide (Volium Flexi) was sprayed twice starting from flower initiation at an interval of 15-16 days (66-69 and 82-84 DAS). The crop was harvested at 122 DAS. The yield was recorded by crop cut from a total of 6m² area having three spots (2 m² in each) of the plot and converted to yield ha⁻¹. The yield and economic performance are presented in Table 1.

Results: The average yield of BARI Chola-10 was 1.98 t ha⁻¹ in Faridpur whereas farmer's cultivated local variety provided 1.51 t ha⁻¹. The highest gross margin (Tk. 85914 ha⁻¹) from BARI Chola-9 in Rangpur due to get more price as well as less variable cost. . Farmer's chose the new variety and preserved seeds for next year's cultivation.

Farmer's opinion: Farmers showed interest in BARI Chola-9, BARI Chola-10 for its higher yield, bold seed size. Pest attack was lower in BARI released variety than local variety. They will cultivate BARI Chola-10 variety in the next year.

Table 1. Yield, cost and return analysis of BARI Chickpea during the *Rabi* season of 2020-2021

Locations	Variety	No. of farmers	Area (ha)	Avg. Seed yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
Faridpur	BARI Chola-10	3	0.40	1.98	118860	53250	65610
	BARI Chola-5	4	0.70	1.51	105840	41010	64830
Rangpur	BARI Chhola-9	4	1.91	1.50	104650	18737	85913
Total (Famer no and Area)		11	3.01	1.66	109783	37666	72118

Product price (Tk kg⁻¹): Seed of BARI Chola-10: 70-75.

PILOT PRODUCTION OF MUNGBEAN IN DIFFERENT LOCATIONS AT FARMERS FIELD

A production program was piloted with BARI Mug-6 at the Kushtia, Crop was sown 15-30 March 2020 and harvested 15 May - 20 June, 2021 at Kushtia during the *Kharif I*, 2021. But in Patuakhali, Borguna, Bhola, Barishal, Jalokati, Pirojpur, Khulna seed were shown 18-20 January 2021 and Harvested 13-30 April 2021. Fertilizer dose (kg ha^{-1}) was followed $\text{N}_{24}\text{P}_{32}\text{K}_{24}\text{S}_{18}\text{Zn}_2\text{B}_1$ kg ha^{-1} . All fertilizer was applied as basal during final land preparation. One irrigation (29 DAS) and one hand weeding (29 DAS) were done. The collected data were averaged and converted into kilogram per hectare as well as economy analysis were presented in Table 1.

Results: The seed yield of BARI Mung-6 was ranged from 1.03 to 1.77 t ha^{-1} . The highest seed yield (1.77 t ha^{-1}) was found in Patuakhali.

Farmer's opinion: Farmers of Madaripur were happy for getting higher yield from BARI Mung-6 but demand one-time harvested variety that may reduce labor cost.

Table 1. Yield and cost return analysis of BARI Mungbean-6 during the year of 2021.

Location	Variety	No of farmer	Days to maturity	Area (ha)	Seed yield (t ha^{-1})
Kushtia	BARI Mug-6	06	54-75	0.16	1.50
Patuakhali	BARI Mug-6	30	85-95	0.57	1.77
Borguna	BARI Mug-6	30	85-95	0.57	1.49
Bhola	BARI Mug-6	20	85-95	0.57	1.32
Barishal	BARI Mug-6	45	85-95	0.57	1.35
Jhalokati	BARI Mug-6	45	85-95	0.57	1.20
Pirojpur	BARI Mug-6	45	85-95	0.57	1.72
Khulna	BARI Mug-6	100	85-95	0.57	1.03

Farmgate price (Tk kg^{-1}): BARI Mung-6:55 and stover: 1.00

PILOT PRODUCTION OF BLACKGRAM IN DIFFERENT LOCATIONS OF CHARLAND AREAS

The pilot production program was executed in the farmer's field of Manikganj, Gaibandha, Rangpur, and Bogura. BARI Mash-3 was used in the production program. The seeds of BARI Mash-3 were collected from Pulse Research Sub-station of BARI, Gazipur, and were sown from 28 to 31 August 2020. The land was fertilized with NPKSZnB at the rate of 20.74-18-20-9-1.5-1.7 kg ha^{-1} , respectively. There was enough rainfall during the growing season. Weeding, control of pests, and other intercultural operations were done as and when required. The crop was harvested from 19 to 28 November 2020. At harvest, the yield data was recorded and converted into yield per hectare.

Results: The yield of the BARI Mash-3 was ranged from 1.32 to 1.44 t ha^{-1} where the highest yield was obtained in Gaibandha (1.44 t ha^{-1}) followed by Rangpur (1.38 t ha^{-1}). The lowest seed yield was obtained at Manikganj (1.32 t ha^{-1}).

Pest incidence: Hairy caterpillar was observed in some plots. Grasshopper was also observed in some plots. The pests were controlled spraying with Karate @ 2 ml L^{-1} and Nitro @ 2 ml L^{-1} water in the field.

Table 1. Yield, cost, and return analysis of BARI Blackgram during the *Kharif-2* season of 2020-21

Locations	Variety	Farmers involved	Area (ha)	Seed yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Manikganj	BARI Mash-3	05	1.00	1.32	92520	51385	41135
Gaibandha	BARI Mash-3	14	2.67	1.44	108000	26500	81500
Rangpur	BARI Mash-3	19	2.49	1.38	103500	22125	81375
Bogura	BARI Mash-3	1	0.13	1.35	94500	32349	62151
Total		39	6.29	-	-	-	-
Average		-	-	1.37	99630	33090	66540

Farmgate price of blackgram @ Tk. 65.00 kg^{-1} and straw @ Tk. 3.00 kg^{-1} , Sherpur: Seed Tk. 45 kg^{-1}

Market price (Tk/kg): OFRD, Rangpur, and OFRD Gaibandha=75; OFRD, Bogura=70

PILOT PRODUCTION OF BARI RELEASED GRASSPEA VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program of Grass pea was piloted at Manikganj, Gaibandha, Rangpur, and Bogura district during the *Rabi* season of 2020-21 in the farmers' field. BARI Khesari-1, BARI Khesari-2, and BARI Khesari-3 were validated in the farmer's field. The seeds of BARI released varieties were collected from the Pulse Research Sub-station of BARI, Gazipur. The trial plots were fertilized with total fertilizers during final land preparation @ 21-18-20-10-2-1 of N-P-K-S-Zn-B were applied as urea, triple superphosphate, and muriate of potash, gypsum, zinc sulfate, and boric acid, respectively. All the fertilizers were applied in the land during final land preparation. Seeds were sown as broadcast @ 55 kg ha⁻¹ in different farmers' fields from 6 to 15 November 2020. Indofil M-45 @ 2 g L⁻¹ and water was sprayed to control downy mildew disease. Root rot disease was controlled using Nativio @ 2g L⁻¹ of water. Nitro @ 2ml L⁻¹ water was sprayed to control pod borer insects. Irrigation was given once at 30 days after sowing. Other plant protection measures were taken as and when required. The crop was harvested from 24 March to 5 April 2021. Data on yield were recorded plot-wise and converted into ton per hectare.

Results: Yield among the grasspea varieties were ranged from 1.29 to 1.65, where the highest yield (1.65 t ha⁻¹) was obtained from BARI Khesari-2 in Manikganj and the lowest yield (1.29 t ha⁻¹) was obtained from BARI Khesari-3 variety in Bogura. The highest gross return was accounted from BARI Khesari-3 (Tk. 95200 ha⁻¹) in Gaibandha due to high market price and gross margin were Tk. 76700 ha in the same location.

Disease and Insect reaction: Downy mildew disease was observed in all the studied varieties at the vegetative growth stage. Indofil M-45 @ 2 g L⁻¹ water was sprayed to control downy mildew disease. Nativio @ 2g L⁻¹ water was sprayed to control root rot disease. Aphid infestation was observed in the plot and it was controlled spraying several times with Nitro (Chloropyrifos + Cypermethrin) @ 2 ml L⁻¹ water.

Table 1. No. of the farmer, area, yield, cost and return analysis of BARI Grass pea varieties during the *Rabi* season of 2020-21.

Locations	Variety	Farmers involved	Area covered (ha)	Seed yield (kg ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Manikganj	BARI Khesari-1	02	0.40	1.47	73500	38000	35500
	BARI Khesari-2	02	0.80	1.65	82500	38000	44500
Gaibandha	BARI Khesari-3	22	6.68	1.36	95200	18500	76700
Rangpur	BARI Khesari-3	17	2.35	1.44	64800	18737	46063
Bogura	BARI Khesari-3	5	1.40	1.29	58050	22933	35117
Total		48	11.63	-	-	-	-
Average		-	-	1.44	74810	27234	47576

Seed price Tk. 40.00 kg⁻¹ Market price (Tk/kg): OFRD, Manikganj=50, OFRD, Rangpur=45, OFRD Gaibandha=70 and OFRD, Bogura=45

PILOT PRODUCTION OF GARDEN PEA IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program of Field pea was conducted at Koyra village under Sadar upazila of Manikganj, Sherpur and Sylhet district during the *Rabi* season of 2020-21 in the farmers' field. BARI Motorshuti-3 was demonstrated in one farmer's field in 0.14 ha of land. The seed of BARI Motorshuti-3 was collected from Pulse Research Sub-station of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 20-18-20-9-1-1.5 kg ha⁻¹ of N-P-K-S-Zn-B applied as urea, triple super phosphate and muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Seeds were sown as broadcast @ 80 kg ha⁻¹ on 13 November 2020. No irrigation was required as the land contained enough soil moisture. Other plant protection measures were taken as and

when required. Green pods were harvested from 02-26 February 2020. Data on yield and yield contributing characters were recorded and converted into ton per hectare.

Results: Yield, cost and return analysis of BARI Motorshuti-3 is shown in Table 1. The higher green pod yield 3.90 t ha⁻¹ was found in Manikganj that gives higher gross return Tk. 117000 ha⁻¹, total variable cost TK. 50180 ha, and gross margin were Tk. 66020 ha⁻¹.

Disease and Insect reaction: Nativo @ 2g L⁻¹ water was sprayed to control root disease. No other disease and insect infestation were observed in the field.

Table 1: Yield, cost and return analysis of Garden pea during the *Rabi* season of 2020-21

Location	Variety	Farmers no.	Area (ha)	Green pod yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Manikganj	BARI	3	0.14	3.75	112500	50180	62320
Sherpur	Motorshuti-3	7	2.50	7.18	287200	90500	196700
Sylhet		50.20		7.25	181250	96000	85250

Price of BARI Motosuti-3; Tk 40.0 kg⁻¹ at Manikganj and Price of output (Tk. Kg⁻¹): Motorshuti- 25.00

PRODUCTION PROGRAMME OF FIELDPEA

The programme was carried out with field pea variety BARI Motor-3 in farmers' field of MLT site, Bhuapur, Tangail during the rabi season of 2020-21 to popularize and disseminate the BARI developed field pea variety i.e., BARI Motor-3. BARI Motor-3 was cultivated among the six farmers covering 0.80 ha of land. The crop was fertilized with 21-17-25-1.5-1 kg NPKSB ha⁻¹, respectively. The seeds of BARI Motor-3 were sown during 3 December, 2020 with 35 kg ha⁻¹ seed rate. The crop was harvested during 9-11 March, 2021. Yield was recorded by crop cut of 20 m² indifferent spots randomly from each plot. The seed yield was 1.40 t ha⁻¹.

Farmers' opinion: According to the farmers' of Bhuapur, Tangail charland, BARI Motor-3 is a profitable crop. Field pea requires less care and low cultivation cost. The farmers are willing to grow BARI Motor-3 in the next year for its better yield, less pest infestation.

Table 1. Performance of BARI Motor-3 during the year of 2020-21

Location	Variety	Farmers (No.)	Area (ha)	Pod yield (t ha ⁻¹)
Tangail	BARI Motor-3	06	0.80	1.40
Faridpur	BARI Motor-3	06	0.10	1.91

PILOT PRODUCTION OF ONION VARIETIES IN CHAR LAND AREAS

A production program of BARI Piaz-1 and BARI Piaz-4 was conducted under farmer's field condition at the Faridpur, Rangpur, Tangail, Bogura, Mymensingh, and Gaibandha during the *Rabi season* of 2020-21 to observe the performance of BARI Piaz-1 and BARI Piaz-4 against local popular cultivar. Seedling was transplanted on 19 Dec to 18 Jan 2020. The crop was fertilized with 140-60-60-30-3-1.5 kg of N-P-K-S-Zn and B ha⁻¹ in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N and K will be applied as basal during final land preparation. Remaining N and K will be applied in two equal splits at 27-33 DAT and 47-56 DAT under moist soil condition and mixed thoroughly with the soil. Pesticides named Roval, Ridomil, Amister top, Confidor, karate were sprayed. Onion varieties were harvested at 73-90 DAT. Data on yield and economic returns were recorded and presented in Table 1.

Results: The highest bulb yield was found 23.44 t ha⁻¹ from BARI Piaz-4 at Faridpur and followed by BARI Piaz-1 (18.25 t ha⁻¹) at Mymensingh. The lowest bulb yield was found 9.51 t ha⁻¹ from BARI Piaz-1 at Bogura. The highest gross return and gross margin per hectare were accounted from BARI Piaz-4 in Faridpur; Tk. 586000 and Tk. 380545ha⁻¹, respectively.

Farmers' opinion: Farmers opined confidently to the BARI Piaz-1 and BARI Piaz-4 (winter Onion) for its higher bulb yield

Table 1. Yield, cost and return analysis of BARI Piaz-1 and BARI Piaz-4 at Rajbari during the *Rabi* season of 2020-21.

Location	Variety	Farmers (no.)	Area (dec)	Avg. bulb yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Faridpur	BARI Piaz-4	6	0.51	23.44	586000	205455	380545
	Local (Lal Teer king)	1	0.40	18.97	569100	242165	326935
Rangpur	BARI Piaz-1	10	1.89	9.93	347550	84225	263325
Tangail	BARI Piaz-1	25	2.46	11.86	355800	140325	215475
	BARI Piaz-4			16.02	480600	140325	340275
Bogura	BARI Piaz-1	10	0.60	9.51	332850	112500	220350
Mymensingh	BARI Peaj-1	6	0.20	18.25	547500	90400	457100
Gaibandha	BARI Piaz-1	9	1.07	11.70	409500	95200	314300
Total		67	7.13	-	-	-	-
Average		-	-	14.96	453613	138824	314788

Price: Bulb: Market price (Tk kg⁻¹): 30 Tk kg⁻¹ Onion and 2Tk kg⁻¹ Onion leaf at Mymensingh, 35 Tk kg⁻¹ at Rangpur, Bogura and Gaibandha
 Input: seed (Tk kg⁻¹): BARI Piaz: 4000, lalter king: 9000
 Bulb: BARI Piaz-4 and Lal teer king: 25.00 Tk kg⁻¹ Lalteer king: 30.00 Tk kg⁻¹

PRODUCTION OF BLACK CUMIN AT FARMERS FIELD IN DIFFERENT LOCATIONS

The production program was conducted at the char land area of Mymensingh, Tangail and Rangpur during the *Rabi* season of 2020-2021 to popularize and disseminate BARI Kalojira-1 among the farmers and also to increase the income through increasing yield. BARI Kalojira-1 was cultivated among the 10 farmers covering 1.70 hectares of land. The crop was fertilized with 60-20-40 kg NPK ha⁻¹. Half of Urea and full amount of TSP and MoP were applied at the time of final land preparation. Remaining urea was top dressed at 45 days after sowing (DAS) before flowering stage. The seeds were sown on 11-24 November, 2020 in broadcast with seed rate of 7 kg ha⁻¹. Intercultural operation, pests and other crop management practices were done properly for normal growth of the crop. The crop was harvested on 18 March to 24 April, 2021. Yield was recorded by crop cut of 20 m² randomly in different spot from each plot.

Results: The yield of BARI Kalojira-1 was ranged from 0.78 to 0.98 t ha⁻¹ whereas the local variety was ranged from 0.65 to 0.70 t ha⁻¹ with an average of 0.69 t ha⁻¹. BARI Kalojira-1 produced average 31.11 % higher yield than the local cultivar. The highest seed yield of BARI Kalojira-1 was obtained in Rangpur (0.98 t ha⁻¹) and the lowest (0.78 t ha⁻¹) was in Tangail (Table 1).

Farmers' opinion: BARI Kalojira-1 gave higher seed yield than local variety. They also chose BARI Kalojira-1 for its higher seed yield, less disease and pest infestation and attractive seed color and size.

Table 1. Crop management and yield of Black cumin varieties during the *Rabi* season of 2020-2021

Location	Farmers (no.)	Area (ha)	Sowing date	Harvesting date	Duration (days)	Seed yield (t ha ⁻¹)		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
						BARI Kalojira-1	Local			
Mymensingh	10	1.0	11-18 Nov 2020	18-24 Mar 2021	129-135	0.78	-	217000	45650	171350
Tangail	10	1.8	20-24 Nov	1-4 Apr	130-133	0.94	0.69	263200	45650	217550
Rangpur	8	1.3	16 Nov-30 Dec 2020	25 Mar-11 April 2021	129-135	0.98		195000	45975	149025
Total	28	4.1								
Average						0.90		675200	137275	537925

PILOT PRODUCTION PROGRAM OF GARLIC AT ON-FARM CONDITION

A total of 19 trials under the production program of garlic with BARI Rosun-1 following improved practices were conducted at Durlavpur, Poranagari, Basila, Ovirampur, Laxmikhola, and Ramchandrapur under the MLT site Shibganj, Bogura during 2020-21 cropping season to increase farmers yield and economic return. Clove sowing of garlic @ 400 kg ha⁻¹ was started from 18 November 2020 and continued up to 29 December 2020. Two times weeding were done at 25-20 and 30-40 days after sowing. Two times spray with Tundra and Pegasus @ 2ml/L was made for controlling insects like leaf feeder, thrips. Iprozim 26WP @ 2g/L was applied to prevent purple blotch disease. Harvesting started on 24 March 2021 and continued till 4 April 2021. Yield ranged from 5.92 to 6.84 t ha⁻¹ with a mean yield of 6.56 t ha⁻¹ for BARI Rosun-1 and 9.68 to 12.5 t ha⁻¹ with a mean yield of 10.88 t ha⁻¹ for BARI Rosun-3. The average unit plot yield was varied from 209.51 kg to 394.74 Kg depending on plot size with a mean yield of 323.08 kg ha⁻¹ whereas the farmer's plot yield was 5.36 t ha⁻¹ with a mean unit plot yield was 159.16 kg (Table 1). Comparatively low yield than the potential yield might be due to the shorter winter period in this year. Cost and return related information presented in Table 1. As improved varieties along with modern management practices contributed to higher yield in demonstration plots, that led to higher gross return (Tk. 651000 ha⁻¹) and net return (Tk. 368185 ha⁻¹) were obtained from demonstration plots and lower gross return (Tk. 521000 ha⁻¹) and net return (Tk. 263975 ha⁻¹) from farmer's plot. Higher gross return in demonstration plots led to higher BCR (2.48) over the farmer's plot (2.03).

Table 1. Cost and return analysis of demonstration/pilot production program of garlic conducted at different locations during 2020-21

Type	Variety	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total cultivation cost (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	BCR
Demonstration plots	BARI Rosun-1	6.51	651000	262815	368185	2.48
Farmers own plot	Local Patnai	5.21	521000	257025	263975	2.03

Bulb sale price: Tk. 100 kg⁻¹

PILOT PRODUCTION OF BARI RELEASED FENUGREEK VARIETIES IN THE CHAR LAND AREAS

The trial results on BARI Methi-2 in the char lands are presented in Table 1. A total of 10 trials at char lands of 2 Upazilla's (Chilmari, Kurigram and Sagghata, Gaibandha) were conducted under OFRD, Rangpur and OFRD, Gaibandha, respectively. Seed sowing started on 16 December 2020 and continued up to 25 December 2020 across the locations. Standard fertilization and intercultural management practices were followed in the trial plots. Harvesting of fenugreek started on 1 April 2021 and continued up to 10 April 2021. From the trial plots of 2 Upazillas, a total of 3514 kg fenugreek was produced. The yield of farmers practiced variety was 1.15 t ha⁻¹. On the other hand, the trial plot yield of BARI Methi-2 was ranged from 1.05 to 1.76 t. ha⁻¹ with an average value of 1.33 t. ha⁻¹. The cost and return analysis (Table 1) showed that the highest gross margin (Tk. 82750 ha⁻¹) obtained from BARI Methi-2 in OFRD, Gaibandha site, and the lowest gross margin (Tk. 53075 ha⁻¹) obtained from OFRD Rangpur site.

Pest incidence: There was no remarkable disease or insect found during the growing period.

Table 1: Yield, cost and return analysis of Garden pea during the *Rabi* season of 2020-21

Location	Variety	Farmers no.	Area (ha)	Seed yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Gaibandha	BARI Methi-2	4	1.60	1.55	139500	56750	82750
Rangpur		6	0.93	1.10	99000	45925	53075
Total (No. of farmers and Area)		10	2.53	-	-	-	-
Average (GR, TVC and GM)		-	-	1.33	119250	51338	67913

Market price (Tk/kg): BARI Methi-2=90

PRODUCTION PROGRAM OF POTATO

The experiment was conducted in the farmers' field of Mymensingh, Kishoreganj, Sherpur, Tangail, Rangpur, Gaibadha, Bogura, Kushtia, Jessore, Faridpur, Bhola and Manikganj district of Bangladesh during winter season of 2020-21. Before planting, the seed tubers were soaked in 3% boric acid to control scab disease and sown on 26 November to 5 December, 2020 maintaining the spacing 60cm × 25cm. Manures and fertilizers were applied at the rate of 10 t ha⁻¹ cowdung along with 160-110-132-13-05-02 kg NPKSZnBha⁻¹ in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half amount of urea and full dose of other fertilizers were applied during final land preparation. The rest amount of urea was applied at 35 days after planting (DAP). Irrigation was done 20 DAP and 45DAP, respectively. Earthing up and weeding were done as and when necessary. The crop was harvested on 11 February to 7 March, 2021.

Results: The tuber yield and other cultural practices of potato production are presented in Table 1. It was observed that the highest tuber yield (49.88 t ha⁻¹) was found from the variety of BARI Alu-41 at Kushtia. The variety BARI Alu-41 showed lower yield in farmer's field condition than expected performance but it is higher yield range from 24.47 to 49.88 t ha⁻¹ than the national average yield 18.0 t ha⁻¹.

Disease and Pest infestations: There was no notable insect pest incidence was observed in potato varieties but cutworm infestation was found very negligible in early stage of potato plants at all locations. Among the locations, a very few numbers of virus infected plant were observed. The common scab incidence was observed in all the locations.

Farmers' opinion: Farmers are very interested to cultivate potato varieties as they sold potato from the field directly and earn a handsome amount of money from potato selling. They also demanded potato seed at due time in coming season. Farmers are happy in growing BARI Alu-41, BARI Alu-46 due to its higher yield and an extra income generation. They also opined that it can easily be fitted in Potato-Boro-T.aman rice cropping pattern without hampering the boro cultivation. They are interested in cultivating for the next year if the seeds are available.

Table 1. Agronomic practices of potato production during 2020-21

Locations	Variety	Farmers involved (no)	Area covered (ha)	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Mymensingh	BARI Alu-41	9	0.64	25.41	355740	165800	189940
Kishoreganj	BARI Alu-46	6	0.25	38.20	534800	165800	369000
	BARI Alu-47	6	.025	39.40	640250	168700	471550
	BARI Alu-53	6	.025	34.18	444340	164800	279540
	BARI Alu-7	8	0.25	34.00	510000	170110	339890
Sherpur	BARI Alu-28	8	0.70	28.08	421200	170110	251090
	BARI Alu-35	8	0.20	35.12	526800	170110	356690
	BARI Alu-36	8	0.40	39.40	591000	170110	420890
	BARI Alu-46	8	0.40	32.78	491700	170110	321590
	BARI Alu-47	8	0.70	41.40	621000	170110	450890
	BARI Alu-50	8	0.30	38.70	580500	170110	410390
	BARI Alu-53	8	0.30	29.67	445050	170110	274940
	BARI Alu-7	7	1.42	26.36	263600	191932	71668
Tangail	BARI Alu-8	7	1.42	27.66	331920	185727	146193
	BARI Alu-28	7	1.42	28.33	339960	191932	148028
	BARI Alu-29	7	1.42	30.00	360000	191932	168068
	BARI Alu-41	8	1.42	32.79	393480	188830	204651
	BARI Alu-46	7	1.42	32.52	341460	191932	149528
	BARI Alu-48	7	1.42	40.00	420000	191932	228068
	BARI Alu-53	7	1.42	27.43	329160	191932	137228
	BARI Alu-63	7	1.42	27.83	333960	191932	142028
	BARI Alu-78	7	1.42	38.00	399000	191932	207068

Locations	Variety	Farmers involved (no)	Area covered (ha)	Tuber yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Rangpur	BARI Alu-25	19	0.53	30.91	309050	65000	244050
	BARI Alu-28	2	0.16	28.65	286500	65000	221500
	BARI Alu-35	3	0.20	28.07	252585	65000	187585
	BARI Alu-41	3	0.20	28.76	287600	65000	222600
	BARI Alu-46	9	0.55	32.50	292500	65000	227500
	BARI Alu-53	3	0.06	31.10	279900	65000	214900
	BARI Alu-77	5	0.34	30.40	304000	65000	239000
Gaibandha	BARI Alu-7	16	0.53	24.75	247500	136700	110800
	BARI Alu-41	25	1.67	30.50	457500	136700	320800
	BARI Alu-53	20	2.78	32.58	488625	136700	351925
Bogura	BARI Alu-25	2	0.24	28.65	343800	150000	193800
	BARI Alu-41	3	0.35	27.50	343800	150000	193800
Kushtia	BARI Alu-7	5	0.62	30.38	394940	160673	234267
	BARI Alu-36	5	0.62	42.00	546000	160673	385327
	BARI Alu-41	5	0.62	49.88	648440	160673	487767
	BARI Alu-51	5	0.62	25.40	330200	160673	169527
	BARI Alu-53	5	0.62	35.00	455000	160673	294327
Jessore	BARI Alu-7	2	0.16	24.37	243700	210000	33700
	BAR Alu-8	2	0.16	23.95	239500	210000	29500
	BARI Alu-35	2	0.16	24.31	243100	210000	33100
	BARI Alu-41	3	0.16	24.47	244700	210000	34700
Faridpur	BARI Alu-28	51	0.20	23.37	327180	213384	113796
	BARI Alu-29	51	0.20	20.30	284200	210884	73316
	BARI Alu-36	51	0.20	31.95	447300	218384	228916
	BARI Alu-41	51	0.20	34.90	488600	220884	267716
	BARI Alu-53	51	0.20	30.06	420840	218384	202456
	BARI Alu-7	51	0.20	21.83	305620	213384	92236
	BARI Alu-25	51	0.20	22.15	310100	213384	96716
Bhola	BARI Alu-7	15	0.61	30.16	361920	153220	208700
	BARI Alu-46	10	0.12	32.45	389400	153220	236180
	BARI Alu-50	12	0.20	28.73	344760	153220	191540
Manikganj	BARI Alu-36	10	0.20	40.40	484800	239319	245481
	BARI Alu-36	12	0.20	36.40	436800	239319	197481
Total		722	32.47				
Average				31.17	391189	167117	224072

Market price: Tangail: Tk. 10.50/- kg (BARI Alu-7, BARI Alu-46, BARI Alu-48, BARI Alu-78) Tk. 12.00/- kg (BARI Alu-8, BARI Alu-28, BARI Alu-29, BARI Alu-41, BARI Alu-53, BARI Alu-63)

Conclusion

The performance of BARI Alu-41, BARI Alu-46 is promising on the basis of yield in the selected cultivation area. For large scale production and popularization of this tuber crop initiative could be taken.

PRODUCTION PROGRAM OF BARI DEVELOPED STEM AMARANTH AT MANIKGANJ

The production program of stem amaranth was conducted in the farmers' field at Boinna Prashad village under Ghior upazila of Manikganj district during Kharif-I season of 2021 to evaluate the performance of BARI released stem amaranth variety. BARI Danta-1 was cultivated in 25 bigha of land in 5 farmers' field. The experimental plots were fertilized with N-P-K-cowdung @ 120-20-75-5000 kg ha⁻¹. Half of urea and full amount of other fertilizers were applied as a basal dose. The remaining amount of urea was applied as top dress at 30 days after sowing. Two times irrigation was provided at 15 and 25 DAS. The seeds were sown as broadcast @ 1.5 kg ha⁻¹ on 11 to 18 March, 2021. Other intercultural operations such as weeding, irrigation and top dressing of urea and plant protection measures were taken as and when required. The crop was harvested on 20 April to 28 April, 2021. Data on different plant characters

and yield were collected and analyzed statistically. The economic return was calculated on the basis of prevailing market price of product.

Results: The yield and economic benefit of BARI Danta-1 is shown in Table 1. BARI Danta-1 produced yield 29.71 t ha⁻¹ and can be harvested within 40 to 45 days after sowing. Gross return (Tk. 148550 ha⁻¹) and gross margin (Tk. 99530 ha⁻¹) was also obtained from BARI Danta-1.

Farmers Opinion: BARI Danta-1 is a high yielding variety than the local one. Both stem and leaf are tasty and stem is fibreless. This variety can be harvested within 45 days. Farmers commented that there is a good demand of BARI stem amaranth variety in the local market.

Conclusion: Considering the yield, stem amaranth var. BARI Danta-1 could be promising in the farmers' field at Manikganj. This variety could be extended in the farmers' field at Manikganj.

Table 1. Yield and yield attributes of stem amaranth varieties grown at Ghior, Manikganj during Kharif-I season of 2021.

Variety	Farmers involved	Area (bigha)	Field duration (days)	Average yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Danta-1	5	2.0	40-45	29.71	148550	49020	99530

Farm gate price of stem amaranth: Tk. 5.00 kg⁻¹

PRODUCTION PROGRAM OF BARI DEVELOPED OKRA AT MANIKGANJ

The production program of okra was conducted at Garakol village under Sadar Upazila of Manikganj district during Kharif-I season of 2021 in the farmers' field. BARI Dharosh-2 was cultivated in four farmer's field in 75 decimal of land. The seed of BARI Dharosh-2 was collected from Horticultural Research Centre of BARI, Gazipur. The experimental plots were fertilized with fertilizers @ 83-30-75-17.9-1.7-0-5000 kg ha⁻¹ of N-P-K-S-Zn-B-Cowdung applied as urea, triple super phosphate and muriate of potash, respectively. Whole amount of cowdung and TSP, half of urea and potash were applied during final land preparation. The remaining amount of urea and MoP were top dressed in three equal splits at 30, 50 and 80 days after sowing. Seeds were sown in line maintaining 50cm × 20cm @ 5.0 kg ha⁻¹ on 04 to 10 March, 2021. No irrigation was required as the land contained enough soil moisture. Other plant protection measures were taken as and when required. Green young fruits were harvested from 29 April to 10 July, 2021. Data on yield and yield contributing characters were recorded and converted into ton ha⁻¹.

Results: The yield and economic benefit of BARI Dharosh-2 is shown in Table 1. BARI Dharosh-2 produced yield 10.66 t ha⁻¹. Gross return (Tk. 170560 ha⁻¹) and gross margin (Tk. 72910 ha⁻¹) was also obtained from BARI Dharosh-2.

Disease and Insect reaction: Autostin@ 2g L⁻¹ water sprayed to control root rot of seedling and Nitro @ 1 ml L⁻¹ water was sprayed to control leaf feeder insects.

Farmers' opinion: Farmers opined that BARI Dharosh-2 is a new crop in the farmers' field at Manikganj. Farmers were interested to cultivate BARI Dharosh-2 for its higher yield. Fruit size is large with attractive green colour.

Conclusion: Considering the yield and return, okra var. BARI Dharosh-2 is a profitable crop and can be cultivated in large scale in the farmers' field at Manikganj.

Table 1: Seed yield of BARI Dharosh-2 grown at Satoria, Manikganj during Kharif-I season of 2020.

Variety	Farmers involved	Area covered (decimal)	Fruit plant ⁻¹ (no.)	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Dharosh-2	4	75.00	20.33	10.66	170560	97650	72910

Price of okra @ Tk. 16.00 kg⁻¹

PRODUCTION PROGRAM OF BARI KANGKONG AT MANIKGANJ

The production program of BARI kangkong variety was conducted at kamta village under Satoria Upazila of Manikganj district during Kharif-I season of 2021 in the farmer's field. BARI Gimkolmi-1 was cultivated in one farmer's field in 2 bigha of land. The seed of BARI Gimkolmi-1 was collected from Horticultural Research Centre of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 130-24-60-18-5000 kg ha⁻¹ of N-P-K-S-Cowdung. Fertilizers were applied as urea, triple super phosphate and muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and whole amount of TSP, MoP, Gypsum and cowdung were applied during final land preparation. The remaining urea was top dressed in five equal splits after each cut of green leaves. Seeds were sown in line maintaining 30cm × 10cm @ 10 kg ha⁻¹ on 23-25 February, 2021. No irrigation was required as the land contained enough soil moisture and sufficient rainfall occurred during the growing season. Other plant protection measures were taken as and when required. Green leaves were harvested 6 times starting from 11 April to 13 July, 2021. Data on yield were recorded and converted into ton ha⁻¹.

Results: The yield and economic benefit of BARI Gimkolmi-1 is shown in Table 1. BARI Gimkolmi-1 produced yield 21.96 t ha⁻¹. Gross return (Tk. 219600 ha⁻¹) and gross margin (Tk. 111820 ha⁻¹) was also obtained from BARI Gimkolmi-1.

Disease and Insect reaction: Jute hairy caterpillar infestation was observed and it was controlled by spraying of Karate @ 2.0 ml L⁻¹ water.

Farmers' opinion: Farmers are interested to cultivate BARI Gimkolmi-1 for its higher leaf yield. They opined those twigs of this variety are tasty and market demand is also high.

Conclusion: Considering the yield and return, Kangkong var. BARI Gimkolmi-1 is a profitable crop and can be cultivated in large scale in the farmers' field at Manikganj.

Table 1: Yield of BARI Gimkolmi-1 grown at Sadar Manikganj during Kharif-I season of 2020.

Variety	Farmers involved	Area covered (Bigha)	Green leaf (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Gimkolmi-1	3	2	21.96	219600	107780	111820

Farm gate price of green leaves @ Tk. 10.00 kg⁻¹

PRODUCTION PROGRAM OF BARI BITTER GOURD AT MANIKGANJ

The production program of BARI bitter gourd variety was conducted at Sutipara, Damrai under Dhaka district during Kharif-I season of 2021 in the farmer's field. BARI bitter gourd-3 was cultivated in three farmer's field in 1.0 bigha of land. The seed of BARI bitter gourd-3 was collected from Horticultural Research Centre of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 80-35-75-18-5-1.8 kg ha⁻¹ of N-P-K-S-Zn-B along with 5.0 t ha⁻¹ of cowdung. Whole amount of cowdung, one-third of urea, K, TPS, Gypsum, Zinc and Boron were applied on week before transplanting of seedling. The remaining amount of urea were applied two equal splits at 25 and 40 DAP. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Fruits were harvested from 5 May to 15 June, 2021. Data on yield were recorded and converted into ton ha⁻¹.

Results: The yield and economic benefit of BARI Bitter gourd-3 is shown in Table 1. BARI Gimkolmi-1 produced yield 17.00 t ha⁻¹. Gross return (Tk. 340000 ha⁻¹) and gross margin (Tk. 245490 ha⁻¹) was also obtained from BARI Bitter gourd-3.

Disease and Insect reaction: The crop was infested by pumpkin beetle and Nitro @ 2 ml L⁻¹ water was sprayed. Thiovit powder @ 5gm L⁻¹ water was sprayed to control powdery mildew disease.

Farmers' opinion: Farmers are interested to cultivate BARI Bitter gourd-3 for its higher yield. They opined that the market demand of this variety is also high.

Conclusion: Considering the yield and return, BARI Bitter gourd-3 is a profitable crop and can be cultivated in large scale in the farmers' field at Dhamrai and Manikganj.

Table 1: Yield of BARI Bitter gourd-3 grown at Sutipara, Dhamrai, Dhaka during Kharif-I season of 2021.

Variety	Farmers involved	Area covered (Bigha)	Fruit yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Bitter gourd-3	3	1	17.00	340000	94510	245490

Price of bitter gourd-3 @ Tk. 20.00 kg⁻¹

PILOT PRODUCTION OF BARI HYBRID MISTIKUMRA-1 VARIETIES IN THE CHAR LAND AREAS

The trial results with BARI Hybrid Mistikumra-1 and BARI Hybrid Mistikumra-3 in different char lands in Rangpur, Gaibandha and Bogura districts are presented in Table 1. A total of 30 trials were conducted at Charland of three upazillas (Saghata of Gaibandha, Sadar of Lalmonirhat and Sariakandi of Bogura,) under OFRD, Gaibandha, OFRD, Rangpur and OFRD, Bogura. Seed sowing started on 22 October 2020 and continued up to 10 November 2020 across the locations. Harvesting of Sweet gourd started on 15 January 2021 and continued up to 15 March 2021. Sex Pheromone trap was set up in the trial plots to control fruit fly infestation in the small, sweet gourds. From the trial plots of 03 Upazillas, a total of 315287 kg sweet gourd was produced. The yield of farmers practiced variety ranged from 15.75 to 28.15 t ha⁻¹ whereas, in the trial plot yield of BARI Hybrid Mistikumra-1 ranged from 20.86 to 36.50 t ha⁻¹ and BARI Hybrid Mistikumra-3 ranged from 30.5 to 38.2 t ha⁻¹. The average yield of BARI Hybrid Mistikumra-1 and BARI Hybrid Mistikumra-3 over the locations was 29.99 and 34.35 t ha⁻¹ (Table 1). The cost and return analysis (Table 1) showed that the highest gross margin (Tk. 434250 ha⁻¹) obtained from OFRD, Gaibandha site, and the lowest gross margin (Tk. 138650 ha⁻¹) obtained from OFRD, Bogura site.

Pest incidence: There was no remarkable disease or insect found during the growing period.

Farmer's opinion: Farmers preferred BARI Hybrid Mistikumra-1 and BARI Hybrid Mistikumra-3 variety due to its uniform shape and size, about two times higher yield than local variety and profuse bearing.

Table 1. Yield and economic performance of BARI Hybrid Mistikumra-1 at different Charland under OFRD, BARI, Rangpur, Gaibandha and Bogura in 2020-21

Location	Variety	Farmer's practice variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
			Min	Max	Av.			
Gaibandha	BARI hybrid Mistikumra-1	15.75	31.20	36.50	33.85	507750	73500	434250
Bogura		21.50	20.86	31.40	26.13	261300	122650	138650
Rangpur	BARI hybrid Mitikumra-3	28.15	30.50	38.20	34.35	480900	74115	406785
Average		21.8	27.5	35.4	31.4	416650	90088	326562

Market price (Tk/kg): 15 in Gaibandha, 14 in Rangpur and 10 in Bogura.

PILOT PRODUCTION PROGRAM OF BARI JHARSHEEM-2 IN HILL VALLEYS OF BANDARBAN

The Pilot Production Program was conducted in two farmers field of Bakichara hill valleys of Bandarban Sadar upazila during the rabi season, 2020-2021. The BARI Jharsheem-2 variety was used as a sowing material of the pilot production program. The land area for demonstrations was 20 decimals. Spacing was maintained 30cm × 15cm. Seeds were planted at 15 cm in row and 30 cm between rows with 2 seeds per hole. The crop was fertilized with 91-21-31-7-1-0 kg ha⁻¹ of N-P-K-S-Zn-B in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid, respectively. Cowdung was used as per 5 t ha⁻¹ during final land preparation. Two third of urea and full amount of all other fertilizers were also applied at final land preparation. Seeds of Jharsheem were sown on 5 December, 2020. The rest of the urea was applied as a top dress at 21 DAS followed by first irrigation and weeding. Other irrigation was done at six weeks after sowing and before harvesting. The crop was harvested at green pod stage at 17 February, 2021. The fungicides Rovral 50 WP were applied for controlling alternaria blight disease.

Results: Yield and yield contributing characters of BARI Jharsheem-2 was presented in Table 1. Pod yield (19.44 t ha⁻¹) was found from Bakichara hill valleys of Bandarban. From the cost and return analysis was presented it was revealed that the gross return was found as Tk. 583350 ha⁻¹ which resulted in gross margin of Tk. 359100 ha⁻¹.

Pest incidence: The fields were partially infested with *Alternaria* blight disease and fungicide Rovral 50 WP were applied two times at 7 days interval on 21 January and 29 January of 2021.

Farmer's Opinion: Total yield of BARI Jharsheem-2 (19.44 t ha⁻¹) was highly appreciated and accepted by the farmers. Farmers also preferred this variety because of its high bearing capacity, good taste and high price in the market.

Table 1. Yield, cost and return analysis of BARI Jharsheem-2 grown at Bakichara hill valleys of Bandarban during the Rabi season of 2020-2021

Variety	Farmers involved	Area covered (decimal)	Pod yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Jharsheem-2	2	20	19.44	583350	224250	359100

Market price of green pod @ Tk. 40.00 kg⁻¹

PRODUCTION PROGRAM OF INTERCROPPING CHILLI WITH ONION

The production program was carried out at the farmers' field at MLT site, Sadar, Bhola during the *Rabi* season of 2020-21 to familiar and popularized among the farmers in Bhola region. Generally, Bhola district is not an onion growing area. Very a few farmers grow onion sporadically. DAE, Bhola reported 700 ha of land area is covered by onion in the rabi season of 2017-18. BARI Morich-2 and BARI Piaz-4 were used in the program. At the same time chilli and onion seedlings were transplanted in field. Unit plot size was 5 decimal. Thirty-five days old chilli seedlings were transplanted in a spacing of 60 cm × 40 cm on 25 January to 03 February 2021. Two rows of onion were transplanted in between two rows of chilli at the same date. Row to row distance of onion (two rows in between chilli rows) was 15 cm. Plant to plant distance of onion was 6 cm. Fertilizer dose was 133.95-77.50-117.87-17.35-2.63 kg ha⁻¹ N-P-K-S-Zn. N, P, K, S and Zn fertilizers were applied in the form of urea, TSP, MoP, gypsum and ZnSO₄ and Boric acid, respectively. The full amount of TSP, gypsum, ZnSO₄ and one third MoP were applied as basal at final land preparation. One third of urea and MoP was top dressed at 15 and 40 days after transplanting. The rest one third of urea was side dressed and earthing up of chilli was done after harvesting of onion. Irrigation was applied twice at 30 and 45 days after transplanting. Weeding was done three times at 20, 45 and 60 days after transplanting. Onion was harvested at 80-85 days after transplanting. Harvesting of chilli started from 15 April to 20 May 2021.

Disease and pest infestation: For purple blotch disease of onion till @ 0.05 ml lit⁻¹ water was sprayed twice at an interval of 15 days. Few cutworms' infestation was observed in the seedling stage and it was controlled by hand picking. Thrips infestation was observed and Volume Flexi was sprayed twice at an

interval of 10-12 days to control it. For controlling chilli fruit borer same dose of Volume Flexi was sprayed once. Chilli was harvested one time after that due to heavy rainfall another harvesting was not possible resulting yield was not up to the mark.

Farmers' opinion: Intercropping onion with chilli is a very good technology to get an extra crop from the same unit of land in the same time. But weeding in intercropping took more time than sole chilli. They demanded onion seed to be available in the local market.

Table 1. Yield, cost and return of intercropping onion with chilli in Bhola, 2020-21

Onion bulb yield (t ha ⁻¹)	Dry chilli yield (t ha ⁻¹)	Chilli equivalent yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
4.16	1.15	2.02	242000	108645	133755

Price (Tk. Kg⁻¹): Chilli seed: 600, Onion seed: 3000, Urea: 16, TSP: 22, MOP: 15; Gypsum: 22, Dry chilli: 120, Onion: 25

PRODUCTION OF FIELD PEA AS RELAY CROP WITH T. AMAN RICE

Field pea (var. BARI Motor-3) was demonstrated through block approach at FSRD site, Gonggarampur, Pabna during the rabi season of 2020-21. The size of the demonstration block was about 1 acre and three farmers were involved with the demonstration. The cooperative farmers were selected after a group discussion meeting organized by the scientist of OFRD, ARS, Pabna. Different inputs (Seed, fertilizers and fungicides) were supplied from OFRD, ARS, Pabna. The seeds of relay crops were sown on 8-10 November, 2020, which was 12-15 days prior to T. Aman rice harvest. Seeds were soaked overnight for seed priming. The fertilizers were applied @ 46-8-21-11 kg N-P-K-S ha⁻¹. The seed rate was 90 kg ha⁻¹. No weeding but three times fungicides (Score) were sprayed starting at the beginning of flowering and continued at 7-10 days interval. The crop was harvested on 02 February to 01 March, 2021. Data on yield and yield contributing characters were collected, compiled and presented accordingly.

Results: The yield contributing characters and yield of pea are presented in the Table 1. The plant population per square meter obtained from different farmers' field was varied from 77 to 102 and it might be due to variation in soil moisture condition for germination of seed. The number of pods per plant was fluctuated and ranged from 09 to 12. Seed yield of BARI Motor-3 was varied from field to field and the average seed yield was recorded 2080 kg ha⁻¹. From the cost and return analysis it was revealed that excellent gross return (Tk. 38800 ha⁻¹) and gross margin (Tk. 102900 ha⁻¹) was obtained from field pea as relay crop with T. Aman rice (Table 1).

Farmer's opinion: Farmers opined that the relay technology was found economically viable and technologically feasible which encourages them and helps to grow as profitable crop in the existing cropping pattern. They preserved seeds to grow field pea in the next year. Farmers opined that spraying of 'Score' may be a good option for controlling the blight disease.

Conclusion: The cultivation of field pea as relay cropping with T. aman rice through block approach created an excellent impact towards the large-scale adoption in the farmers' field. Being high yield potential with higher economic return, the field pea variety itself has made its suitability as relay cropping in the Field Pea – Mungbean/Sesame/Boro - T. Aman cropping pattern.

Table 1. Cost and return obtained from relay field peas at FSRD site, Gonggarampur during rabi, season, 2020-21

Average seed yield (kg ha ⁻¹)	Average straw yield (kg ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
2080	3500	138800	35900	102900

Seed: 60.00Tk. kg⁻¹ and Stover 4.00 Tk. kg⁻¹

PRODUCTION OF GRASS PEA AS RELAY CROP WITH T. AMAN RICE

Grass pea variety BARI Khesari-5 was demonstrated through block approach at FSRD site, Ganggarampur, Pabna and BARI Khesari-2 during the *rabi* season of 2020-21. The seeds of grass pea (var. BARI Khesari-5) were sown on 10-15 November, 2020, which was 12-14 days prior to T. aman rice harvest at Pabna. But in Noakhali BARI Khesari-2 was used to address Fallow-T. Aman + Relay khesari cropping pattern instead of Fallow-T. Aman-Fallow cropping pattern. Seeds were soaked overnight for seed priming. The fertilizers were applied @ 46-8-21-10 kg N-P-K-S ha⁻¹. The seed rate was 70 kg ha⁻¹. No weeding but two times fungicides (Score) were sprayed starting at the beginning of flowering and thereafter 7-8 days interval. The crop was harvested on 10-25 March, 2021. Data on yield and yield contributing characters were collected and compiled accordingly.

Results: The yield and yield contributing characters of grass pea are presented in the Table 1. In Pabna the average seed yield of grass pea recorded 1540 kg ha⁻¹. The average straw of grass pea yield was noted 2200 kg ha⁻¹. From the cost and return analysis it was revealed that satisfactory gross return (Tk. 742540 ha⁻¹) and gross margin (Tk. 38060 ha⁻¹) was obtained from grass pea as relay crop with T. *Aman* rice (Table 1). The average seed yield in Noakhali district was found 969 kg ha⁻¹.

Farmer's opinion: Farmers opined that the relay technology was found economically viable and technologically feasible which encourages them and helps to grow as profitable crop in the existing cropping pattern.

Conclusion: The cultivation of grass pea as relay cropping with T. Aman rice through block approach created good impact towards the large scale adoption in the farmers' field. Being high yield potential with relatively higher economic return, the grass pea variety (BARI Khesari-5) itself has made its suitability as relay cropping in the Grass pea – Mungbean/Sesame/Boro - T. Aman cropping patterns.

Table 2. Cost and return of relay grass pea during the *rabi* season of 2020-21.

Location	Average seed yield (kg ha ⁻¹)	Average stover yield (kg ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Pabna	1540	2200	74250	36190	38060
Noakhali	969	-	53322	14516	38806

Seed: 42.5 Tk. kg⁻¹ and Stover: 4.00 Tk. kg⁻¹

PRODUCTION OF LENTIL AS RELAY CROP WITH AMAN RICE

The production program with BARI developed improved variety BARI Masur-8 was conducted through block approach at FSRD site, Gongarampur, Pabna and Cumilla during the *rabi* season of 2020-21. The seeds of BARI Masur-8 were sown on 9-13 November, 2020 which was 12-14 days before T. aman harvesting. But in Cumilla the seeds were relayed on 25 November, 2020 before 9-10 days of harvesting of B. Aman (Local variety Puichon). Weeding was done in 2 times in whole the cropping period. Seeds were soaked overnight in fresh water for seed priming. The seed rate of lentil was 35 kg ha⁻¹. The fertilizers were applied @ 37-08-20-13 kg N-P-K-S ha⁻¹. No weeding but three times fungicides (Rovral 50 WP) spraying were done starting at the beginning of flowering and continued at 7-10 days interval. The crop was harvested in the first to mid-week of March, 2021. Data on yield and yield contributing characters were collected, compiled and presented in Table 1.

Results: Performance of lentil as relay crop with T. Aman is presented in Table-1. The yield range of lentil was noted 1590-1700 kg ha⁻¹. However, the average seed yield obtained from BARI Masur-8 was 1620 kg ha⁻¹. This satisfactory yield might be obtained due to timely sowing, improved management practices and successfully controlling of stem phyllosticta blight disease through application of Rovral 50 WP. Number of sufficient pods per plant also supported this yield of lentil. In Cumilla lentil yield was found 2100 kg ha⁻¹ relay with B. *Aman* rice

Cost and return: Regarding the cost and return analysis, satisfactory gross return (Tk. 119050 ha⁻¹) and gross margin (Tk. 83060 ha⁻¹) was obtained from relay lentil (Table 1).

Farmer's opinion: Farmers opined that the BARI Masur-8 was high yielder which encourages them to grow as relay crop with T. *Aman* rice because it is more profitable. They preserved seeds with a view to grow this variety in the next season. Farmers opined that spraying of Rovral 50 WP might be a good option for controlling the stem phylum blight disease.

Conclusion: The farmers enriched their skill, knowledge and improved production practices through training and block demonstration to increase the productivity of BARI Masur-8 per unit area. The cultivation of BARI Masur-8 as relay through block approach created an excellent impact towards the large-scale adoption of lentil in the farmers' field. Farmers preserved large amount of seeds for wide area extension in the coming season. Due to technological intervention, there is a chance to improve income and status of the farm family.

Table 1. Cost and return obtained from BARI Masur-8 during the *rabi* season of 2020-21

Locations	Average seed yield (kg ha ⁻¹)	Average stover yield (kg ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Pabna	1620	1130	119050	35990	83060
Cumilla	2100	-	126000	20500	105500

Seed: 70.00 Tk. kg⁻¹ and Stover: 5.00 Tk. kg⁻¹ at Pabna and Market price of Lentil @ Tk. 60 Kg⁻¹ at Cumilla

PILOT PRODUCTION OF LENTIL UNDER STRIP PLANTING SYSTEM IN RAJSHAHI

The trial was conducted in Paba, Rajshahi during 2020-2021 to evaluate the performance of lentil by strip planting system in farmers' field. Among the farmer's field the highest yield was obtained 2439 kg ha⁻¹ and lowest 2150 kg ha⁻¹ and the average yield was 2250 kg ha⁻¹. Farmers are interested to use strip planter machine for lentil cultivation. From the table 1, it was found that the farmer's field the highest yield was obtained 2439 kg ha⁻¹ and the lowest 2150 kg ha⁻¹. The average yield was 2250 kg ha⁻¹. Farmer's stored 780 kg seed for next year lentil production.

Farmer's opinion: variety BARI Masur-8. They also preserved lentil seed to grow own and for distribution to other farmers for the next season. They also informed that strip tillage is a very suitable for time and cost saving technology

Conclusions: BARI Masur-8 shows the excellent performance when it is sown by strip planter machine in the field.

Table 1. Performance of BARI Masur-8 in farmers' field trial at MLT site Paba, Rajshahi during 2020-2021

Sl. No.	Farmers' name	Address	Area (bigha)	Grain yield (kg ha ⁻¹)	Seed stored (kg)
1	Hazi Sukur Mohammad	Thalta, Paba, Rajshahi	1.5	2439	50
2	Md. Abdul Khalek	Thalta, Paba, Rajshahi	1	2200	40
3	Md. Anisur Rahaman	Thalta, Paba, Rajshahi	4	2175	50
4	Md. Rafiq	Pakuria, Paba, Rajshahi	4	2237	100
5	Md. Rohidul	Pakuria, Paba, Rajshahi	1.5	2150	20
6	Lal Mohammad	Pakuria, Paba, Rajshahi	2	2190	50
7	Mohammad Ali jinnaha	Baraipara, Paba, Rajshahi	5	2190	100
8	Md. Dalwar Hossain	Baraipara, Paba, Rajshahi	3	2270	100
9	Md. Abdul Rahaim	Baksara, Paba, Rajshahi	3	2205	50
10	Md. Sohag	Duari, Paba, Rajshahi	1	2400	40
11	Md. Sobur Ali	Baksara, Paba, Rajshahi	2	2400	100
12	Md. Abdul Roshid	Baksara, Paba, Rajshahi	1	2185	40
13	Md. Mostak	Baksara, Paba, Rajshahi	1	2209	40
			Total = 30	Average = 2250	Total = 780

PRODUCTION PROGRAM OF BARI MASH-3 UNDER ZERO TILLAGE IN FARIDPUR

A production program under OFRD, BARI, Faridpur was conducted at farmer's field of the FSRD site & Dicir Char area of Faridpur and the MLT site, Rajbari during the Kharif II, 2020 to demonstrate the performance of BARI Mash-3 and to popularize among the growers in the locality. Eleven (11) farmers were selected for this program with a total of 200 decimals (6 bigha) of land. The treated seeds with provax (Thiram 37.5% + Carboxin 37.5%) were sown @ 30-35 kg ha⁻¹ by broadcast method without ploughing during mid to third week of September, 2020. Different crop management practices are stated in Table 1. All fertilizers were applied @ 20-18-20-10-1.8 N-P-K-S-B kg ha⁻¹ during land preparation. BARI Mash-3 were harvested during 3-8 December, 2020 (75-80 DAS) irrespective of farmers. Yield data were collected after harvest from an area of 5 m² (sample size was 1 m²) from the whole plot avoiding border side of each plot and converted to yield ha⁻¹ area. Data on yield and economics were recorded and presented in Table 2.

Results: Seed yield of BARI Mash-3 was 1084 kg ha⁻¹ which was 26 % higher than that of local variety (860 kg ha⁻¹). But yield of BARI Mash-3 was lower due to excessive rainfall occurs after broadcasting of seed so plant population was not up to the mark. BCR of BARI Mash-3 (2.22) was also higher than local (1.63). The number of preserved seed for next year cultivation was 100 kg.

Farmers' opinion: Farmers showed interest to cultivate BARI Mash-3 because of higher yield (26%) and bold sized seed. Powdery mildew and YMV infection were lower than local. A good amount of BARI Mash-3 seed has been stored by the farmers for growing next year.

Table 2. Seed yield and cost return analysis of BARI Mash-3 and Farmer's existing variety during 2020

Variety	Seed yield (kg ha ⁻¹)	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR	Amount of seed preserved (kg)
BARI Mash-3	1084	70460	31753	38707	2.22	100
Local	860	60180	23390	36770	1.63	30

Input Price (Tk kg⁻¹): Faridpur: Seed of BARI Mash-3: 100.00

Output price (Tk kg⁻¹): Seed: 65.00

Seed Production Program

PRODUCTION OF QUALITY SEED POTATO AT FARMERS LEVEL IN RAJSHAHI

The production program was conducted at the MLT site, Shibpur and Paba, Rajshahi during the rabi season of 2020-2021 to produce disease free quality seed potato at farmers' level. The tubers of BARI released different potato varieties were given to the farmers for producing disease free seeds at on farm level. Performance of BARI Alu-8, BARI Alu-13, BARI Alu-28, BARI Alu-46, BARI Alu-53 and BARI Alu-78 at farmers' level is satisfactory with an average yield of 28.40 t ha⁻¹, 29.7 t ha⁻¹, 26.98 t ha⁻¹, 30.04 t ha⁻¹, 28.93 t ha⁻¹ and 29.89 t ha⁻¹ respectively. Farmer stored highest potato seed (1900 kg) of BARI Alu-78 followed by 1700 kg of BARI Alu-8, 1000 kg of BARI Alu-28, 950 kg of BARI Alu-13, 900 kg of BARI Alu-53 and lowest 750 kg of BARI Alu-46.

Farmers' Opinion: Farmers said that potato seed production and use of own seed reduce production cost of potato. So, they want to produce potato seed for their own use and sell to others. Production of potato seed also gets more return.

Conclusion: It was found that seed plot technique is very effective method to produce good quality potato seed at farmer's level

Table 1: Yield and seed stored of potato varieties under block demonstration during 2020-21

Varieties	Yield (kg ha ⁻¹)	Seed potato stored (kg)
BARI Alu-8	28.40	1700
BARI Alu-13	29.7	950
BARI Alu-28	26.98	1000
BARI Alu-46	30.04	750
BARI Alu-53	28.93	900
BARI Alu-78	29.89	1900

SEED PRODUCTION IN ON-STATION, OFRD, REGION-1, SHYAMPUR, RAJSHAHI

In modern agriculture, seed is a vehicle to deliver almost all agriculture-based technological innovations to farmers so that they can exploit the genetic potential of new varieties. The availability, access and use of seed of adaptable modern varieties is, therefore, determinant to the efficiency and productivity of other packages (irrigation, fertilizers, pesticides) in increasing crop production. As a multi crop research institute Bangladesh Agricultural Research Institute has developed more than 330 varieties of different crops such as such as cereals, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, etc. To popularize and greater adoption of these varieties throughout the country, the production program was undertaken and the following seeds were produced during 2020-21.

Crops	Variety/Line	Date of sowing	Date of harvest	Seed produced
Tomato	BARI Hybrid Tomato-8	22 December 2020	15 March - 5 April 2021	250 g
Garden pea	BARI Motor-2	15 November 2020	22-25 January 2021	04 kg
	BARI Motor-3	15 November 2020	25-26 February 2021	50 kg
Grass pea	BARI Khesari-3	15 November 2020	10-12 March 2021	34 kg
	BARI Khesari-5	15 November 2020	10-12 March 2021	26 kg
Coriander	BARI Dhonia-2	07 November 2020	26 March 2021	50 kg
Black cumin	BARI Kalozira-1	05 November 2020	23-24 March 2021	55 kg
Mustard	BARI Sarisha- 18	13-14 November 2020	27-28 February 2021	480 kg
Onion	BARI Piaz-4 (True seed)	12 November 2020	18-25 March 2021	15 kg
	BARI Piaz-4 (Tuber)	14 January 2021	22 March 2021	600 kg
Lentil	BARI Masur-8	14-15 November 2020	09-11 March 2021	680 kg
Garlic	BARI Rosun-1	09-10 November 2020	27-28 March 2021	200 kg
	BARI Rosun-3	09-10 November 2020	27-28 March 2021	80 kg

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LIST OF FARMING SYSTEMS RESEARCH AND DEVELOPMENT (FSRD) AND MULTILLOCATION TESTING (MLT) SITES

A. FSRD SITES

1. Ajoddhapur (3), Rangpur
2. Gangarampur (11), Pabna sadar, Pabna
3. Sholakundu (12), Faridpur sadar, Faridpur
4. Atia (8), Delduar, Tangail
5. Tarakandi (8,9), Sherpur sadar, Sherpur
6. Subarnachar (18c, 18f), Noakhali sadar, Noakhali
7. Jamla, (13), Dumki, Patuakhali
8. Basantapur (26), Godagari, Barind, Rajshahi
9. Kamal bazar (20), South Surma, Sylhet
10. Charkharicha (8,9), Mymensingh Sadar, Mymensingh
11. Charpara (4), Sonatola, Bogura
12. Chandradighalia (14), Gopalganj Sadar, Gopalganj
13. Jiakokhi (11), Kushtia Sadar, Kushtia
14. Chandura, Rajshahi

B. MLT SITES

Region-1

Pabna	: Atghoria (11&12), Sujanagar (10,11&12), Kashinathpur (11&12) of Pabna, Sirajganj (4,5,7&12)
Shyampur, Rajshahi	: Shibpur, Puthia (11), Paba (11) of Rajshahi
Barind, Rajshahi	: Aamnura (26) of Chapainawabganj, Sapahar (26) of Naogaon
Rangpur	: Gobindaganj (3) of Gaibandha, Domar (3) of Nilphamari, Ulipur (3) of Kurigram, Khalashpir (3) of Pirganj, Hatibandha of Lalmonirhat (3)
Bogura	: Sherpur (4,25), Shibganj (3,4,25), Gabtali (3,4) of Bogura and Joypurhat (3,25)
Rajbari, Dinajpur	: Raniganj (1), Ghoraghat (1) of Dinajpur, Pirgonj (1) of Thakurgaon,
Thakurgaon	: Munshirhat (Thakurgaon sadar)

Region-2

Sherpur	: Melandah(9) of Jamalpur, Nalitabari (8&9), Jhenaigati (8&9) of Sherpur
Tangail	: Ghatail (9,28), Modhupur (9,28), Bhuyapur (7,8), Mirzapur (8,9), Sadar (7,8) of Tangail
Mymensingh	: Trishal (8,9), Netrakona (9), Phulpur (9), Muktagaccha (8,9,28)
Kishoreganj	: Karimganj (8,9), Hossenpur (7,8,9), Nikli (8,19,21), Sadar (8,9)
Narsingdi	: Shibpur (9&28), Monohordi (9&28) & Raipura (8,9&28)
Gazipur	: Manikganj (7,8,10,12), Munshiganj (8,10,12,19) and Dhirashram (28)

Region-3

Jashore	: Tularampur (11), Narail, Seemakhali (11), Magura, Kaliganj (11), Jhenaidah, Jikargacha (11), Jashore
Khulna	: Satkhira sadar (11,13), Bagherhat sadar (11,13,14), Dumuria (11,13,14), Khulna, Batiaghata (11,13), Khulna, Koyra (13), Khulna
Kushtia	: Bheramara (11) of Kushtia, Gangni (11), Mujibnagar (11) of Meherpur and Sadar (11) of Chuadanga
Faridpur	: Rajbari sadar (12), Rajir of Madaripur (10&12)
Patuakhali	: Aamtali (13), Barguna, Kuakata (13) & Bauphal (13), Patuakhali
Barishal	: Banaripara (13&19) and Gournadi (12)
Bhola	: Daulatkhan (18), Charfashion (18)
Gopalganj	: Pirojpur (12,13,14), Tungipara (10,12,14,19), Muksudpur (10, 14, 19), Gopalganj

Region-4

Hathazari	: Patiya (23,29), Fatikchari (29)
Noakhali	: Feni (19a), Laxmipur (18f)
Cumilla	: Barura (19), Debidda (19), Chandina (19), Shaharasti (17,19), Chandpur, Kosba (16,19), Brahmanbaria
Sylhet	: Moulivibazar (20, 29), Zokiganj (20), Sunamganj (20, 21) and Habiganj (20, 21, 22)
Bandarban	: Limujiri (29), Buhalong
Cox's Bazar	: Cox's bazar sadar (23) and Chokoria (23) of Cox's bazar

Note: Numerical figure in parenthesis is no. of AEZ