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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
CSO	Chief Scientific Officer
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
PSO	Principal Scientific Officer
RCBD	Randomized Complete Block Design
REY	Rice Equivalent Yield
SA	Scientific Assistant
SO	Scientific Officer
SRDI	Soil Resource Development Institute
SSO	Senior Scientific Officer
t	Ton
T.	Transplanted
Tk.	Taka
TVC	Total Variable Cost

Preface

On-Farm Research Division of Bangladesh Agricultural Research Institute is going to publish its Annual Research Report based on the research program implemented during 2023-24 through Farming System Research and Development and Multilocation Testing 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 situations 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-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, climate change and crop modeling, integrated farming, family nutrition, homestead production systems, soil fertility management, cropping systems, four crop-based cropping patterns, 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 minor 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, and development partners. Results of these activities are also incorporated in this report. Through the technical support of this division, different activities (training, field day, workshop, and others) were conducted and organized for farmers, DAE personnel, Scientific Assistants and Scientists with the financial support of MoA, KGF, SAC, CIP, FAO, CIMMYT, IRRI, ACIAR and FtFBP during 2023-24.

We are expecting this report to 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, PARTNER, CIMMYT, IRRI, ACIAR, FtFBP, KGF, SAC, CIP, FAO, IDA, IFAD, World Bank 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/SAs who look after the experiments at different locations. Special thanks to the cooperating farmers for their valuable cooperation and support. Last of all, I acknowledge those who worked hard to accomplish this voluminous report successfully.

Dr. Md. Mazharul Anwar
Chief Scientific Officer & Head

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Executive Summary

On-Farm Research Division (OFRD) is one of the largest divisions and recognized as a window of Bangladesh Agricultural Research Institute (BARI). With the alignment of government policy and development vision and feedback from extension agencies, OFRD carried out research and development activities on On-Farm Soil Fertility Management, Improvement of Cropping Systems, Adaptive Trial of Advance Lines and Technologies, Integrated Farming System and Socioeconomic studies at farmers' field of national agricultural hotspots like Rainfed/Drought, Coastal, Charland, Hill, Haor and Plainland ecosystem. One of the important core functions of OFRD is location specific problem-oriented research and technology generation for solving the perceived problems. Research works on soil test based integrated nutrient management with synthetic fertilizer and organic manure at different ecosystems exhibited higher crop yield and improved soil health under different cropping pattern. The effect of organic manure recycling, bio-fertilizer, compound fertilizer and conservation agriculture with crop residue retention on different crops was found better regarding yield and economic return. Significant research effort has been made for the improvement of existing cropping pattern through inclusion of high yielding and short duration new varieties and improved management practices which contributed relatively higher production and farmers' income over farmers managed existing cropping at different ecosystem of Bangladesh. Selection of promising BARI developed varieties/lines of oil seed, pulse, vegetables, fruits, tuber and spices crops through On-Farm adaptive trial with active participation of farmers, extension personnel, scientists open greater scope for introduction of BARI varieties to the farmers. OFRD has developed around 10 homestead-based production model with year-round vegetables and quick growing fruits for different ecosystem utilizing all possible production units or niches which exhibited remarkably higher year-round fruits, vegetables, spices production and supplementary family nutrition (Vit. A, Vit. C, Protein, Iron, Ca etc.) over traditional farming. Adoption of integrated farming system with crops, livestock, fisheries and agroforestry technologies and off-farm activities created an excellent positive impact on existing farming with manifold production and income generation of the farm households. High Barind Tract is represented with extreme hot and erratic rainfall. OFRD has developed technologies with low water requirement crops (Pulse, oil seed), conservation agriculture with minimum tillage and mulching, water management with rainwater stored in mini pond etc. in HBT and made significant contribution in production and income generation. OFRD has accomplished comprehensive research works and generation of viable technologies in coastal ecosystem like adaptation of BARI developed Mungbean, Sunflower and Barley, cultivation of potato, garlic, and wheat with zero tillage, integrated Sorjan based production system with fruits+ vegetables+ fishes being used by the farmers in coastal area. In Charland the ecosystem OFRD gained success in adaptation of different crops with climate and soil characteristics. Greater adoption of BARI developed minor cereals like proso millet, pearl millet, sweet gourd, bitter gourd, chilli, cucumber, potato, sweet potato, maize, zero tillage onion, etc. through pilot production program exhibited remarkably higher production and economic return of the Char households. Greater adoption of BARI developed fruits, vegetables and agroforestry technologies in the hill ecosystem made greater availability of fruits and vegetables round the year for hill people. OFRD has made a lot of diversity in technology generation and wide scale adoption of BARI developed pulse, oil seed, fruits, vegetables, spices, minor cereals etc. in the plain land ecosystem which eventually uplift livelihood of the farmers. Development

of agroforestry technologies with fruit trees and high value vegetables, pulse, oil seed and spices crops at different ecosystem demonstrated 2 to 3 times higher system productivity and farmers income as compared to sole fruits cultivation. Adaptation of summer hybrid tomato varieties and community-based pilot production approach has made remarkable impact on increasing summer tomato production countrywide and created greater opportunities for value chain and marketing. This division acts a bridge between BARI and Extension agency through validation of On-Station technologies at farmer's field. The technologies those prove viable through OFRD validation process at farmers' field are eventually handover to DAE for large scale dissemination. However, pilot production program of new BARI varieties across the country has opened greater availability of seeds of high yielding BARI varieties, development of seed entrepreneurship and Village Seed Bank. OFRD follows Farming Systems Research and Development methodology with farmers training, Field days, Focal group discussion and intensive field monitoring for transferring of technologies on improving soil fertility, improvement of cropping system, cropping pattern improvement, integrated farming, pest management, and socioeconomic development of the farmers at different hotspots of the country. OFRD engaged with generation of climate change adaptation technologies maintaining collaboration with NARS institutes, DAE, DLS, DoF and international organizations like IFAD, ACIAR, CIMMYT, IRRI, CSIRO, BISA and Universities like Columbia University, University of Queensland, Monash University, New York University. As a mirror of BARI, OFRD created excellent impact on sustainable crop production, income generation, food and nutrition security of the rural farm families in Bangladesh.

Achievement of 2023-24 (Mature Technologies)

1. INTERCROPPING OF TARO (MUKHIKACHU) WITH GARLIC UNDER KAROTOA-BANGALI FLOODPLAIN AGROECOLOGICAL ZONE

Name of organization	Bangladesh Agricultural Research Institute (BARI)		
Contract division	CSO, On-Farm Research Division, BARI, Gazipur1701		
Location of application	Bogura region with similar soils of AEZ-4		
Key characteristics of the technology	• Most suitable combination of mukhikachu (100%) and Four rows of garlic in between two rows of taro (mukhikachu) were identified. • Mukhikachu equivalent yield was increased by about 26.75% compared to sole mukhikachu cultivation. • Gross margin increased by 37% compared to sole mukhikachu cultivation.		
Year of experimentation	2022-23		
Production guideline			
Crops	Mukhikachu (Local) and Garlic (BARI Rashun-1)		
Spacing (cm)	Mukhikachu (70 cm x 30 cm) and Garlic (15 cm x10 cm)		
Sowing date	3rd week of November		
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	48-80-40-27-4.8-1.2		
Fertilizer application method	Half of nitrogen and full quantity of cowdung and others fertilizers were applied at the time of final land preparation. Remaining N was top dressed in two equal installments at 25 and 50 days after germination in between two rows of mukhikachu.		
Date of harvesting	Onion: 2 nd week of April and Mukhikachu: 2 nd week of June.		
Yield (t ha ⁻¹)	Mukhikachu= 32.59, Garlic= 5.34 and Mukhikachu equivalent yield= 41.93.		
Intercultural operation	Earthing up will be one time and weeding also 2-3 times.		
Risk involvement in adopting the technology	No risk involvement		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, farmers training, field day, booklet, leaflet, poster etc.		
Expected outcome	Higher yield, as well as an economic benefit, can be achieved by using BARI Rashun-1 and cropping intensity can be increased		
Socioeconomic aspects	Gross return (Tk. ha ⁻¹) 1585600	Total variable cost (Tk. ha ⁻¹) 150450	Gross margin (Tk. ha ⁻¹) 1435150
Recommendation	Mukhikachu can be successfully intercropped with garlic without a significant reduction in the yield of mukhikachu. Farmers can earn better economic benefits by following the cultivation of four rows of garlic in between two rows of mukhikachu.		

2. LEGUME-DOMINATED RICE-BASED SYSTEM IMPROVED CROP PRODUCTIVITY AND PROFITABILITY IN NORTHWEST BANGLADESH

Name of organization	Bangladesh Agricultural Research Institute		
Contract division	CSO, On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Pabna Sadar and Atghoria upazila under AEZ 11, and similar soil environment in Bangladesh		
Key characteristics of the technology	• Rice equivalent yield was obtained 15.1 t ha⁻¹ from legume-dominated rice-based system which is about 18 % higher than cereal-dominated rice-based system and 31 % higher than oilseed-dominated rice-based system. • Gross margin increased by 82-129 % over cereal- and oilseed-dominated rice-based system. • The turn around time can be minimized about 18-22 days by practicing legume-dominated rice-based system as compared to cereal- and oilseed-dominated rice-based system in a year.		
Year of activities	2021-2023		
Production guideline			
Crop	Lentil	Black gram	T. Aman
Variety	BARI Masur-8	BRRI Mash-3	BRRI dhan-75
Spacing	Line to line: 30 cm and continuous sowing	Line to line: 30 cm and continuous sowing	20 cm x 15 cm
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)	20-40-20-10-1.5-1	20-40-20-10-1.5-0	90-10-35-12-1-0
Fertilizer application method	All fertilizer applied as basal before seed sowing	All fertilizer applied as basal before seed sowing	Full dose of PKSZn applied as basal and N applied in 2 equal splits as top-dressed at 15 and 35 days after transplanting of seedlings
Harvesting date	3 rd week of March	3 rd week of June	1 st week of November
Field duration (days)	107	82	83
Yield (t ha ⁻¹)	1.37	1.10	6.0
REY (t ha ⁻¹ year ⁻¹)	15.1		
Economics	Considering the pattern		
	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	496669	212767	294551
Expected outcome	Total productivity and economic return will be increased		
Recommendation	The legume-dominated rice-based cropping pattern, lentil-Blackgram-T. Aman rice is more productive and profitable. It could be suggested for large scale dissemination in medium high land of Pabna and similar agro-ecological regions of Bangladesh.		

3. INTERCROPPING OF GARLIC WITH SUGARCANE

Name of the organization	Bangladesh Agricultural Research Institute		
Contract division	CSO, On-Farm Research Division, BARI, Gazipur 1701		
Location of Application	Tangail and similar region of other AEZs 8 and 9		
Key characteristics of the technology	• Intercropping of garlic with sugarcane is more profitable compared to sole sugarcane cultivation • Most suitable combination is four rows of garlic (26%) in between two rows of sugarcane (100%) were identified. • Sugarcane equivalent yield was increased by about 57.45% from four rows of garlic (26%) in between two rows of sugarcane (100%) compared to sole sugarcane (100%) cultivation. • Cultivation of garlic with sugarcane gross margin increased by about 79% compared to sole sugarcane cultivation.		
Year of the experiment	2022-23 and 2023-24		
Production guideline			
Crop	Sugarcane (100%), garlic (26%)		
Spacing	Sugarcane (150 cm × 50 cm), garlic (10 cm × 10 cm)		
Sowing date	Sugarcane: Second week of October Garlic: Last week of November		
Harvesting date	Sugarcane: Second week of September to last week of October Garlic: Last week of March		
Fertilizer dose (N-P-K kg ha ⁻¹)	55-36-60-15-1-1 kg ha ⁻¹ for sugarcane and for intercrop was 11-7-12-3-0.5-0.5 kg ha ⁻¹ N-P-K-S-Zn-B, respectively		
Fertilizer application	The total amount of PKSZNb was applied in the pit of sugarcane as a basal dose. The urea (N) was divided into three parts and applied during 40-45, 55-60, and 70-75 days after the sugarcane transplanting in the pit. For intercropping all fertilizers except Urea were applied during final land preparation. For garlic Urea was applied 30 days after planting.		
Yield (t ha ⁻¹)	Sole Sugarcane = 115.33 and Sugarcane equivalent yield=181.59		
Risk involvement in adopting the technology	No risk involvement		
Impact on environment	No harmful effects on the environment		
Procedure of transfer	Block demonstration, farmers training, field day, booklet/ leaflet, radio talk, etc.		
Expected outcome	Higher yield, as well as an economic benefit can be achieved by cultivating four rows of garlic in between two rows of sugarcane		
Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Sole Sugarcane (100%)	922640	330850	591790
Sugarcane (100%) + Four rows of garlic (26%)	1422400	489578	932822
Recommendation	Garlic can be successfully intercropped with sugarcane without a significant reduction in the yield of sugarcane. Farmers can earn better economic benefits by following the cultivation of four rows of garlic in between two rows of sugarcane.		

4. DEVELOPMENT OF OILSEED BASED CROPPING PATTERN MUSTARD- BORO RICE-T. AUS RICE IN LESS FLOODED MEDIUM HIGHLAND OF MANIKGANJ

Name of the Organization	Bangladesh agricultural Research Institute (BARI)			
Contract Division	On-Farm Research Division, BARI, Manikganj and similar AEZs.			
Location of application	Pouli village, Sadar Manikganj			
Key characteristics of the technology	Seasonal flooding is a common phenomenon in low lying areas of Manikganj where Mustard-Boro rice-Fallow is the major cropping pattern. Farmers generally grow mustard for a short duration (Tori-7) and then Boro rice (BRRI dhan29) to avoid the adverse effect of flooding immediately after harvesting of Boro rice. Flood water entered the crop fields and inundated the low and medium lowlands. But due to changing climatic conditions, flood water did not enter the rice lands during T. Aus rice growing season in the last two years. So, there is a scope to grow T. Aus rice during that fallow period. Inclusion of T. Aus rice in the existing cropping pattern will increase cropping intensity, total productivity and farmers' income.			
Production guideline	Crop	Mustard	Boro rice	T. Aus rice
	Variety	BARI Sarisha-14	BRRI dhan-89	BRRI dhan-48
	Spacing (cm)	Broadcast	25 cm x 15 cm	25 cm x 15 cm
	Sowing/transplanting	4 Nov. to 7 Feb.	25 Feb. to 3 June	26 June to 23 Sep.
	Fertilizer rate (kg ha ⁻¹) N-P-K-S-Zn-B-Cowdung	115-34-42-24-1.79-1-5000	138-195-82.5-18-2.79-1.27-5000	61-10-41-9-0-0-5000
	Fertilizer application	Half of urea and all other fertilizers to be applied during final land preparation. Rest urea to be top dressed at 20-25 DAS.	One-third of urea and all other fertilizers to be applied during final land preparation. Rest urea to be top dressed at in two equal splits at 15-20 and 35-40 DAS.	One-third of urea and all other fertilizers to be applied during final land preparation. Rest urea to be top dressed at in two equal splits at 15-20 and 35-40 DAS.
	Harvesting time	2 nd week of February	2 nd week of June	Last week of Sep.
	Field duration (days)	90-94	92-96	85-88
	Rice equivalent yield (t ha ⁻¹)	3.98	8.20	4.74
	Yield (t ha ⁻¹)	1.5 to 1.8	7 to 7.5	4.5
	Risk involvement	There is a possibility of seasonal flooding during T. Aus season.		
	Expected outcome	From this technology, an additional T. Aus rice could be obtained during fallow period due to seasonal flooding. The yield of mustard and Boro rice will be increased by 20-30%. Rice equivalent yield could be increased by 79% and gross margin by 276% in newly developed cropping pattern over existing cropping pattern.		

	Socio economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
		553425	366355	187070
	Recommendation	This technology could be suggested for large scale extension in less flooded areas of Manikganj district with similar soils of AEZ-7, 8 and 12.		
Technology adaption	T. Aus rice could be grown in less flooded medium low lands of Manikganj with similar soils of other areas of Bangladesh.			

5. EARLY VARIETIES BARI ALU-79, 90, 77, AND 41 SUITABLE FOR CULTIVATION IN THE NORTHERN REGION OF THE COUNTRY

Technological characteristics	• Ensure planting of early-maturing Aman rice in the field. • Plant potato seeds by mid-October or earlier.				
Technology suitability	Suitable Regions: Rangpur and similar regions of Agro-Ecological Zone 3. Year of Innovation: From Rabi season 2021-22 to 2023-24.				
Technology usage informatio:	Name of		Crop Description		
	Crop		Potato		
	Varieties		BARI Alu-41, BARI Alu-77, BARI Alu-79, and BARI Alu-90		
	Planting distance		60 cm × 25 cm		
	Planting time		Mid-October or earlier		
	Fertilizer dosage (kg/hectare)				
	Urea		290		
	Tsp		150		
	Mop		220		
	Gypsum		110		
	Zinc sulfate		6		
	Boric acid		6		
	Cowdung		5000		
	Fertilizer application method		Apply half of the urea and all other fertilizers during final land preparation, and the remaining half of the urea as a top dressing 30-35 days after planting.		
	Harvest time		March 1-5		
	Field duration (days)		90-95		
	Yield (t ha ⁻¹)		Local: 29.17	Improved: BARI Alu-41: 30.12, BARI Alu-77: 34.28 BARI Alu-79: 41.50, BARI Alu-90: 39.69	
	Risk of technology adaptation		No risk		
	Technology dissemination methods		Block demonstration, farmer training, field days, booklets, and leaflets		
	Expectation		Increase in total production		
Overall economic condition of technology	Varieties	Total Income (Tk. ha ⁻¹)	Total Cost (Tk. ha ⁻¹)	Total Profit (Tk. ha ⁻¹)	
	BARI Alu-41	629979	165000	464979	
	BARI Alu -77	656564	165000	491564	
	BARI Alu -79	910404	165000	745404	
	BARI Alu -90	967968	165000	802968	
	Local	648660	165000	483660	

	Crop inter-cultural operations	After 30-35 days of planting, soil should be heaped around the base of the plants. Timely weeding is necessary for better growth and higher yields.
	Irrigation application	First irrigation: 20-25 days after planting. Second irrigation: 40-45 days after planting. Third irrigation: 60-65 days after planting. In drought-prone areas, irrigation should be applied every 8-10 days for better yields.
	Disease and pest control	Use disease-free seeds and treat seeds if possible. Apply fungicides and insecticides in a timely manner if diseases or pests are observed in the field.
	Harvesting	As an early variety, potatoes can be harvested 60 to 70 days after planting.
Yield/ output from technology	Produces 3-42% more yield compared to local potato varieties.	

6. DEVELOPMENT OF POTATO-GROUNDNUT-T. AMAN RICE CROPPING PATTERN AGAINST POTATO -GROUNDNUT

Features of the Technology	• In Char Ganai, Kaunia, Rangpur, the existing two-crop pattern of Potato (BARI Alu-8) and Groundnut (Local) with fallow land can be converted into a profitable Potato-Groundnut-Transplanted Aman cropping system. • After Potato and Groundnut, fallow land can be utilized to cultivate improved Aman rice (BRRI Dhan-71) as an additional crop, thereby increasing cropping intensity. • The yield of Transplanted Aman rice increased by 53% in the improved cropping system compared to the local system. • Income increased by 70% in the improved cropping system compared to the local one.			
Adaptability of the technology	Suitable Regions: Rangpur and similar areas in AEZ 3. Year of Development: 2020-23			
Technology Usage Information:	Crop	Potato	Groundnut	Aman Rice
	Variety	BARI Alu-25	BARI Chinabadam-9	BRRI Dhan-71
	Sowing/Planting Distance (cm ²)	50 x 10	20 x 15	20 x 15
	Sowing/Planting Time	7-13 November	7-28 January to 2 February	19 June-8 July
	- Urea	249.55	25	217
	- TSP	150	160	60
	- MOP	250	85	60
	- Gypsum	120	300	55
	- Zinc Sulfate	10	-	4
	- Boric Acid	10	10	0
	Fertilizer Application Method	Apply half of the urea and all other fertilizers during the final plowing, and the remaining urea as topdressing 35	Apply half of the urea and all other fertilizers during the final plowing, and the remaining urea as topdressing 40-45 days after	Apply all fertilizers except urea during the final plowing. Urea should be applied in three equal installments 15,

		days after planting.	emergence at flowering time.	30, and 45 days after planting as topdressing.
	Harvesting Time	21-28 January	1-26 June	21-24 September
	Field Duration (day)	70-88	116-121	94-97
	Interval Between Two Crops (day)	17	5	15
	Yield (t ha ⁻¹)	26	2.24	4.58
	Socioeconomic	- Total Income (Tk. ha ⁻¹)	Total Cost (Tk. ha ⁻¹)	Total Profit (Tk. ha ⁻¹)
		771,400	271,414	499,986
	Crop Care	Potato: Provide earthing 30-35 days after planting. Weed timely for better growth and yield.	Groundnut: Clean weeds 15-20 days after sowing. If the soil becomes hard, lift the soil at the base of the plant during flowering.	Aman Rice: Remove weeds by hoeing or hand weeding every 10/15 days after transplanting
	Irrigation:	Potato: Provide the first irrigation within 20-25 days of planting, the second within 40-45 days, and the third within 60-65 days. In drought-prone areas, irrigate every 8-10 days for better yield.	Groundnut: In the Kharif-1 season, 1 irrigation may be provided if needed. In char areas, irrigation is not necessary, but in the Rabi season, 1-2 irrigations may be required on higher lands where soil moisture dries quickly.	Aman Rice: Keep the field moist from transplanting to the booting stage. Increase water during the booting stage, and drain the field as the grains start hardening.
	Pest and Disease Management	Use disease-free seeds and, if possible, treat the seeds before sowing. Apply fungicides and insecticides promptly if pests or diseases are observed.	Even with all care, pests and diseases can reduce Groundnut yield. Follow Integrated Pest Management (IPM) practices.	For Aman rice, follow IPM practices as pests and diseases can significantly reduce yield.
	Harvesting	Potato: After 80-90 days of growth, perform haulm pulling to harden the skin of the potatoes, reducing virus spread during harvesting. Harvest 10-12 days after haulm pulling.	Groundnut: Harvest when the plants' leaves turn yellow and begin to shed. Check the color and veins of mature groundnuts before harvesting. Depending on the variety and	Aman Rice: Harvest when 80% of the grains in the panicle are hard and translucent. Quickly thresh the rice after harvesting without leaving it in the field.

			season, harvest within 120-150 days.	
Adaptation Risk of the Technology	No risk			
Environmental Impact	No harmful impact			
Dissemination Method	Block demonstrations, farmer training, field days, booklets, and leaflets, etc.			
Expectation	Increased total production and profit			
Outcome from Technology	The Potato-Groundnut-Transplanted Aman rice cropping sequence can be easily established. This sequence is more productive and profitable. Compared to the traditional cropping pattern, the Potato-Groundnut-Transplanted Aman rice system results in a 41% increase in yield.			

7. MUSTARD-SESAME-B. AMAN RICE: A PROFITABLE CROPPING SYSTEM IN COMILLA REGION

Name of organization	Bangladesh Agricultural Research Institute		
Contact division	On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Kushtia region with similar soil of AEZ-11		
Key characteristics of the technology	• By inclusion of (HYV) T. Aman, Mustard and Sesame to develop an economically viable cropping pattern. • Improved cropping pattern increased rice equivalent yield 24% over farmers existing pattern. • Improved pattern increased cropping intensity and higher economic return.		
Production guideline			
Crop	Mustard	Sesame	T. Aman
Variety	BARI Sarisha-14	BARI Til-5	BRRRI Dhan-51
Planting method	Broadcast/Line sowing/transplanting		
Spacing (cm)	Broadcast	Broadcast	20 cm × 15 cm
Sowing/Transplanting date	05-12 Nov, 2023	08-16 March, 2024	10-15 July, 2023
Fertilizer dose	115-34-42.5-27-2.7-1.7 Kg ha ⁻¹ of N-P-K-S-Zn-B	57.5-30-25-19.8-0-0 Kg ha ⁻¹ of N-P-K-S-Zn-B	76-23-30-10-1-0 Kg ha ⁻¹ of N-P-K-S-Zn-B
Fertilizer application	Half of N and all other nutrients should be applied as basal during final land preparation. Remaining half of N should be applied as top dress at 25-30 days after sowing.	Half of N and all other nutrients should be applied as basal during final land preparation. Remaining half of N should be applied as top dress at 25-30 days after sowing.	All other fertilizers are applied at the time of final land preparation. N are 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.
Harvesting time	01-08 February, 2024	06-15 June, 2024	20-25 October, 2023
Yield (t ha ⁻¹)	1.62	1.93	5.56
Rice equivalent yield (t ha ⁻¹)	15.13		
Risk involvement in adopting the technology	No risk involvement		

Impact on environment	No harmful effects on the environment.		
Procedure of transfer	Block demonstration, Farmers training, Field day etc.		
Expected outcome	Total productivity and profitability could be increased by including (HYV) T. Aman, Mustard and Sesame in the existing cropping pattern.		
Socioeconomic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Improved cropping pattern	487900	245750	291550
Existing cropping pattern	384750	215750	169000
Recommendation	This technology is agronomically feasible and economically profitable. This technology could be disseminated in the Mustard growing areas of Bangladesh.		

8. IMPROVEMENT FROM FALLOW-T. AUS-T. AMAN RICE TO MUSTARD-T. AUS-T. AMAN RICE UNDER AEZ 20 OF SYLHET

Name of the organization	Bangladesh Agricultural Research Institute (BARI)		
Contact division	On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Surma-Kashiyama flood plain under AEZ 20		
Key characteristics of the technology	➤ Improved pattern is profitable in respect of REY, gross margin and marginal benefit cost ratio. ➤ Improved cropping pattern increases rice equivalent yield by 45% over farmers existing pattern ➤ Improved pattern increases production efficiency and provides higher economic return		
Year of experiment	2021-22 and 2022-23		
Production guideline			
Crop	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan98	BRRI dhan75
Spacing (cm)	Broadcast	20 x 15	20 x 15
Sowing/transplanting date	Last week of November	3 rd week of April	1 st week of August
Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0
Fertilizer application method	In general, all of P,K,S and Zn fertilizers should be applied as basal during final land preparation. N should be applied in three equal splits, the first one as basal/immediately after establishment, the second one at early tillering stage and the third one at 5-7 days before panicle initiation stage.		
Date of harvesting	1 st week of February	Last week of July	First week of November
Yield (t ha ⁻¹)	1.37	4.51	5.35
Intercultural operation	Fertilization, Weeding and disease pest management done as and when necessary		
Field duration (days)	85	90	105
Risk involvement in adopting the technology	No risk involvement		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.		
Expected outcome	Economically viable cropping pattern will be developed		

Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	361560	197000	164560
Recommendation	Alternate cropping pattern (Mustard-T. Aus-T. Aman) can be disseminated to the farmers of northeast part of Country under AEZ-20		

9. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD- SESAME-T. AMAN RICE AGAINST MUSTARD-FALLOW-T. AMAN CROPPING PATTERN IN HOBIGANJ

Name of the organization	Bangladesh Agricultural Research Institute (BARI)		
Contact division	On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Surma-Kushiyara floodplain under AEZ 20		
Key characteristics of the technology	- Improved pattern is profitable in respect of REY, gross margin and marginal benefit cost ratio. - Improved pattern increases production efficiency and provides higher economic return - Improved cropping pattern increases rice equivalent yield by 45% over farmers existing pattern		
Year of experiment	2022-23 and 2023-2024		
Production guideline			
Crop	Mustard	Sesame	T. Aman
Variety	BARI Sarisha-18	BRRI Til-4	Binadhan-16
Spacing (cm)	Broadcast	Broadcast	20 x 15
Sowtransplanting date	2 nd week of November	Last week of March	1 st week of August
Fertilizer Dose (kg ha ⁻¹) N-P-K-S-Zn-B	90-27-40-10-2-1	25-8-10-5--	90-15-50-8-1-
Fertilizer application method	In general, all of P,K,S and Zn fertilizers should be applied as basal during final land preparation. N should be applied in three equal splits, the first one as basal /immediately after establishment, the second one at early tillering stage and the third one at 5-7 days before panicle initiation stage.		
Date of harvesting	1 st week of February	Last week of June	1 st week of november1 st week of November
Yield (t ha ⁻¹)	2.51	2.81	6.68
Intercultural operation	Fertilization, Weeding and disease pest management done as and when necessary		
Field duration (days)	86	102	92
Risk involvement	No risk involvement		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.		
Expected outcome	Economically viable cropping pattern will be developed		
Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	514280	187050	327230
Recommendation	Alternate cropping pattern (Mustard-Sesame-T. Aman) can be disseminated to the farmers of north east part of Country under AEZ-20		

10. EFFECT OF BORON ON THE GROWTH AND SEED YIELD OF SUNFLOWER IN ACIDIC SOIL OF SYLHET REGION

Name of the organization	Bangladesh Agricultural Research Institute (BARI)		
Contact division	On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Surma-Kushiyara flood plain under AEZ 20		
Key characteristics of the technology	➤ Find out the suitable dose of boron for sunflower cultivation in acidic soil. ➤ Improve soil health and nutrient availability ➤ Better growth and yield of sunflower		
Year of experiment	2022-23 and 2023-24		
Production guideline			
Crop	Sunflower		
Variety	BARI Surjomukhi-3		
Spacing	8 cm x 5 cm		
Sowing/transplanting date	3 rd week of November		
Fertilizer dose (kg ha ⁻¹) N-P-K-S-Zn-B	150-110-90		
Fertilizer application method	Half of N, K, S, Mg, Zn, B and Organic fertilizer should be applied as basal during final land preparation. Remaining half N should apply as top dress in two splits at 20-25 DAS and 40-45 DAS (before flower initiation stage) and mixed thoroughly with the soil as soon as possible for better utilization.		
Date of harvesting	Last week of February		
Yield (t ha ⁻¹)	1.67		
Intercultural operation	Fertilization, weeding, thinning, irrigation, spraying of insecticides and weedicides		
Field duration (day)	98		
Risk involvement in adopting the technology	No risk involvement		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, farmers training, booklet/leaflet, radio talk, etc.		
Expected outcome	Economically viable cropping pattern will be developed		
Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	110630	88200	22430
Recommendation	Ensure the fair price with purity to popularize the use of boron in crop production.		

11. EFFECT OF LIME ON THE GROWTH AND SEED YIELD OF SUNFLOWER IN ACIDIC SOIL OF SYLHET REGION

Name of the organization	Bangladesh Agricultural Research Institute (BARI)		
Contact division	On-Farm Research Division, BARI, Gazipur 1701		
Location of application	Surma-Kushiyara flood plain under AEZ 20		
Key characteristics of the technology	Find out the suitable lime dose for production of sunflower in acidic soil. Improve soil health and nutrient availability Enhance the growth and yield of sunflower		
Year of experiment	2022-23 and 2023-24		
Production guideline			
Crop	Sunflower		
Variety	BARI Surjomukhi-3		
Spacing	8 cm x 5 cm		
Sowing/transplanting date	Last week of November		
Fertilizer Dose (N-P=K-S-Zn-B kg ha ⁻¹)	150-110-90		
Fertilizer application method	Half of N, K, S, Mg, Zn, B and Organic fertilizer should be applied as basal during final land preparation. Remaining half N should be applied as top dress in two splits at 20-25 DAS and 40-45 DAS (before flower initiation stage) and mixed thoroughly with the soil as soon as possible for better utilization.		
Date of harvesting	Last week of February		
Yield (t ha ⁻¹)	1.75		
Intercultural operation	Fertilization, weeding, thinning, irrigation, spraying of insecticides and weedicides		
Field duration (days)	95		
Risk involvement in adopting the technology	No risk involvement		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, farmers training, booklet/leaflet, radio talk, etc.		
Expected outcome	Economically viable cropping pattern will be developed		
Socio-economic aspects	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	113750	107500	12200
Recommendation	High market price and unavailability of dolomite lime are the problems against utilization of lime for crop production		

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On-Farm Soil Fertility Management

12. INTEGRATED NUTRIENT MANAGEMENT OF ONION IN FARIDPUR

S. AHMED AND N. SULTANA

Abstract

A trial was conducted at the FSRD Site, Sholakundu, Faridpur during the rabi, 2023-24 to find out a suitable nutrient dose as well to increase sustainable yield and economic of onion under farmers' field condition. The experiment was laid out in randomized complete block design with six dispersed replications using cv. BARI Piaz-4 with the treatment of soil test based (STB) fertilizer dose: 85-25-45-15-0.15-0.5 kg NPKSZnB ha⁻¹, STB dose plus vermicompost 2 ton per hectare and Farmer's practice: 205-125-100-30-3-1-1.5 kg NPKSZnBMg ha⁻¹. On the basis of result, the application of vermicompost with soil test based fertilizer dose to the crop yield found to be good integrated nutrient management practice where it recorded highest bulb yield (21.65 t ha⁻¹). On the basis of gross margin (725400 Tk. ha⁻¹) and benefit cost ratio was 4.10 the T₂ was found to be profitable.

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 Piaz-4 in 2008. Farmers started to cultivate that variety as a high yielder (17-22 t ha⁻¹) than BARI Piaz-1 or Taherpuri (12-16 t ha⁻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, 2023-24 to find out a suitable nutrient dose on BARI Piaz-4 and to increase sustainable yield and cost and return. The Low Ganges River Flood Plain (AEZ-12) soils are medium high land and alkaline in nature (Table 1a). The experiment was laid out in a randomized complete block (RCB) design with six dispersed replications on BARI Piaz-4 in a 5m × 3m plot. The treatment combinations were T₁ (STB) fertilizer dose: 85-25-45-15-0.15-0.5 kg NPKSZnB ha⁻¹, T₂: STB dose plus vermicompost 2 ton per hectare and T₃ (Farmer's practice): 205-125-100-30-3-1-1.5 kg NPKSZnBMg ha⁻¹. The STB and vermicompost treated fertilizers were calculated on the basis of analytical value of soil and vermicompost (Table 1a and 1b). Forty five day's old seedlings were transplanted on 29 December, 2023 maintaining 15cm × 10cm spacing. Urea, TSP, MoP, Gypsum, zinc sulphate and boric acid were the source of N, P, K, S, Zn and B. Initially the soils were fertilized with entire vermicompost, P, S, Zn, B, and half of N and K. Remaining N and K were applied as top dressed in equal installment at 25-30 and 40-45 days after planting. Weeding was done thrice at 16-20, 36 and 40-57 DAP and was irrigated four times at pre planting, immediate after planting, 25 and 47 DAP. Imidacloprid (Imitaf 20 SL and Confidor 70 WG) four times at 13, 24, 38, 48 and 64 DAP and

Emamectin Benzoate (Guilder) two times at 62-72, 75-80 DAT were sprayed for controlling insects. For controlling fungus two times Iprodione (Rovral 50 WP) at 13, 38 DAP, two times Azoxystrobin (20%) + Difenoconazole (12.50%) group (Amistar Top) at 24,48 DAP, one time Fluopyrm (25%) +Trifloxystrobin (25%) group (Luna sendation 50 SC) at 64 DAT were applied. The crop was harvested on 26 March, 2024. Data on yield contributing characters and yield were collected at maturity stage. The collected data were analyzed through R software and the means were separated by DMRT.

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

Item	pH	OM (%)	Total N (%)	K (meq/100g soil)	P	S	Zn	B
Average	7.44	2.66	0.14	0.39	23.6	22.52	1.71	0.80
Interpretation	Slightly alkaline	Medium	Low	High	Optimum	Optimum	Low	Very high

Table 1b. Nutrient status of vermicompost

Item	N	P	K	S
Vermicompost	1.24	2.00	1.06	0.87

Results and Discussions

The results revealed that the single bulb weight and total yield significantly differed among the treatment (Table 2). However, the maximum weight of single bulb (31.12 g) was observed in the treatment which received vermicompost with soil test based fertilizer. The lowest weight of single bulb (28.87g) was noted in T₁ treatment. The highest bulb yield (21.65 t ha⁻¹) was obtained from STB plus vermicompost followed by farmers practice (20.94 t ha⁻¹) treatment. The lowest bulb yield (20.12 t ha⁻¹) was recorded from STB treated plot. The numerical tallest plant (38.8 cm) was recorded in farmers practice whereas plant population at harvest was highest (69.83) in soil test based treatment. The lowest plant height (36.83 cm) was recorded in Soil Test based treatment and lowest plant population (68.83cm) was recorded in STB + Vermicompost 2 t ha⁻¹.

Cost and return analysis: The maximum gross return (Tk. 974250 ha⁻¹) and gross margin (Tk. 725400 ha⁻¹) were obtained from vermicompost treated plot (Table 3). The highest benefit cost ratio (4.10) was calculated from the same followed by STB dose (3.97). The lowest BCR (3.75) was found in farmers practice might be due to higher variable cost.

Farmers' opinion: Farmers were happy and quite convinced to use optimum fertilizer with vermicompost in terms of yield and cost benefit ratio.

Conclusion

On the basis of one year result the treatment T₂ ie. Soil Test Based fertilizer dose with vermicompost (85-25-45-15-0.15-0.5 kg NPKSZnB ha⁻¹ + 2 t vermicompost ha⁻¹) shown maximum yield which was at par with farmers practice (205-125-100-30-3-1-1.5 kg NPKSZnBMg ha⁻¹). Treatment T₂ was found to be profitable as per the B:C ratio (4.10) was highest.

Table 2. Yield and yield attributes of onion as influenced by nutrient management at FSRD site, Faridpur during the 2023-24

Treatment	Plant height (cm)	Plant pop ⁿ m ⁻² (no)	Multiplier bulb (%)	Single bulb wt (g)	Bulb yield (t ha ⁻¹)
T ₁ : STB	36.83 a	69.83 a	1.06 b	28.87 b	20.12 b
T ₂ : STB + 2.0 t Vermicompost ha ⁻¹	37.33 a	68.83 a	0.96 b	31.12 a	21.65 a
T ₃ : Farmers' practice	38.8 a	69.5 a	1.54 a	30.12 a	20.94 ab
CV (%)	4.56	5.24	29.00	2.79	3.55

T₁ (STB following FRG, 2018): N₈₅ P₂₅ K₄₅ S₁₅ Zn_{0.15} B_{0.5} kg ha⁻¹, T₂: T₁ + Vermicompost 2 t ha⁻¹, T₃ (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 2023-24

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	20.12	905400	227582	683815	3.97
T ₂ : STB + 2.0 t Vermicompost ha ⁻¹	21.65	974250	237050	725400	4.10
T ₃ : Farmers' practice	20.94	942300	250969	691331	3.75

Price of input (Tk kg⁻¹): Urea: 27.00, TSP: 27.00, MoP: 20.00, Gypsum: 12.00, Zinc: 250.00, Boron: 320.00, Magnesium sulfate: 160, Vermicompost: 12, seed: 3000.00 Output price (Tk kg⁻¹): Onion bulb: 45.00

13. NUTRIENT MANAGEMENT OF OAT PRODUCTION IN FARIDPUR

S. AHMED AND N. SULTANA

Abstract

The fertilizer management on the yield of oat production were conducted at the FSRD Site, Sholakundu, Faridpur during the *rabi* 2022-23 & 2023-24. The experiment was designed in a randomized complete block design with four replications with cv. BARI Oat-1. The study was carried out with five treatments combinations ie. T₁ (Recommended dose of Barley): 80-30-30-10-3-1 kg NPKSZnB ha⁻¹, T₂:(FRG' 2018):50-7-15-0-1.25-0 kg NPKSZnB ha⁻¹, T₃:(T₂ + 25%):63-9-20-0-1.25-0 kg NPKSZnB ha⁻¹, T₄:(T₂ + 50%):75-11-23-0-1.25-1 kg NPKSZnB ha⁻¹ and T₅ (Farmer's practice): 90-25-25 kg NPK ha⁻¹. The fertilizers of different doses differed significantly. However, the highest filled grain (37.55), 1000 grain weight (23.28g) and grain yield (both yr av. 1.70 t ha⁻¹) were recorded when the soil received FRG recommended fertilizer with extra 25% of all element. The highest gross return, gross margin and best benefit cost ratio 149375 Tk. ha⁻¹, 71531 Tk. ha⁻¹ and 1.95, respectively were obtained from the same treatment.

Introduction

Oat (*Avena sativa*) is a whole-grain cereal. Oat is a very good source of fiber, especially beta glucan, and are high in vitamins, minerals, and antioxidants. Oats are rich in carbs and fiber, but also higher in protein and fat than most other grains. Due to its several benefits, such as lowering blood sugar and cholesterol levels, oats have gained considerable attention as a healthy food. Oat is becoming popular among the health concerned persons in Bangladesh. Bangladesh Agricultural Research Institute has released a variety, BARI Oat-1 which needed a balanced fertilizers doses to cultivate. However, the judicious fertilizer management on oat has not been reported yet. Thus, nutrient management practices applied for oat can contribute to sustainable growth, yield and quality and reduce environmental risks. Therefore, the present study was undertaken (i) to determine the suitable fertilizer dose on the yield of oat and (ii) to evaluate the efficacy of fertilizer on yield maximization.

Materials and Methods

The study was done on oat at the FSRD site, Sholakundu, Faridpur during Rabi 2022-23 and 2023-24 in clay loam medium high land soil in Low Ganges River Floodplain (AEZ-12). The initial soil analysis showed the nutrient status of soil (Table 1). The study was laid out in a randomized complete block design (RCB) with four compact replications on BARI Oat-1 in a 4m × 4m plot. The seeds were continuously sown in 25 cm plant to plant spacing on 4-12th December, 2022 and 2023. There were five treatment combinations T₁: (Recommended dose for Barley): 80-30-30-10-3-1 kg NPKSZnB ha⁻¹, T₂: (FRG' 2018) 50-7-15-0-1.25-0 kg NPKSZnB ha⁻¹, T₃:(T₂ + 25%):63-9-20-0-1.25-0 kg NPKSZnB ha⁻¹, T₄: (T₂ + 50%):75-11-23-0-1.25-1 kg NPKSZnB ha⁻¹ and T₅ (Farmer's practice): 90-25-25 kg NPK ha⁻¹. Urea, TSP, MoP, Gypsum, zinc sulphate and boric acid were the source of N, P, K, S, Zn and B. Initially the soil were fertilized with P, K, S, Zn, B, and half

of N. Remaining N was applied at 30 and 45 days after sowing. The crop management practices used for conducting research is shown in Table 2. Fertilizers were applied according to treatments. Data on yield and yield contributing characters were recorded and analyzed statistically with R software.

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

Item	Texture	pH	OM (%)	Total N (%)	Ca	K	S	Zn	P	B
					(meq/100 g soil)		ppm			
Interpretation	Clay loam	8.3	1.9	0.081	14.4	0.22	23.10	0.78	15.0	0.60
		S. alkaline	Medium	V. low	V. high	Medium	Optimum	Low	Low	Optimum

Table 2. Crop management practices of oat in Faridpur during Rabi 2022-23 & 2023-24 (av 2 years)

Date of seed sowing	Irrigation	Top dressing	Fungicide apply	Harvest
04-12 December 2023	Immediate and 22-27 DAS	22-27 DAS	28-34 DAS (Autostin)	06-30 April 2023 (113-116 DAS)

Results and Discussions

Table 3 shows statistical difference between the treatments which indicates the effect of different fertilizer doses. After two years it revealed that the highest plant population per meter⁻² (241.5) and plant height (153.71cm) were observed in the treatment T₅ i.e. when the soil receive more nitrogen (90 kg ha⁻¹). Nitrogen facilitates vegetative growth, so average two years plant population and height was maximum in T₅ treatment whilst least nitrogenous fertilizer (50 kg ha⁻¹) treated T₂ treatment showed the minimum density (224.1 m⁻²) and plant height (137.24 cm). The treatment T₃ shows maximum average two years grain filling (37.55) whereas T₂ and T₅ had minimum grain filling, 32.10 and 32.80, respectively. Here T₂ faced lack of optimum growth and T₅ had excess vegetative growth, both of which had hampered the reproductive efficiency of the plants. The T₃ treatment produced moderate sized spike (30.73 cm) and fully matured seed e.g. thousand seed weight 23.28 g. So, the highest filled grain spike⁻¹ (37.55), moderate spike length (30.73 cm) with heavy mature seed had produced the highest yield in T₃ (1.70 t ha⁻¹). The STB treated T₂ treatment had the least yield (1.45 t ha⁻¹) due to its minimum number of plant density (224.1 m⁻²) and height (137.24 cm) as well as shortest spike (28.80 cm) with minimum filled grain spike⁻¹ (32.10).

Cost and return analysis

The economic benefit was maximum in T₃ treatment with highest BCR (1.95) and maximum gross margin (Tk. 71531 ha⁻¹) and T₁ had the minimum (Tk. 49502 ha⁻¹). The treatment T₁ produced more yield than T₂, but higher fertilizer dose had make it costlier. So, T₁ had the minimum gross margin (Tk. 49502 ha⁻¹).

Farmers' opinion

Farmers realized to see the effect of several fertilizer doses and convinced to follow soil test based fertilizer with and extra 25% NPK. They also learnt about higher doses is as miss use of fertilizer and also economic losses.

Conclusion

On the basis of two consecutive year results the treatment T₃ i.e. T₂ + 25% NPK: 63-9-20-1.25 kg NPKZn ha⁻¹ gave the highest grain yield. It was about 8.24% higher over farmers practice (T₅). In terms of economy, T₃ also showed the highest BCR (1.95) and gross margin.

Table 3. Yield attributes and yield of oat as influenced by fertilizer management packages at FSRD site, Faridpur during the rabi season of 2023-24

Treatment	Final plant pop ⁿ m ⁻² (no.)	Plant height (cm)	Filled grain spike ⁻¹ (no.)	Spike length (cm)	1000 seed weight (g)	Yield (t ha ⁻¹)
T ₁	208.7 c	158.8 ab	36.9 b	34.65 b	22.85 a	1.58 b
T ₂	208.7 c	151.4 c	33.8 d	31.95 d	22.70 a	1.50 c
T ₃	219.3 b	157.4 abc	39.25 a	33.45 c	22.85 a	1.75 a
T ₄	215.7 bc	158.0 bc	35.8 bc	33.65 bc	22.85 a	1.57 b
T ₅	231.0 a	162.2 a	34.4 cd	36.05 a	22.40 b	1.61 b
CV (%)	12.61	2.75	3.19	2.01	0.50	2.56

T₁: (Recommended dose for Barley): 80-30-30-10-3-1 kg NPKSZnB ha⁻¹, T₂: (FRG' 2018) 50-7-15-0-1.25-0 kg NPKSZnB ha⁻¹, T₃:(T₂ + 25%):63-9-20-0-1.25-0 kg NPKSZnB ha⁻¹, T₄:(T₂ + 50%):75-11-23-0-1.25-1 kg NPKSZnB ha⁻¹ and T₅ (Farmer's practice): 90-25-25 kg NPK ha⁻¹

Table 3. Yield attributes and yield of oat as influenced by fertilizer management packages at FSRD site, Faridpur during rabi season 2022-23

Treatment	Final plant pop ⁿ m ⁻² (no.)	Plant height (cm)	Filled grain spike ⁻¹ (no.)	Spike length (cm)	1000 seed weight (g)	Yield (t ha ⁻¹)
T ₁	241.0 cd	138.87 b	33.18 b	30.32 a	23.25 ab	1.49 b
T ₂	239.5 d	123.07 e	30.40 d	25.65 d	23.45 a	1.40 c
T ₃	245.5 bc	129.97 d	35.85 a	28.00 c	23.70 a	1.65 a
T ₄	250.5 ab	133.52 c	32.50 bc	29.32 b	23.00 ab	1.57 ab
T ₅	252.0 a	145.22 a	31.20 cd	30.92 a	22.87 b	1.51 b
CV (%)	1.3	1.3	3.9	2.03	1.7	3.58

T₁: (Recommended dose for Barley): 80-30-30-10-3-1 kg NPKSZnB ha⁻¹, T₂: (FRG' 2018) 50-7-15-0-1.25-0 kg NPKSZnB ha⁻¹, T₃:(T₂ + 25%):63-9-20-0-1.25-0 kg NPKSZnB ha⁻¹, T₄:(T₂ + 50%):75-11-23-0-1.25-1 kg NPKSZnB ha⁻¹ and T₅ (Farmer's practice): 90-25-25 kg NPK ha⁻¹

Table 3. Average Yield attributes and yield of oat (av of 2 years) as influenced by fertilizer management packages at FSRD site, Faridpur

Treatment	Final plant pop ⁿ m ⁻² (no.)	Plant height (cm)	Filled grain spike ⁻¹ (no.)	Spike length (cm)	1000 seed weight (g)	Yield (t ha ⁻¹)
T ₁	224.8	148.84	35.04	32.49	23.05	1.54
T ₂	224.1	137.24	32.10	28.80	23.08	1.45
T ₃	232.4	143.69	37.55	30.73	23.28	1.70
T ₄	233.1	145.76	34.15	31.49	22.93	1.57
T ₅	241.5	153.71	32.80	33.49	22.64	1.56

Table 4. Cost and Return analysis of oat as influenced by fertilizer management packages at FSRD site, Faridpur during the rabi season of 2022-23 & 2023-24 (average 2 years)

Treatment	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	1.53	134875	85373	49502	1.60
T ₂	1.45	127500	77726	49774	1.67
T ₃	1.70	149375	77845	71531	1.95
T ₄	1.57	137375	78964	58411	1.78
T ₅	1.56	137125	80265	56860	1.73

Input price (Tk kg⁻¹): Urea- 27.00, TSP- 27.00, MoP-20.00, Gypsum- 12.00, Zinc- 250.00, Boron- 300.00. Crop cut and threshing- 80.00 tk decimal⁻¹. **Output price (Tk kg⁻¹):** Oat grain- 87.5.00

14. DEVELOPMENT OF FERTILIZER MANAGEMENT PACKAGE ON POTATO-GROUNDNUT-FALLOW CROPPING PATTERN IN NIKLI, KISHOREGANJ

M.MOHIUDDIN M.Y.H. RAYHAN AND N. SULTANA

Abstract

An experiment was executed at the MLT site Nikli during 2023-2024 to assess the fertilizer management package on Potato-Groundnut-Fallow cropping pattern in Nikli, Kishoreganj. Four different fertilizers were taken as treatments T₁: 1.0 t Lime ha⁻¹ with Soil test based fertilizer dose (Potato:282-58-110-26-10-5, Groundnut:75-58-37-63-5-4 kg NPKSZnB ha⁻¹), T₂: 1.0 t Lime ha⁻¹ with 120% STB (Potato:338-70-132-31-12-6, Groundnut:90-70-44-76-6-5 kg NPKSZnB ha⁻¹), T₃: 1.0 t Lime ha⁻¹ with 80% STB (Potato:226-46-88-21-8-4, Groundnut:60-46-30-50-4-3 kg NPKSZnB ha⁻¹), T₄: Farmers practice (No lime with Potato:345-148-198, Groundnut:120-140-100 kg NPK ha⁻¹). The highest gross return (Tk.722400 ha⁻¹), gross margin (Tk.461948 ha⁻¹) and BCR (2.77) was calculated from T₂:Lime (1.0 t ha⁻¹) with 120% Soil test based recommended fertilizer dose (Potato:338-70-132-31-12-6, Groundnut:90-70-44-76-6-5 kg NPKSZnB ha⁻¹) the lowest gross return (Tk. 568900 ha⁻¹), gross margin (Tk. 329548 ha⁻¹) and BCR (2.37) were from treatment T₃:(Lime (1.0 t ha⁻¹) with 80% Soil test based recommended fertilizer dose).

Introduction

Bangladesh is one of the most densely populated country of the world with population growth rate of 1.579%. The present cropping intensity of the country is 194%. Food requirement is estimated to be doubled in the next 25 years. Under such situations, it is very important to increase cropping intensity and productivity. 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. The land topography and soil characteristics of Haor is different than plain land. The haor area of Kishoreganj belongs to low pH. Soil pH of Nikli is found 4.5 to 5.3 that's why SRDI, Kishoreganj recommended to apply 400kg Dolomite lime per acre during land preparation to increase soil pH for suitable crop cultivation. Considering the above issues, the present study was therefore undertaken to correct the acid soil and to develop a suitable fertilizer dose for the cropping pattern in haor region.

Materials and Methods

A series of field experiments were conducted at the MLT site Nikli, Kishoreganj during 2023-24 to develop suitable fertilizer management package for potato-groundnut-fallow cropping pattern. The experimental plot was strongly acidic and contained very low amount of nutrient element (Table 1). The experiment was conducted in a randomized complete block design with three replication in 6m × 5m plot. Groundnut cv. BARI Chinabadam-9 and potato variety romana were used as planting material in this experiment. Four treatments were T₁: 1.0 t Lime ha⁻¹ with Soil test based fertilizer dose (Potato:282-58-110-26-10-5, Groundnut:75-58-37-63-5-4 kg NPKSZnB ha⁻¹), T₂: 1.0 t Lime ha⁻¹ with 120% STB (Potato:338-70-132-31-12-6, Groundnut:90-70-44-76-6-5 kg NPKSZnB ha⁻¹), T₃: 1.0 t Lime ha⁻¹ with 80% STB (Potato:226-46-88-21-8-4, Groundnut:60-46-30-50-4-3 kg NPKSZnB ha⁻¹), T₄: Farmers practice (No lime with Potato:345-148-198, Groundnut:120-140-100 kg NPK ha⁻¹). All agronomic activities including sowing and harvesting dates, seed rate, plant spacing are mentioned in Table 2. Irrigation, pest managements and other intercultural operations were done as and when necessary. The economic indices like gross return, gross margin were also calculated on the basis of prevailing market price of the inputs and outputs. Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken in plot wise and analyzed statistically.

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

Item	pH	OM (%)	Total N (%)	K (meq 100 g ⁻¹ soil)	P (ppm)	S (ppm)
Value	5.3	0.48	0.02	0.13	50	4.1
Interpretation	Strongly acidic	Very low	Very low	Medium	Very high	Very low

Table 2. Management practices of cropping pattern at Kishoreganj during 2023-2024

Parameters	Two crops based cropping pattern		
Crop	Potato	Groundnut	Fallow
Variety	Romana	BARI Chinabadam-9	-
Date of sowing/ transplanting	24-11-2023	25-01-24	
Seed rate (kg ha ⁻¹)	2000	102	
Spacing	60cm × 25cm	30cm × 15cm	
Date of harvesting	23-01-2024	09-05-23	
Field duration (days)	62	105	

Results and Discussions

The experiment indicated the treatment T₁, lime (1.0 t ha⁻¹) with soil test based recommended fertilizer dose (Potato:282-58-110-26-10-5, Groundnut:75-58-37-63-5-4 (NPKSZnB kg ha⁻¹) was found to be significantly effective by recording the maximum number of plant population m⁻² for both potato (21.0) and groundnut (31.0) with minimum number of disease infection 8% and 13% respectively. But treatment T₂ i.e. (lime 1.0 t ha⁻¹) with 120% STB fertilizer dose (Potato: 338-70-132-31-12-6, Groundnut: 90-70-44-76-6-5 (NPKSZnB kg ha⁻¹) showed highest yield for both potato (14.73 t ha⁻¹) and groundnut (2.55 t ha⁻¹).

Cost and return analysis: The highest gross return (Tk. 722400 ha⁻¹), gross margin (Tk. 461948 ha⁻¹) and BCR (2.77) was calculated from treatment T₂ and the lowest gross return (Tk. 568900 ha⁻¹), gross margin (Tk. 329548 ha⁻¹) and BCR (2.37) were from treatment T₃ (Lime (1.0 t ha⁻¹) with 80% STB fertilizer dose).

Farmers' opinion: Farmers were pleased to observe the performance of treatment lime (1.0 t ha⁻¹) with 120% soil test based recommended fertilizer dose (Potato:338-70-132-31-12-6, Groundnut:90-70-44-76-6-5 (NPKSZnB kg ha⁻¹). They are interested to apply lime in their field and test their soil sample before cultivation of any crops.

Table 3. Effect of fertilizer packages on yield and yield contributing characters on potato at Nikli, Kishoreganj during 2023-2024

Treatment	Plant pop ⁿ m ⁻² (no)	Potato m ⁻² (no)	Weight of potato m ⁻² (g)	% Scab infection	Yield (t ha ⁻¹)
T ₁	21	144	1331	8	13.31
T ₂	21	142	1473	12	14.73
T ₃	18	118	1031	15	10.31
T ₄	17	112	1193	21	11.93

T₁: 1.0 t Lime ha⁻¹ with Soil test based fertilizer dose (Potato:282-58-110-26-10-5, Groundnut:75-58-37-63-5-4 kg NPKSZnB ha⁻¹), T₂: 1.0 t Lime ha⁻¹ with 120% STB (Potato:338-70-132-31-12-6, Groundnut:90-70-44-76-6-5 kg NPKSZnB ha⁻¹), T₃: 1.0 t Lime ha⁻¹ with 80% STB (Potato:226-46-88-21-8-4, Groundnut:60-46-30-50-4-3 kg NPKSZnB ha⁻¹), T₄: Farmers practice (No lime with Potato:345-148-198, Groundnut:120-140-100 kg NPK ha⁻¹)

Table 4. Effect of fertilizer packages on yield and yield contributing characters on groundnut at Nikli, Kishoreganj during 2023-2024

Treatment	Germination (%)	Plant m ⁻² (no)	Mature nut m ⁻² (no)	Disease infection (%)	Yield (t ha ⁻¹)
T ₁	89	31	327	13	2.41
T ₂	91	29	334	23	2.55
T ₃	85	28	313	17	2.36
T ₄	79	26	285	29	2.27

Table 5. Cost and return analysis of potato and groundnut at Nikli, Kishoreganj during 2023-24

Treatment	Potato yield (tha ⁻¹)	Groundnut yield (t ha ⁻¹)	Potato equivalent yield over groundnut (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	13.31	2.41	8.84	664400	249902	414498	2.66
T ₂	14.73	2.55	9.35	722400	260452	461948	2.77
T ₃	10.31	2.36	8.65	568900	239352	329548	2.37
T ₄	11.93	2.27	8.32	607600	251025	356575	2.42

T₁: Lime (1.0 t ha⁻¹) with Soil test based fertilizer dose, T₂: Lime (1.0 t ha⁻¹) with 120% STB, T₃: Lime (1.0 t ha⁻¹) with 80% STB, T₄: Farmers practice; Price of groundnut = 110 Tk kg⁻¹, Price of potato = 30 Tk kg⁻¹.

Conclusion

The climatic and soil condition of this haor land was congenial to potato and groundnut cultivation but now a days reduction of soil pH is a core problem in this area. We found a better result from T₂ i.e 1.0 ton Lime ha⁻¹ plus 338-70-132-31-12-6 kg NPKSZnB ha⁻¹ for Potato and 90-70-44-76-6-5 kg NPKSZnB ha⁻¹ is the best fertilizer dose for Potato-Groundnut-Fallow cropping pattern in acidic soils in haor region in Kishoreganj.

15. EFFECT OF RHIZOBIUM INOCULUM ON THE YIELD OF BARI MOTORSHUTI-3 IN THE FARMERS FIELD

S. SULTANA, M.M. ZAMAN AND N. SULTANA

Abstract

An experiment was conducted in the farmers' field of Muktagacha upazila under Mymensingh district with the close supervision of On Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh, during winter 2023-2024 to observe the effect of rhizobium on the yield of BARI Motorshuti-3. The experiment was conducted in Randomized Complete Block design with three replications and three treatments: Rhizobium inoculum plus recommended P and K (24 and 30 kg ha⁻¹, respectively), Rhizobium inoculum and rec. P and K i.e. 24 and 30 kg ha⁻¹, respectively with vermicompost (5 t ha⁻¹) and Uninoculated (Rec. 48-24-30 kg NPK ha⁻¹). The combined application of vermicompost, rhizobium and recommended chemical fertilizers gave the highest pod yield of 9.22 t ha⁻¹ followed by application of rhizobium with recommended chemical fertilizers (7.51 t ha⁻¹) and the lowest pod yield (5.33 t ha⁻¹) was recorded from uninoculated treatment. The maximum gross return (Tk. 691500 ha⁻¹) was recorded from rhizobium + vermicompost + recommended chemical fertilizers.

Introduction

Garden pea (*Pisum sativum* L.) is a popular vegetable crop in the world, which is rich in protein, carbohydrate, and vitamin A and C. In Bangladesh, it is grown in winter season for using fresh pods, edible green seeds, and is also used as dry seed. 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 helps in improvement of soil fertility by nitrogen fixation. The soils of Muktagacha region of Mymensingh district are very suitable for garden pea production and farmers of the region do not follow the balanced fertilizers and used to cultivate the locally available variety. However, using rhizobium inoculum and vermicompost instead of urea fertilizer can improve the soil health as well as the yield. Therefore, this study was undertaken to find out i. a suitable fertilizer package and ii. to study the effects of rhizobium on garden pea.

Materials and Methods

The trial of garden pea was conducted at Muktagacha MLT site under Mymensingh district during Rabi 2023-2024. The seeds of BARI Motorshuti-3 was sown on 22 November, 2023 maintaining

the spacing 30cm × 15cm in a plot of 7.5m × 6.0m. The crop was fertilized according to the treatment combinations: T₁: Rhizobium inoculum (BARI RPS-501, 1.5 kg ha⁻¹) + recommended 24 and 30 kg P & K ha⁻¹, T₂: Rhizobium inoculum (1.5 kg ha⁻¹) and vermicompost (5 t ha⁻¹) + Rec. 24 and 30 kg P & K ha⁻¹, T₃: Uninoculated (Rec. 48-24-30 kg ha⁻¹ NPK). Rhizobium inoculum was added to the seeds and dried under the shade before sowing. Urea, triple super phosphate and muriate of potash were used as the source of NPK where entire vermicompost, triple super phosphate, muriate of potash and one third of urea were applied in the soil during final land preparation. Remaining urea was splitted and top dressed at 20 and 35 days after sowing. Other intercultural operations and plant protection measures were taken as and when necessary. The crop harvesting was started on 14 January, 2024 and ending on 13 February, 2024. There was no notable insect pest incidence was observed in BARI Motorshuti-3 experimental field. Data on yield and yield contributing characters were recorded and statistically analyzed following Statistix10 computer program.

Results and Discussions

Yield and yield contributing characters of BARI Motorshuti-3 under the treatment combinations has been presented in Table 1. The highest plant height (45.9 cm), branch per plant (4.0), average pods per plant (8.4) were recorded from rhizobium + vermicompost + recommended P and K treated treatment followed by rhizobium with recommended P and K. In case of seeds per pod (3-7) were found similar in all three treatments. According to the root and shoot analysis, root length (7.3 cm), root and shoot dry weight (0.29 g and 7.8 g, respectively) were found to be highest from rhizobium + vermicompost + recommended P and K treatment combinations. The root nodules seemed very small while it found from tap root and lateral roots that could not be separated. Thus, root and nodule weight were measured together. However, total number of nodules were counted highest from rhizobium + vermicompost + P and K treated treatment and it was 22, while the lowest nodule number (4.0) was recorded from uninoculated chemical fertilizer treated treatment. Green pod weight per m² was measured around 870 g. The highest green pod yield (9.22 t ha⁻¹) was calculated from rhizobium + vermicompost treatment followed by sole rhizobium (without vermicompost) application (7.51 t ha⁻¹).

Cost and return analysis: From the Table 2, it revealed that by cultivation of BARI Motorshuti-3 with rhizobium inoculum and vermicompost, the maximum gross return was calculated as Tk. 691500 ha⁻¹ whereas from uninoculated treatment the farmer could earn only Tk. 399825 ha⁻¹.

Farmer's opinion: Farmers' are interested in cultivating BARI Motorshuti-3 in using vermicompost with rhizobium due to having the short duration, large pod and higher market price.

Conclusion

The performance of rhizobium with vermicompost on BARI Motorshuti-3 is promising on the basis of yield and other characters especially its duration in the selected cultivation area. For large scale production and popularization of BARI Motorshuti-3 along with soil quality improvement rhizobium and/or vermicompost is a better option.

Table 1. Effect of rhizobium on the yield and yield attributes of BARI Motorshuti-3 at Muktagacha, Mymensingh during 2023-24

Treatment	Plant height (cm)	Branch plant ⁻¹ (no)	Pod plant ⁻¹ (no)	Root length (cm)	Root dry wt (g)	Shoot dry wt (g)	Nodule plant ⁻¹ (no)	Yield (t ha ⁻¹)
T ₁	45.7	2.7	6.1	7.2	0.19	5.20	19.70	7.51
T ₂	45.9	4.0	8.4	7.3	0.29	7.80	22.00	9.22
T ₃	40.3	2.4	4.4	6.3	0.23	4.70	4.00	5.33
CV (%)	6.49	12.77	15.24	13.9	19.17	10.24	14.61	4.82
LSD (0.05)	6.45	0.88	2.17	2.18	0.10	1.37	5.04	0.80

T₁: Rhizobium inoculum (BARI RPS-501, 1.5 kg ha⁻¹) + recommended 24 and 30 kg P & K ha⁻¹, T₂: Rhizobium inoculum (1.5 kg ha⁻¹) and vermicompost (5 t ha⁻¹) + Rec. 24 and 30 kg P & K ha⁻¹, T₃: Un-inoculated (Rec. 48-24-30 kg ha⁻¹ NPK)

Table 2. Cost and return analysis of BARI Motorshuti-3 at Muktagacha, Mymensingh, 2023-24

Treatment	Yield (kg ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	7516	563700	56700	507000
T ₂	9220	691500	96700	594800
T ₃	5331	399825	59345	340480

T₁: Rhizobium inoculum (BARI RPS-501, 1.5 kg ha⁻¹) + recommended 24 and 30 kg P & K ha⁻¹, T₂: Rhizobium inoculum (1.5 kg ha⁻¹) and vermicompost (5 t ha⁻¹) + Rec. 24 and 30 kg P & K ha⁻¹, T₃: Un inoculated (Rec. 48-24-30 kg ha⁻¹ NPK)

Price of input and output (Tk kg⁻¹): Urea 17.00 ,TSP 24.00, MoP 16.00, Gypsum 10.00, Zinc sulphate 130.00, Boric acid 300.00, Cowdung 1.00, Vermicompost 20.00, Selling price of motorshuti (Tk kg⁻¹): 75.00

16. DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR POTATO PRODUCTION

N. SULTANA AND M.M. ZAMAN

Abstract

A fertilizer trial on potato was conducted at Mymensingh region under close supervision of On Farm Research Division of Bangladesh Agricultural Research Institute, Mymensingh during robi season in the year 2023-2024 to evaluate the performance of different fertilizers dose and to develop a fertilizer recommendation for potato production in farmers' field. The trial was consisted of six fertilizer doses viz. T₁: Farmers practice (P from DAP and N from Urea), T₂: Farmers practice (P from DAP and N from Urea and rest N from DAP), T₃: Farmers practice (P from TSP and N from Urea), T₄: Upper limit of low fertility level, FRG' 2018, T₅: P from DAP and rest N from Urea and T₆: Control. The yield performance of those treatment on potato appeared to be promising. It was found that maximum number of tubers (12.8) plant⁻¹ and weight of tuber per plant (632.0 g) was recorded in plot, which received fertilizer through T₅ i.e. proposed fertilizer dose. In case of T₄ i.e. the FRG recommended fertilizer dose recorded highest yield of potato (28.92 t ha⁻¹) which was statistically at par with T₁, T₂, T₃ and T₅. From the study the highest gross return (Tk. 867630 ha⁻¹) and gross margin (Tk. 651830 ha⁻¹) were estimated from the treatment T₄. The lowest gross return (Tk. 477900 ha⁻¹) and gross margin (Tk. 273949 ha⁻¹) were recorded from T₆ when lowest amount of fertilizers were applied. The result led to conclusion that the most effective and economic fertilizer application in potato is FRG' 2018 recommendation dose and it is 135-30-135-15-10-4-1.6 kg NPKSMgZnB ha⁻¹ along with 5 ton cowdung ha⁻¹ fertilizer are the promising level for excellent results in potato crop under plain land conditions at Gouripur, Mymensingh.

Introduction

Potato (*Solanum tuberosum* L.) is the most popular vegetable fourth largest food crop in the world and plays an irreplaceable role in ensuring food security (Zhau *et al.* 2021). Potato rich in carbohydrate, protein, dietary fiber, vitamins minerals amino acids etc. which made potato the most popular vegetables in the world, In Asia, Bangladesh is the fourth largest potato producing country. Research on nutrient management around the world as well in Bangladesh shows that the amount of fertilizer applied is higher than the amount of nutrients absorbed by the crop, and there is a lower rate of fertilizer utilization. The majority of potato growers depend on P in the form of diammonium phosphate (DAP) and N in the form of urea (Ehio SIS, 2014). Moreover, K has a crucial role in the higher productivity of potato tubers because it plays an important role in photosynthesis, regulation of opening and closing of stomata, and favoring high energy status, which helps in timely and appropriate nutrient translocation and water uptake in plants (Parvez *et al.*, 2013). The use of organic fertilizers is increasing world-wide and a careful combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with excellent soil health (Fahad *et al.*, 2022). While fertilization plays an important role in ensuring food security, over-fertilization will reduce crop yields, accelerate soil acidification, increase greenhouse gas emissions, and ultimately reduce economic income (Li *et al.*, 2015). In order to

give farmers scientific fertilization recommendations, it is necessary to find out the fertilization habits and yield status of farmers. In Gouripur region of Mymensingh district the similar scenario of fertilizer application to be used by farmers like huge amount of fertilizers which are not completely uptake by the plants and a residual fertilizers are remained in the soils which is loss of fertilizers and economy as well harmful to the soil health has come out during survey. Basically this is the common situation all over the country which is needed to know. From the above facts the main objectives of this study were to (i) investigate the amount of NPK fertilizer per ton of potato; (ii) clarify the fertilization methods of farmers, their potato yields, and the relationship between yield and fertilization; and (iii) identify the reasonable fertilization of NPK.

Materials and Methods

The experiment was conducted at Gouripur upazila of Mymensingh district during the cropping season 2023-2024 under farmer's field condition. Before initiated the experiment a survey work was done to fix up the treatment combinations. The survey was conducted in Gouripur upazila which was located in between 24°38' and 24°50' north latitudes and in between 90°27' and 90°44' east longitudes. The potatoes were primarily planted by individual farmers, and a few are managed by cooperatives on a large scale. Six fertilizers doses were applied on BARI Alu-62 in the farmers' field likely to feasibility of fertilizers used in the farmers' field. The six treatments were approaches as T₁: Farmers' practice (when P were calculated from DAP and N from Urea), T₂: Farmers practice (when P were calculated from DAP and N from Urea and rest N from DAP), T₃: Farmers practice (when P were calculated from TSP and N from Urea), T₄: Upper limit of low fertility level of fertilizers (FRG' 2018), T₅: P from DAP and rest N from Urea and T₆: Control. However, the calculated fertilizers were as follows (Table 1). The experiment was evaluated in randomized complete block design with six replications. In a 42m² (7m × 6m) plot, the potato tuber was planted on 26th November, 2023 maintaining the spacing 60cm × 25cm. Manures and fertilizers were applied in treatment wise as per calculation in the form of urea, triple super phosphate, Di ammonium phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Entire CD, TSP, DAP, MoP, gypsum, zinc sulphate, boric acid and half of urea were applied as basal during final land preparation. The rest 50% urea was top dressed at 40 days after planting. Ear thing up and weeding were done after one month of planting. Irrigations were done two to three times or as per needed. The crop was harvested on 16th February, 2024. Data on yield and yield contributing characters were recorded and analyzed statistically following STAR program.

Table 1. Fertilizers doses applied in the potato field

Treat	Approach	N	P	K	S	Mg	Zn	B	CD
		(kg ha ⁻¹)							(t ha ⁻¹)
T ₁	Group1: Farmers practice (P: DAP, N: Urea)	74	167	111	22	1	3	1.5	10
T ₂	Group2: Farmers practice (P: DAP, N: Urea & DAP)	141	167	111	22	1	3	1.5	10
T ₃	Group3: Farmers practice (P: TSP, N: Urea)	74	32	111	22	1	3	1.5	10
T ₄	Upper limit of low fertility level (FRG' 2018)	135	30	135	15	10	4	1.6	5
T ₅	P: DAP, N: Urea (proposed)	150	45	135	15	10	4	1.6	5
T ₆	Control	0	0	135	15	10	4	1.6	5

Results and Discussions

Response of potato to diammonium phosphate and triple super phosphate was significantly differed (Table 2). Although, plant height, stem per hill and tuber per plant did not differ significantly. However, numerically tallest plant was observed in T₂ treatment which was 65.13cm while shortest plant was seen in T₆ treatment (53.67 cm). The highest number of stem plant⁻¹ (4.3) which was observed in the treatment (T₃ and T₅) with DAP treated treatment followed by the treatment with FRG treated plot (T₄) and the least one was in no urea and no TSP treatment (T₁). There was no significant variation in number of tuber plant⁻¹ among. Numerically maximum number of tuber was observed in T₅ treatment (12.8) followed by T₂ treatment (11.3) the minimum was obtained from T₆ treatment (8.47). Treatment T₅ produced the highest tuber

weight per plant (632.0) which was statistically identical to that of the treatment T₁, T₂, T₃ and T₄ (476.67, 531.67, 478.0 and 529.0) followed by the treatment T₂ (531.67). Although all yield contributing characters did not varied significantly their cumulative effect resulted a substantial variation in tuber yield. However, the maximum tuber yield (28.92 t ha⁻¹) was obtained from the treatment with FRG (T₄) which was at par with that of the treatment T₁, T₂, T₃ and T₅ (26.92, 27.03, 27.84, 27.95 t ha⁻¹). The lowest tuber yield was obtained from least treatment T₆ (15.93 t ha⁻¹).

Cost and return analysis: The cost and return of potato vary due to yield potentiality and total variable cost. It has been observed that the highest gross return (Tk. 867630 ha⁻¹) as well as gross margin (Tk. 651830 ha⁻¹) were obtained from the treatment T₄ (Table 3) which was followed by the Treatment T₅ whose gross return (Tk. 838800 ha⁻¹) and gross margin (Tk. 623638 ha⁻¹) were calculated as well whilst lowest gross return (Tk. 477900 ha⁻¹) and gross margin (Tk. 273949 ha⁻¹) were observed in T₆ treatment.

Farmers' opinion: Basically farmers realized that farmers practice with DAP or TSP fertilizers did not effect on yield rather its one kind of fertilizer loss in potato cultivation. Preferably farmers concern about the FRG recommended fertilizer as those are not much more fertilizers they used. Furthermore, farmers are convinced from the message from dealer or supplier of various kind of fertilizers or Pesticides Company, in this context it is needed to motivate the farmer to use judicial amount of fertilizers for potato cultivation.

Table 2. Yield and yield contributing characters of potato as influenced by fertilizers packages at Mymensingh during 2023-2024

Treatment	Days to emergenc	Plant height (cm)	Stem hill ⁻¹ (no)	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)
T ₁	17.3	61.00	3.9	9.8	474.67ab	26.92a
T ₂	17.0	65.13	4.0	11.3	531.67a	27.03a
T ₃	17.3	58.33	4.3	10.1	478.0ab	27.84a
T ₄	16.7	57.53	4.1	9.93	529.00ab	28.92a
T ₅	16.7	63.60	4.3	12.8	632.0a	27.95a
T ₆	18.0	53.67	3.2	8.47	368.00	15.93b
CV (%)	-	10.34	9.89	11.51	11.33	5.48

T₁: Farmers practice (P from DAP and N from Urea), T₂: Farmers practice (P from DAP and N from Urea and rest N from DAP), T₃: Farmers practice (P from TSP and N from Urea), T₄: Upper limit of low fertility level, FRG' 2018, T₅: P from DAP and rest N from Urea and T₆: Control

Table 3. Cost and return analysis of potato under different fertilizers management at farmers' field of Mymensingh during 2023-2024

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	807600	222554	585046
T ₂	811200	225732	585468
T ₃	834900	211044	623856
T ₄	867630	215800	651830
T ₅	838800	215162	623638
T ₆	477900	203951	273949

T₁: Farmers practice (P from DAP and N from Urea), T₂: Farmers practice (P from DAP and N from Urea and rest N from DAP), T₃: Farmers practice (P from TSP and N from Urea), T₄: Upper limit of low fertility level, FRG' 2018, T₅: P from DAP and rest N from Urea and T₆: Control; Price of input and output (Tk kg⁻¹): Urea 17.00, TSP 24.00, MoP 16.00, Gypsum 10.00, Zinc sulphate 130.00, Boric acid 300.00, Cowdung 1.00, selling price of potato (Tk kg⁻¹): 30.00

Conclusion

Appropriate amount of fertilizers reduces fertilizer requirement and increased farmers' income. On the basis of one year result, FRG' 2018 recommended rate of fertilizer (T₄) i.e. 135-30-135-15-10-4-1.6 kg NPKSMgZnB ha⁻¹ along with 5 ton cowdung ha⁻¹ shown maximum result. The analysis of the level of yield and fertilization status of farmers indicated that farmers should reduce their applications of N and P fertilizers through diammonium phosphate. All the farmers should increase the amount of K fertilizers applied regardless of the yield of potatoes.

17. EFFECT OF POTASSIUM ON YIELD OF MUKHIKACHU

N. SULTANA AND M.M. ZAMAN

Abstract

Potassium is the most abundant element next to Nitrogen and phosphorus which is largely required by the plants. Potassium as fertilizer is seen to increase yield and productivity in protein and starch rich grain. Thus, a trial of response of mukhikachu to K fertilizer was conducted to evaluate the performance of different level of K fertilizers dose and to develop a judicious fertilizer recommendation for mukhikachu cultivation. The trial was consisted of five level of K in combination with recommended fertilizer doses viz. T₁: Recommended fertilizer dose (161-40-23-6-2 kg NPSZnB ha⁻¹ with 0.0 kg ha⁻¹ K of potassium, T₂: RFD + 50 kg K ha⁻¹, T₃: RFD + 100 kg K ha⁻¹, T₄: RFD + 150 kg K ha⁻¹ and T₅: Farmers practice (9-35-20-4 kg NPKS ha⁻¹ (P as a source of DAP where N=14 kg ha⁻¹). The trial was conducted on cv. BARI Mukhikachu-2 in a randomized complete block design at Fulbaria upazila, Mymensingh. The yield performance of those treatment on mukhikachu appeared to be promising. However, significantly the highest number of corm (25.70) and corm weight (498.0 g) as thus of yield (38.16 t ha⁻¹) were obtained from the treatment T₃ where 100 kg K with recommended fertilizers dose which was followed by T₂ (corm plant⁻¹ 24.90 and yield 31.74 t ha⁻¹) when it received recommended fertilizer dose plus 50 kg K ha⁻¹. From the study the highest gross return (Tk. 2289600 ha⁻¹) and gross margin (Tk. 2096600 ha⁻¹) were estimated from the same treatment T₃. The lowest gross return (Tk. 1524000 ha⁻¹) and gross margin (Tk. 1349103 ha⁻¹) were recorded from T₅ where lowest amount of fertilizers were applied. The result principally concluded that potassium fertilizer is most effective and economical method of fertilizer application in mukhikachu and 161-100-40-23-6-2 kg NPKSZnB ha⁻¹ fertilizer are the promising level of K for excellent result in mukhikachu cultivation at Fulbaria, Mymensingh region.

Introduction

Taro (*Colocasia esculenta* L.) is one of the major staple root crops in different countries of the world. It is an important edible aroids well-known mukhikachu in Bangladesh belonging to the family Araceae. It is a survival food crop rich source of Carbohydrate and also contain sufficient quantity of protein (Verma *et al.*, 1996) and contributes a considerable part in the total supply of bulky vegetables are scarce in the market (Siddique *et al.*, 1988). However, the yield potential is seldom realized, the yield limiting factors, soil fertility is one of the major factor affecting the yield of the crop. Soil fertilization is the most common method of providing essential nutrients to the plants. When potassium supply is inadequate, a reduction occurs in exchangeable or plant available soil K which is indicative of loss of K from the soil plant system (Xie and Zhou, 2012). Potassium is not found free in nature and is mined as potash (KOH) which is chief macroelement next to nitrogen (N) and phosphorus (P) for the survival and proper functioning of living organism. Potassium is very important for tuber formation because it is known to be essential for the synthesis and translocation water, nutrients and carbohydrate (Bose and Som, 1986) in plant tissue. Despite the importance, little is known of the fertility and K requirements of the mukhikachu plant. In Mymensingh district, the soils of Fulbaria upazila are acidic red, very low in organic matter. This soil is very much suitable for aroids production but the farmer are not concern about judicious fertilizer use. This research was designed to study the response of mukhikachu to relatively high rates of fertilization and to investigate the N, P, and K requirements of mukhikachu under upland conditions in Mymensingh.

Materials and Methods

The experiment was conducted at Fulbaria upazila of Mymensingh district during the cropping season 2023-2024 under farmer's field condition. Fulbaria upazila is located at 24°6'33" N latitude and 90°26'67" E longitudes. Five fertilizers doses including the dose used by farmer were approached on BARI Mukhikachu-2 in the farmers' field likely to feasibility of fertilizers used in the farmers' field. However, the five treatments were arranged as T₁: Recommended fertilizer dose (161-40-23-6-2 kg NPSZnB ha⁻¹ with 0.0 kg ha⁻¹ K of potassium, T₂: RFD + 50 kg K ha⁻¹, T₃:

RFD + 100 kg K ha⁻¹, T₄: RFD + 150 kg K ha⁻¹ and T₅: Farmers practice (9-35-20-4 kg NPKS ha⁻¹ (P as a source of DAP where N=14 kg ha⁻¹). During final land preparation recommended fertilizer dose with 10 cowdung and in farmers practice 7 ton cowdung per hectare were used. The experiment was evaluated in randomized complete block design with six dispersed replications. In a 42m² (7m × 6m) plot, the mukhikachu corm was planted on 8-12th April, 2023 maintaining the spacing 50cm × 30cm. Manures and fertilizers were applied in treatment wise as per calculation in the form of urea, triple super phosphate, di ammonium phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Entire CD, TSP, DAP, gypsum, zinc sulphate, boric acid and half of MoP were applied as basal during final land preparation. Rest MoP and half of urea were top dressed at 40-50 days after planting in the row. Another half of urea were top dressed at 90-100 DAP in the row. After two times of top dress ear thing up was done accordingly after planting. Weeding was done as and when necessary. Irrigations were done two to three times or as per needed. The crop was harvested on 10 to 15th December, 2023. Data on yield and yield contributing characters were recorded and analyzed statistically following STAR program.

Table 1. Chemical properties of initial soil (0 -15 cm depth) of the experimental field at Fulbaria, Mymensingh during 2023-24

	pH	OM (%)	Total N (%)	K (meq/100g soil)	P	S	Zn	B
					ppm			
Soil test value	4.6	0.93	0.046	0.34	4.75	25.48	0.17	0.16
Interpretation	Strongly acidic	Very low	Very low	High	Very low	Medium	Very low	Low

Results and Discussions

The response of mukhikachu to K levels was assessed by examining growth and yield parameters. The result revealed that K had significant effect on the growth and yield of mukhikachu, except for the plant height (Table 2). The maximum yield (38.16 t ha⁻¹) was obtained by application of 100 kg K ha⁻¹. The maximum number of stem (6.00) per hill, highest number of corm (25.70) and corm weight per plant (498.0 g) were recorded in treatment T₃ which was superior over rest of treatments followed by treatment T₂. The minimum were obtained from T₅ (stem hill⁻¹ 3.00; corm plant⁻¹ 22.86; corm wt. plant⁻¹ 404.0g). The presented data shown that treatment T₃ produced maximum (38.16 t ha⁻¹) yield of corm per hectare, which is superior over all other remaining treatments followed by T₂ (31.74 t ha⁻¹). The minimum yield per hectare was recorded in T₅ (25.40 t ha⁻¹). In combination of medium level of potassium with chemical fertilizer exhibited an increased yield per hectare. It was clear from the Table 2, the treatment T₃ i.e. 161-40-23-6-2 kg NPSZnB ha⁻¹ with 100.0 kg ha⁻¹ of potassium recorded maximum yield. This was found to be significantly superior over other treatments, the results of present investigation are in agreement with the finding obtained by Salam *et al.* (2003).

Cost and return analysis: Economic analysis showed that the highest net benefit was obtained in treatment combination of 100 kg K ha⁻¹ with recommended NPSZnB (Table 3). Total variable cost differed due to potassium rate and farmers application (Table 3). Treatment T₄ (with highest K) involved with the highest TVC (Tk. 194000 ha⁻¹) followed by the treatment of 100 kg K ha⁻¹ (Tk. 193000 ha⁻¹). However, the highest gross return (Tk. 2289600 ha⁻¹) and gross margin (Tk. 2096600 ha⁻¹) were calculated from the treatment where 100 kg K Ha⁻¹ were applied with recommended urea, phosphorus, gypsum, zinc sulphate and boric acid. Thus, 100 kg K ha⁻¹ was found optimum for taro production based on this experiment in Fulbaria upazila of Mymensingh district.

Farmers' opinion: Farmers are realised about the phenomenon of the application of potassium fertilizers. They positively commented on the yield and yield parameter like as shape and size of corm as well higher yield and willing to apply recommended potassium fertilizer in next time cultivation.

Table 2. Yield and yield contributing character of Mukhikachu at Fulbaria, Mymensingh during 2022-2023

Treatment	Plant height (cm)	Stem hill ⁻¹ (no)	Corm plant ⁻¹ (no)	Cormel plant ⁻¹ (no)	Corm wt plant ⁻¹ (g)	Cormel wt plant ⁻¹ (g)	Yield (t ha ⁻¹)
T ₁	97.00	4.60	24.20	3.00	430.0	39.20	31.30
T ₂	96.45	4.80	24.90	3.80	435.0	40.60	31.74
T ₃	103.60	6.00	25.70	5.00	498.0	47.80	38.16
T ₄	97.90	4.20	23.76	3.80	438.0	40.00	31.38
T ₅	97.90	3.00	22.86	3.40	404.0	35.20	25.40
CV(%)	4.58	10.66	6.5	10.23	8.97	9.0	9.47
LSD _(0.05)	-	1.12	0.896	0.924	53.04	4.89	6.57

T₁: Recommended fertilizer dose (161-40-23-6-2 kg NPSZnB ha⁻¹ with 0.0 kg ha⁻¹ K of potassium, T₂: RFD + 50 kg K ha⁻¹, T₃: RFD + 100kg K ha⁻¹, T₄: RFD + 150 kg K ha⁻¹ and T₅: Farmers practice (9-35-20-4 kg NPKS ha⁻¹ (P as a source of DAP where N=14 kg ha⁻¹))

Table 3. Cost and return analysis of sweet gourd as influenced by fertilizers management at Gouripur, Mymensingh during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	1878000	191000	1687000
T ₂	1904400	192000	1712400
T ₃	2289600	193000	2096600
T ₄	1882800	194000	1688800
T ₅	1524000	174897	1349103

Price of input and output (Tk kg⁻¹): Urea 17.00, TSP 24.00, MoP 16.00, Gypsum 10.00, Zinc sulphate 130.00, Boric acid 300.00, Cowdung 1.00, Selling price of mukhikachu (Tk kg⁻¹): 60.00

Conclusion

The amount of fertilization had a substantial impact on the requirements of the crop. Appropriate amount of fertilizers reduces fertilizer requirement and increased farmers' income. On the basis of one year result, recommended rate of fertilizer with medium amount of K (T₃) i.e. 161-40-23-6-2 kg NPSZnB ha⁻¹ + 100 kg K ha⁻¹ shown maximum result. Thus, 100 kg K ha⁻¹ with recommended rate of NPSZnB is the effective fertilizer to get maximum benefit for mukhikachu cultivation in Fulbaria upazila of Mymensingh district.

18. INTEGRATED NUTRIENT MANAGEMENT FOR THE YIELD OF SWEET GOURD

N. SULTANA AND M.M. ZAMAN

Abstract

The present investigation was carried out at farmers' field, Gouripur upazila under Mymensingh district of Bangladesh. The experiment was conducted in randomized complete block design with six replications using the variety BARI Hybrid Mistikumra-2 with the treatments of soil test based fertilizer, reduced doses of chemical fertilizers (IPNS with cowdung), 25% increased NPK plus STB were tested in comparison with control (farmer's practice). On the basis of results, in combination with highest level of inorganic and organic fertilizer application to the crop found to be sound integrated practice. Where it recorded maximum number of fruits (4.0) and fruit weight (2.20 kg) and fruit circumference (62.33 cm) and yield per hectare (41.66 t ha⁻¹). According to the economic point of view, the treatment T₄ also recorded the highest gross return (Tk. 624900 ha⁻¹) and gross margin (Tk. 525954 ha⁻¹) where the total variable cost was (Tk. 98946 ha⁻¹). Although this treatment was used by farmer but considering the cost of fertilizer and soil status, the treatment with integrated nutrient management system (T₂) might be profitable and remunerative judicious for sweet gourd cultivation in Mymensingh region.

Introduction

Sweet gourd (*Cucurbita moschata*) is a carotene rich vegetables belongs to cucurbitaceae family. It extensively grown in tropical and subtropical world-wide. In Bangladesh, it is grown both in winter and summer in almost all parts of the country. This fruit is used as vegetable in immature and mature stage and they are consumed as vegetable processed food as stock feed. The yellow and orange fleshed fruits are very rich in carotene (3,332 IU), which is precursor of Vitamin-A with fair quantities of vitamins B and C. As the cultivation of sweet gourd is fast expanding, the growers often come across one or more problems that limit its fullest expressions of growth and productivity. Hence, these problems could be overcome partially or completely by using different agrochemicals like mineral nutrients and growth regulators. The optimum doses of nitrogen, phosphorus and potassium vary greatly with the length of growing season, fertility status of soil, soil type, cultivar, geographical location and the environmental factors. Nitrogenous and phosphatic fertilizer contribute a lot fulfilling the nutrient requirement but their excessive chemical fertilizer caused health and ecological hazard and deteriorate physiochemical properties of soil. Therefore, find an alternate or complementary source of nutrients that may enhance the yield without having adverse effects on soil properties and fruit quality. Organic manures produce organic acids which have the capacity of holding cation and anions so integration of nitrogenous fertilizers with organic manures is more beneficial in releasing cations slowly to the plants. Hence, Addition of organic manures maintain buffer soil pH and help availability of nutrient to the plant. Since limited work has been done by the former on integration of chemical fertilizer with organic manure in sweet gourd, so the experiment was conducted to find out the integrated effect of chemical fertilizers in combination with organic manures for obtaining a high economic return on growth and yield of sweet gourd.

Materials and Methods

The trial was conducted at Gouripur upazila of Mymensingh district during the cropping season 2023-2024 under farmer's field condition. The Gouripur upazila is located in between 24°38' and 24°50' north latitudes and in between 90°27' and 90°44' east longitudes. Soils of the experiment plot was medium highland with loamy textured, low available nitrogen and medium in potassium and very low in phosphorus and sulphur. However, the nutrient element of experimental plot is given below (Table 1). Four fertilizers were approached on BARI Hybrid Mistikumra-2 in the farmers' field likely to feasibility of fertilizers used in the farmers' field. However, the four treatments were arranged as T₁: Soil Test Based fertilizer dose (70-40-42-24-1-1 kg NPKSZnB ha⁻¹), T₂: Integrated Plant Nutrient System with 5 ton cowdung per hectare as of T₁ (45-33-31-24-1-1 kg NPKSZnB ha⁻¹), T₃: T₁ + 25% NPK (88-50-53-24-1-1 kg NPKSZnB ha⁻¹ and T₄: Farmers practice (102-49-86-11-4-1 kg NPKSZnB ha⁻¹ along with 10 ton cowdung per hectare). A 60 m² (12m×5m) plot, plants were spaced at 2m × 2m thereby keeping 24 plants per plot and was evaluated in a randomized complete block design with six dispersed replications. The sweet gourd seedling were planted on 27th December, 2023. Manures and fertilizers were applied in treatment wise as per calculation in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. In case of recommended treatment entire CD, TSP, gypsum, zinc sulphate, boric acid, MoP and 1/3rd of urea were applied as basal in pit during final land preparation and rest urea was top dressed at 25 and 50 days after planting. On the contrary in farmers practice, all nutrient element were applied in pit during final land preparation except urea and MoP, which were top dressed in three equal split at 20, 40, and 60 days after planting. Weeding was done as and when necessary. Irrigations were done two to three times or as per needed. The crop was harvested on 25th March to 20th April, 2024. Data on yield and yield contributing characters were recorded and analyzed statistically following STAR program.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Gouripur, Mymensingh during 2023-24

	pH	Total N (%)	K (meq/100g soil)	P	S	Zn	B
				ppm			
Soil test value	5.7	0.11	0.17	4.9	4.0	0.85	0.21
Interpretation	Slightly acidic	Low	Medium	Very low	Very low	Low	Low

Results and Discussions

The yield and yield contributing characters of sweet gourd did not differed significantly (Table 2). However, numerically the treatment T₂ and T₄ mutually produced maximum (4.0) number of fruits per vine. The minimum (3.3) number of fruits per vine was recorded in T₁. The maximum weight of fruit was recorded in treatment T₄ (2.63 kg) which was superior over rest of the treatments, followed by treatments T₃. The minimum weight of fruit was recorded in T₁ (2.20 kg). The maximum number of fruits in the treatment T₂ and T₄ i.e. 45-33-31-24-1-1 kg NPKSZnB ha⁻¹ integration with 5 ton CD per hectare and 102-49-86-11-4-1 kg NPKSZnB ha⁻¹ along with 10 t CD ha⁻¹. This may be due to the application of inorganic and organic fertilizers. Similar result obtained by Das and Swain (1977). Treatment T₄ recorded maximum (63.50 cm) circumference of fruit, which was found to be followed by the treatment T₃ (62.33 cm). Whereas, minimum (58.00 cm) diameter of fruit was recorded in the treatment T₂. The presented data shown that treatment T₄ produced maximum (41.66 t ha⁻¹) yield of fruit per hectare, which is superior over all other remaining treatments followed by T₁ (40.66). The minimum yield per hectare was recorded in T₂ (39.74 t ha⁻¹). In combination of highest level of chemical fertilizer with organic manures exhibited an increased yield per hectare. It was clear from the Table 2, the treatment T₄ i.e. 102-49-86-11-4-1 kg NPKSZnB along with 10 t CD ha⁻¹ recorded maximum yield. This was found to be significantly superior over other treatments, the results of present investigation are in agreement with the finding obtained by Gupta and Srinivas (1976).

Cost and return analysis: Total variable cost differed due to fertilizer rate (Table 3). Economic analysis showed that the highest gross margin was obtained in treatment combination with highest amount of fertilizers in farmers practice (Table 3). However, the treatment T₄ (with highest fertilizers dose) i.e. in farmers practice involved with the highest TVC (Tk. 98946 ha⁻¹) followed by the treatment T₃ (Tk. 92442 ha⁻¹). The highest gross return (Tk. 624900 ha⁻¹) and gross margin (Tk. 525954 ha⁻¹) were calculated from the treatment where the highest amount of fertilizers i.e. the farmers practice. Soil test-based fertilizer dose treated treatment resulted a good amount of gross margin (Tk. 520749 ha⁻¹).

Farmers' opinion: Farmers are very much concern about the fertilizers used in sweet gourd cultivation. After one year study the result favored the dose used by the farmer. Farmers preferred the BARI Hybrid Mistikumra-2 with farmers dose with cowdung as the yield potentiality and the collection of fruit for long time after the application of fertilizers and they believe that so.

Table 2. Yield and yield contributing character of sweet gourd as influenced by fertilizers management at Gouripur, Mymensingh during 2023-24

Treatment	Fruit plant (no)	Fruit wt (kg)	Fruit circumference (cm)	Fruit length (cm)	Yield (t ha ⁻¹)
T ₁	3.3	2.20	58.67	24.67	40.66
T ₂	4.0	2.43	58.00	25.67	39.74
T ₃	3.6	2.47	62.33	25.67	40.06
T ₄	4.0	2.63	63.50	22.17	41.66
CV(%)	8.32	7.84	10.76	9.70	8.85

T₁: Soil Test Based fertilizer dose (70-40-42-24-1-1 kg NPKSZnB ha⁻¹), T₂: Integrated Plant Nutrient System with 5 ton cowdung per hectare as of T₁ (45-33-31-24-1-1 kg NPKSZnB ha⁻¹), T₃: T₁ + 25% NPK (88-50-53-24-1-1 kg NPKSZnB ha⁻¹ and T₄: Farmers practice (102-49-86-11-4-1 kg NPKSZnB ha⁻¹ along with 10 ton cowdung per hectare)

Table 3. Cost and return analysis of sweet gourd as influenced by fertilizers management at Gouripur, Mymensingh during 2023-24

Treatment	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	40.66	609900	89151	520749
T ₂	39.74	596100	89355	506745
T ₃	40.06	600900	92442	509458
T ₄	41.66	624900	98946	525954

Price of input and output (Tk kg⁻¹): Urea 17.00, TSP 24.00, MoP 16.00, Gypsum 10.00, Zinc sulphate 130.00, Boric acid 300.00, Cowdung 1.00; selling price of sweet gourd (Tk kg⁻¹): 15.00

Conclusion

On the basis of one year results, the treatment T₄ i.e. 102-49-86-11-4-1 kg NPKSZnB ha⁻¹ along with 10 ton cowdung per hectare shown maximum result, which was numerically similar to other treatment. Treatment T₄ was found to be profitable and remunerative as per highest gross margin was found. The results should be repeated one year more.

19. ON FARM TRIAL OF MUNGBEAN TO BIOFERTILIZER

M.M. BASHIR, M.S. ISLAM AND N. SULTANA

Abstract

The experiment was conducted at the farmers' field of Char Wapda, Sadar, Noakhali during the late rabi season of 2023-24 to popularize the rhizobium biofertilizer technology for producing mungbean. The (T₁) recommended: 18-27-8-1 kg PKSzn ha⁻¹, (T₂) rhizobium inoculum (2 kg ha⁻¹) with recommended: 18-27-8-1 kg PKSzn ha⁻¹ and (T₃) recommended chemical fertilizer: 22-18-27-8-1 kg NPKSZn ha⁻¹ were comprised in Randomized Complete Block design with three replications. Number of nodules plant⁻¹, number of seeds pod⁻¹ and seed yield varied significantly due to the treatment effect. The maximum seed yield (1.35 t ha⁻¹) was obtained from the treatment with rhizobium inoculum plus recommended PKSzn which was statistically identical to that of the treatment with nitrogenous fertilizer. Treatment without urea or rhizobium produced the lowest seed yield (1.14 t ha⁻¹). According to top gross margin (Tk. 74230 ha⁻¹), treatment T₂ found to be profitable for mungbean cultivation.

Introduction

Mungbean (*Vigna radiata* L.) is an important legume crop which is grown over six million hectares worldwide (about 8.5% of the global pulse cultivation area) (Gayacharan *et al.*, 2020). In Bangladesh mungbean cultivated in an area 27440 hectare of land and production are 19450 tons (BBS, 2011). In many developing countries, mungbean sprouts have long been considered as raw food because of their excellent texture and abundant nutrients, including ascorbic acid, dilatory fiber, essential amino acids and vitamins (Ebert *et al.*, 2017; Singh *et al.*, 2017), particularly six ployphenolic compounds, including caffeic acid, gallic acid, *p*-coumaric acid, catechin and rutin have been identified in mungbean. In Bangladesh it is cultivated during *rabi*, late *rabi*, *kharif*-I and *kharif*-II seasons after receding flood water. *Bradyrhizobium* bacteria forms nodules in the roots of mungbean plant which fixes atmospheric nitrogen and used for its own benefit simultaneously. However, the effect of rhizobium on the yield of mungbean has not been reported many more. Therefore, the experiment was undertaken to popularize the rhizobium biofertilizer technology for producing mungbean in the farmer's level.

Materials and Methods

The experiment was carried out at farmer's field of Char Wapda, Noakhali during *rabi* season, 2023-24 in a Randomized Complete Block design with three dispersed replications. The

experiment was designed following the treatments (T₁) recommended: 18-27-8-1 kg PKS₂Zn ha⁻¹, (T₂) rhizobium inoculum (2 kg ha⁻¹) with recommended: 18-27-8-1 kg PKS₂Zn ha⁻¹ and (T₃) recommended chemical fertilizer: 22-18-27-8-1 kg NPKS₂Zn ha⁻¹. The fertilizers in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied during final land preparation. The rhizobium inoculum @ 2 kg ha⁻¹ was mixed with BARI Mung-6 and sown on 10th February, 2024 in a 5m × 8m plot. The intercultural operations such as weeding was done once at 25 days after sowing, parching was done to facilitate birds for controlling insect pest. At flowering stage Ripcord 10 EC @ 2ml L⁻¹ was sprayed to control thrips. The crop was harvested on 25-30 April, 2024. Data on yield and yield contributing characters were recorded and statistically analyzed following Statistix10 computer program.

Results and Discussions

Results obtained from the study have been presented in Table 1. Number of nodules plant⁻¹, number of seeds pod⁻¹ and seed yield varied significantly due to the treatment effect. The highest number of nodules plant⁻¹ (21.47) was observed in the treatment (T₂) with biofertilizer followed by the treatment with urea (T₃) and the least one was in no urea and no biofertilizer treatment (T₁). There was no significant variation in number of nodules plant⁻¹ between the treatments T₁ and T₃. Treatment T₂ also produced the highest number of seeds pod⁻¹ (12.70) which was statistically identical to that of the treatment T₃ (12.23) followed by the treatment T₁ (11.82). Although all yield contributing characters did not varied significantly their cumulative effect resulted a substantial variation in seed yield. However, the maximum seed yield (1.35 t ha⁻¹) was obtained from the treatment with biofertilizer (T₂) which was at par with that of the treatment T₃ (1.26 t ha⁻¹) followed by the least treatment T₁ (1.14 t ha⁻¹).

Cost and return analysis: Total variable cost (TVC) differed due to the urea and biofertilizer application (Table 2). Treatment T₃ (with urea) involved the highest TVC (Tk. 34780 ha⁻¹) followed by the treatment T₂ (with biofertilizer). However, the highest gross return (Tk. 108000 ha⁻¹) and gross margin (Tk. 74230 ha⁻¹) were calculated from the treatment where biofertilizers were applied with recommended phosphorus, potassium, gypsum and zinc sulphate. Recommended fertilizer treated treatment resulted a good amount of gross margin (Tk. 66020 ha⁻¹).

Farmer's opinion: Farmers are interested in growing mungbean specially BARI Mungbean-6 with the application of rhizobium inoculum due to its higher yield as well as higher income. But it was not available in the local market.

Table 1. Yield and yield attributes of mungbean at Char Wapda, Sadar, Noakhali during late *rabi* season of 2023-2024

Treatment	Plant height (cm)	Nodule plant ⁻¹ (no.)	Pod plant ⁻¹ (no.)	Seed pod ⁻¹ (no.)	100 seeds wt. (g)	Yield (t ha ⁻¹)
T ₁	54.10	16.83 b	18.77	11.82 b	4.82	1.14 b
T ₂	58.03	21.47 a	22.67	12.70 a	4.97	1.35 a
T ₃	53.90	15.97 b	19.57	12.23 ab	5.06	1.26 ab
CV (%)	11.38	8.66	10.36	3.65	NS	0.16
LSD (0.05)	NS	3.55	NS	0.56	1.03	8.90

T₁: 18-27-8-1 kg PKS₂Zn ha⁻¹, T₂: 18-27-8-1 kg PKS₂Zn ha⁻¹+ rhizobium inoculum and T₃: 22-18-27-8-1 kg NPKS₂Zn ha⁻¹.

Table 2. Cost and return analysis of mungbean at Char Wapda, Sadar, Noakhali during late *rabi* season of 2023-2024

Treatment	Seed yield (t ha ⁻¹)	Gross return Tk. ha ⁻¹	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	1.14	92200	33570	57630
T ₂	1.35	108000	33770	74230
T ₃	1.26	100800	34780	66020

Biofertilizer price Tk. 100 kg⁻¹; selling price mungbean: Tk. 80 kg⁻¹

Conclusion

Considering yield potentiality and economic point of view, it was found that application of Rhizobium inoculum instead of urea fertilizer could reduce production cost as well as increase return from mungbean cultivation.

20. EFFECT OF DIFFERENT FERTILIZER DOSES AND APPLICATION METHODS FOR POTATO PRODUCTION UNDER ZERO TILL CONDITION IN COASTAL AREA

M.M. ISLAM, H.M.K. BASHAR, M.S.I. KHAN AND N. SULTANA

Abstract

The experiment was conducted at MLT site Kalapara, Patuakhali during Rabi season of 2023-24 on cv. BARI Alu-72 in Randomized Complete Block design with three replication and six treatments. Two levels of fertilizers T₁ (recommended): 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ and T₂ (STB): 120-40-80-20-2-1.5 kg NPKSZnB ha⁻¹ were applied in three application methods P₁: ring placement, P₂: side placement and P₃: broadcasting. Methods of fertilizer application showed significant variation on number of tuber plant⁻¹, weight of tuber per plant, and tuber yield per hectare. Interaction showed significant differences in all the characters studied. It was found that maximum number of tubers (5.99) plant⁻¹, weight of tuber per plant (525 g) and tuber yield hectare⁻¹ (21.89 tons) was recorded in plots, which received fertilizer through side placement. In case of interaction, best results were recorded in plots where fertilizer was applied at the rate of 125-50-100-30-2-1.5 kg N-P-K-S-Z-B ha⁻¹ through side placement. The result lead to the conclusion that “side placement” is the most effective and economical method of fertilizer application in potato and 125-50-100-30-2-1.5 kg N-P-K-S-Zn-B ha⁻¹ fertilizer are the promising level for excellent results in potato crop under the zero tillage conditions at Kalapara, Patuakhali.

Introduction

The goal of fertilizer placement is to maximize root-nutrient contact, especially at the early stages of crop/root development, without causing emergence or establishment problems. Placing fertilizer in the region that will have the highest density of fine roots, or in a location that the fertilizer will move to this region, is needed to optimize yield. Tillage was considered as an art and in the recent years, research evidence has focused tillage as science. There are various systems of tillage, such as minimum tillage, zero tillage, and conventional tillage. From time immemorial various methods of ploughing have been tried by trial and error, based on the labor availability and economic status of the farmer. Fertilizers are applied by different methods to make the nutrient easily available to crops, to reduce the fertilizer losses and for easy application. Basal dose of fertilizer application has a significance importance in the vegetative growth and in maintain yield characteristics. Foliar application of nutrients for increasing and exploiting genetic potential of the crop is considered as an efficient and economic method of supplementing the nutrient requirement and enhancing the nutrient availability. Fertilizers are applied by different methods to make the nutrient easily available to crops, to reduce the fertilizer losses and for easy application. Basal dose of fertilizer application has a significance importance in the vegetative growth and in maintain yield characteristics. Foliar application of nutrients for in-creasing and exploiting genetic potential of the crop is considered as an efficient and economic method for supplementing the nutrient requirement and enhancing the nutrient availability. The objective of the present research study is an effort to evaluate various methods of fertilizer application with respect to different level of fertilizer in potato variety.

Materials and Methods

The experiment was conducted at MLT site Kalapara, Patuakhali during the Rabi season of 2023-24 under farmers' field condition. The experiment was laid out in two factor randomized

complete block design with three compact replications having unit plot size 5m x 4m. The soils of experimental plot was acidic in nature and containing very low amount of organic matter. However, the nutrient status of saline soils are given below (Table 1). The experiment was designed with two doses of fertilizers in factor A: T₁: Recommended dose: 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ and T₂: STB: 120-40-80-20-2-1.5 NPKSZnB ha⁻¹ with three types of fertilizer application methods in factor B i.e. P₁: ring placement, P₂: side placement and P₃: broadcasting. Soil test based fertilizer was calculated according to initial soil status. Just after placement of tuber the organic fertilizers vermicompost 5 t ha⁻¹ plus ash were applied as covering. Seeds of BARI Alu-72 were sown on 18 December, 2023 and harvested on 21 March, 2024. Recommended cultural practices from Tuber Crops Research Centre, BARI were done as and when necessary. A 15 days interval spray schedule of Mancozeb @ 2 g L⁻¹ started from 30 days after planting and continued up to 60 days of age to control disease or as preventive measure. At the age of 60, 15 days interval Mancozeb 40% and Carbendazim 10% spray schedule was maintain up to 15 days before harvesting. Data were collected plot wise and analyzed statistically.

Table 1. Initial soil nutrient status of experimental plot during 2023-24

Item	pH	EC (dS/m)	OM (%)	Total N (%)	K (meq/100g soil)	P	S	Zn	B
	5.0	0.98	1.1	0.06	0.20	ppm			
Interpretation	Acidic	Low	Very low	Very low	Low	Very low	High	Low	Low

Result and Discussions

Number of Tubers Plant⁻¹: Analysis of variance for number of tubers plant⁻¹ showed highly significant differences among various methods of fertilizer application is due to different fertilizer rates. This declared differences in due to methods and amount of fertilizer application in potato (Table 2 and Table 3). Maximum number of tubers plant⁻¹ were recorded from side placement (5.99) and ring placement (5.86) with applying 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ fertilizer rates in zero tilled potato field with straw mulching (Table 3). The minimum number of 5.37 tubers plant⁻¹ were recorded in broadcasting methods. From the interaction, in side placement method of fertilizer application maximum number (6.17) of tubers plant⁻¹ were recorded when fertilizer were applied @ 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ (Table 4). Studying all the three methods of fertilizer application it is clear that side placement methods is efficient and responsive as compared to other, while applying nitrogen, phosphorus, potassium and sulphur as its maximum (125, 50, 100 and 30 kg ha⁻¹) level. Born and Magrim (1987) also reported similar results that increasing in level causes significant increases in number of tubers plant⁻¹, especially of large size tubers and this is mostly marked in sandy soil.

Weight of Tubers Plant⁻¹: Statistically high significant variations (P<0.01) were observed among the different methods of fertilizer application, fertilizer rates and also for interaction between them (Table 2, Table 3 and Table 4). Across two different fertilizer doses and three methods of fertilizer application method the weight of tuber ranged from 492 to 525 g in potato variety BARI Alu-72 (Table 3). Maximum tuber weight of 495g were produced at 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ fertilizer doses while minimum of 436g were at the applying 100-40-80-20-2-1.5 kg NPKSZnB ha⁻¹ fertilizer doses. Placement methods produced maximum (525 g) and minimum (492g) tuber per plant. Side placement method produced 525g tuber per plant and 7% more as compared to ring placement and broadcasting methods respectively. Interaction effect of fertilizer placement and fertilizer doses the highest tubers weight per plant was recorded (510 g) from the combination of T₁P₂ treatments (Table 4).

Tuber yield: Over two fertilizer doses and three application methods of fertilizer, potato yield ranged from 19.43 to 22.23 tones ha⁻¹. Ring placement, side placement and broadcasting methods of fertilizer application produced 21.11, 22.23 and 20.47 tones ha⁻¹ tuber, respectively, when applying at 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ fertilizer (Table 4). Maximum tuber yield (22.23 ton ha⁻¹) was produced from 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ with side placement treated plot. Minimum tuber yield produced at control treatment by using broadcasting (18.37

ton ha⁻¹) methods. Friesslaben and Thomaschewski (1988) reported that 6 to 8 % increase in potato production is possible when nitrogen and phosphorous applied in besides rows of seed tubers.

Cost and return analysis: The highest gross return (Tk. 555750 ha⁻¹), gross margin (Tk. 349750 ha⁻¹) and benefit cost ratio (2.69) was recorded from side placement of recommended chemical fertilizer. The lowest economic return was recorded in broadcasting of soil test based fertilizer dose plot which were Tk. 485750 ha⁻¹ and Tk. 287750 ha⁻¹ and BCR was 2.45.

Farmers' opinion: Farmers were very much interested in cultivating zero tillage potato with side placement methods for its easy application system, low fertilizer requirements and higher yield.

Table 2. Effect of fertilizer dose on yield and yield attributes at Kalapara, Patuakhali during Rabi, 2023-24

Treatments	Plant height at 60 DAP	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)
T ₁	49.67	6.35	495	22.57
T ₂	44.32	5.76	436	20.49
P-Value	1.54	078	11.57	2.08

T₁: Recommended dose: 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ and T₂: STB: 120-40-80-20-2-1.5 NPKSZnB ha⁻¹

Table 3. Effect of fertilizer application methods on yield and yield attributes at Kalapara, Patuakhali during Rabi, 2023-24

Treatment	Plant height at 60 DAP	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)
P ₁	45.79	5.86	505	19.64
P ₂	47.49	5.99	525	21.89
P ₃	50.36	5.37	492	18.37
CV (%)	6.53	3.47	10.19	6.04
LSD (0.05)	5.78	1.77	19.85	8.87

P₁: Ring placement method, P₂: Side placement method and P₃: Broadcasting method

Table 4. Interaction effect of fertilizer doses and application methods on yield and yield attributes at Kalapara, Patuakhali during Rabi, 2023-24

Treatment	Plant height at 60 DAP	Tuber plant ⁻¹ (no)	Tuber wt plant ⁻¹ (g)	Tuber yield (t ha ⁻¹)
T ₁ P ₁	47.73	6.11	500	21.11
T ₁ P ₂	48.58	6.17	510	22.23
T ₁ P ₃	50.02	5.86	493.5	20.47
T ₂ P ₁	45.05	5.81	470.5	20.07
T ₂ P ₂	45.91	5.88	480.5	21.19
T ₂ P ₃	47.34	5.57	464	19.43
CV (%)	6.53	3.47	10.19	6.04
LSD (0.05)	5.78	1.77	19.85	8.87

T₁: Recommended dose: 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ and T₂: STB: 120-40-80-20-2-1.5 NPKSZnB ha⁻¹; P₁: Ring placement method, P₂: Side placement method and P₃: Broadcasting method

Table 5. Cost and return analysis of potato under the fertilizer dose and application methods of the trial at Kalapara, Patuakhali during 2023-24

Treatment	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁ P ₁	21.11	527750	215000	312750	2.45
T ₁ P ₂	22.23	555750	206000	349750	2.69
T ₁ P ₃	20.47	511750	202500	309250	2.53
T ₂ P ₁	20.07	501750	201100	300650	2.50
T ₂ P ₂	21.19	529750	203000	326750	2.61
T ₂ P ₃	19.43	485750	198000	287750	2.45

T₁: Recommended dose: 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ and T₂: STB: 120-40-80-20-2-1.5 NPKSZnB ha⁻¹; Price of input and output (Tk kg⁻¹): Urea 17.00, TSP 24.00, MoP 16.00, Gypsum 10.00, Zinc sulphate 130.00, Boric acid 300.00, Cowdung 1.00, Vermicompost 20.00, Selling price of potato (Tk kg⁻¹): 25.00

Conclusion

Proper fertilizer application methods reduce fertilizer requirement and increase farmers' income in zero tillage potato production system. In zero-tillage system, tubers are planted directly into untilled soil which contains previous crop residues. This system minimize soil disturbance and allow crop residues to remain on the soil. The results showed that according to the yield and nutrient requirements, the recommended rate of fertilizer 125-50-100-30-2-1.5 kg NPKSZnB ha⁻¹ in side placement is the effective fertilizer and application method to get maximum benefit for potato cultivation in zero tillage condition in saline soil.

21. RESPONSE OF VERMICOMPOST ON GROWTH, YIELD AND FRUIT QUALITY OF WATERMELON IN COASTAL SALINE SOIL

M.M. ISLAM, H.M.K. BASHAR, M.S.I. KHAN AND N. SULTANA

Abstract

An experiment was conducted at MLT site Kuakata, Patuakhali in Rabi season of 2023-24 to observe the effect of vermicompost dose on yield and fruit quality of watermelon under farmers' field condition. The trial was conducted in Randomized Complete Block design with three replications and four treatments. The treatment combinations were T₁: 1.0 t Vermicompost ha⁻¹ + 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₂: 2.0 t Vermicompost ha⁻¹ + 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₃: 3.0 t Vermicompost ha⁻¹ + 150-50-125-40-5-4 kg NPKSZnB ha⁻¹ and T₄: Farmers practice 150-50-125-40-5-4 kg NPKSZnB ha⁻¹ (no vermicompost). The highest yield (32.19 t ha⁻¹) were obtained when 3 ton vermicompost were applied with inorganic fertilizer. Total Soluble Solids was recorded in the highest in in the same treatment. The lowest TSS was found in Farmers' practice where no vermicompost was used. The highest gross return (Tk. 515040 ha⁻¹), gross margin (Tk. 326140 ha⁻¹) and BCR (2.73) in 3 ton vermicompost with recommended inorganic fertilizer was found to be judicious for watermelon cultivation in coastal region.

Introduction

Watermelon is a dominant fruit crop in coastal region which needed frequent watering and continues nutrient supply for growth and fruit development. Coastal farmer traditionally cultivate watermelon in using inorganic fertilizers. But it is reported that organic manures having humic substances not only improve soil fertility by modifying soil physical and chemical properties (Asik *et al.*, 2009), (Heitkamp *et al.*, 2011) but also improves the moisture holding capacity of the soil. Organic fertilizers are mineralized slowly and nutrients become available for a longer period of time and reduce irrigation frequency. The effects of different kinds of organic fertilizer on the growth, yield, quality, and nutrient absorption and utilization of watermelon were examined to provide theoretical basis for adequate fertilization and efficient production of watermelon in gravel-mulched field (Ouda and Mahadeen, 2008). In another study, suggested that effects of mineral and organic fertilization in the plant development, nutritional status, and fruit yield of melon (De Souza *et al.*, 2018). In addition to providing nutrients, they also help growing plants and physical, chemical and biological characteristics of soil. However, the effect of organic matter on yield and quality of watermelon in coastal soil has yet to determine. The study therefore were aim (i) to determine the effects of organic fertilizers on yield and fruit quality, and (ii) to determine the optimum amount of organic matter in watermelon production.

Materials and Methods

An experiment was conducted at MLT site Kuakata, Patuakhali during the rabi season of 2023-24 to find out the dose of vermicompost on watermelon in farmers field condition. Different doses of vermicompost along with recommended doses inorganic fertilizers were used in this trial. The treatment combinations were T₁: 1.0 t Vermicompost ha⁻¹ + Recommended 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₂: 2.0 t Vermicompost ha⁻¹ + Rec. 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₃: 3.0

t Vermicompost ha⁻¹ + Rec. 150-50-125-40-5-4 kg NPKSZnB ha⁻¹ and T₄: Farmers practice 150-50-125-40-5-4 kg NPKSZnB ha⁻¹ with no vermicompost. The trial was conducted in Randomized Complete Block design with three replication in a 10m × 4m plot. Seedling were transplanted on 25 December, 2023. The chemical fertilizers were applied in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. Entire fertilizers, one third of MoP and all amount of vermicompost were applied during final land preparation. Remaining MoP and full doses of urea splitted in to three and applied at 20 days after planting, flowering and fruiting stage. The crop was harvested on 15 April, 2024. The yield and yield contributing characters were analysed accordingly.

Result and Discussions

Vermicompost enhance emergences percentage of watermelon production. In different vermicompost treated treatment, individual fruit weight was identified between 5.29 kg to 7.42 kg (Table 1). Fruit weight results of vermicompost application were higher than the control. As part of the study, the effects of vermicompost at different volume ratios on quality and yield of watermelon were studied. The highest fruit yield (32.19 t ha⁻¹) was obtained from highest rate of vermicompost treated (3.0 t ha⁻¹) treatment while the lowest yield (25.85 t ha⁻¹) was observed in without vermicompost treated treatment (T₄). The results showed that vermicompost could increase soil nutrients, organic matter and enzyme activities; the watermelon yield and the contents of free amino acid, soluble protein, soluble sugar and vitamin C in fruit were also enhanced (Joshi *et. al.*, 2015). When control and vermicompost applications were compared for fruit height, width and fruit shell thickness the results of all applications were found statistically significant. Fruit width and length results were higher in vermicompost treated treatments than the control application. The highest result of fruit width and length were obtained from vermicompost application by 26.73 cm and 26.87 cm, respectively from T₃ treatment (Table 1). The content of TSS was found to be higher on vermicompost applied plots compared with control plots. Highest (9.78) TSS (%) was identified under vermicompost (T₃) application (Table 1). According to Koca, 2006; TSS content of carrot ranged between 6.87-11.01% increased when applied vermicompost.

Cost and return analysis: The highest gross return (Tk. 515040 ha⁻¹), gross margin (Tk. 326140 ha⁻¹) and BCR (2.73) was recorded from 3 ton vermicompost per hectare with recommended chemical fertilizer for watermelon production. The lowest economic return was recorded from without vermicompost treated plot which was Tk. 413600 ha⁻¹ and BCR (2.45).

Table1. Plant populations, growth and yield contributing parameters of watermelon at Kuakata, Patuakhali during 2023-24

Treatment	Vine length (cm)	Fruit length (cm)	Fruit width (cm)	Individual fruit wt (g)	Fruit yield (t ha ⁻¹)	TSS (%)
T ₁	232.56ab	23.61c	24.64 ab	6.58ab	28.24b	9.51a
T ₂	240.69a	25.72 ab	26.65 a	6.59ab	30.57ab	9.45 ab
T ₃	236.66a	26.87 a	26.73 a	7.42a	32.19a	09.78a
T ₄	228.58b	24.15 b	22.49 b	5.29b	25.85c	9.10b
CV (%)	8.48	7.54	11.98	7.70	4.14	9.13
LSD (0.05)	23.08	4.58	4.78	2.79	2.82	0.58

T₁: 1.0 t Vermi. ha⁻¹+Recommended 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₂: 2.0 t Vermi. ha⁻¹+Rec. 150-50-125-40-5-4 kg NPKSZnB ha⁻¹, T₃: 3.0 t Vermi. ha⁻¹+Rec. 150-50-125-40-5-4 kg NPKSZnB ha⁻¹ and T₄: Farmers practice (no vermi.) 150-50-125-40-5-4 kg NPKSZnB ha⁻¹

Table 2. Cost and return analysis of watermelon at Kuakata, Patuakhali during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable Cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
T ₁	451840	173600	278240	2.60
T ₂	489120	183600	305520	2.66
T ₃	515040	188900	326140	2.73
T ₄	413600	168500	245100	2.45

Watermelon Price (Tk kg⁻¹) = 16

Effect on salinity

Salinity level of the experimental plots was 0.63 dS/m during plantation then it increased with time up to 7.52 dS/m throughout the growing season (Fig. 1). It was observed that salinity levels were lower in organic fertilizer treated treatments that enhance productivity of watermelon yield in coastal saline soil. The highest salinity was observed in farmers practice (FP) where no organic fertilizer was used.

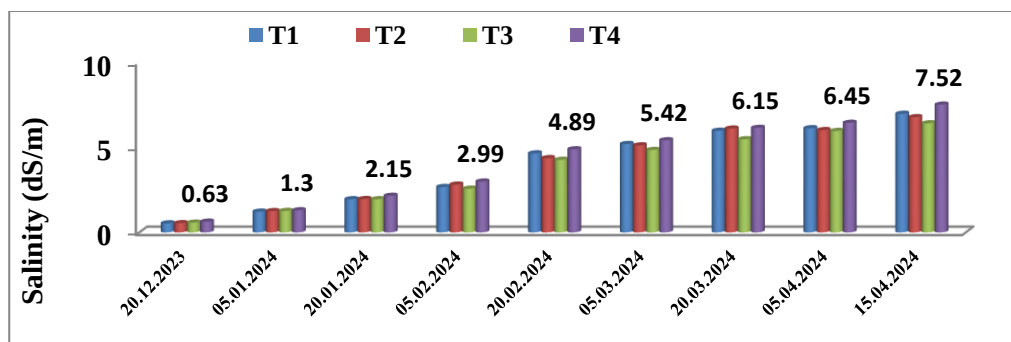


Fig 1. Salinity level of different treatments

Farmer's opinion

Farmers are very much interested to use vermicompost with inorganic doses as it gave more production and its maximum seed germination percentage with its higher survival rates.

Conclusion

Results indicated that vermicompost has positive effect on yield and quality of watermelon. It can be recommended that 3.0 t vermicompost ha⁻¹ with inorganic fertilizers (150-50-125-40-5-4 kg NPKSZnB ha⁻¹) is the judicious fertilizers to get significant benefit in watermelon cultivation in coastal region. To disseminate and popularization of this technology for the farmers of the desired location, piloting should be initiated through extension and other stakeholder.

22. EFFECT OF BORON ON THE GROWTH AND SEED YIELD OF SUNFLOWER IN ACIDIC SOIL OF SYLHET REGION

M.I. NAZRUL AND N. SULTANA

Abstract

Basal application of boron plays an important role in the growth and yield of sunflowers. Sunflower productivity is mainly affected by balance fertilizer and water availability. This study was undertaken to determine the growth and yield response of sunflower (*Helianthus annuus L.*) under five different levels of boron T₁: 0.0 kg boron ha⁻¹, T₂: 1.0 kg boron ha⁻¹, T₃: 1.5 kg boron ha⁻¹, T₄: 2.0 kg boron ha⁻¹ and T₅: 2.5 kg boron ha⁻¹. The experiment was conducted at Hakaluki haor in robi season in a randomized complete block design with six dispersed replications. Results showed that boron application significantly influenced the yield and yield attributes, and highest level of boron (2.5 kg ha⁻¹) provided highest plant height (110.67cm), head diameter (20.83 cm), 1000 seed weight (79.63 g), seeds head⁻¹ (1053) and seed yield (1.83 t ha⁻¹) of sunflower. Higher gross return and gross margin was obtained from T₅ (2.5 kg ha⁻¹ of boron), followed by T₃ (1.5 kg ha⁻¹ of boron).

Introduction

Sunflower (*Helianthus annuus L.*) is an oil seed crop which distinctly superior to other oil seed crop plays a major role in vegetable oil industry in whole world. Sunflower oil is a premium oil

due to contain 55-65% linoleic acid, 20-30% oleic and other different fatty acids. Balanced nutrition is the most important issue to increase crop yield and improving the quality of agricultural product. Boron (B) is a naturally occurring immobile micronutrient which has a principal role on plant cell wall and membrane constancy, increased grain yield. Boron deficiency during vegetative phase causes deformation of pollen tube and inhibits fertilization at flowering stage which can reflect in higher number of empty seed, decreased fruit as well as seed setting, seed abortion, impaired embryogenesis, and male sterility. Thus with increase in number of filled grain, yield is increased. Most of soils in Sylhet region of Bangladesh are acidic in nature, low in organic matter has caused deficiency in micronutrients including boron. In this region, sunflower cultivation is increasing day by day but in some cases unfilled grains are found in harvest. Sunflower has been found to be sensitive to B deficiency and is sometimes used as an indicator for assessing indicator of available B in soils. It is thought that strongly acid soils (pH less than 5.0) tend to be low in available boron because of boron absorption to iron and aluminium oxide surfaces of soil minerals. Although the positive effect of boron on crop production has been studied, limited information is available on the influence of boron nutrient in sunflower crop cultivation in acid soils. Considering the above fact on importance of boron the experiment has been designed to determine the optimum dose of boron fertilizer to achieve better growth and yield of sunflower in the Sylhet region.

Materials and Methods

A field experiment was conducted at Hakaluki haor to quantify the proper dose of boron fertilizer in BARI Surjomukhi-3 during winter in two consecutive years 2023-24. The soil was clay loam having strongly acidic (pH value 4.80), very low in phosphorus and potassium ($P=0.05 \mu\text{g g}^{-1}$ soil, $K=0.05 \text{ meq } 100 \text{ g}^{-1}$ soil), low in nitrogen and boron but optimum sulphur ($S=25 \mu\text{g g}^{-1}$ soil) and medium in organic matter (1.82%). The experiment was laid out in a randomized complete block (RCB) design with six dispersed replications. Each replication was divided into five plots where different doses of boron were applied according to treatments. The unit plot size was $8\text{m} \times 5\text{m}$. The experiment was comprised of 5 treatments viz. T_1 : $0.0 \text{ kg boron ha}^{-1}$, T_2 : $1.0 \text{ kg boron ha}^{-1}$, T_3 : $1.5 \text{ kg boron ha}^{-1}$, T_4 : $2.0 \text{ kg boron ha}^{-1}$ and T_5 : $2.5 \text{ kg boron ha}^{-1}$. The experimental plots were fertilized at the rate of 150-110-90 and 120 kg ha^{-1} N-P-K and S (FRG' 2018). Boric acid (Bingo, 20% Boron) was used as the source of boron and applied according to experimental treatment set up. Seeds were sown on 20-25 November at the rate of 13 kg ha^{-1} and crop was harvested at 98 days after sowing. Intercultural operations such as weeding, thinning, irrigation, spraying of insecticides and weedicides were done uniformly. Different growth parameters were recorded from different days after sowing of seeds for observing effect on plant growth. At harvesting stage, 10 sample plants were randomly uprooted from each unit plot to collect data on different yield contributing characters and 1 m^2 area was selected for yield data. Data were analyzed by statistical analysis program STAR. The significance of the mean differences among the treatments was estimated by the least significant deferent test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussions

Plant height at maturity (cm): Plant height at maturity was significantly affected by different levels of boron (Table 1). The tallest plant (110.67 cm) was observed in plots treated with 2.5 kg ha^{-1} boron followed by (106.67 cm) at T_4 whereas shortest plant (86.0 cm) was in treatment 0.0 kg ha^{-1} boron. Our results corroborated with the findings of Zahoor *et al.* 2011.

Stem diameter (cm): The potential growth of sunflower is determined by its vigorously growing stem. The maximum stem diameter (2.83 cm) was obtained from plots treated with 2.5 kg ha^{-1} boron. While minimum stem diameter (2.10 cm) was observed in plots with control treatment (0.0 kg ha^{-1} boron).

Head diameter (cm): Data indicated that boron levels significantly affected the head diameter of sunflower (Table 1). The treatment T_5 (2.5 kg ha^{-1} boron) gave the maximum head diameter (20.00 cm) which was statistically similar (18.90 cm) with the treatment T_4 (2.0 kg ha^{-1} of boron).

On the contrary, minimum head diameter (15.90 cm) was recorded at control level where no boron was applied (T_1). These results are in line with Zahoor *et al.* 2011; Khan *et al.*, 2000; Oyinlola, 2007; who observed that the head diameter of sunflower increased with boron application.

Number of seeds per head: The number of seeds per head contributes significantly towards the final yield of sunflower. A greater number of seeds per head directly influenced the yield of crop. Data in Table 1 indicated that maximum number (1053) of seeds were obtained in higher level of boron treatment, and minimum number (679) of seeds was obtained in the treatment with zero kg boron application. These results are in line with the findings of Khan *et al.*, 2000) who supported positive effects of boron on number of seeds of sunflower crop. Due to application of boron, increases in number of seeds per head were increased due to increased translocation of assimilates from source to sink.

1000 seeds weight (g): Data presented in Table 1 revealed that a maximum 1000 seeds weight was obtained by the application at the rate 2.5 kg ha⁻¹ of boron followed by B application at 2.0 kg ha⁻¹ of boron. The lowest 1000 seed weight (79.63 g) was observed in control treatment.

Seed yield of sunflower: Significantly, the highest grain yield 1.83 t ha⁻¹ was obtained with applying 2.5 kg ha⁻¹ of boron, followed by 1.81 t ha⁻¹ with the application of 2.0 kg boron ha⁻¹. Our results confirmed the finding of earlier researchers who also observed that grain yield significantly increased when boron levels increased (Zahoor *et al.*, 2011).

Cost and return analysis : Cost and return analysis showed that the higher gross margin (Tk. 30200 ha⁻¹) was obtained from T_5 (Table 2), followed by T_4 (Tk. 29150 ha⁻¹) which was very close to T_3 . However, the lower gross margin (Tk. 6750 ha⁻¹) was recorded in T_1 where boron was absent but it is essential for sunflower cultivation in acidic soil. It is noted that recommended doses of fertilizer along with increase dose of born reflected the cost of cultivation.

Farmer's opinion: Two issues have been raised by the farmers viz. ensure the fair price with purity to popularize the use of boron in crop production.

Table 1. Effect of boron on the seeds yield and yield contributing characters of sunflower at Hakaluki haor during 2023-24

Treatment	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	Seeds head ⁻¹ (no.)	Seeds head ⁻¹ (no.)		1000 seeds wt. (g)	Seed Yield (t ha ⁻¹)
					Filled	Unfilled		
T_1	86.00	2.10	15.90	679	584	98	68.53	1.45
T_2	94.00	2.20	16.70	776	689	86	71.27	1.61
T_3	101.00	2.63	17.50	883	837	79	77.47	1.81
T_4	106.67	2.80	18.90	935	863	72	78.30	1.81
T_5	110.67	2.83	20.00	1053	859	61	79.63	1.83
CV (%)	1.75	8.39	0.31	1.90	4.31	3.07	1.76	1.67
LSD (0.05)	3.29	NS	0.10	30.93	62.18	4.59	2.48	0.05

T_1 : 0.0 kg boron ha⁻¹, T_2 : 1.0 kg boron ha⁻¹, T_3 : 1.5 kg boron ha⁻¹, T_4 : 2.0 kg boron ha⁻¹ and T_5 : 2.5 kg boron ha⁻¹.

Table 2. Cost and return analysis of sunflower under different treatment at Hakaluki haor in 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T_1	94250	87500	6750
T_2	104650	88000	16650
T_3	117650	88250	29400
T_4	117650	88500	29150
T_5	118950	88750	30200

T_1 : 0.0 kg boron ha⁻¹, T_2 : 1.0 kg boron ha⁻¹, T_3 : 1.5 kg boron ha⁻¹, T_4 : 2.0 kg boron ha⁻¹ and T_5 : 2.5 kg boron ha⁻¹. Price of Sunflower (non seed); 65 Tk.kg⁻¹. Price of boron: 500 Tk.kg⁻¹

Conclusion

From the findings it may be concluded that the seed yield was increased with the increasing of born level and maximum seed yield (1.83 t ha⁻¹) of sunflower was obtained from 2.5 kg ha⁻¹ of born with higher gross margin (Tk. 30200 ha⁻¹).

23. EFFECT OF LIMING ON THE GROWTH AND SEED YIELD OF SUNFLOWER IN ACIDIC SOIL OF SYLHET REGION

M. I. NAZRUL AND N. SULTANA

Abstract

A field experiment was conducted at Hakaluki haor under multi locational testing (MLT) site, Moulvibazar during winter in two consecutive year 2023-24 to quantify the proper dose of lime for cultivation of BARI Surjomukhi-3. Six lime treatments viz. T₁: 0.0 t dolomite ha⁻¹, T₂: 0.5 t dolomite ha⁻¹ T₃: 1.0 t dolomite ha⁻¹, T₄: 1.5 t dolomite ha⁻¹, T₅: 2.0 t dolomite ha⁻¹, T₆: 2.5 t dolomite ha⁻¹ were applied in a trial. The study was designed in Randomized Complete Block Design with six dispersed replications. The different characters of sunflower viz. plant height (cm), stem diameter (cm), head diameter (cm), achenes head⁻¹, 1000 achenes wt. (g), and achenes yield (t ha⁻¹) were significantly increased by the application of lime. The application of lime 2.5 tha⁻¹ significantly increased most of the growth parameters of sunflower compared to that of other doses including control. The application of lime had a significant effect on the seed yield of sunflower. The highest seed yield was found in T₅ (1.78 t ha⁻¹), which was statistically identical with the seed yields obtained in T₆ and T₄ treatments but superior to those found in T₁, T₂, T₃ treatments. Thus, the application of lime 1.50 tha⁻¹ is enough for satisfactory yield of sunflower with higher economic profit.

Introduction

Sunflower (*Helianthus annuus* L.) is an exotic North American plant but commercialization as a crop now a days across the globe. This oil seed crop plays a major role in vegetable oil industry in whole world. Sunflower oil contains 55-65% linoleic acid, 20-30% oleic and other different fatty acid. The soils of Sylhet region in Bangladesh are acidic in nature, low in organic matter and micronutrient content. This acid soil is constraints for crop production as it make less availability of phosphorus and toxicity of aluminum. Liming act as reclamation of soil acidity increases the availability of P, Ca, Mg and Mo and renders iron, and manganese insoluble and harmless, increases fertilizer effectiveness and decreases plant diseases (Sahai, 1990), promotes the decomposition of organic matter by making condition more favorable for the growth of microorganisms. Though liming is an important practice for the crop production under acidic soil, but farmers rarely use lime in their fields. Ameliorative of acid soil with liming @ 1-1.5 t ha⁻¹ showed increases the soil pH and observed a profound growth and yield of wheat, cabbage, and cauliflower. Souza *et. al.* (1997) reported that the application of lime enhanced the available N, P, Ca, Mg, S, and Zn content in soils, which reflected in their uptake by sunflower. Since soil amendment with appropriate doses of dolomitic lime may be enhance the growth and yield of sunflower. Therefore, trial was conducted to determine the optimum dose of lime to achieve better growth and yield of sunflower under acidic soil condition.

Materials and Methods

A field experiment was conducted at Hakaluki haor under multi locational testing site, Moulvibazar during winter in two consecutive year 2023-24 to quantify the proper dose of lime for cultivation of BARI Surjomukhi-3. The soil was clay loam having strongly acidic (pH value 4.80), very low in phosphorus and potassium (P=0.05 µg g⁻¹ soil, K=0.05 meq 100 g⁻¹ soil), low in nitrogen and boron but optimum sulphur (S=25 µg g⁻¹ soil) and medium in organic matter (1.82%). The experiment was laid out in a randomized complete design with six dispersed

replications in a 8m × 5m plot. Each replication was divided into five plots where different doses of boron were applied according to treatments. The experiment was comprised of 6 treatments viz. T₁: 0.0 t dolomite ha⁻¹, T₂: 0.5 t dolomite ha⁻¹, T₃: 1.0 t dolomite ha⁻¹, T₄: 1.5 t dolomite ha⁻¹, T₅: 2.0 t dolomite ha⁻¹ and T₆: 2.5 t dolomite ha⁻¹. The experimental plots were fertilized at the rate of 150-110-90 and 120 kg N-P-K-S ha⁻¹ (FRG' 2018). Dolomitic lime (20% calcium and 10% magnesium) was used as the source of liming materials. Seeds of sunflower were sown on 25-28 November at the rate of 13 kg ha⁻¹ and crop was harvested at 95-100 days after sowing. Intercultural operations such as weeding, thinning, irrigation, spraying of insecticides and weedicides were done uniformly. Different growth parameters were recorded from different DAS of seeds for observing effect on plant growth. At harvesting stage, 10 sample plants were randomly uprooted from each unit plot to collect data on different yield contributing characters and 1 m² area was selected for yield data. Data were analyzed by statistical analysis program STAR. The significance of the mean differences among the treatments was estimated by the least significant deferent test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussions

Statistical analysis of the data revealed that levels of dolomite lime had a highly significant effect for all the parameters of sunflower.

Plant height at maturity (cm): Plant height at maturity was significantly affected by different levels of boron (Table 1). The tallest plant (88.00 cm) was observed in plots treated with T₆ (2.5 t ha⁻¹ of lime) followed by T₅ (2.0 t ha⁻¹ of lime) whereas the shortest plant (79.67cm) was observed in the treatment with no dolomite was applied.

Stem and head diameter (cm): The potential growth of sunflower is determined by its vigorously growing stem. The maximum stem diameter (3.20 cm) was obtained from the plots treated with 2.5 t ha⁻¹ of lime while minimum stem diameter (2.13 cm) was observed in plots with control treatment (0.0 t ha⁻¹ of lime).

Head diameter (cm): Data indicated that different levels of dolomitic lime significantly affected the head diameter of sunflower. The maximum head diameter (20.40 cm) was observed at 2.5 t ha⁻¹ of lime which was statistically similar (19.00 cm) with the treatment 2.0 kg ha⁻¹ of lime whereas minimum value (16.10 cm) was found from the control plots in 0.0 kg ha⁻¹ of lime. These results are in line with Antunovic *et al.* (2002) who observed maximum head diameter (19.25 cm) in plants applied with 2 t ha⁻¹ of lime.

Number of seeds per head: The number of seeds per head contributes significantly towards the final yield of sunflower. Data in Table 1 indicated that maximum number (982) of seeds were obtained in higher level of lime treatment (2.5 t ha⁻¹) which was statistically (945) at par with 2.0 t ha⁻¹ of lime and minimum number (622) of seeds was obtained in the treatment with zero lime application. These results are in line with the findings of Loschi *et al.* (2015) and Blamey and Nathanson (1978) who supported positive effects of lime on number of seeds of sunflower crop.

1000 seeds weight (g): Data presented in Table 1 revealed that a maximum 1000 seeds weight (84.60g) was obtained by the application of 1.5 t ha⁻¹ of lime followed by 2.0 t ha⁻¹. The lowest 1000 seeds weight (67.40g) was observed in control treatment.

Seeds yield of sunflower: Grain yield was significantly increased by the lime application over control in the experiment (Table 1). The significantly highest grain yield of 1.78 t ha⁻¹ was obtained with application of 2.0 t ha⁻¹ of lime, followed by 1.75 and 1.72 t ha⁻¹ with application of 2.5 and 1.5 t ha⁻¹ of lime, respectively. Our results confirmed the finding of earlier researchers who also observed that grain yield significantly increased when lime levels increased (Loschi *et al.*, 2015; Blamey and Nathanson, 1978).

Cost and return analysis

Cost and return analysis showed that the higher gross margin (Tk. 13700 ha⁻¹) was obtained from T₃ (Table 2), followed by T₄ (Tk. 12300 ha⁻¹) was recorded in which was very close to T₃. However,

the lower gross margin (Tk. 6250 ha⁻¹) was recorded in T₆ where maximum level of lime was applied but it was not economically profitable due to higher variable cost.

Farmer's opinion: Farmers expressed their satisfaction having good yield but perturbed about the high market price and unavailability of dolomite lime for crop production.

Table 1. Effect of lime on the achenes yield and yield contributing characters of sunflower at Hakaluki haor during 2023-24

Treatment	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	Seeds head ⁻¹ (no)	Seeds head ⁻¹ (no)		1000 Seeds wt. (g)	Seed yield (t ha ⁻¹)
					Fill	Unfill		
T ₁	79.67	2.13	16.10	622	544	105	67.40	1.53
T ₂	81.50	2.30	16.70	736	647	88	72.50	1.59
T ₃	81.30	2.40	17.50	782	702	80	77.47	1.68
T ₄	85.5	2.60	18.30	858	788	69	84.60	1.72
T ₅	83.00	2.90	19.00	945	783	62	83.53	1.78
T ₆	88.00	3.20	20.40	982	794	52	80.77	1.75
CV (%)	1.39	3.43	0.50	0.98	4.10	8.16	2.90	0.84
LSD (0.05)	3.86	0.25	0.25	22.87	82.50	17.67	6.40	0.04

T₁: 0.0 t dolomite ha⁻¹, T₂: 0.5 t dolomite ha⁻¹, T₃: 1.0 t dolomite ha⁻¹, T₄: 1.5 t dolomite ha⁻¹, T₅: 2.0 t dolomite ha⁻¹, T₆: 2.5 t dolomite ha⁻¹.

Table 2. Cost and benefit analysis of sunflower as influenced by different lime combinations at Hakaluki haor in 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	97500	87500	10000
T ₂	103350	91500	11850
T ₃	109200	95500	13700
T ₄	111800	99500	12300
T ₅	115700	103500	12200
T ₆	113750	107500	6250

T₁: 0.0 t dolomite ha⁻¹, T₂: 0.5 t dolomite ha⁻¹, T₃: 1.0 t dolomite ha⁻¹, T₄: 1.5 t dolomite ha⁻¹, T₅: 2.0 t dolomite ha⁻¹, T₆: 2.5 t dolomite ha⁻¹. Price of sunflower (non seed): 65 Tk kg⁻¹. Price of lime: 8 Tk kg⁻¹

Conclusion

Liming significantly influences growth and yield of sunflowers. The overall best performance (yield and gross margin) was observed in the doses of 1.0 to 1.5 t ha⁻¹ dolomite. The study shows that the recommended fertilizer dose with liming (1.0-1.5 t ha⁻¹ dolomite) could be used for sunflower production for increasing crop yield and higher net returns.

24. EFFECT OF FERTILIZER ON TURMERIC AT MADHUPUR TRACT UNDER AEZ-28

T. TASMIMA, M.A. RAHAMAN, S. ROY, K. ROY, G. PAUL AND N. SULTANA

Abstract

A field experiment was conducted at MLT site, Madhupur (AEZ-28), Tangail during 2023-24 to find out an optimum fertilizer dose on turmeric in Madhupur tract. Six treatment combinations viz. T₁: STB T₂: T₁ + 20% extra NK, T₃: T₁ + 20% extra NKS, T₄: T₁ + 20% extra NKSZn, T₅: IPNS basis fertilizer with cowdung (5 t ha⁻¹), T₆: Farmers' practice. The experiment was laid out in randomized complete block design with three compact replications. The treatments showed significant differences in terms of yield and yield contributing characters. The highest fresh rhizome yield (20.17 t ha⁻¹) was recorded from IPNS basis fertilizer with 5 t ha⁻¹ cowdung i.e. (91-20-66-8-1.5-1.2 kg NPKSZnB ha⁻¹) treatment combination. The highest gross return (Tk. 605100 ha⁻¹) and gross margin (Tk. 428827 ha⁻¹) were recorded from IPNS treatment (T₅) which received 5 t cowdung ha⁻¹ i.e. 91-20-66-8-1.5-1.2 kg NPKSZnB ha⁻¹. The lowest gross return (Tk. 413700 ha⁻¹) and gross margin (Tk. 235658 ha⁻¹) were obtained from

farmers practice (T₆). The results indicated that the application of IPNS basis fertilizer with 5 t ha⁻¹ cowdung ie. 91-19.5-65.5-8-1.5 kg NPKSZn ha⁻¹ dose is the optimum fertilizer dose to produce maximum rhizome yield and higher economic return.

Introduction

Turmeric (*Curcuma longa*) is one of the major spices crop grown in Bangladesh. Turmeric is cultivated in 3257 hectare land and produces 14372 ton yield in Tangail District (DAE, Tangail, 2021). The farmers of the Madhupur are as usually used to cultivate local turmeric variety and they do not apply the proper fertilizer management in that area. As a result, farmer does not get the maximum benefit from turmeric cultivation. Spices Research Centre of Bangladesh Agricultural Research Institute has released a number of variety with their recommended fertilizer dose for Madhupur tract for turmeric cultivation. In hill area of Madhupur there is enough scope for improved and economically profitable fertilizer management package for turmeric cultivation. So the present study was undertaken to find out the optimum fertilizer dose for turmeric in Madhupur tract and also increase productivity and economic return of farmers.

Materials and Methods

A field experiment was conducted at MLT site, Madhupur (AEZ-28), Tangail during 2023-24 to find out an optimum fertilizer dose on Turmeric in Madhupur tract. Before conducting the experiment, initial composite soil samples (0-15 cm) were collected from the experimental plots and collected samples were analyzed. The initial soil analysis values were presented in Table 1. Soil test values indicate that the soils of experimental plots are strongly acidic in nature. So, 4 kg per decimal agricultural lime (CaCO₃) was used to maintain soil acidity and it was applied 15 days prior to planting. The experiment was laid out in randomized complete block design with three compact replications on BARI Halud-5. The unit plot size was 8m × 5m. Six treatment combinations were followed T₁: STB (116-27-77-8-1.5 kg N-P-K-S and Zn ha⁻¹), T₂: T₁ + 20% extra NK (139-27-92-8-1.5 kg N-P-K-S-Zn ha⁻¹), T₃:T₁ + 20% extra NKS (139-27-92-9.6-1.5 kg N-P-K-S-Zn ha⁻¹), T₄:T₁ + 20% extra NKSZn (139-27-92-8-1.8 kg N-P-K-S-Zn ha⁻¹), T₅: IPNS basis fertilizer (91-19.5-65.5-8-1.5 kg N-P-K-S-Zn ha⁻¹ along with 5 t cowdung ha⁻¹), T₆: Farmers' practice (115-50-125-16-1.0 kg N-P-K-S-Zn ha⁻¹). Except N, entire nutrients and half of K were applied during final land preparation in the form of TSP, MoP, gypsum, zinc sulphate. Urea and rest MoP were top dressed in three installments at 50, 80 and 120 days after planting. The seeds (rhizome) were planted @ 2000 kg ha⁻¹ during 18-20 April, 2023. Weeding and other crop management practices were done properly for normal growth of the crop. A little leaf blight was found at the middle to later growth stages of plant in all the treatment which was controlled successfully through Tilt spray. The crop was harvested during 24-28 February, 2024. Necessary data were collected plot wise and analyzed statistically using Statistics10 and presented in Table 2.

Table 1. Chemical properties of initial soil (0 -15 cm depth) of the experimental field at MLT site Madhupur during 2023-24

Soil test value	pH	OM	Total N	K	Ca	Mg	P	S	Zn	B
		(%)	(%)	(meq/100g soil)			ppm			
	5.1	1.39	0.01	0.25	1.7	1.8	8.08	2.18	0.462	0.30
Interpretation	Strongly acidic	Low	Very low	Medium	Low	High	Low	Low	Medium	Low

Results and Discussions

The result revealed that plant height, yield and yield contributing characters were significantly influenced by the nutrient management. Significantly the tallest plant (176.60 cm) was observed in the treatment when plants were treated with STB plus 20% extra NK followed by farmers practice (T₆) (160.67 cm) and the shortest plant was observed in IPNS (T₅) (160.67cm). Maximum number of primary fingers per plant was found in T₅ treatment (8.66), which was statistically identical with other treatments. The maximum number of secondary fingers per plant was obtained from IPNS basis treatment (31.04), though it was at par with T₄ treatment (30.11). The lowest number of secondary fingers per plant was obtained from T₆ treatment (25.48). The finger

weight per plant was recorded maximum from T₅ treatment (229.33 g) and the lowest in T₆ treatment (148.67 g). The rhizome yield varied from 13.79 to 20.17 t ha⁻¹ in the different treatments. The highest rhizome yield (20.17 t ha⁻¹) was recorded in T₅ treatment IPNS basis fertilizer with cowdung (5 t ha⁻¹) followed by T₄ treatment (17.17 t ha⁻¹) and T₃ (17.03 t ha⁻¹). Whereas T₆ treatment (Farmers' practices) gave the lowest rhizome yield (13.79 t ha⁻¹) which was statistically identical with T₁ treatment (STB as per FRG' 2018). As the number of fingers per plant and the finger weight per plant were higher in T₅ treatment, the highest yield obtained in that treatment was justified (Table 2).

Cost and return analysis: The maximum gross return (Tk. 605100 ha⁻¹) and gross margin (Tk. 428827 ha⁻¹) were recorded from the treatment IPNS with 5 t cowdung ha⁻¹ i.e. 91-20-66-8-1.5-1.2 kg NPKSZnB ha⁻¹. The lowest gross return (Tk. 413700 ha⁻¹) and gross margin (Tk. 235658 ha⁻¹) were obtained from farmers practice (115-50-125-16-1.0 kg N P K S Zn ha⁻¹) (Table 3).

Farmers' opinion: Farmers are impressed to see the higher yield and economic return of BARI Halud-5 with IPNS basis (91-20-66-8-1.5- 1.2 kg NPKSZnB ha⁻¹ with 5 t cowdung ha⁻¹) nutrient management and willing to apply in next year cultivation.

Table 2. Effect of nutrient management packages on yield and yield contributing characters of turmeric at Madhupur (AEZ-28) during 2023-24

Treatment	Plant height (cm)	Primary finger plant ⁻¹ (no.)	Secondary finger plant ⁻¹ (no.)	Finger wt. plant ⁻¹ (g)	Rhizome yield (t ha ⁻¹)
T ₁	161.87	7.29	27.23	187.00	15.93
T ₂	176.60	7.79	29.37	188.00	16.03
T ₃	166.67	6.50	29.87	194.00	17.03
T ₄	168.90	7.37	30.11	197.33	17.17
T ₅	160.67	8.66	31.04	229.33	20.17
T ₆	174.30	5.50	25.48	148.67	13.79
CV (%)	5.80	6.02	7.88	8.23	10.98
LSD (0.05)	7.97	1.52	8.02	17.48	3.33

T₁: STB (116-27-77-8-1.5 kg N-P-K-S and Zn ha⁻¹) (FRG; 2018), T₂: T₁ + 20% extra NK (139-27-92-8-1.5 kg N-P-K-S-Zn ha⁻¹), T₃: T₁ + 20% extra NKS (139-27-92-9.6-1.5 kg N-P-K-S-Zn ha⁻¹), T₄: T₁ + 20% extra NKSZn (139-27-92-8-1.8 kg N-P-K-S-Zn ha⁻¹), T₅: IPNS basis fertilizer (91-19.5-65.5-8-1.5 kg N-P-K-S-Zn ha⁻¹ along with 5 t cowdung ha⁻¹), T₆: Farmers' practice (115-50-125-16-1.0 kg N-P-K-S-Zn ha⁻¹)

Table 3. Cost and return analysis of turmeric as influenced by different nutrient management packages at MLT site Madhupur (AEZ-28) during 2023-24

Treatment	Rhizome yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	15.93	477900	176662	301238
T ₂	16.03	480900	177747	303153
T ₃	17.03	510900	177723	333177
T ₄	17.17	515100	177723	337377
T ₅	20.17	605100	176273	428827
T ₆	13.79	413700	178042	235658

Input and output price per Kg: Rhizome as seed= Tk. 30, Urea= Tk. 22, TSP= Tk. 22, MoP= Tk. 15, Gypsum= Tk. 12, Boric acid= Tk. 200, Zinc sulphate= Tk. 500, Labour= Tk. 550

Conclusion

There was an overall increase of yield in all the treatment over farmers practice. Soil test based fertilizers along with 5 t cowdung ha⁻¹ i.e. IPNS basis 91-19.5-65.5-8-1.5 kg NPKSZn ha⁻¹ contributed to achieve the sustainable crop production in the hill tract of Madhupur.

25. INTEGRATED NUTRIENT MANAGEMENT FOR GROWTH AND YIELD OF BARI BEGUN-12

U. K. LAILY, M. Z. FERDOUS, M. K. ISLAM, M. U. S. KHATUN AND M. A. H. TALUKDER

Abstract

The field experiment was conducted during the Rabi season of 2023-2024 in On Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Rangpur to observe the effect of organic fertilizer on the growth and yield of BARI Begun-12. Five fertilizer doses viz. T₁: Soil test based fertilizer dose (STB), T₂: Recommended fertilizer dose (RFD), T₃: STB + Vermicompost 3.0 t ha⁻¹ and T₄: STB + Cowdung 10.0 t ha⁻¹ and T₅: Control. Among the treatments, the highest number of fruits plant⁻¹ (9.60) and fruit yield (53.22 t ha⁻¹) were obtained from T₃ (STB + Vermicompost 3.0 t ha⁻¹) treatment. The lowest number of fruits plant⁻¹ (7.02) and fruit yield (37.10 t ha⁻¹) were obtained from T₅ (control) treatment. The highest gross return (Tk. 1064400 ha⁻¹) and gross margin (Tk. 670260 ha⁻¹) was also recorded from T₃ (STB + Vermicompost 3.0 t ha⁻¹) treatment. The lowest gross return (Tk. 742000 ha⁻¹) and margin (Tk. 352815 ha⁻¹) were recorded from T₅ treatment, respectively.

Introduction

One of the key components in raising agricultural productivity is fertilizer. Modern cultivars of many crops require comparatively more fertilizer than traditional cultivars in order to achieve a good yield. However, because fertilizers are expensive, Bangladeshi farmers frequently cannot afford to utilize the necessary quantity of fertilizers. On the other hand, the organic matter content of most of the soils of Bangladesh is very low (0.8-1.8%) as compared to desired (2.5% and above) levels (Hossain *et al.*, 1995). Therefore, it becomes an immense need to formulate an optimum fertilizer recommendation that would produce satisfactory yields and would maintain soil health to ensure sustainable crop production. One of the alternatives to economize the use of chemical fertilizer is to incorporate crop residues or farmyard manure in combination with chemical fertilizers (Ferdous *et al.*, 2018, 2020). Organic matter in combination with chemical fertilizer showed excellent response to rice cultivation reported Bhuiya and Akanda (1982). Brinjal (*Solanum melongena*) is the third most important vegetables in terms of both yield and production area in Bangladesh. Recently Bangladesh Agricultural Research Institute (BARI) developed new varieties BARI Begun-12. It has potentiality to bump up the yield and brinjal production of the country. BARI Begun-12 is gaining popularity in farmers all over Bangladesh for its size and shape. But 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. Hence, higher fertilizer dose may require for full exploitation of yield potentiality of brinjal in our country. Now, there is a need to resort the fertilizer requirement for BARI Begun-12. Integrated plant nutrient management is the application of inorganic fertilizer in combination with organic fertilizer to maintain soil fertility and to balance nutrient supply in order to boost up the crop yield per unit area (Patra *et al.*, 2000, Roberts *et al.*, 2017). Organic matter in soil is an imperative indicator of soil fertility which can improve soil structure, nutrient exchange and maintain soil physical conditions. Optimum dose of fertilizer application provides better agronomic and economic benefits to vegetable growers. Therefore, the present investigation was undertaken to determine the optimum organic fertilizer dose for growth and yield of BARI Begun-12.

Materials and Methods

The experiment was conducted at On Farm Research Division, BARI, Rangpur during the Rabi season 2023-24 with a view to find out the optimum dose of fertilizer of brinjal. Geographical location of the station is Latitude: 25°43.258'N, Longitude: 089°15.732'E, with an elevation of 32.2 m from the sea level. The soil belongs to the general soil type under the AEZ-3 (Anowar *et al.*, 2015; Ferdous *et al.*, 2016). The land was medium high with loamy to sandy loam. Before conducting the experiment, the soil sample was analyzed from SRDI, Rangpur. Initial soils status of the experimental plots was analyzed (Table 1). The experiment was laid out in a randomized complete block design with three replications. There were five treatments. T₁: Soil Test Based

fertilizer Dose (STB) (133.18-25-51.50-6.66-0.85-2.69 NPKSBZn kg ha⁻¹), T₂ : Recommended fertilizer dose (RFD) (138.25-50-100-17.99-1.70-0 NPKSZn kg ha⁻¹), T₃: STB (133.18-25-51.50-6.66-0.85-2.69 NPKSBZn kg ha⁻¹) + Vermicompost 3.0 t ha⁻¹, T₄: STB (133.18-25-51.50-6.66-0.85-2.69 NPKSBZn kg ha⁻¹) + Cowdung 10 t ha⁻¹ and T₅ : Control (90.92-203.2-77.5-8.99-0-0 NPKSBZn kg ha⁻¹). The unit plot size was 5 m × 4.8 m. One third of MoP and rest of other fertilizers except urea were applied during final land preparation. Remaining two third of MoP was divided into three split and applied at 20 DAP, at flowering stage and fruiting stage. Urea was applied in four equal installments at 20 DAP, at flowering stage and two times at fruiting stage. Dates of transplanting were 18 October 2023. Crops were harvested from 1st January, 2024. Standard crop management practices with irrigation, weeding and lower branch pruning were done properly. Plant protection measures for other pest were taken. Furadan was applied @ 33 kg ha⁻¹ during transplanting. Five plants were selected randomly from each plot to record plant height, individual fruit weight, length and breadth of fruit. Collected data were compiled and analyzed with Statistix10 software. Production costs of brinjal included the cost of all operations (eg., land preparation, seed, sowing, irrigation, application of organic manure and chemical fertilizer, spraying of insecticides and fungicides, and harvesting). White fly, Jasid, aphid and brinjal fruit and shoot borer infestation was observed that was well controlled by spraying of insecticides. To prevent issues with wilting, the fungicide Kasumin 2% SL (kasugamycin) was applied. 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.

Table 1. Initial status of soils of the experimental plots, at OFRD, Rangpur

Observation	pH	OM (%)	Total N (%)	Mg	K	P	S	B	Zn
				meq/100g soil	ppm				
Value	5.8	1.65	0.10	2.03	0.26	112.73	24.30	-	2.01
Critical level	-	-	0.12	0.5	0.12	7.0	10.0	0.2	0.6
Interpretation	Slightly acid	Low	Low	Very high	High	Very high	Optimum	Low	Very high

Source: Soil Resources Development Institute, Rangpur, Year 2023-24

Results and Discussions

The yield and yield contributing characters of brinjal such as fruit length, number of fruits plant⁻¹ and fruit yield differed significantly due to different fertilizer management (Table 2) but plant height, fruit diameter and single fruit weight showed non significance difference. The highest plant height (83.47 cm) was recorded from T₂ (RFD) fertilizer treatment. The highest fruit length (25.70 cm), number of fruits plant⁻¹ (9.26), single fruit weight (0.697 kg) and fruit yield (53.22 t ha⁻¹) was recorded from T₃ (STB + Vermicompost 3.0 t ha⁻¹) treatment and the second height fruit yield was found from T₁ (STB) treatment. The present results are in line with the findings of Ferdous, *et al.* (2018 and 2020), Rahman *et al.* (2011), Yadav and Garg (2016), and Haque *et al.* (2018), who also reported better yields of field and vegetable crops with the application of vermicompost, poultry manure and bio slurry. The yield benefits associated with organic manure (cowdung or poultry manure or poultry bio slurry) application are credited to its higher nutrient supplying capacity compared with chemical fertilizer (Haque *et al.*, 2018). The lowest fruit yield (37.10 t ha⁻¹) was found in T₅ (control) treatment.

Cost and return analysis: The highest gross return (Tk. 1064400 ha⁻¹) and gross margin (Tk. 670260 ha⁻¹) was found in T₃ (STB + Vermicompost 3 t ha⁻¹) treatment. The variable cost was also higher in T₃ (STB + Vermicompost 3.0 t ha⁻¹) treatment because of higher price of vermicompost. Ferdous *et al.* (2018) reported that variable cost in the treatment IPNS was higher because of the additional cost of bioslurry. The lowest gross return (Tk. 742000 ha⁻¹) and gross margin (Tk. 352815 ha⁻¹) were recorded from T₅ (control) treatment.

Table 2. Yield and yield contributing characters of BARI Begun-12 at OFRD, BARI, Rangpur during 2023-24

Treatments	Plant height (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruits plant ⁻¹ (no)	Single fruit wt (kg)	Fruit yield (t ha ⁻¹)
T ₁ : Soil Test Based Fertilizer	78.23	23.53b	9.42	8.57ab	0.693	47.28ab
T ₂ : Recommended Fertilizer Dose	83.47	23.07b	9.36	8.00bc	0.683	43.43bc
T ₃ : STB + Vermicompost 3 t ha ⁻¹	76.70	25.70a	9.29	9.60a	0.697	53.22a
T ₄ : STB + Cowdung 10 t ha ⁻¹	72.43	23.13b	9.26	8.44abc	0.680	45.46b
T ₅ : Control	77.43	21.13c	9.28	7.02c	0.667	37.10c
Level of significance	NS	**	NS	*	NS	**
CV (%)	4.84	4.04	2.60	9.81	7.51	9.01
LSD (0.05)	11.40	1.78	0.46	1.54	0.097	7.68

Table 3. Cost and return analysis of BARI Begun-12 at OFRD, BARI, Rangpur during 2023-24

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁ : Soil Test Based Fertilizer	945800	376641	569159
T ₂ : Recommended Fertilizer Dose	868600	392245	476355
T ₃ : STB + Vermicompost 3 t ha ⁻¹	1064400	394140	670260
T ₄ : STB + Cowdung 10 t ha ⁻¹	909200	389140	520060
T ₅ : Control	742000	389185	352815

Price (Tk./kg): Brinjal = 20

Conclusion

Highest yield and gross return was found from the combination of STB + Vermicompost 3 t ha⁻¹ fertilizer treatment. This is the results of 1st year study. For more confirmation trial should be repeated in the next year.

26. EFFECT OF GYPSUM FERTILIZER ON GROUNDNUT IN CHARLAND

MOST. UMMAY SALMA KHATUN, MD. ZANNATUL FERDOUS, MD. KHAIRUL ISLAM, UMMAY KULSUM LAILY AND MD. AL-AMIN HOSSAIN TALUKDER

Abstract

A field trial was conducted in the farmer's field under stable Charland of Bongram, Chilmari, Kurigram during Rabi 2023-24 to identify the suitable dose of gypsum as a source of calcium and sulphur fertilizer under water deficit condition. Four gypsum fertilizer treatments (T₁: Recommended dose (RDCF), T₂: RDCF+25% of recommended gypsum, T₃: RDCF+50% of recommended gypsum and T₄: Farmer's practice) were tested in the farmer's field. The variety was BARI Chinabadam-8. Among the treatments, the T₃ (2.38 t ha⁻¹) gave the maximum pod yield and 2nd highest yield produced by T₂ (2.10 t ha⁻¹). The T₁ gave minimum yield (1.56 t ha⁻¹). The maximum gross return (309400 Tk. ha⁻¹) and gross margin (140475 Tk. ha⁻¹) was also obtained from T₃.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important food legume and oilseed crop in the world. It belongs to the botanical family Fabaceae also called as Leguminosae. It is very rich in protein and quality oil (Gohari *et al.* 2014; Gohari and Niyaki, 2010). It is also an economically important food legume containing 44-56% oil and 22-30% protein on a dry seed basis. Groundnut is an important warm-season oilseed crop and is one of the most important oil producing crops in Bangladesh and ranking second in area and production (Jahan *et al.*, 2022). In Bangladesh, groundnut is grown in both the *Rabi* and *Kharif* seasons. Groundnut is a major cash crop in the

semi-arid tropics, where it is mostly grown under rain fed conditions. Because of lower farming cost and excellent market price with huge demand farmers have been expanding groundnut cultivation every year in Bangladesh. But yield of groundnut is not satisfactory. The low yield in groundnut is ascribed by bad weather conditions, drought stress and high temperature and salinity stresses. Among the environmental stresses the drought stress is the most important one, which limits production of groundnut. Drought in many parts of the world, especially in warm and dry areas crop yield drastically reduces (Porudad and Beg, 2003). Drought is considered as the major abiotic stress in many parts of the world (Malhotra *et al.*, 2004). At present, drought stress is a very common problem in northern region of Bangladesh. To deal with water scarce conditions small scale solutions would be more acquiescent and can be easily implemented with high probability of large-scale changes (Munang and Nkem, 2011). Calcium is the most critical element in growth and development of groundnut seeds. Enough calcium content in the soil around the groundnut pods leads to increased yield, oil content and protein content of the kernel. Calcium fertilizer under drought stress could promote groundnut growth, increase the chlorophyll content, leaf photosynthetic rate and the root vitality, increase the recovery ability of groundnut during rewatering after drought stress, alleviate the impact of drought stress on groundnut. Applying Ca fertilizer under drought stress increased pod and kernel yields because of the increase of kernel rate and pod number per plant. It also increased the fat and protein contents of groundnut kernel, and improved kernel quality under drought stress. To get good yields of quality groundnut pods, an adequate amount of Ca should be present in the soil from early flowering of crop production onwards. Calcium is an essential plant nutrient that plays a significant role in groundnut seed development at the end of the growing season. So, application of calcium is necessary for pod growth and increased peg strength. David *et al.* (2001) found that calcium increases pod yield and improves market grade factors. Gypsum enhances soil structure by improving water penetration and reducing crusting, which is known for its effective pegging and supports the creation and filling up of pods in groundnut. Calcium and sulphur also play an important role in enhancing production and productivity of groundnut. In Bangladesh, groundnut is primarily grown in dry river beds, and drought seems to adversely affect groundnut yield and quality. In northern region of Bangladesh, stable charland area is increasing day by day and there is a scope to produce and expand groundnut in the charland area. Therefore, it is necessary to study the effect of gypsum fertilizer on groundnut under charland. From the above views, the present research work was conducted to identify the suitable dose of gypsum fertilizer for groundnut under drought condition of charland.

Materials and Methods

The field trial was conducted at stable Charland of Bongram, Chilmari, Kurigram (AEZ-2) during the Rabi 2023-24. 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 30 cm row to row distance and seed to seed were 15 cm. Seeds were sown on 04-12 October, 2023. Four gypsum fertilizer treatments viz., T₁= recommended dose of chemical fertilizer (RDCF), T₂=RDCF+25% of recommended gypsum, T₃=RDCF+50% of recommended gypsum and T₄=Farmer's practice was used for the study. The variety was BARI Chinabadam-8. The whole land was fertilized with 46-25-30-1-2 N-P-K-B- zinc, respectively. Half dose of nitrogen fertilizer and full dose of all other fertilizers were applied as basal and the remaining N fertilizer was applied as top dress. Cowdung was also applied at the rate of 10 t ha⁻¹ before final land preparation and incorporated in the soil properly. The initial soil samples of the experimental field were collected and analyzed following standard methods (Table 1). The Gypsum was used as a source of Ca and S nutrients and calculated based on soil test value (STB dose 172 kg ha⁻¹ gypsum). The gypsum was applied as treatment specification to different plots. The crop was harvested on 26 February 04 March, 2024. The seed yield and yield components of groundnut were recorded and analyzed statistically.

Table 1. Initial status of soils of the experimental plots at Char Bongram, Chilmari, Kurigram

Observation	pH	OM (%)	Total N	Ca	Mg	K	P	S	B	Zn
				meq/100g			$\mu\text{g/g}$			
Value	7.6	0.28	0.01	-	1.47	0.18	5.59	38.28	-	2.07
Critical level	-	-	0.12	2.0	0.5	0.12	7.0	10.0	0.2	0.6
Interpretation	Slightly alkaline	Very Low	Very Low	-	Optimum	Medium	Low	High	Low	High

Source: Soil Resources Development Institute, Rangpur, Year 2023-24

Results and Discussions

A significant variation was observed among the treatments on the yield and most of the yield contributing parameters (Table 2). The maximum plant height (31.17 cm) was recorded from T₃. Maximum number of pods plant⁻¹ (11.17) was recorded from T₃ followed by T₂ (10.33). Among the treatments, T₃ (2.38 t ha⁻¹) gave the maximum pod yield and the T₄ (1.56 t ha⁻¹) contributed the minimum one. The maximum gross return (309400 Tk. ha⁻¹) and gross margin (140475 Tk. ha⁻¹) was obtained from T₃ (Table 3).

Farmer's opinion: Farmers opined that application of higher amount of gypsum fertilizer produced higher nut pod yield than recommended dose and farmer's practice.

Table 2. Effect of gypsum fertilizer on yield and yield attributes of groundnut at Chilmari, Kurigram during 2023-24

Treatment	Plant height (cm)	Pod plant ⁻¹ (no)	Pod wt plant ⁻¹ (g)	100 kernel wt. (g)	Yield (t ha ⁻¹)
RDCF	30.17a	8.17b	20.17c	45.17a	1.77c
RDCF+25% Rec gypsum	31.0a	10.33a	22.0b	45.17a	2.10b
RDCF+50% Rec gypsum	31.17a	10.67a	24.83a	45.33a	2.38a
Farmer's practice	29.33a	7.67b	18.17d	45.0a	1.56d
Level of significance	NS	**	**	NS	**
CV (%)	5.18	7.22	5.26	5.46	6.97
LSD (0.05)	1.937	0.817	1.377	3.033	0.194

Table 3. Cost and return of groundnut at Chilmari, Kurigram during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
RDCF	230100	167575	62525
RDCF+25% Rec gypsum	273000	168250	104750
RDCF+50% Rec gypsum	309400	168925	140475
Farmer's practice	202800	157293	45507

Price (Tk./kg): Groundnut=130

Conclusion

The highest yield and gross return were found from T₃ (RDCF+50% of recommended gypsum). This is the first year result in charland of Char Bongram. However, this experiment needs to repeat for further evaluation in the next year.

27. EFFECT OF POTASSIUM FERTILIZER ON GROUNDNUT IN CHARLAND

MOST. UMMAY SALMA KHATUN, MD. ZANNATUL FERDOUS, MD. KHAIRUL ISLAM, UMMAY KULSUM
LAILY AND MD. AL-AMIN HOSSAIN TALUKDER

Abstract

A field trial was conducted in the farmer's field under stable Charland of Bongram, Chilmari, Kurigram during Rabi 2023-24 to identify the suitable dose of potassium fertilizer under water deficit condition. Four potassium fertilizer treatments (T_1 : Recommended dose of MoP (RDCF), T_2 : RDCF+25% of recommended MoP, T_3 : RDCF+50% of recommended MoP and T_4 : Farmer's practice) were tested in the farmer's field. The variety was BARI Chinabadam-8. The potassium fertilizer was tested for yield and yield components like plant height, no. of pods plant⁻¹, weight of pods plant⁻¹, 100 kernels wt. and pod yield etc. Among the treatments, T_3 (2.39 t ha⁻¹) gave maximum pod yield and 2nd highest seed yield produced by T_2 (2.07 t ha⁻¹). T_1 gave minimum yield (1.57 t ha⁻¹). The maximum gross margin (Tk. 142165 ha⁻¹) was obtained from T_3 .

Introduction

Groundnut (*Arachis hypogaea* L.) is an important food legume and oilseed crop in the world. It belongs to the botanical family Fabaceae also called as Leguminosae. It is very rich in protein and quality oil (Gohari *et al.* 2014; Gohari and Niyaki, 2010). It is also an economically important food legume containing 44-56% oil and 22-30% protein on a dry seed basis. Groundnut is an important warm-season oilseed crop and is one of the most important oil producing crops in Bangladesh and ranking second in area and production. In Bangladesh, groundnut is grown in both the *Rabi* and *Kharif* seasons. Groundnut is a major cash crop in the semi-arid tropics, where it is mostly grown under rain fed conditions. Because of lower farming cost and excellent market price with huge demand farmers have been expanding groundnut cultivation every year in Bangladesh. But yield of groundnut is not satisfactory. The low yield in groundnut is ascribed by bad weather conditions, drought stress and high temperature and salinity stresses. Among the environmental stresses the drought stress is the most important one, which limits production of groundnut. Drought in many parts of the world, especially in warm and dry areas crop yield drastically reduces (Porudad and Beg, 2003). Drought is considered as the major abiotic stress in many parts of the world (Malhotra *et al.*, 2004). At present, drought stress is a very common problem in northern region of Bangladesh. To deal with water scarce conditions small scale solutions would be more acquiescent and can be easily implemented with high probability of large-scale changes (Munang and Nkem, 2011). Potassium as a macro-nutrient plays important roles in plant growth and development. Potassium has a role in cell expansion, maintains the turgor pressure of plants, assists in osmo regulation of cell, helps in opening and closing of stomata and activates more than 60 enzymes (Hawkesford *et al.*, 2012). In Bangladesh, groundnut is primarily grown in dry river beds, and drought seems to adversely affect groundnut yield and quality. In northern region of Bangladesh, stable charland area is increasing day by day and there is a scope to produce and expand groundnut in the charland area. Therefore, it is necessary to study the effect of potassium fertilizer on groundnut under charland. From the above views, the present research work was conducted to identify the suitable dose of potassium fertilizer for groundnut under drought condition of charland.

Materials and Methods

The field trial was conducted at stable Charland of Bongram, Chilmari, Kurigram (AEZ-2) during the Rabi 2023-24. 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 30 cm row to row distance and seed to seed were 15 cm. Seeds were sown on 04-12 October, 2023. Four potassium fertilizer treatments viz., T_1 : recommended dose of chemical fertilizer (RDCF), T_2 : RDCF+25% of recommended MoP, T_3 : RDCF+50% of recommended MoP and T_4 : Farmer's practice was used for the study. The variety was BARI Chinabadam-8. The whole land was fertilized with 43-25-31-1.23-2 N-P-S-B-Zn kg ha⁻¹ in the form of urea, triple super phosphate, gypsum and boric acid,

respectively. Half dose of nitrogen fertilizer and full dose of all other fertilizers were applied as basal and the remaining N fertilizer was applied as top dress. Cowdung was also applied at the rate of 10 t ha⁻¹ before final land preparation and incorporated in the soil properly. The initial soil samples of the experimental field were collected and analyzed following standard methods. Soil chemical properties has been presented in Table 1. The K was used as a form of muriate of potash (MoP) and calculated based on soil test value (STB dose 30 kg ha⁻¹ gypsum). The MoP was applied as treatment specification to different plots. The crop was harvested on 24 February-03 March, 2024. The seed yield and yield components of groundnut were recorded and analyzed statistically.

Table 1. Initial status of soils of the experimental plots at Char Bongram, Chilmari, Kurigram

Observation	pH	OM (%)	Total N (%)	Mg	K	P	S	B	Zn
				meq/100g soil			ppm		
Soil test value	8.1	0.55	0.03	1.62	0.15	10.12	48.05	-	1.93
Critical level	-	-	0.12	0.5	0.12	7.0	10.0	0.2	0.6
Interpretation	Slightly alkaline	Very Low	Very Low	High	Low	Medium	Very High	Low	High

Source: Soil Resources Development Institute, Rangpur, Year 2023-24

Results and Discussions

A significant variation was observed among the treatments on the pod yield and most of the yield contributing parameters (Table 2). Among the K level, T₃ (2.39 t ha⁻¹) which contained 25% higher K nutrient gave the maximum pod yield. The T₄ produced the minimum yield (1.57 t ha⁻¹). The highest number of pods plant⁻¹ (11.17) was recorded from T₃ which contributed to higher pod yield in the treatment. The maximum gross return (310700 Tk. ha⁻¹) and gross margin (142165 Tk. ha⁻¹) was obtained from the same treatment T₃ (Table 3).

Farmer's opinion: Farmers are opined that application of higher amount of potassium fertilizer than recommended does increased groundnut yield compared to RDCF and farmer's practice.

Table 2. Effect of potassium fertilizer on yield and yield attributes of groundnut at Chilmari, Kurigram during 2023-24

Treatment	Plant height (cm)	Pod plant ⁻¹ (no)	Pod wt. plant ⁻¹ (g)	100 kernel wt (g)	Yield (t ha ⁻¹)
RDCF	29.17b	9.33c	18.57c	45.0a	1.75c
RDCF+25% Rec MoP	29.67ab	10.33b	21.60b	45.33a	2.07b
RDCF+50% Rec MoP	31.0a	11.17a	23.53a	45.33a	2.39a
Farmer's practice	27.17c	7.33d	16.63d	45.0a	1.57d
Level of significance	**	**	**	NS	**
CV (%)	5.03	6.97	5.63	5.01	5.20
LSD (0.05)	1.811	0.817	1.391	2.785	0.138

Table 3. Cost and return of groundnut at Chilmari, Kurigram during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
RDCF	227500	167106	60394
RDCF+25% Rec MoP	269100	167823	101277
RDCF+50% Rec MoP	310700	168535	142165
Farmer's practice	204100	157293	46807

Price (Tk./kg): Groundnut=130

Conclusion

The highest pod yield and gross return was recorded from T₃ (RDCF+50% of recommended MoP) treatment. So, we can recommend farmers to apply T₃ (RDCF+50% of recommended MoP) for groundnut cultivation at Charland of Chilmari. The experiment needs to repeat for further evaluation in the next year.

28. EFFECT OF NUTRIENT MANAGEMENT ON THE PRODUCTIVITY OF MUSTARD (CANOLA) IN NORTH-WEST BANGLADESH

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Abstract

The area of Rapeseed-Mustard in Bangladesh is increasing rapidly due to development of high yielding varieties and higher price of edible oil. However, unbalanced fertilization is one of the main challenges that affects its seed yield. A field trial was carried out at three locations viz., Barind land of Godagari under Rajshahi (AEZ-26), char land of Bogura Sadar (AEZ-3) and on-station of Rangpur (AEZ-3) under supervision of OFRD of Bangladesh Agricultural Research Institute during Rabi 2023-24 to find out an optimum and economic fertilizer dose for BARI Sarisha-18. The experiment consists of four nutrient packages for all sites viz., T₁: Soil test-based fertilizer (STB) (FRG' 2018), T₂: T₁ +25% NPKS, T₃: T₁ +50% NPKS, T₄: Farmers Practices (Average of 20 Farmers). The additional one treatment namely Khamari app based nutrient package was for Rangpur. The experiment was laid out in a randomized complete block design with three replications. In Rajshahi, the T₃ (2.17 t ha⁻¹) produced the highest seed yield which was similar that of T₂ (1.87 t ha⁻¹). The T₃ also gave the maximum gross return (Tk. 151900 ha⁻¹), gross margin (Tk. 123742 ha⁻¹) and MBCR (2.88). In Bogura, the T₃ also showed the highest seed yield (2.07 t ha⁻¹), gross return (Tk. 143610 ha⁻¹) and gross margin (Tk. 94110 ha⁻¹). But the T₁ gave the highest seed yield (1.79 t ha⁻¹), gross return (Tk. 124999 ha⁻¹), gross margin (Tk. 76717 ha⁻¹) and MBCR (1.59).

Introduction

Rapeseed-Mustard is the most important oil crop contributing the lion share in the domestic edible oil of Bangladesh. Its area coverage and production are increasing gradually due to development of short duration and high yield potential varieties by BARI and Bangladesh Govt. initiatives. Bangladesh Agricultural Research Institute (BARI) has developed a high-quality canola type oil-seed variety (BARI Sarisha-18). This variety has less amount of erucic acid content which is not harmful to human body and it is proved as good quality cooking oil. It is high yielding and market price is higher. The area and demand of this variety is increasing tremendously due to its potentiality of fitting in the Mustard-Boro-T. Aman rice cropping pattern. The seed yield of BARI Sarisha-18 is being fluctuated (DAE, 2023). Some farmers reported that seeds of late sown mustard show shrinkage and low or late germination tendency. This might be due to imbalanced fertilizer management practice. Additionally, the soil of AEZ-3 and AEZ-26 is characterized by low pH and deficit in micronutrient especially boron which is very crucial for seed formation. Normally, farmers apply similar dose of fertilizer as of short duration varieties. The fertilizer rate could not be fulfilled the demand of BARI Sarisha-18 for potential yield. Crop production system with high yield targets cannot be sustainable unless nutrients are judiciously supplied to soil against nutrient mining. It is utmost need to solve this problem immediately to keep up the ever-increasing cultivation of BARI Sarisha-18 throughout the country for healthy oil production. Keeping these views in mind, the present study has been proposed to determine optimum nutrient package for BARI Sarisha-18 in Rangpur region.

Materials and Methods

The experiment was conducted on mustard (Canola) at farmers field of Farming System Research and Development site, Basantapur, Godagari, Rajshahi (lat. 24.4253804° N; long. 88.4129489° E; 22 masl) under Barind station, Rajshahi; charland of Bogura and on-station of Rangpur under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI) during the period of Rabi 2023-24 to find out an optimum and economic fertilizer dose for mustard (Canola). The experimental sites belong to the agro-ecological zone of High Barind Tract (AEZ#26) and Active Tista Floodplain (AEZ#3). The experimental sites enjoy subtropical monsoon climate characterized by heavy precipitation during the months of April to October and scanty rainfall during the months of November to March. The levels of the fertilizers were calculated on the basis of high yield goal as per Fertilizer Recommendation Guide' 2018. The chemical properties of initial soil are presented in Table 1. The treatments for all sites were T₁: Soil test-based fertilizer

(STB) (FRG, 2018), T₂: T₁ +25% NPKS, T₃: T₁ +50% NPKS, T₄: Farmers Practices (Average of 20 Farmers). The khamari app based nutrient treatment, additional one treatment, was applied for Rangpur site. 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. The canola variety was BARI Sarisha-18. The experiment was laid out in a randomized complete block design with three replications. Size of each unit plot was 20 m² (5×4 m). The seeds were shown on line with spacing 30 cm of line-to-line distance and continuous seeding. The STB fertilizer doses at Rajshahi were used @ 124-25-77-18-2-1 kg ha⁻¹ N-P-K-S-Zn-B and farmers' practice (Average of 20 Farmers) were used @ 86-28-60-14-0-1 kg ha⁻¹ N-P-K-S-Zn-B t ha⁻¹, respectively. For Bogura, 124-30-47-5-2-1.2 kg ha⁻¹ N-P-K-S-Zn-B was the STB based nutrient treatment. Half of urea and all other fertilizers were applied into the soil at the final land preparation. The rest urea was applied as a top-dress at 22-24 days after sowing and after 1st irrigation. The crop was sown on 8 November 2023 at Rajshahi, 28 November 2023 at Bogura and 30 October 2023 at Rangpur. Crop management practice such as weeding, thinning, irrigation and plant protection measures were done as per requirement. The crops were harvested on 25 February 2024 at Rajshahi, 08 March 2024 at Bogura and 17 February 2024 at Rangpur. Data on yield attributes were taken 5 randomly selected plants per plot. Yield was recorded at 10% moisture content of mustard seed. The collected data were compiled and tabulated properly for statistical analysis. Analysis of variance was done with the help of open-source computer package R. Difference among treatment means were tested with least significant difference (LSD) test (R Core Team, 2024).

Results and Discussions

Yield components and seed yield at Rajshahi: Yield and yield attributes of BARI Sarisha-18 were significantly affected by nutrient packages except plant population of unit area (Table 2). Plant height was the maximum when the crop was fertilized with 50% higher rate of NPKS (T₃) of STB dose was applied. The T₂ which required 25% higher rate of NPKS showed similar performance to T₃. The crop fertilized with STB dose and FP produced similar and minimum heighted plant. Treatments T₃ and T₂ gave similar and maximum no. of siliqua plant⁻¹ (152 & 139), seeds siliqua⁻¹ (28.43 & 27.40) and 1000-seed weight (3.78 & 3.73 g) while higher values of the parameters were recorded from T₃. The T₁ which contained STB fertilizer package recorded significantly lower performance in comparison with T₃ and T₂ regarding those parameters. The lowest performance of aforesaid parameters was recorded in T₄ when crop was fertilized with farmers fertilizer practice. Seed yield is a complex character and it depends upon on many characters. The T₃ (2.17 t ha⁻¹) produced the highest seed yield among the treatments due to better performance of yield components. The T₂ (1.87 t ha⁻¹) gave similar seed yield of T₃. The T₁ and T₄ produced identical seed yield between themselves and the values were 1.68 and 1.57 t ha⁻¹, respectively. The lowest seed yield was obtained from T₄ (1.57 t ha⁻¹). Stover yield was the maximum in T₂.

Yield components and seed yield at Bogura: Significant variation was observed among the treatments in all characters except plant population and thousand seed weight (Table 3). The highest plant height was observed in T₃ (128.22 cm) which was identical to T₁ (125.79 cm) and T₂ (125.86 cm) but differed from the T₄ (120.84 cm). The no of siliqua plant⁻¹ was the maximum in T₃ (98.70) that was also similar with T₁ (87.28) and T₂ (90.88) and the T₄ (82.74) gave the lowest one. Better performance yield contributing characters like nos. of seeds siliqua⁻¹ resulted in higher seed yield in T₃ treatment (2.07 t ha⁻¹) followed by T₂ (1.97 t ha⁻¹) and T₁ (1.91 t ha⁻¹) treatments. The highest stover yield was found from T₃ (3.02 t ha⁻¹) followed by T₂ (2.85 t ha⁻¹) and T₁ (2.81 t ha⁻¹) while the lowest stover yield was observed in T₄ (2.59 t ha⁻¹).

Yield components and seed yield at Rangpur: Significant variation was observed among the treatments in yield and yield contributing characters (Table 4). The tallest plants were observed in T₃ (169.21 cm), while the shortest one was in T₅ (149.07 cm). The number of siliques per plant was significantly different among treatments, with T₁ having the highest number (209.77) and T₃ showing the lowest (154.87). The T₁ produced the highest seed yield (1785.7 kg ha⁻¹) and T₃ the lowest (1425.0 kg ha⁻¹). The soil test-based treatment (T₁) demonstrated superior

performance in terms of seed yield. Additional NPKS (T_2 and T_3) did not enhance and sometimes reduced yield, indicating that the basic STB recommendation might be sufficient in the on-station soil.

Cost and return analysis: In Rajshahi, gross return, total variable cost, gross margin and marginal benefit-cost ratio have been shown in Table 5. Treatment T_3 (T_1 +50% NPKS) gave the maximum gross return (Tk. 151900 ha⁻¹) and gross margin (Tk. 123742 ha⁻¹). On the other hand, T_4 (Farmers practice) gave the minimum gross return (Tk. 117600 ha⁻¹) because of its lower yield. The highest MBCR over FP was found in T_3 (2.88) and the lowest one in T_1 (1.24). In Bogura, cost and return analysis from Table 6 indicated that the highest gross return (Tk. 143610 ha⁻¹) was obtained from T_3 followed by T_2 (Tk. 136600 ha⁻¹) and T_1 (Tk. 132580 ha⁻¹) but the lowest gross return (Tk. 121520 ha⁻¹) was observed in T_4 . Higher gross return contributed to the higher gross margin in T_3 (Tk. 94110 ha⁻¹) and lower in T_4 treatment (Tk. 72020 ha⁻¹). In Rangpur, the highest gross return (BDT. 124999 ha⁻¹) was found from soil test-based dose (T_1), while the lowest one (BDT. 99750 ha⁻¹) was from T_3 STB+50% NPKS treatment (Table 7). The total variable cost differed due to the variation in the amount of fertilizer used in different treatments. The highest gross Margin of BDT. 76717 ha⁻¹ was also recorded from T_1 , followed by Khamari apps treatment (Tk. 67782 ha⁻¹), and the lowest one (Tk. 41902 ha⁻¹) was earned from T_3 treatment. The highest MBCR was estimated in T_1 (1.59), followed by Khamari app dose (1.54). Farmers' practice also showed better MBCR (1.34) compared to both the added NPKS treatments.

Farmer's opinion: BARI Sarisha-18 (Canola) is only a healthy edible oil containing variety in Bangladesh. So, Farmers are choosing the variety. But they demanded to develop short duration Canola variety.

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

Depth (0-15 cm)	pH	Organic matter (%)	K	Total N (%)	P	S	B	Zn
			meq/100g soil					
Rajshahi	7.2	1.69	0.13	0.08	14.3	15	0.44	1.19
	Neu	Low	Med	V. low	Med	Low	Med	Med
Bogura	7.02	1.64	0.06	0.08	11.81	11.55	0.29	0.35
	Neu	Low	V. low	V. low	Med	Med	Low	V. low
Rangpur	5.88	1.65	0.10	0.10	112.73	24.30	0.28	2.01
	Alk	Low	Med	Low	V. High	Opt	Low	High

Table 2. Effect of nutrient management on Mustard (Canola) at FSRD site, Basantapur, Godagari, HBT, Rajshahi during 2023-24

Treatment	Plant ht (cm)	Plant Pop. /m ²	Siliqua /Plant	Seed /Siliqua	1000 Seed wt. (g)	Seed yield (t/ha)	Stover yield (t/ha)
T_1 :STB	138.13 bc	76.06	116.73 b	25.73 ab	3.54 b	1.68 b	2.25 c
T_2 :STB+25% NPKS	147.20 ab	79.28	139.00 ab	27.40 a	3.73 ab	1.87 ab	2.79 a
T_3 :STB+50% NPKS	163.06 a	70.57	152.06 a	28.43 a	3.78 a	2.17 a	2.59 b
T_4 :Farmers' practice	128.20 c	76.22	75.73 c	24.10 b	3.27 c	1.57 b	2.10 d
LSD	16.15	28.16	30.87	3.07	0.22	0.43	0.07
CV (%)	5.61	18.66	10.92	5.82	3.17	9.74	1.49

*LSD=least significant difference, CV= co-efficient of variation, STB= soil test based

Table 3. Performance of Mustard at different nutrient combinations in the Bogura under BARI Sarisha-18 during 2023-24

Treatment	Plant height (cm)	Plant Pop./m ²	Siliqua /Plant	Seed /Siliqua	1000 Seed wt. (g)	Seed yield (t/ha)	Stover yield (t/ha)
T_1 :STB	125.79ab	80.89	87.28ab	24.26ab	3.91	1.91ab	2.81ab
T_2 : STB+25%NPKS	125.86ab	81.00	90.88ab	24.43ab	3.96	1.97ab	2.85ab
T_3 :STB+50% NPKS	128.22a	80.64	98.70a	27.00a	3.97	2.07a	3.02a
T_4 :Farmers' practice	120.84b	84.63	82.74b	21.90b	3.88	1.75b	2.59b
CV(%)	2.79	5.27	8.26	9.58	2.11	6.98	7.78

Table 4. Yield and yield attributes of mustard (Canola) as influenced by different nutrient management in Rangpur region

Treatments	Plant height (cm)	Number of branches plant ⁻¹	Number of siliqua plant ⁻¹	Length of pod (cm)	Number of seeds pod	Yield (kg ha ⁻¹)
T ₁ : Soil test based	160.33ab	4.46bc	209.77a	7.37a	26.33a	1785.7a
T ₂ : STB+25% NPKS	162.40ab	4.53abc	187.33b	7.08a	25.33a	1562.3bc
T ₃ : STB+50% NPKS	169.21a	5.20a	154.87c	7.04a	23.77a	1425.0c
T ₄ : Khamari app	165.33a	5.0ab	196.60ab	7.30a	26.11a	1595.7b
T ₅ : Farmers' practice	149.07b	4.22c	167.47c	7.07a	23.89a	1460.3bc
Level of Significance	*	**	**	NS	NS	**

Table 5. Cost and return analysis of Mustard (Canola) at FSRD site, Basantapur, Godagari, HBT, Rajshahi during 2023-24

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR over FP
T ₁ = STB	117600	19772	97828	1.24
T ₂ = STB+25% NPKS	130900	23964	106936	2.02
T ₃ = STB+50% NPKS	151900	28158	123742	2.88
T ₄ = Farmers' practice (FP)	109900	13569	96331	-

Input cost (Tk. kg⁻¹): Urea: 27, TSP:27, MoP:20, gypsum:30, zinc sulphate:200, boric acid:200, Output price⁻¹): BARI Sarisha-18: 70 (average)

Table 6. Cost and return analysis of different nutrient combinations in the Bogura under BARI Sarisha-18 during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)			Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	From seed (Tk.)	From stover (Tk.)	Total (Tk.)		
T ₁ = STB	124150	8430	132580	49500	83080
T ₂ = STB+ 25% NPKS	128050	8550	136600	49500	87100
T ₃ = STB+ 50% NPKS	134550	9060	143610	49500	94110
T ₄ =FP	113750	7770	121520	49500	72020

*Seed= 65 Tk kg⁻¹ *Straw= 3 Tk kg⁻¹

Table 7. Cost and return of mustard (Canola) as influenced by different nutrient management in Rangpur region during 2023-24

Treatments	Yield (kg ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable Cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
T ₁ = Soil test based	1785.7	124999	48282	76717	1.59
T ₂ =STB+25% NPKS	1562.3	109361	53065	56296	1.06
T ₃ = STB+50% NPKS	1425.0	99750	57848	41902	0.72
T ₄ = Khamari app	1595.7	111699	43917	67782	1.54
T ₅ =Farmers' practice	1460.3	102221	43650	58571	1.34

Price of input and output: Urea Tk. 27/kg, TSP Tk. 27/kg, MoP Tk. 22/kg, Gypsum Tk. 12/kg, Cowdung Tk. 1/kg

Conclusion

From the 1st year study, it may be concluded that fertilized with STB + 25% NPKS is suitable for the cultivation for BARI Sarisha-18 at Barind and Bogura while STB dose is optimum for Rangpur.

29. PHOSPHORUS MANAGEMENT IN CONSERVATION AGRICULTURE UNDER LENTIL-BLACK GRAM-MAIZE SYSTEM: CROP YIELD AND PRODUCTIVITY

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Abstract

Lentil-black gram-maize cropping system is an emerging maize-based system in the Eastern Indo-Gangetic Plains. However, with the conventional method of crop establishment, crop residue management and imbalance phosphorus (P) fertilization, the productivity of the Lentil-maize cropping system is low. Thus, an effort was undertaken to create and assess the effectiveness of conservation agricultural technologies and P management under a maize-based system in the area in terms of crop performance, crop yield and system productivity. Treatments included three types of tillage - 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 dose of P (P1), 100 % of recommended dose of P (P2) and 150 % of recommended dose of P (P3)) were evaluated. Results showed that improvement of yield contributing characters led to improve yield of lentil, black gram and maize under SP by 11 % and 10 %, 4 % respectively, and NT increased black gram yield by 6 %, but decreased maize and lentil yield by 2-5 % as compared to CT. In the case of P levels, the higher dose of P (150 % of recommended P) improved the yield contributing characters, the yield of component crop increased. The maize equivalent black gram yield (MEBY) and maize equivalent lentil yield (MELY) in SP and NT were significantly higher (by 0.4-0.6 t/ha and 0.7-1 t/ha) than MEBY in CT. The MEBY and MELY in HR, and in P3 were higher as compared to LR, and P1 and P2 treatments. Finally, the maize equivalent system yield (MESY) was significantly higher in SP was 8-9 % higher than CT and NT treatments, and the MESY in HR was 6 % higher than LR treatment, and the MESY of P3 was 4-8 % higher than that of P2 and P1 treatments. As a result, growing lentil-black gram-maize cropping system under SP and HR with P3 is recommended in EIGP due to its potential of improvement of crop yield and productivity.

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 promoting 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-ecosystem 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 crop 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 maize-legume system is scanty. In addition, nutrient management for crop production in maize-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 maize-based system of South Asia. Therefore, an attempt has been undertaken to evaluate CA practices (tillage, residue along with maize-based rotation crop) and P management on crop performance and soil fertility of lentil-black gram-maize cropping pattern in northwest Bangladesh. We 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 lentil-blackgram-maize cropping has been undertaken to evaluate the effects of P

management in CA on the performance of different crops in maize-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 is 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. Before the field trial, the land was cultivated with Lentil-Mungbean-T. Aman rice for 6 years. The current rotation of the trial, Lentil-Black gram-Maize is practicing in this on-going long-term experiment. In this report, we are only presenting the data of Lentil-Black gram-Maize rotation in 2022-23. The experiment included four replicates for each treatment in a split-split-plot design. The main plot consists 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 e.g. 50 % of recommended dose of P-P1, 100 % of recommended dose of P – P2 and 150 % of recommended dose of P – P3 were assigned in a sub-sub-plot. The dimensions of the main plots were 16 m X 16 m, the sub-plots were 16 m x 8 m and the sub-sub-plots were 16 m x 2.2 m. The experimental plots were fertilized according to FRG-2018. Full doses of all fertilizers, except P fertilizer were broadcasted before planting. 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 crop management were done as per requirement. Data on yield contributing characters such as plant population/m², plant height, number of branches/plants, number of pods/plants, number of seeds/pod and 1000-seed weight of lentil and black gram, and plant population/m², plant height, ear number/m², ear length, ear diameter, number of grains/ear and 1000-seeds weight of maize were recorded from ten randomly selected plants of each plot. The seed and straw/stover yield was recorded from the pre-selected central area of two square meters (4 m X 1 m = 4 m² area of lentil and black gram and 2 m X 2.4 m = 4.8 m² of maize) of each plot and converted to ton per hectare (t/ha). The crop yield was reported at 12-14 % moisture content. Maize equivalent yield of lentil/black gram was calculated by multiplying the yield of lentil/black gram with its price and divided by price of maize. Maize equivalent yields were totaled and expressed as maize equivalent system yield (MESY). The GenStat 17th Edition, R-software packages and Microsoft Excel were used for all statistical analyses. The mean differences between treatments were separated by the least significant difference (LSD) at $P \leq 0.05$ for the measured variables.

Results and Discussions

Effect of tillage, residue retention and P management on lentil

Seed yield of lentil: The main effect of tillage, residue and P levels had significant on seed yield of lentil (Figure 1). However, the interaction results are not presented here as the interaction of tillage x residue, tillage x P levels, residue x P levels and tillage x residue x P levels are not significant. The highest seed yield of lentil was recorded under SP followed by CT, and lowest in NT treatment. The seed yield of lentil increased by 4 % in HR compared to LR plots. The increases in lentil yield in HR plots can likely be attributed to the role of crop residues in storing the soil moisture and minimize the adverse impact of heat stress during reproductive phase under dryland situation and improved other soil properties (Islam et al., 2022; Singh et al., 2016), and weed suppression due to mechanical barrier by higher amount of surface residue (Chou, 1999). Regarding P levels, the highest seed yield of lentil obtained from P3 (1946 kg/ha) and the second highest yield was recorded in P2 (1851 kg/ha) while the lowest was recorded from P1 (1775 kg/ha).

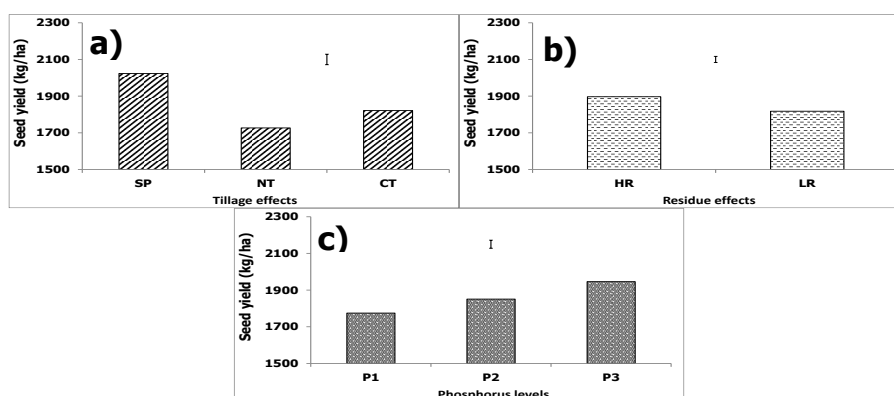


Fig 1. Effects of tillage (a), crop residue (b) and phosphorus levels (c) on seed yield of lentil

Stover yield of lentil: Tillage, residue and different P levels had significant effect on straw yield of lentil (Figure 2). However, the interaction results are not presented as the interaction of tillage x residue, tillage x P levels, residue x P levels and tillage x residue x P levels are not significant. The highest straw yield of lentil was recorded under SP followed by CT, and lowest in NT treatment. The straw yield of lentil increased by 4 % in HR compared to LR plots. In case of P levels, the highest straw yield of lentil obtained from P3 (1764 kg/ha) and the second highest yield was recorded in P2 (1694 kg/ha) while the lowest was recorded from P1 (1653 kg/ha).

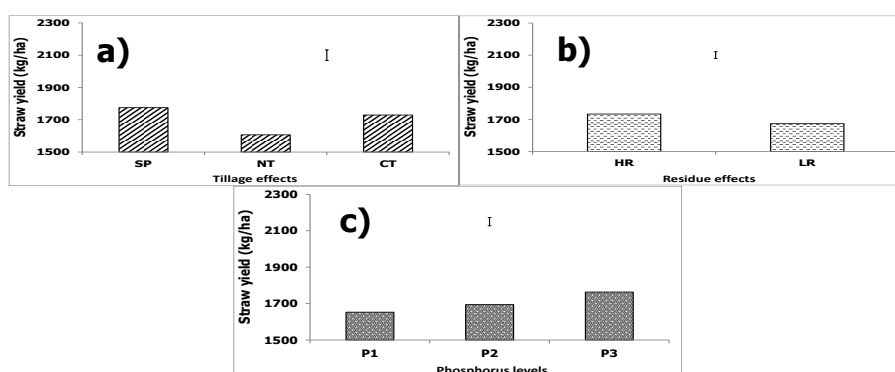


Fig 2. Effects of tillage (a), crop residue (b) and phosphorus levels (c) on stover yield of lentil

Effect of tillage, residue retention and P management on black gram

Seed yield of black gram: The main effect of tillage, residue and P levels had significant on seed yield of black gram (Figure 3). However, the interaction effects are not presented here as the interaction of tillage x residue, tillage x P levels, residue x P levels and tillage x residue x P levels are not significant. The highest seed yield of black gram was recorded under SP (1521 kg/ha) followed by NT (1468 kg/ha), and the lowest in CT treatment (1381 kg/ha). The seed yield of black gram in HR (1528 kg/ha) was higher as compared to LR treatment (1385 kg/ha). The increases in black gram yield in HR plots can likely be attributed to the retention crop residues over time improved soil properties (Islam *et al.*, 2022; Singh *et al.*, 2016), and weed suppression due to mechanical barrier by higher amount of surface residue (Chou, 1999). Regarding P levels, the highest seed yield of black gram obtained from P3 (1527 kg/ha) and the second highest yield was recorded in P2 (1448 kg/ha) while the lowest was recorded from P1 (1396 kg/ha).

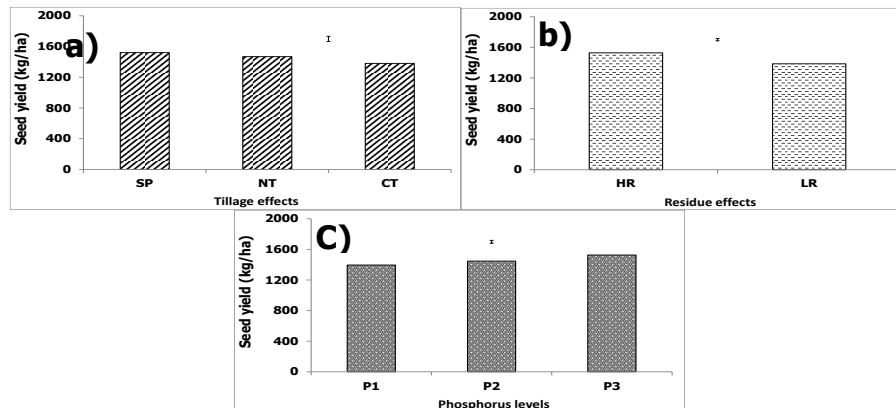


Fig 3 Effects of tillage (a), crop residue management (b) and phosphorus levels (c) on seed yield of black gram

Stover yield of black gram: Tillage, residue and different P levels had significant effect on stover yield of black gram (Figure 4), but none of the interaction (tillage x residue, tillage x P levels, residue x P levels and tillage x residue x P levels) are not significantly affected on stover yield of black gram. The highest stover yield of black gram was recorded under SP (2842 kg/ha) followed by NT (2764 kg/ha), and the lowest in CT treatment (2657 kg/ha). The stover yield of black gram increased by 7 % in HR as compared to LR plots. In case of P levels, the highest stover yield of black gram obtained from P3 (2842 kg/ha) and the second highest yield was recorded in P2 (2764 kg/ha) while the lowest was recorded from P1 (2657 kg/ha).

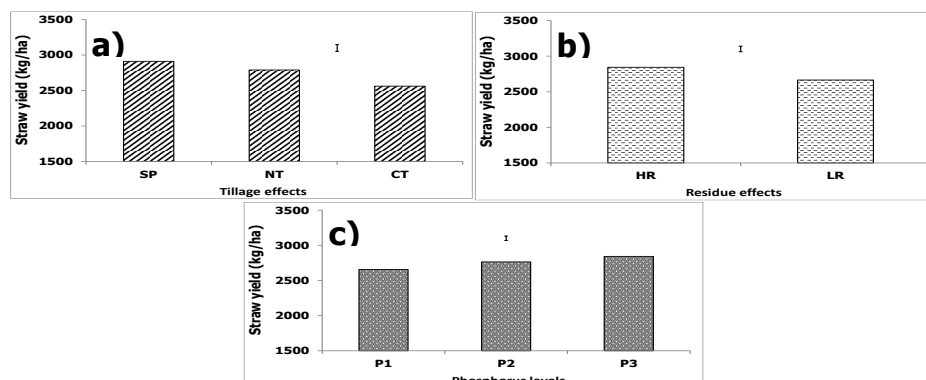


Fig 4. Effects of tillage (a), crop residue management (b) and phosphorus levels (c) on stover yield of black gram

Yield of maize: The grain yield of maize in SP was 0.28-0.43 t/ha higher than the yield of maize in CT and NT system (Figure 5). The maize yields in HR were 0.22 t/ha higher than LR. Regarding P levels, the yields of maize in P3 was 0.17-0.28 t/ha higher than that of P2 and P1.

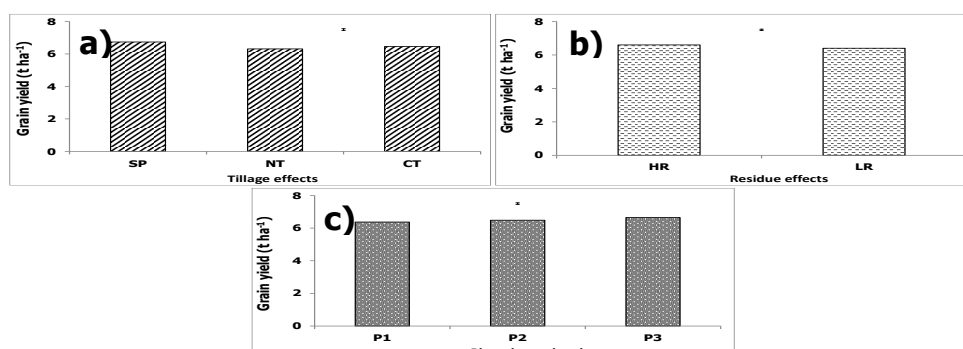


Fig 5. Effects of tillage (a), crop residue (b) and phosphorus levels (c) on grain yield of maize

The stover yield of SP was 0.19-0.52 t/ha higher than the stover yield of NT and CT (Figure 6). The stover yield of HR was 0.28 t/ha higher than that of LR, and the stover yield of P3 was 0.16-0.32 t/ha higher than the stover yield of P2 and P1.

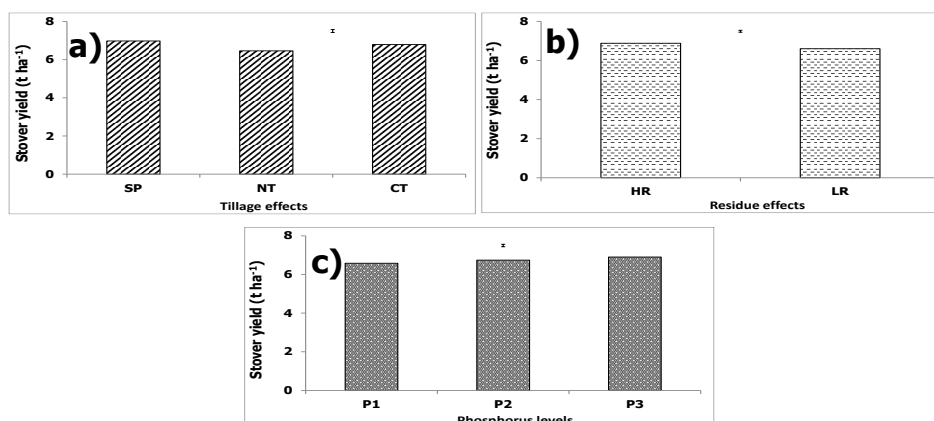


Fig 6. Effects of tillage (a), crop residue management (b) and phosphorus levels (c) on stover yield of maize

System productivity: Annual total maize equivalent yield of the lentil-black gram-maize cropping system ranged from 16.7 to 21.2 t/ha across all treatments (Table 1). The maize equivalent system yield (MESY) was significantly higher in SP (19.6 t/ha), which had 8-9 % higher than CT and NT treatments, and the MESY in HR was 6 % higher than that of LR treatment. In case of P levels, the MESY of P3 was 4 % and 8 % higher than that of P2 and P1 treatments.

Table 1. System productivity (t/ha) of maize equivalent yield (MESY) as affected by tillage, residue and P management practices in 2022-23.

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
System productivity (MESY)												
SP	19.1	19.7	21.2	18.5	19.1	19.7	19.6	0.4**	0.2**	0.2**	ns	ns
NT	17.8	18.4	19.2	16.7	17.4	18.1	17.9					
CT	18.3	18.4	19.2	16.7	17.6	18.1	18.1					
Mean	19.0			18.0								
CV (%): Tillage (1.2), Tillage *Residue (1.1), Tillage *Residue* P levels (1.7)												

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

Conclusion

It can be concluded that practicing SP increased seed yield of lentil (11%), black gram (10%) and maize (4%) over farmer practices at Ishwardi in 2022-23. The results suggested that the improved performance of yield components might be attributed to increase yield of component crop of lentil-black gram-maize rotation in SP and NT over CT. The higher load of residue also increased yield of all crops in the rotation. The increased level of recommended P fertilizer (150 % of recommended P) increased the yield of lentil, black gram and maize which might be attributed due to improvement of yield contributing characters. The MESY was increased under SP, HR and P3 treatments. However, this study will be continued for a long-term period to concrete conclusion.

30. EFFECT OF NITROGEN LEVELS ON CROP PRODUCTIVITY AND PROFITABILITY OF DIFFERENT RICE-BASED CROPPING SYSTEMS

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Abstract

The rice-based cropping system is the mainstay for the food security of Eastern Indo-Gangetic Plain in South Asia but the productivity and profitability of the system is under threat. We hypothesized that legume-dominated rice-based cropping with optimum levels of nitrogen fertilizer will increase the productivity and profitability of the system. Therefore, an on-station field experiment was conducted to assess crop productivity, nutrient use efficiency and economic return in diversified rice-based cropping systems at Agriculture Research Station, Pabna, Bangladesh in 2021-22 and 2022-23. Three cropping systems: wheat-pre-monsoon rice-monsoon rice - CBS, mustard- sesame - monsoon rice - OBS, lentil - mung bean-monsoon rice- LBS in main plots and four levels of nitrogenous fertilizer-0% N of recommended N dose (RND) – control (N0), 50% of RND (N50), 100% of RND (N100) and 150% of RND (N150) in a split-plot design with three replications. In Year 1, the rice yield was not significantly different due to different cropping pattern. However, the legume-based pattern (LBS) resulted in increased and economic return of rice crops in Year 2. Thus, indicating that the legume crops before and after rice crops increased yield of rice crops. With increasing N rates increased crop yield, productivity and economic returns in CBS and OBS. Conversely, above N50 rates, the yield, productivity and economic return of LBS decreased. In case of the rice equivalent yield (REY) of Crop 2 and Crop 5, the yield in CBS along with N150 (6.8 and 6.5 t ha⁻¹) were higher while the lowest was recorded in OBS with N0 (0.8 and 1.4 t ha⁻¹). However, the REY of Crop 5 under CBS and LBS (4.6 t ha⁻¹) was at a similar level. The Crop 3 in both Year 1 and Year 2, the highest REY was recorded from LBS along with N50 (6.7 and 5.6 t ha⁻¹) while the lowest REY recorded from OBS with N0 treatments (1.1 and 1.6 t ha⁻¹). Finally, the highest system REY was recorded from CBS along with N150 (15.6 t ha⁻¹) while the lowest REY recorded from OBS with N0 treatments (4.7 t ha⁻¹) in Year 1. Regarding N levels, the gross return and gross margin increased with increasing N amount up to 150 kg ha⁻¹ while the production cost reduced with decreasing the N levels. The result suggests that the system REY of LBS N50 and CBS N150 were higher while OBS N0 had the lowest system REY (6.7 t ha⁻¹). The legume dominated system (LBS) and reducing N fertilizer by half increased profitability through increasing crop productivity and gross margin.

Introduction

Although the productivity of the rice-based system is vital to food security of Eastern Indo-Gangetic Plain (EIGP), the sustainability of the system is risk due to the low soil nitrogen (N) supply (Wan et al., 2012). The crop production of EIGP encompasses several constraints including declining crop production and productivity, deterioration of soil fertility and low diversity of production systems and increasing cost of production. These constraints have been aggravated by continuous cereal cropping without proper nutrient management and indiscriminate use of chemical fertilizers on soil and crops. Continuous cultivation of cereal cropping system in South Asia is under threat with decline in soil fertility, total factor productivity and overall sustainability. Although the rice-wheat cropping system in South Asia occupies vast areas and feeds numerous populations (Ladha *et al.*, 2003). However, the system has begun to decrease crop yield and worsening of soil health (Timsina & Connor, 2001), because of the gradual decrease in the supply of soil nutrients (Timsina & Connor, 2001) and formation of plough pan at the subsoil zones (Ladha et al., 2003). Apart from, the soils of EIGP are naturally low in N due to their topography, which prevents soil organic matter, which is the main source of soil N from accumulating in subtropical and tropical climates (Dwivedi et al., 2017). In this region, crop productivity is mostly dependent on external N inputs and N-efficient crop production techniques (Dhawan *et al.*, 2021). Therefore, it is crucial to use the appropriate N fertilizers in conjunction with effective N management techniques for sustainable crop production and reducing environmental degradation.

Legume crops are known to crop diversification and improve soil quality through their unique ability of biological N₂ fixation, leaf litter fall and deep root system. We hypothesized that inclusion of pulses in the rice-based cropping system using optimum nutrients for a long period may have an impact on the crop productivity and soil fertility. Therefore, the effect of inclusion of pulses in the puddled rice system under different nitrogen (N) management indices would be evaluated in the proposed study.

Materials and Methods

Experimental site and soil: The experiment was conducted on alluvial and calcareous soil at Agriculture Research Station, Bangladesh Agriculture Research Institute, Pabna (24°01' N, 89.23' E). The study area was under the High Ganges River Floodplain (AEZ-11) in Bangladesh. The experiment was initiated with the monsoon rice of 2021 and continues till to date. However, we are reporting six crops grown in 2021-22 and 2022-23. The experimental site is classed as medium-high land on calcareous soil in the High Ganges Floodplain zone (FAO/UNDP, 1988). The basic soil characteristics are given in Table 1. The climate of the site is subtropical and is strongly influenced by the monsoon rainfall. Average annual rainfall is about 1500±300 mm with more than 85% of it occurring from mid-June to the end of September. November and December are the driest months and precipitation is light in January and February. Mean temperature is lowest (10 °C) in January and highest (35 °C) in May. Groundwater is the source of water for irrigation, pumped from deep boreholes. The study started with the rice season in June 2021 and is continuing till to date. However, the two years of yield and economic return (2021-22 and 2022-23) have been reporting and the present report ending with pre-monsoon season crop in June 2023.

Table 1. Initial soil properties (0-15 cm soil depth) from the experimental fields prior to the experiment starting in 2021.

Soil properties	Value
Clay (%)	23
Silt (%)	25
2Sand (%)	55
Bulk density (g/cc)	1.52
Soil textural class	Sandy loam to clay loam
pH (1:1 soil: water)	8.5
EC (dS m ⁻¹) (1:1 soil: water)	0.37
Total organic carbon (%)	0.69
Total N %	0.06
P (µg/g)	40.6
S (µg/g)	17.7
B (µg/g)	0.42

Treatments and design: The two-way factorial experiment was laid out in a split-plot design with three replications. The two factors consisted of three cropping pattern – wheat-pre-monsoon rice-monsoon rice (cereal-dominated rice-based system-CBS), mustard-sesame-monsoon rice (oilseed-dominated rice-based system - OBS), lentil-mung bean – monsoon rice (legume-dominated rice-based system -LBS); four levels of nitrogenous fertilizer – 0 % N of recommended N dose -control- RND (N0), 50 % of RND (N50), 100 % of RND (N100) and 150 % of RND (N150). The RND was based on existing recommendations for those crops (BARC, 2018): 90 kg N ha⁻¹ for rice, 21 kg N ha⁻¹ for lentil, mung bean and black gram, 90 kg N ha⁻¹ for mustard and 58 kg N ha⁻¹ for sesame. Cropping pattern was assigned to main-plots and sub-plots represented four N rates. The size of the individual sub-plot was 8 m × 2.5 m.

Crop management practices: Before starting the experiment, the land was cultivated and leveled properly to homogenize, and the land layout of the experiment was prepared. The experiment was initiated with an exhaust rice crop, monsoon rice during July to October. Details of all the cropping practices are given in Table 2. Nitrogenous fertilizer as per treatment were

applied manually and seeds of wheat, mustard, lentil, sesame and mung bean were sown manually maintaining standard spacing (Table 2). All crop protection measures were taken to prevent insect and disease attacks.

Table 2. Packages of practices adopted in various rice-based cropping systems, 2021-22 & 2022-23

Cropping pattern	Crop	Cultivar	Seed rate (kg/ha) or seedling age	Distance in rows (cm)	Sowing/planting date (2021-22/2022-23)	Harvesting data (2021-22/2022-23)
CBS	Wheat	BARI Gom-33	120	20	30.11.21	19.03.22
					26.11.22	15.03.23
	Pre-monsoon season rice	BRRI Dhan 48	25-day-old	20	20.04.22	04.08.22
					11.04.23	12.07.23
	Monsoon rice	BRRI Dhan 75	25-day-old	20	23.08.22	17.11.22
					01.08.22	23/10/22
OBS	Mustard	BARI Sharisha-17	7.5	30	30.11.21	23.02.22
					26.11.22	20.02.23
	Sesame	BARI Til-4	7.5	30	05.04.22	06.07.22
					29.03.23	25.06.23
	Monsoon rice	BRRI Dhan 75	25-day-old	20	23.08.21	17.11.21
					01.08.22	23/10/22
LBS	Lentil	BARI Masur-8	35	30	30.11.21	16.03.23
					26.11.22	12.03.23
	Mungbean/ Black gram	BARI Mung-6/ BARI Mash-3	25	30	05.04.22	05.07.22
					29.03.23	19.06.23
	Monsoon rice	BRRI Dhan 75	25-day-old	20	23.08.21	17.11.21
					01.08.22	23/10/22

CBS: Wheat-rice-rice; OBS: Mustard-Sesame-rice; LBS: Lentil-Mung bean-rice

Harvesting: Except mung bean, all crops are harvested under various cropping systems for grain and straw yield from two randomly selected quadrates of 1 m² from each plot. Mung bean was harvested thrice from a pre-selected 2 m² area of each plot by hand picking at 2 to 3 -week intervals at physiological maturity. The grain yields of rice, wheat, mustard, lentil, sesame, mung bean and black gram were reported at 12 – 14 % moisture level. The straw samples from the selected quadrats were collected and weighed. The economic part of each crop was separated manually after harvesting. Sub-samples of grain and straw yield were oven-dried to constant weight at 70 °C. Crop residues were removed at ground level, which resembles the predominant farmers' practice in this area. For comparing the productivity of different crops and total system productivity of the different scenarios, the yield of non-rice crops was converted into rice equivalent yield (t ha⁻¹) using the following equation with maize as the example:

Rice equivalent (specific crop) yield (t ha⁻¹) = Yield of individual crop (t ha⁻¹) × Minimum support price of individual crop (USD t⁻¹) / Minimum support price of rice (USD t⁻¹)

Economic analysis: The labour required to complete each operation (land preparation, irrigation, and herbicide or insecticide application, crop harvesting and picking pods) in a particular treatment plot was recorded and converted to person-days ha⁻¹ considering 8 h as equivalent to one person-day and the daily labour wage was Taka 500 (1US\$ = 106.49 Tk) per person day⁻¹. The prices of all inputs based on the Government fixed fertilizer price (for fertilizers) and local market price are given in Table 3. Each of the treatments of the experiment was evaluated based on total variable cost, gross return, and gross margin. Total variable cost was calculated considering the land preparation, labour, seed, fertilizer, irrigation, herbicide, fuel cost for threshing. Gross return was calculated by multiplying the amount of produce by its corresponding price at harvest. Gross margin was calculated by subtracting variable cost from gross return.

Table 3. Minimum support price and rates for calculating costs of key inputs in economic analysis during different seasons. (1 USD =106.49 BDT on date 06/05/2023)

Particulars	Rice (monsoon rice)	Rice (pre-monsoon rice)	Wheat	Mustard	Lentil	Mung bean	Black gram	Sesame
Price of grain (USD kg ⁻¹)	0.28	0.28	0.42	0.939	0.939	0.939	1.174	0.939
Price of straw (USD kg ⁻¹)	0.046	0.046	0.018	0.018	0.046	0.018	0.019	0.018
Tillage cost (USD number-1 ha ⁻¹)	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13
Labour wage (USD person-day ⁻¹)	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69
Urea (USD kg ⁻¹)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
TSP (USD kg ⁻¹)	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
MoP (USD kg ⁻¹)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Gypsum (USD kg ⁻¹)	0.09	0.09	0.09	0.093	0.09	0.09	0.09	0.09
ZnSO ₄ (USD kg ⁻¹)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Boron (USD kg ⁻¹)	3.19	3.19	3.19	3.19	3.19	3.19	3.19	3.19
Irrigation (USD ha ⁻¹)	176.1	295.8	42.26	42.26	42.26	42.26	42.26	42.26
Seed (USD kg ⁻¹)	0.52	0.52	0.61	0.939	1.13	1.13	1.13	1.13
Insecticide/fungicide (USD ha ⁻¹)	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13

Statistical analysis

Analysis of variance (ANOVA) for completely randomized block design was performed using the GensStat Software. The differences between treatment means were compared using a LSD test at $P < 0.05$ (Gomez and Gomez, 1984).

Results and Discussions

In 2021-22, the rice yields as crop 1 of different cropping patterns were similar, however, with increasing nitrogen levels up to 150 kg ha⁻¹ increased rice yields (Table 4). The rice yields of N150 (5.2 t ha⁻¹) were the highest followed by N100 (4.9 t ha⁻¹) and N50 (4.1 t ha⁻¹) while the rice yields in N0 (3.0 t ha⁻¹) was lowest. The REY of crop 2 in CBS (5.0 t ha⁻¹) were significantly higher than the REY in OBS (2.2 t ha⁻¹) and LBS (3.2 t ha⁻¹) while the lowest REY of crop 2 was recorded in CP2 (2.2 t ha⁻¹). Regarding N levels, the REY of crop 2 was higher with N150 (4.5 t ha⁻¹) followed by N100 (3.8 t ha⁻¹) and N50 (3.3 t ha⁻¹) and the lowest REY was recorded with N0 (2.5 t ha⁻¹). In case of interaction between cropping pattern and N levels, the highest REY was recorded from CBS along with N150 (6.8 t ha⁻¹), while the lowest REY recorded from OBS with N0 treatments (0.8 t ha⁻¹). The REY of crop 3 in LBS (5.9 t ha⁻¹) were significantly higher than the REY in OBS and CBS (2.3 and 2.5 t ha⁻¹) while the lowest REY of crop 3 was recorded in CBS (2.3 t ha⁻¹). Regarding N levels, the REY of crop 3 was higher with N100 (3.0 t ha⁻¹), which was statistically similar with N150 (4.0 t ha⁻¹), but, the REY of crop 3 was lower in N0 (2.8 t ha⁻¹). For interactions between cropping pattern and N levels, the highest REY was recorded from LBS along with N50 (6.7 t ha⁻¹), while the lowest REY recorded from OBS with N0 treatments (1.1 t ha⁻¹). Annual total rice equivalent yield of the three cropping systems ranged from 4.7 to 15.6 t ha⁻¹ across cropping systems and N levels (Table 4). The system REY of LBS (13.4 t ha⁻¹) were higher than CBS (11.7 t ha⁻¹) and OBS (8.8 t ha⁻¹), and the lowest REY was recorded from OBS (8.8 t ha⁻¹). In case of N levels, the system REY of crop 3 in N150 (13.6 t ha⁻¹) were higher followed by N100 (12.6 t ha⁻¹) and N50 (10.9 t ha⁻¹), and the lowest REY was recorded from N0 (8.1 t ha⁻¹). In case of interaction between cropping pattern and N levels, the highest system REY was recorded from CBS along with N150 (15.6 t ha⁻¹), while the lowest REY recorded from OBS with N0 treatments (4.7 t ha⁻¹).

In 2022-23, for crop 4, the rice yields of LBS (6 t ha⁻¹) were higher than that of OBS (5.0 t ha⁻¹) while the rice yield was lower in CBS (4.7 t ha⁻¹); however, with increasing nitrogen levels up to 150 kg/ha increased rice yields (Table 4). The rice yields were higher in N150 (6.0 t ha⁻¹) followed by N100 (5.7 t ha⁻¹), N50 (5.2 t ha⁻¹), while the yield of rice was lower in N0 (4.0 t ha⁻¹). The interaction of LBSN100 resulted in highest rice yields (6.4 t ha⁻¹) followed by LBS N150 (6.2 t ha⁻¹).

¹), LBS N50 and OBS N150 (6 t ha⁻¹), however, the rice yield was lowest in CBSN0 (3.1 t ha⁻¹). The REY of crop 5 in CBS and LBS (4.6 t ha⁻¹) were significantly higher than the REY in OBS (3.0 t ha⁻¹). Regarding N levels in crop 5, the REY was higher with N150 (4.9 t ha⁻¹) followed by N100 (4.6 t ha⁻¹) and N50 (4.0 t ha⁻¹) and the lowest REY was recorded with N0 (2.7 t/ha). The interaction of CBS N150 resulted in highest REY of crop 5 (6.5 t ha⁻¹) followed by CBS N100 (5.5 t ha⁻¹) and LBSN50 (5.4 t ha⁻¹), however, the rice yield was lowest in CBSN0 (3.1 t ha⁻¹). The REY of crop 6 in LBS (4.6 t ha⁻¹) were significantly higher than the REY in CBS (3.1 t ha⁻¹) while the lowest REY of crop 6 was recorded in OBS (2.5 t ha⁻¹). Regarding N levels, the REY of crop 6 was higher with N150 (4.0 t ha⁻¹) followed by N100 (3.6 t ha⁻¹) and N50 (3.5 t ha⁻¹), but the REY was lower in N0 (2.6 t ha⁻¹). For interactions between cropping pattern and N levels in crop 6, the highest REY was recorded from LBS along with N50 (5.6 t ha⁻¹) followed by LBSN0 (4.4 t ha⁻¹), LBSN100 (4.3 t ha⁻¹) and LBS150 (4.1 t ha⁻¹), while the lowest REY recorded from OBS with N0 treatments (1.6 t ha⁻¹). The system REY of the three cropping systems ranged from 6.7 to 17.0 t ha⁻¹ across cropping systems and N levels (Table 4). The system REY of LBS (15.1 t ha⁻¹) were higher than CBS (12.4 t ha⁻¹) and OBS (10.5 t ha⁻¹), and the lowest REY was recorded from OBS (10.5 t/ha). In case of N levels, the system REY in N150 (14.8 t ha⁻¹) were higher followed by N100 (13.9 t/ha) and N50 (12.6 t ha⁻¹), and the lowest system REY was recorded from N0 (9.3 t ha⁻¹). In case of interaction between cropping pattern and N levels, the highest system REY was recorded from LBS along with N150 (17.0 t ha⁻¹) followed by CBSN150 (16.4 t ha⁻¹) and LBSN100 (15.2 t ha⁻¹), while the lowest REY recorded from OBS with N0 treatments (6.7 t ha⁻¹).

Cost and return analysis: The total cost of production, gross return, and gross margin for all cropping system and N levels differed significantly and differed significantly at the total system level in 2021-22 and 2022-23 (Table 5). This was mainly due to differences in labour costs, fertilizer costs, irrigation, intercultural operation costs, harvesting and threshing costs required for growing different crops of different cropping systems. In 2021-22, the total costs of production were highest in CBS, followed by OBS, and were the lowest in LBS (Table 5). Total production cost in LBS (USD 1969 ha⁻¹) was the lowest among the cropping system. The production cost in OBS (USD 2056 ha⁻¹) was lower than in CBS (USD 2428 ha⁻¹). The LBS was profitable; the gross return of LBS was 11 % higher than CBS and was 52 % higher than in OBS. The gross margin of LBS was 68 % higher than CBS and was 233 % higher than OSB. Regarding N levels, the gross return and gross margin increased with increasing N amount up to 150 kg/ha while the production cost reduced with decreasing the N levels.

In 2022-23, the total costs of production were highest in CBS (2428 USD/ha), followed by the OBS (2056 USD/ha), and were the lowest in LBS (1898 USD/ha) (Table 5). The LBS was profitable; the gross return of LBS was 18.2 % higher than CBS and was 43 % higher than in OBS. The gross margin of LBS was 82 % and 129 % higher than in CBS and OBS, respectively. Regarding N levels, the gross return and net return increased with increasing N amount up to N150 in both CBS and OBS. However, the gross return and gross margin increased with increasing N amount up to N50, but decreased after N50. This study suggested that legume crops reduced the need of N fertilizer. Pampana et al. (2016) reported that above 80-100 kg/ha of N rate, the N fixation and yield of chickpea, pea and white lupin decreased.

Table 4. Rice equivalent yield of each crop and system productivity (rice equivalent yield) of different rice-based cropping systems as influenced by cropping pattern and nitrogen levels

Cropping patterns	Crop 1 (Kharif-2: monsoon rice)					Crop 2 (Rabi: wheat, mustard and lentil)					Crop 3 (Kharif-1: Aus, sesame, mung bean/black gram)					System REY				
	N levels					N levels					N levels					N levels				
	N0	N50	N100	N150	Mean	N0	N50	N100	N150	Mean	N0	N50	N100	N150	Mean	N0	N50	N100	N150	Mean
Rice equivalent yield (t/ha) in 2021-22																				
CBS	2.8	3.9	4.8	5.4	4.2	2.5	4.8	5.9	6.8	5.0	1.6	2.0	2.9	3.5	2.5	7.0	10.7	13.5	15.6	11.7
OBS	2.8	4.1	5.1	5.2	4.3	0.8	1.6	2.5	3.8	2.2	1.1	1.8	2.7	3.4	2.3	4.7	7.5	10.3	12.5	8.8
LBS	3.5	4.1	4.7	5.0	4.3	3.6	3.6	2.9	2.9	3.2	5.7	6.7	6.4	4.7	5.9	12.7	14.4	14.0	12.5	13.4
Mean	3.0	4.1	4.9	5.2	3.0	2.3	3.3	3.8	4.5		2.8	3.5	4.0	3.9		8.1	10.9	12.6	13.6	
CV (%)																				

CP	5.1					8.6					9.7					5.9				
N levels	9.1					14.2					7.6					6.5				
CP X N	9.1					14.2					7.6					6.5				
LSD _{0.05}																				
CP	ns					0.68					0.78					1.5				
N levels	0.39					0.49					0.27					0.7				
CP X N	ns					0.89					0.78					1.6				
Rice equivalent yield (t/ha) in 2022-23																				
Cropping patterns	Crop 4 (Kharif-2: monsoon rice)					Crop 5 (Rabi: wheat, mustard and lentil)					Crop 6 (Kharif-1: Aus, sesame, black gram)					System REY				
CBS	3.1	4.6	5.2	5.7	4.7	2.2	4.1	5.5	6.5	4.6	1.9	2.8	3.6	4.2	3.1	7.2	11.5	14.3	16.4	12.4
OBS	3.6	4.9	5.5	6.0	5.0	1.4	2.4	3.9	4.3	3.0	1.6	2.1	2.9	3.6	2.5	6.7	9.4	12.3	13.8	10.5
LBS	5.3	6.0	6.4	6.2	6.0	4.4	5.4	4.6	3.9	4.6	4.4	5.6	4.3	4.1	4.6	14.0	17.0	15.2	14.1	15.1
Mean	4.0	5.2	5.7	6.0		2.7	4.0	4.6	4.9		2.6	3.5	3.6	4.0		9.3	12.6	13.9	14.8	
CV (%)																				
CP	2.0					3.0					2.9					1.9				
N levels	4.1					5.5					5.1					2.9				
CP X N	4.1					5.5					5.1					2.9				
LSD _{0.05}																				
CP	0.23**					0.28**					0.22**					0.54**				
N levels	0.21**					0.22**					0.17**					0.36**				
CP X N	0.36**					0.39**					0.31**					0.68**				

¹ CBS - Cereal dominated cropping system (rice-wheat-rice); OBS - oilseed dominated cropping system (mustard-sesame-rice); LBS - legume dominated cropping system (rice-lentil-mung bean/black gram-rice); CP- Cropping pattern

Table 5. Economic analysis of various rice-based cropping systems under different nitrogen levels

Cropping systems and N levels	Total cost of production (USD ha ⁻¹)		Gross return (USD ha ⁻¹)		Gross margin (USD ha ⁻¹)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Cereal dominated rice-based system (rice-wheat-rice)						
N0	2327	2327	2205	2337	-122	10
N50	2394	2394	3399	3699	1005	1305
N100	2461	2461	4241	4535	1780	2073
N150	2528	2528	4902	5209	2373	2681
Mean	2428	2428	3687	3945	1259	1517
Oilseed dominated rice-based system (rice-mustard-sesame)						
N0	1976	1976	1490	2084	-486	108
N50	2030	2030	2330	2925	301	896
N100	2083	2083	3144	3785	1061	1703
N150	2136	2136	3805	4255	1669	2119
Mean	2056	2056	2692	3262	636	1206
Legume dominated rice-based system (rice-lentil-mung bean/black gram)						
N0	1925	1854	3856	4305	1932	2451
N50	1954	1884	4364	5210	2410	3326
N100	1983	1913	4271	4741	2288	2828
N150	2013	1943	3849	4400	1836	2458
Mean	1969	1898	4085	4664	2117	2766
LSD _{0.05}						
CP			440.3**	166**	440.3**	166**
N levels			237.7**	110**	237.7**	110**
CP X N			497.4**	207**	497.4**	207**

1 USD = 106.49 BDT; CP – Cropping pattern, mung bean in 2021-22, black gram in 2022-23

Conclusion

This study evaluated various nitrogen management under diverse rice-based cropping systems to address the fast-emerging constraints such as increasing shortages of crop and productivity decline and increasing production cost of rice-based system in Bangladesh. The experimental results exhibited that legume-dominated rice-based system can increase crop productivity, rice equivalent yield, and the system-level crop productivity and economic returns with using less production cost. It has been established that legume crops can successfully be grown without or

with a small amount of nitrogenous fertilizer application in rice-based systems. The legume-dominated system not only increases productivity and economic returns but also reduced significant amount nitrogenous fertilizer. This reduction of nitrogenous fertilizer significantly reduced production cost and environmental externalities.

31. EFFECT OF DIFFERENT LEVELS OF SULPHUR ON BOLTING AND YIELD OF ONION

M.A. ISLAM, M. MANIRUZZAMAN, M.Z. HASAN, M. A. SUBORNA, M.S.H. MOLLA AND M.R. ALAM

Abstract

Onion has a high sulphur (S) need, which impacts bulb quality and productivity. However, it should be applied cautiously in the field since it has acidic effects and negatively impacts the plant. The present on-farm trial was conducted to study the effect of different levels of S [0% (0 kg ha⁻¹) - S₀, 50 % (13.2 kg ha⁻¹) - S₅₀, 75 % (19.8 kg ha⁻¹) - S₇₅, 100% (26.4 kg ha⁻¹) - S₁₀₀, 150 % (39.6 kg ha⁻¹) - S₁₅₀, 200 % (52.8 kg ha⁻¹) - S₂₀₀, 250% (66 kg ha⁻¹) - S₂₅₀] application on the yield and bolting of onion. The plant height, bulb diameter, individual bulb weight, bulb yield and straw yield of onion were increased significantly with application of S levels up to 200 kg ha⁻¹ and afterwards it started to decline. The tallest plant (56 cm), the highest horizontal (14.3-14.4 cm) and vertical bulb diameter (12.1-12.3 cm) and individual bulb weight (32.5-33.4 g) were observed in S150 and S200 treatments. The lowest bolting number (86389 - 93333) and bolting percentage (13-14%) was obtained from S150 and S200. Application of S150 and S200 also resulted in the highest bulb yield (19.7 - 20.0 t ha⁻¹) and gross margin (Tk. 1022667-1064467 ha⁻¹).

Introduction

The onion (*Allium cepa* L.) is one of the most commercial vegetables cum spice crop (Mishu et al., 2013). Onion is primarily used as a salad and cooked in various ways in curries, fried, boiled, baked, and used in soup making and preparation of pickles (Jaggi, 2005). Onion is known for its flavor, pungency, which is due to sulphur (S) -containing compound allylpropyldisulphide, and also eco-friendly stored grain protectant. Onion is an S-loving plant and is required much for proper growth and yield of onion (Kumar and Singh, 1995). Sulphur has been recognized as an important nutrient for higher yield and quality of onion bulbs. Sulphur is essential for building up sulphur-containing amino acids as well as for good vegetative growth and bulb development in onion. According to Porto et al. (2007) and Mishu *et al.* (2013), onions have a high S requirement. Onion growth can be largely impeded at any stage by a suboptimal supply of S to plant, leading to reduced bulb yields (Mishu *et al.*, 2013). While the effects of S on onion yield have been researched in Bangladesh, different levels of S in this unique soil site and bolting have received little attention. Therefore, the effect of different levels of Sulphur on bulb yield and bolting of onion would be evaluated in the proposed study.

Materials and Methods

The on-farm field experiment was conducted in the cool dry season of 2023-24 at FSRD site, Pirpur, Pabna (24°22' N, 89°23' E, 40 m above sea level). The climate of the site is characterized by hot and humid summers (mean maximum temperature 36 °C in May-June), and cool winters (mean minimum temperature 10 °C in January) with an average annual rainfall of 1450 mm (70-80% of which was received during June-August). The soil of experimental site was sandy loam (Typic Haplustept) in texture with pH 8.0. Initial soil properties at 0-15 cm soil depth are summarized in Table 1.

Table 1. Initial soil properties of Onion field at Pirpur, Pabna before starting of S experiment in December 2023

Soil pH	OC (%)	N (%)	P	S	B	Zn	K
			Micro-gram/gram soil				Me/100 g soil
8.0	0.15	0.88	22.5	12.0	1.27	0.74	0.26

The site is in AEZ-11 (High Ganges River Floodplain), on flood-free, high land with typical fine textured (silty clay loam), medium-permeability soil. Soil sub-samples were collected at the start of the experiment in December 2023. The planting of onion was on 25 December, 2023 and harvesting was on 28 March, 2024. One irrigation was given immediately after transplanting and 2nd irrigation was given at 20-22 days after transplanting (DAT) and 40-45 DAT during the crop growth depending on soil condition. Seven levels of S fertilizer 0% S (0 kg ha⁻¹ S) – S0, 50% S (13.2 kg ha⁻¹ S) – S50, 75% S (19.8 kg ha⁻¹ S) – S75, 100% (26.4 kg ha⁻¹ S)–S100, 150% S (39.6 kg ha⁻¹ S)–S150, 200% S (52.8 kg ha⁻¹ S)–S200 and 250% S (66 kg ha⁻¹ S)–S250 of recommended S fertilizer as Soil Test Basis (STB) were used as treatment variables. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In addition to S fertilizer, other manures and fertilizers such as, cowdung 5 t ha⁻¹, urea 194 kg ha⁻¹, triple super phosphate 116 kg ha⁻¹, murate of potash 94 kg ha⁻¹, zinc sulphate (ZnSO₄) 11 kg ha⁻¹ (FRG' 2018) were applied. The entire amount of cowdung, TSP, MoP, gypsum, ZnSO₄, 1/3 of MP were applied during final land preparation. Rest 2/3 MoP and total amount of urea were top dressed in three equal installments at 15, 30 and 45 days after transplanting. All plots were separated by earthen banks lined with plastic to a depth of 30 cm. The variety was BARI Piaj-1 and the seed rate of onion was 7.5 kg ha⁻¹. Seedlings were raised in seedbed and 45-day-old healthy seedlings were transplanted in 1 m X 1 m plot maintaining a distance of 15 cm X 10 cm keeping plot to plot and block to block distance 50 cm and 100 cm, respectively. Two hand weeding were carried out during the crop growth period and the experimental plots were kept weed free. The pandia herbicide applied just after sowing. Mixture of Fifanon and Noin fungicide applied to control foot rot disease. Mixture Emitaf and Noin applied to control aphid. Emitaf, rovril and jaj applied to control dry rot and purple diseases. Indian Kripcord and Mancozeb applied to control white fly. Data were collected from five randomly selected plants from each plot. The harvest area was 3 m X 0.75 m = 2.25 m² for collecting bulb and straw yield. Bulb and straw yield were reported as fresh weight in t ha⁻¹. The bolting number, weight and percentage was collected at 66 DAT, 73 DAT, 80 DAT and 87 DAT. The cost and return analysis were carried to evaluate the economic performance of onion under different levels of S by estimating the varying costs and returns based on the current local market prices. Gross returns, net returns and marginal rate of return were calculated using the following formulas. The gross return was calculated by multiplying the bulb or straw yield and local market price. The gross margin was calculated by deducting the total variable cost from gross return. All data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) for RCB design using Statistix 10 software. The least significant difference test was used to decipher the main and interaction effects of treatments at 5% level of significance ($P < 0.05$) by using least significant test. Correlation and regression analysis was performed using data analysis tool pack of Ms Excel (2007).

Results and Discussions

The effects of different S levels were significant ($P \leq 0.05$) for plant height, horizontal and vertical bulb diameter, individual bulb weight, bulb and straw yield of onion (Table 1). Application of S @ 150 and 200 kg ha⁻¹ produced the tallest plants (56 cm) followed by S100 (54 cm) and the intermediate plants found in S72 and S250 (51-52 cm). The shortest plants (49 cm) and (50 cm) were found in control (S0) and S50. Both horizontal and vertical onion bulb diameter are significantly affected by the levels of S. The highest horizontal bulb diameter (14.3-14.4 cm) was obtained in S150 and S200 while the lowest horizontal bulb diameter (13.5 cm) was obtained in S0 and the intermediate horizontal bulb diameter (13.6-13.7 cm) was found in S50, S75 and S250 treatments. Similarly, the highest vertical bulb diameter (12.1-12.3 cm) was obtained from S150

and S200, but the lowest vertical bulb diameter (11.2-11.4 cm) was obtained in S0 and S50 treatments. The breath of onion bulb was not significantly different due to different levels of S. The significant variation of individual onion bulb weight was observed when different levels of S were applied. The maximum individual bulb weight (32.5-33.4 g) was recorded in S100, S150 and S200 treatments and the lowest individual bulb weight (29.0-29.9 g) was recorded in S0, S50, S75 and S250 treatments. Finally, bulb yield of onion was influenced by different levels of S. The highest yield of bulb (20.0 t ha⁻¹), (19.7 t ha⁻¹) and (19.5 t ha⁻¹) were obtained from S150, S200 and S100 treatments, while the lowest yield of bulb (17.2-17.8 t ha⁻¹) was obtained from S0 and S50 treatment and the intermediate yield of bulb (18.0-18.3 t ha⁻¹) was obtained from S250 and S75 treatments. Similarly, the highest straw yield (5.1 t ha⁻¹), (4.6 t ha⁻¹) and (4.1 t ha⁻¹) were obtained from S15, S200 and S100 treatments, while the lowest straw yield (3.4-3.6 t ha⁻¹) was obtained from S0 and S50 treatment and the intermediate straw yield (3.8-3.9 t ha⁻¹) was obtained from S250 and S75 treatments. Similar result was reported by Nahar *et al.* (2020) and Raina and Jaggi (2008) reported that the bulb yield of onion was started to reduce when S fertilizer was increased after a certain level.

Bolting number and percentage: Application of S150 and S200 decreased bolting number and percentages significantly than other levels of S (Figure 1). However, the highest bolting number per hectare (109722- 110000) and bolting percentage (16.5 %) was collected from S0 and S250 treatments, while the lowest bolting number (86389 – 93333) and bolting percentage (13-14 %) was obtained from S150 and S200.

The production cost, gross return and gross margin are presented in Table 2. The production cost increased with increasing the S fertilizer application. The gross returns of onion in S150 (Tk. 1251667 ha⁻¹) and S200 (Tk. 1213167 ha⁻¹) were higher those of S75, S100 and S250 (Tk. 1090000-1182500 ha⁻¹). The S0 had the lowest gross return of onion (1030000 Tk. ha⁻¹). The S150 and S200 had the highest gross margin (Tk. 1022667-1064467 ha⁻¹) followed by S75 and S100 (Tk. 924073 -998600 ha⁻¹), and S0, S50 and S250 had the lowest gross margin (Tk. 852700 -896200 ha⁻¹).

Table 2. Effects of different levels of Sulphur on growth and yield of onion

S levels	Plant population m ⁻²	Plant height (cm)	Horizontal bulb diameter (cm)	Vertical bulb diameter (cm)	Bulb breath (cm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
S0	67	49	13.5	11.2	3.9	29.0	17.2	3.4
S50	67	50	13.7	11.4	4.2	29.4	17.8	3.6
S75	67	51	13.9	11.8	4.2	29.9	18.3	3.9
S100	67	54	14.1	11.9	4.0	32.5	19.5	4.1
S150	67	56	14.4	12.3	4.4	33.4	20.0	5.1
S200	67	56	14.3	12.1	4.3	32.9	19.7	4.6
S250	67	52	13.6	11.9	3.6	29.3	18.0	3.8
LSD (0.05)	-	2.9	0.42	0.63	ns	1.1	0.6	0.8
CV (%)	-	3.1	1.7	3.0	10.1	2.0	1.9	11.3

S₀ - 0 kg/ha S, S₅₀ - 13.2 kg/ha S, S₇₅ -19.8 kg/ha S, S₁₀₀ - 26.4 kg/ha S, S₁₅₀ - 39.6 kg/ha S, S₂₀₀ -52.8 kg/ha S and S₂₅₀ - 66 kg/ha S

Table 2. Effects of different levels of Sulphur on cost and return of onion

S levels	Total variable cost (Tk. ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
S0	177300	1030000	852700	5.8
S50	180600	1069167	888567	6.4
S75	182260	1106333	924073	6.7
S100	183900	1182500	998600	6.4
S150	187200	1251667	1064467	5.6
S200	190500	1213167	1022667	5.9
S250	193800	1090000	896200	6.1
LSD (0.05)		55790	55790	0.3
CV (%)		2.8	3.3	2.8

S₀ - 0 kg/ha S, S₅₀ - 13.2 kg/ha S, S₇₅ -19.8 kg/ha S, S₁₀₀ - 26.4 kg/ha S, S₁₅₀ - 39.6 kg/ha S, S₂₀₀ -52.8 kg/ha S and S₂₅₀ - 66 kg/ha S

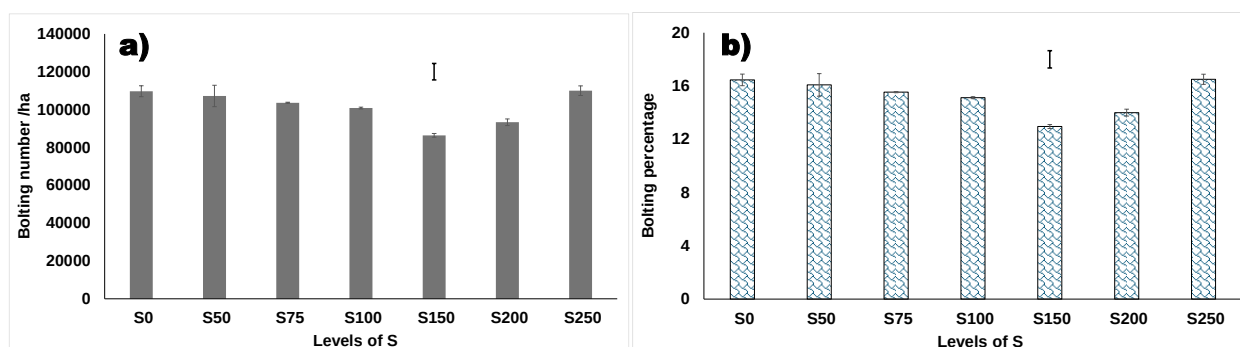


Figure 1. Effects of Sulphur levels (S₀ - 0 kg/ha S, S₅₀ - 13.2 kg/ha S, S₇₅ -19.8 kg/ha S, S₁₀₀ - 26.4 kg/ha S, S₁₅₀ - 39.6 kg/ha S, S₂₀₀ -52.8 kg/ha S and S₂₅₀ - 66 kg/ha S) on bolting number and percentage relative to total plant population per hectare

Conclusion

The onion yield under the S levels increase with increased rate from 50% to 200%, but a decline at 250% of S levels of the onion crop. Application of S₁₅₀ and S₂₀₀ resulted in the highest bulb yield (19.7 - 20.0 t ha⁻¹), straw yield (4.6-5.1 t ha⁻¹) and gross margin (Tk. 1022667-1064467 ha⁻¹) and decreased bolting number and percentage. However, this is first year experiment, and the experiment will be continued for the next year to concrete conclusion.

32. INTEGRATED NUTRIENT MANAGEMENT FOR CABBAGE UNDER AGRO-FORESTRY SYSTEM

M. MANIRUZZAMAN, M. S. H. MOLLA, M. A. ISALM, M. Z. HASAN, M. A. SUBORNA AND M. R. ALAM

Abstract

An experiment was carried out at the FSRD site, Ganggarampur, Pabna during the *Rabi* season of 2023-24 to evaluate the performance of different nutrient management options in mango-based agroforestry system. Four nutrient management practices viz. recommended dose (FRG'2018), IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost along with farmers practice were evaluated in this study. The IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost exhibited significantly higher card yield which were 21% and 18% higher than recommended dose, respectively. Regarding economic return higher gross margin (Tk. 431340 ha⁻¹) was also attained from IPNS + 5 t ha⁻¹ cowdung.

Introduction

In Bangladesh, fruit orchard especially Ber, Litchi, Guava and Mango orchard increasing considerably in last few years. A vast area is going under orchard every year so, it is possible to produce some vegetable crops such as cabbage and tomato under agroforestry system. It will be a good option for producing vegetable from the same land. In the tropics and sub-tropics rapid degradation of organic matter is the major problem, where through vegetable production, there has a less chance to add biomass in the soil. So, from the view of sustainable productivity of soil, addition of organic matter through integrated nutrient management system may be helpful. Trees on farms can enhance coping capacity of small farmers to risks through crop and income diversification, soil and water conservation and efficient nutrient cycling and conservation. A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required.

Materials and Methods

The experiment was carried out at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2023-24. Four nutrient management practices viz. recommended dose (FRG-18), IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost along with farmers practice were evaluated in

this study. The experiment was laid out in RCB design with four replications having a unit plot size 6m x 5m. The seedlings of cabbage (Atlas-70) were transplanted on 3 November, 2023. The land was fertilized according to the treatment composition presented in Table 1. One third of total N and the entire amount of P, K, S, Zn, B, well decomposed cowdung and vermicompost were applied as basal during final land preparation. Remaining N was applied in two equal splits as top dress after 22 and 55 DAT (days after transplanting) on 25 November, 2023 and 5 January, 2024 followed by an irrigation. Weeding was done two times on 5 December, 2023 and 10 January, 2024 to control weeds. Insecticide Nitro, Regent and Abamectin were applied alternately three times on 20 November, 2023; 1 December, 2023 and 10 December, 2023 to control *Spodoptera* insect. The harvesting of crops was started on 2 February and continued up to 25 February, 2024. All the relevant data were recorded carefully and analyzed statistically.

Table 1. Nutrient composition under different management practices for cabbage under mango-based agroforestry system

Treatments	N	P	K	S	Zn	B	Cowdung	Vermicompost
Recommended dose	120	36	30	12	2.5	1	-	-
IPNS with 5 t ha ⁻¹ cowdung	105	31.5	23.1	12	2.5	1	5 t	-
IPNS with 3 t ha ⁻¹ vermicompost	85	20	15	12	2.5	1	-	3 t
Farmers Practice	253	90	125	22	5.5	1.9	-	-

Results and Discussions

Data on yield contributing characters and yield are presented in Table 1. Card length, card diameter, individual curd weight and yield varied significantly due to different nutrient management options. The IPNS + 5 t ha⁻¹ cowdung provided maximum card length, card diameter and individual card weight which was identical with IPNS + 3 t ha⁻¹ vermicompost. While, minimum card length, card diameter and individual card weight was recorded from recommended dose. The highest yield was obtained from IPNS + 5 t ha⁻¹ cowdung which is statistically similar to IPNS + 3 t ha⁻¹ vermicompost and first one was 21% and second one was 18% higher than recommended dose, respectively. However, the lowest yield was recorded from recommended dose which is identical to farmers practice. Maximum yield in IPNS + 5 t ha⁻¹ cowdung and IPNS + 3 t ha⁻¹ vermicompost may be due to higher card diameter and individual card weight.

Cost and return analysis: Cost and return analysis is presented in Table 2. Regarding economic benefit, maximum gross return (Tk. 591750 ha⁻¹) and gross margin (Tk. 431340 ha⁻¹) was obtained from IPNS + 5 t ha⁻¹ cowdung which was followed by IPNS + 3 t ha⁻¹ vermicompost. However, minimum gross return (Tk. 488750 ha⁻¹) and gross margin (Tk. 333340 ha⁻¹) was recorded from recommended dose.

Farmer's opinion: Farmers expressed their satisfaction to see higher yield performance of cabbage and economic return from IPNS with 5 t ha⁻¹ cowdung. They also preferred IPNS with 3 t ha⁻¹ vermicompost because of satisfactory yield and return.

Table 2. Yield and yield contributing characters of cabbage under different nutrient management options at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2023-24.

Treatments	Card length (cm)	Card diameter (cm)	Individual card weight (kg)	Yield (t ha ⁻¹)
Recommended dose	25.2c	62.3c	1.57b	48.9b
IPNS with 5 t ha ⁻¹ cowdung	28.2a	66.6 a	1.89a	59.2a
IPNS with 3 t ha ⁻¹ vermicompost	26.9ab	65.5 a	1.82a	57.6a
Farmers practice	26.3bc	64.2b	1.74ab	54.9b
LSD (0.05)	1.43**	1.13**	0.23*	9.28*
CV (%)	3.35	3.09	8.32	7.28

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, ns = not significant

Table 3. Cost and return analysis from cabbage under different nutrient management at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2023-24.

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Recommended dose	488750	155410	333340
IPNS with 5 tha ⁻¹ cowdung	591750	160410	431340
IPNS with 3 tha ⁻¹ vermicompost	576000	185410	390590
Farmers Practice	546250	162040	384210

Price: 10.00 Tk kg⁻¹

Conclusion

It can be concluded that IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost provided significantly higher yield than recommended dose and farmers' practice.

33. DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR FOXTAIL MILLET AT CHARLAND OF BOGURA

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Abstract

The experiment was conducted in the farmer's field of Gozaria char, Sariakandi, Bogura during Rabi, 2023-2024 to develop a suitable fertilizer dose for foxtail millet. The treatments were T₁: recommended dose of FRG' 2018 (28-20-37-10-0.5-0.5 kg ha⁻¹ of NPKSZnB), T₂: T₁ + 25% NPKSZn, T₃: T₁ + 50% NK, T₄: T₁ + 1 kg B ha⁻¹ and T₅: Farmers practice (46-15-20-14-1.5-1.3 kg ha⁻¹ of NPKSZnB (Average of 20 farmers). According to the treatment specifications, the soil test based and other doses were estimated. Treatments were assigned randomly, and fertilizer doses were applied accordingly following randomized complete block design. The maximum seed yield (2.18 t ha⁻¹) was recorded from T₄ treatment that was statistically similar to T₅ and the minimum one (1.92 t ha⁻¹) from T₁ treatment. The highest gross return (Tk. 152600 ha⁻¹) was amounted from T₄ treatment against the cultivation cost of Tk. 35265 ha⁻¹ that together led to the higher gross margin (Tk. 117335 ha⁻¹). Lower gross return (Tk. 134400 ha⁻¹) as well as gross margin (Tk. 99505 ha⁻¹) was obtained from the T₁ treatment.

Introduction

Millet is a minor cereal crop in Bangladesh. Its cultivation now has been concentrated in the charland only. Comparatively low yield, competition from other high value as well as high yield potential crops it has been shifted from the mainstream agriculture to char areas of different rivers i.e. Padma, Jamuna, Tista etc. Char areas have been found promising for cultivation of kaon. Millet and cheena together occupy nearly 1182-hectare of land with the annual production of 1229 metric tons (BBS, 2016). The average yield is 1.04 t/ha (BBS, 2016). The reasons for low yield are i) lack of improved varieties, ii) inadequate and irrational use of fertilizers by the farmers and iii) depletion of native soil fertility and soil productivity specially in charland. To combat these problems, it is necessary to use optimum dose of fertilizers. Considering the above facts, the experiment has been undertaken to find out an optimum dose of fertilizer for the cultivation of millet in the charland condition.

Materials and Methods

The experiment was conducted in the farmer's field of Gozaria char, Sariakandi, Bogura during Rabi, 2023-24. The BARI Kaon-2, foxtail millet variety, were tested in the experiment. Five treatments viz. T₁: recommended dose of FRG'2018 (28-20-37-10-0.5-0.5 kgha⁻¹ of NPKZnB), T₂: T₁ + 25% NPKSZn, T₃: T₁ + 50% NK, T₄: T₁ + 1kg B ha⁻¹ and T₅: Farmers practice (46-15-20-14-1.5-1.3 kg ha⁻¹ of NPKSZnB (Average of 20 farmers). The experiments were laid out in RCB Design with three replications having plot size 20 m². One farmer considered as one replication. Soil

samples were collected from the experimental field and sent to the SRDI laboratory, Bogura for chemical analysis. The soil analysis result presented in Table 1. Half urea and all others fertilizers were applied at final land preparation. Rest urea was applied at 40 days after sowing (DAS) followed by irrigation. Seeds were sown on 16 January, 2024. One irrigation was applied at 40 DAS. The crop was harvested during 27 April, 2024. At harvest, 10 randomly selected plants from each plot were carefully uprooted to record plant height (measured from the root-stem junction to the top of the shoot), tillers plant⁻¹, panicle length, seed panicle⁻¹, 1000 seed weight and seed yield. The yield per plot was recorded and converted into yield per hectare. Data were analyzed statistically using statistix-10. There is no pest incidence in the crop.

Results and Discussions

The yield and yield contributing performance of foxtail millet are presented in Table 2. Significant variation was found among the treatments of all characters. The highest plant height (118.00 cm) was obtained from T₄ and it was significantly different from all other treatments. The highest number of tillers plant⁻¹ (4.13) in T₄ treatment which was followed by T₁ and T₃ treatments. The highest panicle length (18.67 cm) was also in T₄ and the lowest one (14.47 cm) from T₂. The maximum weight of 1000-seed was (2.50 g) in T₄ and the lowest one (2.26 g) in T₁ treatment. The highest seed yield was also in T₄ (2.18 t ha⁻¹). The lowest seed yield (1.92 t ha⁻¹) was found in T₁ treatment. The economic performance is presented in Table 3. The highest gross return (Tk. 152600 ha⁻¹) and gross margin (Tk. 117335 ha⁻¹) was calculated from T₄ and the lowest gross return (Tk. 134400 ha⁻¹) and gross margin (Tk. 99505 ha⁻¹) from T₁ treatment.

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

Matter	pH	OM (%)	Total N (%)	K meq 100g ⁻¹	P	S	Zn	B
					$\mu\text{g g}^{-1}$ soil			
Value	7.5	1.71	0.09	0.12	11.75	34.33	1.36	0.28
Interpretation	N	L	VL	L	L	H	Optimum	L

N= Neutral, H=High, L=Low, VL=Very low

Table 2. Yield and yield contributing characters of foxtail millet at Gozaria char, Sariakandi, Bogura during *Rabi*, 2023-24

Treatment	Plant height (cm)	Tillers plant ⁻¹ (no)	Panicle length (cm)	Seed weight panicle ⁻¹ (g)	1000 seed wt. (g)	Yield plot ⁻¹ (kg)	Seed yield (t ha ⁻¹)
T ₁	114.33 b	3.46 ab	16.60 ab	5.80 b	2.26 c	3.90 c	1.92 d
T ₂	113.67 b	3.27 b	14.47 b	5.53 b	2.46 ab	4.16 b	2.05 bc
T ₃	114.33 b	3.40 ab	15.07 ab	6.33 ab	2.40 abc	3.96 c	1.95 cd
T ₄	118.00 a	4.13 a	18.67 a	6.80 a	2.50 a	4.43 a	2.18 a
T ₅	112.47 b	3.25 b	16.63 ab	6.06 ab	2.33 bc	4.26 ab	2.10 ab
CV (%)	11.27	5.71	8.11	5.05	6.55	5.56	5.55

* T₁: Recommended dose of FRG'2018 T₂: T₁ + 25% NPKSZn T₃: T₁ + 50% NK T₄: T₁ + 1kg B ha⁻¹ T₅: Farmers practice (46-15-20-14-1.5-1.3 kg ha⁻¹ of NPKSZnB (Average of 20 farmers).

Table 3. Cost and return analysis of foxtail millet at Gozaria char, Sariakandi, Bogura during *Rabi*, 2023-24

Treatment	Grain yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	1.92	134400	34895	99505
T ₂	2.05	143500	37599	105901
T ₃	1.95	136500	37805	98695
T ₄	2.18	152600	35265	117335
T ₅	2.10	147000	36334	110666

Market price of foxtail millet @Tk.70 kg⁻¹

Farmers' opinion: Previously farmers of the area cultivated local variety and use of imbalanced fertilizer dose. They are very happy to see the new variety and interested in growing BARI Kaon-2 for its higher yield and economic return use for suitable fertilizer dose.

Conclusion: The treatment T₄ gave the attractive yield and economic return in the Char land of Gozaria Char, Sariakandi, Bogura.

34. INTEGRATED NUTRIENT MANAGEMENT FOR POINTED GOURD

MD. RAHMAT ALI MOLLAH, MD. SAHIDUL ALAM AND MD. TANBIR HASAN

Abstract

The experiment was conducted in the farmer's field of Chack Shudo, Gabtoli, Bogura during Rabi, 2022-2023 to find out a suitable combination of organic and inorganic fertilizers dose and to increase maximum yield for pointed gourd. The treatments were T₁: recommended dose of FRG' 2018, T₂: IPNS with Cowdung 5 t ha⁻¹, T₃: IPNS with Vermicompost 2 t ha⁻¹, and T₄: Farmers practice (50-45-75-15-1.57-1.28 kg ha⁻¹ of NPKSZnB (Average of 20 farmers). According to the treatment specifications, the STB and other doses were estimated. The treatments were assigned randomly, and fertilizer doses were applied accordingly following randomized complete block design. Maximum fruit yield (14.76 t ha⁻¹) was recorded from T₂ treatment that was statistically similar to all other treatment and the minimum (11.43 t ha⁻¹) from T₄ treatment (Farmers practice). The highest gross return (Tk. 221400 ha⁻¹) was amounted from T₂ treatment against the cultivation cost of Tk. 52500 ha⁻¹ that together led to the higher gross margin (Tk. 168900 ha⁻¹). Lower gross return (Tk. 171450 ha⁻¹) as well as gross margin (Tk. 120850 ha⁻¹) was obtained from the T₄ treatment (Farmers practice).

Introduction

Pointed gourd (*Trichosanthes dioica* R.) is one of the most nutritive vegetables in Bangladesh belongs to the family cucurbitaceae. Though pointed gourd is a summer vegetable but now its vine is transplanted in January and fruit harvesting starts from April and continued up to November-December. The farmers of Gabtoli, Bogura district are growing pointed gourd from long days. The area and production of patal was 352 ha and 3172 ton, respectively in 2017-18 (BBS, 2018). Farmers in that area apply different doses of chemical fertilizers without following any recommended guidelines resulting poor yield and soil deterioration. In Gabtoli, vermicompost and cowdung is available in local market. So, for sustainable soil health and yield, combination of inorganic and organic nutrients should easily be applied by farmers. But the rate of organic manure is not yet developed for Gabtoli. The present study is undertaken to find out a suitable combination of organic and inorganic fertilizers and to increase maximum yield of pointed gourd.

Materials and Methods

The experiment was conducted in the farmer's field of Chack Shudo, Gabtoli, Bogura during Rabi, 2022-2023 to find out a suitable combination of organic and inorganic fertilizers dose and to increase maximum yield for pointed gourd. The treatments were T₁: recommended dose of FRG' 2018, T₂: IPNS with CD 5 t ha⁻¹, T₃: IPNS with VC 2 t ha⁻¹, and T₄: Farmers practice (50-45-75-15-1.57-1.28 kg ha⁻¹ of NPKSZnB (Average of 20 farmers). The experiments were laid out in RCB design with six replications having plot size 480 m². One farmer considered as a replication. Soil samples were collected from the experimental field and sent to the SRDI laboratory, Bogura for chemical analysis. The soil analysis result presented in Table 1. Entire amount of manure and chemical fertilizer except urea will be applied in pit 5-7 days before planting and mixed thoroughly with the soil. Entire urea will be applied in 4 equal installments at the 3rd, 6th, 9th and 12th weeks of planting around the plant as side dressing under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Vines were planted on 8

December, 2022. Three irrigation was applied at 10 February 2023, 5 March 2023 and 6 April 2023. Two weeding was done at 5 April 2023 and 2 May 2023. The crop was harvested during 5 May, 2023 to 10 December, 2023. At harvest, 10 randomly selected plants from each plot and recorded days to first flower, days to first harvest, fruits plant⁻¹, single fruit weight, fruit length, fruit diameter, weight of fruit plant⁻¹ and fruit yield. Tundra was sprayed at three times to control insects. Ridomil gold was applied to control fungus. The yield per plot was recorded and converted into yield per hectare. Data were analyzed statistically using statistix-10.

Results and Discussions

The yield and yield contributing performance of pointed gourd are presented in Table 2. Significant variation was found among the treatments only number of fruits plant⁻¹ and not significant all other characters but numerically the highest performance in T₂ treatment. The highest number of fruits plant⁻¹ (310) was obtained from T₂ treatment and it was significantly different from all other treatments. Single fruit weight (64.33 g) was maximum in T₂ treatment. The maximum fruit length was also 12.00 cm in T₂ and the lowest (9.00 cm) from T₄. The maximum fruit diameter (4.20 cm) was also in T₂ and the minimum one (3.83 cm) in T₁ treatment. The fruit weight plant⁻¹ was maximum in 19.92 kg at T₂ and minimum in 15.44 kg at T₄ treatment. The maximum fruit yield was also in T₂ treatment (14.76 t ha⁻¹). The minimum fruit yield (11.43 t ha⁻¹) was found in T₄ treatment. The economic performance are presented in Table 3. The highest gross return (Tk. 221400 ha⁻¹) and gross margin (Tk. 168900 ha⁻¹) was calculated from T₂ and the lowest gross return (Tk. 171450 ha⁻¹) and gross margin (Tk. 120850 ha⁻¹) from T₄ treatment.

Farmers' opinion: Previously farmers of the area were used of imbalanced fertilizer dose. They are very happy to see the new combination of organic and inorganic fertilizer and uses for its higher yield and economic return.

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

Matter	pH	OM (%)	Total N (%)	K meq 100 g ⁻¹ soil	P	S	Zn	B
					μg g ⁻¹ soil			
Value	6.3	1.35	0.07	0.20	153.7	17.68	3.38	0.37
Interpretation	N	L	VL	M	VH	M	VH	M

N= Neutral, H=High, VH= Very high, M= Medium, L=Low, VL=Very low

Table 2. Yield and yield contributing characters of pointed gourd at Gabtoli, Bogura, 2023-24

Treatment	Days to first flower	Days to first harvest	Fruits plant ⁻¹ (no)	Single fruit wt (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit wt plant ⁻¹ (kg)	Yield t/ha
T ₁	117.67	137.67	280.00 ab	56.00	10.00	3.83	15.73	11.65
T ₂	114.33	134.00	310.00 a	64.33	12.00	4.20	19.92	14.76
T ₃	114.67	139.00	306.67 ab	63.83	11.85	4.17	19.57	14.50
T ₄	120.00	137.00	266.67 b	57.67	9.00	4.00	15.44	11.43
LSD	NS	NS	*	NS	NS	NS	NS	NS
CV%	6.27	5.95	7.45	8.92	10.02	14.39	15.08	15.36

T₁: Recommended dose of FRG'2018 T₂: IPNS with CD 5 t ha⁻¹ T₃: IPNS with VC 2 t ha⁻¹ T₄: Farmers practice (50-45-75-15-1.57-1.28 kg ha⁻¹ of NPKSZnB (Average of 20 farmers). LS= Level of significant NS= Not significant

Table 3. Cost and return analysis of pointed gourd at Gabtoli, Bogura during 2023-24

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	174750	48558	126192
T ₂	221400	52500	168900
T ₃	217500	55800	161700
T ₄	171450	50600	120850

Maret price of pointed gourd @Tk.15 kg⁻¹

Conclusion: The treatment T₂ gave the attractive yield and economic return in the Chack Shudo of Gabtoli, Bogura.

Improvement of Cropping Systems

35. DEVELOPMENT OF LENTIL-MILLET-T. AMAN RICE CROPPING PATTERN AGAINST LENTIL-FALLOW-T. AMAN RICE IN BARIND AREA

M. S. HOSSAIN AND J. C. BARMAN

Abstract

The experiment was made at farmers' field of FSRD site, Basantapur, Rajshahi during 2021-22 and 2022-23 to study productivity and economic return of some cropping patterns in High Barind Tract. There were three cropping patterns in the study i.e., two improved cropping patterns over existing Lentil-Fallow-T. Aman rice. The improved cropping patterns were Lentil-Prosop millet-T. Aman rice and Lentil-Foxtail millet-T. Aman rice. The experiment was conducted with randomized complete block design with three dispersed replications. The maximum rice equivalent yield was obtained from Lentil-Prosop millet-T. Aman rice pattern (11.19 t ha⁻¹). However, Lentil-Prosop millet-T. Aman rice cropping pattern resulted in higher variable cost; nevertheless, it gave the highest values gross return, gross margin and marginal benefit-cost ratio. This cropping pattern gave on an average 24.6% higher system rice equivalent yield (REY) compared to the existing Lentil-Fallow-T. Aman rice pattern.

Introduction

The Lentil-Fallow-T. Aman rice cropping pattern is one of the leading cropping patterns in High Barind Tract (HBT) specially Godagari, Tanore, Chapainawabganj sadar, and Nachole. There is a long fallow period especially after harvest of lentil. Before one-decade, mungbean was cultivated but that is now hardly found in the field due to pest infestation, labour shortage etc. Jute is not possible to cultivate because of rotting problem. There is change to damage sesame at the maturity stage due to rainfall. Farmers are reluctant to cultivate dhaincha because of no direct cash income. In these circumstances, millet can be an alternative for utilizing the fallow land in Kharif-1 season. Prosop millet matures within 70 days. So, it can easily be grown in the fallow window between lentil and T. Aman rice. Keeping the point of view, the study was undertaken to assess diversification and intensification of Lentil-Fallow-T. Aman rice cropping pattern in terms of productivity, production efficiency, land use efficiency and economic return.

Materials and Methods

The experiment was conducted at the farmers' field of FSRD site, Basantapur, Rajshahi during 2021-22 and 2022-23 to study Lentil-Millet (prosop/foxtail millet)-T. Aman rice cropping patterns against the existing Lentil-Fallow-T. Aman rice cropping pattern in High Barind Tract soils. The experimental site belongs to the agroecological zone of High Barind Tract (AEZ#26). The experiment was designed with three cropping patterns L-Pm-R: Lentil-Prosop-millet-T. Aman rice; L-Fm-R: Lentil-Foxtail millet-T. Aman rice and L-F-R: Lentil-Fallow-T. Aman rice (check) following randomized complete block design with three dispersed replications. The unit plot size was 20 m x 10 m. 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 according to FRG-2018. The details of crop management under different crop sequences are given in Table 1. For Lentil all inorganic fertilizers were applied at the time of final land preparation. For prosop millet and foxtail millet, half of urea and all the inorganic fertilizers were applied at the time of final land preparation. The rest of urea was top dressed at 20 day-after sowing after irrigation. 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. All the crops were harvested at maturity from an area of central 6.0 m². Data on yield of various crops in sequences were recorded and converted to ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle.

Results and Discussion

The results revealed that there was no significant difference was found on the seed yield of lentil among the cropping patterns in both the years (Table 2). The grain yield of prosop millet tended

to be higher (1.45 and 1.48 t ha⁻¹ in 2021-22; Y1 and 2022-23; Y2, respectively) in L-Pm-R pattern than that of L-Fm-R (1.18 and 1.12 t ha⁻¹ in Y1 and Y2, respectively). Higher pros millet yield suggested that it has more economic yield producing potentiality which was mainly due to contribution of genetic make-up. Grain yield of rice was the maximum (4.95 and 5.10 t ha⁻¹ in Y1 and Y2, respectively) in L-F-R followed by L-Pm-R (4.85 and 4.85 t ha⁻¹ in Y1 and Y2, respectively). The L-Fm-R gave the minimum yield (4.78 and 4.75 t ha⁻¹ in Y1 and Y2, respectively) (Table 2). This yield variation was mainly due to the variation of yield attributes. The system rice equivalent yield (REY) differed among the cropping patterns (Table 2). The pattern L-Pm-R recorded the highest REY (11.19 and 11.71 t ha⁻¹ in Y1 and Y2, respectively) than rest of the patterns. Total productivity increased by 24.6% and 18.6% in L-Pm-R and L-Fm-R, respectively over L-F-R. The pattern having proso millet generated higher production efficiency (PE) (36.9 kg⁻¹ ha⁻¹ day⁻¹) than that of foxtail millet included pattern (32.4 kg⁻¹ ha⁻¹ day⁻¹) (Table 3). The highest land use efficiency (LUE) (90.2%) was recorded in L-Fm-R followed by L-Pm-R and the lowest LUE in L-F-R (83.8%) (Table 3). The L-Pm-R had a maximum gross return (Tk. 324400 ha⁻¹), which also recorded the highest gross margin (Tk. 204400 ha⁻¹) and MBCR (1.89) over L-F-R (Table 3).

Farmers prefer Cheena than Kaon due to easily threshable, short duration, higher market demand.

Table 1 Details of crop management practices adopted for different crops in field experiments

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Lentil	BARI Masur-8	50	Broad casting	3 rd week of Nov.	2 nd week of March	20	20	20	10	-	1.0
Proso millet	BARI Cheena-1	50	do	3 rd week March	Last week of May	60	20	40	-	-	-
Foxtail millet	BARI Kaon-2	50	do	3 rd week March	Last week of May	60	20	40	-	-	-
T. Aman rice	BRRI dhan51	30	20 x 15	2 nd week of July	1 st week of Nov.	97	20	28	10	2	-

Table 2 Yield of component crops and system level in different cropping pattern

Cropping pattern	Lentil (t ha ⁻¹)		Millet (t ha ⁻¹)		T. Aman rice (t ha ⁻¹)		System REY (t ha ⁻¹)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
L-Pm-R	1.58	1.65	1.45	1.48	4.85 ab	4.85ab	11.19	11.71
L-Fm-R	1.56	1.62	1.18	1.12	4.78 b	4.75b	10.65	10.93
L-F-R	1.56	1.67	-	-	4.95 a	5.10a	8.98	9.55
LSD	NS	NS	**	**	0.35	0.32	-	-
CV (%)	7.71	8.50	-	-	5.08	6.50	-	-

Table 3 Production efficiency, land use efficiency and profitability of tested cropping patterns (average)

Cropping pattern	Field duration of crop sequence (day)	Production efficiency (kg ⁻¹ ha ⁻¹ day ⁻¹)	Land use efficiency (%)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
L-Pm-R	303	36.93	83.01	324400	120000	204400	1.89
L-Fm-R	329	32.37	90.14	308720	120000	188720	1.33
L-F-R	233	38.54	63.84	260550	90000	170550	-

Input (Tk. kg⁻¹): Urea: 22, TSP: 22, MoP: 15, gypsum: 10, zinc sulphate: 120, boric acid: 300, lentil seed: 40, cheena and kaon seed: 60, power tiller (1 pass): 3000 Tk ha⁻¹, irrigation (1 time): 2000 Tk ha⁻¹ and Labour: 400 Tk day⁻¹(8 hours)

Output: Lentil: 75 Tk kg⁻¹, rice grain: 29 Tk kg⁻¹, proso millet (cheena) seed: 45 Tk kg⁻¹, foxtail millet (kaon) seed: 45 Tk kg⁻¹

Conclusion

From the above results, it is revealed that improved cropping pattern Lentil-Proso millet-T. Aman rice gave higher productivity and profitability.

36. DEVELOPMENT OF IMPROVED CROPPING PATTERN MUSTARD-SESAME-B. AMAN RICE IN CUMMILA

M. JAMAL UDDIN

Abstract

A field experiment was conducted at the farmers' field of Kesobpur, Titas, Cumilla under AEZ 19 during (2022-23) in order to fit sesame in the existing Mustard-Fallow-B. Aman rice cropping pattern for increasing cropping intensity and farmer's income. Two treatments i.e., T₁: Existing cropping pattern i.e. Mustard (Tori-7)-Fallow-B. Aman rice (Local) and T₂: Alternate cropping pattern i.e. Mustard (BARI Sarisha-18)-Sesame (BARI Til-4)-B. Aman rice (BRRI dhan91) was experimented. Findings revealed that Rice Equivalent Yield (REY) in improved cropping pattern is 10.338 t ha⁻¹, which is higher over existing pattern (3.19 t ha⁻¹) due to cultivate additional crop in fallow period. Higher gross return (Tk. 258450 ha⁻¹) and gross margin (Tk. 129560 ha⁻¹) as well as higher MBCR (2.65) was found in improved cropping pattern over existing one. This might be happened due to additional yield of sesame and higher yield of modern variety BARI Sarisha-18 and BRRI dhan91.

Introduction

In order to produce more food within a limited area, the most important options are to increase the cropping intensity along with production efficiency of the individual crop by using optimum management practices (Mondol *et al.*, 2015). Recently with the development of short duration varieties of rice, mustard, sesame, opportunities have been created to accommodate three or four crops in same piece of land in a year. Cropping intensity can be increased from 191-400 % by cultivation of four crops in one cropping, two cropping and three cropping land (BARI, 2017). On farm Research Division (OFRD, 2014) of BARI also have developed four crops based cropping system. Mustard-Fallow-B. Aman is one of the major cropping patterns in Cumilla particularly in Titas & Meghna upazila areas. Mustard and sesame are promising oil seed crops, which can be easily grown in this area. On-farm research division has already tested its feasibility with BARI Sarisha-18 and BARI Til-4. After harvest of mustard, lands remain fallow until B. Aman rice cultivation at this period BARI Sarisha-18 can easily be fitted in Mustard-Sesame-B. Aman rice pattern for increasing cropping intensity and farmers income.

Materials and Methods

The trial was conducted at the farmers' field of Kesobpur, Titas under AEZ 19 with the following rice-based cropping pattern during 2022-23 in order to fit sesame in the Mustard-Fallow-B. Aman rice cropping pattern. The experiment was laid out in a randomized complete block design with five dispersed replications. There were two treatments i.e., T₁: Existing cropping pattern (Mustard-Fallow-B. Aman) and T₂: Improved cropping pattern (Mustard-Sesame-B. Aman). The details of the crop management for the cropping patterns have been presented in the Table 1. BARI developed recent popular mustard (i.e. BARI Sarisha-18) were sown with broadcasting method in the field. Seed weight (over dry) and by-product yield were taken from whole plot and defoliated dried leaves were incorporated with the soil. Fertilizer management and intercultural operations like weeding, thinning and pest management for mustard (Kabir and Haque, 2012) sesame (Azad *et al.* 2017) and B. Aman rice (Rahman *et al.* 2008) were done, respectively. Seed and foliage (over dry) weights were taken from whole plot and whole plant except seed was incorporated with the soil. Seedlings were grown in adjacent plot and transplanting was done with 18-22 days old seedling of rice var. BRRI dhan91 at a spacing of 20cm x 15cm during 3rd week of June. 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 return was calculated on the basis of prevailing market price of the commodities.

Results and Discussion

Yield and return from improved and existing cropping pattern are presented in Table 1. Results revealed that the average yield of mustard, sesame and yield of rice in improved cropping pattern were recorded as 1.62, 1.34 and 2.25 t ha⁻¹, respectively, where in the existing cropping pattern of

Mustard (Tori-7) and B. Aman (Local) produces 0.998 and 1.97 t ha⁻¹, respectively. Higher yield of mustard, sesame and B Aman rice were recorded in alternate cropping pattern compared to the existing cropping pattern due to the inclusion of modern high yielding varieties and maintenance of good management practices. The findings revealed that Rice Equivalent Yield (REY) in the improved cropping pattern was almost 30.9% higher than the existing cropping pattern due to the inclusion of modern high yielding varieties such as BARI Sarisha-18 for mustard and inclusion of one extra crop in the existing pattern like sesame with the improved management technologies in the improved cropping pattern. The result of the study similar with the Naher *et. al.*, (2016) and Hossain *et. al* (2014) who stated that short duration varieties and improved cropping pattern increases total productivity and profitability over farmers existing pattern.

Cost and return analysis have shown in Table 2. Higher gross return (Tk 258450ha⁻¹) and gross margin (Tk. 129560 ha⁻¹) were found in improved pattern and while it was found lower in existing cropping pattern i.e. gross return (Tk.158450 ha⁻¹) and gross margin (Tk.73358 ha⁻¹) were found in existing cropping pattern (Mustard -Fallow-B. Aman). Satisfactory MBCR (2.05) was found from improved pattern over existing pattern.

Farmers opined that three-crop based cropping pattern (Mustard-Sesame-B. Aman rice) was found to be profitable and their income also increased rather than existing pattern.

Table 1 Crop Management practices, yield and return from the pattern at Kesobpur, Titas in Cumilla

Parameters	Existing CP (T ₁)			Improved CP (T ₂)		
Crop	Mustard	Fallow	B. Aman	Mustard	Sesame	B. Aman
Variety	Tori-7	-	Local (Farchun)	BARI Sarisha-18	BARI Til-4	BRRI dhan91
Date of sowing	10 Nov., 22	-	15 June, 23	4-5 Dec., 22	15-18 Mar., 23	25 June, 2023
Date of harvesting	15 Jan, 23	-	20 Nov, 23	6-8 March 2023	15-18 June, 2023	20 Nov, 2023
Field duration (day)	66	-	158	92	89	146
Turnaround time (day)	156			8-9	7-9	
Yield (t ha ⁻¹)	0.998	-	2.5	1.62	1.34	2.25
REY (t ha ⁻¹)	3.2			10.3		
Gross return (Tk. ha ⁻¹)	158080			258450		
TVC (Tk. ha ⁻¹)	84722			128890		
Gross margin (Tk. ha ⁻¹)	73358			129560		
MBCR	2.05					

Note: Sale price (Tk./kg): Tori-7: 80.0, B.Aus-25.0, BARI Sarisha-18: 90.0, BARI Til-4: 85.0 and BRRI dhan91: 25.0

Conclusion

Based on the productivity and profitability, Mustard (BARI Sarisha-18)-Sesame (BARI Til-4)-B. Aman (BRRI dhan91) rice cropping pattern could be suitable for the farmers of that area.

37. DEVELOPMENT OF IMPROVED CROPPING PATTERN POTATO-MUNGBEAN-T. AUS-YARD LONG BEAN AGAINST POTATO-YARD LONG BEAN-T. AUS-T. AMAN RICE

M. JAMAL UDDIN

Abstract

A field experiment was conducted at the farmers' field of Gobindapur, Chandina, Cumilla under AEZ-19 with the following rice-based cropping pattern during 2022-23 to fit Mungbean in the existing cropping pattern for increasing cropping intensity. Two treatments i.e., T₁: Existing cropping pattern (Potato-Yard long bean-T. Aus-T. Aman) and T₂: Improved cropping

pattern (Potato- Mungbean-T. Aus-Yard long bean) was studied. Research findings revealed that Rice equivalent yield (REY) in improved cropping pattern was obtained 53.982 t ha⁻¹, which is almost double over existing pattern (27.036 t ha⁻¹). Higher gross return was found to be at Tk. 1619460 ha⁻¹) and gross margin at Tk. 1270334 ha⁻¹. The MBCR was found to be 4.97 in improved cropping pattern implies that the improved cropping pattern over existing one is economically viable.

Introduction

Improvement of rice based cropping pattern is an utmost important in national issues for ensuring food security and poverty alleviation. The main challenge of the new millennium is to increase 50% yield per unit land area through manipulating the limited land resource. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing three or more crops over the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices (Mondol *et al.*, 2015). Recently with the development of technologies/varieties, opportunities have been created to accommodate three/four crops in same piece of land in a year. Cumilla is the highest rice growing district in Bangladesh. Potato is a promising cash crop in this region. Improve cropping systems can generate employment opportunities; earn additional income for the rural poor and save foreign exchange through producing these crops (Hossain *et al.*, 2017). So, the present experiment was undertaken to increase the cropping intensity and productivity and income of farmers.

Materials and Methods

The trial was conducted at the farmers' field of Gobindapur, Chandina, Cumilla under AEZ 19 with the following rice based cropping pattern during 2022-23 to fit Mungbean in the existing cropping pattern. The experiment was laid out in a randomized complete block design with three dispersed replications. There were two treatments i.e., T₁: Existing cropping pattern i.e. Potato (BARI Alu-7)-Yard long bean (Local)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49) and T₂: Improved cropping pattern: Potato (BARI Alu-36)-Mungbean (BARI Mung-6)- T. Aus (BRRI dhan85)-Yard long bean (Hybrid). The details of the crop management for the cropping patterns have been presented in the Table 1. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management for potato were done according to Kabor and Haque (2012). BARI Alu-36 was planted with 60 cm x 25 cm spacing in the cropping system field. Tuber and foliage (over dry) weights were taken from whole plot and whole plant except tuber was incorporated with the soil. Data on yield of the all crops and necessary information were recorded carefully. The rice equivalent yield was calculated using the following formula: For example: REY = [Potato yield (kg) × Potato price (Tk. kg⁻¹)] / price of rice grain (Tk. kg⁻¹) and so on.

Results and Discussion

Yield and economic performance of developed and existing cropping pattern during 2022-23 are presented in Table 1. Total productivity of different cropping sequences was determined by Rice Equivalent Yield (REY) which was calculated from yield of component crops. Rice equivalent yield was different under different cropping sequences. From the research findings it was revealed that higher REY (53.982 t ha⁻¹) was recorded from the improved cropping sequence and the lower (27.036 t ha⁻¹) from the existing cropping sequence. Rice equivalent yield in the improved cropping pattern was almost doubled than the existing cropping pattern due to the inclusion of one pulse crop (Mungbean) and use of modern high yielding varieties such as BARI Mungbean-6 and technologies in the improved cropping pattern. Naher *et. al* (2016) and Hossain *et. al* (2014) stated that improved cropping pattern increases total productivity and profitability over existing pattern.

Cost and return analysis: The higher gross return (Tk.1619460 ha⁻¹) and gross margin (Tk. 1270334 ha⁻¹) were obtained from improved cropping pattern. Satisfactory MBCR (4.97) was found from improved pattern over existing pattern. According to Mondal *et al.*, 2014 this

improved cropping pattern could play a vital role to meet the food security in increasing population in the country.

Farmers' opinion: Four crop based cropping pattern to be a profitable if it is successfully implemented in the field; but they were worried about labour shortage which can be solved through combined harvester.

Table 1. Management practices, and yield of existing and improved patterns at Gobindapur, Chandina, Cumilla during 2022-23

Parameters	Existing CP (T ₁)				Improved CP (T ₂)			
Crop	Potato	Yard long bean	T. Aus	T. Aman	Potato	Mungbean	T. Aus	Yard long bean
Variety	BARI Alu-7	Local	BRRI dhan48	BRRI dhan49	BARI Alu-36	BARI Mung-6	BRRI dhan85	Hybrid (KegorNatoki)
Planting/sowing date	12/12/22	15/3/23	26/5/23	4/9/23	8-10/12/22	11-12/3/23	22-24/5/23	14-18/8/23
Harvesting date	10 March, 2023	27/4/2023 to 23/5/23	16/8/2023	25/11/2023	9 March, 2023	11-20 May 2023	6-8 Aug, 2023	20 Sept to 28 Oct. 2023
Field duration (day)	87	83	115	112	85.5	71	106	82
Turnaround time (day)					2-3	6-8	8-10	
Yield (t ha ⁻¹)	30.8	13.07	3.50	3.90	35.82	1.01	3.95	17.60
REY (t ha ⁻¹)	27.04				53.98			
Gross return (Tk. ha ⁻¹)	811080				1619460			
TVC (Tk. ha ⁻¹)	226738				325536			
Gross margin (Tk. ha ⁻¹)	584342				1270334			
MBCR	4.97							

Note: Sale price (Tk./kg): BARI Alu-7: 20.0, Yard long bean local-60.0, BRRI dhan48& 49: 30.0, BARI Alu-36: 15.0, BARI Mung-6: 80.0, BRRI dhan85: 28.0 and Yard long bean hybrid-40.0

Conclusion

Potato (BARI Alu-36)-Mungbean (BARI Mung-6)- T. Aus (BRRI dhan85)-Yard long bean (Hybrid) is economically viable, technically feasible and socially acceptable. So, this pattern can be disseminated in that area.

38. DEVELOPMENT OF IMPROVED CROPPING PATTEN MUSTARD -T. AUS - T. AMAN AGAINST MUSTARD-FALLOW-T. AMAN

M. JAMAL UDDIN

Abstract

A field experiment was conducted at the farmers' field of Usufpur, Debidwar in Cumilla under AEZ-19 with the following rice based cropping pattern during 2022-23 to utilize fallow land between two crops in the existing cropping pattern for increasing cropping intensity. Two treatments i.e., T₁: Existing cropping pattern (Mustard-Fallow-T. Aman) and T₂: Improved cropping pattern (Mustard-T. Aus-T. Aman) was studied. Research findings revealed that Rice equivalent yield (REY) in improved cropping pattern was obtained 5.14 t ha⁻¹, which is more than double over existing pattern (2.48 t ha⁻¹). Higher gross return was found to be at Tk. 179900 ha⁻¹) and gross margin at Tk. 108271 ha⁻¹. MBCR was found to be 42.51 in improved cropping pattern implies that the improve cropping pattern over existing one is economically viable.

Introduction

Sustainable crop production through improvement of cropping pattern in rice based system or utilizing the fallow period regarded as an important national issue such as food security, poverty alleviation and opportunity in creation of job. Inclusion of short duration oil seed crop like mustard and high yielding rice varieties as well as improved crop production technology paid an important factor. Mustard is an important oil seed crop in Bangladesh. T. Aus and T. Aman rice are cultivated in monsoon (May–October), are mostly rainfed and often partially irrigated. Moreover, now a days T. Aus rice cultivation is becoming popular in somewhere medium highland areas of Bangladesh which followed Fallow-T. Aus-T. Aman rice cropping pattern. Another more, after T. Aman harvest, a long period been remained fallow preceding the T. Aus rice cultivation. Admittedly, potential adoption of mustard, T. Aus in Fallow-Fallow-T. Aman or Fallow-Boro-T. Aman rice cropping system would increase crop, crop productivity, generate employment and bring additional income of rural poor people by utilizing fallow and underused land of the country. Therefore, the present study has undertaken to study the economic feasibility of growing three crops in a year on same piece of land by incorporating mustard and or T. Aus in the existing pattern.

Materials and Methods

The trial was conducted at the farmers' field of Kesobpur, Titas under AEZ-19 with the following rice based cropping pattern during 2022-23 in order to fit sesame in the Mustard-Fallow-B. Aman rice cropping pattern. The experiment was laid out in a randomized complete block design with seven dispersed replications. There were two treatments *i.e.*, T₁: Existing cropping pattern (Mustard-Fallow-T. Aman) and T₂: Improved cropping pattern (Mustard-T. Aus-T. Aman). Fertilizer management and intercultural operations like weeding, thinning, irrigation and pest management for mustard (Kabir and Haque, 2012), T. Aus (Azad et al., 2017) and T. Aman rice (Rahman et al., 2008) was done, respectively. BARI developed recent popular mustard (*i.e.* BARI Sarisha-18) were sown with broadcasting method in the field. Seed weight (over dry) and by-product yield were taken from whole plot and defoliated dried leaves were incorporated with the soil. Seed and foliage (over dry) weights were taken from whole plot and whole plant except seed was incorporated with the soil. 18-22 days old seedling of BRRI dhan85 and Binadhan7 were transplanted maintaining with 20cm x 15cm spacing. 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 all crops were recorded carefully.

Results and Discussion

Yield and return from improved and existing cropping pattern are presented in Table 1. Results revealed that the average seed yield of mustard, grain yield of T. Aus and T. Aman rice in improved cropping pattern were recorded as 2.0, 3.20 and 3.80tha⁻¹, respectively, where in the existing cropping pattern of Mustard (Tori-7), fallow and T. Aman (Local) produces 0.878 and 4.2 t ha⁻¹, respectively.

Rice equivalent yield (REY) was different under two cropping sequences. Findings revealed that higher REY (5.14 t ha⁻¹) was recorded from the improved cropping sequence *i.e.* Mustard-T. Aus-T. Aman and the lower 2.48t ha⁻¹) from the existing cropping sequence. Rice equivalent yield in the improved cropping pattern was more than double than the existing cropping pattern due to the inclusion of T. Aus and technologies in the improved cropping pattern. The result of the study similar with the Naher *et al.* (2016) and Hossain *et al.* (2014) who stated that short duration varieties and improved cropping pattern increases total productivity and profitability over farmers existing pattern.

Higher gross return (Tk 179900 ha⁻¹) and gross margin (Tk. 108271 ha⁻¹) were found in improved pattern and while it was found lower in existing cropping pattern *i.e.* gross return (Tk. 86800 ha⁻¹) and gross margin (Tk. 39047 ha⁻¹) were found in existing cropping pattern (Mustard -Fallow-T. Aman rice). The higher total variable cost (Tk. 71629 ha⁻¹) was recorded from cropping

sequence Mustard-T. Aus-T. Aman rice due to the inclusion of T. Aus rice. MBCR was found in improved cropping pattern 2.51 implies that the improved pattern is economically profitable compare to existing pattern. Mondal et al., 2014 opined that the improved or alternate cropping pattern will play a vital role to meet the food also for growing population in the country.

Farmers opined that three-crop based cropping pattern (Mustard-T. Aus-T. Aman rice) was more profitable than existing pattern. They are very much interest to continue this type of cropping pattern utilizing their fallow land in future.

Table 1. Management practices, yields and economics of existing and improved cropping patterns at Usufpur, Debidwar in Cumilla during 2022-23

Parameters	Existing CP (T ₁)			Improved CP (T ₂)		
Crop	Mustard	Fallow	T. Aman	Mustard	T. Aus	T. Aman
Variety	Tori-7	-	BRRI dhan49	BARI Sarisha-18	BRRI dhan85	Binadhan7
Date of sowing	25 Nov , 2022	-	25 June 2022	27 Nov. 2022	8 April, 2023	9 Aug, 2022
Date of harvesting	29 Jan, 2023	-	28 Oct, 2022	26 Feb. 2023	2 Aug, 2023	25 Nov, 2022
Field duration (days)	65	-	126	95	112	106
Turn around time						
Yield (t ha ⁻¹)	0.88	-	4.20	2.05	3.50	3.8
REY (t ha ⁻¹)	2.48			5.14		
Gross return (Tk. ha ⁻¹)	86800			179900		
TVC (Tk. ha ⁻¹)	47753			71629		
Gross margin (Tk. ha ⁻¹)	39047			108271		
MBCR	3.90					

Note: Sale price (Tk./kg):- Tori-7: 70.0, 0, BRRI dhan49: 25.0, BARI Sarisha-18: 90.0, BARI Mung-6: 80.0, BRRI dhan85: 35.0 and Binadhan7-350.0

Conclusion

It might be concluded that Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan85)-T. Aman rice (var. Binadhan7) is economically viable, technically feasible and socially acceptable. So, this pattern can be disseminated in that area.

39. DEVELOPMENT OF POTATO-JUTE LEAF-CUCUMBER-T. AMAN CROPPING PATTERN AGAINST EXISTING MAIZE-FALLOW-T. AMAN CROPPING PATTERN

M.MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site Hossainpur, Kishoreganj during 2021-2022 and 2022-23 (AEZ 9) to increase cropping intensity, yields and economic return. It was laid out in RCB design with six dispersed replications. The results revealed that the mean rice equivalent yield of improved cropping pattern was 51.38 t ha⁻¹ which was 231% higher than that of existing cropping pattern (15.54 t ha⁻¹). The improved cropping pattern gave higher gross margin (Tk. 471267 ha⁻¹) compared to existing pattern (Tk. 139914 ha⁻¹). Land use efficiency (76%) of improved cropping pattern was 15% higher than that of existing cropping pattern. Therefore, farmers in Kishoreganj could follow improved cropping pattern for higher crop productivity and profitability where lands remain fallow before transplanting of Aman rice.

Introduction

A number of reports on different cropping pattern are available in Bangladesh and India that an additional crop could be introduced without much changes or replacing the existing ones for

considerable increases of productivity as well as profitability of the farmers (Khan et al., 2005; Nazrul *et al.*, 2013, Kamrozzaman *et al.*, 2015). There is very little scope of increasing cultivable land but there are scopes of increasing cropping intensity from the present level of 190% to 250% by improving the present cropping pattern incorporating short duration crops like: potato, lentil, mustard etc. in the existing cropping pattern in different unfavorable ecosystem. Many Farmers of Kishoreganj district usually cultivate maize after T. Aman rice harvest. All these two crops land can easily be cultivated with jute leaves as vegetables and cucumbers by cultivating short duration high yielding BARI released potatoes after cultivating T. Aman rice. Jute leaves can be grown easily under moisture stressed condition in high to medium low land (BJRI, 1990). In case of potato crops, the farmers have been using overdoses of chemical fertilizer, which affected the subsequent crop as residues. As a result, jute leaf grown after potato affected significantly (Khan et al, 1998). Potato-Jute leaf-Cucumber-T. Aman is a newly developed cropping pattern which is suitable in Kishoreganj. Therefore, the present study was designed to evaluate the feasibility and profitability of four crops based cropping pattern in Kishoreganj.

Materials and methods

The improved/alternate cropping pattern Potato-Jute leaf-Cucumber-T. Aman was conducted against Maize-Fallow-T. Aman at the MLT site, Hossainpur, Kishoreganj during 2021-22 and 2022-23 in the medium highland under AEZ # 9. The experiment was laid out in RCB design with six (six farmers' field) replications. Unit plot size was 10 decimals. All agronomic activities including sowing and harvesting dates, seed rate, plant spacing, fertilizer management (FRG, 2018) etc. are mentioned in table 1. For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). Land use efficiency, Production efficiency and rice equivalent yield (REY) were calculated using standard formula. The economic indices like gross return and gross margin were also calculated on the basis of prevailing market price of the inputs and outputs (produces). Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases. Data on yield and economics of all the crops were taken plot wise and stated in table 1.

Results and Discussions

On an average, the higher rice equivalent yield (51.38 t ha⁻¹) was obtained from Potato-Jute leaf-Cucumber-T. Aman cropping pattern (IP) than the farmers existing pattern (15.54 t ha⁻¹) due to inclusion of high yielding potato and cucumber variety and improved management practices (Table 1). Results indicated that farmer's pattern Maize- Fallow- T. Aman gave lower yield due to imbalance use of fertilizer and poor management practices etc. The total rice equivalent yield was 231% higher than the existing cropping pattern (Table 1). The land-use efficiency of Potato-Jute leaf-Cucumber-T. Aman pattern (76.30) was 15% higher than that of existing pattern (66.30%) (Table 1). The land use efficiency was higher in Potato-Jute leaf-Cucumber-T. Aman due to cultivation of potato with jute leaf and cucumber in the pattern. The similar trend of the findings was cited by Nazrul et al. (2017), Rahman et al. (2015) and Nazrul et al. (2013). The production efficiency of Potato-Jute leaf-Cucumber-T. Aman pattern was found to be 198.98 kg ha⁻¹ day⁻¹ while in existing cropping pattern it was found to be 65.30 kg ha⁻¹ day⁻¹ for Maize-Fallow-T. Aman pattern (Table 1).

Cost and Return analysis: The gross margin in improved cropping pattern was about 243% higher than that of the traditional pattern which indicates the superiority of the improved cropping pattern over the farmer's cropping pattern.

Farmers' opinion: Farmers are interested to grow BARI released variety of potato in this area. They opined that the potato (var. BARI Alu-25) cultivation in improve cropping pattern gave higher economic return against the Maize-Fallow-T. Aman rice cropping pattern.

Table 1. Management practices, yield, economics and productivity of alternate cropping pattern and existing cropping pattern at Kishoreganj during 2021/22 to 2022/23

Parameters	Year	Improved Four crops based cropping pattern				Existing Cropping Pattern	
Crop		Potato	Jute leaf	Cucumber	T. Aman	Maize	T. Aman
Variety		BARI Alu-25	CVL-1	Thailand-1	BRRI dhan75/ Binadhan16	Miracle	Binadhan16
Date of sowing/ transplanting	2021-22	10-12-21	25-03-22	30-05-22	04-08-22	08-12-21	25-08-22
	2022-23	24-11-22	25-02-23	28-04-23	08-08-23	04-12-22	14-08-23
Seed rate (kg ha ⁻¹)		1800	25	1	30	22	30
Spacing		60×25 cm	Broadcast	60×25 cm	25×15cm	60×25 cm	25×15cm
Fertilizer dose (kg ha ⁻¹) N. P. K. S. Zn and B		138-40- 120-20- 3.59-1.70	23-20- 37.50-11-0- 0	115-80- 100-36-0-0	161-50-75-14- 0-02	300-70- 125-46-07- 02	173-60-88- 18-0-02
Date of harvesting	2021-22	10-03-22	30-04-22	25-07-22	31-10-22	05-05-22	22-11-22
	2022-23	20-02-23	08-04-23	30-06-23	10-11-23	03-05-23	18-11-23
Field duration (days)	2021-22	90	36	56	89	148	90
	2022-23	88	41	63	94	150	96
Turnaround time (days)	2021-22	40	15	30	10	15	112
	2022-23	15	5	21	38	12	107
Yield (t ha ⁻¹)	2021-22	27.53	4.20	22.58	4.66	9.09	4.85
	2022-23	28.83	3.65	25.00	4.87	9.87	4.89
REY (tha ⁻¹)	2021-22	52.7				15.1	
	2022-23	50.1				16.0	
Grass return (Tk. ha ⁻¹)	2021-22	1193170				323155	
	2022-23	1189308				380047.5	
TVC (Tk. ha ⁻¹)	2021-22	706617				199330	
	2022-23	733326.6				224045	
Gross margin (Tk. ha ⁻¹)	2021-22	486554				123825	
	2022-23	455980.9				156002.5	
Land use efficiency (%)	2021-22	74.25				65.21	
	2022-23	78.36				67.40	
Production efficiency (kg ha ⁻¹ /day)	2021-22	194.39				63.36	
	2022-23	203.56				67.24	
MBCR	2021-22						
	2022-23						

2021-22-Unit price (Tk/kg): Potato = 16.61, Jute leaf=10, Cucumber=25.79, T. Aman rice =21.43, rice straw = 1.50, Maize= 22.50 and Maize straw=1.00. 2022-23 (Tk/kg): Potato = 16.50, Jute leaf=10, Cucumber=21.60, T. Aman rice =23.75, rice straw = 2.00, Maize= 25.00 and Maize straw=1.00.

Conclusion

The total system productivity, land use efficiency and profitability of Potato (var: BARI Alu-25)-Jute leaf (var: BJRI patshak-1)-Cucumber- T. Aman rice were much higher than Maize-Fallow-T. Aman rice cropping pattern due to inclusion of short duration HYV of potato. Thus, this pattern can be successfully disseminated for increasing cropping intensity, system productivity and profitability.

40. IMPROVEMENT OF SWEET GOURD-KENAF-FALLOW CROPPING PATTERN AGAINST EXISTING CROPPING PATTERN IN HAOR AREAS OF KISHOREGANJ

M. MOHIUDDIN

Abstract

The experiment was conducted in Old Meghna Estuarine Floodplain Soils of the Agro-Ecological Zone (AEZ) 19 at Nunir haor and Pata chapra haor under the Multi-location Testing Site, Nikli, Kishoreganj for 2021-22 and 2022-23 to increase crop productivity and economic return. Two-crop based pattern Sweet gourd-Kenaf-Fallow was tested at on-farm condition over the existing single-crop based pattern only boro rice after flood water receded. Results showed that the highest rice equivalent yield (13.19 t ha^{-1}) was obtained from improved pattern. The highest -average gross return and gross margin of the two crops pattern were obtained Tk. 292756 and Tk. 136006 ha^{-1} which were 73 and 67% higher over farmers' pattern. The marginal benefit cost ratio (MBCR) was found 2.47 which indicated the superiority of two crops pattern over the farmers' existing pattern.

Introduction

The cropping pattern in an area depends largely on agroclimatic, technical and institutional factors (Vaidyanathan, 1987). There is very little scope of increasing cultivable land but there are scopes of increasing cropping intensity from the present level of 190% to 250% by improving the present cropping pattern incorporating short duration crops like: lentil, mustard, potato etc. in the existing cropping pattern in different unfavourable ecosystem. Haor (lands go under water and remains under water about 5-6 months generally from June to November) areas are under unfavourable ecosystem covering an area of 1.99 million hectares and accommodating about 19.37 million people of Bangladesh (CEGIS, 2012). There are 373 haor/wetlands located in the districts of Sunamganj, Habiganj, Netrakona, Kishoreganj, Sylhet, Maulvibazar and Brahmanbaria. Generally, unfavorable ecosystem is less productive and remains fallow in most of the part of the year. The present cropping intensity of haor is only about 107% which is very low then the country's cropping intensity 195%. After flood water receded 15-20% land in haor areas is suitable for crop cultivation in third week to last week of October. At that time, farmers are waiting for cultivating Boro rice by irrigation with deep tube well up to third week of December to first mid-January. As a result, a vast area remains fallow for a long time (about 80 to 90 days) before Boro rice cultivation. So, there is an opportunity to increase cropping intensity and crop productivity. The farmers' of Nikli, Goroi traditionally grow local variety Sweet gourd for vegetable purpose. Insertion of a new crop Sweet gourd in cropping pattern would increase the total productivity. After harvesting of Sweet gourd farmers can easily grow Jute (Kenaf) in its proper growing time which will not be affected by flash flood. Farmers would bear additional cost of Boro rice cultivation and other expanses from income of Sweet gourd and fulfill their nutritional need. The present study was taken: i) To develop two-crop based cropping pattern for haor areas and ii) To increase cropping intensity, productivity and income of the farmers

Materials and methods

The study was carried out 2021-22 and 2022-23 at farmer's field, at 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 (Sweet gourd -Kenaf-Fallow) and FP: farmer's pattern (Fallow-Boro rice-Fallow) through incorporation of high yielding varieties with improved management practices. In the improved pattern, Sweet gourd var. hybrid Dhaka-1 and Kenaf- HC 95 were introduced against fallow period and Boro rice var. BRRI dhan29 was used in farmers 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. Land use efficiency, Production efficiency and rice equivalent yield (REY) were calculated using standard formula.

Results and Discussions

Results of improved cropping pattern Sweet gourd-Kenaf-fallow and the farmer's existing pattern fallow-boro rice-fallow have been presented in Table 1. After two years of the study, the result revealed that average fruit yield of sweet gourd and Kenaf were 19.65 t ha⁻¹, 2.2 t ha⁻¹, respectively. Grain yield of boro rice in farmers pattern was 7.30 t ha⁻¹. Jute stick yield was found 4.30 t ha⁻¹ on an average. Improved cropping pattern produced 75% higher REY (13.19 t ha⁻¹) over farmers' existing pattern (7.52 t ha⁻¹) (Table 1). Average production efficiency in two year (61.99) in terms of kg ha⁻¹/day was obtained from improved cropping pattern followed by farmers pattern (Table 1). Land utilization index (LUI) was higher (59%) in improved pattern compared to farmers' pattern (42%) period of the year (Table 1). The higher land utilization index in improved pattern because this pattern occupied the field for longest duration (214 days), whereas farmers' pattern occupied the field for 153 days of the year.

The average gross return of improved cropping pattern (292756 Tk ha⁻¹) showed its superiority by 73% over farmers' existing pattern (169428 Tk ha⁻¹). The gross margin was 67% higher in the improved pattern (136006 Tk ha⁻¹) than farmers' pattern (81268 Tk ha⁻¹). The mean marginal benefit cost ratio (MBCR) was found 1.80 which indicated the superiority of the improved cropping pattern over the farmers' pattern.

Farmers' opinion: They opined that the sweet gourd cultivation before kenaf gave the higher economic return against the Fallow-Boro-Fallow pattern. All the land which fallow year after year especially Kanda lands belong to this cropping system can be brought under cultivation and the farmers will be more benefitted by introducing this cropping pattern in the upper catena where more irrigation and weeding is required to cultivate boro rice.

Table 1 Agronomic practices of improved and farmers' existing pattern during 2021-22 and 2022-23

Parameters	Year	Improved cropping pattern			Existing Cropping Pattern		
Crop		Sweet gourd	Kenaf	Fallow	Fallow	Boro	Fallow
Variety		Hybrid Dhaka-1	HC-95			BRRI dhan29	
Date of sowing/ transplanting	2021-22	30.10.21	5.3.22			2.1.22	
	2022-23	3.11.22	5.3.23			29.12.22	
Seed rate (kg ha ⁻¹)		5	15			30-35	
Spacing		2m x 2m	Broadcast			20cm × 15cm	
Fertilizer dose kg ha ⁻¹) N. P. K. S. Zn and B		81-35-75-18-5-02	115-40-63-14-0-0			140-18-53-08-03-02	
Date of harvesting		10-26 Feb	9-20 June			16-25 April	
Field duration (days)		110-115	96-107			106-115	
Turnaround time (days)	2021-22	40	15			15	
	2022-23	15	5			12	
Yield (t ha ⁻¹)	2021-22	18.8	2.18			7.24	
	2022-23	20.6	2.26			7.36	
Straw/stick yield (t ha ⁻¹)	2021-22		4.14			4.0	
	2022-23		4.46			4.12	
REY (t ha ⁻¹)	2021-22	14.77 (Average: 13.19)			7.44 (Average: 7.52)		
	2022-23	11.60			7.60		
GR (Tk. ha ⁻¹)		292756			169428		
TVC (Tk. ha ⁻¹)		156750			88160		
GM (Tk. ha ⁻¹)		136006			81268		
LUI (%)		58.63			41.92		
PE (kg ha ⁻¹ /day)		61.99			49.16		
MBCR		1.80					

REY=Rice equivalent yield, GR= Grass return, TVC=Total variable cost, GM= Gross margin, PE=production efficiency and LUI= land utilization index

Conclusion

The alternate cropping patterns is profitable than that of existing pattern. By practicing the alternate cropping pattern farmers can utilize 50-60 days turnaround time and can increase cropping intensity. Thus, cultivation of alternate cropping patterns would help to increase total production, farmer's income, improve soil health and reduce nutritional imbalance of human being.

41. DEVELOPMENT OF POTATO-GROUNDNUT-FALLOW CROPPING PATTERN AGAINST EXISTING FALLOW-BORO RICE-FALLOW

M.MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site, Nikli during 2023-2024 to introduce two-crop based Potato-Groundnut-Fallow cropping pattern as well as to increase crop productivity and economic profit for the farmers. It was laid out in RCBD design with four dispersed replications. The improved cropping pattern gave the highest yield (47 t ha^{-1}) against existing cropping pattern (7.57 t ha^{-1}). The improved cropping pattern gave the higher gross margin ($357193 \text{ Tk ha}^{-1}$) compared to existing pattern (87722 Tk ha^{-1}). The MBCR (2.68) indicates the superiority of the improved two crop based cropping pattern over the farmer's one crops based cropping pattern.

Introduction

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 or First week of October 20-30% areas of Nikli upazila is suitable for crop cultivation. There is a great scope of increasing cropping intensity as well as crop productivity here. If we insert potato, farmers can easily cultivate two crops like groundnut after short duration potato. Considering the above facts, a trial on potato-groundnut-fallow was conducted in the same piece of land in a year at Mohorkuna in Kishoreganj.

Materials and methods

The improved/alternate cropping pattern Potato-Groundnut-Fallow was conducted against Fallow-boro-Fallow at the MLT site, Nikli, Kishoreganj during 2023-24 in the medium highland. The soil of the experimental field was sandy loam. The experiment was laid out in RCBD design with four (four farmers' field) replications. Unit plot size was 10 decimals. 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. For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). The economic indices like gross return, gross margin and benefit cost ratio (BCR) were also calculated on the basis of prevailing market price of the inputs and outputs (produces). Crop cut was done from an area of 1 m^2 at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in table 1.

Results and Discussions

Table 1 reveals that all the component crops in cropping pattern Potato-Groundnut-Fallow under improved practices (IP) gave significantly higher yield. On an average, the higher grain yield was obtained from Potato (12.13 t ha^{-1}) in improved pattern (IP) than the existing pattern due to high yielding variety and improved management practices. The rice equivalent yield reveals that improved cropping pattern produced higher production over farmers' existing cropping pattern (Table 1). The total rice equivalent yield was 25.47 t ha^{-1} in improved cropping pattern which was

(17.9 t ha⁻¹) higher than the existing (7.57 t ha⁻¹) one crop-based cropping pattern. Lower rice equivalent yield (7.57 t ha⁻¹) was obtained in the farmer's pattern due to use of traditional management practices in boro rice.

The improved two crops based cropping pattern showed its superiority over the farmer's one crop based cropping pattern. The gross margin was substantially higher in the improved pattern (357193Tk ha⁻¹) than that of the traditional pattern (87722 Tk ha⁻¹). The MBCR (2.68) indicates the superiority of the improved two crop based cropping pattern over the farmer's one crops based cropping pattern.

Farmers' opinion: Farmers opined that in improved two crops based cropping pattern, use of modern high yielding groundnut variety (BARI Chinabadam-9) with insertion of Potato instead of Fallow-boro-Fallow can increase farm production and income. They showed their interest to replace their existing Fallow-boro-Fallow pattern by the newly developed Potato-Groundnut-Fallow cropping pattern.

Table 1 Management practices of alternate cropping pattern and existing cropping pattern at Kishoreganj during 2023-2024

Parameters	Improved cropping pattern			Existing Cropping Pattern		
Crop	Potato	Groundnut	Fallow	Fallow	Boro rice	Fallow
Variety	Romana	BARI Chinabadam-9			BRRRI dhan29	
Date of sowing/transplanting	22-11-2023	23-01-24			15-01-2023	
Seed rate (kg ha ⁻¹)	2000	102			50	
Spacing	60cm × 25cm	30cm × 15cm			20cm × 15cm	
Fertilizer dose (kg ha ⁻¹) N. P. K. S. Zn and B	171-48-185-42-4-2	0-15-25-20-2-1			140-18-53-08-03-02	
Date of harvesting	22-01-2024	07-05-23			16-03-2023	
Field duration (days)	61	105			108	
Yield (t ha ⁻¹)	12.13	2.25			7.57	
Rice equivalent yield (t ha ⁻¹)	15.16	10.31			7.57	
Rice equivalent yield (t ha ⁻¹)	25.47			7.57		
Gross return (Tk. ha ⁻¹)	363900	247500			181680	
Total variable cost (Tk. ha ⁻¹)	139577	114630			93958	
Gross margin (Tk. ha ⁻¹)	224323	132870			87722	
Total gross margin (Tk. ha ⁻¹)	357193			87722		
MBCR (Whole pattern)	2.68					

GR= Gross return, TVC = Total variable cost and GM= Gross margin; Price of groundnut = 110 Tk/kg; Price of potato = 30 Tk/kg.

42. DEVELOPMENT OF POTATO-JUTE-T. AMAN CROPPING PATTERN AGAINST WHEAT-JUTE-T. AMAN CROPPING PATTERN

M.MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site, Hossainpur, Kishoreganj during 2021-2022 and 2022-23 under AEZ 9 to improve the existing cropping pattern, increase cropping intensity, yields and economic return through incorporating of modern crop varieties and improved management practices. It was laid out in RCB design with six dispersed replications. The results revealed that the mean rice equivalent yield of improved cropping pattern was 33.83 t ha⁻¹ which was 62% higher than that of existing cropping pattern (16.60 t ha⁻¹). The improved cropping pattern gave the higher gross margin (Tk. 289095 ha⁻¹) compared to existing pattern (Tk. 87170 ha⁻¹). Production efficiency (116.84%) of improved cropping pattern was 118% higher than that of existing cropping pattern. The average gross return

(Tk. 806365 ha⁻¹) was recorded in improved cropping pattern which was 110% higher than that of existing pattern (Tk. 383920 ha⁻¹). Therefore, farmers in the study area could follow improved cropping pattern for higher crop productivity and profitability.

Introduction

In Kishoreganj, land area under Wheat-Jute-T. Aman rice cropping pattern is increasing but there has a great scope of cultivating vegetable-based Potato-Jute-T. Aman rice cropping pattern. If farmers adapted to vegetables-based pattern, productivity, cropping intensity, as well as farmers income will be increased. In this regard, vegetable based cropping pattern is now a demand of time. So, the experiment was taken to evaluate the cropping patterns at farmer's field and hence to increase economic return, employment opportunity and woman's participation, cropping intensity with nutritious food as well as retain soil fertility.

Materials and methods

The improved/alternate cropping pattern Potato-Jute-T. Aman rice was conducted against Wheat-Jute-T. Aman rice at the MLT site, Hossainpur, Kishoreganj during 2021-22 and 2022-23 in the medium highland under AEZ-9. The soil of the experimental field was sandy loam. The experiment was laid out in RCB design with six (six farmers' field) replications. Unit plot size was 10 decimals. 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. For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). The economic indices like gross return and gross margin were also calculated on the basis of prevailing market price of the inputs and outputs (produces). Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in table 1. Land use efficiency, Production efficiency and rice equivalent yield (REY) were calculated using standard formula.

Results and discussions

On an average, the higher grain yield was obtained from Potato (29.07 t ha⁻¹), Jute (2.95 t ha⁻¹) and T. Aman (4.90 t ha⁻¹) in improved pattern (IP) than the existing pattern due to high yielding variety and improved management practices (Table 1). Results indicated that farmer's pattern Wheat-Jute- T. Aman gave lower yield due to traditional variety, imbalance use of fertilizer and poor management practices etc. The average rice equivalent yield of Potato was the highest (20.67 t ha⁻¹), Jute (9.14 t ha⁻¹) and T. Aman had the rice equivalent yield (5.03 t ha⁻¹) in improved cropping pattern (Table 1). The total rice equivalent yield was (34.83 t ha⁻¹) in improved cropping pattern which was 61.93% higher than the existing (16.60 t ha⁻¹) cropping pattern (Table 1). Average production efficiency in two years (116.84) in terms of kg ha⁻¹/day was obtained from improved cropping pattern followed by farmer's pattern (Table 1). The higher production efficiency in improved pattern might be due to inclusion of high yielding potato and Kenaf varieties and improved management practices. Similar trend was noted by Nazrul et al. (2013) and Khan et al. (2006).

The land use efficiency of Potato-Jute-T. Aman pattern was 3.90% lower than that of existing pattern (Table 12). The land use efficiency was lower in improve pattern due to cultivation of short duration potato variety in the pattern.

The average gross return of improved cropping pattern (Tk. 806365 ha⁻¹) showed its superiority by 110% over farmers' existing pattern (Tk. 383920 ha⁻¹). The average variable cost of the improved pattern (Tk. 517270 ha⁻¹) was higher than farmers' pattern (Tk. 296750 ha⁻¹) due to inclusion of potato and improve management which takes extra cost of inputs of the production. The gross margin was substantially higher in the improved pattern (Tk. 289095 ha⁻¹) than farmers' pattern (Tk. 87170 ha⁻¹). The higher gross margin of the improved pattern (232%) was achieved mainly higher yield advantages of the component crops (Table 3) which revealed that

inclusion of potato and Kenaf in the existing pattern might be profitable and acceptable to the farmers.

Farmers' opinion: Farmers' opinion Farmers are interested to grow BARI released potato variety in this area. They opined that the potato (var. BARI Alu-25) cultivation before jute gave the higher economic return against the Wheat-Jute-T. Aman pattern. Training on production technology for Potato-Jute-T. Aman pattern is needed.

Table 1 Crop management practices of alternate cropping pattern and existing cropping pattern at Kishoreganj during 2021-22 and 2022-23

Parameters	Year	Improved cropping pattern			Existing Cropping Pattern		
Crop		Potato	Jute	T. Aman	Wheat	Jute	T. Aman
Variety		BARI Alu-25	Robi-1/Kenaf	BRRI dhan75	BARI Gom-26	JRO-524	BRRI dhan49
Date of sowing/ transplanting	2021-22	25.11.21	30.3.22	5.8.22	5.12.21	5.4.22	25.8.22
	2022-23	23.11.22	25.3.23	4.8.23	30.11.22	29.3.23	22.8.23
Seed rate (kg ha ⁻¹)		1800	15	35	120	7	30
Spacing		60×25cm	Broadcast	25×15cm	Broadcast	Broadcast	25×15cm
Fertilizer dose (kg ha ⁻¹) N, P, K, S, Zn and B		138-40-120-20-3.59-1.70	76-20-38-11-0-0	161-50-75-14-0-1.5	187-68-132-20-01-01	78-30-50-0-0-0	173-60-88-18-0-02
Date of harvesting		20-24 Feb	20-28 July	2-4 Nov.	17-26 March	20-25 July	20-22 Nov.
Field duration (day)		88-89	112-124	90-93	106-110	111-112	90
Turnaround time (day)	2021-22	21-22	34-35	7-15	13	10	31
Yield (t ha ⁻¹)	2021-22	26.4	2.29	4.57	3.17	2.01	4.35
	2022-23	31.8	3.61	5.22	3.05	2.16	4.68
REY (tha ⁻¹)	2021-22	33.44 (Average: 34.83)			16.41 (Average: 16.60)		
	2022-23	36.22			16.79		
GR (Tk. ha ⁻¹)		806365			383920		
TVC (Tk. ha ⁻¹)		517270			296750		
GM (Tk. ha ⁻¹)		289095			87170		
LUI (%)		81.6			84.8		
PE (kg ha ⁻¹ /day)		116.8			53.6		
MBCR		1.80					

Unit price (Tk/kg in 2021-22): Potato = 17, Wheat=25, T. Aman rice =22.50, rice straw = 1, Jute = 75 and Jute stick=5.50, Unit price (Tk/kg in 2022-23): Potato = 16, Wheat=28, T. Aman rice =23.75, rice straw = 2, Jute = 55 and Jute stick=5.00 [REY=Rice equivalent yield, GR= Grass return, TVC=Total variable cost, GM= Gross margin, PE=production efficiency and LUI= land utilization index]

Conclusion

The total crop productivity (in terms of REY), land use efficiency and profitability of improved cropping pattern i.e., Potato (var: BARI Alu-25)-Jute (var: Kenaf HC-95)-T. Aman were much higher than that of existing cropping pattern Wheat-Jute-T. Aman due to inclusion of high yielding variety of potato. Thus, potato var. BARI Alu-25 can be successfully accommodated in the existing cropping pattern which increased cropping intensity and system productivity with reasonable profitability.

43. DEVELOPMENT OF SWEET POTATO-KENAF-FALLOW CROPPING PATTERN AGAINST FALLOW-BORO-FALLOW CROPPING PATTERN IN HAOR AREA

M. MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site, Nikli during 2022-2023 to introduce two crops based Sweet Potato-Kenaf-Fallow cropping patterns as well as to increase crop production and economic return of the farmers. It was laid out in RCBD design with six dispersed replications. The improved cropping pattern gave the highest rice equivalent yield (20.27 t

ha⁻¹) against existing cropping pattern (7.50 t ha⁻¹). The improved cropping pattern gave the higher gross margin (Tk. 335403 ha⁻¹) compared to existing pattern (Tk. 104390 ha⁻¹). The marginal benefit cost ratio was recorded 2.82 in improved cropping pattern over existing cropping pattern.

Introduction

Sweet potato (*Ipomoea batatas*) is a major food crop, which serves as a source of energy and nutrition in many countries. The crop is regarded as a food security crop due to its low input requirements, ease of production and high nutritional component. Purple flashed sweet potato are also quite excellent sources of vitamin-A and its main pigments, especially β -carotene and carotenoids are closely associated by the improvement of immune system of human beings, reduce the risk of cardiovascular complexities, age-related macular degeneration, and cataract development (Wu et al., 2008). The average cropping intensity in Nikli upazila of Kishoreganj is 112% whereas national average is 195%. 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 in this area by introduce BARI sweet potato in this area. Potential adoption of sweet potato in Fallow-Boro-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, the below mention cropping patterns will be conducted at Patachapra haor in Kishoreganj. Hence the trail will be conducted to improve the existing cropping pattern, increase cropping intensity, increase yield and economic return, access to food and nutrition, employment opportunity and woman's participation.

Materials and Methods

The experiment was conducted at the farmers' field of Nikli upazila under Kishoreganj district of Bangladesh during 2022-23. The improved cropping pattern (IP) Sweet Potato-Kenaf-Fallow was tested against the farmers' pattern (FP) Fallow-Boro-Fallow cropping pattern with six dispersed replications. Unit plot size was 35 decimals. All agronomic management and other relevant information are furnished in table 1. Crop cut was done from an area of one square meter at three spots from each plot for yield samples in all cases. For comparison between crop sequences, the yields of all crops were converted into rice equivalent on the basis of prevailing market prices of individual crop (Verma and Modgal, 1983).

Results and discussions

Table 1 reveals that all the component crops in cropping pattern Sweet Potato-Kenaf-Fallow under improved practices (IP) gave significantly higher yield. On an average, the higher grain yield was obtained from Sweet Potato (32 t ha⁻¹) and Kenaf (5.25 t ha⁻¹) in improved pattern (IP) than the existing pattern due to high yielding variety and improved management practices. Sen et al. (1988) stated that significant variations among the genotypes were happened might be due to the adoption of proper cultural management techniques. Several researchers found that yield potentiality of sweet potato depends on the genetic make-up of plants (Naskar and Chowdhury, 1994; Siddique et al., 1988; Yooyongwech *et al.*, 2014). The rice equivalent yield reveals that improved cropping pattern produced higher production over farmers' existing cropping pattern (Table 1). The total rice equivalent yield was 20.27 t ha⁻¹ in improved cropping pattern which was (12.77 t ha⁻¹) higher than the existing (7.5 t ha⁻¹) one crop based cropping pattern.

The benefit cost ratio of improved pattern and rice-based farmers' existing pattern are presented in Table 1. From the economic point of view, the gross margin of improved cropping pattern (Tk. 335403 ha⁻¹) showed its superiority by 321.29% over farmers' existing pattern (Tk. 104390 ha⁻¹). The marginal benefit cost ratio (MBCR) was found 2.82 which indicated the superiority of the improved cropping pattern over the farmers' pattern. The marginal benefit cost ratio (MBCR) also showed that inclusion of sweet potato and Kenaf in the existing pattern might be profitable and acceptable to the farmers.

Farmers' opinion: They are very much impressed and interested on purple flesh sweet potato especially var. BARI Mishti Alu-17 due to its carotene rich and creating market demand in haor area.

Table 1. Management practices of alternate cropping pattern and existing cropping pattern at Kishoreganj during 2022-2023

Parameters	Improved cropping pattern			Existing Cropping Pattern		
Crop	Sweet Potato	Kenaf	Fallow	Fallow	Boro rice	Fallow
Variety	BARI Mistialu-17	HC-95			BRRI dhan29	
Date of sowing/ transplanting	10-11-2022	15-03-2023			10-01-2023	
Seed rate(kgha ⁻¹)	-	15			50	
Spacing	60cm × 40cm	Continuous			20cm × 15cm	
Fertilizer dose (kg ha ⁻¹) N, P, K, S, Zn and B	110-65-115-18-5-02	115-40-63-14-0-0			140-18-53-08-03-02	
Date of harvesting	12-03-2023	20-06-2023			28-04-2023	
Field duration (day)	122	97			108	
Yield (t ha ⁻¹)	32	5.25			7.5	
Rice equivalent yield (t ha ⁻¹)	13.71	6.56			7.5	
Rice equivalent yield (t ha ⁻¹)	20.27			7.5		
Gross return (TK ha ⁻¹)	384000	183750			210000	
Total variable cost (Tk. ha ⁻¹)	153577	78770			105610	
Gross margin (Tk. ha ⁻¹)	230423	104980			104390	
Total Gross margin (Tk. ha ⁻¹)	335403			104390		
MBCR (Whole pattern)				2.82		

GR= Gross return, TVC=Total variable cost and GM= Gross margin; Price of Sweet potato = 12 Tk/kg, Price of Kenaf = 35 Tk/kg, Price of Rice = 28 Tk/kg.

Conclusion

The total crop productivity (in terms of REY), land use efficiency and profitability of improved cropping pattern were much higher than that of existing cropping pattern due to inclusion of high yielding variety of sweet potato. Thus, sweet potato var. BARI Misti Alu-17 can be successfully accommodated in the existing cropping pattern which increased cropping intensity and system productivity with reasonable profitability.

44. DEVELOPMENT OF T. AMAN-MUSTARD-BORO CROPPING PATTERN AGAINST T. AMAN-FALLOW-BORO CROPPING PATTERN

M.MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site, Nikli during 2023-2024 to introduce three-crop based T. Aman-Mustard-Boro rice cropping patterns as well as to increase crop production and economic return of the farmers. It was laid out in RCBD design with four dispersed replications. The total rice equivalent yield was (16.98 t ha⁻¹) in improved cropping pattern which was (3.68 t ha⁻¹) higher than the existing (13.3 t ha⁻¹) two crop based cropping pattern. Lower rice equivalent yield (13.3 t ha⁻¹) was obtained in the farmer's pattern due to fallow period and traditional management practices.). The MBCR (4.20) indicates the superiority of the improved three crop based cropping pattern over the farmer's two crops based cropping pattern.

Introduction

The present cropping intensity of the country is about 195%. Food requirement is estimated to be doubled in the next 25 years. Under such condition, it is very important to increase cropping intensity and for this reason, more suitable crop (s) should be accommodated in the existing

cropping pattern. One of the major cropping patterns is practiced by farmers' in Kishoreganj region is Boro-T. Aman-Fallow. After harvest of T. Aman and before going to transplanting Boro rice, around 80-85 days remains fallow. To increase the cropping intensity, this fallow period might be utilized by inclusion of any short duration crop like mustard. BARI released mustard var. BARI Sarisha-14 is a high value oil crop might be introduced after T. Aman harvesting without hampering the existing cropping sequence. Again, the productivity of existing pattern is low due to local varieties and poor management practices. However, introducing modern variety and improved technology of Boro and T. Aman rice offered the opportunity to overcome the situation. Hence, the study was conducted with alternate cropping pattern T. Aman –Mustard-Boro cropping pattern against T. Aman-Fallow-Boro cropping pattern to increase yield and economic return.

Materials and Methods

The improved/alternate cropping pattern T. Aman-Mustard-Boro was conducted against T. Aman-Fallow-Boro at the MLT site, Nikli, Kishoreganj during 2023-24 in the medium highland. The soil of the experimental field was sandy loam. The experiment was laid out in RCBD design with four (four farmers' field) replications. Unit plot size was 10 decimals. All agronomic management, economics and all other information are presented in Table 1. Irrigation, pest managements and other intercultural operations were done as and when necessary. For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). The economic indices like gross return, gross margin and marginal benefit cost ratio (MBCR) were also calculated on the basis of prevailing market price of the inputs and outputs (produces). Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases.

Results and Discussions

The results revealed that all the component crops in cropping pattern T. Aman-Mustard-Boro under improved practices (IP) gave significantly higher yield. The rice equivalent yield reveals that improved cropping pattern produced higher production over farmers' existing cropping pattern (Table 1). The total rice equivalent yield was 16.98 t ha⁻¹ in improved cropping pattern which was (3.68 t ha⁻¹) higher than the existing (13.3 t ha⁻¹) two crop based cropping pattern. Lower rice equivalent yield (13.3 t ha⁻¹) was obtained in the farmer's pattern due to fallow period and traditional management practices.

The gross margin was substantially higher in the improved pattern (Tk. 195380 ha⁻¹) than that of the traditional pattern (Tk. 128080 ha⁻¹). The MBCR (4.20) indicates the superiority of the improved three crop based cropping pattern over the farmer's two crops based cropping pattern.

Farmers' opinion: Farmers opined that in improved three crops based cropping pattern, use of modern high yielding rice variety (BRRI dhan92) with insertion of mustard instead of T. Aman-Fallow-Boro can increase farm production and income. They showed their interest to replace their existing T. Aman-Fallow-Boro pattern by the newly developed T. Aman-Mustard-Boro cropping pattern.

Table 1 Management practices and economic analysis of alternate cropping pattern and existing cropping pattern at Kishoreganj during 2023-2024

Parameters	Improved cropping pattern			Existing Cropping Pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Variety	Binadhan16	BARI Sarisha-14	BRRI dhan92	BRRI dhan49		BRRI dhan89
Date of sowing/ transplanting	09-08-2023	14-11-2023	09-02-2024	18-08-2023		08-01-2024
Seed rate(kgha ⁻¹)	50	8	50	50		50
Spacing	20cm × 15cm	Broadcasting	20cm × 15cm	20cm × 15cm		20cm × 15cm

Parameters	Improved cropping pattern			Existing Cropping Pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Fertilizer dose (kg ha ⁻¹) N, P, K, S, Zn & B	140-18-53-08-0-02	115-32-40-25-2-2	130-30-53-08-0-02	140-18-53-08-0-02		173-60-78-18-0-02
Date of harvesting	10-11-2023	30-01-24	27-06-2024	29-11-2023		02-06-2024
Field duration (days)	94	77	139	103		146
Yield (t ha ⁻¹)	5.26	1.54	7.87	5.33		7.97
Rice equivalent yield (tha ⁻¹)	5.26	3.85	7.87	5.33		7.97
Rice equivalent yield (tha ⁻¹)	16.98			13.3		
Gross return (Tk/ ha ⁻¹)	126240	92400	188880	127920		191280
Total variable cost (Tk. ha ⁻¹)	82560	41350	88230	82560		108560
Gross margin (Tk. ha ⁻¹)	43680	51050	100650	45360		82720
Gross margin (Tk.ha ⁻¹), Pattern	195380			128080		
MBCR (Whole pattern)	4.20					

GR= Gross return, TVC = Total variable cost and GM= Gross margin; Price of mustard = 60tk/kg. Price of rice: 24 Tk/kg.

Conclusion

The total crop productivity (in terms of REY) and profitability of improved cropping pattern were much higher than that of existing cropping pattern due to inclusion of high yielding varieties of mustard. Thus, mustard var. BARI Sarisha-14 can be successfully accommodated in the existing cropping pattern which increased cropping intensity and system productivity with reasonable profitability.

45. DEVELOPMENT OF VEGETABLE BASED CROPPING PATTERN USING SUMMER TOMATO TRELLIS AGAINST BLACKGRAM-MUSTARD-SESAME

M. MANIRUZZAMAN, M. Z. HASAN, M. A. ISALM, and M. S. H. MOLLA

Abstract

The program was carried out at the farmers' field during 2023-24 at MLT site, Atghoria, Pabna to increase total system productivity and to ensure maximum utilization of summer tomato trellis. The program was implemented in four farmer's fields with two summer tomato based cropping patterns i.e., i) summer tomato-sweet gourd/yard long bean, ii) summer tomato-bitter gourd/sponge gourd along with farmer's existing black gram-mustard-sesame cropping pattern. The system summer tomato equivalent yield (STEY) were recorded as 59.0 and 52.9 t ha⁻¹, respectively from summer tomato-sweet gourd/yard long bean and summer tomato-bitter gourd/sponge gourd cropping patterns whereas STEY 8.62 t ha⁻¹ were recorded from the existing cropping pattern. The gross margin, production efficiency and land use efficiency were higher in summer tomato based cropping patterns than existing pattern.

Introduction

In Pabna district, the cultivation of summer tomato is increasing day by day. The farmers have to establish bamboo trellis for summer tomato cultivation which is very costly. Farmers get economic return from tomato only during the fruiting seasons. The remaining period they have to remove those trellis for cultivating other crops which is time consuming and costly. There are some vegetables which can be easily grown on those trellis and some vegetables can be grown on the ground land of trellis. So, vegetable cultivation in summer tomato trellis may be good option for the farmers to generate additional income from those trellis and minimize their cost for trellis.

Materials and Methods

The program was conducted at the farmers' field condition in at MLT site, Atghoria, Pabna during 2023-24. Modern and high yielding vegetable varieties BARI Hybrid Tomato-8 of Tomato, Jilik of sweet gourd, BGL-248 of yard long bean, Nobab of bitter gourd and Wander of sponge gourd were cultivated in improved pattern while farmer cultivate field crops with crop varieties i.e., BARI Sarisha-14 of mustard, local of black gram and BARI Til-4 of sesame variety in existing cropping pattern. All agronomic activities including sowing and harvesting dates, plant spacing, fertilizer management (FRG, 2018) etc. are mentioned in table 1. For comparison between crop sequences, the yields of all crops were converted into summer tomato equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). Land use efficiency, Production efficiency and summer tomato equivalent yield (STEY) were calculated using standard formula. The economic indices like gross return and gross margin were also calculated on the basis of prevailing market price of the inputs and outputs (produces). Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in table 1.

Results and Discussion

Yield of all the component crop and system REY are presented in Table 2. The component crop summer tomato, sweet gourd and yard long bean provided 38.2, 20.8 and 7.4 t ha⁻¹ fruit yield, respectively from the summer tomato-sweet gourd/yard long bean cropping pattern with system STEY 59.0 t ha⁻¹. Besides, the component crop summer tomato, bitter gourd and sponge gourd provided 37.3, 4.6 and 19.3 t ha⁻¹ fruit yield, respectively from the summer tomato-bitter gourd/sponge gourd cropping pattern with system STEY 52.8 t ha⁻¹. On the contrary, the grain yield of Blackgram, Mustard and Sesame were 1.42, 1.53 and 1.38 t ha⁻¹, respectively, with 8.62 t ha⁻¹ STEY in the existing pattern.

Maximum gross margin (Tk. 1861117 ha⁻¹) was found from summer tomato-sweet gourd/yard long bean followed by summer tomato-bitter gourd/sponge gourd pattern whereas existing pattern provided minimum gross margin Tk. 206790 ha⁻¹. Marginal benefit cost ratio of summer tomato-sweet gourd/yard long bean and summer tomato-bitter gourd/sponge pattern gourd were 4.7 and 4.4 respectively, over existing pattern (Table 2). Production efficiency (PE) and land use efficiency % (LUE%) were also higher in summer tomato based cropping patterns than farmer's existing pattern.

Farmers' opinion: Farmers were highly impressed with the summer tomato based cropping patterns. They were very interested to cultivate summer tomato based cropping patterns instead of their existing cropping pattern.

Table 1. Details of cultural practices adopted for different crops in field experiments

Crop	Variety	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
					N	P	K	S	Zn	B
CP1: Summer tomato-Yard long bean/Sweet gourd										
Summer tomato	BARI Hybrid Tomato-8	60 x 40	20.08.23	5 Nov. to 05Feb	250	90	125	22	5.5	2
Sweet gourd	Jilik	2m x 2m	10.03.24	10 May to 10 July	75	36	40	14	1	1
Yard long bean	BGL-248	2.5m x 15cm	10.04.24	10June to 30 July	23	30	75	-	-	-
CP2: Summer tomato- Sponge gourd/Bitter gourd										
Summer tomato	BARI Hybrid Tomato-8	60 x 40	20.08.23	5 Nov. to 05Feb	250	90	125	22	5.5	2
Bitter gourd	Nobab	1.5mx 1m	10.03.24	15 May to 15 June	75	20	20	5	1	0
Sponge gourd	Wander	1.5m x 1m	15.04.24	25 May to 10Aug	85	35	88	18	2.5	1.7
CP3: Black gram-Mustard-Sesame (Existing pattern)										

Crop	Variety	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
					N	P	K	S	Zn	B
Blackgram	Local	Broadcast	12.08.23	30.10.23	18	16	20	10	0	1
Mustard	BARI Sarisha-14	Broadcast	10.11.23	08.02.24	103	30	45	27	1	2
Sesame	BARI Till-4	Broadcast	20.03.24	27.06.24	60	30	25	18	0	0

Table 2. Yield of component crops and system level in different cropping pattern

Cropping pattern	Cropping pattern-1			Cropping pattern-2			Existing cropping pattern		
Crops	Summer tomato	Sweet gourd	Yard long bean	Summer tomato	Bitter gourd	Sponge gourd	Blackgram	Mustard	Sesame
Field duration	168	121	111 (relay)	168	106	117 (relay)	80	90	98
Yield (tha ⁻¹)	38.2	20.8	7.4	37.3	4.6	19.3	1.42	1.53	1.38
STEY (tha ⁻¹)	38.2	14.7	6.10	37.3	6.50	9.10	3.00	2.70	2.92
System STEY (tha ⁻¹)	59.0			52.9			8.62		
GR(Tk. ha ⁻¹)	2507500			2248250			366350		
TVC (Tk. ha ⁻¹)	646383			619848			191690		
GM(Tk. ha ⁻¹)	1861117			1628402			174660		
MBCR	4.7			4.4			-		
PE (kg ⁻¹ ha ⁻¹ day ⁻¹)	19.4			16.0			3.2		
LUE (%)	85			90			73		

Input: Urea: 22 Tk. kg⁻¹, TSP: 22 Tk kg⁻¹, MoP: 16 Tk. kg⁻¹, gypsum: 30 Tk kg⁻¹, zinc sulphate: 320 Tk kg⁻¹, boric acid: 600 Tk kg⁻¹, power tiller (1 pass): 3000 Tk ha⁻¹, irrigation (1 time): 2000 Tk. ha⁻¹ and Labour: 500 Tk. day⁻¹(8 hours);

Output (Tk kg⁻¹): Tomato: 42.5, Sweet gourd: 30, Yard long bean: 35, Bitter gourd: 60, Sponge gourd: 20, Black gram: 90, Mustard: 75, Sesame: 90

Conclusion

The study concludes that improved cropping pattern summer tomato-sweet gourd/yard long bean and summer tomato-bitter gourd/sponge provided 8 times and 7 times higher system productivity (in term of summer tomato equivalent yield) and then existing pattern, respectively. Furthermore, summer tomato-based patterns provide higher gross margin, productivity efficiency, land use efficiency and satisfactory MBCR over farmer's existing pattern.

46. IMPROVEMENT OF T. AMAN RICE-MUSTARD-SESAME CROPPING PATTERN

M. MANIRUZZAMAN, M. Z. HASAN, M. A. ISALM, and M. S. H. MOLLA

Abstract

The program was carried out at the farmers' field during 2023-24 to improve T. Aman-Mustard-Sesame rice cropping pattern at MLT site, Atghoria, Pabna. The program was implemented in six farmer's field. Yield of T. Aman, Mustard and Sesame rice were recorded as 4.98, 1.85 and 1.52 t ha⁻¹, respectively with rice equivalent yield (REY) 14.2 t ha⁻¹ in the improved cropping pattern whereas REY 12.2 t ha⁻¹ were recorded in the existing cropping pattern. The gross margin was higher in improved cropping pattern than existing pattern due to inclusion of modern high yielding varieties.

Introduction

Rice based cropping pattern is the major cropping pattern in Bangladesh agriculture. (Haque, 1998). T. Aman-Mustard-Sesame is a dominant cropping pattern in Pabna region with old traditional crop varieties in Bangladesh. Bangladesh Rice Research Institute (BRRI) has recommended the T. Aman- Mustard-Sesame cropping pattern (BARC, 2001; Khan *et al.*, 2004) with the inclusion of 70-75 days local mustard variety (Tori 7) in the transition period between T. Aman and Boro rice. But the farmers harvest poor yield from local var. Tori7 that can be increased manifold by introducing high yielding varieties (Alam and Rahman, 2006; Basak *et al.*,

2007). Bangladesh Agricultural Research Institute (BARI) has developed high yielding yellow seeded mustard (*Brassica campestris*) varieties, BARI Sarisha-17 whose yield potential is higher than Tori-7. T. Aman-Mustard-Sesame crop sequence can be improved easily by inclusion of these mustard varieties with higher economic return.

Materials and Methods

The program was conducted at the farmers' field condition in at MLT site, Atghoria, Pabna during 2023-24. Modern and high yielding crop varieties BARI Sarisha-17 of mustard, BRRI dhan75 of T. Aman rice and BARI Til-4 of sesame were cultivated in improved pattern while farmer cultivate old traditional crop varieties i.e., BARI Sarisha-14 of mustard, BinaDhan7 of T. Aman rice and local sesame variety in existing cropping pattern. Economic analysis was done on the basis of prevailing local market price of the commodities. Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). The REY was calculated on the basis of average market price of T. Aman rice.

Results and Discussion

Yield of all the component crop and system REY are presented in Table 2. The component crop T. Aman, Mustard and Sesame provided 4.98, 1.85 and 1.52 t ha⁻¹ grain yield, respectively in the improved cropping pattern with system REY 14.2 t ha⁻¹. On the contrary, the grain yield of T. Aman, Mustard and Sesame were 4.35, 1.55 and 1.32 t ha⁻¹, respectively, with 12.2 t ha⁻¹ REY in the existing pattern. Improved cropping pattern provided 16% higher system REY compared to existing pattern mainly due to inclusion of modern high yielding crop varieties. Maximum gross margin was found from improved pattern Tk.247185 ha⁻¹ whereas existing pattern provided minimum gross margin Tk. 206790 ha⁻¹. Marginal benefit cost ratio of improved cropping pattern was 3.06 over existing pattern (Table 1).

Farmers' opinion: Farmers were highly impressed with the high yielding, more oil containing and short duration mustard variety BARI Sarisha-17 that can be easily fitted in between T. Aman and Sesame. They were very interested to include modern yielding varieties in their existing cropping pattern.

Table 1. Crop performance of improved cropping pattern (T. Aman-Mustard-Boro) against the existing pattern T. Aman-Fallow-Boro in FSRD site, Ganggarampur, Pabna, 2023-24

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	T. Aman	Mustard	Sesame	T. Aman	Mustard	Sesame
Variety	BinaDhan7	BARI Sarisha-14	Local	BRRI dhan75	BARI Sarisha-17	BARI Til-4
Sowing/transplanting date	6-8/8/23	16/11/23	22/3/24	6-8/8/23	16/11/23	22/3/24
Spacing	20 cm ×15 cm	Broadcast	Broadcast	20 cm × 15 cm	Broadcast	Broadcast
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	105-30-37-20-0-2	103-30-45-27-1-2	60-30-25-18-0-0	85-10-40-10-1.5-0	90-27-40-10-0-1	75-20-40-18-2-0
Harvesting date	5-10/11/23	5-10/02/24	20-25/06/24	5-10/11/23	23-26/02/24	23-28/06/24
Field duration	90-95	85-90	95-100	88-92	90-92	95-100
Turnaround time	45	10	40	46	16	25
Grain or seed yield (t ha ⁻¹)	4.35	1.55	1.32	4.98	1.85	1.52
Straw or stover yield (t ha ⁻¹)	5.16	2.37	2.84	4.96	2.48	3.53
REY (t ha ⁻¹)	12.20			14.2		
Gross return (Tk. ha ⁻¹)	401770			461770		
Total variable cost (Tk. ha ⁻¹)	194980			214585		
Whole pattern GM (Tk. ha ⁻¹)	206790			247185		
MBCR (Whole pattern)	3.06					

Price (Tk kg⁻¹): T. Aman rice=30; Rice straw= 5; Mustard seed= 75; Mustard stover= 2. Sesame seed= 90 and stover=2

Conclusion

From the results, it can be concluded that Improved cropping pattern provided 16% and 20% higher system REY and gross margin than existing pattern, respectively. Furthermore, short duration with high yielding mustard variety BARI Sarisha-17 can easily be grown during the fallow period between T. Aman and Sesame It will help to increase productivity and minimize the shortage of edible oil for the increasing population of Bangladesh.

47. DEVELOPMENT OF OIL SEED BASED CROPPING PATTERN MUSTARD-JUTE-T. AMAN RICE

M Z FERDOUS, M E HAQUE, M A U ALAM AND M A A H TALUKDER

Abstract

The field experiment was conducted during 2023-24 to increase the cropping intensity and productivity by incorporation of oilseed crop in cropping patterns against the existing two-crop based cropping pattern. The developed cropping pattern (Mustard-Jute-T. Aman) were tested against existing cropping pattern (T. Aman rice-Grass pea) in the farmers field under stable charland of Chilmari, Kurigram. Fibre or grain or seed yield of jute, T. Aman, and mustard pea were recorded as 2.87, 4.87 and 1.88t ha⁻¹, respectively with rice equivalent yield (REY) 16.58 t ha⁻¹ in the improved cropping pattern; whereas 4.49 and 2.62 t ha⁻¹ grain or seed yield of T. Aman and grass pea with REY 7.23 t ha⁻¹ were recorded in the existing cropping pattern. Production efficiency was 53.31 and 30.77 Kg ha⁻¹day⁻¹, and land use efficiency was 85.21 and 53.31 in alternate and existing cropping pattern, respectively. The whole pattern gross margin was higher in improved pattern (Tk. 294460 ha⁻¹) than existing pattern (Tk. 90420 ha⁻¹). The MBCR was 2.49 in alternate pattern over existing pattern.

Introduction

Mustard is the most important and popular oil seed crop, which is mainly grown in winter season in Bangladesh. The area under mustard is declining due to competition with other *rabicrops* as well as late harvesting of long duration T. Aman rice. Though the production of edible oil is being decreased, the demand is increasing day by day with the increasing population. To fulfill this demand, Bangladesh has to import a large quantity of edible oil every year at the cost of huge amount of foreign exchange. Cultivation of low yielder local varieties with poor fertilizer management is the major cause for poor yield of mustard in the country (Alam and Rahman 2006). High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, Bangladesh Agricultural Research Institute (BARI) has developed a number of high yielding varieties of mustard with yield potential up to 2.5 t ha⁻¹. The present national average yield of mustard is only 1.1 t ha⁻¹ (Anon. 2015). In those patterns, the farmers are using local variety of mustard (Tori-7) with poor fertilizer management and harvest poor yield of mustard. By introducing the high yielding varieties with better management packages the yield of mustard can be increased to a satisfactory level. Therefore, the production program of oilseed based cropping pattern was carried out at farmers field to popularize BARI developed high yield potential mustard variety among the farmers under oilseed based cropping pattern and to increase oil seed production and farmers income.

Materials and Methods

The experiment was conducted at the farmers' field under stable charland condition during 2023-24 to increase the cropping intensity and productivity. The pilot production program of oil seed based cropping pattern Mustard-Jute-T. Aman rice was conducted at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, Rangpur against existing cropping pattern (T. Aman rice-Grass pea). The alternate cropping pattern consist of 4 crops was compared with 2 crop-based famers' existing pattern. 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 on the basis of prevailing local market price of the commodities. 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 the 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 sulphate for Zn and Boric acid for B.

Data on 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 summation of individual (component) crop yield of each cropping cycle. Land use efficiency, Production efficiency and rice equivalent yield (REY) were calculated using standard formula.

Results and discussion

Yield and economic performance of alternate and existing cropping patterns during 2023-24 are presented in Table 1. The yield of jute fibre, T. Aman grain, and mustard were recorded as 2.87, 4.87 and 1.88 t ha⁻¹, respectively with rice equivalent yield (REY) 16.58 t ha⁻¹ in the improved cropping pattern whereas 4.49 and 2.62 t ha⁻¹ grain or seed yield of T. Aman and grass pea with REY 7.23 t ha⁻¹ were recorded in the existing cropping pattern during 2023-24. Maximum production efficiency (53.31 kg ha⁻¹ day⁻¹) was obtained from alternate cropping pattern. The lower production efficiency 30.77 kg ha⁻¹ day⁻¹ was found in farmers existing pattern (Table 1). Land use efficiency indicated that alternate cropping pattern used the land for 85.21% time of the year, whereas farmers existing pattern used the land for 66.01% time of the year (Table 1). The whole pattern gross margin was higher in alternate pattern (Tk. 294460 ha⁻¹) than existing pattern (Tk. 90420 ha⁻¹). The MBCR was 2.49 in alternate pattern over existing pattern.

Table 1 Crop performance of improved cropping pattern Jute-T. Aman-Mustard against the existing pattern T. Aman-Grasspea

Pattern	Existing cropping pattern			Improved cropping pattern		
Crop	T. Aman	Grass pea	Fallow	Jute	T. Aman	Mustard
Variety	Local (Gainja)	Local	-	O-795	BRRI dhan87	BARI Sarisha-18
Spacing (cm)	20 × 15	Broadcast	-	Broadcast	20 × 15	Broadcast
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	-
Date of sowing/transplanting	20 July	15 Nov.	-	6-8 April	5-10 August	20-30 November
Harvesting date	05 Nov.	22 Mar.	-	25-29 Jul.	17-20 Nov.	25-28 February
Field duration (day)	108	127	-	110	104	97
Turnaround time (day)	10	120	-	36	6	10
Grain/fibre/tuber/fruit yield (t ha ⁻¹)	3.23	1.28	-	2.87	4.87	1.88
Straw/stover/stalk yield (t ha ⁻¹)	3.62	-	-	6.81	5.50	2.44
REY (t ha ⁻¹)	4.49	2.62	-	6.19	5.60	4.70
Whole pattern REY (t ha ⁻¹)	7.23			16.58		
Production efficiency (kg ha ⁻¹ day ⁻¹)	30.77			53.31		
Land use efficiency (%)	66.01			85.21		
Gross return (Tk. ha ⁻¹)	98850	57600	-	185820	168100	143440
Total variable cost (Tk. ha ⁻¹)	44600	21430	-	80345	67390	55165
Gross margin (Tk. ha ⁻¹)	54250	36170	-	105475	100710	88275
Whole pattern GM (Tk. ha ⁻¹)	90420			294460		
MBCR (Whole pattern)				2.49		

Price (Tk. kg⁻¹): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-30, Rice straw-4.5, Jute fiber-60.0, Jute stick-2.0, Mustard- 75.0, Mustard stover-1.0 and Grass pea-45

Farmer's opinion

Farmers expressed that BARI Sarisha-18 is a high-yielding variety, encouraging them to cultivate it as a profitable crop within their existing cropping pattern. They preserved seeds with the intention of planting this variety in the next season. Despite the relatively long growing period of BARI Sarisha-18, they preferred it due to its higher seed and stover yield, and its suitability for the Mustard-Jute-T. Aman cropping pattern.

Conclusion

The experimentation shows that cultivating alternative cropping patterns is more profitable than the existing ones. By adopting the improved cropping pattern, we can utilize 109-day turnaround time and increase cropping intensity. In some years, T. Aman is damaged by floods, making it a chance crop. Therefore, adopting alternative cropping patterns would help increase total production and enhance farmers' income.

48. PILOT PRODUCTION PROGRAM OF OIL SEED BASED CROPPING PATTERN POTATO-GROUNDNUT-T. AMAN RICE

M Z FERDOUS, M E HAQUE, M A U ALAM AND M A A H TALUKDER

Abstract

A set of alternate cropping pattern (ACP) were tested against farmers existing cropping pattern (FCP) at char jagotber, Rajpur, Lalmonirhat, under OFRD, Rangpur during 2023-24 to incorporate oilseed crop in cropping pattern and disseminate among the farmers in respective locations. Alternate cropping pattern consists of groundnut, potato and T. Aman crops was compared with three crop-based farmers' existing cropping pattern Maize-T. Aman-Tobacco. In all the replication, ACPs were more profitable and viable than those of FCPs in terms of agronomic and economic point of view. Rice equivalent yield (REY), crop productivity and profitability were higher in ACPs than FCPs. Inclusion of oilseed crops in the existing cropping pattern and replacing old and traditional varieties by modern varieties enhanced productivity and profitability.

Introduction

Agriculture is the main livelihood for *char* dwellers in Bangladesh. *Char* livelihood largely depends on agricultural production. Cropping systems in *char* are quite different from the other land areas because of sandy soil texture and environmental variability (Kabir, 2006). Only a few specific crops are grown in the *char* area such as maize, groundnut, seasonal paddy, and some vegetables. Most of the *char* farmers keep their lands fallow during the main cropping season: Kharif (May to October) because of high evaporation which renders cultivation impossible without irrigation. Instead, the Rabi season (November to April) is the main cropping season in the *char* area, when temperatures are lower which is best for vegetable cultivation (Lahiri-Dutt and Samanta, 2007). Groundnut is the most important and popular oil seed crop, which is mainly grown in *char* areas of Bangladesh. Cultivation of low yielder local varieties with poor fertilizer management is the major cause for poor yield of oilseed crops in the country (Alam and Rahman 2006). High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, Bangladesh Agricultural Research Institute (BARI) has developed a number of high yielding varieties of groundnut with yield potential up to 3 t ha⁻¹. By introducing the high yielding varieties with better management packages the yield of oilseed crops can be increased at satisfactory level. Therefore, the production program of potato-groundnut-T. Aman cropping pattern was carried out at farmers field to popularize BARI developed high yield potential crop variety among the farmers and to increase oil seed production and farmers income.

Materials and Methods

Experiments on alternate cropping pattern (ACP) were conducted at Char Jagotber, Lalmonirhat under OFRD, Rangpur during Rabi season 2023-24 to observe the cropping pattern performance at char areas and to popularize and disseminate to the farmers among char areas. Each experiment covered six bigha, one bigha for each farmer. 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. Alternate cropping pattern Potato-Groundnut-T. Aman was executed against the farmers existing cropping pattern tobacco-maize-T. Aman. The details of the varieties used and cultural operations adopted in different crops under the both alternate and farmers' cropping pattern are given in Table 1. 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 dressed in 2-3 splits. 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 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 yield of various crops in sequences were recorded and converted to ton per hectare. The data of FP was recorded from adjacent farmers' plots. Land use efficiency, Production efficiency and rice equivalent yield (REY) were calculated using standard formula.

Results and discussion

Yield and economic performance of alternate and existing cropping patterns during 2023-24 are presented in Table 1. The yield of groundnut, T. Aman grain, and potato were recorded as 1.70, 4.69 and 32.43 t ha⁻¹, respectively with rice equivalent yield (REY) 32.22 t ha⁻¹ in the improved cropping pattern whereas 9.18, 4.84 and 2.47 t ha⁻¹ seed yield of Maize, T. Aman and Tobacco leaf respectively with REY 18.99 t ha⁻¹ were recorded in the existing cropping pattern during 2023-24. Maximum production efficiency (95.61 kg ha⁻¹day⁻¹) was obtained from alternate cropping pattern. The lower production efficiency 53.36kg ha⁻¹day⁻¹ was found in farmers existing pattern (Table 1). Land use efficiency indicated that alternate cropping pattern used the land for 85.21% time of the year, whereas farmers existing pattern used the land for 66.01% time of the year (Table 1).

The whole pattern gross margin was higher in alternate pattern (Tk. 572654 ha⁻¹) than existing pattern (Tk. 369856 ha⁻¹). The MBCR was 2.05 in alternate pattern over existing pattern.

Farmers opined that Potato-Groundnut-T. Aman rice cropping pattern was superior to existing cropping pattern.

Table 1 The average crop performance of alternate cropping pattern (ACP) Vs, Farmers' cropping pattern (FCP) at char jagotber, Rajpur, Lalmonirhat, under OFRD, Rangpur, 2023-24

Parameter	Farmers' cropping pattern			Alternate cropping pattern		
Crop	Maize	T. Aman	Tobacco	Groundnut	T. Aman	Potato
Variety	NH 7720	Swarna	Motihar	BARI Chinabadam-9	BRRI dhan87	BARI Alu-25
Spacing	60cm×25cm	20cm×15cm	90cm×60cm		20cm×15cm	60cm×45cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha ⁻¹)	255-75-80-52-3-1.5	70-15-38-0-0-0	69-36-55-0.7-0-0	55-42-61-37-2.5-1.8	90-6-33-4-0-0	135-30-90-15-2-1.0
Date of sowing/transplanting	3-8/4/23	24-27/7/23	10-13/11/23	24-28/2/23	20-25/7/23	11-20/11/23
Harvesting date	20-23/7/23	3-7/11/23	22-28/3/24	10-15/7/23	25-28/10/23	20-25/2/24
Field duration	108	102	133	132	103	102
Turnaround time	10	7	5	6	10	12
Crop yield (t ha ⁻¹)	9.18	4.84	2.47	1.70	4.69	32.43
Straw/stover yield (t ha ⁻¹)		5.52			5.44	-

Parameter	Farmers' cropping pattern			Alternate cropping pattern		
Crop	Maize	T. Aman	Tobacco	Groundnut	T. Aman	Potato
REY (t ha ⁻¹)	4.59	5.67	8.73	5.10	5.50	21.62
Total REY (t ha ⁻¹)	18.99			32.22		
Gross return (Tk. ha ⁻¹)	137743	170126	261971	153000	165051	648600
Total variable cost (Tk. ha ⁻¹)	56875	64400	78700	90560	64400	239037
Gross margin (Tk. ha ⁻¹)	80868	105726	183271	62440	100651	409563
GM (Tk. ha ⁻¹)	369865			572654		
Production efficiency (kg ha ⁻¹ day ⁻¹)	55.36			95.61		
Land use efficiency (%)	94.0			92.3		
MBCR (Whole pattern)	2.05					

Price (Tk. kg⁻¹): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-30, Rice straw-4.50, Maize 15, Tobacco-106, Potato-20, Groundnut-90, REY: rice equivalent yield, MBCR: marginal benefit cost ratio, GM: gross margin

Conclusion

From the above discussion, it is evident that adopting alternative cropping patterns is more profitable than sticking to the existing ones. Implementing these improved cropping patterns allows us to utilize turnaround time effectively and increase cropping intensity.

49. VERIFICATION OF YIELD GAP MINIMIZATION IN POTATO - MAIZE - T. AMAN RICE CROPPING PATTERN THROUGH RECOMMENDED MANAGEMENT SYSTEM

S.M.A.H.M. Kamal, M.U.S. Khatun and M.A.H. Talukder

Abstract

A study was meticulously conducted at the Lalmonirhat MLT site, Rangpur, under AEZ-3, to meticulously assess the yield gap between the research and farmers' management of the Potato-Maize-T. Aman Rice cropping pattern. Potato equivalent yield (total pattern) for farmer management (T₂) and research management (T₁) were robustly recorded at 80.57 t ha⁻¹ and 74.30 t ha⁻¹, respectively. The gross margin of total pattern was at Tk. 620672 ha⁻¹ and Tk. 547853 ha⁻¹ for T₂ and T₁ treatment, respectively. The cropping pattern base BCR of T₂ treatment was higher at 2.80, whereas 2.59 recorded for T₁ treatment. The total variable cost of the farmer's management was Tk. 344624 ha⁻¹ whereas total variable cost for research management was decisively determined to be Tk. 343747 ha⁻¹. However, despite the higher production cost, T₂ treatment yielded 6.20 t ha⁻¹ with higher gross margin of Tk. 72823 ha⁻¹ compared to T₁ treatment.

Introduction

The major cropping pattern is Potato-maize-T. Aman rice in Rangpur region. Here, potato, maize and Aman rice are important food crops and being cultivated throughout the country. Now these crops are also cash crops in this region. Potato optimum potential tuber yield is around 30-35 t ha⁻¹ in farmer's field by farmers management but in research management its tuber yield is 45-60 t ha⁻¹ in BARI demonstrated different farmer's field. The previous data, the number & the weight of tuber were recorded maximum 12-15 from research & 10-12 from farmer's management, and 0.90-1.15 kg from research & 0.45-0.50 kg hill⁻¹ from farmer's management respectively. The recommended spacing of potato was maintained as 60 cm x 25 cm in research management. But, presently, farmer management spacing of potato was maintained 55 cm x 20 cm and same way, the T. Aman rice crop it was maintained at research management 20 cm x 20 cm spacing and 20 cm x 15 cm of spacing of farmers' management. The farmers idea, use of number plants, fertilizers and good variety effect were given more yields. Normally, farmers are used higher dose of fertilizers over the research management. But, both ideas are showing some gaps. So, it is necessary to verify the both management for higher yield compare to research management with farmer management to find out the yield gap of research and farmers management and to observe the soil fertility.

Materials and Methods

The experiment was conducted at Lalmonirhat MLT site, under AEZ # 3 during Rabi season 2022-23 to find out the yield gap and observe the soil fertility of research and farmers management at the farmers field. Initial soil analysis report of experiment location were as follow-

Sample no.	PH	OC (%)	N (%)	P (µg/g)	K (meq/100g)	S (µg/g)	Zn (µg/g)	B(µg/g)
Avg.	5.11	2.45	0.107	91.62	0.099	11.96	0.260	0.226
Crit. Level	-	-	0.12L	10.0VH	0.12L	10.0L	0.6L	0.2L

The experiment was laid out in Randomized Complete Block Design (RCB) with six dispersed replications. Each replication is each farmer. This was two treatments such as i) Research's management (STB fertilizer dose+Rec.spacing+Rec.Irrigation+ Rec. Pest control) and ii) Farmer's management (Farmers fertilizer dose+ FP Spacing+FP Irrigation+FP Pest control) in Potato-Maize-T. Aman rice cropping pattern. Soil test based fertilizer dose and other management.

Treatment wise management package of two cropping patterns were followed as below table -

	Research's management (STBD) (T ₁)			Farmer's management (T ₂)		
Items	Potato	Maize	T. Aman	Potato	Maize	T. Aman
Variety	BARI Alu 25	BARI maize 17	BRRi dhan87	BARI Alu-25	NH-7720	Sharna
Spacing (cm)	60 × 25	60 × 25	20 × 20	55 × 20	55 × 20	20 × 15
Seed rate (kg ha ⁻¹)	2500	25	30	2500	25	30
Fertilizer dose (Urea-TSP-MoP-Gypsum-Zinc Sulphate-Boron kg ha ⁻¹)	350-220-300-122-10-8 - 6000	450-125-250-222	195-50-60-65	450-350-380-120-12-10-10000	305	206
Harvest date	3-5 March	5-8 July	22-25 Oct.	3-5 March	5-8 July	22-25 Oct.
Crop duration (day)	85-90	125-128	102-105	85-90	125-128	102-105

The size of the unit plot was five decimals for each variety. Weeding, irrigation and spraying were done as required. Fertilizers were applied at the rate of treatment wise (above table) (BARI Krishi Projukti Hand Book, 2018) as respectively. Half of Urea, whole amount of TSP, MoP, Gypsum, Zinc and Boron were applied as basal. Remaining the rest of urea was top dressed at crop wise. Data were taken on different growth parameters like plant height, tuber plant⁻¹, tuber weight hill⁻¹ and tuber yield. All data were compiled and analyzed with manually.

Results and Discussions

The results have been presented in table 1. The potato equivalent yield of farmer (T₂) and research (T₁) management were 80.5 and 74.3 t ha⁻¹ respectively. The gross margin Tk .620672 and 547853 ha⁻¹ were recorded from T₂ and T₁ treatment. The BCR of T₂ (2.80) treatment was higher than T₁ (2.59) treatment. But, the cropping pattern base total variable cost of farmer's management was recorded Tk. 344624 ha⁻¹. The research's management total variable cost was Tk. 343747 ha⁻¹. Besides, yield and gross margin of T₂ was higher than T₁ treatment. It was 6.20 t ha⁻¹ of the yield and Tk.72823 ha⁻¹ of gross margin be due to closer spacing at farmer management.

Table 1 Yield and economics of crops grown under research and farmers managed cropping patterns at MLT site College Para, Lalmonirhat during 2022-23

Parameters	Research's management (STBD) (T ₁)			Farmer's management (T ₂)		
Crop	Potato	Maize	T. Aman	Potato	Maize	T. Aman
Yield (t ha ⁻¹)	45.8	7.40	4.80	47.9	8.50	5.42
PEY (t ha ⁻¹)	74.3			80.5		
Gross return (Tk. ha ⁻¹)	891600			965300		
TVC (Tk. ha ⁻¹)	343747			344624		
Gross margin (Tk. ha ⁻¹)	547853			620676		
BCR	2.59			2.80		

Price (Tk. kg⁻¹): Potato =12, Maize=30, Aman rice=25, Urea =22, TSP= 22, MoP=15, Gypsum =10, ZnSO₄=100, Boron= 150 and Cowdung =2 PEY=Potato equivalent yield.

Conclusion

After the end of one year completed this experiment, the farmer's management result was performed better. But soil fertility was another observation. So, final recommendation will be furnished after next two year.

50. VALIDATION OF FERTILIZER DOSE FOR POTATO-MAIZE-T. AMAN RICE CROPPING PATTERN IN RANGPUR

S. M. A. H. M. Kamal, Ummay Kulsum Laily and M. A. H. Talukder

Abstract

An on-farm trial was meticulously conducted at the Lalmonirhat MLT site in Rangpur under AEZ#3 to pinpoint the optimal fertilizer dose for the Potato-Maize-T. Aman rice cropping pattern. Impressively, the highest potato equivalent yield of 58.40 t ha⁻¹ was achieved from T₂, which is identical to T₃ and T₄. T₁ and T₅ yielded the lowest at 54.08 t ha⁻¹ and 53.10 t ha⁻¹, respectively. Furthermore, the results show that T₂ produced the highest gross return (GR), while T₃ stood out with the highest gross margin (GM) and Benefit-Cost Ratio (BCR) of 2.19, attributed to the use of soil test-based fertilizers. From the above results, there is sound evidence to recommend the soil test-based (STB) fertilizer dose (T₃) as the optimal choice for this cropping pattern. It is evident that this approach will not only optimize yields but also ensure the long-term health of the soil.

Introduction

In Rangpur region, one of the major cropping patterns is Potato-Maize-T. Aman rice cropping pattern. About 70 % land area is covered by this cropping pattern on medium to high land condition. But, the main problem is the quantity of fertilizer dose; farmers do not apply the Potato recommended dose of BARI. They mean, this recommended dose is not enough for better potato production. Farmers use their fertilizer dose in this pattern. The farmer's fertilizer dose is not similar to recommended fertilizer dose of BARI. Farmer's dose only higher then recommended dose on the first crop of potato. They also use more organic fertilizer (Cowdung) with 40-60 Kg dec.⁻¹ were less in recommended dose. Only, Urea and sometime MoP are used in the second and third crop maize and T. Aman rice. Farmer's idea, recommended dose of BARI of first crop potato cannot fulfill the maximum tuber yield. So, their own dose is appropriate to potato production. Not only this, but Maximum farmers also use only Urea and MoP fertilizer in Maize crop after potato harvest and similarly, follow in T. Aman rice crop. Fertilizer recommended guide and BARI Progitir hand book recommended dose are not similar. Farmers are confused which dose is better. So, it is necessary of verify the farmers ideal, research idea, remove confusion fertilizer dose and finally conclude at effective fertilizer dose of this area for this major cropping pattern under this objective to find out the perfect fertilizer dose of the Potato-Maize-T. Aman rice cropping pattern.

Materials and Methods

The experiment was conducted at College Para, Lalmonirhat MLT site, under On-Farm Research Division, BARI, Rangpur during the year of 2021-22 to find out the optimum or perfect fertilizer dose of this Potato-Maize-T. Aman rice cropping pattern. Initial soil analysis report of experiment location were as fallow-

Sam no.	P ^H	OC (%)	N (%)	P (µg/g)	K (meq/100g)	S (µg/g)	Zn (µg/g)	B(µg/g)
Avg.	6.35	1.67	0.124	88.88	0.377	8.21	0.615	0.382
Crit. Level	-	-	0.12L	10.0VH	0.12H	10.0L	0.6L	0.2L

This area was belonged to vary high P and high K nutrient after soil analysis. There were crop wise five treatments as below table-They were followed such as recommended dose T₁:

Recommended Fertilizer Dose (RFD), T₂: 20% Higher Recommended Fertilizer Dose (HRFD), T₃: Soil Test Base Fertilizer Dose (STBFD) and T₄: Farmer Fertilizer Dose of 25 % Farmers (FD_{25% F}). and T₅: Farmers Fertilizer Dose of 75 % Farmers (FD_{75% F}) (Kirisi Progiktir Hand Book, 2020 and Fertilizer Recommended Guide, 2018). Maximum farmers use full fertilizers in potato crop but in pattern base 75 % farmers use only urea fertilizer at next Maize, *Boro* and T. *Aman* rice crop in Potato – Maize – T. *Aman* rice and Potato – *Boro* – T. *Aman* rice cropping pattern respectively and rest of 25 % farmers use to apply other fertilizer with urea. The design was randomized complete block with three replications. Each replication was one farmer. The weed management and intercultural operation were done as per required. The unit plot size was 15 decimal of each farmer. Data on yield and yield attributes was recorded and converted to ton per hectare.

Crop management package of this cropping pattern was followed as below table

Items	Potato	Maize	T. <i>Aman</i> rice
Sowing date	25-30 Nov.	10-12 March	02-05 Aug.
Variety	BARI Alu-53	ACI-Down-A	Sowarna (Local)
Spacing	60 cm X 25 cm	60 cm X 25 cm	20 cm X 20 cm
Fertilizer dose (Urea-TSP-MoP- Gypsum-Zinc Sulphate-Boron- Cowdung kg ha ⁻¹)	T ₁ : RFD	350-220-300-122-10-8 - 10000	450-125-250-222
	T ₂ : 20% HRFD	420-264-360-146-12-10- 12000	540-150-150-266
	T ₃ :STBFD	250-50-90-90-9-6-6000	500-100-80-90
	T ₄ : FD 25% F	450-350-380-120-12-10- 12000	305-225-220-166-0- 9
	T ₅ : FD 75% F	450-350-380-120-12-10- 12000	305
Harvest date	02-03 March	20-25 July	13-15 Nov.
Duration (days)	90-95	125-130	110-115

Results and Discussion

Results and discussions have been presented in table-1, 2 and 3. It was found that T₂ produced the highest tuber yield (32.25 t ha⁻¹) which is identical to T₃, T₄ and T₅ treatment. The lowest tuber yield (30.60 t ha⁻¹) was recorded from T₁ treatment. The highest GR (389400 Tk. ha⁻¹) was recorded for T₄. But, the highest GM (204629 Tk. ha⁻¹) and BCR (2.17) from T₃ was recorded due to lowest TVC (174171 Tk. ha⁻¹). The highest grain yield of maize (5.71 t ha⁻¹ ha) and T. *Aman* rice (5.04 t ha⁻¹) was recorded from T₂ treatment and this was identical with T₃ and T₄. The lowest grain yield of maize (4.31 t ha⁻¹) and T. *Aman* rice (4.15 t ha⁻¹) was recorded from T₅ due to use by only urea fertilizer after potato harvest. About 75% farmers did not use other nutrients (P, K and S) after potato harvest in this region. The highest GR and TVC were recorded from T₂ due to use of higher fertilizer dose from both maize and T. *Aman* rice. But, the highest GM and BCR were come from T₃ due to lowest TVC (using of balance or soil requirement fertilizer dose). So, Soil test base T₃ was best than other treatments.

The highest potato equivalent yield (58.40 t ha⁻¹) was found from T₂ which was identical to T₃ (56.82 t ha⁻¹) and T₄ (56.12 t ha⁻¹). The lowest yield (54.08 t ha⁻¹) and (53.10 t ha⁻¹) was recorded from T₁ and T₅. The highest GR (Tk.797250ha⁻¹) was come from T₂. But, the highest GM (371618) and BCR (2.19) were recorded from T₃ due to using of soil test based fertilizers. After 2 years observation T₃ will be better fertilizer recommended dose for Potato-Maize-T. *Aman* rice cropping pattern. Other treatments were required more amounts of fertilizers than T₃. The excess cost of all fertilizers in T₁, T₂, T₄, T₅ were Tk. 14570, Tk.21596, Tk.24042, Tk.8312 ha⁻¹ than T₃ (Table 2). So, soil test base treatment (T₃) would perform better.

Farmers' Opinion: The farmers were pleased to observe this experiment.

Table 1 Average yield and economics of Potato-Maize-T. *Aman* rice cropping pattern at MLT site College Para, Lalmonirhat during 2021-22 and 2022-23

Treatment	Yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)	BCR
Potato					
T ₁ : RD	30.60b	367200	193181	174019	1.89
T ₂ : 20% HRD	32.25a	387000	201764	185236	1.69
T ₃ : STBD	31.55ab	378600	174171	124429	2.17
T ₄ : FD _{25%} F	31.95ab	389400	204696	178704	1.88
T ₅ : FD _{75%} F	31.95ab	389400	204696	178704	1.88
CV (%)	5.19	-	-	-	-
Maize					
T ₁ : RD	4.96ab	148800	78186	70615	1.91
T ₂ : 20% HRD	5.71a	171300	79693	82607	2.02
T ₃ : STBD	5.52a	165400	74503	90947	2.03
T ₄ : FD _{25%} F	5.16a	154150	77348	77302	2.00
T ₅ : FD _{75%} F	4.31b	129300	64976	64324	2.00
CV (%)	8.97	-	-	-	-
T. <i>Aman</i> rice					
T ₁ : RD	4.84ab	132875	64361	68515	2.06
T ₂ : 20% HRD	5.04a	138450	66171	72282	2.08
T ₃ : STBD	5.02a	137875	61633	76242	2.23
T ₄ : FD _{25%} F	4.92a	135450	60911	69540	2.04
T ₅ : FD _{75%} F	4.15b	125125	60605	64520	2.06
CV (%)	7.70	-	-	-	-
Potato Equivalent Yield of Potato- Maize - T. <i>Aman</i> rice					
T ₁ : RD	54.08bc	648875	335727	313148	1.93
T ₂ : 20% HRD	58.40a	697250	347628	349122	2.00
T ₃ : STBD	56.82ab	681930	310307	371618	2.19
T ₄ : FD _{25%} F	56.12ab	673500	347955	325546	1.95
T ₅ : FD _{75%} F	53.10c	623435	325073	293149	1.48
CV (%)	5.19	-	-	-	-

Price (Tk. kg⁻¹): Potato =12, Maize=30, T. *Aman* rice=25, Urea =22, TSP = 22, MoP=15, Gypsum=10, Zn=100, B= 150 and Cowdung = 2

Table 2 Compared to profit and chemical fertilizers cost (Tk. ha⁻¹) with STBD of Potato-Maize-T. *Aman* rice cropping pattern at MLT site College Para, Lalmonirhat during 2021-22

Treat.	Urea	TSP	MoP	Gyp sum	Zn SO ₄	B	Excess Cost from STBD	Average 2 years
T ₁ :RD	995 (85)	395 (215)	610 (400)	409 (157)	10 (-1)	8 (2)	+14570	313148 (- 58470)
T ₂ :20% HRD	1194 (284)	474 (294)	582 (372)	492 (240)	12 (3)	10 (4)	+21596	353172 (- 18446)
T ₄ : FD _{25%} F	961 (51)	710 (530)	728 (518)	286 (34)	12 (3)	19 (13)	+24042	325546 (- 46072)
T ₅ : FD _{75%} F	961 (51)	350 (170)	380 (170)	120	12 (3)	10	+8312	293148 (- 78470)
T ₃ : STBD	910	180	210	252	9	6	31450	371618

Price (Tk. Kg⁻¹): Urea =22, TSP = 22, MoP=15, Gypsum =10, ZnSO₄=100-, Boron = 150 (-) = Excess fertilizer over STBD

Conclusion

The use of fertilizers and total production cost of RD, 20% HRD, FD_{25%} F and FD_{75%} F was more high than STBD. It was 78470 Tk. ha⁻¹ for T₅ and 58470 Tk. ha⁻¹ for T₁ respectively. If farmers use only STBD in their fields then only urea will be safe 3560 Kg. ha⁻¹ or 70 bags. This is a great achievement for our nation.

51. DEVELOPMENT OF POTATO + MAIZE - JUTE - T. AMAN RICE CROPPING PATTERN AGAINST POTATO + CUCUMBER -T. AMAN CROPPING PATTERN

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Abstract

A field experiment was conducted at the MLT site Madhupur, Tangail during 2022-23 under AEZ #9 to improve the productivity of existing cropping pattern by introducing new crops and crop varieties as well as higher yield and economic return of the farmers. It was laid out in RCB design with six dispersed replications. Improved cropping pattern Potato+ Maize- Jute-T. Aman was tested against the existing pattern Potato+ Cucumber-T. Aman. The improved cropping pattern gave the higher gross margin (Tk. 516565 ha⁻¹) compared to existing pattern (Tk. 361080 ha⁻¹).

Introduction

Potato+Cucumber-T. *Aman* is one of the major existing cropping pattern at the MLT site, Modhupur, Tangail. After T. *Aman* harvest, farmers generally cultivate potato and after potato harvest they cultivate cucumber which take long time in the field and after cucumber they grow T. *Aman* rice. Under this situation, if potato is cultivated with maize as intercrop and after maize harvest jute can easily be introduced against cucumber which improve the soil health and increase soil fertility without hampering T. *Aman* cultivation. Thus the improved cropping pattern may be higher productive and economically profitable than the existing cropping pattern. Hence, the present experiment was conducted to improve the productivity of existing cropping pattern by introducing new crops and crop varieties as well as higher yield and economic return of the farmers.

Materials and Methods

The improved cropping pattern Potato (var. BARI Alu-44)+ Maize (var. BARI Hybrid Maize-9)-Jute (var. BJRI Jute-8)-T. *Aman* (var. BARI dhan75) was conducted against Potato (Diamant)+ Cucumber (Hybrid)-T. Aman (var. BARI dhan49) at the MLT site, Madhupur, Tangail during 2022-2023 in the medium highland situation under AEZ # 9 to improve the existing cropping pattern, increase cropping intensity, yields and economic return. The experiment was laid out in RCB design with six dispersed (six farmer's field) replications. Unit plot size was 10m x 8m. All agronomic activities including sowing/ transplanting and harvesting dates, seed rate, plant spacing, fertilizer management etc. are mentioned in Table 1. Recommended fertilizer packages (FRG, 2018) following the application methods were used for all the crops. Irrigation, pest managements and other intercultural operations were done as and when necessary. Crop cut was done from an area of 2m² at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in Table 2.

Results and Discussion

Results of the present study have been presented in Tables 2. Higher potato yield (22.36 t ha⁻¹) was obtained from improved pattern (IP). Satisfactory maize yield (6.87 t ha⁻¹) was obtained as intercrop of maize with potato in IP. From IP farmers get additional jute yield (2.17 t ha⁻¹). On an average, the yield of T. Aman rice in improved pattern increased by 12%, over the crop of the farmer's existing pattern.

The improved cropping pattern (ICP) Potato+ Maize- Jute-T. Aman rice had the longer field duration than farmer's existing cropping pattern (FECp) Potato+ Cucumber-T. Aman rice in the year but produced more number of crops in a year (Table 1). As a result, land use efficiency was higher in ICP than FECp.

Improved cropping system produced 25% higher rice equivalent yield over farmer's traditional cropping system (Table 2). Inclusion of a new crop and high yielding varieties and improvement management practices in the ICP increased the rice equivalent yield.

From the economic point of view, the ICP (improved cropping pattern) showed its superiority

over FECF (farmer's existing cropping pattern) during the one cycle cropping year. Gross return of the ICP was Tk.887250, which was 39% higher than that of farmers pattern (Table 2). The production cost per hectare of the improved pattern was 33% higher than that of FECF (Tk.278255). The gross margin was substantially 43% higher in the improved pattern (Tk. 516565) than that of the farmer's pattern (Tk. 361080). The higher gross margin of the improved pattern was achieved mainly due to higher yield advantages of components crops.

Farmer's opinion

Farmers opined that the improved cropping pattern (Potato+ Maize- Jute-T. Aman) gave the higher economic return against the farmer's existing cropping pattern (Potato+ Cucumber-T. Aman). They also opined that the practice would be expanded in next season.

Table 1 Crop management of existing and improved patterns at the MLT site, Madhupur, Tangail during 2022-23

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	Potato	Maize	Jute	T. Aman	Potato	Cucumber	T. Aman
Variety	BARI Alu-44	BHM-9	BJRI Pat-8	BRRI dhan75	Diamant	Hybrid (metal seed)	BRRI dhan49
Sowing/ Transplanting date	8-10 Nov. 22	6-10 Dec. 22	16-24 May, 23	20-23 Aug. 23	23-26 Nov. 22	25- 29 Dec. 22	20-27 July, 23
Seed rate (kg ha ⁻¹)	1500	25	8	50	1500	5	50
Spacing	60 cm ×25cm	60 cm × 30cm	Broadcast	20cm × 20cm	60 cm ×25cm	2m x2m	20cm × 20cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	161-40-125-20-3-1	76-0-30-0-0	92-10-30-17-3-0	69-10-41-11-4-0	115-30-125-21-3.7-1.8	94-15-0-0-0	61-0-0-0-0
Date of harvesting	19-21 Jan. 23	8-10 May, 23	14-18 Aug. 23	5-8 Nov. 23	24-27 Feb. 23	20 -25 May, 23	10-18 Nov. 23

Table 2 Yield, cost and return analysis of alternate and existing cropping pattern at the MLT site, Modhupur, Tangail during 2022-23

Items	Improved cropping pattern				Existing cropping pattern		
Crop	Potato	Maize	Jute	T. Aman	Potato	Cucumber	T. Aman
Variety	BARI Alu-44	BHM-9	BJRI Pat-8	BRRI dhan75	Diamant	Hybrid (metal seed)	BRRI dhan49
Grain yield (t ha ⁻¹)	22.36	6.87	2.17	4.08	17.68	16.85	3.65
Straw yield (t ha ⁻¹)			3.5	4.78			4.63
Field duration (days)	75	108	90	77	93	86	114
Turn around time (days)	3	-	7	5	10	-	62
Gross return (Tk. ha ⁻¹)	402480	206100	147350	131320	318240	202200	118895
TVC (Tk. ha ⁻¹)	150696	70510	73109	76370	149214	57184	71857
Gross margin (Tk ha ⁻¹)	251784	135590	74241	54950	169026	145016	47038
Whole pattern REY (t ha ⁻¹)	30.55				24.41		
Whole Pattern GR (Tk. ha ⁻¹)	887250				639335		
Whole pattern TVC (Tk. ha ⁻¹)	370685				278255		
Whole Pattern GM (Tk. ha ⁻¹)	516565				361080		
MBCR	2.68						

Input: Seed (Potato Tk. 32/-, Maize Tk. 400/-, Jute Tk. 200/- and T. Aman Tk. 60/- per kg), fertilizer (Urea Tk.16/-, TSP Tk. 22/-, MoP Tk. 15/-, Zinc sulphate Tk. 190/- and Gypsum Tk. 30/- per kg), Output: Unit price (Tk. kg⁻¹): Potato=18.00, Maize Tk. 30.00, Jute Tk. 55.00, Cucumber = 12, Rice = 27.50, Rice straw = 4.00

Conclusion

Improved cropping pattern is profitable and economic viable than the farmer's existing cropping pattern. This is the result of one year cycle,. After the completion of 2nd year cycle, a concrete conclusion may be drawn.

52. DEVELOPMENT OF MUSTARD-SESAME-T. AMAN CROPPING PATTERN AGAINST BORO-FALLOW-T. AMAN IN ACTIVE BRAHMAPUTRA JAMUNA FLOODPLAIN OF GAIBANDHA

MD. JAHANGIR ALAM, MD. SHOHEL RANA AND ABDULLAH AL MAHMUD

Abstract

The experiment was conducted at Kamolpur, Saghata, Gaibandha during 2022-23 to increase the cropping intensity and productivity in rice-based cropping patterns. The system productivity based on rice equivalent yield (REY) in the alternate cropping pattern was 13.93 t ha⁻¹, which was 28% higher than that of the existing cropping pattern (10.89 t ha⁻¹). The gross return from the alternate cropping pattern was Tk. 348180 ha⁻¹, 28% more compared to the existing cropping pattern with a value of Tk. 272200 ha⁻¹. Similarly, the higher gross margin was recorded from the alternate cropping pattern (Tk. 95080 ha⁻¹) or 30% higher than the existing cropping pattern (Tk. 72900 ha⁻¹). Finally, the marginal benefit-cost ratio (MBCR) of the whole cropping pattern was 1.41 over the existing cropping pattern. Replacement of Boro rice, as well as the inclusion of oilseed crops (sesame and mustard) in the existing cropping system using modern improved varieties, has resulted in increased productivity and profitability.

Introduction

Bangladesh produces approximately 1 million tons of oilseeds annually (BBS, 2020). However, the nation must import around 2.0 million tons each year to meet demand. The per capita consumption of edible oil in Bangladesh has risen by 20% over the past five years, reaching 16.4 kg in 2020 (Financial Express, 2021). In the same period, the total consumption of edible oil surged by 36%, from 2.22 million tons in 2015 to 3.03 million tons in 2020. To satisfy the increasing demand, Bangladesh expends a significant amount of foreign currency on importing edible oil and oilseeds. A published report indicates that Bangladesh's oil consumption trend is the highest among developing countries (Oil World, 2019). Imports fulfill about 90 to 92 percent of the annual oil demand (Financial Express, 2021). The area dedicated to oilseed cultivation is decreasing annually due to economic and technical factors (BBS, 2020). Consequently, there is an imperative to enhance per unit production by increasing yields and intensifying cropping systems. This can be achieved by optimizing the current cropping patterns/systems, incorporating short-duration crops like Aman rice, mustard, and sesame. An alternative cropping pattern, such as Mustard-Sesame-T. Aman, is proposed to augment cropping intensity and productivity.

Materials and Methods

The experiment was conducted at Kamolpur, Saghata, Gaibandha under the supervision of the On-Farm Research Division (OFRD), BARI, Gaibandha during 2022-23. A three crop-based alternative cropping pattern Mustard-Sesame-T. Aman cropping pattern with their existing Boro-Fallow-T. Aman cropping pattern was tested. The plot size was 1 ha. Recommended fertilizer package (FRG, 2018) along with the application methods were done to support the normal growth of the crops. An agronomic performance like field duration and rice equivalent yield of cropping patterns was calculated. Economic analysis was done based on the prevailing market price of the commodities.

Results and Discussion

In 2022-23, the boro and T. Aman rice yield were 5.40 and 4.95 t ha⁻¹ in the existing (Boro-Fallow-T. Aman) cropping pattern. On the contrary, the yield of sesame, T. Aman, and mustard was 1.28, 4.73, and 1.45 t ha⁻¹ in, respectively in the alternate (Sesame-T. Aman-Mustard) cropping pattern. In terms of system rice equivalent yield (REY) the higher value was observed in the alternate cropping pattern (13.93 t ha⁻¹), 28% more than that of the existing cropping pattern (10.89 t ha⁻¹). The reason was mainly due to the inclusion of sesame and mustard in the existing cropping pattern instead of Boro rice which plays a crucial role in increasing the total system yield.

Higher gross margin has been recorded from the alternative cropping pattern (Tk. 95080 ha⁻¹) or 30% more than the existing cropping pattern (Tk. 72900 ha⁻¹). Finally, the marginal benefit-cost ratio (MBCR) of the entire cropping pattern was 1.41 over the existing cropping pattern. Due to high market prices of sesame and mustard, gross return, as well as gross margins, were revealed higher in the alternative crop pattern.

Farmers' opinion: Initially, the farmers were perplexed about the feasibility of cultivating three crops a year on their land. Now, they are quite optimistic and intrigued by the three-crop rotation patterns, which they believe will boost their productivity and profitability.

Table 1. Details of the crop management of existing and alternate cropping patterns at Kamolpur, Saghata, Gaibandha during 2022-2023.

Pattern	Existing cropping pattern			Alternate cropping pattern		
Crop	Boro	Fallow	T. Aman	Mustard	Sesame	T. Aman
Variety	BRRI dhan28	-	Guti Swarna	BARI Sarisha-14	BARI Til-4	BRRI dhan87
Spacing (cm ²)	20 x 15	-	20 x 15	30 x conti.	30 x 5	20 x 15
Unit plot size (m ²)	-	-	-	1 ha	1ha	1ha
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	120-20-45-15-1-0	-	135-25-20-8-0-0	100-30-40-25-1-1	50-30-25-20-1-1	80-20-50-10-1-1
Date of sowing/transplanting	20-25 Jan. 22	-	15-20 Jul. 22	5-10 Nov. 22	15-20 Feb.23	20-25 Jul. 23
Harvesting date	1-5 May 22	-	18-23 Nov. 22	20-25 Jan. 23	20-25 May 23	25-26 Oct. 23

Table 2. Crop performance of existing and alternate cropping patterns at Kamolpur, Saghata, Gaibandha during 2022-2023.

Pattern	Existing cropping pattern			Alternate cropping pattern		
Crop	Boro	Fallow	T. Aman	Mustard	Sesame	T. Aman
In-field duration	102		124	80	95	103
Turnaround time	73		66	26	54	7
Grain or seed yield (t ha ⁻¹)	5.40		4.95	1.45	1.28	4.73
Straw or stover yield (t ha ⁻¹)	7.25		6.20	-	-	5.98
REY (t ha ⁻¹)	10.89			13.93		
Gross return (Tk. ha ⁻¹)	272200			348180		
TVC (Tk ha ⁻¹)	199300			253100		
Gross margin (Tk ha ⁻¹)	72900			95080		
MBCR (Whole pattern)	1.41					

* Rice grain- 25, Rice straw- 1.0, Sesame-100 and Mustard -75; REY: rice equivalent yield, MBCR: marginal benefit cost ratio.

53. IMPROVEMENT OF MUSTARD-BORO-T. AMAN CROPPING PATTERN IN KUSHTIA

J. A. MAHMUD, M. M. MORSHED, M. M. HOSSAIN

Abstract

An experiment was conducted at Kushtia sadar upazila during 2023-2024 to improved Mustard-Boro-T. Aman cropping pattern with improved varieties. The improved cropping pattern provided 43% higher system rice equivalent yield over existing pattern. Gross return and gross margin (Tk. 489150 ha⁻¹ and Tk. 265375 ha⁻¹ respectively) were higher in proposed pattern than existing cropping pattern. The marginal benefit cost ratio 1.45 of improved pattern was also satisfactory over farmer's practice.

Introduction

Fallow-Boro-T. Aman is one of the major existing cropping patterns in Kushtia. Generally, farmers of the region cultivate T. Aman rice followed by Boro where there is a long period around 90 days

remained fallow which could be utilized by inclusion of any short duration crop. In this context, mustard might be a promising crop cultivation in between T. Aman and Boro rice. On the country, increasing cropping intensity as well as proper utilization of land, a three crop-based pattern would be highly encouraged. Hence, therefore the trial will be initiated for higher yield and economic return.

Materials and Methods

The experiment was conducted at the farmer's field in Kushtia under AEZ-11 during the year 2023-24. The experiment was laid out in RCB design with 6 dispersed replications. Here the old varieties in Fallow-Boro (BRRI Dhan28)-T. Aman (Binadhan7) were replaced by modern and high yielding varieties in Mustard (BARI Sarisha-14)-Boro (Rod mini)-T. Aman (BRRI dhan87) cropping pattern. All the materials and methods followed during implemation of this experiment were stated in table-1. Intercultural operation was done as when necessary. After maturity different data were collected accordingly and subjected to statistical analysis.

Table 1 Crop management of improved and existing cropping pattern at Kushtia during 2023-24

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Mustard	Boro	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-14	Rod mini	BRRI dhan87	-	BRRI dhan28	Binadhan7
Spacing (cm)	Broadcast	25cm x 20cm	20cm x 20cm	-	25cm x 20cm	20cm x 20cm
Fertilizer dose (NPKSZn&B kg ha ⁻¹)	115-34-45-29-2-2	115-30-37.5-27-5-0.44	76-23-30-10-1-0	-	115-30-37.5-27-5-0.44	76-23-30-10-1-0
Date of planting/sowing	11 Nov, 2023	10 Feb, 2024	05 Aug, 2023	-	05 Feb, 2024	05 Aug, 2023
Weeding (no.)	1	2	2	-	2	2
Date of harvesting	05 Feb, 2024	15 May, 2024	05 Nov, 2023	-	15 May, 2024	15 Nov, 2023

Results and Discussion

Yield, cost and return of alternative cropping pattern with recent varieties of Mustard-Boro-T. Aman rice cropping pattern were shown in Table 2. The component crop T. Aman, Mustard and Boro provided 5.80, 1.45 and 4.95 t ha⁻¹ grain yield, respectively in the improved cropping pattern with system REY 14.13 t ha⁻¹. On the contrary, the grain yield of T. Aman and Boro were 5.15 and 4.75 t ha⁻¹, respectively, with 9.90 t ha⁻¹ REY in the existing pattern. Gross return and gross margin of improvement cropping pattern were Tk. 489150 ha⁻¹ and Tk. 265375 ha⁻¹ where as in existing cropping these were Tk. 354500 ha⁻¹ and Tk. 183750 ha⁻¹, respectively. Satisfactory MBCR (1.45) was found from improved pattern over existing pattern.

Farmer's opinion: Farmers who involve in this experiment were satisfied with new improved crop varieties. Gross returns of improved varieties were more than that of existing varieties. Farmers are interested to grow these new crop varieties including short duration mustard variety instead of older as it gives higher return.

Table 2 Performance of improved and existing cropping pattern at Kushtia during 2023-24

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Mustard	Boro	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-14	Rod mini	BRRI dhan87	-	BRRI dhan28	Binadhan-7
Grain/seed (t ha ⁻¹)	1.45	4.95	5.80	-	4.75	5.15
Straw yield (t ha ⁻¹)	2.20	5.05	7.10	-	5.25	6.25
Rice equivalent yield(t ha ⁻¹)	14.13			9.90		
Gross return (Tk ha ⁻¹)	489150			354500		
Total variable cost (Tk ha ⁻¹)	223775			170750		
Gross margin (Tk ha ⁻¹)	265375			183750		
MBCR	1.45					

Price (Tk/kg): Mustard @ 70 Tk/kg, Straw @ 2.00 Tk/kg, Boro rice @ 30 Tk/kg, T. Aman @ 30 Tk/kg, Straw @ 5.00 Tk/kg

Conclusion

Based on findings, it may be concluded that improved cropping pattern in which modern crop varieties were used is profitable to the farmers. It may contribute to 10-20% higher yield the existing pattern.

54. DEVELOPMENT OF ALTERNATE CROPPING PATTERN SUNFLOWER-T. AUS-T. AMAN AGAINST FARMERS EXISTING PATTERN RELAY GRASSPEA-FALLOW-T. AMAN

M. M ISLAM, H M K BASHAR AND M S I KHAN

Abstract

The experiment was conducted at MLT site, Kuakata, Kalapara, Patuakhali during the year of 2023-24 to determine the profitability of Sunflower (BARI Surjomukhi-2)- T. Aus Rice (BRRI dhan48) - T. Aman Rice (BRRI dhan49) cropping pattern against the farmers' existing Grasspea (BARI Khessari-3) - Fallow - T. Aman Rice (Sarnogota) pattern. Total grain yield in terms of REY of improve cropping pattern was 14.09 t ha^{-1} which was 68% higher than that of existing cropping pattern (8.39 t ha^{-1}). The highest gross return (Tk. 324280 ha^{-1}), gross margin (Tk. 151330 ha^{-1}) and satisfactory MBCR (2.49) were obtained from improve 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 grasspea were major Robi crops in the coastal upazilas. But due to unusual rainfall at November and December sometimes grasspea become damaged. In this situation it is needed to select an alternate crop of grasspea. Sunflower is such a crop which can be grown instead of cowpea and after that T. Aus rice could be transplant there in time. After grasspea 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 will be increased. For the reason to develop new pattern and to increase farmers' income the trial was undertaken.

Materials and Methods

The experiment was conducted at Kalapara, Patuakhali during the year of 2023-24. The alternate cropping pattern Sunflower (BARI Surjomukhi-2) - T. Aus Rice (BRRI dhan48) - T. Aman rice (BRRI dhan49) against the farmers' existing pattern Grasspea - Fallow - T. Aman rice (Sarnoghota). The unit plot size was 20 decimal. Details of crop management including fertilizer application are presented in Table 1.

Results and Discussion

Results of improved cropping pattern Sunflower-T. Aus-T. Aman and farmers existing pattern relay grasspea-Fallow-T. Aman has been presented in Table 2. The result revealed that yield of sunflower, T. Aus and T. Aman were 1.61 t ha^{-1} , 3.24 and 3.92 t ha^{-1} respectively at improved cropping pattern. While, mean yield of relay grasspea and T. Aman rice were 1.34 t ha^{-1} and 3.29 t ha^{-1} respectively at existing cropping pattern.

The mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield ($14.09 \text{ ton ha}^{-1}$) over farmers (8.39 ton ha^{-1}) pattern. Inclusion of high yielding sunflower and rice variety and improved management practices increased 68% REY over farmers practices.

Gross return of improved pattern (324280 Tk ha⁻¹) showed its superiority by 68% over farmers existing pattern (135450 Tk ha⁻¹). Improved cropping pattern gave higher gross margin (Tk. 151330 ha⁻¹) and satisfactory MBCR (2.49) 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 grasspea is reducing day by day so they showed their interest to grow sunflower instead of 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 1 Management practices of alternate cropping pattern and existing cropping pattern (MLT site, Kuakata, Patuakhali) during 2023-24

Parameters	Improved pattern			Existing pattern		
Season	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2	Rabi
Variety	BRRI dhan48	BRRI dhan49	BARI Surjomukhi-2	Fallow	Sarnoghota	BARI Khessari-3
Date of sowing	05.05.2023	26.07.2023	26.12.2023	-	20.07.2023	21.11.2023
Transplanting date	05.06.2023	24.08.23	-	--	01.09.2023	-
Seedling age (day)	30	28	-	-	40	-
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	Broadcasting
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 (DAT)	35 & 60	-	-	-	-	-
Date of harvest	16.08.2023	17.12.2023	01.05.2024		20.12.2023	23-24.03.2024

Table 2 Yield and economic analysis of alternate cropping pattern and existing cropping pattern (MLT site ,Kalapara)

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Sunflower	T. Aus	T. Aman	Grasspea	Fallow	T. Aman
Seed/grain yield (t ha ⁻¹)	1.61	3.24	3.92	1.34	-	3.29
Straw yield (t ha ⁻¹)	-	2.79	4.04	-	-	4.18
REY (t ha ⁻¹)	5.49	3.87	4.73	4.28		4.11
Pattern REY (t ha ⁻¹)	14.09			8.39		
Gross return (Tk ha ⁻¹)	120750	85230	118200	107200	-	103150
TVC (Tk ha ⁻¹)	76700	47500	48750	26900	-	48000
Gross margin (Tk ha ⁻¹)	44050	37730	69450	80300		55150
Pattern Gross return (Tk ha ⁻¹)	324280			135450		
Pattern TVC (Tk ha ⁻¹)	172950			74900		
Pattern Gross margin (Tk ha ⁻¹)	151330			60550		
MBCR (whole pattern)	2.49					

Unit price (Tk. kg⁻¹): T. Aman rice= 25, Aus rice=22, Rice straw = 5, Sunflower = 75, Grasspea = 80

Conclusion

The results obtained from the study indicated that improved cropping pattern is more profitable than the farmer's existing pattern. So, Sunflower - T. Aus - T. Aman rice may be the one of the major patterns in coastal area.

55. DEVELOPMENT OF ALTERNATE CROPPING PATTERN VEGETABLE-VEGETABLE-T. AMAN RICE AGAINST VEGETABLE- FALLOW - T. AMAN

M M ALAM, M AHMAD AND M H RAHMAN

Abstract

The experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2020-2021, 2021-2022 and 2022-2023 to improve the existing cropping pattern by inclusion of vegetable and to increase crop yield and farmers' income. The experiment was laid out in 3600 m² of land under 6 farmers. Alternate cropping pattern Potato (BARI Alu-40) – Ladies finger (BARI Derosh-2) - T. Aman (BRRI dhan72) gave higher whole pattern gross margin (Tk. 473499 ha⁻¹) against the existing pattern Cabbage (Atlas 70) – Fallow - T. Aman (BRRI dhan49) [(Tk. 230620 ha⁻¹)].

Introduction

Farmers at Narsingdi followed different types of cropping pattern. Vegetable-Fallow – T. Aman is one of the important cropping patterns to its. Ensuring food security for increased population, the country needs to be increased production by increasing cropping intensity. Tuber Research Centre BARI has developed a number of high yielding potato varieties. It needs to popularize among the farmers by fitting potato the existing cropping pattern Vegetable - Fallow - T. Aman. The alternate cropping pattern was Vegetable - Vegetable - T. Aman. On-farm trial will help to popularize and evaluate the new cropping pattern among the farmers. With this view in mind, the trial was undertaken.

Materials and Methods

The trial was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2020-21, 2021-2022 and 2022-2023. Unit plot size was 600 m². The improved cropping pattern was Vegetable (BARI Alu-40) - Vegetable (BARI Derosh-2) - T. Aman (BRRI dhan72) against existing cropping pattern Vegetable (Atlas 70) - Fallow - T. Aman (BRRI dhan49). 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 it's 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 has needed 199 days' field duration. The newly introduced crop in the farmers existing pattern was Vegetable (BARI Derosh-2 and BARI Alu-40). A short duration T. Aman rice variety (BRRI dhan72) was also introduced for timely sowing of Vegetable variety BARI Derosh-2. Total field duration of three crops pattern Vegetable – Vegetable - T. Aman rice has needed 300 days (excluding seedling age of rice) to completed the one cycle (Table1). In this way the three cycle are completed. Result indicated that vegetable could be easily fitted in Vegetable – Fallow - T. Aman rice cropping pattern. The Average yield of vegetable in the alternate cropping pattern were 14.97 t ha⁻¹. The Average yield of Vegetable (BARI Alu-40) and BRRI dhan72 was 36.77 and 4.25 t ha⁻¹, respectively from the alternate cropping pattern. The Average yield of Vegetable (Atlas 70) and BRRI dhan49 were 49.07 and 4.16 t ha⁻¹, respectively in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (31.97t ha⁻¹ yr⁻¹) over farmers' existing cropping pattern (14.81t ha⁻¹ yr⁻¹). Inclusion of BARI Derosh-2 in existing cropping pattern increased REY 46.32% compared to farmers' practice (Table 1).

Cost and return: Gross return of improved cropping pattern was Tk. 902550 ha⁻¹ which was more than 114.81% higher over farmers' pattern. Farmers' pattern gave the lower gross return

TK. 420900ha⁻¹ Total variable cost was higher in improved pattern (TK.428916 ha⁻¹) might be due to inclusion of BARI Derosh-2 in the pattern. The gross margin was substantially higher in the alternate pattern Tk. 473499 ha⁻¹ than farmers' pattern (TK. 230620 ha⁻¹). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of vegetable (BARI Derosh-2) as a component crop.

Farmers opinion: Farmers were highly satisfied to see the higher returns of alternate cropping pattern Potato (BARI Alu-40) - Vegetable (BARI Derosh-2) - T. Aman (BRRI dhan72) against existing pattern Vegetable (Atlas 70) – Fallow - T. Aman (BRRI dhan49) due to higher yield as well as return and fit in the pattern. They also opined that the practice would be expanded in this area.

Table 1: Management practices of crops grown under existing and alternate cropping patterns at Shibpur, Narsingdi during 2020-21, 2021-22 and 2022-23

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Vegetable	Fallow	T. Aman	Vegetable	Vegetable	T. Aman
Variety	Atlas 70	-	BRRI dhan49	BARI Alu-40	BARI Derosh-2	BRRI dhan72
Spacing(cm)	60×45	-	20×15	60×25	50×40	20×15
Seedling age (days)	25	-	30-35	-	-	25-30
Transplanting date	10-15 November,22	-	5-10 July, 23	25-28 November,22	8-12 March 23	20-24 July, 23
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn and B)	180-45-60-0-0	-	130-20-30-12-0-2.5	135-30-90-10-2-1	90-30-60-15-2-1.4	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	8-18 February,23		18-26 Oct. 23	22-28 February. 23	23-30 June, 23	22-28 Oct. 23
Field duration (seedling to seed)	90-95		105-108	90-93	107-110	95-97
Turnaround time (days)	T. Aman to Vegetable, 19	-	Vegetable to T. Aman, 45	T. Aman to Vegetable, 30	Vegetable to Vegetable, 12	Vegetable to T. Aman, 24
Yield (t ha ⁻¹) 2020-21	48.4	-	4.10	35.30	14.5	4.24
Yield (t ha ⁻¹) 2021-22	50.6	-	4.21	38.4	16.6	4.28
Yield (t ha ⁻¹) 2022-23	48.2		4.16	36.6	13.8	4.22
Average	49.07	-	4.16	36.77	14.97	4.25
Rice Equivalent Yield (t ha ⁻¹)	14.81			31.97		
Gross margin (Tk. ha ⁻¹)	183100	-	47520	323400	108625	41474
Total variable cost (Tk. ha ⁻¹)	111320	-	78960	225515	115875	87526
Gross return (Tk. ha ⁻¹)	294420	-	126480	549000	224550	129000
Whole pattern Gross margin (Tk. ha ⁻¹)	230620			473499		

Price (tk. kg⁻¹): Potato-15, T. Aman Rice -28, Rice straw-3.00, Cabbage-6, Derosh-15

Conclusion

From the above discussion, it could be concluded that yield as well as returns from alternate cropping pattern Vegetable (BARI Alu-40) - Vegetable (BARI Derosh-2) - T. Aman (BRRI dhan72) showed higher than existing pattern in the study area.

56. DEVELOPMENT OF ALTERNATE CROPPING PATTERN VEGETABLE-JUTE-T. AMAN RICE AGAINST WHEAT- JUTE - T. AMAN RICE

M M ALAM, M AHMAD AND M H RAHMAN

Abstract

The experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2021-2022 and 2022-2023 to improve the existing cropping pattern by inclusion of vegetable and to increase crop yield and farmer's income. The experiment was laid out in 4800 m² of land under 6 farmers. Alternate cropping pattern Potato (BARI Alu-40) - Jute (Desi Pat-5) - T. Aman (BRRI dhan71) gave higher whole pattern gross margin (Tk.596074 ha⁻¹) against the existing pattern Wheat (BARI Gam-21) - Jute (CVL-1) - T. Aman (BRRI dhan87) (Tk. 173196 ha⁻¹).

Introduction

Farmers at Narsingdi followed different types of cropping pattern. Wheat- Jute – T. Aman is one of the important cropping patterns to them. 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. It needs to popularize among the farmers by fitting potato the existing cropping pattern Wheat - Jute - T. Aman. The alternate cropping pattern was Potato - Jute - T. Aman. On-farm trial will help to popularize and evaluate the new cropping pattern among the farmers. With this view in mind, the trial was undertaken.

Materials and Methods

The trial was conducted at OFRD, BARI, Shibpur, Narsingdi during the year of 2021-22 and 2022-2023. Unit plot size was 800 m². The improved cropping pattern was Potato (BARI Alu-40) - Jute (Desi pat-5) - T. Aman (BRRI dhan71) against existing cropping pattern Wheat (BARI Gam-21) - Jute (CVL-1) - T. Aman (BRRI dhan87). 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

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 Wheat - Jute - T. Aman rice has needed 333 days' field duration. The newly introduced crop in the farmers existing pattern was Potato (BARI Alu-40). A short duration T. Aman rice variety BRRI dhan71 was also introduced for timely sowing of Potato variety BARI Alu-40. Total field duration of three crops pattern Vegetable – Jute - T. Aman rice has needed 331 days (excluding seedling age of rice) to complete the one cycle (Table1). In this way the two cycle was completed. Result indicated that Potato could be easily fitted in Wheat - Jute - T. Aman rice cropping pattern. The average yield of Vegetable (BARI Alu-40), Jute (Desi pat 5) and BRRI dhan71 were 40.1, 1.97 and 4.36 t ha⁻¹, respectively from the alternate cropping pattern. The average yield of Wheat (BARI Gam-21), Jute (CVL-1) and BRRI dhan87 were 2.89, 1.50 and 4.79 t ha⁻¹, respectively in existing pattern.

Improved cropping pattern produced higher rice equivalent yield (31.12 t ha⁻¹ yr⁻¹) over farmers' existing cropping pattern (13.45 t ha⁻¹ yr⁻¹). Inclusion of rice in existing cropping pattern increased REY 43.22% compared to farmers' practice (Table 1)

Cost and return: Gross return of improved cropping pattern was Tk. 926330 ha⁻¹ which was more than 108.01% higher over farmers' pattern. Farmers' pattern gave the lower gross return TK. 445340 ha⁻¹. Total variable cost was higher in improved pattern (TK. 330256 ha⁻¹) might be due to inclusion of Potato in the pattern. The gross margin was substantially higher in the alternate pattern Tk. 596074 ha⁻¹ than farmers' pattern (TK. 173196 ha⁻¹). The higher gross

margin of the alternate pattern was achieved mainly due to inclusion of Potato as a component crop.

Farmers opinion: Farmers were highly satisfied to see the higher returns of alternate cropping pattern Potato (BARI Alu-40) - Jute (Deshi pat-5) - T. Aman (BRRI dhan71) against existing pattern Wheat (BARI Gam-21) - Jute (CVL-1) - T. Aman (BRRI dhan87) due to higher yield as well as return and fit in the pattern. They also opined that the practice would be expanded in this area.

Table 1: Agronomic management practices of the crops grown under the existing and alternate cropping patterns at Shibpur, Narsingdi during 2021-22 and 2022-23

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Wheat	Jute	T. Aman	Vegetable	Jute	T. Aman
Variety	BARI Gam-21	CVL-1	BRRIdha87	BARI Alu-40	Deshi pat-5	BRRI dhan71
Spacing(cm)	20×15	-	20×15	30×25	20×15	20×15
Seedling age (days)	-	-	30-35	-	-	30-35
Transplanting days	18-22 November,21; 15-20 November,22	15-20 March,22; 18-24 March,23	1-10 August,22; 4-8 August, 23	01-05 December,21; 01-05 December,22	25-30 March,22; 24-28 March,23	11-15 August,22; 10-14 August, 23
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn and B)	100-36-25- 20-0-0	70-10-10- 20-0-0	130-20-30 - 12-0-2.5	161-44-132- 22-5-2	90-10-6- 20-0-0	130-20-30- 12- 0- 2.5
Fertilizer application	Basal & Top dress	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	2 Weeding	2 Weeding
Harvesting date	2-10 March, 23	20-30 July, 23	6-15 November, 22	01-10 March, 23	1-8 August, 23	12-20 November,23
Field duration (seedling to seed)	106-110	125-130	95-100	90-95	130-134	95-100
Turnaround time (days)	T. Aman to Wheat, 10	Wheat to Jute, 15	Jute to T. Aman, 12	T. Aman to Vegetable, 12	Vegetable to Jute, 15	Jute to T. Aman, 7
Yield (t ha ⁻¹) 2021-22	2.92	1.6	4.82	40.00	1.98	4.34
Yield (t ha ⁻¹) 2022-23	2.86	1.4	4.76	40.2	1.96	4.38
Average Yield (t ha ⁻¹)	2.89	1.5	4.79	40.1	1.97	4.36
REY (t ha ⁻¹)	13.45			31.12		
GM (Tk. ha ⁻¹)	58370	56084	58742	459500	90190	46384
TVC (Tk. ha ⁻¹)	85350	96416	90278	142000	97560	90696
GR (Tk. ha ⁻¹)	143720	152500	149120	601500	187750	137080
Whole pattern GM (Tk. ha ⁻¹)	173196			596074		

Conclusion

From the above discussion, it could be concluded that yield as well as returns from alternate cropping pattern Potato (BARI Alu-40) - Jute (Deshi pat-5) - T. Aman (BRRI dhan71) showed higher than existing pattern in the study area.

57. IMPROVEMENT OF EXISTING CROPPING PATTERN FALLOW- FALLOW-T. AMAN RICE THROUGH INCLUSION OF GROUNDNUT AND RICE IN COX'SBAZAR REGION

M. AHMED AND M.S. BHUIYAN

Abstract

The study was conducted at the farmer's field in Cox'sbazar during the year of 2023-2024 to determine the productivity and profitability of cropping patterns viz. improved pattern (IP): Groundnut (BARI China Badam-9) -Fallow -T. Aman (BRRI dhan49) by introducing high

yielding varieties of Groundnut and rice in existing pattern (EP): Fallow- Fallow -T. Aman rice (Horidhan). Results showed that the improved pattern with improved management practices provided better yield and economic return than existing pattern. The higher mean gross margin (Tk. 196750 ha⁻¹) with marginal benefit cost ratio (5.21) was obtained over existing pattern.

Introduction

At present Fallow - Fallow - T. Aman rice cropping sequences are widely followed by farmers under medium high land to medium low land in Cox'sbazar region. Transplantation of Aman rice is being dependent on rainfall, which sown during early monsoon. This delayed transplantation of T. Aman rice that causes late cultivation and harvesting of, which hampered timely cultivation of rabi crops. Farmer's used long duration variety for T. Aman, a vast area remains fallow for a long time after the harvest of T. Aman rice due to moisture stress up to next season for cultivation of T. Aman rice following the existing cropping pattern (Fallow- Fallow -T. Aman rice). Little effort has been made for on-farm evaluation of the improved technologies of Groundnut - Fallow -T. Aman rice cropping pattern in Cox'sbazar area. The present study was initiated to determine productivity and economic feasibility of an improved package of technologies over the farmer's existing practices.

Materials and Methods

The study was conducted at the farmer's field in Cox'sbazar during the year of 2023-2024 at farmer's field. This trial was conducted to determine the productivity and profitability of cropping patterns viz. improved pattern (IP): Groundnut (BARI Chinabadam-9) - Fallow -T. Aman rice (BRRI dhan49) by introducing high yielding varieties of groundnut and rice in existing pattern (EP): Fallow- Fallow -T. Aman rice (Horidhan).

Results and Discussions

The average yield of T. Aman was varied from 4.50 t ha⁻¹. In groundnut, the variety BARI Chinabadam-9 was produced 2.11 t ha⁻¹ of seed yield in IP whereas only 4.55 t ha⁻¹ of Horidhan yield was produced by EP.

Farmers' opinion: Farmers opined that the insertion of high yielding short duration new varieties in improved pattern instead of only T. Aman was more beneficial.

Table 1. Yield and economic analysis of improved and existing cropping pattern at Ramu, Cox'sbazar during the year of 2023-2024

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Groundnut	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Chinabadam-9		BRRI dhan49			Hori dhan
Seed/grain yield (tha ⁻¹)	2.11		4.50			4.55
Total Yield	6.61			4.55		
Gross return (Tk ha ⁻¹)	263750		126000			127400
Total variable cost (Tk ha ⁻¹)	105000		88000			88000
Gross margin (Tk ha ⁻¹)	158750		38000			39400
Total Gross return (Tk ha ⁻¹)	389750			127400		
Total variable cost (Tk ha ⁻¹)	193000			88000		
Total Gross margin (Tk ha ⁻¹)	196750			39400		
MBCR	5.21					

Unit price (TK.kg⁻¹): Ground nut =125.00 and T. Aman = 28.00

Conclusion

The study revealed that improved pattern is more productive, sustainable and remunerative for medium high land under Cox'sbazar. So, farmers of commanding area could follow Groundnut (var. BARI Chinabadam-9) - Fallow- T. Aman rice (var. BRRI dhan49) cropping pattern for higher productivity and profitability.

58. DEVELOPMENT OF FOUR CROPS BASED CROPPING PATTERN MUSTARD-MUNGBEAN-T. AUS-T. AMAN AGAINST MUSTARD-D. AUS-T. AMAN RICE CROPPING PATTERN IN BHOLA

G N HASAN, R H ANIK AND M ISLAM

Abstract

The On-farm trial was conducted at MLT site Daulatkhan and Bhola sadar under AEZ-18 during 2023-2024 to increase cropping intensity and productivity through a four crop-based cropping pattern instead of farmer's existing practice of Mustard-D. Aus-T. Aman. The four crop-based cropping pattern was Mustard- Mungbean-T. Aus-T. Aman and variety of each crop were BARI Sarisha-14, BARI Mung-8, BRRI dhan82 and BRRI dhan72/87 respectively. It was observed that four crop patterns produced the highest rice equivalent yield (REY) (18.25 t ha⁻¹) than farmer's practice (12.23 t ha⁻¹) in Bhola district. Cost-benefit analysis showed that the four-crop pattern gave the highest gross return in both locations. The marginal benefit-cost ratio of the four crop patterns over the existing pattern was 3.53 which indicates four crops are a profitable venture.

Introduction

Mustard-D.Aus-T. Aman rice is one of the important cropping patterns in Bhola. According to DAE, Mustard-D.Aus-T. Aman pattern covers as an area of 8035 ha of land in last year. 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 four or more crops over the same piece of land round the year and ii) to increase the productive efficiency of the individual crop. After harvesting of T. Aman, farmers' usually grown mustard. After harvesting of mustard land remains fallow in some days before sowing of D.aus rice which may be utilize by growing short duration mungbean. If cropping pattern (Mustard-Mung-T. Aus-T. Aman) is done properly farmer will get more benefit at a time. The present study has taken to observe the performance of Mustard-T. Aus- T. Aman rice cropping pattern.

Materials and Methods

The On-farm trial was conducted at Daulatkhan, Bhola sadar upazilla under Bhola district during 2023-2024. The trial field belongs to the agro-ecological zone (AEZ 18). The alternate cropping pattern Mustard-Mungbean-T. Aus-T. Aman was tested against existing cropping pattern Mustard-D. Aus-T. Aman. Crop varieties as used in the alternate cropping pattern were Mustard (BARI Sorisha-14), Mung (BARI Mung- 8), T. Aus (BRRI dhan82) and T. Aman (BRRI dhan87) whereas , the crop variety used in the existing cropping pattern were Mustard (Local), D. Aus (BRRI dhan48) and T. Aman (Sarna/BRRI dhan52) respectively. Three farmers were selected as dispersed replications covering a total of 100 decimals of land in three different locations. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. Pest management and other intercultural management practices were done as and when necessary.

Aphid was observed in the mustard field, and it was controlled by sprayed with Imitaph @ 2 g L⁻¹ water. For controlling flower thrips of mungbean, Intrapid @ 1.ml L⁻¹ water was applied 2 times starting from flowering at an interval of 7 days. For controlling of pod borer alternate spray was done with Success & Volume flexi @ 1.2 ml L⁻¹ and 0.5 ml L⁻¹ water respectively. 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.

For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield of Aman 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. The productivity of crop sequences was compared by calculating their economic rice equivalent yield (REY). 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.

Table 1. Agronomic Parameters of four crops-based cropping pattern Mustard-Mungbean-T. Aus-T. Aman against Mustard-D. Aus-T. Aman rice cropping pattern during 2023-24 in Bhola district

Parameters	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Mustard	D. Aus	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Variety (Dawlatkhan)	Local	BRRIdhan48	BRRIdhan52	BARI Sorisha-14	BARI Mung-8	BRRIdhan82	BRRIdhan87
Variety (Bhola sadar)	Local	BRRIdhan8	BRRIdhan52	BARI Sarisha-14	BARI Mung-8	BRRIdhan82	BRRIdhan87
Spacing	Broadcast	Dibbling	30×30	Broadcast	30 x 6	20 x 15	25 x 15
Unit plot size	30 Decimal			30 Decimal			
Seedling age (days)	-	-	35	-	-	20-25	35
Fertilizer dose (CD t h ⁻¹) N-P-K-S-Zn-B kg ha ⁻¹	90-27-60-15-5-2-0	150-50-75-35-5	150-110-50-30-10	90-27-60-15-5-2-0	24-32-24-18-2-1	150-52-75-38-5	180-120-100-68-12
Date of transplanting/sowing	26 Dec 23-04 Jan. 24	14-19 April. 23	28-22 August, 23	28 Nov. 23	18-23, Feb.24	11-14 May, 23	13-17 Aug. 23
Date of harvesting	01-04 April, 24	04-09 Aug. 23	13-18 Dec, 23	12-18 Feb, 24	23 April to 03 May, 24	05-08 August,23	22-24 Nov. 23
Fertilizer application	Basal	Basal & Top dress	Basal & Top dress	Basal	Basal	Basal & Top dress	Basal & Top dress
Intercultural Operation	2 Weeding	4 Weeding	2 Weeding	2 Weeding	2 Weeding	2 Weeding	2 Weeding
Field duration (days)	90	110	115	80	65-80	85	100
Turnaround (days)	T. Aman to Mustard (13)	Mustard to D. Aus (15)	D. Aus to T. Aman (15)	T. Aman to Mustard (6)	Mustard to Mungbean (6)	Mungbean to T. Aus (7)	T. Aus to T. Aman (7)

Results and Discussion

Crop management practices, of existing and alternate cropping patterns, are shown in Table 1. Existing cropping pattern, Mustard-D.Aus-T. Aman rice required 315 days and alternate cropping pattern Mustard-Mungbean-T. Aus-T. Aman took 339 days (excluding seedling age of rice) to complete the cycle. Turnaround time in the existing cropping pattern was 50 days whereas it was only 26 days in four crops based on alternate cropping pattern.

Yield and economic return of existing and alternate cropping pattern are shown in Table 2 & Table 3. In MLT site Daulatkhan the average yield of different four crops in alternate cropping pattern of Mustard, Mungbean, T. Aus and T. Aman was 1.26, 1.18, 4.24 and 4.97 t ha⁻¹ while in existing cropping pattern of Mustard, D. Aus, T. Aman and was 0.94, 3.65 and 4.75 t ha⁻¹ respectively (Table-2). Higher rice equivalent yield was obtained in alternate cropping patterns due to the introduction of new crops and varieties.

Cost and return: The higher gross return (Tk. 401500 ha⁻¹) and gross margin (Tk. 193470 ha⁻¹) were obtained in alternate pattern over existing pattern (gross return: Tk. 269060 ha⁻¹ and gross margin: Tk. 95510 ha⁻¹). The MBCR was calculated at 3.53 indicating that alternate cropping patterns will produce more returns than the existing farmer's pattern (Table 2).

Farmer's opinion: The concepts of four crops-based cropping pattern were acceptable to the farmers in the locality. They opined that consciousness is needed for maintaining time frame of the four-crop based pattern. Income and production efficiency was higher than existing cropping pattern. Neighboring farmers showed very much interest to adopt the alternate cropping pattern. They demanded quality seed in due time.

Table 2. Yield, cost and return of four crops-based cropping patterns in Bhola district during 2023-24 cropping season

Parameters	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Mustard	D. Aus	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Variety	Local	BRRI dhan48	BRRI dhan52	BARI Sorisha-14	BARI Mung-8	BRRI dhan82	BRRI dhan87
Grain/seed yield (t ha ⁻¹)	0.94	3.65	4.75	1.26	1.18	4.24	4.97
Straw yield (t ha ⁻¹)	-	-	4.50	-	-	-	4.88
Rice Equivalent Yield (t ha ⁻¹)	3.42	3.65	5.16	4.58	4.02	4.24	5.41
Whole pattern Rice equivalent yield (t ha ⁻¹)	12.23			18.25			
Gross return (Tk ha ⁻¹)	75240	80300	113520	100760	88440	93280	119020
TVC (Tk ha ⁻¹)	42750	62500	68300	42750	34280	58500	72500
Gross margin (Tk ha ⁻¹)	32490	17800	45220	58010	54160	34780	46520
Whole pattern Gross return (Tk. ha ⁻¹)	269060			401500			
Whole pattern TVC (Tk. ha ⁻¹)	173550			208030			
Whole pattern Gross margin (Tk. ha ⁻¹)	95510			193470			
Whole pattern MBCR	3.53						

Input: Seed (Mustard Tk. 80/-, Mungbean Tk. 75/-, D. Aus rice Tk. 50/- and T. Aman Tk. 40/- per kg), fertilizer (Urea Tk.16/-, TSP Tk. 22/-, MoP Tk. 15/-, Zinc sulphate Tk. 190/- and Gypsum Tk. 20/- per kg), labour and fungicides (Tk. 8500/-) Output: Unit price (Tk. kg⁻¹): Mustard=75.00, Mungbean = 60, Rice = 22.00, Rice straw = 2.00

Conclusion

Four crop-based cropping pattern Mustard- Mungbean-T. Aus-T. Aman gave highest the REY and gross margin over the existing pattern Mustard-T. Aus-T. Aman. The rice equivalent yield and production efficiency was increased in alternative cropping pattern remarkably. The MBCR (3.53) of alternative cropping pattern over existing cropping pattern was also promising.

59. DEVELOPMENT OF FOUR CROPS BASED CROPPING PATTERN POTATO-MUNGBEAN-T. AUSH-T. AMAN AGAINST POTATO-D. AUS-T. AMAN RICE CROPPING PATTERN IN BHOLA

G N HASAN, R H ANIK AND M ISLAM

Abstract

The study was performed at MLT side Daulatkhan and Bhola sadar under Bhola district during 2023-24 cropping season. The experimental design was RCB with four dispersed replications. In Alternate pattern, the yield of T. Aus, T. Aman, Potato and Mungbean rice was 4.17, 4.58, 20.79 and 1.19 t ha⁻¹ respectively where as in existing pattern, the yield of D. Aus, T. Aman and Potato was 3.53, 4.32 and 18.13 t ha⁻¹ respectively. The Alternate cropping pattern gave higher Rice Equivalent Yield (30.09 t ha⁻¹) while existing one recorded 21.98 t ha⁻¹. The whole system Rice Equivalent Yield was 31 % higher in alternate pattern due to addition of high yielding improved varieties. The MBCR was calculated 4.82 indicating that alternate cropping pattern could produce more returns than the existing farmers, pattern

Introduction

Potato-D.Aus-T. Aman rice is one of the important cropping patterns in Bhola. According to DAE, Potato-D.Aus-T. Aman pattern covers as an area of 8700 ha of land. The main challenge of the Sustainable Development Goal (SDG) is to increase double production per unit area. 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 four or more crops ii) to increase the productive efficiency of the individual crop. After harvesting of T. Aman, farmers usually grow potato and then land remains fallow around 2 months before sowing of D. aus rice which may be utilized by growing mungbean. If cropping pattern (Potato-Mung-T. Aus-T. Aman) is done properly farmer will get more benefit at a time. The present study has taken to observe the performance of Potato-Mung-T. Aus-T. Aman rice cropping pattern.

Materials and Methods

The study was performed at MLT side Daulatkhan, Bhola sadar under Bhola district during 2023-24 cropping season. In order to improve the existing cropping pattern Potato-D. Aus-T. Aman to increase yield and economic through rice based cropping system. The trial field belongs to the agro-ecological zone of (AEZ-18). The experimental design was RCB with four dispersed replications. The four crop based cropping pattern Potato (BARI Alu-25)-Mungbean (BARI Mug-8)-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan -87) was tested against the existing cropping pattern Potato (Local)-D. Aush (BRRI Dhan48)-T. Aman (BRRI Dhan52). The unit plot size was 33 decimals. All agronomic practices including sowing date, transplanting date and harvesting dates, seed rate, plant spacing, fertilizer etc. were mentioned in Table 1. Fertilizer packages (FRG 2018) and the standard application methods were used for all the crops. Irrigation, pest managements and other protective measures were taken as and when necessary. The cost and return analysis also calculated on the basis of prevailing market price of the inputs and outputs (produced). Crop cut was done from three areas of 1 m² of each plot for measuring yield. The data on yield cost and return analysis of all the crops were taken plot wise and made up of average and stated in Table 2.

Rice Equivalent Yield (REY): For comparison between crop sequences, the yield of every crop was converted into rice equivalent on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REV) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

$$\text{Rice equivalent yield (t ha}^{-1}\text{/yr)} = \frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\text{Market price of rice}}$$

The economic analysis was done for gross return, gross margin and marginal benefit cost ratio was calculated on the basis of prevailing market price of the produces. Economic analysis involved collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour and insecticides. The output and inputs were valued at market prices. The MBCR of the farmer's prevalent pattern and any replacement for it can be computed as the marginal value product (MVP) over the marginal value cost (MVC). The marginal of prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

$$\text{Marginal Benefit Cost Ratio (MBCR)} = \frac{\text{Gross return (E)} - \text{Gross return (F)}}{\text{TVC(E)} - \text{TVC(F)}} = \frac{\text{MVP}}{\text{MVC}}$$

Table 1. Crop management practices used in existing and alternate cropping pattern during 2023-24 in Bhola district

Items	Existing cropping pattern (ECP)			Alternate cropping pattern (ACP)			
Crop	D. Aus	T. Aman	Potato	T. Aus	T. Aman	Potato	Mungbean
Variety	BRRI dhan48	BRRI dhan52	Local	BRRI dhan82	BRRI dhan87	BARI Alu-72	BARI Mug-8
Date of sowing/ Transplanting	07-12 May 2023	05-10 Sep. 2023	25-27 Jan. 2024	15-18 May 2023	27-30 Aug. 2023	21-22 Dec 2023	10-12 March, 2024
Seedling age (days)	Dibbling	35	Direct seeded	20	25	Direct seeded	Broadcast
Seed rate (kg ha ⁻¹)	50	45	1500	40	40	1500	20
Spacing (cm)	20 x 15	25 x 20	50 x 20	20 x 15	20 x 15	60 x 20	Broadcast
Fertilizer dose (NPKSZn kg ha ⁻¹)	150-50-75-35-5	150-110-50-30-10	115-30-125-20-4-2	150-52-75-38-5	180-120-100-68-12	115-30-125-20-4-2	23-17-17-0-0
Date of harvesting (range)	15-20 Aug 2023	20-29 Dec. 2023	26-30 April 2024	20-21 Aug. 2023	10-15 December 2023	05-08 March, 2024	08-11 may, 2024
Field duration (days)	100	120	90	85	100	85	60

Result and Discussion

Crop management practices of existing and alternate cropping patterns are shown in Table 1. Existing cropping pattern D. Aus-T. Aman-Potato required 332 days and Alternate cropping pattern T. Aus-T. Aman-Potato-Mungbean took 330 days (excluding seedling age of rice) to complete the cycle.

Yield and economic return of Alternate cropping pattern and existing pattern are shown in Table 2. In Alternate pattern, the yield of T. Aus, T. Aman, Potato and Mungbean rice was 4.17, 4.58, 20.79 and 1.19 t ha⁻¹ respectively where as in existing pattern, the yield of D. Aus, T. Aman and Potato was 3.53, 4.32 and 18.13 t ha⁻¹ respectively. The Alternate cropping pattern gave higher Rice Equivalent Yield (30.22 t ha⁻¹) while existing one recorded 23.07 t ha⁻¹. The whole system Rice Equivalent Yield was 31 % higher in alternate pattern due to addition of high yielding improved varieties.

Cost and return: Higher gross return (Tk. 664840 ha⁻¹) and gross margin (Tk. 365930 ha⁻¹) were obtained in alternate cropping pattern over existing cropping pattern (gross return: Tk. 507540 ha⁻¹ and gross margin: Tk. 241290 ha⁻¹). The gross margin of the alternate cropping pattern was 51.66 % higher than that of the existing pattern. The MBCR was calculated 4.82 indicating that alternate cropping pattern could produce more returns than the existing farmers, pattern (Table 2).

Pest infestation: Rice hispa infestation was observed before the tillering stage and Virtako was used as per schedule. In case of potato, common cut worm like insects, common scab was observed. The crop was sprayed by Mancozeb (Dithane M 45) and Mancozeb + Metalaxyl (Ridomil Gold MZ 68 WG) 2 to 4 times at 7 to 15 days' interval @ 2 gm L⁻¹ to control late blight of potato. Mungbeans were sprayed 4 times by Imidacloprid (Imitaf 20 SL) @ 0.5 ml L⁻¹ at 24- 35 DAS and 48-67 DAS to control thrips. The crop was also sprayed by Chlorpyrifos+Cypermethrin (Nitro 505 EC) @1ml L⁻¹ one time at 50-65 DAS to control pod borer.

Farmers' opinion: Farmers realized that use of high yielding modern varieties instead of local varieties or old HYVs can increase production as well as their income. Farmers liked BRRI dhan87 as gave better yield but rat and bird infestation were high during ripening stage because of non-availability of food in other fields at that time.

Table 2. Yield, cost and return analysis of alternate and existing cropping pattern in Bhola district during 2023-24 cropping season.

Items	Farmers existing cropping pattern (ECP)			Alternate cropping pattern (ACP)			
Crop	D. Aus	T. Aman	Potato	T. Aus	T. Aman	Potato	Mungbean
Variety	BRRI dhan48	BRRI dhan52	Local	BRRI dhan82	BRRI dhan87	BARI Alu-25	BARI Mug-8
Grain yield (t ha ⁻¹)	3.53	4.32	18.13	4.17	4.58	20.79	1.19
Straw yield (t ha ⁻¹)	-	4.25	-	-	4.44	-	-
Gross return (Tk. ha ⁻¹)	77660	103540	326340	91740	109560	374220	89250
TVC (Tk. ha ⁻¹)	62500	68300	135450	58500	65500	140630	34280
Gross margin (Tk. ha ⁻¹)	15160	35240	190890	27100	37300	200770	37720
Whole pattern REY (t ha ⁻¹)	23.07			30.22			
Whole Pattern GR (Tk. ha ⁻¹)	507540			664840			
Whole pattern TVC (Tk. ha ⁻¹)	266250			298910			
Whole Pattern GM (Tk. ha ⁻¹)	241290			365930			
MBCR	4.82						

Input: Seed (Potato Tk. 40/-, Mungbean Tk. 100/-, D. Aus and T. Aus rice Tk. 50/- and T. Aman Tk. 40/- per kg), fertilizer (Urea Tk.16/-, TSP Tk. 22/-, MoP Tk. 15/-, Zinc sulphate Tk. 190/- and Gypsum Tk. 30/- per kg), Output: Unit price (Tk. kg⁻¹): Potato=18.00, Mungbean = 75, Rice = 22.00, Rice straw = 2.00

Conclusion

From the experimentation, the cultivation of alternate cropping pattern is profitable than that of existing cropping pattern. Inclusion of BARI Alu-25, BARI Mug-8, BRRI dhan 82 and BRRI dhan 87 gave higher yield and economic benefit.

60. DEVELOPMENT OF ONION-BASED CROPPING PATTERNS AGAINST ONION - JUTE- T AMAN RICE CROPPING PATTERN

M. N. A SIDDQUIE, M. J. ISLAM, M. M. I. CHOWDHURY

Abstract

The experiment was conducted at the experimental field of on-farm research division, Shyampur, Rajshahi during 2021-22 and 2022-23 to study productivity, production efficiency, land use efficiency and economics of onion based alternate cropping patterns (AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, and AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice) over the existing Onion (Bulb)-Jute- T Aman rice cropping pattern in High Ganges River Floodplain (AEZ 11). The experiment was conducted with randomized complete block design with three replications. The higher rice equivalent yield (55.41 t ha⁻¹) and (87.36 t ha⁻¹) was recorded from AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T Aman over the existing cropping pattern EP: Onion-Jute-T Aman (26.37 t ha⁻¹) and (34.12 t ha⁻¹) in 2021-22 and 2022-23 respectively. The AP1 had a maximum gross return (Tk. 1697170 ha⁻¹) and (Tk. 2654020 ha⁻¹) which also contributed to higher net return (Tk. 1020333 ha⁻¹) and (Tk. 1964746 ha⁻¹) and BCR (2.52) and (3.85) than EP in 2021-22 and in 2022-23 respectively.

Introduction

Onion (*Allium cepa*) is one of the most significant profitable vegetable crops, which is used as spices in our daily meal in Bangladesh. Onion production may not fulfil the demand for our country due to increase in population day by day. As such, importation of onion from outside is being done very often. Bangladesh has supportive climate and adequate resources for onion production, processing, and marketing etc. In Bangladesh, Approximately 64% (9.03 million hectare (ha)) of Bangladesh's land area (about 14.4 million ha) is under cultivation. Cultivable land is declining due to urbanization and water erosion, but the total cropped area is increasing

as a result of changing land utilization patterns (i.e., double and triple cropping). Considering the above facts, some improved cropping patterns are suggested for trial against existing Onion-Jute-T. Aman rice to screen suitable, productive and profitable patterns.

Materials and Methods

The experiment was conducted at the experimental field of on-farm research division, Shyampur, Rajshahi during 2021-22 and 2022-23 to study the performance of alternate cropping patterns (AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, and AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice) against existing cropping pattern (EP: Onion (Bulb)-Jute- T Aman) in High Ganges River Flood plain soils. The experiment was designed with four cropping patterns following randomized complete block design with three dispersed replications. The unit plot size was 5m x 4m. The treatments were- Alternate cropping patterns (AP): AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, and AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and existing pattern (EP): Onion (Bulb)-Jute- T Aman. 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. The first and second year's crop cycles have been completed and third cycle is ongoing. The details of the varieties used and cultural operations adopted in different crop sequences during 2021-22 and 2022-23 are given in Table 1 and Table 2 respectively. All the crops were harvested at maturity from an area of central 3.0 m². Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle.

Table 1. Details of cultural practices adopted for different component crops in field experiments during 2021-2022

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Onion	BARI Piaj-1	1200	10 x 8	2 Nov 2021	1 Jan 2022	155	80	75	18	3.5	2
Onion	BARI Piaj-1	7.5	10 x 5	5 Jan 2022	27 Mar 2022	155	80	110	18	3.5	2
Potato	BARI Alu-13	1875	60 x 20	2 Nov 2021	1 Jan 2022	130	35	130	13	4.5	1.5
Mustard	BARI Sarisha-14	7.5	30 x cont.	2 Nov 2021	22 Jan 2022	115	35	43	24	1.5	2
Jute	JRO 524	7	30 x cont.	5 Apr 2022	29 Jul 2022	111	10	42	13	-	-
T. Aus	BRRI dhan98	35	20 x 15	4-25 Apr 2022	30 June-16 Jul 2022	70	10	40	6	2	-
Aman	BRRI dhan75	35	20 x 15	10 Jul-4 Aug 2022	10-27 Oct 2022	76	12	53	11	2	-
Aman	Sworna	35	20 x 15	4 Aug 2022	15 Nov 2022	90	12	53	11	2	-

Table 2. Details of cultural practices adopted for different component crops in field experiments during 2022-2023

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Onion	BARI Piaj-1	1200	10 x 8	30 Oct 2022	18 Dec 2022	155	80	75	18	3.5	2
Onion	BARI Piaj-1	7.5	10 x 5	26 Dec 2022-15 Jan, 2023	25 Mar-8 Apr, 2023	155	80	110	18	3.5	2
Potato	BARI Alu-13	1875	60 x 20	21 Oct 2022	18 Dec 2022	130	35	130	13	4.5	1.5
Mustard	BARI Sarisha-14	7.5	30 x cont.	26 Oct 2022	8 Jan 2023	115	35	43	24	1.5	2
Jute	JRO 524	7	30 x cont.	7-9 Apr 2023	20-22 Jul 2023	111	10	42	13	-	-
T. Aus	BRRI dhan98	35	20 x 15	8-13 Apr 2023	3-8 Jul 2023	70	10	40	6	2	-

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Aman	BRR dhan75	35	20 x 15	9-26 Jul 2023	5-15 Oct 2023	76	12	53	11	2	-
Aman	Sworna	35	20 x 15	2 Aug 2023	24 Nov 2023	90	12	53	11	2	-

Results and Discussion

Effect of onion based cropping pattern on component crops yield and system productivity

Cropping cycle 2021-2022: The yield of onion and T. Aman rice were similar in all cropping sequences (Table 3). But Onion (leaf+bulb) (23.33t ha⁻¹), Potato (29.8 t ha⁻¹), Mustard (1.52 t ha⁻¹) and T. Aus showed their productive yield against Jute. The total production of sequence in terms of rice equivalent yield (REY) was significantly higher in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman (55.41 t ha⁻¹) followed by AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T. Aman (38.56 t ha⁻¹) and EP: Onion-Jute-T. Aman (26.37 t ha⁻¹) produced the lowest rice equivalent yield.

Cropping cycle 2022-2023: The yield of onion and T. Aman rice were similar in all cropping sequences (Table 4). But Onion (leaf+bulb) (27.2 t ha⁻¹), Potato (218.97 t ha⁻¹), Mustard (1.25 t ha⁻¹) and T Aus showed their productive yield against Jute. The total production of sequence in terms of rice equivalent yield (REY) was significantly higher in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman (87.36 t ha⁻¹) followed by AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T. Aman (66.27 t ha⁻¹) and EP: Onion-Jute-T. Aman (26.37 t ha⁻¹) produced the lowest rice equivalent yield.

Effect of onion based cropping pattern on field duration of crop sequence and production efficiency (PE)

Cropping cycle 2021-2022: The cropping patterns showed variation on field duration of crop sequence and production efficiency (Table 6). The higher field duration was found in AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T Aman (346 days) due to the effect of long duration crops in the sequence. The AP1 (325 days) and EP (304 days) produced the lower duration. The Production efficiency (PE) was observed maximum in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T Aman (170.5 kg⁻¹ ha⁻¹ day⁻¹). This is due to the higher production of this sequence in which the contribution of onion (leaf+bulb) is quite obvious. However, the AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T Aman rice produced the PE (111.5 kg⁻¹ ha⁻¹ day⁻¹) and AP3 : Mustard-Onion (Bulb)-T. Aus rice-T. Aman rice showed the lowest PE (83.5 kg⁻¹ ha⁻¹ day⁻¹) in the sequences.

Cropping cycle 2022-2023: The cropping patterns showed variation on field duration of crop sequence and production efficiency (Table 7). The higher field duration was found in AP3: Mustard-Onion (bulb)- T. Aus-T Aman (342 days) due to the effect of long duration crops in the sequence. The AP1 (316 days) and EP (305 days) produced the lower duration. Considering turnaround time (TA) between consecutive crops of the proposed sequences (Table 5a, 5b,5c), AP1 found more flexible to farmers due to higher turnaround time between crops followed by AP2 and AP3. The Production efficiency (PE) was observed (Table 7) maximum in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T Aman (276.5 kg⁻¹ ha⁻¹ day⁻¹). This is due to the higher production of this sequence in which the contribution of onion (leaf+bulb) is quite obvious. However, the AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T Aman rice produced the PE (198.4 kg⁻¹ ha⁻¹ day⁻¹) and AP3 : Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice showed the lowest PE (106.7 kg⁻¹ ha⁻¹ day⁻¹) in the sequences.

Effect of onion based cropping patterns on land use efficiency (LUE) and employment generation

Cropping cycle 2021-2022: Land use efficiency (LUE) and employment generation varied by the cropping patterns (Table 6). In general, patterns intensified by potato crops recorded higher LUE than the existing cropping system. The higher LUE (94.8 %) was recorded in AP2: Potato (Early

harvest)-Onion (bulb)- T. Aus-T. Aman rice followed by AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice (92.1%) whereas the lower LUE (86.7 %) was recorded in EP: Onion-Jute-T Aman rice cropping pattern. The AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T Aman sequence provided the most employment generation (760 man-day ha⁻¹) followed by AP1:Onion (leaf+bulb)-Onion (bulb)- T. Aus- T Aman (751 man-day ha⁻¹). The AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion-Jute-T Aman rice produced the lower and similar employment generation (585 man-day ha⁻¹each).

Cropping cycle 2022-2023: Land use efficiency (LUE) and employment generation varied by the cropping patterns (Table 7). In general, patterns intensified by mustard crops recorded higher LUE than the existing cropping system. The higher LUE (93.6 %) was recorded in AP3: Mustard-Onion (bulb)- T. Aus-T. Aman rice followed by AP2: Potato (Early harvest)- Onion (Bulb)-Jute-T. Aman rice (91.5%) whereas the lower LUE (83.5 %) was recorded in EP: Onion-Jute-T Aman rice cropping pattern. The AP1: Onion (Leaf+bulb)-Onion (bulb)- T. Aus-T Aman sequence provided the most employment generation (763 man-day ha⁻¹) followed by AP2:Potato (Early harvest)-Onion (bulb)- Jute- T Aman (760 man-day ha⁻¹). The AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion-Jute-T Aman rice produced the lower and similar employment generation (585 man-day ha⁻¹each).

Economic Performance

Cropping cycle 2021-2022: Economic performance of the patterns was presented in the Table 8. Cropping pattern attributed a remarkable impact on cost of production, gross return, net return, profitability, relative economic efficiency (REE) and benefit cost ratio (BCR). The annual gross return, cultivation cost, net return and BCR were considered for choosing suitable cropping pattern. In general, inclusion of the onion (leaf+Bulb) crop markedly enhanced both the return and cultivation cost. The AP1:Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman had a maximum gross return (Tk. 1697170ha⁻¹) along with a higher cultivation cost (Tk. 676837 ha⁻¹), which also contributed to higher net return (Tk. 1020333ha⁻¹) and BCR (2.52) than Onion-Jute-T Aman rice cropping pattern. The maximum profitability (2795.4 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (181.5 %) was obtained in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman rice sequence followed by AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T. Aman rice sequence with profitability (1368.6 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (37.8 %) which is due to higher value of total produce of onion (leaf+bulb). The minimum profitability (992.9 Tk. ha⁻¹ day⁻¹) was found in EP: Onion-Jute-T Aman rice sequence.

Cropping cycle 2022-2023: Economic performance of the patterns was presented in the Table 9. Cropping pattern attributed a remarkable impact on cost of production, gross return, net return, profitability, relative economic efficiency (REE) and benefit cost ratio (BCR). The annual gross return, cultivation cost, net return and BCR were considered for choosing suitable cropping pattern. In general, inclusion of the onion (leaf+Bulb) crop markedly enhanced both the return and cultivation cost. The AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman had a maximum gross return (Tk. 2654020 ha⁻¹) along with a higher cultivation cost (Tk. 689274 ha⁻¹), which also contributed to higher net return (Tk. 1964746 ha⁻¹) and BCR (3.85) than Onion-Jute-T Aman rice cropping pattern. The maximum profitability (5383 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (225.3 %) was obtained in AP1: Onion (leaf+ bulb)-Onion (bulb)- T. Aus- T. Aman rice sequence followed by AP2: Potato (Early harvest)-Onion (bulb)- T. Aus-T. Aman rice sequence with profitability (3668.0 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (121.7 %) which is due to higher value of total produce of onion (leaf+bulb). The minimum profitability (1654.6Tk. ha⁻¹ day⁻¹) was found in EP: Onion-Jute-T Aman rice sequence.

Farmers reaction: Farmers are very much interested to follow the alternate pattern in balance and diversified way due to inclusion of good and high income generating alternate onion (leaf + bulb) and potato (Early harvest) crop in the system instead of Jute in existing pattern.

Table 3. Component crops yield and Rice Equivalent yield in different cropping system, 2021-22

CPs	Yield of component crops (t ha ⁻¹)							REY (t ha ⁻¹)
	Onion (Leaf+Bulb)	Potato	Mustard	Onion (Bulb)	Jute	T. Aus	T. Aman rice	
AP1	23.33	-	-	17.84	-	4.47	4.97	55.41
AP2	-	29.8	-	17.87	2.94	-	4.89	38.56
AP3	-	-	1.52	17.73	-	4.36	4.87	28.06
EP	-	-	-	17.93	3.05	-	5.17	26.37

AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion (Bulb)-Jute- T Aman

Table 4. Component crops yield and Rice Equivalent yield in different cropping system, 2022-23

CPs	Yield of component crops (t ha ⁻¹)							REY (t ha ⁻¹)
	Onion (Leaf+Bulb)	Potato	Mustard	Onion (Bulb)	Jute	T. Aus	T. Aman rice	
AP1	27.2	-	-	20.57	-	4.0	4.96	87.36
AP2	-	18.97	-	20.13	2.66	-	5.40	66.27
AP3	-	-	1.25	20.67	-	4.1	5.37	36.5
EP	-	-	-	20.0	2.88	-	5.45	34.12

AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion (Bulb)-Jute- T Aman

Table 5a. Crop duration and turnaround time (TA) among component crops of different proposed alternate (APs) and existing patterns (EP) during 2022-23.

CPs	Component crops duration and turnaround time (TA) in days								Pattern Duration (day)
AP1	Onion (Leaf+Bulb)	TA	Onion (Bulb)	TA	T. Aus	TA	T. Aman	TA	
	50	7	90	13	87	5	89	24	316
D/T or D/P	30/10/2022		26/12/2022		8/4/2023		9/7/2023		
D/H	18/12/2022		25/3/2023		3/7/2023		5/10/2023		
EP	Onion(Bulb)		Jute		-	-	T. Aman		
	85	11	105	10	-	-	115	39	305
D/T or D/S	3/1/2023		9/4/2023		-	-	2/8/2023		
D/H	28/3/2023		22/7/2023		-	-	24/11/2023		

Table 5b. Crop duration and turnaround time (TA) among component crops of different proposed alternate (APs) and existing patterns (EP) during 2022-23.

CPs	Component crops duration and turnaround time (TA) in days								Pattern Duration (day)
AP2	Potato (Early harvest)	TA	Onion (Bulb)	TA	Jute	TA	T. Aman	TA	
	58	7	90	13	104	5	82	5	334
D/T or D/P	21/10/2022		26/12/2022		7/4/2023		26/7/2023		
D/H	18/12/2022		25/3/2023		20/7/2023		15/10/2023		
EP	Onion(Bulb)		Jute		-	-	T. Aman		
	85	11	105	10	-	-	115	39	305
D/T or D/S	3/1/2023		9/4/2023		-	-	2/8/2023		
D/H	28/3/2023		22/7/2023		-	-	24/11/2023		

Table 5c. Crop duration and turnaround time (TA) among component crops of different proposed alternate (APs) and existing patterns (EP) during 2022-23.

CPs	Component crops duration and turnaround time (TA) in days								Pattern Duration (day)
AP3	Mustard	TA	Onion (Bulb)	TA	T. Aus	TA	T. Aman	TA	
	81	6	84	4	87	6	90	13	342
D/T or D/P	26/10/2022		15/1/2023		13/4/2023		15/7/2023		
D/H	8/1/2023		8/4/2023		8/7/2023		12/10/2023		
EP	Onion(Bulb)		Jute		-	-	T. Aman		
	85	11	105	10	-	-	115	39	305
D/T or D/S	3/1/2023		9/4/2023		-	-	2/8/2023		
D/H	28/3/2023		22/7/2023		-	-	24/11/2023		

Table 6. Field duration of sequence, Production efficiency, Land use efficiency of the proposed Alternate patterns (APs) over the existing (EP) Onion- Jute-T. Aman cropping pattern during 2021-22.

Cropping pattern	Field duration of crop sequence (day)	Production efficiency (kg ⁻¹ ha ⁻¹ day ⁻¹)	Land use efficiency (%)	Man day ha ⁻¹
AP1	325	170.5	89.0	751
AP2	346	111.5	94.8	760
AP3	336	83.5	92.1	585
EP	304	86.7	86.7	585

AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion (Bulb)-Jute- T. Aman

Table 7. Field duration of sequence, Production efficiency, Land use efficiency of the proposed Alternate patterns (APs) over the existing (EP) Onion- Jute-T. Aman cropping pattern during 2022-23.

Cropping pattern	Field duration of crop sequence (day)	Production efficiency (kg ⁻¹ ha ⁻¹ day ⁻¹)	Land use efficiency (%)	Man day ha ⁻¹
AP1	316	276.5	86.6	763
AP2	334	198.4	91.5	760
AP3	342	106.7	93.6	585
EP	305	111.9	83.5	585

AP1: Onion (Leaf+Bulb)-Onion (Bulb)-T. Aus rice-T. Aman rice, AP2: Potato (Early harvest)-Onion (Bulb)- Jute- T. Aman, AP3: Mustard- Onion (Bulb)-T. Aus rice-T. Aman rice and EP: Onion (Bulb)-Jute- T. Aman

Table 8. Economics of the onion based proposed Alternate patterns (APs) over the existing (EP) Onion- Jute-T. Aman rice cropping pattern during 2021-22.

Cropping pattern	Gross return (Tk. ha ⁻¹)	Cost of cultivation (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Profitability (Tk. ha ⁻¹ day ⁻¹)	Relative Economic Efficiency (%)	BCR
AP1	1697170	676837	1020333	2795.4	181.5	2.52
AP2	1172720	673197	499523	1368.6	37.8	1.75
AP3	880550	514154	366396	1003.8	1.1	1.72
EP	806450	444041	362409	992.9	-	1.83

Input: Urea: 16 Tk kg⁻¹, TSP: 22 Tk kg⁻¹, MoP: 15 Tk kg⁻¹, gypsum: 7 Tk kg⁻¹, zinc sulphate: 120 Tk kg⁻¹, boric acid: 150 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Potato seed: 40Tk kg⁻¹, Rice seed:35 Tk kg⁻¹, Mustard seed:150Tk kg⁻¹,Jute seed: 350 Tk kg⁻¹, Onion seed (Bulb): 50Tk kg⁻¹, Onion seed (True seed): 2500Tk kg⁻¹, and Labour: 500 Tk day⁻¹ (8 hours)

Output: Rice grain (BRRI Dhan 75): 30Tk kg⁻¹, Rice grain (Shorna): 25Tk kg⁻¹, Onion (Leaf+Bulb) : 40Tk kg⁻¹,Onion (Bulb) : 25Tk kg⁻¹, Potato: 12Tk kg⁻¹, Mustard: 80Tk kg⁻¹ and Jute: 65Tk kg⁻¹.

Table 9. Economics of the onion based proposed Alternate patterns (APs) over the existing (EP) Onion- Jute-T. Aman rice cropping pattern during 2022-23.

Cropping pattern	Gross return (Tk. ha ⁻¹)	Cost of cultivation (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Profitability (Tk. ha ⁻¹ day ⁻¹)	Relative Economic Efficiency (%)	BCR
AP1	2654020	689274	1964746	5383.0	225.3	3.85
AP2	2019880	681055	1338825	3668.0	121.7	2.97
AP3	1135330	520633	614697	1684.1	1.8	2.18
EP	1057250	453341	603909	1654.6	-	2.33

Input: Urea: 16 Tk kg⁻¹, TSP: 22 Tk kg⁻¹, MoP: 15 Tk kg⁻¹, gypsum: 7 Tk kg⁻¹, zinc sulphate: 120 Tk kg⁻¹, boric acid: 150 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Potato seed: 40Tk kg⁻¹, Rice seed:35 Tk kg⁻¹, Mustard seed:150Tk kg⁻¹, Jute seed: 350 Tk kg⁻¹, Onion seed (Bulb): 50Tk kg⁻¹, Onion seed (True seed): 2500Tk kg⁻¹, and Labour: 500 Tk day⁻¹ (8 hours)

Output: Rice grain (BRRI Dhan 75): 30Tk kg⁻¹, Rice grain (Shorna): 25Tk kg⁻¹, Onion (Leaf+Bulb) : 60Tk kg⁻¹, Onion (Bulb) : 35Tk kg⁻¹, Potato: 50 Tk kg⁻¹, Mustard: 70Tk kg⁻¹ and Jute: 65Tk kg⁻¹.

Conclusion

It was concluded that the existing onion based cropping system can effectively be diversified with inclusion of onion (leaf+bulb) and potato (Early harvest) in the alternate patterns which were viable systems in productivity and economic point of view. However, for concrete conclusion it should be repeated further.

61. IMPROVEMENT OF CROPPING PATTERNS WITH SUMMER VEGETABLES AND T. AUS RICE

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Abstract

The experiment was conducted at the experimental field of on-farm research division, Shyampur Rajshahi during 2021-22 and 2022-23 to study the performance of alternate cropping patterns: AP1= Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice and AP2= Potato-Stem amaranth- T. Aus- T. Aman against existing cropping pattern: EP= Potato-Boro-T. Aman rice. The experiment was conducted with a RCB design with three replications. A higher rice equivalent yield (39.1 and 48.2 t ha⁻¹) was recorded from AP2 and Production efficiency (PE) was observed to be highest in AP2 (126.1 and 147.4 kg⁻¹ ha⁻¹ day⁻¹). The higher Land Use Efficiency (LUE (94% and 95.3%) was recorded in AP1. The AP2 had a maximum gross return (Tk. 1202900 and 1446950 ha⁻¹) and higher net return (Tk. 654694 and 840247 ha⁻¹) and BCR (2.19 and 2.38).

Introduction

Bangladesh is a densely populated country of the world and increasing day by day whereas cultivable land decreasing. There is very little scope of increasing cultivable land but there are some scopes of increasing cropping intensity from the present cropping intensity 190% to 400%. Potato-Boro rice-T Aman rice cropping system is widely followed system of Rajshahi region. But profitability of this pattern is decreasing day by day due to higher input cost, water scarcity and low product cost. It seems to be pertinent to suggest a suitable cropping sequence for the farmers in order to get more income and profit. Therefore, a suitable potato based cropping system has to be identified to ensure the productivity and profitability of farmer's. Considering the facts, non-rice crops like sweet gourd and stem amaranth have been included between potato, boro rice and T. Aman rice to increase production and benefit of farmers.

Materials and Methods

The experiment was conducted at the experimental field of on-farm research division, Shyampur Rajshahi during 2021-22 and 2022-23 to study the performance of alternate cropping patterns: AP1= Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice and AP2= Potato-Stem amaranth- T. Aus- T. Aman against existing cropping pattern: EP= Potato-Boro-T. Aman rice in High Ganges

River Flood plain soils. The experiment was designed with three cropping patterns following randomized complete block design with three replications. The unit plot size was 5m x 4m. The treatments were- Alternate cropping patterns (AP): AP1= Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice; AP2= Potato-Stem amaranth- T. Aus rice- T. Aman rice and existing cropping pattern EP= Potato-Boro-T. Aman rice. 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. Second cycle has been completed. The details of the varieties used and cultural operations adopted in different crop sequences are given in Table 1 and 2. All the crops were harvested at maturity from an area of central 3.0 m². Data on yield of various crops in sequences were recorded and converted to ton per hectare.

Table 1. Details of cultural practices adopted for different component crops in fields, 2021-22

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Potato	BARI Alu-56	1875	60 x 20	1 Dec 2021	23 Feb 2022	130	35	130	13	4.5	1.5
Sweet gourd	BARI Hybrid Misti Kumra-1	0.8	2m x 2m	20 Jan 2022 (Relay)	15 May 2022	80	35	75	16	4.5	2
Stem Amaranth	BARI Data-1	4	30 x cont.	25 Feb 2022	16 Apr 2022	115	30	75	12	-	-
T. Aus	BRRRI dhan98	35	20 x 15	25 Apr-22 May 2022	18 Jul-15 Aug 2022	70	10	40	6	2	
T. Aman	BRRRI dhan75	35	20 x 15	31 Jul-22 Aug 2022	19-29 Oct 2022	76	12	53	11	2	-
Boro rice	BRRRI dhan28	45	20 x 25	2 Mar 2022	15 Jun 2022	120	18	75	18	4	-

Table 2. Details of cultural practices adopted for different component crops in field experiments during 2022-23

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Potato	BARI Alu- 56	1875	60 x 20	10 Nov 2022	13 Feb 2023	130	35	130	13	4.5	1.5
Sweet gourd	BARI Hybrid Misti Kumra-1	0.8	2m x 2m	16 Jan 2023 (Relay)	22 April 2023	80	35	75	16	4.5	2
Stem Amaranth	BARI Data-1	4	30 x cont.	16 Feb 2023	8 Apr 2023	115	30	75	12	-	-
T. Aus	BRRRI dhan98	35	20 x 15	26 Apr 2023	17 Jul 2023	70	10	40	6	2	
T. Aman	BRRRI dhan75	35	20 x 15	26 Jul-23	12 Nov 2023	76	12	53	11	2	-
Boro rice	BRRRI dhan28	45	20 x 15	9 Feb 2023	13 May 2023	120	18	75	18	4	-

Results and Discussion

A. Effect of summer vegetables and T Aus on component crops yield and system productivity cropping patterns

The yield of potato, stem amaranth and T. Aman rice were similar in all cropping sequences in both year (Table 3 & 4). But Sweet gourd (21.83 and 20.39 t ha⁻¹) is different. The total production of sequence in terms of rice equivalent yield (REY) was higher in AP2: Potato-Stem amaranth- T. Aus- T. Aman (39.1 and 48.2 t ha⁻¹) followed by AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice (36.4 and 46.1 t ha⁻¹) and EP: Potato-Boro rice-T Aman (21.2 and 29.8 t ha⁻¹).

B. Effect of onion based cropping pattern on field duration of crop sequence and production efficiency (PE)

The higher field duration was found in AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice (343 and 348 days).The Production efficiency (PE) was observed maximum in AP2: Potato-Stem amaranth- T. Aus- T. Aman (126.1 and 147.4 kg⁻¹ ha⁻¹ day⁻¹). However, the AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice produced the highest PE (106.2 and 132.5 kg⁻¹ ha⁻¹ day⁻¹)

and EP: Potato-Boro rice- T Aman showed the lowest PE (75.3 and 98.7 kg⁻¹ ha⁻¹ day⁻¹) in the sequences. (Table 5 & 6).

C. Effect of potato based cropping patterns on land use efficiency (LUE) and employment generation

The higher LUE (94 % and 95.3%) was recorded in AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice followed by AP2: Potato-Stem amaranth- T. Aus- T. Aman (85% and 89.6%) whereas AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice sequence provided the most employment generation (534 and 525 man-day ha⁻¹) followed by AP2: Potato-Stem amaranth- T. Aus- T. Aman (529 and 512 man-day ha⁻¹). The EP: Potato-Boro rice-T. Aman produced the lower employment generation (422 and 420 man-day ha⁻¹). (Table 5 & 6).

Economic Performance: The AP2: Potato-Stem amaranth- T. Aus- T. Aman had a maximum gross return (Tk. 1202900 and 1446950 ha⁻¹) which also contributed to higher net return (Tk. 654694 and 840247 ha⁻¹) and BCR (2.19 and 2.38) than Potato-Boro rice-T. Aman rice cropping pattern. The maximum profitability (1793.7 and 2302 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (216.4 % and 146%) was obtained in AP2: Potato-Stem amaranth- T. Aus- T. Aman rice sequence (Table 7 & 8).

Table 3. Component crops yield and Rice Equivalent yield in different cropping system, 2021-22

CPs	Yield of component crops (t ha ⁻¹)						REY (t ha ⁻¹)
	Potato	Sweet gourd	Stem Amaranth	Boro Rice	T. Aus	T. Aman	
AP1	26.26	21.83	-	-	4.75	5.18	36.4
AP2	26.68	-	37.13	-	4.71	5.14	39.1
EP	26.19	-	-	6.48	-	5.12	21.2

AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice, AP2: Potato-Stem amaranth- T. Aus- T. Aman, and EP: Potato-Boro rice- T. Aman.

Table 4. Component crops yield and Rice Equivalent yield in different cropping system during 2022-2023

CPs	Yield of component crops (t ha ⁻¹)						REY (t ha ⁻¹)
	Potato	Sweet gourd	Stem Amaranth	Boro Rice	T. Aus	T. Aman	
AP1	27.15	20.39	-	-	5.5	5.48	46.1
AP2	27.7	-	37.09	-	5.62	5.6	48.2
EP	27.93	-	-	6.02	-	5.11	29.8

Table 5. Field duration of sequence, Production efficiency, Land use efficiency of the summer vegetables and T Aus based proposed Alternate patterns (APs) over the existing (EP) Potato- Boro-T Aman cropping pattern during 2021-22.

Cropping pattern	Field duration of crop sequence (day)	Production efficiency (kg ⁻¹ ha ⁻¹ day ⁻¹)	Land use efficiency (%)	Man day ha ⁻¹
AP1	343	106.2	94	534
AP2	310	126.1	85	529
EP	282	75.3	77	422

AP1: Potato-Sweet gourd (Relay)-T. Aus rice-T. Aman rice, AP2: Potato-Stem amaranth- T. Aus- T. Aman, and EP: Potato-Boro rice- T. Aman

Table 6. Field duration of sequence, Production efficiency, Land use efficiency of the summer vegetables and T. Aus based proposed Alternate patterns (APs) over the existing (EP) Potato- Boro-T. Aman cropping pattern during 2022-23.

Cropping pattern	Field duration of crop sequence (day)	Production efficiency (kg ⁻¹ ha ⁻¹ day ⁻¹)	Land use efficiency (%)	Man, day ha ⁻¹
AP1	348	132.5	95.3	525
AP2	327	147.4	89.6	512
EP	302	98.7	82.7	420

Table 7. Economics of the Summer vegetables and T. Aus based proposed Alternate patterns (APs) over the existing (EP) Potato- Boro-T. Aman rice cropping pattern during 2021-22.

Cropping pattern	Gross return (Tk. ha ⁻¹)	Cost of cultivation (Tk. ha ⁻¹)	Net Return (Tk. ha ⁻¹)	Profitability (Tk. ha ⁻¹ day ⁻¹)	Relative Economic Efficiency (%)	MBCR
AP1	1350000	569727	557813	1528.3	169.5	5.02
AP2	1474200	548206	654694	1793.7	216.4	7.77
EP	818100	463747	206933	566.9	-	-

Input: Urea: 16 Tk kg⁻¹, TSP: 22 Tk kg⁻¹, MoP: 15 Tk kg⁻¹, gypsum: 10 Tk kg⁻¹, zinc sulphate: 220 Tk kg⁻¹, boric acid: 150 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Potato seed: 40 Tk kg⁻¹, Rice seed: 35 Tk kg⁻¹, Stem amaranth seed: 900 Tk kg⁻¹, Sweet gourd seed: 14000 Tk kg⁻¹, and Labour: 500 Tk day⁻¹ (8 hours)

Output: Rice grain: 30 Tk kg⁻¹, Potato: 12 Tk kg⁻¹, Sweet gourd: 22 Tk kg⁻¹ and Stem Amaranth: 15 Tk kg⁻¹.

Table 8. Economics of the Summer vegetables and T. Aus based proposed Alternate patterns (APs) over the existing (EP) Potato- Boro-T. Aman rice cropping pattern during 2022-23.

Cropping pattern	Gross return (Tk. ha ⁻¹)	Cost of cultivation (Tk. ha ⁻¹)	Net Return (Tk. ha ⁻¹)	Profitability (Tk. ha ⁻¹ day ⁻¹)	Relative Economic Efficiency (%)	MBCR
AP1	1382150	634291	747859	2049	115	4.30
AP2	1446950	606703	840247	2302	146	6.42
EP	892500	520298	372202	1020	-	-

Input: Urea: 27 Tk kg⁻¹, TSP: 27 Tk kg⁻¹, MoP: 20 Tk kg⁻¹, gypsum: 10 Tk kg⁻¹, zinc sulphate: 320 Tk kg⁻¹, boric acid: 620 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Potato seed: 60 Tk kg⁻¹, Rice seed: 35 Tk kg⁻¹, Stem amaranth seed: 900 Tk kg⁻¹, Sweet gourd seed: 14000 Tk kg⁻¹, and Labour: 500 Tk day⁻¹ (8 hours), **Output:** Rice grain: 30 Tk kg⁻¹, Potato: 20 Tk kg⁻¹, Sweet gourd: 25 Tk kg⁻¹ and Stem Amaranth: 15 Tk kg⁻¹.

Conclusion

The alternate cropping pattern (Potato-sweet gourd-T. Aus-T. Aman and Potato-stem amaranth-T. Aus-T. Aman) were better than existing potato based cropping system ((Potato-Boro-T. Aman) which were viable systems in productivity and economic point of view.

62. DEVELOPMENT OF ALTERNATE CROPPING PATTERN MUSTARD-PROSO MILLET (Cheena)-T. AUS-T. AMAN AGAINST EXISTING MUSTARD-MAIZE-T. AMAN RICE

M. S. RAHMAN, M. N. A. SIDDIQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A comparative field trial was conducted at the farmer's field at Paba, Rajshahi, to study the comparative agronomic performance and economic return of four crops based on cropping patterns. The cropping patterns were as follows: AP = Mustard (BARI Sarisha-14)-Proso Millet (BARI China-1)-Maize (Premier 559)-Transplanted Aman Rice (Binadhan17) and EP = Mustard (BARI Sarisha-14)-Maize (Premier 559)-Transplanted Aman Rice (Binadhan17). The results showed that the higher rice equivalent yield (REY) of 16.09 t ha⁻¹ was obtained from the cropping pattern AP than EP, and it was 13.28. The higher gross return (Tk. 482700 ha⁻¹), Total variable cost (Tk. 275638 ha⁻¹), gross margin (Tk. 207062 ha⁻¹), and BCR (1.75) were obtained in AP. In EP, the gross return (Tk. 398400 ha⁻¹), total variable cost (Tk. 238138 ha⁻¹), gross margin (Tk. 160262 ha⁻¹), and BCR (1.67) were recorded.

Introduction

Bangladesh is a densely populated country of the world and population increasing day by day whereas cultivable land is decreasing every year. There is very little scope of increasing cultivable land but there are some scopes of increasing cropping intensity from the present cropping

intensity 190% to 400% by improving the present cropping pattern by incorporating short duration crops in the rice based cropping pattern. Proso millet is a fast-growing, short-season, drought tolerant, low input crop. So it is a great chance to incorporate this crop in the existing cropping pattern. The present experiment was undertaken to study the feasibility of growing four crops in a year in a piece of land by incorporating proso millet in the present cropping pattern.

Materials and Methods

The experiment was conducted at the farmers' field of Baroipara, under the multilocation testing (MLT) site, Paba, Rajshahi during 2022-23 to study the performance of alternate cropping patterns: AP= Mustard-Proso millet-Maize-T. Aman rice against existing cropping pattern: EP= Mustard-Maize-T. Aman rice in High Ganges River Flood plain soils. The experiment was designed with two cropping patterns following randomized complete block design with three replications. The unit plot size was 8m x 5m. The treatments were- Alternate cropping patterns (AP): AP= Mustard-Proso millet-Maize-T. Aman rice and existing cropping pattern EP= Mustard-Maize-T. Aman rice. 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. The initial soil properties of the experimental field were presented in Table 1. The details of the varieties used and cultural operations adopted with chemical fertilizers in AP and EP crop sequences are given in Table 2. In both patterns sowing date, harvesting date and nutrients package were same. All the crops were harvested at maturity from an area of central 3.0 m². Data on yield of various crops in sequences were recorded and converted to ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of different crop sequences was compared by calculating their economic rice equivalent yield (REY).

Table 1. Initial soil properties of the experimental field

Sample	PH	OM (%)	Total N (%)	K	P	S	Zn	B
				Meq/100g				
Value	7.2	0.68	0.06	0.19	17	21.2	0.15	0.24
Critical level	-	-	0.12	0.12	10	10.0	0.60	0.20
Interpretation	Slightly Alkaline	Very low	Very low	Low	Low	Opt.	Very low	Low

Table 2. Details of cultural practices adopted for different component crops in the alternate cropping pattern during 2022-23

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing	Date of harvesting	Rate of fertilizer application (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Mustard	BARI Sarisha-14	7.5	60 x 20	6 Nov 2022	02 Feb 2023	114	35	43	27	2	2
Proso millet	BARI China-1	20	2m x 2m	06 Feb 2023	20 April 2023	35	11	21	5	1	0
Maize	Premier 559	27	60 x 20	23 April 2023	31 Jul 2023	110	20	50	16	2	1
T. Aman	Binadhan17	35	20 x 15	5 Aug 2023	3 Nov 2023	69	11	42	11	0	0

Results and Discussion

The yield of mustard was similar in both treatments, it was 1.23 t ha⁻¹ in alternate pattern and 1.24 t ha⁻¹ was exiting cropping pattern. Proso millet was the second crop in the four-crop sequence. The yield of proso millet was 1.86 t ha⁻¹ in the 1st cropping cycle. The yield of maize was 5.92 t ha⁻¹ in alternate cropping pattern and 6.12 t ha⁻¹ in existing cropping pattern. The yield of T. Aman was 4.57 t ha⁻¹ in alternate cropping pattern and 4.67 t ha⁻¹ in existing cropping pattern (Table 3). The higher REY was recorded in the alternate cropping pattern (16.09 t ha⁻¹) than existing cropping pattern (13.28 t ha⁻¹) (Table 3). The higher LUE (97 %) was recorded in AP: Mustard-proso millet - Maize-T. Aman rice than that of EP: Mustard- Maize-T. Aman rice (76.7%)

that indicates the higher yield and higher economic importance of the sequence. The AP sequence provided the most employment generation (474 man-day ha⁻¹) than the lower employment generation (442 man-day ha⁻¹). (Table 4).

The AP had a higher gross return (Tk. 482700 ha⁻¹) along with a moderate cultivation cost (Tk. 275638 ha⁻¹), which also contributed to a higher net return (Tk. 207062 ha⁻¹) and BCR (1.75) than the EP. The higher profitability (2049 Tk. ha⁻¹ day⁻¹) and relative economic efficiency (101%) were obtained in the AP sequence than in the EP (Table 5).

Farmers opinion: The existing cropping system can effectively be diversified with inclusion of proso millet in the alternate patterns which were viable systems in productivity and economic point of view.

Table 3. Component crops yield and Rice Equivalent yield in different cropping system, 2022-23

CPs	Yield of component crops (t ha ⁻¹)				REY (t ha ⁻¹)
	Mustard	Proso millet	Maize	T. Aman	
AP	1.23	1.81	5.92	4.57	16.09
EP	1.24	-	6.12	4.67	13.28

Table 4. Field duration of sequence, Land use efficiency of alternate and existing cropping pattern during 2022-23.

Cropping pattern	Field duration of crop sequence (day)	Land use efficiency (%)	Man, day ha ⁻¹
AP1	354	97	474
EP	280	76.7	442

Table 5. Economics of the Alternate patterns (APs) over the existing (EP) cropping pattern during 2022-23.

Cropping pattern	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Profitability (Tk. ha ⁻¹ day ⁻¹)	Relative Economic Efficiency (%)	BCR
AP	482700	275638	207062	2049	101	1.75
EP	398400	238138	160262	1020		1.67

Input: Urea: 27 Tk kg⁻¹, TSP: 27 Tk kg⁻¹, MoP: 20 Tk kg⁻¹, gypsum: 10 Tk kg⁻¹, zinc sulphate: 320 Tk kg⁻¹, boric acid: 620 Tk kg⁻¹, furadan: 150 Tk kg⁻¹, Mustard seed: 150 Tk kg⁻¹, Rice seed: 60 Tk kg⁻¹, Maize seed: 700 Tk kg⁻¹, Proso millet seed: 60 Tk kg⁻¹, and Labour: 500 Tk day⁻¹ (8 hours)

Output: Rice grain: 30 Tk kg⁻¹, Mustard: 80 Tk kg⁻¹, Proso millet: 50 Tk kg⁻¹ and Maize: 25 Tk kg⁻¹.

Conclusion

From the results of the experiments, it may be concluded that the alternate cropping pattern is agronomically feasible and economically profitable. At the same time, by adopting these cropping patterns, cropping intensity and productivity will be increased.

63. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD (Sarisha-17)- BORO- T. AMAN RICE AGAINST FALLOW- BORO- T. AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. N. A. SIDDIQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' fields of Karomja, Paba and Mypara, Puthia, Rajshahi during 2022-2023 to develop the Mustard-Boro-T. Aman rice cropping pattern. There were two treatments, i.e., T₁: Existing Cropping Pattern: Fallow-Boro (Jirasail)-T. Aman (Swarna) and T₂: Alternate Cropping Pattern: Mustard (BARI Sarisha-17)-Boro (BINAdhan17)-T. Aman (BRRI dhan51/BRRI dhan87). In the alternate cropping pattern of

Paba and Puthia, rice equivalent yield was higher (16.18 t ha⁻¹) and (16.39 t ha⁻¹) than the existing cropping pattern (11.85 t ha⁻¹) and (12.21 t ha⁻¹) respectively. Total gross return of the improved cropping pattern also higher in Paba and Puthia were (Tk. 515910 ha⁻¹ and Tk. 527970 ha⁻¹) whereas gross margin (Tk. 286210 ha⁻¹ and Tk. 237113 ha⁻¹) respectively over existing cropping pattern and MBCR was 2.04, and 1.52

Introduction

Bangladesh is one of the most densely populated (1008 per sq km) countries. There is little scope to increase cultivable land, but there is some scope to increase current cropping intensity from 190% to 250% by improving current cropping patterns to include short-duration crops in rice-based crops. Oilseeds are important crops grown mostly in the rabi season. The recent development of short-duration rice and mustard varieties has made it possible to grow three or more crops on the same land in a year. Generally, farmers 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 the inclusion of a suitable Rabi crop like mustard. Keeping this in mind we have developed Mustard-Boro rice-T. Aman rice cropping pattern against Fallow-Boro rice-T. Aman rice.

Materials and Methods

The experiment was conducted at Karomja, Paba, Mypara, Puthia, and Rajshahi during 2022–23 in the High Ganges River Floodplain (AEZ-11) to develop a Mustard-Boro-T. Aman cropping pattern. The experiment was laid out in a randomized, complete block design. The area of the land was 1 hectare in Paba and 4.67 hectares in Puthia. There were two treatments, i.e., T₁: Existing Cropping Pattern: Fallow-Boro (Jirasail)-T. Aman (Swarna) and T₂: Alternate Cropping Pattern: Mustard (BARI Sarisha-17)-Boro (BINadhan17)-T. Aman (BRRI dhan51/BRRI dhan87). All agronomic activities, including sowing and transplanting, harvesting, spacing, fertilizer management, etc., are presented in Table 1 & 2. The recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. In the mustard field, Rovral @ 2 g L⁻¹ was applied to control the alternaria blight of mustard. In Boro and T. Aman, stem borer and sheath blight were observed in some plots. Follicur @ 0.5 ml/L was sprayed to control sheath blight and Nitro @ 2 ml/10 L for stem borer. For economic comparison between two crop sequences, the yield of all crops was converted into a rice-equivalent yield on the basis of the 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 the prevailing market price of the commodities. Relevant data were taken and computed.

Table 1. Management practices of existing and alternate cropping patterns during 2022-2023 at karomja, Paba, Rajshahi

Crop	Cultivar/varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-17	7	Broadcast	10-25 Nov.2022	01-13 Feb. 2023	115	34	42.5	27	1	1.7
Boro	BINA Dhan17	35	20 x 15	14-16 March 2023	13-15 June 2023	121	18	75	20	2.3	-
T. Aman rice	BRRI dhan51	35	20 x 15	25-28 July 2023	6-10 Nov. 2023	69	10.5	41.25	10.90	-	-
Existing CP											
Boro	Jirasail	35	20 x 15	15-20 February 2023	03-05 May 2023	131	30	75	6.75	1.6	1.3
T. Aman rice	Swarna	35	20 x 15	8-10 July 2023	10-12 Nov. 2023	178.78	45	112.5	13.57	1.6	1.3

Table 2. Management practices of existing and alternate cropping patterns during 2022-2023 at Mypara, Puthia, Rajshahi

Crop	Cultivar/varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	ate of sowing/ ransplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-17	7	Broadcast	2-10 Nov.2022	25-27 Jan. 2023	115	34	42.5	27	1	1.7
Boro	BINA Dhan17	35	20 x 15	26 Feb. - 03 Mar. 2023	03-15 June 2023	121	18	75	20	2.3	-
. Aman rice	BRRI dhan87	35	20 x 15	21-25 July 2023	22-25 Oct. 2023	69	10.5	41.25	10.90	-	-
Existing CP:											
Boro	Jirasail	35	20 x 15	21-24 February 2023	20-25 May 2023	131	30	75	6.75	1.6	1.3
. Aman rice	Swarna	35	20 x 15	10-12 July 2023	10-14 Nov 2023	178.78	45	112.5	13.57	1.6	1.3

Results and discussion

Yield, cost, and return of improved patterns and existing patterns are presented in Tables 3 and 4. In the alternate cropping pattern of Paba, the yields of mustard, Boro, and T. Aman rice were 1.57, 5.93, and 5.47 t ha⁻¹, respectively, while in the existing pattern, the yields of Boro and T. Aman rice were 6.33 and 5.1 t ha⁻¹, respectively. Alternate cropping patterns gave a higher rice equivalent yield (16.18 t ha⁻¹) than the existing cropping pattern (11.85 t ha⁻¹). Total gross return and gross margin of the improved cropping pattern were Tk. 515910 ha⁻¹ and Tk. 286210 ha⁻¹, whereas in the existing cropping pattern, those were Tk. 383750 ha⁻¹ and Tk. 224050 ha⁻¹, respectively, and MBCR was 2.04. On the other hand, in the alternate cropping pattern of Puthia, yields of mustard, Boro, and T. Aman rice were 1.78, 6.5, and 4.72 t ha⁻¹, respectively, while in the existing pattern, yields of Boro and T. Aman rice were 6.79 and 4.97 t ha⁻¹, respectively. Alternate cropping patterns gave a higher rice equivalent yield (16.39 t ha⁻¹) against the existing cropping pattern (12.21 t ha⁻¹). Total gross return and gross margin of the improved cropping pattern were Tk. 527970 ha⁻¹ and Tk. 237113 ha⁻¹, whereas in the existing cropping pattern, those were Tk. 406070 ha⁻¹ and Tk. 195170 ha⁻¹, respectively, and MBCR was 1.52.

Farmers opinion: Farmers' have shown keen interest in alternate cropping pattern due to higher yields and income.

Table 3. Yield, cost and return analysis of existing and alternate cropping pattern during 2022-2023 at karomja, Paba, Rajshahi

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallo w	T. Aman
Seed /grain yield (t ha ⁻¹)	1.57	5.93	5.47	6.33	-	5.10
Straw yield (t ha ⁻¹)	2.38	6.12	6.03	7.08	-	5.65
Gross return (Tk ha ⁻¹)	125600	208120	182190	223800	-	169950
Total variable cost (Tk ha ⁻¹)	59260	92780	77660	92700	-	77000
Gross margin (Tk ha ⁻¹)	66340	115340	104530	131100	-	92950
W. Pattern REY (t ha ⁻¹)	16.18			11.85		
W. Pattern gross return (Tk ha ⁻¹)	515910			393750		
W. Pattern TVC (Tk ha ⁻¹)	229700			169700		
W. Pattern gross margin (Tk ha ⁻¹)	286210			224050		
MBCR	2.04					

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Table 4. Yield, cost and return analysis of existing and alternate cropping pattern during 2022-2023 at Mypara, Puthia, Rajshahi

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.78	6.5	4.72	6.79	-	4.97
Straw yield (t ha ⁻¹)	3.20	6.95	5.04	7.56	-	5.67
Gross return (Tk ha ⁻¹)	142400	228850	156720	239960	-	166110
Total variable cost (Tk ha ⁻¹)	79200	117322	94335	116900	-	94000
Gross margin (Tk ha ⁻¹)	63200	111528	62385	123060	-	72110
W. Pattern REY (t ha ⁻¹)	16.39			12.21		
W. Pattern gross return (Tk ha ⁻¹)	527970			406070		
W. Pattern TVC (Tk ha ⁻¹)	290857			210900		
W. Pattern gross margin (Tk ha ⁻¹)	237113			195170		
MBCR	1.52					

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk 80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Conclusion

From the results of the experiments, it may be concluded that the alternate cropping pattern is agronomically feasible and economically profitable.

64. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD (Sarisha-14)- BORO-T. AMAN RICE AGAINST FALLOW- BORO- T. AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' field of Juranpur, Tanore and Mypara, Puthia, Rajshahi during 2022-2023 to develop Mustard- Boro- T. Aman rice cropping pattern. There were two treatments i.e., T₁: Existing Cropping pattern: Fallow- Boro (Jirasail)-T. Aman (Swarna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-14)- Boro (BINAdhan17/ BRRRI dhan81)-T. Aman (BRRRI dhan51/ BINAdhan17). In Paba, alternate cropping pattern gave higher rice equivalent yield (15.32 t ha⁻¹) against existing cropping pattern (11.70 t ha⁻¹). Total gross return and gross margin of improved cropping pattern were Tk. 496780 ha⁻¹ and Tk.267455 ha⁻¹ whereas in existing cropping pattern those were Tk. 387830 ha⁻¹ and Tk. 220010 ha⁻¹, respectively and MBCR was 1.78. On the other hand, in Puthia, Alternate cropping pattern gave higher rice equivalent yield (15.13 t ha⁻¹) against existing cropping pattern (11.87 t ha⁻¹). Total gross return and gross margin of improved cropping pattern were Tk. 489400 ha⁻¹ and Tk.198798 ha⁻¹ whereas in existing cropping pattern those were Tk. 392810 ha⁻¹ and Tk. 181490 ha⁻¹, respectively and MBCR was 1.22 due to introduction of new crops and varieties.

Introduction

Fallow-Boro rice-T. Aman rice is one of the major existing cropping patterns in Rajshahi district. Generally, farmers are cultivating 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 Rabi crop like mustard. Mustard might be a promising crop. This cropping pattern require minimum water and will increase cropping intensity as well as productivity and profitability. Therefore, the present experiment was undertaken to increase productivity and income of farmers in AEZ-26 and AEZ-11.

Materials and Methods

The experiment was conducted at Juranpur, Tanore in High Barind Tract (AEZ-26) and Mypara, Puthia, Rajshahi in High Ganges River Floodplain (AEZ-11) during 2022-23 to develop Mustard-

Boro -T. Aman cropping pattern. The experiment was laid out in a randomized complete block design. Area of the land was 1 hectare in Paba and 3.33 hectare in Puthia. There were two treatments i.e., T₁: Existing Cropping pattern: Fallow-Boro (Jirasail)-T. Aman (Swarna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-14)-Boro (BINAdhan17/BRRI dhan81) - T. Aman (BRRI dhan51/BINAdhan17). All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1 & 2. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. In mustard field Rovral@2 gm L⁻¹ was applied for controlling alternaria blight of mustard. In Boro and T. Aman, stem borer and sheath blight were observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Nitro @ 2 ml/10 L for stem borer. For economic comparison between two crop sequences, the yield of all crops was converted into rice 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 computed.

Table 1. Management practices of existing and alternate cropping patterns during 2022-2023 at Juranpur, Tanore, Rajshahi

Crop	Cultivar/varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-14	7	Broadcast	12-25 Nov.2022	29 Jan. - Feb. 2023	115	34	42.5	27	1	1.7
Boro	BINA dhan17	35	20 x 15	14-26 March 2023	18-22 June 2023	121	18	75	20	2.3	-
T. Aman rice	BRRI dhan51	35	20 x 15	26-28 July 2023	5-10 Nov. 2023	69	10.5	41.3	10.9	-	-
Existing CP:											
Boro	Jirasail	35	20 x 15	15-20 February 2023	03-05 May 2023	131	30	75	6.75	1.6	1.3
T. Aman rice	Swarna	35	20 x 15	8-10 July 2023	8-12 Nov. 2023	179	45	113	13.6	1.6	1.3

Table 2. Management practices of existing and alternate cropping patterns during 2022-2023 at Mypara, Puthia, Rajshahi

Crop	Cultivar/varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-14	7	Broadcast	01-07 Nov.2022	21-27 Jan. 2023	115	34	42.5	27	1	1.7
Boro	BRRI dhan81	35	20 x 15	20-24 Feb. 2023	10-16 June 2023	121	18	75	20	2.3	-
T. Aman rice	BINA dhan17	35	20 x 15	25 July 2023	22 Oct. 2023	69	10.5	41.25	10.90	-	-
Existing CP:											
Boro	Jirasail	35	20 x 15	21-24 February 2023	20-25 May 2023	131	30	75	6.75	1.6	1.3
T. Aman rice	Swarna	35	20 x 15	10-12 July 2023	10-14 Nov 2023	178.78	45	112.5	13.57	1.6	1.3

Results and Discussion

Yield, cost and return of improved pattern and existing pattern are presented in Table 3 & 4. In alternate cropping pattern of Paba, yield of mustard, Boro and T. Aman rice were 1.46, 6.3 and 4.71 t ha⁻¹, respectively while in existing pattern, yield of Boro and T. Aman rice were 6.43 and 4.85 t ha⁻¹, respectively. Alternate cropping pattern gave higher rice equivalent yield (15.32 t ha⁻¹) against existing cropping pattern (11.70 t ha⁻¹). Total gross return and gross margin of improved cropping pattern were Tk. 496780 ha⁻¹ and Tk. 267455 ha⁻¹ whereas in existing cropping pattern, those were Tk. 387830 ha⁻¹ and Tk. 220010 ha⁻¹, respectively and MBCR was 1.78. On the other hand, in alternate cropping pattern of Puthia, yield of mustard, Boro and T. Aman rice were 1.49, 5.85 and 4.92 t ha⁻¹, respectively while in existing pattern, yield of Boro and T. Aman rice were 6.31 and 5.14 t ha⁻¹, respectively. Alternate cropping pattern gave higher rice equivalent yield (15.13 t ha⁻¹) against existing cropping pattern (11.87 t ha⁻¹). Total gross return and gross margin of improved cropping pattern were Tk. 489400 ha⁻¹ and Tk. 198798 ha⁻¹ whereas in existing cropping pattern, those were Tk. 392810 ha⁻¹ and Tk. 181490 ha⁻¹, respectively and MBCR was 1.22.

Farmers opinion: Farmers' shown keen interest in alternate cropping pattern due to higher yield and income.

Table 3. Yield, cost and return analysis of existing and alternate cropping pattern during 2022-2023 at Juranpur, Tanore, Rajshahi

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.46	6.30	4.71	6.43	-	4.85
Straw yield (t ha ⁻¹)	3.61	7.33	5.03	7.18	-	5.01
Gross return (Tk ha ⁻¹)	116800	223590	156390	227300	-	160530
Total variable cost (Tk ha ⁻¹)	59160	92655	77510	92500	-	75710
Gross margin (Tk ha ⁻¹)	57640	130935	78880	134800	-	85210
W. Pattern REY (t ha ⁻¹)	15.32			11.70		
W. Pattern gross return (Tk ha ⁻¹)	496780			387830		
W. Pattern TVC (Tk ha ⁻¹)	229325			168210		
W. Pattern gross margin (Tk ha ⁻¹)	267455			220010		
MBCR	1.78					

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Table 4. Yield, cost and return analysis of existing and alternate cropping pattern during 2022-2023 at Mypara, Puthia, Rajshahi

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.49	5.85	4.92	6.31	-	5.14
Straw yield (t ha ⁻¹)	3.03	6.71	5.09	7.10	-	5.13
Gross return (Tk ha ⁻¹)	119200	207330	162870	223220	-	169590
Total variable cost (Tk ha ⁻¹)	79100	117202	94300	116920	-	94400
Gross margin (Tk ha ⁻¹)	40100	90128	68570	106300	-	75190
W. Pattern REY (t ha ⁻¹)	15.13			11.87		
W. Pattern gross return (Tk ha ⁻¹)	489400			392810		
W. Pattern TVC (Tk ha ⁻¹)	290602			211320		
W. Pattern gross margin (Tk ha ⁻¹)	198798			181490		
MBCR	1.22					

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Conclusion

From the results of the experiments, it may be concluded that the alternate cropping pattern is agronomically feasible and economically profitable.

65. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD (Canola)-BORO- T. AMAN RICE AGAINST FALLOW- BORO- T. AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. N. A. SIDDIQUE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' field of Chanduria, Tanore, Rajshahi during 2020-2023 to develop Mustard- Boro- T. Aman rice cropping pattern. There were two treatments i.e., T₁: Existing Cropping pattern: Fallow- Boro (BRRI dhan28)-T. Aman (Swarna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-18)- Boro (BRRI dhan81)-T. Aman (BRRI dhan87). Alternate cropping patterns gave higher rice equivalent yields (17.07, 15.32 and 16.3 t ha⁻¹), gross return (Tk. 488062, 520780 and 440646 ha⁻¹) and gross margin (Tk. 257057, 291455 210946 ha⁻¹) than those of existing cropping patterns in the 1st, 2nd and 3rd cropping, respectively. After inclusion of the alternate cropping pattern, MBCR was 2.48, 2.33 and 2.04 in the 1st, 2nd and 3rd cropping, respectively.

Introduction

Fallow-Boro rice-T. Aman rice is one of the major existing cropping patterns at Tanore Upazila of Rajshahi district. Generally, farmers of the upazila cultivate T. Aman rice followed by Boro rice and around 90 days remains fallow after T. Aman rice harvest and before transplanting of Boro rice which could be utilized by inclusion of a suitable Rabi crop like mustard. The Oilseed Research Centre (ORC) of BARI has developed a new variety BARI Sarisha-18 which crop duration is 100 days, yield 2-2.5 t ha⁻¹ and have low erusic acid. This cropping pattern require minimum water and will increase cropping intensity as well as productivity and profitability. Therefore, the experiment was undertaken to develop a new alternate cropping pattern and to increase productivity as well as income of farmers.

Materials and Methods

The experiment was conducted at Chanduria, Tanore, Rajshahi during 2020-2021 to 2021-22 in High Ganges River Floodplain (AEZ-11) to develop Mustard- Boro -T. Aman cropping pattern. The experiment was laid out in a one ha block approach including six farmers. There were two treatments i. e, T₁: Existing Cropping pattern: Fallow-Boro (BRRI dhan28)-T. Aman (Swarna) and T₂: Alternate Cropping pattern: Mustard (BARI Sarisha-18)-Boro (BRRI dhan81) - T. Aman (BRRI dhan87). All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1, Table 2 and Table 3 for the 1st, 2nd and 3rd cropping cycle respectively. Recommended fertilizer package of BARI and BRRI along with the application methods were done to support the normal growth of the crops. In mustard field Rovral@2 gm L⁻¹ was applied for controlling alternaria blight of mustard. In Boro and T. Aman, stem borer and sheath blight were observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer. For economic comparison between two crop sequences, the yield of all crops was converted into rice equivalent yield on the basis of prevailing market price of individual crops. The economic indices i.e., gross return, total variable cost, gross margin, and benefit cost ratio were also calculated on the basis of prevailing market price of the commodities. Relevant data were taken and computed.

Table 1. Management practices of existing and alternate cropping patterns during 2020-2021

Crop	Cultivar/ varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-18	7	Broadcast	05-10 Nov.2020	20 -28 Feb.2021	115	34	43	27	1	1.7
Boro	BRRI dhan81	35	20 x 15	20-28 Feb. 2021	25-30 Jul 2021	93	12	26	12	1	-

T. Aman	BRRIdhan87	35	20 x 15	25-30 July 2021	25-30 Oct. 2021	90	10	25	12	1	-
Existing CP:											
Boro	Jirasail	35	20 x 15	20-25 Jan 2021	10-12 Apr. 2021	138	15	60	14	1	-
T. Aman	Swarna	35	20 x 15	10-15 July 2021	05-10 Nov. 2021	138	15	60	14	1	-

Table 2. Management practices of existing and alternate cropping patterns during 2021-2022

Crop	Cultivar/ varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-18	7	Broadcast	5-10 Nov.2021	19 Feb. 2022	115	34	42.5	27	1	1.7
Boro	BINA dhan7	35	20 x 15	27 Feb. 2022	2 June 2022	121	18	75	20	2.3	-
T. Aman	BRRRI dhan51	35	20 x 15	14-15 July 2022	5 Nov. 2022	69	11	41	10.9	-	-
Existing CP:											
Boro	BRRRI dhan28	35	20 x 15	20-28 Feb. 2022	25-30 May 2022	131	30	75	6.75	1.6	1.3
T. Aman	Swarna	35	20 x 15	10 -15 July 2022	8-12 Nov. 2022	179	45	113	13.6	1.6	1.3

Table 3. Management practices of existing and alternate cropping patterns during 2022-2023

Crop	Cultivar/ varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-18	7	Broadcast	18 Nov.2022	2 Mar. 2023	115	34	42.5	27	1	1.7
Boro	BINA dhan17	35	20 x 15	14-16 Mar 2023	18-20 June 2023	121	18	75	20	2.3	-
T. Aman	BRRIdhan51	35	20 x 15	10 July 2023	10 Nov. 2023	69	11	41	10.9	-	-
Existing CP:											
Boro	BRRIdhan28	35	20 x 15	20-25 Feb. 2023	15-25 May 2023	131	30	75	6.75	1.6	1.3
T. Aman	Swarna	35	20 x 15	10 July 2023	10 Nov. 2023	179	45	113	13.6	1.6	1.3

Results and discussion

Yield, cost, and return of alternate cropping patterns and existing patterns are presented in Tables 4, 5 and 6, respectively. In the alternate cropping pattern, yields of Mustard, Boro, and T. Aman rice were 1.91, 5.98, and 5.7 t ha⁻¹ in the 1st cropping cycle, 1.76, 6.30, and 4.78 t ha⁻¹ in the 2nd cropping cycle, and 1.57, 5.93, and 5.26 t ha⁻¹ in the 3rd cropping cycle, respectively, while in the existing pattern, yields of Boro and T. Aman rice were 5.82 and 4.79 t ha⁻¹ in the 1st cropping cycle, 6.43 and 4.25 t ha⁻¹ in the 2nd cropping cycle, and 6.33 and 5.34 t ha⁻¹ in the 3rd cropping cycle, respectively. Alternate cropping patterns gave higher rice equivalent yields (17.1, 16.1, and 16.3 t ha⁻¹) against existing cropping patterns (11.0, 11.1, and 12.9 t ha⁻¹). Total gross return (Tk.

488062, 520780, and 440646 ha⁻¹) and gross margin (Tk. 257057, 291455, and 210946 ha⁻¹) of alternate cropping patterns were found to be higher than those of existing cropping patterns (GR: Tk. 321810, 378330, and 348000 ha⁻¹, and GM: Tk. 155155, 210120, and 178300 ha⁻¹). After inclusion of the alternate cropping pattern, MBCR was 2.48, 2.33, and 2.04 in the 1st, 2nd, and 3rd cropping cycles, respectively.

Farmers opinion: Farmers' showed keen interest in alternate cropping pattern due to higher yield and income.

Table 4. Yield, cost and return analysis of existing and alternate cropping pattern, 2020-2021

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.91	5.98	5.7	5.82	-	4.79
Straw yield (t ha ⁻¹)	2.51	6.91	6.36	6.40	-	5.45
Gross return (Tk ha ⁻¹)	134202	187240	166620	181580	-	140230
Total variable cost (Tk ha ⁻¹)	64320	96350	72835	96235	-	70420
Gross margin (Tk ha ⁻¹)	69882	93390	93785	85345	-	69810
W. Pattern REY (t ha ⁻¹)	17.07			11.04		
W. Pattern gross return (Tk ha ⁻¹)	488062			321810		
W. Pattern TVC (Tk ha ⁻¹)	233505			166655		
W. Pattern gross margin (Tk ha ⁻¹)	257057			155155		
MBCR	2.48					

Price of output: T. Aman: Tk 27 kg⁻¹, straw 2 kg⁻¹, Mustard: Tk70.00 kg⁻¹, straw: Tk 0.2 kg⁻¹, Boro rice: Tk. 29 kg⁻¹ and straw: Tk 2 kg⁻¹

Table 5. Yield, cost and return analysis of existing and alternate cropping pattern, 2021-2022

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.76	6.30	4.78	6.43	-	4.25
Straw yield (t ha ⁻¹)	3.61	7.33	5.27	7.18	-	5.01
Gross return (Tk ha ⁻¹)	140800	223590	156390	227300	-	151030
Total variable cost (Tk ha ⁻¹)	59160	92655	77510	92500	-	75710
Gross margin (Tk ha ⁻¹)	81640	130935	78880	134800	-	75320
W. Pattern REY (t ha ⁻¹)	16.1			11.1		
W. Pattern gross return (Tk ha ⁻¹)	520780			378330		
W. Pattern TVC (Tk ha ⁻¹)	229325			168210		
W. Pattern gross margin (Tk ha ⁻¹)	291455			210120		
MBCR				2.33		

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Table 6. Yield, cost and return analysis of existing and alternate cropping pattern during 2022-2023 at karomja, Paba, Rajshahi

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.57	5.93	5.26	6.33	-	5.34
Straw yield (t ha ⁻¹)	2.38	6.12	6.03	7.08	-	6.25
Gross return (Tk ha ⁻¹)	125600	208120	154080	223800	-	156680
Total variable cost (Tk ha ⁻¹)	59260	92780	77660	92700	-	77000
Gross margin (Tk ha ⁻¹)	66340	115340	76420	131100	-	79680
W. Pattern REY (t ha ⁻¹)	16.3			12.9		
W. Pattern gross return (Tk ha ⁻¹)	440646			348000		
W. Pattern TVC (Tk ha ⁻¹)	229700			169700		
W. Pattern gross margin (Tk ha ⁻¹)	210946			178300		
MBCR				2.04		

Price of output: T. Aman: Tk 30 kg⁻¹, straw 3 kg⁻¹, Mustard: Tk80.00 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Conclusion

It may be concluded that the alternate cropping pattern is agronomically feasible and economically profitable. At the same time, by adopting these cropping patterns, cropping intensity and productivity will be increased.

66. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD- MAIZE- T. AMAN RICE AGAINST FALLOW- BORO- T. AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' field of Paba, Rajshahi, during 2021–2022, and 2022–2023, to develop a Mustard-Maize-T. Aman rice cropping pattern. There were two treatments, i.e., T₁: Existing Cropping Pattern: Fallow-Boro (BRRI dhan28)-T. Aman (Sharna) and T₂: Alternate Cropping Pattern: Mustard (BARI Sarisha-18)-Maize (Laltir Hybrid 559)-T. Aman (BRRI dhan75). Alternate cropping patterns gave higher rice equivalent yields (16.43 t ha⁻¹ and 16.4 t ha⁻¹), total gross return (Tk. 443722 ha⁻¹ and Tk. 442530 ha⁻¹) and gross margin (Tk. 215417 ha⁻¹ and 204390 ha⁻¹) in the 1st and 2nd cropping cycle respectively over existing cropping patterns. After inclusion of the alternate cropping pattern, MBCR was 2.0 and 1.75 in the 1st and 2nd cropping cycle respectively.

Introduction

Fallow-Boro rice-T. Aman rice is one of the major existing cropping patterns at Paba Upazila in Rajshahi district. Generally, farmers of the upazila cultivate T. Aman rice (long-duration variety), followed by Boro rice, and around 80–90 days remains fallow after harvesting T. Aman rice and before transplanting Boro rice. BARI Sarisha-18 is a new variety with crop duration of (90-100 days), a potential yield of 2–2.5 t ha⁻¹, and low erusic acid. Beside these, the area is under level barind tract and water is a crisis for irrigating the boro rice crop. So, less water-required crops are needed to cultivate in the region. In this context, maize might be a promising crop. With this view, the experiment was undertaken to develop a new alternate cropping pattern (Mustard-Maize- T. Aman) and to increase the productivity and income of farmers in AEZ-11.

Materials and Methods

The experiment was conducted at Dharmahata, Paba, and Rajshahi during 2021–2022, 2022–2023, in the High Ganges River Floodplain (AEZ-11), to develop an alternate cropping pattern: Mustard, Maize, and T. Aman. The experiment was laid out in a block approach where 1 ha of land comprising six farmers is included in each pattern. There were two treatments, i.e., T₁: Existing Cropping Pattern (ECP): Fallow-Boro (BRRI dhan28)-T. Aman (Swarna) and T₂: Alternate Cropping Pattern (ACP): Mustard (BARI Sarisha-18)-Maize (Laltir Hybrid559/Premium)-T. Aman (BRRI dhan75). All agronomic activities, including sowing and transplanting, harvesting, spacing, fertilizer management, etc., are presented in Tables 1 and 2 for the 1st and 2nd cropping cycles, respectively. In the mustard field, Rovral at 2 gm L⁻¹ was applied for controlling alternaria blight of mustard, and Nitro at 2 ml L⁻¹ was applied for controlling flea beetle. In Boro and T. Aman, stem borer and sheath blight were observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5 g/10 L for stem borer. The yield of all crops was converted into a rice-equivalent yield on the basis of the prevailing market price of individual crops. The economic indices, i.e., gross return, total variable cost, gross margin, and marginal benefit cost ratio, were also calculated on the basis of the prevailing market price of the commodities.

Table 1. Management practices of existing and alternate cropping patterns during 2021-2022

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP											
Mustard	BARI Sarisha-18	7	Broadcast	05-10 Nov.2021	20 Feb. 2022	115	34	43	27	1	1.7
Maize	Laltir Hybrid 559	22.5	60 x 20	3-7 Mar. 2022	05-10 July 2022	152	52	74	26	-	1
T. Aman	BRRRI dhan75/87	35	20 x 15	25-30 July 2022	25-30 Oct. 2022	90	10	25	12	1	-
Existing CP:											
Boro	BRRRI dhan28	35	20 x 15	25-30 Jan. 2022	10-12 Apr. 2022	138	15	60	14	1	-
T. Aman rice	Swarna	35	20 x 15	15-20 July 2022	10-15 Nov. 2022	138	15	60	14	1	-

Table 2. Management practices of existing and alternate cropping patterns during 2022-2023

Crop	Cultivar	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ transplantation	Date of harvesting	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP											
Mustard	BARI Sarisha-18	7	Broadcast	14-21 Nov. 2022	3-5 Mar. 2023	115	34	42.5	27	1	1.7
Maize	Premier	22.5	60 x 20	2-4 April 2023	13 June 2023	122	43	60	26	3.2	-
T. Aman	BRRIdhan75	35	20 x 15	10-24 August 2023	4-16 November 2023	69	10.5	41.3	10.9	-	-
Existing CP:											
Boro	BRRIdhan28	35	20 x 15	25-30 Jan. 2023	10-12 Apr. 2023	131	30	75	6.75	1.6	1.3
T. Aman	Swarna	35	20 x 15	10-24 August 2023	4-16 November 2023	179	45	113	14	1.6	1.3

Results and Discussion

In the alternate cropping pattern, yields of Mustard, Maize, and T. Aman rice were 2.04, 6.40, and 4.8 t ha⁻¹ in the 1st cropping cycle and 1.75, 6.69 and 4.53 t ha⁻¹ in the 2nd cropping cycle, respectively, while in the existing pattern, yields of Boro and T. Aman rice were 5.81 and 4.76 t ha⁻¹ in the 1st cropping cycle and 5.75 and 4.73 t ha⁻¹ in the 2nd cropping cycle, respectively. In the 1st cropping cycle, the alternate cropping patterns gave higher rice equivalent yields (16.43 t ha⁻¹) against existing cropping patterns (11.03 t ha⁻¹). Total gross return (Tk. 443722 ha⁻¹) and gross margin (Tk. 215417 ha⁻¹) of alternate cropping patterns were found to be higher than those of existing cropping patterns (GR: Tk. 320298 ha⁻¹ and GM: Tk. 153643 ha⁻¹). After inclusion of the alternate cropping pattern, MBCR was 2.00 in the both cropping cycles as shown in Table 3. In the 2nd cropping cycle, the alternate cropping patterns gave higher rice equivalent yields (16.4 t ha⁻¹) against existing cropping patterns (11.8 t ha⁻¹). Total gross return (Tk. 442530 ha⁻¹) and gross margin (Tk. 204390 ha⁻¹) of alternate cropping patterns were found to be higher than those of existing cropping patterns (GR: Tk. 317760 ha⁻¹ and GM: Tk. 151022 ha⁻¹). After inclusion of the alternate cropping pattern, MBCR was 1.75 in the 2nd cropping cycle, respectively, as shown in Table 4.

Farmers opinion: Farmer's showed keen interest in alternate cropping pattern due to higher yields and income.

Table 3. Yield, cost and return analysis of existing and alternate cropping patterns, 2021-2022

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Maize	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	2.04	6.40	4.80	5.81	-	4.76
Straw yield (t ha ⁻¹)	3.01	7.12	5.36	6.34	-	5.30
Gross return (Tk ha ⁻¹)	143402	160000	140320	181170	-	139128
Total variable cost (Tk ha ⁻¹)	64320	91150	72835	96235	-	70420
Gross margin (Tk ha ⁻¹)	79082	68850	67485	84935	-	68708
W. Pattern REY (t ha ⁻¹)	16.43			11.03		
W. Pattern GR (Tk ha ⁻¹)	443722			320298		
W. Pattern TVC (Tk ha ⁻¹)	228305			166655		
W. Pattern GM (Tk ha ⁻¹)	215417			153643		
MBCR	2.00					

Price of output: T. Aman: Tk 27 kg⁻¹, Straw Tk. 2 kg⁻¹, Mustard: Tk. 70 kg⁻¹, Straw: Tk 0.2 kg⁻¹, Maize: Tk 25.00 kg⁻¹, Boro rice: Tk. 29 kg⁻¹ and straw: Tk 2 kg⁻¹

Table 4. Yield, cost and return analysis of existing and alternate cropping patterns, 2022-2023

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Mustard	Maize	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha ⁻¹)	1.75	6.69	4.53	5.75	-	4.73
Straw yield (t ha ⁻¹)	2.45	7.80	5.46	6.01	-	5.64
Gross return (Tk ha ⁻¹)	140490	168810	133230	178770	-	138990
Total variable cost (Tk ha ⁻¹)	65153	98650	74335	92618	-	74120
Gross margin (Tk ha ⁻¹)	75337	38475	57895	117095	-	66870
W. Pattern REY (t ha ⁻¹)	16.4			11.8		
W. Pattern GR (Tk ha ⁻¹)	442530			317760		
W. Pattern TVC (Tk ha ⁻¹)	238138			166738		
W. Pattern GM (Tk ha ⁻¹)	204392			151022		
MBCR	1.75					

Price of output: Mustard: T. Aman: Tk 27 kg⁻¹, Straw Tk. 2 kg⁻¹, Mustard: Tk. 70 kg⁻¹, Straw: Tk 0.2 kg⁻¹, Maize: Tk 25.00 kg⁻¹, Boro rice: Tk. 29 kg⁻¹ and straw: Tk 2 kg⁻¹ Tk. 80 kg⁻¹, Maize: Tk 25 kg⁻¹, Boro rice: Tk. 32 kg⁻¹ and straw: Tk 3 kg⁻¹

Conclusion

From the results of the experiments, it may be concluded that the alternate cropping pattern is agronomically feasible and economically profitable. By adopting these cropping patterns, cropping intensity and productivity will be increased.

67. COMPARATIVE YIELD PERFORMANCE OF BARI RELEASED SHORT DURATION MUSTARD VARIETY (BARI Sarisha-14) AGAINST LOCAL (Tori-7) POPULAR VARIETY IN MUSTARD-RICE CROPPING SYSTEM

M. S. RAHMAN, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

The experiment was carried out at farmers' field, of Singra and Gurudashpur, Natore during Rabi season of 2023-24 to test the yield performance of BARI released mustard variety BARI Sarisha-14 against local mustard variety Tori-7. The experiment was consisted with two treatments i.e., T₁: BARI Sarisha-14 and T₂: Tori 7 (Local). BARI released mustard variety BARI Sarisha-14 performed better over the local Tori 7. The higher seed yield was recorded from BARI Sarisha-14 in both the locations whereas the lower seed yield was obtained from Tori 7 in the same area. BARI released mustard variety of BARI Sarisha-14 showed better performance regarding yield over the local Tori 7. Farmers' can go for Boro rice cultivation after harvest of mustard varieties if they wish. Therefore, considering the farmers' preference, BARI Sarisha-14 can locally be adapted for greater extension.

Introduction

Bangladesh has a great deficit in oilseed production. The production is only one third of the requirement. Oilseed crops cover an area of about 0.75 million hectares producing about 0.36 million tons of edible oil. BARI has released some varieties of mustard. Among the mustard varieties, BARI Sarisha-14 (*B. campestris type*) is high yielding, short duration (80-85 days) and suitable for cultivation in T. Aman- Mustard-Boro Cropping pattern. Farmers' of Natore, Pabna and Sirajganj grow local popular Tori-7 mustard variety in Mustard-Boro rice or Mustard-Boro-T. Aman cropping patterns. There is a great scope to include high yielding BARI Sarisha-14 against Tori-7 to improve yield and income of farmers without affecting crops sequence of those popular cropping patterns. That is why; the experiment was conducted to compare the yield performance of BARI Sarisha-14 and Tori-7 in those patterns in same area.

Materials and Methods

The experiment was conducted at farmers field of Singra and Gurudashpur, Natore during Rabi season of 2023-24 to assess the yield performances of BARI Sarisha-14 against Tori 7. The experiment was laid out in a large field covering 3000 m² in each location. It was consisted with two treatments i.e., T₁: BARI Sarisha-14 and T₂: local Tori 7. Half of the total plot was allocated for each variety. Seeds of each variety was broadcasted in Singra and Gurudashpur at 19 November, 2023 and 28 November, 2023 respectively. The fields were fertilized with 115-34-43-27-3-3 kg N-P-K-S-Zn-B ha⁻¹ respectively. All the fertilizers except Urea with total amount were applied during final land preparation. The Urea was divided into three equal amount of installments and 2/3rd Urea was applied as basal whereas the rest 1/3rd was applied as top dress after first irrigation at 25 days after seeding. The fields were lightly infested with aphid and *Alternaria* leaf spot. Insecticide imitaf and fungicide Rovral were applied three times at 7 days' interval. The Tori-7 was harvested at 20 February, 2024 and 11 February, 2024 in Gurudashpur and Singra respectively. The variety BARI Sarisha-14 was also harvested at 28 February, 2024 and 14 February, 2024 in Gurudashpur and Singra respectively. Several samples were harvested and the relevant data were recorded carefully and analysed statistically.

Results and Discussion

In Singra, BARI Sarisha-14 produced the tallest plants (87.7 cm) and lower plant height was observed from Tori-7 (67.3 cm). Tori -7 took minimum days for maturity (85 days). On the other hand, BARI Sarisha-14 required maximum days for maturity (88 days). Maturity days was slightly higher in BARI Sarisha-14 which was not affect the next crop of the sequence. BARI Sarisha-14 produced the minimum number of siliqua (49), whereas maximum was observed in Tori (51.3). Maximum number of seeds (23) was found inside the siliqua in BARI Sarisha-14 and minimum in Tori 7 (16.3). Maximum seed yield was recorded from BARI Sarisha-14 (1.62 t ha⁻¹) and Tori-7 produced the minimum seed yield (1.47 t ha⁻¹) which was not significantly different from each other. In Gurudashpur, BARI Sarisha-14 produced the tallest plants (112.3 cm) and lower plant height was observed from Tori-7 (75 cm). Tori -7 took minimum days for maturity (85 days). On the other hand, BARI Sarisha-14 required maximum days for maturity (90 days). BARI Sarisha 14 produced the similar number of siliqua (42.3), with Tori (42.7). Maximum number of seeds (25.7) was found inside the siliqua in BARI Sarisha-14 and minimum in Tori 7 (15.5). Maximum seed yield was recorded from BARI Sarisha-14 (1.99 t ha⁻¹) and Tori-7 produced the minimum seed yield (1.40 t ha⁻¹) which were significantly different from each other.

Farmers' opinion: Farmers opined that the BARI Sarisha-14 under demonstration took slightly longer duration as well as produced higher yield over the local Tori-7. However, between the tested varieties, they preferred BARI Sarisha-14 due to its higher yield and short duration nature which will not hamper their popular cropping patterns.

Table 1: Performance of BARI released mustard (BARI Sorisha-14) against local variety (Tori-7) at farmers field of Singra, Natore during 2023-24

Varieties	Crop duration (days)	Plant population (no)	Plant height (cm)	No of branches plant ⁻¹	No of siliqua plant ⁻¹	No of seeds siliqua ⁻¹	Seed yield (t ha ⁻¹)
Tori-7	85	87.7	54.7	3.3	51.3	16.3	1.47
BARI Sorisha-14	88	67.3	104.7	5.3	49	23	1.62
T-test	-	0.02	0.00	0.07	0.85	0.04	0.17
Level of Sig.	-	*	**	ns	ns	*	ns

Table 2: Performance of BARI released mustard (BARI Sorisha-14) against local variety (Tori-7) at farmers field of Gurudashpur, Natore during 2023-24

Varieties	Crop duration (days)	Plant population (no)	Plant height (cm)	No of branches plant ⁻¹	No of siliqua plant ⁻¹	No of seeds siliqua ⁻¹	Seed yield (t ha ⁻¹)
Tori-7	85	112.3	65.4	3	42.7	15.5	1.40
BARI Sorisha-14	90	75	101.8	3.8	42.3	25.7	1.99
T-test	-	0.02	0.01	0.21	0.91	0.01	0.04
Level of Sig.	-	*	**	ns	ns	**	*

Conclusion

BARI released mustard variety of BARI Sarisha-14 showed better performance regarding yield over the local Tori-7. Therefore, considering the farmers' preference, BARI Sarisha-14 can locally be adapted for greater extension.

68. DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD - SESAME - T. AMAN RICE AGAINST MUSTARD - FALLOW - T. AMAN CROPPING PATTERN IN HOBIGANJ

M. I. NAZRUL AND F. BEGUM

Abstract

A field trial was conducted at the farmers' field of Baniachang, Hobiganj during the year of 2022-2023 to develop Mustard-Sesame-T. Aman rice cropping pattern. There were two treatments viz. EP (Existing Cropping pattern): Mustard (BARI Sarisha-18)-Fallow-T. Aman (BRRI dhan75) and AP (Alternate Cropping pattern): Mustard (BARI Sarisha-18)-Sesame (BARI Til-4)-T. Aman (Binadhan16). In alternate cropping pattern, yield of mustard, sesame and T. Aman rice were 8.13, 6.56, and 7.67 t ha⁻¹, respectively while in existing pattern, yields of mustard and T. Aman rice were 8.15 and 5.58 t ha⁻¹, respectively. Alternate cropping pattern gave higher amount of whole pattern rice equivalent yield (22.36 t ha⁻¹) against existing cropping pattern (13.73 t ha⁻¹); which was 62.85 % higher over existing pattern. Total gross return and gross margin of improved cropping pattern were Tk. 514280 ha⁻¹ and Tk. 327230 ha⁻¹ whereas in existing cropping pattern, those values were Tk. 315790 ha⁻¹ and Tk. 178190 ha⁻¹, respectively and MBCR was 1.84.

Introduction

Fallow-Fallow-T. Aman rice and Mustard-Fallow-T. Aman rice these two are important existing cropping patterns at Baniachang of Hobiganj district. Generally, farmers of those areas mainly cultivate T. Aman rice followed by mustard or land remain fallow for a long period (around 105 days) after T. Aman rice harvest which could be utilized by inclusion of a suitable kharif-I crop like sesame. It might be a suitable crop in between mustard and T. Aman rice to utilize fallow land. Besides, BARI Til-5 is a new variety which field/crop duration 90-100 days, yield 1.5-1.7 t ha⁻¹ and have white seed coat with high demand in bakery house. This cropping pattern require minimum

water, helps to use fallow lands, and will increase cropping intensity, productivity, and profitability of farmers. With this view in mind, the experiment was undertaken to increase productivity and income of farmers in AEZ-20.

Materials and Methods

The experiment was conducted at the farmers' field of Baniachang, Hobiganj during two consecutive years of 2022-2023 and 2023-2024 to develop Mustard-Sesame-T. Aman rice cropping pattern. There were two treatments viz. EP (Existing Cropping pattern): Mustard (BARI Sarisha-18)-Fallow-T. Aman (BRRI dhan75) and AP (Alternate Cropping pattern): Mustard (BARI Sarisha-18)-Sesame (BARI Til-4)-T. Aman (Binadhan16). The experiment was laid out in a randomized complete block design with six replications. All agronomic activities including sowing/transplant, harvest, 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 based on prevailing market price of individual crops. The economic indices viz. gross return, gross margin, and benefit cost ratio were also calculated based on the prevailing market price of the commodities. Relevant data were taken and computed. Rovral@2 gm L⁻¹ was applied for controlling Alternaria blight of mustard and Til. In T. Aman rice, stem borer and sheath blight were observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer.

Table 1. Management practices of existing and alternate cropping patterns during 2022-2024

Crop	Cultivar/ varieties	Seed rate (kg ha ⁻¹)	Spacing (cm ²)	Date of sowing/ Transplant	Date of harvest	Fertilizer (kg ha ⁻¹)					
						N	P	K	S	Zn	B
Alternate CP:											
Mustard	BARI Sarisha-18	7	Broadcast	15-20 Nov 22 10-15 Nov 23	15-20 Feb 23 10-15 Feb 24	90	27	40	10	2	1
Sesame	BARI Til-4	7	Broadcast	25-24 Mar 23 25-28 Mar 24	25-30 June 23 -	25	8	10	5	-	-
T. Aman	Binadhan16	35	20 x 15	05-10 Aug 22	05-10 Nov 22	90	15	50	8	1	-
Existing CP:											
Mustard	BARI Sarisha-18	7	Broadcast	15-20 Nov 22	15-20 Feb 23	115	25	50	20	2	-
Fallow	-	-	-	-	-	-	-	-	-	-	-
T. Aman	BRRI dhan75	35	20 x 15	05-10 Aug 22	05-10 Nov 22	140	15	60	14	1	-

Results and Discussion

Yield, cost and return of improved pattern and existing pattern are presented in Table 2. In alternate cropping pattern, the rice equivalent yields (REY) of mustard, sesame, and T. Aman rice were 8.13, 6.56, and 7.67 t ha⁻¹, respectively while in existing pattern, yields of mustard and T. Aman rice were 8.15 and 5.58 t ha⁻¹, respectively. Alternate cropping pattern gave higher amount of whole pattern rice equivalent yield (22.36 t ha⁻¹) against existing cropping pattern (13.73 t ha⁻¹); which was 62.85 % higher over existing pattern. Total gross return and gross margin of improved cropping pattern were Tk. 514280 ha⁻¹ and Tk. 327230 ha⁻¹ whereas in existing cropping pattern, those values were Tk. 315790 ha⁻¹ and Tk. 178190 ha⁻¹, respectively and MBCR was 1.84.

Farmers showed keen interest in alternate cropping pattern due to higher yield and income.

Table 2. Yield, cost and return analysis of existing and alternate cropping pattern, 2022-2023

Observation	Alternate cropping pattern						Existing cropping pattern					
	Mustard		Sesame		T. Aman		Mustard		Fallow		T. Aman	
Crop	22-23	23-24	22-23	23-24	22-23	23-24	22-23	23-24	22-23	23-24	22-23	23-24
Seed /grain yield (t ha ⁻¹)	2.14	2.16	1.53	-	6.51	-	2.15	2.12	-	-	4.61	-
Straw yield (t ha ⁻¹)	2.51	2.51	2.81	-	6.68	-	2.40	2.43	-	-	5.55	-

T. aman rice EY (t ha ⁻¹)	7.91+0.22= 8.13	6.32+0.24 =6.56	6.51+1.16 =7.67	7.94+0.21= 8.15	-	4.61+0.97 =5.58
Gross return (Tk. ha ⁻¹)	186990	150880	176410	187450	-	128340
Total variable cost (Tk. ha ⁻¹)	55600	51450	80000	55600	-	82000
Gross margin (Tk. ha ⁻¹)	131390	99430	168410	131850	-	46340
W. Pattern REY (t ha ⁻¹)	22.36 (62.85)			13.73		
W. Pattern GR (Tk. ha ⁻¹)	514280			315790		
W. Pattern TVC (Tk. ha ⁻¹)	187050			137600		
W. Pattern GM (Tk. ha ⁻¹)	327230			178190		
MBCR	1.84					

Price of output (Tk.kg⁻¹): T. Aman: 23., rice straw: 4, Mustard: 85, mustard: straw 2, Til seed: Mustard: 95, Til stick/straw: 2

69. IMPROVEMENT FROM FALLOW-T. AUS-T. AMAN RICE TO MUSTARD-T. AUS-T. AMAN RICE UNDER AEZ 20 OF SYLHET REGION

M. I. NAZRUL

Abstract

An experiment was executed at multilocation testing (MLT) sites, Moulvibazar during two consecutive years of 2021-2022 and 2022-2023 to see the performance of improved cropping pattern and to increase the productivity and income of the farmers. The experimental design was RCB with six (6) dispersed replications. The existing cropping pattern (EP): Fallow-T. Aus-T. Aman rice and improved cropping pattern (IP): Mustard-T. Aus-T. Aman rice, respectively tested under this experimentation. BARI Sarisha-14, BRRI dhan98 of T. Aus rice and BRRI dhan75 of T. Aman rice were used in this trial. The improved pattern (IP) provided 15.72 t ha⁻¹ of T. Aman rice equivalent yield which was almost 66 % higher than that of existing pattern EP. Similarly, the higher total gross margin (Tk. 164560 ha⁻¹) with marginal benefit cost ratio (2.28) was obtained over the existing pattern.

Introduction

In the Sylhet region, Fallow-T. Aus-T. Aman rice etc. are the important cropping patterns widely followed by farmers. About 40-60 % land remains fallow for a long time (December-May) after the harvest of T. Aman rice due to moisture stress up to Kharif-I season and farmers of this region are waited for cultivation of sesame/jute/T. Aus rice following the existing cropping pattern (Fallow-T. Aus- T. Aman rice) under rainfed condition. Shaheb and Nazrul (2012) reported that mustard varieties can be grown well in fallow land of Sylhet where var. BARI Sarisha-14 and BARI Sarisha-17 could be more suitable and produced higher seed yield. But little effort has been made for on-farm evaluation of the improved technologies of Mustard-T. Aus-T. Aman rice cropping pattern in Sylhet area. The present study was therefore, initiated to determine productivity and economic feasibility of an improved package of technologies over the farmer's existing practices.

Materials and Methods

An experiment was executed at multiplication testing (MLT) site, Moulvibazar, during two consecutive years of 2021-22 and 2022-2023 to see the performance of improved cropping pattern and to increase the productivity and income of the farmers. The experimental design was RCB with six (6) dispersed replications. The existing cropping pattern (EP): Fallow-T. Aus-T. Aman rice and improved cropping pattern (IP): Mustard-T. Aus-T. Aman rice, respectively tested under this experimentation. BARI Sarisha-14, BRRI dhan98 of T. Aus rice and BRRI dhan75 of T. Aman rice were used in this trial. The area covered by 1200 m² in each replication. The details crop management practices for mustard, T. Aus and T. Aman rice under both patterns during the years of 2021-2022 and 2022-2023 were presented in Table 1. Seed grain⁻¹ yield of mustard, T. Aus and T. Aman rice was measured plot wise and converted into T. Aman rice equivalent yield. All data were then analyzed following MS excel package. T. Aman rice equivalent yield was calculated based on the prevailing market price of individual crop.

Total Rice equivalent yield = $Y_{sr} + (Y_{im} \times P_m)/P_r$ (i)

Where, Y_{sr} = Yield of sole T. Aman rice ($t\ ha^{-1}$);

Y_{im} = Yield of component crop mustard ($t\ ha^{-1}$)

P_r = Selling price of rice; P_m = Selling price of mustard

Results and Discussions

Yield of rice and mustard: In rice, the average yield of T. Aus and T. Aman was varied from 4.51-5.35 $t\ ha^{-1}$. In mustard, the variety BARI Sarisha-14 produced 1.37 and 1.29 $t\ ha^{-1}$ of average seed yield in IP, whereas lands remain fallow in EP at that period. The variety of T. Aus and T. Aman rice gave higher grain yields under the existing cropping pattern, which might be due to use of improved rice variety. The higher average yield of T. Aus (4.51 $t\ ha^{-1}$) and T. Aman (5.35 $t\ ha^{-1}$) rice was provided by IP in 2021-2022.

T. Aman rice equivalent yield: The total productivity of the cropping sequence was ascertained by the rice equivalent yield (REY) which was calculated from the yields of component crops. REY was varied under cropping sequences. In an average result revealed that the higher REY (15.72 $t\ ha^{-1}$) was recorded from IP as compared to EP (9.49 $t\ ha^{-1}$). Inclusion of mustard as new crop and modern variety of T. Aman rice in IP increased REY 65.64 % as compared to EP.

Table 1. Management practices followed in improved and existing cropping pattern at MLT site, Moulvibazar, 2021-2023

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan98	BRRI dhan75	-	BRRI dhan48	Binadhan16
Date of sowing/transplanting	29-11-21	23-04-22	02-08-22	-	16-04-22	01-08-22
Seed rate ($kg\ ha^{-1}$)	7.5	26	26	-	26	26
Spacing (cm)	-	20 x 15	20 x 15	-	20 x 15	20 x 15
Fertilizer dose (N-P-K-S-Zn-B, $kg\ ha^{-1}$)	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0	-	134-53-83-60-0-0	165-60-105-86-0-0
Date of harvesting	08-02-22	27-07-22	03-11-22	-	25-07-22	18-11-22
Field duration (days)	85	90	105	-	90	110
Turnaround time (days)	75	05	05	135	10	10

Table 2. Yield and economic analysis of improved and existing cropping pattern at MLT site, Moulvibazar, 2021-2022 and 2022-23

Observation	Improved cropping pattern						Existing cropping pattern					
Crop	Mustard		T. Aus		T. Aman		Fallow		T. Aus		T. Aman	
Year	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23
Variety	BARI Sarisha-14		BRRI dhan98		BRRI dhan75		-		BRRI dhan48		Binadhan16	
Seed/grain yield (tha ⁻¹)	1.37	1.29	4.51	5.17	5.35	5.25	-	-	4.46	4.90	4.89	4.41
Straw yield (tha ⁻¹)	1.42	1.32	5.40	5.32	6.15	5.37	-	-	5.50	5.0	5.16	4.50
REY	5.18	4.88	4.59	5.18	5.88	5.72	-	-	4.55	4.90	4.72	4.80
Total REY	15.65+15.78= Avr. 15.72						9.27+9.70= Avr. 9.49					
Gross return (Tk. ha ⁻¹)	115690		112470		133400		-		108790		109480	
Total variable cost (Tk. ha ⁻¹)	49000		68000		80000		-		68000		78000	
Gross margin (Tk. ha ⁻¹)	66690		55970		53400		-		40790		31480	
Total Gross return (Tk. ha ⁻¹)	361560						218270					
Total variable cost (Tk. ha ⁻¹)	197000						146000					
Total Gross margin (Tk. ha ⁻¹)	164560						72270					
MBCR	2.28											

Unit price (Tk. kg^{-1}) Mustard: 85.00, Mustard straw: 2.00, Rice Straw: 2.00, T. Aus: 21.00, T. Aman: 23.00

Conclusion

From the findings it can be concluded that improved pattern is profitable in respect of REY, gross margin, and marginal benefit cost ratio.

70. INCREASE CROPPING INTENSITY AND PRODUCTIVITY BY ADOPTION OF SHORT DURATION MUSTARD VARIETIES IN RICE BASED CROPPING SYSTEM

N SULTANA, M. M. RAHMANAND A.K.M.Z.U. NOOR

Abstract

The experiment was conducted at FSRD, Tarakandi, Sherpur of On-Farm Research Division, BAR1, Sherpur during 2023-2024 to study the comparative agronomic performance of existing cropping pattern Fallow- Boro-T. Aman rice and improved cropping pattern Mustard- Boro-T. Aman rice by introducing a short duration mustard (BARI Sarisha-14) after T. Aman rice harvest. The higher rice equivalent yield (16.64 t ha^{-1}) was obtained from improved cropping pattern which was 52.66% higher over farmers existing pattern. At the same time improved cropping pattern Mustard- Boro-T. Aman rice gave higher gross return (Tk. 4,55,972/- ha^{-1}) and gross margin (Tk. 1, 86,832/- ha^{-1}) which was (65.65%) higher over farmers pattern. Farmers practice gave the lower gross return (Tk. 3.03.000/- ha^{-1}) and gross margin (Tk. 1,12,785/- ha^{-1}).

Introduction

Farmers at Sherpur followed different types of cropping pattern. Fallow-Boro-T. Aman rice is one of the important cropping Patterns. Oilseed Research Centre, BARI has developed a number of short duration high yielding mustard varieties. It needs to popularize among the farmers by fitting mustard in the existing cropping pattern Fallow-Boro-T. Aman rice. The alternate cropping pattern was Mustard -Boro-T. Aman rice. On-farm trial will help to popularize and evaluate the new cropping pattern among the farmers. With this view in mind, the trial was undertaken.

Materials and Methods

The experiment was conducted at Vatshala, under On-Farm Research Division, Bangladesh Agricultural Research Institute, Sherpur during the year of 2023-24 to study the comparative agronomic performance of existing cropping pattern Fallow-Boro-T. Aman rice and improved cropping pattern Mustard- Boro-T. Aman rice by introducing a new crop mustard (BARI Sarisha-14) after T. Aman rice harvest. The experiment was laid out in a randomized complete block design with two dispersed replications. The unit plot size was 1.5 ha. Two cropping pattern viz. alternate cropping pattern (Mustard-Boro-T. Aman rice) and farmers' cropping pattern (Fallow-Boro-T. Aman rice) were the treatment of the experiment. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. All field operations and management practices were closely monitored and data were recorded and presented in Table 1. The collected data were averaged and presented in tabular form. Agronomic performance like field duration, and rice equivalent yield of cropping patterns were calculated. For comparison between crop sequences the yield of every crop was converted into rice equivalent on the basis of prevailing market price of individual crop (Ahlawat and Sharma, 1993). The economic analysis was done for gross return, gross margin and marginal benefit cost ratio and it was done on the basis of prevailing market price of the commodities. The Marginal Benefit Cost Ratio (MBCR) was computed as CIMMYT, 1988.

Results and Discussion

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 Fallow- Boro-T. Aman rice has needed 200 days field

duration. Total field duration of three crops pattern Mustard- Boro-T. Aman rice has needed 283 days (excluding seedling age of rice) to complete the cycle (Table1). Result indicated that mustard could be easily fitted in Rice-Rice cropping pattern. Average grain yield of BARI Sarisha-14 in the alternate cropping pattern was 1.67 t ha⁻¹. The grain yield of Sachcha (hybrid) and Dhani gold was 6.85 and 5.28 t ha⁻¹, respectively from the alternate cropping pattern. The grain yield of BRRI dhan28 and Dhani Gold (hybrid) was 5.70 and 5.2 t ha⁻¹ in existing pattern. Improved cropping pattern produced higher rice equivalent yield (16.64 t ha⁻¹yr⁻¹) over farmers' existing cropping pattern (10.90 t ha⁻¹yr⁻¹) Inclusion of mustard in existing cropping pattern increased REY 52.66 % compared to farmers' practice (Table 1).

Gross return of improved cropping pattern was Tk. 4,55,972 ha⁻¹ which was more than 50.48% higher over farmers' pattern. Farmers' pattern gave the lower gross return Tk. 3,03,000 ha⁻¹. Total variable cost was higher in improved pattern (Tk. 2,69,140 ha⁻¹). The gross margin was substantially higher in the alternate pattern Tk. 1,86,832 ha⁻¹ than farmers' pattern (Tk. 1,12,785 ha⁻¹) (Table 2).

Farmers opinion: Farmers were highly satisfied to see the higher returns of alternate cropping pattern Mustard-Boro-T. Aman rice against existing pattern Fallow-Boro-T. Aman rice due to higher yield as well as gross return of the improved pattern. They also opined that this pattern would be expanded in this area.

Table 1. Agronomic parameters of alternate cropping pattern and existing cropping pattern at Tarakandi, Sherpur during 2023-24

Parameter	Alternate cropping pattern			Existing cropping pattern		
	Boro	T. Aman	Mustard	Fallow	Boro	T. Aman
Variety	Sachchal (Hybrid)	Dhani gold (Hybrid)	BARI sarisha-14	-	BRRI dhan28	Dhani gold (Hybrid)
Sowing/transplanting	07-09 Feb., 2023	25-28 July, 2023	8-9Nov., 2023	-	20-30 Jan., 2023	25-30 July, 2023
Seed rate (kg ha ⁻¹)	40	40	6	-	40	40
Planting method	Line	Line	Broadcast	-	Line	Line
Spacing (Row x hill)	20cm x 15cm	20cm x15cm	-	-	20cm x 15cm	20cm x 15cm
Seedling age (days)	35	30	-	-	35	30
Seedling hill ⁻¹	2	2	-	-	-	2
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5	103-32-40-24-1.6-1.7	-	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	-	Basal & top dress	Basal & top dress
Weeding (no.)	Once at 25 DAS	Once at 30 DAS	Once at 20 DAS	-	Once at 25 DAS	Once at 30 DAS
Irrigation (no.)	30	10	-	-	30	10
Insect and disease control	Chemical	Chemical	Chemical	-	Chemical	Chemical
Harvesting time	09-11 May, 2023	30Oct.-2 Nov.,2023	30Jan.-2Feb.2024	-	10-15 May, 2023	31 Oct.-3 Nov.,2023
Grain yield (t ha ⁻¹)	6.85	5.28	1.67	-	5.70	5.20
By product yield (t ha ⁻¹)	7.15	5.61	1.97	-	6.0	5.4
Field duration (days)	102	98	83	-	105	95
REY (t ha ⁻¹ yr ⁻¹)	16.64			10.90		
Gross return (Tk. ha ⁻¹)	1,78,436	1,56,696	1,20,840	-	1,48,800	1,54,200
TVC (Tk. ha ⁻¹)	97,995	92,220	78,925	-	97,995	92,220
Gross Margin (Tk. ha ⁻¹)	80,441	64,476	41,915	-	50,805	61,980
Gross return (Tk. ha ⁻¹)	4,55,972			3,03,000		
TVC (Tk. ha ⁻¹)	2,69,140			1,90,215		
Gross Margin(Tk. ha ⁻¹)	1,86,832			1,12,785		
BCR	1.69			1.59		

Unit price (Tk/Kg): Boro rice=24.00, T. Aman rice=27.50, Mustard=70.00, Rice straw Boro=2.00, Rice straw Aman=2.00, Mustard straw=2.0

Conclusion

From the above result it should be concluded that improved cropping pattern was more productive and remunerative compared to existing pattern so, it could be suggested for large scale production in medium high land of Sherpur.

71. INCREASE CROPPING INTENSITY AND PRODUCTIVITY BY ADOPTION OF SHORT DURATION MUSTARD VARIETIES IN RICE BASED CROPPING SYSTEM

N SULTANA, M. M. RAHMANAND A.K.M.Z.U. NOOR

Abstract

The experiment was conducted at Multilocation Testing site (MLT), Baoushi, Sarishabari, Jamalpur under On-Farm Research Division, BARI, Sherpur during 2023-24 to study the comparative agronomic performance of existing cropping pattern Fallow- Boro-T. Aman rice and improved cropping pattern Mustard- Boro-T. Aman rice by introducing a short duration mustard (BARI Sarisha-14) after T. Aman rice harvest. The higher rice equivalent yield (17.00 t ha^{-1}) was obtained from improved cropping pattern which was 57.4 % higher over farmers existing pattern. At the same time improved cropping pattern Mustard- Boro-T. Aman rice gave higher gross return (Tk. 4,59,425/- ha^{-1}) and gross margin (Tk. 1,55,975/- ha^{-1}). Farmers practice gave the lower gross return (Tk. 2,95,800/- ha^{-1}) and gross margin (Tk 71,300/- ha^{-1}).

Introduction

Farmers at Jamalpur region followed different types of cropping pattern. Fallow-Boro-T. Aman rice is one of the important cropping Patterns. Oilseed Research Centre, BARI has developed a number of short duration high yielding mustard varieties. It needs to popularize among the farmers by fitting mustard in the existing cropping pattern Fallow-Boro-T. Aman rice. The alternate cropping pattern was Mustard -Boro-T. Aman rice. On-farm trial will help to popularize and evaluate the new cropping pattern among the farmers. With this view in mind, the trial was undertaken.

Materials and Methods

The experiment was conducted at Multilocation Testing site (MLT), Boushi, Sarishabari, Jamalpur under On-Farm Research Division, Bangladesh Agricultural Research Institute, Sherpur during the year of 2023-24. The experiment was laid out in a non-replicated design with two dispersed replications. The unit plot size was 1.5 ha. Two cropping pattern viz. alternate cropping pattern (Mustard-Boro-T. Aman rice) and farmers' cropping pattern (Fallow-Boro-T. Aman rice) were the treatment of the experiment. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. All field operations and management practices were closely monitored and data were recorded and presented in Table 1. The collected data were averaged and presented in tabular form. Agronomic performance like field duration, and rice equivalent yield of cropping patterns were calculated. For comparison between crop sequences the yield of every crop was converted into rice equivalent on the basis of prevailing market price of individual crop (Ahlawat and Sharma, 1993). Rice Equivalent Yield (REY) was calculated with the following formula and Production Efficiency ($\text{kg ha}^{-1} \text{ day}^{-1}$) was also calculated. The economic analysis was done for gross return, gross margin and marginal benefit cost ratio and it was done on the basis of prevailing market price of the commodities. The Marginal Benefit Cost Ratio (MBCR) was computed as CIMMYT, 1988.

Results and Discussion

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 Fallow- Boro-T. Aman rice has needed 201 days field duration where three crops pattern Mustard- Boro-T. Aman rice has needed 291 days (excluding seedling age of rice) to complete the cycle (Table1). Average grain yield of BARI Sarisha-14 in the alternate cropping pattern was 1.53 t ha⁻¹. The grain yield of BRRI dhan89 and BRRI dhan49 was 6.36 and 5.56 t ha⁻¹ from the alternate cropping pattern. The grain yield of BRRI dhan28 and Dhanigold (Hybrid) was 5.70 and 5.1 t ha⁻¹ in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (17.00 t ha⁻¹yr⁻¹) over farmers' existing cropping pattern (10.8 t ha⁻¹yr⁻¹). Inclusion of mustard in existing cropping pattern increased REY 57.4 % compared to farmers' practice (Table 1).

Cost and return: Gross return of improved cropping pattern was Tk. 4, 59,425/-ha⁻¹ which was more than 67 % higher over farmers' pattern. Farmers' pattern gave the lower gross return Tk. 2, 95,800/-ha⁻¹. Total variable cost was higher in improved pattern (Tk. 3.03.450/- ha⁻¹). The gross margin was substantially higher in the alternate pattern Tk. 1.55.975ha⁻¹ than farmers' pattern (Tk. 71,300/-ha⁻¹). (Table 1).

Farmers opinion: Farmers were highly satisfied to see the higher returns of alternate cropping pattern Mustard-Boro-T. Aman rice against existing pattern Fallow-Boro-T. Aman rice due to higher yield as well as gross return of the improved pattern. They also opined that this pattern would be expanded in this area.

Table 1. Agronomic parameters of alternate cropping pattern and existing cropping pattern at Boushi, Jamalpur, 2023-24

Parameter	Alternate cropping pattern			Existing cropping pattern		
	Boro	T. Aman	Mustard	Fallow	Boro	T. Aman
Variety	BRRI dhan89	BRRI dhan49	BARI sarisha-14	-	BRRI dhan28	Dhanigold (Hybrid)
Sowing/transplanting	24 Jan., 2023	22July, 2023	8 Nov., 2023	-	20 Jan., 2023	20 July, 2023
Seed rate (kg ha ⁻¹)	40	40	6	-	40	40
Planting method	Line	Line	Broadcast	-	Line	Line
Spacing (Row x hill)	20 cm x 15 cm	20cm x 15cm	-	-	20cm x 15cm	20cm x 15cm
Seedling age (days)	35	30	-	-	35	30
Seedling hill ⁻¹	2	2	-	-	-	2
Fertilizer dose (kg N-P-K-S-Zn-B ha ⁻¹)	139-21-75-20-2.5-2.5	79-17-50-18-3.5-0	103-32-40-24-1.6-1.7	-	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	-	Basal & top dress	Basal & top dress
Weeding (DAS)	25	30	22	-	25	30
Irrigation (no.)	40	3	-	-	40	3
Insect and disease control	Chemical	Chemical	Chemical	-	Chemical	Chemical
Harvesting time	10 May, 2023	5 Nov.,2022	26 Jan., 2024	-	8 May, 2023	4 Nov. 2023
Grain yield (t ha ⁻¹)	6.36	5.56	1.53	-	5.70	5.10
By product yield (t ha ⁻¹)	7.5	7.4	2.45	-	6.50	6.4
Field duration (days)	106	106	79	-	107	107
REY (t ha ⁻¹ yr ⁻¹)	17.00			10.80		
Gross return (Tk. ha ⁻¹)	1,74,025	1,53,800	1,31,600	-	1,55,500	1,40,300
TVC (Tk ha ⁻¹)	1,21,000	1,03,500	78,925	-	1,21,000	1,03,500
Gross Margin(Tk. ha ⁻¹)	53,025	50,300	52,675	-	34,500	36,800
Gross return (Tk. ha ⁻¹)	4,59,425			2,95,800		
TVC (Tk. ha ⁻¹)	3,03,450			2,24,500		
Gross Margin(Tk. ha ⁻¹)	1,55,975			71,300		
BCR	1.51			1.31		

Unit price (Tk/Kg): Boro rice=25, T. Aman rice=25., Mustard=70, Rice straw Boro=2.0, Rice straw Aman=2.00, Mustard=2.00.

Conclusion

From the above result it should be concluded that improved cropping pattern was more productive and remunerative compared to existing pattern so, it could be suggested for large scale production in medium high land of Jamalpur.

72. DEVELOPMENT OF ALTERNATE CROPPING PATTERN SOYBEAN-D. AUS/T. AUS-T. AMAN CROPPING PATTERN IN COASTAL SALINE AREA OF NOAKHALI

M SHAHIDUL ISLAM and MIA M BASHIR

Abstract

The experiment was conducted at the farmers' field during 2021-22 to 2023-24 at Subarnachar and Sadar upazilla of Noakhali district under AEZ-18 to evaluate the feasibility and financial viability of improved cropping pattern (Soybean-T. Aus-T. Aman) against existing cropping pattern (Soybean-Fallow-T. Aman). Average result of the two years revealed that the improved cropping pattern produced higher rice equivalent yield 12.92 t ha^{-1} compared to existing cropping pattern 8.70 t ha^{-1} . Land use efficiency and production efficiency in the improved cropping pattern were higher 83.29% and $33.88 \text{ kg ha}^{-1} \text{ day}^{-1}$, respectively over existing cropping pattern 57.81% and $29.29 \text{ kg ha}^{-1} \text{ day}^{-1}$ respectively. Gross margin (GM) in the improved cropping pattern was Tk. 205070 ha^{-1} whereas it was Tk. 144655 ha^{-1} in existing cropping pattern. The marginal benefit cost ratio (MBCR) was 2.34 over existing cropping pattern.

Introduction

Among the coastal agro-ecological zones (AEZ), 'Young Meghna Estuarine Floodplain' (AEZ-18) in the Noakhali and Laxmipur district is one of the potential ones, where the current cropping intensity is very low compared with other regions of the country. The Soybean-Fallow-T. Aman rice is one of the existing and important cropping patterns in this area. In this system, the land remains fallow for more than 112 days after the harvest of soybean. An extra T. Aus rice could be incorporated in this existing cropping pattern. Therefore, the present study was conducted to evaluate the feasibility and financial viability of the three-crop based improved cropping pattern 'Soybean-T. Aus-T. Aman' against the existing pattern 'Soybean-Fallow-T. Aman' for introduction and promotion in the coastal areas of Bangladesh.

Materials and methods

The experiment was conducted at farmers' field of Subarnachar and Sadar upazilla of Noakhali district during 2021-22 to 2023-24 under Agro Ecological Zone-18. There were two treatments: improved cropping pattern (Soybean-T. Aus-T. Aman and farmers' existing cropping pattern (Soybean-Fallow-T. Aman). The experiment was laid out in a randomized complete block design with three dispersed replications in medium highland. Unit plot size was 0.5 ha. Soil reaction was mildly alkaline (pH 8.03). Variety used for different crops, sowing/planting dates, harvesting dates, main field duration, fertilizers, turn-around times, cost and return analysis were presented in Table 1. Fertilizer application for improved pattern was done based on soil test value following Fertilizer Recommendation Guide 2018 along with the application methods to support the standard growth of the crops. For T. Aus seedling growing and transplanting irrigation was done twice in each. Pre sowing BARMAC Clear up Bio 360 herbicide 3 lit ha^{-1} was applied for weed controlling in soybean and one hand weeding was also done at 20-25 days after sowing (DAS). One time hand weeding at 20-25 DAS was done for both T. Aus and T. Aman rice. No disease or pest infestation was occurred in soybean and T. Aus rice. In T. Aman rice stem borer and blast disease were observed. Furadan 5G @ 10 kg ha^{-1} was applied to control rice stem borer. Heconazol @ 2 ml lit^{-1} of water was sprayed twice in an interval of 10 days to control rice blast.

Results and Discussion

In improved cropping pattern soybean seed yield was 1.87 t ha⁻¹. Grain and straw yield of T. Aus rice were 4.11 and 3.80 t ha⁻¹, respectively, whereas grain and straw yield of T. Aman rice were 4.32 and 4.75 t ha⁻¹, respectively. It was revealed that soybean yield was 3.89% higher in improved cropping pattern compared to farmers' existing pattern due to improved management. Improved cropping pattern produced higher rice equivalent yield (12.92 t ha⁻¹yr⁻¹) over farmers' existing cropping pattern (8.70 t ha⁻¹yr⁻¹). Rice equivalent yield calculation showed 48.48% yield increased in improved pattern over existing pattern and land use efficiency increased 44.08% in the improved cropping pattern. Higher production efficiency (33.88 kg ha⁻¹day⁻¹) was obtained from improved cropping pattern compared to farmers' practice (29.29 kg ha⁻¹day⁻¹). Gross return of improved pattern was Tk. 335450 ha⁻¹ which was 45.85% higher over farmers' existing pattern (Table 1). Farmers' existing pattern produced lower gross return (TK. 230000 ha⁻¹). The gross margin was also higher (41.77%) in the improved pattern (Tk. 205070 ha⁻¹) than farmers' pattern (Tk. 144655 ha⁻¹). The higher gross margin of the improved pattern was achieved mainly due to incorporation of T. Aus rice. The marginal benefit cost ratio (MBCR) was found 2.34 which indicated the superiority of the improved pattern over the farmers' pattern.

Farmers' opinion: Both seedling raising and transplanting of T. Aus rice requires irrigation, if rainfall starts late. In this period irrigation water is very scarce in the area. If irrigation source is available or monsoon starts earlier it is possible to bring a considerable area under Soybean-T. Aus-T. Aman rice cropping pattern.

Table 1. Crop management, yield, cost and return of improved cropping pattern and existing cropping pattern at Sadar, Noakhali (average of two crop cycles)

Items	Improved cropping pattern			Existing cropping pattern		
Crop	Soybean	T. Aus	T. Aman	Soybean	Fallow	T. Aman
Variety	BARI Soybean-5	BRRI dhan48	BRRI dhan52	BARI Soybean-5		BRRI dhan52
Seed rate (kg ha ⁻¹)	125	40	40	140		50
Spacing (cm)	30 × conti.	25 × 15	25 × 15	Broadcast		25 × 15
Sowing method	Line	T.planting	T. planting	Broadcast		T. planting
Plot size	0.5 ha	0.5 ha	0.5 ha	0.5 ha		0.5 ha
Seedling age (days)	-	20-25	20-25	-		40-45
Fertilizer dose as N-P-K-S-Zn-B kg ha ⁻¹	26-37-40- 16-2.5-1	93-13-40- 0-2	87-16-50- 0-2	26-37-40- 16-2.5-1		87-16-50- 0-2
Sowing/Transplanting date	10-12 Jan	20-25 May	28-30 Aug	10-12 Jan		15-20 Aug
Top dressing (DAS/DAT)	25, 45	15, 45	15, 45	25, 45		15, 50
Weeding (no.)	1 (herbicide) + 1 HW	2 HW	1 HW	1 (herbicide) + 1		1 HW
Irrigation (no.)	-	2	-	-		-
Harvesting date	25-28 Apr	22-25 Aug	15-20 Dec	25-28 Aprl		05-10 Dec
Main field duration	98	94	112	96		115
Turn-around time	24	7	33	111		43
Grain/Seed yield (t ha ⁻¹)	1.87	4.11	4.32	1.80		4.38
Straw yield (t ha ⁻¹)	-	-	4.75	-		4.90
Rice equivalent yield (t ha ⁻¹ yr ⁻¹)	12.92			8.70		
Land use efficiency (%)	83.29			57.81		
Production efficiency (kg ha ⁻¹ day ⁻¹)	33.88			29.29		
Whole pattern GR (Tk. ha ⁻¹)	335450			230000		
Whole pattern TVC (Tk. ha ⁻¹)	130380			85345		
Whole pattern GM (Tk. ha ⁻¹)	205070			144655		
MBCR over existing pattern	2.34					

Price of soybean = Tk. 60 kg⁻¹, BRRI dhan48 = Tk. 25 kg⁻¹, BRRI dhan52 = Tk. 25 kg⁻¹ Straw price of T. Aman rice = Tk. 12500 ha⁻¹, HW = hand weeding

Conclusion

Improved cropping pattern, Soybean-T. Aus-T. Aman could be profitability and economically viable for Noakhali and Laxmipur region if irrigation water is available during T. Aus seedling growing and transplanting.

73. DEVELOPMENT OF ALTERNATE CROPPING PATTERN SUNFLOWER-JUTE-T. AMAN AGAINST FARMERS EXISTING FALLOW-JUTE-T. AMAN PATTERN IN GOPALGANJ

M M HOWLADER AND D HALDER

Abstract

The experiment was conducted at the MLT site, Tungipara, Gopalganj Sader and Moksedpur under Gopalganj district and Najirpur, Pirojpur during 2022-23 and 2023-24 to improve the productivity and profitability of existing cropping pattern Fallow-Jute-T. Aman by new cropping pattern. It was found that improved cropping pattern Sunflower-Jute-T. Aman gave highest rice equivalent yield (REY) 21.25t ha⁻¹ where farmers practice gave 17.04t ha⁻¹. In case of economic return, improved cropping Sunflower-Jute-T. Aman gave highest gross return Tk. 595000 ha⁻¹ and gross margin Tk. 210400 ha⁻¹. The MBCR of 1.44 in improved pattern meaning superiority of improved pattern over existing pattern.

Introduction

In order to mitigate the food demand it is necessary to intensify the crop production through introducing new crop in cropping pattern. The main challenge of the new millennium is to increase per unit yield at least 50% through manipulating the limited land resource. Gopalganj mainly a low laying area and water receding period is here very late that's why farmers cannot sow mustard and vegetables in early *rabi* season and their main cropping pattern is Fallow-Jute-T. Aman. There is a good opportunity to introduce sunflower which can supplement grain demand of this district. BARI Surjumukhi-3 is a dwarf and short duration composite variety. So, it easily introduce in existing cropping pattern. Considering the above facts an alternate cropping pattern sunflower-Jute-T. Aman was designed and conducted against farmers existing Fallow-Jute-T. Aman cropping pattern.

Materials and Methods

An experiment was conducted at Tungipara, Sader and Muksudpur under Gopalganj district and Nazirpur under Pirojpur district during 2022-23 and 2023-24. Alternate cropping pattern Sunflower-Jute-T. Aman was tested against farmers' existing pattern Fallow-Jute-T. Aman. The experiment was carried at 4 locations having an area of 33 decimal each location. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1. Relevant data were taken and analyzed statistically. 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). Rice Equivalent Yield (REY) was calculated by a formula used by Ahlawat and Sharma, 1993.

Results and Discussion

Yield performance: Yield and total rice equivalent yield of existing and alternate cropping pattern was shown in Table 2. The average yield of different three crops in alternate cropping pattern sunflower, Jute and T. Aman were 1.90, 3.91 and 4.98 t ha⁻¹, respectively while the yield of jute and T. Aman in existing cropping pattern was 3.70 and 5.3t ha⁻¹, respectively. At the same time, in case of alternate cropping pattern stalk yield of jute and straw yield of rice were 7.30 and 5.48t ha⁻¹ while in existing pattern the stalk yield of jute and straw yield of rice was 7.40 and 5.85

t ha⁻¹. Finally, the rice equivalent yield was found highest in alternate cropping pattern and it was 21.25t ha⁻¹, may be due to the introduction of new crop while the rice equivalent yield 17.04 was recorded from existing cropping pattern.

Cost and return: Economic analysis shows that alternate cropping pattern gave highest gross return (Tk. 595000) and gross margin (Tk. 210400) whereas existing pattern gave gross return and gross margin Tk. 477120 and Tk. 184220, respectively. The marginal benefit cost ratio (MBCR) was found 1.44 which indicates alternate pattern is profitable than farmers practice (Table 2).

Farmers' opinion: Farmers and their neighbors were happy to obtain higher total rice equivalent yield and income from alternate cropping pattern over existing cropping pattern.

Table 1. Agronomic management practices and rice equivalent yield of the crops for the existing and alternate cropping pattern at Gopalganj during 2022-23 and 2023-24.

Parameters	Existing cropping pattern			Alternate cropping pattern		
Crop	Fallow	Jute	T. Aman	Sunflower	Jute	T. Aman
Variety	-	JRO-524	BRRi dhan87	BARI Surjumukhi-3	JRO-524	BRRi dhan87
Spacing	-	Broadcast	20 cm x 15cm	50cm x25cm	Broadcast	20cm x 15cm
Unit plot size (deci.)	-	33	33	33	33	33
Seedling age (days)	-	-	30	-	-	30
Date of sowing/ transplanting	-	25-28 March 23	04-05 August 23	10-13 Dec. 2022	01-03 April 2023	04-05 August 2023
Fertilizer dose (kg ha ⁻¹ N-P-K-S-Zn-B)	-	90-15-75-24-4-0	77-12-42-10-3-0	94-35-85-30-3.5-2.0	90-15-75-24-4-0	77-12-42-10-3-0
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-1	Weeding-2	Weeding-2 Irrigation-2	Weeding-2 Irrigation-1	Weeding-2
Date of harvesting	-	28-31 July 2023	17-19 Nov. 2023	22-23 March 2023	26-28 July 2023	17-19 Nov. 2023
Field duration (day)	-	113	105	101	116	105
Turn-around time (day)	-	T. Aman to jute 131-132	Jute to T. Aman 7	T. Aman to sunflower 23-24	Sunflower to Jute 09-10	Jute to T. Aman 09

Table 2. Yield and cost benefit analysis of existing and alternate cropping patterns pattern (Sunflower - Jute- T. Aman) in Gopalganj during 2022-23 and 2013-24.

Parameters		Existing cropping pattern			Alternate cropping pattern		
Crop		Fallow	Jute	T. Aman	Wheat	Jute	T. Aman
✓	Grain /Fibre Yield (t ha ⁻¹)		3.70	5.30	1.90	3.91	4.98
	Straw/ Stalk Yield (t ha ⁻¹)		7.40	5.85	-	7.30	5.48
	Rice Equivalent Yield –REY (t ha ⁻¹)		10.80	6.23	4.07	11.33	5.85
	Total REY(t ha ⁻¹)		17.04		21.25		
	Total gross return		477120		595000		
	Total variable cost		292900		374600		
Total gross margin			184220		220400		
MBCR			1.44				

Price (Tk. kg⁻¹): T. Aman =28.00, Sunflower =60.00, Jute= 65.00, Rice straw =4.00, Jute stalk =4.00

Conclusion

The research findings indicated that Sunflower-Jute-T. Aman cropping pattern is applicable in some areas of Gopalganj regions and it can be easily fitted against the existing pattern with higher benefit. It is the 1st year result, for further conformation the experiment need to be repeated in the next year.

74. DEVELOPMENT OF FOXTAIL MILLET-JUTE-T. AMAN CROPPING PATTERN AGAINST FALLOW-JUTE-T. AMAN CROPPING PATTERN

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Abstract

The experiment was conducted at the farmers' field of multi-location testing (MLT) site, Challisha, Netrokona under On-Farm Research Division (OFRD), Mymensingh during 2020-21, 2021-22 and 2022-23 to develop an economically viable cropping pattern by inclusion of Foxtail millet (kaon) in fallow period in fallow-Jute-T. Aman cropping pattern. The inclusion of kaon in fallow period and replaced with high yielding varieties of rice and jute the three years average higher rice equivalent yield (19.27 t ha^{-1}) was obtained from improved cropping pattern which was 77.44% higher than farmer existing pattern. The gross return and gross margin were increased by 41.87% in Kaon-Jute- T. Aman sequences compared to existing farmers practices. The marginal benefit cost ratio, land utilization index and production efficiency indicated the superiority of the improved pattern over the farmers' existing pattern.

Introduction

In Bangladesh, decreasing agricultural land makes it impossible to meet the issue of providing food security by horizontal expansion; an increase in crop production might be achieved through vertical expansion by increasing cropping intensity and minimizing production losses. Around 2419 ha lands of some pocket area Netrokona district are existed Fallow-Jute-T. Aman cropping pattern. The area is comparatively possessing scarcity of irrigation water to cultivate boro rice. The benefit of inclusion of extra crop in the fallow land will largely depend on the selection of suitable crop varieties and adoption of sustainable agronomic practices. Foxtail millet can be cultivated easily with low input and irrigation in this area. Because, it has drought tolerant ability. So, foxtail millet might be a promising crop for cultivation in fallow land of considered location. In this context, the present experiment was undertaken.

Materials and Methods

The experiment was conducted at the farmers' field of multi-location testing (MLT) site, Challisha, Netrokona under On-Farm Research Division (OFRD), Mymensingh during 2020-21, 2021-22 and 2022-23 to develop an economically viable cropping pattern by inclusion of Kaon in fallow period of fallow-Jute-T. Aman cropping pattern. BARI developed BARI kaon-2 and BARI Kaon-3, BJRI developed HC-95 and BRRI developed short duration high yielding BRRI dahn75 were used in improved pattern. The experiment was laid out in a randomized complete block design with two dispersed replications. The unit plot size was 30 decimal. The agronomic practices and intercultural operations for crop production under improved and farmers' existing pattern are presented in Table 1. All field operations and management practices of both improved and farmers' patterns were closely monitored and data were recorded for agro-economic performances. Agronomic performances like field duration, rice equivalent yield, production efficiency and land utilization index were calculated. For comparison between crop sequences, the yields of all crops were converted into rice equivalent on the basis of prevailing market prices of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by prevailing market price of that crop divided by market price of rice.

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. The three years average field duration of farmers existing pattern Fallow-Jute-T. Aman was 244 days. On the other hand, the three years average field duration of the improved cropping pattern was 335 days (excluding seedling age). Results indicated that kaon could be easily fitted in Fallow-Jute-T. Aman cropping

pattern of Netrokona region. In case of improved pattern, the three years average grain and byproduct yield BARI Kaon-2 & BARI Kaon-3 was 2.24 t ha⁻¹ and 4.94 t ha⁻¹ respectively. The three years average fibre and Jute stick yield of HC-95 was 3.10 t ha⁻¹ and 3.59 t ha⁻¹, respectively. The three years average grain and straw yield of BRRI dhan75 was 4.13 t ha⁻¹ and 6.23 t ha⁻¹, respectively.

In case of existing pattern, the three years average fibre and Jute stick yield of CVL-1 were 2.10 t ha⁻¹ and 2.40 t ha⁻¹ and grain and straw yield of BRRI dhan32 was 3.67 t ha⁻¹ and 4.27 t ha⁻¹, respectively. From the study it was revealed that the improved cropping pattern under Kaon-Jute-T. Aman gave higher grain and by-product yield (Table 1). Crops in improved pattern produced higher grain yield than farmers' practice due to utilization of fallow land and change of variety with improved production technologies. The lower yield crops in farmers' practice influenced by fallow period, low yielding varieties and lack of proper management. Similar results in higher productivity were also obtained by Nazrulet *et al.* (2013), Khan *et al.* (2006) and Khan *et al.* (2005).

Rice equivalent yield: The three years mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield (19.27 t ha⁻¹yr⁻¹) over farmers' (10.86 t ha⁻¹yr⁻¹) pattern (Table 2). Inclusion of high yielding kaon, jute and rice varieties and modern production technology in the improved pattern influenced increased the rice equivalent yield and total productivity increased by 77.44% compared to farmers' practice. Lower rice equivalent yield was obtained in the farmers' pattern due to variety and traditional management practices.

Production efficiency: The three years mean production efficiency (28.27) in terms of kg ha⁻¹ day⁻¹ was obtained from improved cropping pattern (Table 2). The higher production efficiency of improved cropping pattern might be due to the modern varieties and proper management practices. The lower production efficiency (23.68) kg ha⁻¹ day⁻¹ was found in farmers' pattern due to traditional management practices. Similar trend were noted by Nazrulet *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005) and Krishna and Reddy (1997).

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 three years mean LUI indicated that improved pattern used the land for 91.78% period of a year, whereas farmers' pattern used the land for 66.76% period of a year (Table 2). The higher land utilization index in improved pattern because this pattern occupied the field for 335 days, whereas farmers' pattern occupied the field for 244 days of the year.

Cost and return analysis: The benefit cost ratio of improved pattern and farmers' existing pattern are presented in Table 3. From the economic point of view, the three average gross return of improved cropping pattern (Tk. 581890.00 ha⁻¹) showed its superiority by 41.87% over farmers' existing pattern (Tk. 338250.00 ha⁻¹). The three average production cost of the improved pattern (Tk. 136240.00 ha⁻¹) was higher than farmers' pattern (Tk. 79500.00 ha⁻¹) due to inclusion of Kaon which takes extra labour for production and as well as taking money for buying kaon seed, fertilizer and pesticides etc. The three years mean marginal benefit cost ratio (MBCR) was found 4.29 which indicated the superiority of the improved cropping pattern over the farmers' pattern. The marginal benefit cost ratio (MBCR) also showed that inclusion of kaon in the existing pattern might be profitable and acceptable to the farmers of Netrokona.

Farmers' opinion: All the farmers under the present study expressed their satisfaction to see the higher returns of improved cropping pattern. They are interested in cultivating kaon in the future during the fallow period.

Table 1. Agronomic parameters of improved cropping pattern and farmers' existing pattern at Challisha under sadar upazila of Netrokona district during the 2020-21, 2021-22 and 2022-23

Parameter	Year	Improved Pattern (IP)			Farmers' Pattern (FP)		
		Kaon	Jute	T. Aman	Fallow	Jute	T. Aman
Variety	2020-21	BARI Kaon-2,3	HC-95	BRRI dhan75	-	CVL-1	BRRI dhan32
Sowing/ transplanting	2020-21	14.12.2020	10.04.2021	19.8.2021	-	03.4.2021	17.8.2021
	2021-22	09.12.2021	12.04.2022	01.8.2022	-	05.4.2022	16.8.2022
	2022-23	28.12.2022	24.04.2022	11.8.2023	-	10.4.2023	13.8.2023
Seedling age (days)	2020-21	-	-	41	-	-	45
	2021-22	-	-	29	-	-	43
	2022-23	-	-	32	-	-	43
Seed rate (kg ha ⁻¹)	2020 to 2023	8	10	40	-	8	50
Planting method	2020 to 2023	Broadcast	Broadcast	line		Broadcast	line
Spacing (Row×hill)	2020 to 2023	Continuous	Continuous	20cm × 15cm		Continuous	20cm × 15cm
Seedling hill ⁻¹	2020 to 2023	-	-	2-3	-	-	3-4
Fertilizer dose (NPKS kg ha ⁻¹)	2020 to 2023	60-20-40-9	111-10-42-13	101-50-35-13		111-10-42-13	101-50-35-13
Fertilizer application method	2020 to 2023	Basal and top dress.	Basal and top dress.	Basal and top dress.		Basal and top dress.	Basal and top dress.
Weeding (no)	2020 to 2023	Once at 16-20 DAT	None	Twice at 16 and 30 DAT		2-4 times	Once at 20-30 DAT
Irrigation (no)	2020 to 2023	Once at 30-40 DAT	None	N/A		-	N/A
Insect/ Rodent control	2020 to 2023	None	None	IPM		None	Chemical
Harvesting time	2020-21	04.4.2021	16.8.2021	28.11.2021		08.8.2021	20.12.2021
	2021-22	09.4.2022	30.7.2022	19.11.2022		05.8.2022	06.12.2022
	2022-23	20.4.2023	09.8.2023	25.11.2023		08.10.2023	15.12.2023
Seed/Grain yield (t ha ⁻¹)	2020-21	2.50	3.21	4.23		2.1	3.75
	2021-22	2.06	3.00	4.00		1.9	3.80
	2022-23	2.16	3.10	4.15		2.3	3.45
	Average	2.24	3.10	4.13		2.10	3.67
By product yield (t ha ⁻¹)	2020-21	5.46	3.78	6.40		2.40	4.20
	2021-22	4.63	3.30	6.00		2.10	4.80
	2022-23	4.73	3.70	6.30		2.70	3.80
	Average	4.94	3.59	6.23		2.40	4.27
TAT (days)	2020-21	16	05	03		104	09
	2021-22	23	03	01		120	11
	2022-23	33	04	02		115	05
Field duration (days)	2020-21	111	129	101		127	125
	2021-22	120	110	108		122	112
	2022-23	113	107	106		120	125

Table 2. Productivity of improved and existing cropping patterns at Kestopur, Challisha under sadarupazila of Netrokona district during 2020-21, 2021-22 and 2022-2023

Productivity	Improved Pattern (Kaon-Jute-T. Aman)				Farmers' Pattern (Fallow-Jute-T. Aman)			
	2020-2021	2021-2022	2022-2023	Mean	2020-2021	2021-2022	2022-2023	Mean
REY (tha ⁻¹ yr ⁻¹)	19.55	19.84	18.42	19.27	10.61	11.35	10.62	10.86
PE (kg ha ⁻¹ day ⁻¹)	29.15	26.80	28.87	28.27	23.23	24.36	23.47	23.68
LUI (%)	93.42	92.60	89.32	91.78	69.04	64.11	67.12	66.76

REY=Rice equivalent yield, PE=production efficiency, LUI= land utilization index and F= fallow

Table 3. Cost and return analysis of improved and farmers' existing cropping pattern in Netrokona during 2020-21, 2021-22 and 2022-2023

Parameters	Gross return (Tk. ha ⁻¹)				Total variable cost (Tk. ha ⁻¹)				MBCR			
	2020-21	2021-22	2022-23	Mean	2020-21	2021-22	2022-23	Mean	2020-21	2021-22	2022-23	Mean
Improved pattern	548860	579100	617710	581890	131440	135600	141680	136240	4.51	4.25	4.11	4.29
Farmers' pattern	297000	340500	377250	338250	75680	79520	83300	79500				

Price of input and output (2020-2021): Urea: 16 Tk. kg⁻¹, TSP: 22.00 Tk. kg⁻¹, MoP: 15.00 Tk. kg⁻¹, Gypsum: 10.00 Tk. kg⁻¹, Kaon seed: 75 Tk/kg, Jute seed: 600, rice seed: 50/-Tk. kg⁻¹ Selling price (Tk. kg⁻¹): Kaon: **50/-**, T. Aman: **28/-**, Kaon straw: 2/-, Rice straw: **5/-** and Jute Fibre: **70/-**, Jute stick: **10/-**, Price of input and output (2021-2022): 16 Tk. kg⁻¹, TSP: 22.00 Tk. kg⁻¹, MoP: 15.00 Tk. kg⁻¹, Gypsum: 10.00 Tk. kg⁻¹,

Kaon seed: 80 Tk/kg, Jute seed: 600, rice seed: 55Tk. kg⁻¹,

Selling price (Tk. kg⁻¹): Kaon: **50/-**, T. Aman: **30/-**, Kaon straw: 2/-, Rice straw: **5/-** and Jute Fibre: **90/-**, Jute stick: **15/-**

Price of input and output (2022-2023): Urea: 27 Tk. kg⁻¹, TSP: 27.00 Tk. kg⁻¹, MoP: 20.00 Tk. kg⁻¹, Gypsum: 12.00 Tk. kg⁻¹, Kaon seed: 80 Tk/kg, Jute seed: 600, rice seed: 70Tk. kg⁻¹, Selling price (Tk. kg⁻¹): Kaon: **50/-**, T. Aman: **35/-**, Kaon straw: 2/-, Rice straw: **7/-** and Jute Fibre: **80/-**, Jute stick: **17/-**

Conclusion

From the above discussion it should be concluded that Kaon-Jute-T. Aman cropping pattern is more productive than existing pattern and also applicable in a vast areas of Netrakona.

75. INCREASE CROPPING INTENSITY AND PRODUCTIVITY BY ADOPTION OF SHORT DURATION MUSTARD VARIETY IN RICE BASED CROPPING SYSTEM IN NETROKONA AND MYMENSINGH DISTRICT

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Abstract

The experiment was conducted at Multi-location testing (MLT) site at Netrakona and Trishal, Mymensingh under On-Farm Research Division (OFRD), Mymensingh during 2023-24 to study the comparative performances of existing cropping pattern (T. Aman-Fallow-Boro) and improved cropping pattern (T. Aman-Mustard-Boro). The improved cropping pattern resulted in significantly higher rice equivalent yields (17.24 t ha⁻¹ yr⁻¹ in Netrakona and 15.37 t ha⁻¹ yr⁻¹ in Mymensingh) compared to the traditional farmers' pattern (10.73 t ha⁻¹ yr⁻¹ in Netrakona and 10.14 t ha⁻¹ yr⁻¹ in Mymensingh). Economically, the gross return of the improved cropping pattern was substantially higher, with a 60.13% increase in Netrokona and 27.12% increase in Mymensingh compared to the farmers' pattern. The gross margin and mean marginal benefit-cost ratio (MBCR) also favored the improved pattern, with MBCR values of 3.56 in Netrokona and 1.49 in Mymensingh.

Introduction

Oilseeds crops are mostly grown in rabi (winter) season in Bangladesh. Rapeseed-mustard yield can be increased by 20-25% only replacing traditional variety by high yielding short duration ones, like BARI Sarisha-14 in existing rice-based cropping system (OFRD, 2014). Farmers of Mymensingh and Netrakona district followed different types cropping patterns. T. Aman-Fallow-Boro rice is one of the major cropping patterns which covered 65.85% of total pattern in Mymensingh whereas 62.79% in Netrakona district. So there has an ample scope to increase cropping intensity by inclusion mustard after T. Aman harvest. With this point of view, the experiment was undertaken to increase productivity and income of farmers of these areas.

Materials and Methods

The experiment was conducted at the farmers' field of multi-location testing (MLT) site, Challisha, Netrokona and Trishal, Mymensingh under On-Farm Research Division (OFRD), Mymensingh

during 2023-24 to study the comparative performances of existing cropping pattern (T. Aman-Fallow-Boro) and improved cropping pattern (T. Aman-Mustard-Boro) by introducing short duration high yielding mustard variety BARI Sarisha-14 after short duration high yielding T. Aman varieties *i.e.* BRRI dhan71, BRRI dhan75 & Binadhan17. In Boro season, improved pattern has used high yielding modern varieties *i.e.* BRRI dhan88, BRRI dhan89 and BRRI dhan92. Two cropping pattern viz. improved cropping pattern (T. Aman-Mustard-Boro) and farmers existing cropping pattern (T. Aman-Fallow-Boro) were included of the experiment.

Results and Discussion

The results showed that mustard could be easily integrated into the rice-rice cropping pattern by using short-duration Aman rice varieties. The mean rice equivalent yield demonstrated that the improved cropping pattern produced a higher rice equivalent yield (17.24 t ha⁻¹ yr⁻¹ in Netrokona and 15.37 t ha⁻¹ yr⁻¹ in Mymensingh) compared to the farmers' pattern (10.73 t ha⁻¹ yr⁻¹ in Netrokona and 10.14 t ha⁻¹ yr⁻¹ in Mymensingh) (Table 2 & 3). The lower yield in the farmers' pattern was attributed to the variety and traditional management practices used. Economically, the gross return of the improved cropping pattern (Tk. 566,315.00 ha⁻¹) was 60.13% higher than the farmers' existing pattern (Tk. 353,650.00 ha⁻¹) in Netrokona. In Mymensingh, the gross return of the improved pattern (Tk. 477,610.00 ha⁻¹) was 27.12% higher than the farmers' existing pattern (Tk. 375,700.00 ha⁻¹). The gross margin was significantly higher in the improved pattern for both locations. The mean marginal benefit-cost ratio (MBCR) was 3.56 in Netrokona and 1.49 in Mymensingh, indicating the superiority of the improved cropping pattern over the farmers' pattern. The MBCR also suggested that incorporating Mustard into the existing pattern could be profitable and acceptable to farmers.

Farmers' opinion: Farmers expressed their satisfaction with the higher returns of improved cropping pattern. They are interested in cultivating mustard in the future during the fallow period of Aman and Boro rice.

Table 1. Agronomic management practices of improved and farmers' existing cropping patterns at Netrakona and at Bagan, Bir Rampur, Trishal upazila of Mymensingh, 2023-2024

Parameter	Improved Pattern (IP)			Farmers' Pattern (FP)		
	T. Aman	Mustard	Boro	T. Aman	F	Boro
Varieties	BRRI dhan71 BRRI dhan75 Binadhan17	BARI Sarisha-14	BRRI dhan88 BRRI dhan89 BRRI dhan92	BRRI dhan49 BRRI dhan32	-	BRRI dhan29
Sowing	12-15 July, 2023	21-28 Nov. 2023	02 Jan., 2024	05-10 July, 2023	-	25-30 Dec, 2023
Transplanting	9-18 Aug. 2023	-	12 Feb. 2024	20-25 Aug. 2023	-	07-12 Feb. 2023
Seedling age (day)	25-30 days	-	41	44-50	-	47
Spacing (Row×hill)	20cm × 15cm	Continuous	20cm × 15cm	20cm × 15cm	-	20cm × 15cm
Fertilizer dose (kg NPKSZnB ha ⁻¹)	85-18-60-15-4	120-34-45-28-2- 2	140-20-75-20- 4	90-12-40	-	150-15-50-15
Harvesting time	13-20 Nov., 2023	07-15 Feb. 2024	15 May, 2023	01-05 Dec., 2023	-	01-05 June, 2024
TAT (days)	85	8	7	79	-	69
Field duration (days)	90	81	94	103	-	114

Table 2. Yield and economic analysis of improved and existing cropping patterns at Challisha under Sadar upazila of Netrokona district during 2023-2024

Items	Existing cropping pattern (EP)			Improved cropping pattern (IP)		
	T. Aman	Fallow	Boro	T. Aman	Mustard	Boro
Crop						
Variety	BRRI dhan32	-	BRRI dhan29	BRRI dhan75 /Binadhan17	BARI Sarisha-14	BRRI dhan89/ BRRI dhan92
Grain Yield (t ha ⁻¹)	4.0	-	5.9	4.49	1.76	8.2

Items	Existing cropping pattern (EP)			Improved cropping pattern (IP)		
Crop	T. Aman	Fallow	Boro	T. Aman	Mustard	Boro
Straw yield (t ha ⁻¹)	5.4	-	6.5	5.83	-	6.3
Rice Equivalent Yield (t ha ⁻¹)	4.41	-	6.32	4.87	3.81	8.56
Whole pattern REY (t ha ⁻¹)	10.73			17.24		
Gross return (Tk ha ⁻¹)	132300		221350	146520	114400	305395
TVC (Tk ha ⁻¹)	74694		100056	70926	64155	99405
Gross margin (Tk ha ⁻¹)	57606		121294	75594	50245	205990
Whole pattern GR (Tk. ha ⁻¹)	353650			566315		
Whole pattern TVC (Tk ha ⁻¹)	174750			234486		
Whole pattern GM (Tk. ha ⁻¹)	178900			331829		
Whole pattern MBCR	3.56					

REY=Rice equivalent yield and F= fallow

Price of input and output: Urea: 22.00 Tk. kg⁻¹, TSP: 22.00 Tk. kg⁻¹, MOP: 15.00 Tk. kg⁻¹, Gypsum: 12.00 Tk. kg⁻¹, Zinc sulphate: 150.00 Tk. kg⁻¹, Boric acid: 240.00 Tk. kg⁻¹, mustard seed: 85, rice seed: 40

Selling price (Tk. kg⁻¹): Mustard: 65, Boro: 35, T. Aman: 30, Rice straw: 5

Table 3. Yield and economic analysis of improved and existing cropping patterns at Bagan and Bir Rampur under Trishal upazila of Mymensingh during 2023-2024

Items	Existing cropping pattern (EP)			Improved cropping pattern (IP)		
Crop	T. Aman	Fallow	Boro	T. Aman	Mustard	Boro
Variety	BRRI dhan49	-	BRRI dhan29	BRRI dhan71	BARI Sarisha-14	BRRI dhan88
Grain Yield (t ha ⁻¹)	3.20	-	5.20	3.58	1.50	5.25
Straw yield (t ha ⁻¹)	3.60	-	5.70	3.80	3.38	5.50
Whole pattern REY (t ha ⁻¹)	10.14			15.37		
Gross return (Tk ha ⁻¹)	103200	-	272500	97100	111760	268750
TVC (Tk ha ⁻¹)	75690	-	102700	77340	68200	101400
Gross margin (Tk ha ⁻¹)	27510	-	169800	19760	43560	167350
WP GR (Tk. ha ⁻¹)	375700			477610		
Whole pattern TVC (Tk ha ⁻¹)	178390			246940		
WP GM (Tk. ha ⁻¹)	197310			230670		
Whole pattern MBCR	1.49					

REY=Rice equivalent yield and F= fallow

Price of input and output: Urea: 22.00 Tk. kg⁻¹, TSP: 22.00 Tk. kg⁻¹, MOP: 15.00 Tk. kg⁻¹, Gypsum: 12.00 Tk. kg⁻¹, Zinc sulphate: 150.00 Tk. kg⁻¹, Boric acid: 240.00 Tk. kg⁻¹, mustard seed: 85, rice seed: 40

Selling price (Tk. kg⁻¹): Mustard: 70/-, Boro: 25/-, T. Aman: 30/-, Rice straw: 5/- and mustard straw: 2/-

Conclusion

From the above discussion it should be concluded that the T. Aman-Mustard-Boro cropping pattern is more productive than existing pattern and applicable in vast areas of Netrakona and Mymensingh district.

76. IMPROVEMENT OF MUSTARD-BORO-T. AMAN CROPPING PATTERN IN KUSHTIA

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Abstract

An experiment was conducted at Kushtia sadar upazila during 2023-2024 to improved cropping pattern Mustard-Boro-T. Aman with improved varieties. The cropping pattern Fallow-Boro (BRRI Dhan28)-T. Aman (Binadhan7) were replaced by Mustard (BARI Sarisha-14)-Boro (Rod meni)-T. Aman (BRRI Dhan87). Gross return and gross margin (Tk. 489150 ha⁻¹ and Tk. 265375 ha⁻¹) were higher in proposed where existing cropping pattern were Tk. 354500 ha⁻¹ and Tk. 183750 ha⁻¹, respectively. The marginal benefit and cost ratio 1.45 was much higher over farmer's practice.

Introduction

Fallow-Boro-T. Aman is one of the major existing cropping patterns in Kushtia. Generally, farmers of the region cultivate T. Aman rice followed by Boro where there is a long period around 90 days remained fallow which could be utilized by inclusion of any short duration crop. In this context, mustard might be a promising crop cultivation in between T. Aman and Boro rice. On the country, increasing cropping intensity as well as proper utilization of land, a three crop-based pattern would be highly encouraged. Hence, therefore the trial will be initiated for higher yield and economic return.

Materials and Methods

The experiment was conducted at the farmer's field in Kushtia under AEZ-11 during the year 2023-24. The experiment was laid out in RCB design with 6 dispersed replications. Here the varieties Fallow-Boro (BRRI Dhan28)-T. Aman (Binadhan7) were replaced by Mustard (BARI Sarisha-14)-Boro (Rod mini)-T. Aman (BRRI dhan87). All the materials and methods followed during implection of this experiment were stated in table-1. Intercultural operation was done as when necessary. After maturity different data were collected accordingly and subjected to statistical analysis.

Results and Discussion

Yield, cost and return of alternative cropping pattern with recent varieties Mustard-Boro-T. Aman were shown in Table 2. Gross return and gross margin of improvement cropping pattern were Tk. 489150 ha⁻¹ and Tk. 265375 ha⁻¹ where as in existing cropping these were Tk. 354500 ha⁻¹ and Tk. 183750 ha⁻¹, respectively. The MBCR was 1.45. Rice equivalent yield was higher in improved cropping pattern (14.13 t ha⁻¹) whereas existing pattern was (9.90 t ha⁻¹).

Farmer's opinion: Farmers who involve in this experiment were satisfied with new improved crop varieties. Gross returns of improved varieties were more than that of existing varieties. Farmers are interested to grow these new crop varieties including short duration mustard variety instead of older as it gives higher return.

Table 1. Crop management of Improved and existing cropping pattern at Kushtia during 2023-24

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Mustard	Boro	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-14	Rod mini	BRRI dhan87	-	BRRI dhan28	Binadhan-7
Spacing (cm)	Broadcast	25 x 20	20 x 20	-	25 x 20	20 x 20
Fertilizer dose (NPKSZn&B kg ha ⁻¹)	115-34-45-29-2-2	115-30-37.5-27-5-0.44	76-23-30-10-1-0	-	115-30-37.5-27-5-0.44	76-23-30-10-1-0
Date of planting/sowing	11 Nov, 2023	10 Feb, 2024	05 Aug, 23	-	05 Feb, 2024	05 Aug, 23
Weeding (no.)	1	2	2	-	2	2
Date of harvesting	05 Feb, 2024	15 May, 24	05 Nov, 23	-	15 May, 2024	15 Nov, 2023

Table 2. Performance of Improved and existing cropping pattern at Kushtia during 2023-24

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Mustard	Boro	T. Aman	Fallow	Boro	T. Aman
Variety	BARI Sarisha-14	Rod meni	BRRI dhan87	-	BRRI dhan28	Binadhan7
Grain/seed (t ha ⁻¹)	1.45	4.95	5.80	-	4.75	5.15
Straw yield (t ha ⁻¹)	2.20	5.05	7.10	-	5.25	6.25
Rice equivalent yield (t ha ⁻¹)	14.13			9.90		
Gross return (Tk ha ⁻¹)	489150			354500		
Total variable cost (Tk ha ⁻¹)	223775			170750		
Gross margin (Tk ha ⁻¹)	265375			183750		
MBCR	1.45					

Price (Tk/kg): Mustard @ 70 Tk/kg, Straw @ 2.00 Tk/kg, Boro rice @ 30 Tk/kg, T. Aman @ 30 Tk/kg, Straw @ 5.00 Tk/kg

Conclusion

Based on findings, it may be concluded that improved cropping pattern in which modern crop varieties were used is profitable to the farmers. It may contribute to 10-20% higher yield the existing pattern.

77. INTERCROPPING OF GARLIC WITH SUGARCANE

S. ROY, M. A. RAHAMAN, T. TASMIMA, G. PAUL AND K. ROY

Abstract

An experiment was conducted at the FSRD site, Atia, Delduar, Tangail during 2022-23 to find out the suitable crop for intercropping with sugarcane under farmers' field conditions for increasing cropping intensity and increasing productivity and economic returns. Four treatments viz., T_1 = sole sugarcane (100%), T_2 = Sugarcane (100%) + three rows of garlic (20%), T_3 = Sugarcane (100%) + four rows of garlic (26%), T_4 = Farmers' practice (Sugarcane 100% + two rows of garlic 13%). The results revealed that three rows of garlic in between two rows of sugarcane resulted in the highest sugarcane equivalent yield (181.59 t ha^{-1}) as well as gross margin (Tk. 1061870 ha^{-1}) and the lowest sugarcane equivalent yield (115.33 t ha^{-1}) as well as gross margin (Tk. 591790 ha^{-1}) was recorded in sole sugarcane.

Introduction

Intercropping one or more crops with sugarcane is an appropriate approach to get additional farm income besides the main crop of sugarcane. During the early stages of sugarcane growth, some short-duration crops can be grown as intercrop in the vacant spaces between two cane rows. Farmers of the Tangail district especially in Delduar upazila cultivate huge amounts of chewing-type sugarcane. Most of the farmers do not cultivate short-duration crops as intercropped with sugarcane and few of the farmers practice vegetables as intercropped with sugarcane. Because of this consideration, the experiment was undertaken to find a suitable crop for intercropping with sugarcane under farmers' field conditions for increasing cropping intensity and increasing productivity and economic returns.

Materials and methods

The experiment was conducted at the FSRD site, Atai, Delduar, Tangail under AEZ-8 during 2022-23. The experiment was laid out following in RCB design with four replications. The unit plot size was 40 m^2 . There were four treatments viz., T_1 = Sole sugarcane (100%), T_2 = Sugarcane (100%) + three rows of garlic (20%), T_3 = Sugarcane (100%) + four rows of garlic (26%), T_4 = Farmers' practice (Sugarcane 100%+ two rows of garlic 13%). Spacing for sugarcane and garlic was $150 \text{ cm} \times 50 \text{ cm}$ and $10 \text{ cm} \times 10 \text{ cm}$, respectively. The fertilizer dose for sugarcane was 55-36-60-15-1-1 kg ha^{-1} NPKSZnB, respectively. The fertilizer dose for intercrop was 11-7-12-3 kg ha^{-1} . The total amount of PKSZnB was applied in the pit of sugarcane as a basal dose. The urea was applied in three instalments at 40-45, 55-60, and 70-75 days after the sugarcane transplanting in the pit. For intercropping all fertilizers except Urea are applied during final land preparation. Urea was applied 30 days after planting of garlic. The variety of sugarcane and garlic was Bomby and BARI Rashun-3, respectively. Seedling of sugarcane and clove of garlic was transplanted on 12 October and 16 November 2022, respectively. The sugarcane was harvested on 15 September to 25 October 2023, and garlic on 30 March 2023. Carbofuran was applied during the pit preparation of sugarcane @ 33 kg ha^{-1} to control borer-type insects and termites. Rovral 50WP @ 2 g L^{-1} was applied to control the leaf blight of garlic. Data on yield and yield-contributing attributes were recorded and analyzed with the CropStat analytical package. The cost and return analysis were computed based on the prevailing market price.

Results and Discussion

Statistical analysis of data obtained from different yield characteristics of sugarcane revealed that

there were significant differences between intercropping treatments except for individual sugarcane weights. The highest plant height was observed in the T₁ treatment (413 cm) followed by T₂ (401 cm) and T₃ (400 cm) whereas the lowest was in T₄ (396 cm). The highest individual sugarcane weight was observed in the T₁ treatment (2.73 kg) followed by T₂ (2.60 kg) whereas the lowest in T₃ (2.40 kg). The maximum number of canes was observed in T₁ (55333) followed by T₂ (51333) whereas the lowest in T₄ (46000). A similar trend was observed in fresh cane yield on a weight basis. The maximum yield was found from T₁ (115.33 t ha⁻¹) followed by T₃ (107.33 t ha⁻¹) and T₂ (98.67 t ha⁻¹). On the other hand, the minimum yield was found in T₄ (94.67 t ha⁻¹) treatment (Table 1). The maximum sugarcane equivalent yield was observed in T₃ (181.59 t ha⁻¹) treatment i.e., four rows of garlic grown in between lines of sugarcane whereas the minimum equivalent yield was 129.61 t ha⁻¹ from sole sugarcane (Table 2). In cost and return analysis, the highest gross return (Tk. 1452720 ha⁻¹) and gross margin (Tk. 1061870 ha⁻¹) were observed in T₃ treatment whereas the lowest gross return (Tk. 922640 ha⁻¹) and gross margin (Tk. 591790 ha⁻¹) in T₁ treatment (Table 3). The cost and return were calculated considering the prevailing market price.

Farmers' opinion: Farmers are interested in growing garlic as an intercrop with sugarcane using the prescribed cultivation procedure, intercropping combination, and variety. They will continue practicing this intercropping system in the future.

Table 1. Cane yield and yield components of sugarcane affected by intercropping with garlic at the FSRD site, Atia, Delduar, Tangail during 2022-23

Treatment	Plant height (cm)	Individual sugarcane weight (kg)	Number of cane ha ⁻¹	Cane yield (t ha ⁻¹)
T ₁	413	2.73	55333	115.33
T ₂	401	2.60	51333	98.67
T ₃	400	2.47	51000	107.33
T ₄	396	2.40	46000	94.67
LSD (0.05)	10	NS	6950	11.32
CV (%)	1.30	7.00	6.80	5.40

T₁: Sole Sugarcane, T₂: Sugarcane (100 %) + Three rows of garlic (20%), T₃: Sugarcane (100 %) + Four rows of garlic (26%), T₄ = Farmers practice (Sugarcane 100%) + Five rows of garlic (33%)

Table 2. Yield of garlic affected by intercropping with sugarcane and sugarcane equivalent yield at FSRD site, Atia, Delduar, Tangail during 2022-23

Treatment	Cane yield		Garlic yield (t ha ⁻¹)	SEY (t ha ⁻¹)
	Number ha ⁻¹	Weight (t ha ⁻¹)		
T ₁	55333	115.33	-	115.33
T ₂	51333	98.67	3.95	162.86
T ₃	51000	107.33	4.57	181.59
T ₄	46000	94.67	2.15	129.61

Farm gate price (Tk. kg⁻¹): Sugarcane: 8, Garlic:130

Table 3. Cost and return calculation of sugarcane intercropping with garlic at FSRD site, Atia, Delduar, Tangail during 2022-23

Treatment	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁	922640	330850	591790
T ₂	1302880	385850	917030
T ₃	1452720	390850	1061870
T ₄	1036880	370850	666030

Conclusion

The intercropping of sugarcane with garlic is a profitable technology for the farmers. This is the first-year result. For concrete decisions, this experiment should be repeated in the next year.

78. INTERCROPPING OF TOMATO+SWEET GOURD WITH CAULIFLOWER

M. A. ISLAM, M.M. ZAMAN AND N. SULTANA

Abstract

An experiment was carried out at Boror char, Mymensingh from August 2023 to May 2024 to find out the performance intercropping of Tomato + Sweet gourd with Cauliflower at medium-high land under AEZ-9 without trellis. The highest cauliflower equivalent yield (94.79 t ha^{-1}) was found from Cauliflower + Tomato + Sweet gourd (T_1) and the lowest yield (40.20 t ha^{-1}) was found from sole cauliflower treatment. The highest gross return (Tk. 1420350 ha^{-1}), gross margin (Tk. 1212790 ha^{-1}) and benefit-cost ratio (6.84) was found from Cauliflower + Tomato + Sweet gourd (T_1) and the lowest gross return (Tk. 603000 ha^{-1}), gross margin (Tk. 499340 ha^{-1}) and benefit-cost ratio (5.82) was found from sole Cauliflower (T_4).

Introduction

Intercropping is a popular agricultural technology to increase productivity and yield stability while minimizing resource use and impact on environment (Alizadeh *et al.*, 2010). Inter or relay cropping systems are more stable than sole cropping. Farmers in the char land of Mymensingh are used to grow chilli/tomato as relay intercropping with cauliflower. For getting higher productivity and economic return, it is in need to find out the optimum relaying intercropping combination of cauliflower, tomato and sweet gourd intercropping system. As such, the experiment was carried out to determine the cauliflower for relay intercropping with tomato and sweet gourd for increased production and economic return.

Materials and Methods

The experiment was conducted at Boror char, Mymensingh during August 2023 to May 2024 to find out performance intercropping of Tomato + Sweet gourd with Cauliflower at medium high land under AEZ-9 without trellis. The experiment consisted of five treatments, viz., T_1 = Cauliflower + Tomato + Sweet gourd, T_2 = Cauliflower + Tomato, T_3 = Cauliflower + Sweet gourd, T_4 = Sole cauliflower, T_5 = Farmers practices. The treatments were tested in randomized complete block design with 3 dispersed replications. The unit plot size was $10.0 \text{ m} \times 1.0 \text{ m}$ and spacing for cauliflower & tomato was $60 \text{ cm} \times 50 \text{ cm}$ and sweet gourd was $2.0 \text{ m} \times 20 \text{ m}$. Commercial variety Bandhan for cauliflower, BARI hybrid tomato-11 for tomato and BARI Misti kumra-2 for sweet gourd were used as test materials. Cauliflower was transplanted on 30 October 2023, Tomato was transplanted on 20 November 2023, Chilli was transplanted on 20 November 2023 and sweet gourd was transplanted on 22 December 2023. Cauliflower was harvested on 01 Jan. to 05 Jan. 2024, Tomato was harvested on 10 Feb. to 20 March. 2024, Chilli harvest started on 18 Feb. 2024 and continued up to 8 May 2024 and sweet gourd harvest started on 15 April. 2024 and continued up to 8 May 2024. Fertilizer 127-30-60-18-2 kg ha^{-1} NPKSB with cowdung 10 t ha^{-1} for T_1 = Cauliflower+Tomato+Sweet gourd, Fertilizer 70-55-110-33-3 kg ha^{-1} NPKSB with cowdung 10 t ha^{-1} for T_4 = sole cauliflower (FRG' 2018) and Fertilizer 105-45-90-27-3 kg ha^{-1} NPKSB with cowdung 10 t ha^{-1} for T_2 = Cauliflower+Tomato and T_3 = Cauliflower+Sweet gourd. Whereas T_5 = Farmers practices (cauliflower+chilli) was treated with 115-50-100-30-3 kg ha^{-1} NPKSB and cowdung 10 t ha^{-1} (FRG, 2018). All amount of cowdung, TSP, gypsum, borax and one-third of nitrogen, half of muriate of potash were applied during final land preparation. Remaining nitrogen fertilizer was applied in three equal splits after transplanting and remaining muriate of potash was applied in two equal splits after transplanting. Weeding, irrigation and other intercultural operations were done as and when necessary. The yield of cauliflower and sweet gourd was calculated in tons per hectare considering the whole plot as harvest area. Ten plants of Tomato and Chilli from each plot were selected randomly to collect data on yield components. Equivalent yield of component crops was determined following the method of Anjaneyulu *et al.* (1982). Collected data were analysed statistically with the help of a computer package program STAR and the means were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

Results and Discussion

The yield and yield contributing characters of Cauliflower, Tomato, Sweet gourd and chilli have been presented in table 1. The result indicated that all the yield attributes were influenced due to relaying Tomato+Sweet gourd with Cauliflower intercropping system. However, the highest cauliflower yield (40.20 t ha^{-1}) was recorded from sole cauliflower treatment and the lowest was (26.10 t ha^{-1}) was found from T_5 treatment that is farmer practices. From table 2 the highest cauliflower equivalent yield (94.69 t ha^{-1}) was obtained from T_1 treatment that is Cauliflower+Tomato+Sweet gourd and the lowest cauliflower equivalent yield (40.2 t ha^{-1}) was obtained from T_4 treatment that is sole Cauliflower.

Cost and return analysis: The highest gross return (Tk. 1420350 ha^{-1}), gross margin (Tk. 1212790 ha^{-1}) and benefit cost ratio (6.84) was found from Cauliflower+Tomato+Sweet gourd (T_1) and the lowest gross return (Tk. 603000 ha^{-1}), gross margin (Tk. 499340 ha^{-1}) and benefit cost ratio (5.82) was found from sole Cauliflower (T_4) (Table 2).

Farmer's opinion: Farmers are highly interested to follow relaying Tomato+Sweet gourd with Cauliflower intercropping system due to its higher yield and gross margin.

Table 1. Yield and yield attributes of intercropping of Tomato+Sweet gourd with Cauliflower during 2023-24 at Boror char, Mymensingh

Treatment	Plant ht (cm)	Length of curd (cm)	Breadth of curd (cm)	Single curd wt. (g)	Yield (t ha^{-1})			
					Cauliflower	Tomato	Sweet gourd	Chilli
T_1	35.5	12.20	17.27	805.7	32.13	42.8	23.6	-
T_2	37.1	10.47	16.73	857.7	34.30	46.8	-	-
T_3	38.3	12.03	16.40	738.0	29.60	-	25.4	-
T_4	41.1	12.87	17.87	1030.0	40.20	-	-	-
T_5	31.1	12.77	15.03	645.7	26.10	-	-	22.9
LSD (0.05)	3.39	ns	ns	60.70	2.91			
CV (%)	4.93	12.29	7.68	3.95	4.77			

Here, T_1 = Cauliflower+Tomato+Sweet gourd, T_2 = Cauliflower+Tomato, T_3 = Cauliflower+Sweet gourd, T_4 = Sole cauliflower, T_5 = Farmers practices

Table 2. Cost and return analysis of intercropping of Tomato+Sweet gourd with Cauliflower during 2023-24 at Boror char, Mymensingh

Treatment	Cauliflower equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_1	94.69	1420350	207560	1212790	6.84
T_2	71.74	1076100	165840	910260	6.49
T_3	60.08	901200	161720	739480	5.57
T_4	40.20	603000	103660	499340	5.82
T_5	71.90	1078500	169834	908666	6.35

Sell price/kg: Cauliflower= Tk. 15, Tomato= Tk. 12, Sweet gourd= Tk. 18, Chilli = Tk. 30,
Total cost considered seeds, fertilizer, labour, irrigation and additional cost only.

Conclusion

From the study it may be concluded that relaying Tomato+Sweet gourd with Cauliflower intercropping system showed higher yield and economic return. This is first year trial so it may repeat one year more for final recommendation.

79. EFFECT OF INTERCROPPING ONION WITH OKRA AT CHARLAND OF MYMENSINGH

N. SULTANA AND M.M. ZAMAN

Abstract

The experiment was carried out at the farmers' field of Mymensingh region under OnFarm Research Division, Bangladesh Agricultural Research Institute, Mymensingh to find a suitable intercrop system in increasing the yield of onion and okra during two consecutive years 2021-2022 and 2022-2023. For this instance, the treatments consisted of T₁: Sole okra (45cm × 30cm), T₂: Sole onion (15cm × 10cm), T₃: One row onion in between two rows of okra, T₄: Two rows of onion in between two rows of okra, T₅: Three rows of onion in between two rows of okra. Between the intercropped treatments, three rows of onion between two rows of okra showed higher okra equivalent yield (61.23 and 61.20 t ha⁻¹) and land equivalent ratio of 1.74 and 1.59 compared to other treatments. Based on intercultural operation, yield (okra equivalent yield 58.31 and 59.67 t ha⁻¹) and LER (1.67 and 1.59) two rows of onion in between two rows of okra are the best intercropping system to be followed in okra onion intercropping system.

Introduction

Intercropping is one of the most common ways in sustainable agricultural systems which have an important role in increasing productivity and sustainability of yield by utilization of resources and environmental factors (Alizadeh *et al.*, 2010). Okra is widely grown at farmers field in char land of Mymensingh region. Intercropping of onion with okra systems may increase production and fulfill the demand for okra and onion. In this consideration, the experiment was conducted to find out the suitable intercrop combination of onion with okra for higher productivity and profitability in the char land of Mymensingh.

Materials and Methods

The experiment was conducted at the farmers' field of Gouripur under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2021-2022. The treatments were arranged as T₁: Sole okra (45cm × 30cm), T₂: Sole onion (15cm × 10cm), T₃: One row of onion in between two rows of okra, T₄: Two rows of onion in between two rows of okra, T₅: Three rows of onion in between two rows of okra. The crop varieties were used as BARI Piaz-4 for onion and BARI Dherosh-2 for okra. The experiment was laid out in a randomized complete block design with six dispersed replications. The unit plot size was 3.0m × 3.0m. The sole okra seeds were sown on 7th January 2021 and 18th December, 2022 maintaining the spacing 45cm × 30cm. Whereas onion seedling was planted on 10th January'2022 and 28th December 2022, respectively maintaining the spacing 15cm × 10cm. All the treatments were arranged according to the planting geometry. Fertilizers for okra were applied at the rate of 69-20-75 kg N-P-K ha⁻¹ in the form of urea, triple super phosphate, muriate of potash, respectively along with 14 ton cowdung per hectare (Mondal and Wahhab, 2001). The DAP @ 150 kg ha⁻¹ were top dressed in the plot after two months of sowing. Half of urea and potassium and total amount of CD and phosphorus were applied as basal during final land preparation. The remaining 50% urea and MoP were top dressed at three equal installments of 25 days after planting as well 50 and 80 DAP. Irrigation and weeding were done as and when necessary to keep the field reasonably weed-free. Onion was harvested on 14th April, 2022 as well 26th March, 2023 at physiological maturity. Ten onion plants were selected randomly for recording data on yield attributes and yield. Okra harvesting started on 1st April 2022 and continued up to 23rd June'2022 while in the second year, it was started on 8th March and continued 3rd July 2023. At early stage Rovral 2mgL⁻¹ was sprayed for controlling damping off disease of onion. Amister top 2mL⁻¹ was sprayed to control tip burn disease of onion. Ten plants were selected randomly for the yield components and yield of okra accordingly. The yield of the individual crop was converted into an equivalent yield based on the prevailing market price of the individual crop (Prasad and Srivastava, 1991). Land equivalent

ratio (LER) was used as the criteria for measuring the efficiency of intercropping advantages using the resources of environment compared to monoculture (Mead and Willey, 1980).

The data recorded for different characters and statistically analysed using analysis of variance technique with SPSS and Least Significant Difference (LSD) test at 5% level of probability.

Results and Discussions

Yield performance of intercrops

Okra: Plants m⁻² and no. of okra plant-2 were found insignificant. Maximum plant height (144.43 cm) was obtained from T₁ followed by T₃ (143.76cm). The shortest plant (141.33 cm) was recorded from T₄. However, the highest fruit yield (41.23 t ha⁻¹) was found from sole treatment followed by T₃, T₄ and T₅ (39.70, 39.13 and 38.90 t ha⁻¹). The lowest yield (38.90 t ha⁻¹) was obtained from T₄.

In the year 2022-2023, the yield and yield contributing characters did not show any significant difference. However, maximum yield (40.67 t ha⁻¹) of okra was recorded in T₁ followed by T₅, T₃ and T₄ (38.83, 38.43 and 37.47 t ha⁻¹), respectively.

In both the years, the fruit yield of okra in intercropping situations differed but did not remarkably reduce might be the plant did not compete with light, space and radiation. In intercrop treatments had the yield of next to sole crop might favored the growth of intercropped okra and judicious use of growth resources.

Onion: Yield and yield contributing characters of different treatments of onion was significantly influenced by onion okra intercropping systems. A higher plant population was observed in sole onion treatment (66.0) followed by T₅ (three rows of onion in between two rows of okra (57.0) and the lowest plant population (20.0) was recorded from one row of onion in between two rows of okra (T₂). However, the highest bulb length (16.5 cm) was recorded from T₁ (sole onion) followed by one row of onion in between two rows of okra (12.3 cm). The lowest bulb length (11.3 cm) was observed in three rows of onion in between two rows of okra might be due to interspace competition among the plant population. Single bulb weight was highest (66.8 g) in sole onion while the lowest one was in three rows onion in between two rows of okra (40.3g). The highest bulb yield (18.87 t ha⁻¹) was observed in T₁ treatment (sole onion) which statistically differed with other treatments T₃ (one row of onion in between two rows of onion) T₃ (two rows of onion in between two rows of okra) and T₄ (three rows of onion in between two rows of okra). The lowest onion yield was obtained from T₂ treatment (10.36 t ha⁻¹). Two rows of onion in between two rows of okra (T₃) and three rows of onion in between two rows of okra (T₄) yielded statistically similar yield (13.83 and 15.0 t ha⁻¹) might be due to similar interspace competition. This corroborates with the findings of Uddin *et al.* (2003). In the second year, sole onion gave the highest yield (19.90 t ha⁻¹) followed by T₅, T₄ and T₃ treatment which intercropped with three rows of onion in between two rows of okra, two rows of onion in between two rows of okra and one row of onion in between two rows of okra.

Land equivalent ratio: The land equivalent ratio (LER) was used to assess the performance of an intercrop relative to the corresponding sole crop (Mead and Willey, 1980). If the value of LER is more than one (1.00), it indicated a total yield advantage of growing intercrops over sole crops, since the index denotes how much land would be required for growing sole crops to obtain the same yields of each component as was obtained in intercropping. The highest LER value (1.74) obtained from T₄ treatment (three rows of onion in between two rows of okra) which might be due to maximum complementary use of different growth resources in intercropping system. In the year 2022-2023, The highest LER value (1.59) obtained from T₄ treatment (three rows of onion in between two rows of okra) which might be due to maximum complementary use of different growth resources in intercropping system.

Cost and return analysis: On the basis of okra equivalent yield, the highest monetary return (Tk918450 ha⁻¹) was revealed from T₅ (three rows of onion in between two rows of okra) which

gave an additional income of Tk300000 ha⁻¹ over sole okra. On the other hand, by contrast with onion equivalent yield the highest gross return (Tk 972900 ha⁻¹) was recorded from T₁ (one row onion in between two rows of okra. These results are in concordance with those (Khan *et al.*, 2017; Ghosh *et al.*, 2004; Seran and Brintha, 2009).

On the basis of okra equivalent yield, the highest monetary return (Tk. 918000 ha⁻¹) was revealed from T₅ (three rows of onion in between two rows of okra) which gave an additional income of Tk 307950 ha⁻¹ over sole okra. On the other hand, by contrast with onion equivalent yield the highest gross return (Tk 980400 ha⁻¹) was recorded from T₅ (three rows of onion in between two rows of okra. These results are in concordance with those (Khan *et al.*, 2017; Ghosh *et al.*, 2004; Seran and Brintha, 2009).

Farmers' opinion: Farmers were happy to this system of intercropping of onion with okra because of highly remunerative compared to monoculture of any of the two crops. Farmers have chosen two rows of onions in between two rows of okra as it is easier to intercultural operation and also economically sound with bigger sized onion as well as vigorous growth of okra

Table 1. Fruit yield and yield contributing characters of okra in onion-okra intercropping systems at Gouripur under On Farm Research Division, Mymensingh during 2021-2022

Treatment	Plants m ⁻² (no.)	Plant height (cm)	Fruit plant ⁻¹ (no.)	Frut yield (t ha ⁻¹)
T ₁	12.0	144.43a	43.0	41.23a
T ₂	-	-	-	-
T ₃	11.6	143.76ab	42.8	39.70b
T ₄	11.6	141.33b	42.2	38.90b
T ₅	11.8	142.23ab	42.9	39.13b
CV (%)	1.33	0.64	0.53	1.03

Note: T₁: Sole okra, T₂: Sole onion, T₃: One row of onion in between two rows of okra, T₄: Two rows of onion in between two rows of okra, and three rows of onion in between two rows of okra

Table 2. Fruit yield and yield contributing characters of okra in onion-okra intercropping systems at Gouripur under On-Farm Research Division, Mymensingh during 2022-2023

Treatment	Plants m ⁻² (no.)	Plant height (cm)	Fruit plant ⁻¹ (no.)	Frut yield (t ha ⁻¹)
T ₁	12.0	138.27	40.77	40.67
T ₂	-	-	-	-
T ₃	11.8	134.73	40.13	38.43
T ₄	12.0	134.63	40.27	37.47
T ₅	11.8	133.67	39.73	38.83
LSD (0.05)	NS	NS	NS	NS
CV (%)	1.19	1.37	1.52	3.05

Table 3. Bulb yield, yield contributing characters of onion in onion-okra intercropping systems at Gouripur upazila under On-Farm Research Division, Mymensingh during 2021-2022

Treatment	Plants m ⁻² (no.)	Plant height (cm)	Leaves plant ⁻¹ (no.)	Bulb length (cm)	Bulb diameter (cm)	Single bulb wt. (g)	Bulb yield (t ha ⁻¹)
T ₁	-	-	-	-	-	-	-
T ₂	66.0a	54.0a	10.4a	16.5a	7.6a	66.8a	18.87a
T ₃	20.0d	38.7b	6.6b	12.3bc	6.2b	50.5b	10.36c
T ₄	36.3c	39.2b	5.9c	12.0b	6.3b	45.6c	13.83b
T ₅	57.0b	38.8b	6.7 b	11.3c	5.9b	40.3d	15.00b
CV (%)	2.06	4.56	4.18	3.04	5.25	0.67	4.23

Note: T₁: Sole okra, T₂: Sole onion, T₃: One row of onion in between two rows of okra, T₄: Two rows of onion in between two rows of okra and T₅: Three rows of onion in between two rows of okra

Table 2a. Bulb yield, yield contributing characters of onion in onion-okra intercropping systems at Gouripur upazila under On-Farm Research Division, Mymensingh during 2022-2023

Treatment	Plants m ⁻² (no.)	Plant height (cm)	Leaves plant ⁻¹ (no)	Bulb length (cm)	Bulb diameter (cm)	Single bulb wt (g)	Bulb yield (t ha ⁻¹)
T ₁	-	-	-	-	-	-	-
T ₂	64.67a	46.00	7.33	8.17	16.73	76.67	19.90a
T ₃	20.33d	46.33	9.33	7.83	17.17	71.00	10.53c
T ₄	37.00c	47.20	8.00	7.73	17.00	70.33	13.23bc
T ₅	57.67b	47.00	8.67	8.00	17.17	69.00	15.40b
CV (%)	2.38	12.23	8.27	3.91	3.52	14.00	14.23

Table 4. Onion and okra equivalent yield and land equivalent ratio of different treatments in onion-okra intercropping systems under On-Farm Research Division, Mymensingh during 2021-2022

Treatment	Okra equivalent yield (t ha ⁻¹)	Onion equivalent yield (t ha ⁻¹)	Partial relative yield (t ha ⁻¹)		Land equivalent ratio (LER)
			Okra	Onion	
T ₁	41.23	-	1.00	-	1.00
T ₂	-	18.87	-	1.00	
T ₃	55.04	48.65	0.96	0.55	1.51
T ₄	59.67	48.05	0.94	0.73	1.67
T ₅	61.23	48.22	0.95	0.79	1.74

Table 5. Okra equivalent yield and Cost and return analysis of onion okra intercropping system in Gouripur upazila under Mymensingh during 2022-2023

Treatment	Okra equivalent yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	40.67	610050	135100	474950
T ₂	-	-	-	-
T ₃	54.71	820650	135100	685550
T ₄	58.31	874650	135100	739550
T ₅	61.20	918000	135100	782900

Market price of okra and onion (kg/Tk):15 and 20

Table 6. Onion equivalent yield and Cost and return analysis of onion okra intercropping system in Gouripur upazila under Mymensingh during 2022-2023

Treatment	Onion equivalent yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	-	-	-	-
T ₂	19.90	398000	137200	260800
T ₃	48.72	974400	139200	835200
T ₄	48.00	960000	138200	821800
T ₅	49.02	980400	139200	841200

Conclusion

From the study, it might be concluded that two rows of onion in between two rows of okra were the most productive and profitable among the treatments tested in okra onion intercropping systems.

80. PERFORMANCE OF BUSHBEAN INTERCROPPED WITH GROUNDNUT IN HAOR AREAS OF SYLHET REGION

M. I. NAZRUL

Abstract

An experiment was conducted at farmers field of Hakaluki Haor under MLT site, Moulvibazer during the two consecutive years 2022-23 and 2023-24. Five intercrop combinations, T₁: sole groundnut, T₂: sole bush bean, T₃: alternate row of groundnut and bush bean, T₄: Two rows of groundnut in between paired rows of bush bean and T₅: Two rows of bush bean in between paired rows of groundnut were considered. The experiment was set up in randomized complete block design with six dispersed replications. The maximum average seed yield was obtained from sole bush bean. The higher ground nut equivalent yield (4.35 tha⁻¹) was obtained from T₃ (alternate row of groundnut and bush bean), the lowest yield (2.47 tha⁻¹) was found from the T₁ (sole bush bean). The highest gross return (Tk. 391500 ha⁻¹) and gross margin (Tk. 227028 ha⁻¹) was also recorded from T₃ (Alternate row of groundnut and bushbean), which was more than 76 and 331% higher over sole groundnut respectively. On the contrary, lower gross margin (Tk. 55505 ha⁻¹) was obtained from bush bean as sole crop.

Introduction

The farmers of haor areas of Sylhet region cultivating groundnut and bush bean in separate fields. Both crops are economically very important for haor farmers. Winter is the best period to cultivate haor land because in kharif time the lands remain under water. So farmers have very limited access to the field with many crops in the season. As a result, intercrops and mixed intercrops can be the way to minimize their demand of various crops for family nutrition. French bean (*Phaseolus vulgaris* L.) locally called as Forsa is an important leguminous crop mostly grown as a green vegetable in Bangladesh. The immature pod, tender parts and also dry beans are also used as curry. On the contrary, groundnut is one of the most important oil seed crops but recently the area of groundnut is being decreased due to the competition with rabi crops (Alom *et. al.*, 2009). Moreover, during winter mostly the upper part of haor capturing by various rabi crops which also causes for declining groundnut production area. As it is a long duration crop (140-150 days), and seed price is also higher, so farmers showed less interest on it; but the soil is suitable for groundnut and these two crops can be cultivated in the same plot without hampering the yield of ground nut. Therefore, the present study was conducted to find out the suitable intercrop combination for maximising per unit yield and economic return through intercropping of bush bean with groundnut.

Materials and Methods

The experiment was conducted at farmers field of Hakaluki Haor under MLT site, Moulvibazer during two consecutive years 2022-23 and 2023-24. Five intercrop combinations, T₁: sole groundnut, T₂: sole bush bean, T₃: alternate row of groundnut and bush bean, T₄: Two rows of groundnut in between paired rows of bush bean and T₅: Two rows of bush bean in between paired rows of groundnut were considered. The experiment was set up in randomized complete block design with six dispersed replications. The seeds of ground nut and bush bean were sown by maintaining the spacing of 30 cm × 15 cm. The sole crop of ground nut was fertilized with 12-25-31-24-2-1 kg ha⁻¹ of N-P-K-S-Zn-B in the form of urea, triple super phosphate, and murate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and all other fertilizers were used at final land preparation. The remaining N fertilizer was applied in top dressing at flowering stage and mixed thoroughly with the soil as soon as possible for better utilization. The seeds of bush bean and companion crop were sown on 10-15 November. Intercultural operations were done as and when necessary. There was no remarkable disease or pest attack on crops. The mature seed of companion crop (bush bean) was harvested on 10-12 February and ground nut was harvested on 10-15 April. Data on yield and other attributes of both crops were collected from 10 randomly selected plants 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 ground nut: The yield and yield contributing characters were varied statistically with the variation of intercrop combinations, the highest number of pods plant⁻¹ (46.67) was harvested from T₁ (sole ground nut) statistically similar number of pods plant⁻¹ (42.00) was produced by T₃ (Alternate row of groundnut and bush bean). The result in table 1 showed a significant (P<0.05) among the intercrop combinations the highest 100-kernel weight was observed 46.00 on T₁ (Sole ground nut) followed by of T₄ and T₃ and the lowest 100-kernel weight was obtained from T₅.

Shelling percentage: The results revealed that a significant (P<0.05) difference found in shelling percentage of the different intercrop combinations of groundnut and bush bean sown in table 1. The combination T₁ (Sole ground nut) had the highest shelling percentage (67.69 %) followed by T₃ and T₄ with 66.67 and 65.67 % respectively. The lowest shelling percentage of 60.61 was recorded in T₅.

Pod yields (t ha⁻¹): The results indicated a significant (P<0.05) effect of intercrop combinations on pod yields. T₁ (Sole bush bean) had the highest pod yield with 2.47 t ha⁻¹ followed by T₃ (Alternate row of groundnut and bush bean) with 2.18 tha⁻¹. The lowest pod yield (1.70 tha⁻¹) was obtained by T₅ (Two rows of bush bean in between paired rows of groundnut).

Haulm Yield (t ha⁻¹): The results indicated a significant (P<0.05) effect of intercrop combinations on haulm yields of ground nut in the trial. The highest haulm yield with 8.67 tha⁻¹ was observed in T₁ (Sole bush bean) followed by T₄ with 6.23 tha⁻¹. The lowest haulm yield (5.40 tha⁻¹) was obtained by T₅ (Two rows of bush bean in between paired rows of groundnut).

Companion crop yield: The average yields of companion crop under intercrop combinations were 4.60, 2.97, 2.30 and 2.50 t ha⁻¹ from T₂ (sole bush bean), T₃ (alternate row of groundnut and bush bean), T₄ (Two rows of groundnut in between paired rows of bush bean) and T₅ (Two rows of bush bean in between paired rows of groundnut), respectively (Table 2). Results showed that T₂ gave the highest seed yield (4.92 t ha⁻¹) of bush bean among the intercropping systems.

Ground nut equivalent yield (GEY): Ground nut equivalent yield was expressed in total productivity of this system. Ground nut equivalent yields higher in all the intercrops that was ranged from 3.51-4.35 tha⁻¹ than both sole crops yields (2.47-3.32 tha⁻¹). The maximum equivalent yield (4.35 tha⁻¹) was recorded in T₃ intercropped combination which was followed by T₅ and T₄; the total productivity also increases of 76, 42, 38 and 34 percent over sole ground nut (Table 2).

Cost benefit analysis: The intercrop combination T₃ (Alternate row of groundnut and bush bean) showed higher monetary return than both sole crops and all other combinations. The highest gross return (Tk. 391500 ha⁻¹) and gross margin (Tk. 227028 ha⁻¹) was recorded from T₃ (Alternate row of groundnut and bush bean), which was more than 76 percent higher over sole ground nut. On the contrary, the lowest gross margin (Tk. 55505 ha⁻¹) was obtained from groundnut as sole crop.

Farmer's opinions: Ground nut intercropped with bush bean was found to be a profitable practice. From this practice farmers can earn extra income without hampering the existing crop (ground nut) and also supplement their family nutrition from companion crops.

Conclusion

From the results of two succeeding years of experimentation, it can be concluded that alternate row of bush bean and groundnut is suitable for higher yield of economic profit.

Table 1. Yield of bushbean, yield and yield attributes of ground nut in intercropping system at Hakaluki Haor under MLT site, Kulaura 2023-24

Treatment	Bush bean yield (tha ⁻¹)	Pods plant ⁻¹ of G. nut	100 kernel. wt. (g)	Shelling (%)	Pod yield (t ha ⁻¹)	Haulm yield (tha ⁻¹)
T ₁	0.00	46.67	46.00	67.69	2.47	8.67
T ₂	4.60	0.00	0.00	0.00	0.00	0.00
T ₃	2.97	42.00	44.33	66.67	2.18	5.90
T ₄	2.30	38.67	43.00	65.67	1.77	6.23
T ₅	2.50	44.00	42.00	60.61	1.70	5.40
CV (%)	6.35	2.61	1.33	2.13	6.80	2.51
LSD (0.05)	2.30	1.68	0.88	2.11	2.30	0.26

Note: T₁: sole groundnut, T₂: sole bush bean, T₃: alternate row of groundnut and bush bean, T₄: Two rows of groundnut in between paired rows of bush bean and T₅: Two rows of bush bean in between paired rows of groundnut

Table 2. Yield of companion crop and ground nut equivalent yield (GEY) under bush bean base intercropping system 2023-24

Treatments	Yield of companion crops (t ha ⁻¹)	GEY (t ha ⁻¹)	% increase of GEY over sole ground nut
T ₁ : Sole ground nut	-	2.47	-
T ₂ : Sole bush bean	4.60	3.32	34
T ₃ : Alternate row of groundnut and bush bean	2.97	4.35	76
T ₄ : Two rows of groundnut	2.30	3.43	38
T ₅ : Two rows of bush bean	2.50	3.51	42

Table 3: Cost benefit analysis of bush bean base intercropping system during 2023-24.

Treatments	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
T ₁ : Sole ground nut	222300	166795	55505
T ₂ : Sole bush bean	298800	161950	136850
T ₃ : Alternate row of groundnut and bush bean	391500	164472	227028
T ₄ : Two rows of groundnut	308700	164472	144228
T ₅ : Two rows of bush bean	315900	164472	151428

Price in Tk. Kg⁻¹: Bush bean non-seed: 65, Ground nut: 90

81. PERFORMANCE OF INTERCROPS WITH PANIKACHU IN CHARLAND OF SHERPUR

M. M. RAHMAN, A.K.M.Z.U. NOOR AND N. SULTANA

Abstract

The experiment was conducted to investigate growth and yield of vegetable and spices and taro grown alone as monocropping and in different intercrop combinations at farmers field of FSRD site Tarakandi, Sherpur during 2022-23. The highest taro equivalent yield was obtained from Taro+ coriander leaf (T₃) (87.95 t ha⁻¹) which was 22.95% higher over the sole crop, while the lowest taro equivalent yield was obtain from sole taro (71.53 t ha⁻¹). The maximum gross return (14, 11,503 Tk ha⁻¹) and gross margin (9, 55,970 Tk ha⁻¹) was also found in T₃ treatment.

Introduction

Intercropping is the practice of growing more than one crop simultaneously in alternating rows of the same field (Beets, 1990). The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop

of the mixture (Launay et al., 2009; Mucheru-Muna et al., 2010). Intercropping system is more productive than sole crop, especially under adverse conditions. Intercropped legumes fix most of their N from the atmosphere and not compete with cereals for N resources (Vesterager et al., 2008). Increased leaf cover in intercropping systems helps to reduce weed populations once the crops are established (Beets, 1990).

Aroid/taro (Panikachu) is one of the important tuber crops in Bangladesh during the summer season. Total lowland taro (panikachu) production is 38,502 ton and area is 17,008 (BBS, 2018). 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 the stolon, leaf blade and leaf stalk. A large amount of stolons are being exported every year to abroad. Yield of aroids are markedly influenced by planting materials. Farmers in this region grow local variety which is low yield potentiality and susceptible to pest and diseases. BARI has developed some panikachu varieties, which are high yielder and less susceptible to pest 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.

Therefore, the present study was undertaken to verify the agro-economic performance of intercropping of vegetable and spices with panikachu and to find out the appropriate intercrop combination for higher yield and economic return.

Materials and Methods

Field experiment was conducted to investigate growth and yield of vegetable and spices and taro grown alone as monocropping and in various combinations (intercropping). The experiment was conducted at FSRD site Tarakandi, under Sherpur district during the cropping season of 2022-23 at the farmer's field under AEZ-9. The design of the experiment was Randomized Complete Block with six dispersed replications. Five treatments combination viz., T_1 = Sole taro, T_2 = taro + spinach, T_3 = taro + coriander leaf, T_4 = taro + radish and T_5 = taro + stem amaranth. Taro variety was BARI Panikachu-2. Unit plot size was 4.5m × 3.6m. Taro was planted on 15 November 2022. Seeds of inter crops were sown in between taro line on 16 November 2022. The crop was fertilized with a dose of 350-175-300-125-14-10 kg ha⁻¹ of Urea-TSP-MOP- Gypsum- Zinc sulphate- Boric acid, respectively and 15 t ha⁻¹ of cowdung. Half of MOP and full dose of TSP, Gypsum, Zinc sulphate, Boric acid and cowdung were applied in plot during the final land preparation. One fifth of Urea was top dressed started from 20-25 days after planting (DAP) and other 4 installments were applied at an interval of 25-30 days after that 1st top dressed. Rest of MoP was top dressed at 50-60 DAPS with the second top dressed of Urea. Other intercultural operations like weeding, earthing up, irrigation etc. were done as per schedule. There were no notable significant diseases and pest infestation was observed in the plots. Spinach was harvested on 17 December 2022, coriander was harvested on 17 December 2022, radish was harvested on 2 January 2023 and stem amaranth was harvested on 17 January 2023. The stolon harvesting was started from April, 2023 rhizome was harvested in July 2, 2023. Data were collected on yield and yield contributing characters and were calculated by STAR.

Result and Discussions

Yield and yield attributes: From the results it is revealed that coriander leaf required only 32 days as inter crops whereas stem amaranth harvested by 63 days. Yield of spinach was found highest (30.63 t ha⁻¹) as inter crops and coriander leaf resulted lowest (2.38 t ha⁻¹). The maximum stolon yield (25.78 t ha⁻¹) was obtained from t_1 treatment i.e. Sole taro and the minimum stolon yield resulted from T_4 (19.79 t ha⁻¹). Rhizome yield was found highest in T_3 (60.54 t ha⁻¹) and the lowest yield in T_2 (45.23 t ha⁻¹). The highest taro equivalent yield was resulted from t_3 treatments (87.95 t ha⁻¹) which was 22.95% increase over the sole crop, while lowest from t_1 (71.53 t ha⁻¹).

Cost and Return: Cost and return analysis revealed that highest gross return (Tk. 9,55,970/-ha⁻¹) was obtained from T₃ treatment (taro+ coriander leaf) followed by T₂ treatment. In case of gross margin, the highest (Tk. 14,11,503/-ha⁻¹) was resulted from T₃ treatment.

Farmer's opinion: Taro with leafy vegetables intercropped was found as a profitable practice at Sherpur region though they faced some difficulties performing different intercultural operations like weeding and fertilization. Therefore, they can earn more income easily without hampering the main crop (Taro).

Table 1. Yield and yield contributing characters of leafy vegetables under intercrop combinations at sherpur during the year of 2022-23

Treatments	Duration of intercrop (Days)	Yield of intercrops (t ha ⁻¹)	Stolon yield (t ha ⁻¹)	Rhizome yield (t ha ⁻¹)	Taro equivalent yield (t ha ⁻¹)	Yield increase over sole crop (%)
T ₁ = Sole taro	-	-	25.75a	45.78b	71.53	-
T ₂ = Taro+ spinach	35	30.63a	22.45bc	45.23b	79.93	11.74
T ₃ =Taro+ coriander leaf	32	2.38d	22.92ab	60.54a	87.95	22.95
T ₄ = Taro+ radish	48	18.84b	19.79c	49.62b	78.83	10.20
T ₅ =Taro+ stem amaranth	63	14.92c	24.53 ab	46.56b	78.46	9.6
LSD (0.05)		2.17	3.10	5.75		
CV (%)		13.51	11.17	9.34		

Table 2. Taro Equivalent yield and cost and return of intercrops at Sherpur during the year of 2022-23.

Treatments	Taro Equivalent Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ = Sole taro	71.53	12,58,871	3,98,200	8,60,738
T ₂ = Taro+ spinach	79.93	13,69,601	4,69,470	9,00,131
T ₃ =Taro+ coriander leaf	87.95	14,11,503	4,45,450	9,55,970
T ₄ = Taro+ radish	78.83	12,76,240	4,82,500	7,73,740
T ₅ =Taro+ stem amaranth	78.46	13,49,868	4,63,900	8,86,001

Price of output: (Tk. Kg⁻¹): Spinach- 8; Coriander Leaf-30; Radish -10, Stem Amaranth -10, Stolon-30; Rhizome-10.

Conclusion

Intercropping of vegetable and spices is possible with taro found promising and more profitable than sole taro cultivation. For more confirmation this experiment should be continued next year.

82. PERFORMANCE OF EARLY BULKING POTATO VARIETY AS INTERCROP WITH WINTER HYBRID MAIZE AT MANIKGANJ

M. R. AMIN AND M. E. HAQUE

Abstract

The experiment was conducted at Kamta village under Satoria upazila of Manikganj district during Rabi season of 2023-24 to validate the developed potato and hybrid maize intercropping in farmers' field and its economic performance. Two intercrop combinations, T₁ = Maize normal row (60cm x 25cm) +one row potato and T₂= Sole maize (60cm x 25cm) were evaluated. The experiment was laid out in RCB design with three replications. The variety of hybrid maize was Pacific hybrid-9217 and the variety of potato was BARI Alu-44. The highest maize equivalent yield (17.31 t ha⁻¹), gross return (Tk.484680 ha⁻¹), gross margin (Tk. 162120 ha⁻¹) and BCR (1.50) were obtained from treatment T₁= Maize normal row (60cm x 25cm) +one row potato). The lowest maize equivalent yield (8.99 t ha⁻¹), gross return (Tk.251720 ha⁻¹), gross margin (Tk. 81115 ha⁻¹) and BCR (1.47) were obtained from sole cropping of maize.

Introduction

Intercropping is a traditional practice for marginal farmers of developing countries. It increases total productivity through better utilization of land, Labor and growth resources. Greater productivity in intercropping system is commonly achieved by minimizing inter-specific competition and maximizing complementary use of growth resources. Inter-specific competition may be minimized through judicious choice of crops. Maize is spaced crop and cultivated throughout the year, so there is a scope of using this space through growing other crop as intercrop. Potato is also cultivated in *Rabi* season and it is a short statured crop. The demand of potato as vegetables remain unchanged whole the year round. The market price of potato is also high in the beginning of winter season. So, early bulking variety of potato may be intercropped with winter hybrid maize which may increase total productivity as well as increase crop diversity. In context, the present investigation was undertaken to validate early bulking variety of potato and hybrid maize intercropping in farmers' field.

Materials and Methods

The experiment was conducted at Kamta village under Saturia upazila of Manikganj district during *Rabi* season of 2023-24. The experiment was laid out in RCB design with three replications. The variety of hybrid maize was Pacific hybrid-9217 and the variety of potato was BARI Alu-44. Two intercrop combinations, T_1 = Maize normal row (60cm x 25cm) + one row potato, T_2 = Sole maize (60cm x 25cm) were evaluated. The crop was fertilized with 276-50-150-35.2-4.3-1.7 kg N-P-K-S-Zn-B ha⁻¹ 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 tasseling stage (65 DAS) of maize after harvesting of potato and mixed thoroughly with the soil as soon as possible for better utilization. Potato tuber was sown on 19 November, 2023 and maize seed was sown on 11 December, 2023. The crop was irrigated twice after fertilization at 35 and 60 DAS. Weeding, earthing up and other intercultural operations were done as per requirement. Potato was harvested at a time on 02 February, 2024 and hybrid maize was harvested on 10 May, 2024. Cut worm infestation was observed in the seedling stage and it was controlled by application of Dersban @ 2 ml per 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 @ 2 ml 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 to prevent leaf feeding insects.

The yield of both crops were recorded and analyzed statistically. Maize equivalent yield was calculated by converting the yield of potato into the yield of maize on the basis of prevailing market price of both crops using the following formula,

$$\text{Maize Equivalent Yield (REY)} = \frac{\text{Yield of individual crop (kg ha}^{-1}\text{)} \times \text{market price of that crop}}{\text{Market price of maize grain (Tk. kg}^{-1}\text{)}}$$

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 higher maize grain yield (8.64 t ha⁻¹) was recorded in sole maize (T_2) and lower from potato-maize intercrop treatment T_1 producing 7.90 t ha⁻¹ of maize with 8.50 t ha⁻¹ of potato. Yield from sole maize treatment T_2 was obtained 8.64 t ha⁻¹ of maize only.

Maize equivalent yield: The intercrop combination produced the highest maize equivalent yield than sole maize (Table 2). The highest maize equivalent yield (17.31 t ha⁻¹) was obtained from T_1 = Maize (60cm x 25cm) + 1 row of potato (60cm x 25cm) followed by the lowest maize equivalent yield (8.99 t ha⁻¹) was found in sole cropping of maize. Maize equivalent yield from potato-maize intercrop system gave 92.54% higher yield over sole maize cultivation.

Cost and return analysis: Cost and return of maize and potato intercropping system is shown in Table 2. The higher gross return (Tk. 484680.00 ha⁻¹) and gross margin (Tk. 162120.00 ha⁻¹) was recorded in T₁= Maize (60cm x 25cm) + 1 row of potato (60cm x 25 cm) and lower gross return (Tk. 251720.00 ha⁻¹) and gross margin (Tk. 81115.00 ha⁻¹) was obtained from sole maize (Table 2). Total variable cost was maximum in treatment T₁= (Tk. 322560.00 ha⁻¹) due to higher cost of seed tuber and higher number of day laborer required for potato planting, crop management and harvesting compared to sole maize cultivation T₂= (Tk. 170605.00 ha⁻¹).

Farmers' opinion: Farmers showed interest in cultivation of maize intercropped with potato for higher yield and economic return. The neighbouring farmers was motivated, and more area will be cultivated following this intercrop system in the next growing season.

Table 1. Yield and yield contributing characters of maize under maize and potato intercrop system at Satoria, Manikganj during 2023-24

Treatment	Plant height (cm)	Length of cob (cm)	Diameter of cob (cm)	Grain cob ⁻¹ (no.)	1000-seed weight (g)	Grain yield of maize (t ha ⁻¹)	Straw yield of maize (t ha ⁻¹)	yield of potato (t ha ⁻¹)
T ₁ (maize-potato intercrop)	188.60	14.56	4.72	496.40	230.66	7.90	8.72	8.50
T ₂ (sole maize)	202.33	16.40	5.39	538.13	235.23	8.64	9.81	--
T-value	-3.13	-0.95	-1.93	-2.39	-1.19	-3.33		
Level of sig.	**	ns	ns	*	ns	ns	ns	

Table 2. Cost and return of maize and potato intercropping system at Satoria, Manikganj during 2023-24.

Treatment	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	17.31	484680	322560	162120	1.50
T ₂	8.99	251720	170605	81115	1.47

Price of input and output: Urea Tk. 27.00 kg⁻¹, TSP Tk. 27.00 kg⁻¹, MoP Tk. 20.00 kg⁻¹, Gypsum Tk. 15.00 kg⁻¹, Zinc sulphate Tk. 320.00 kg⁻¹, Boric acid Tk.580.00 kg⁻¹, Cost of maize seed: Tk. 650.00 kg⁻¹ cost of potato seed: Tk. 50.00 kg⁻¹, Price of maize seed: Tk. 28.00 kg⁻¹ and Stover: Tk. 1.00 kg⁻¹, Potato: Tk.30.00 kg⁻¹

Conclusion

Maize equivalent yield, gross margin and BCR over sole cropping were found higher in maize and potato intercropping treatment. It could be concluded that one row of potato in between two rows of maize was more profitable compared to sole maize cultivation.

83. MIXED CROPPING OF LENTIL WITH GROUNDNUT VARYING DIFFERENT PLANT POPULATION AT THE CHARLAND OF TANGAIL

M. A. RAHAMAN, S. ROY, T. TASMIMA, K. ROY AND G. PAUL

Abstract

The experiment was conducted in the farmers' field at the MLT site, Bhuapur, Tangail during Rabi 2023-24 under AEZ# 8 to verify the performance of lentil as mixed crop with groundnut in char lands and to increase production and farmers' income. The treatment combinations used for the experiment were T₁: Sole groundnut (100%), T₂: Groundnut (100%) + lentil (20%), T₃: Groundnut (100%) + lentil (30 %) and T₄: Groundnut (100%) + lentil (40%). Results revealed that the yield of groundnut decreased with the increase of lentil population. In addition, all the mixed cropping combinations showed superior in terms of gross return, gross margin and groundnut equivalent yield (GEY) than sole cropping. The highest groundnut equivalent yield (2.29 t ha⁻¹) was found in the treatment combination of 100% groundnut + 40% lentil. From cost and return analysis it was observed that the combination

of 100% groundnut + 40% lentil (T₅) gave the highest gross return (Tk.206370 ha⁻¹) and gross margin (Tk. 94659 ha⁻¹) where sole groundnut (T₁) gave the lowest gross return and gross margin (Tk 174600 and 80289 ha⁻¹).

Introduction

Groundnut is a cash-earning and excellent edible oil seed crop. Seeds contain about 50% oil and 22-29% protein. In Bangladesh, about 32 thousand hectares of land is under the cultivation of groundnut and the total production is around 47 thousand tons. The farmers of Tangail cultivate groundnut in a vast area of char land. Most of the farmers are cultivating locally available groundnut varieties. The local varieties are susceptible to different pest and diseases. In this char area local lentil also grown scattered. Both Groundnut and Lentil are cultivated as sole crop throughout the country in *rabi* season and sometimes as mixed crop in farmer's field. It is observed that, some farmers of Bhuapur char area cultivate lentil as a mixed crop with groundnut without determining benefit, cost and return and land use efficiency. The Farmers do not maintain proper seeding ratio, planting time and other management practices. Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Therefore the present study was conducted to verify the agronomic and economic performance of mixed cropping of groundnut with lentil and also ensure the maximum utilization of the land for higher yield and income.

Materials and Methods

The experiment was carried out at the MLT site, Bhuapur, Tangail during Rabi 2023-24 under AEZ# 8. It was laid out in a Randomized Complete Block Design with three dispersed replications. It consists of four treatments as T₁: Sole Groundnut, T₂: Groundnut (100%) + lentil (20%), T₃: Groundnut (100%) + lentil (30%) and T₄: Groundnut (100%) + lentil (40%). The seed rate was followed as 100 and 8 kg ha⁻¹ for groundnut and lentil, respectively. According to the treatments, seeds of Groundnut (BARI Chinabadam-8) were sown in line with 30 cm x 15 cm spacing and lentil (BARI Moshur-8) were broadcasted in groundnut plot. Both groundnut and lentil seeds were sown on 18 November, 2023. The unit plot size was 80 m² (10 m x 8 m). The plots were fertilized with 12, 32, 43, 54 and 2 kg ha⁻¹ N, P, K, S and B, respectively. Half of the nitrogen and full quantity of P K S B was applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. The remaining N was top-dressed at the flowering stage and covered with soil for proper establishment of the crop. Plant protection measures and all other management practices were done as and when necessary. Lentil was harvested on 10 March 2024 whereas Groundnut on 6 May 2024. Data on different crop parameters were collected from the 10 sample plants and then the average was taken which was further analyzed by computer program CropStat. Groundnut equivalent yield (GEY) and economic analysis were calculated to ascertain the efficiency of mixed cropping. Groundnut equivalent yield was calculated by converting the yield of mixed crops with the yield of Groundnut based on prevailing market prices of individual crops according to Islam *et al* (2006).

Results and Discussion

Yield and yield attributes of Groundnut: The results indicate that most of the yield attributes of groundnut were influenced due to mixed cropping with lentils (Table 1) except kernel pod⁻¹ and 100 pod weight. Maximum number of mature pod plant⁻¹ (21.80) was recorded in T₁ which was statistically identical to T₂. The lowest number of pods plant⁻¹ (7.70) was obtained from T₄. 100-pod weight did not differ significantly among the treatments. Pod yield differed significantly among the treatments. The highest pod yield was recorded in sole situation T₁ (1.94 t ha⁻¹) and the lowest in T₄ (1.79 t ha⁻¹). The yield of Groundnut decreased with the increasing of lentil population in the mixed-cropped situation might be due to competition for nutrients and less light interception between the sole and the intercrops.

Groundnut equivalent yield: Results showed that the maximum groundnut equivalent yield (2.29 t ha⁻¹) was obtained from the treatment T₄ (100% Groundnut + 40% lentil) which was close to T₃ treatment (Groundnut (100%) + lentil (30%). The lowest groundnut equivalent yield (1.94

t ha⁻¹) was obtained from T₁ treatment (sole groundnut). So, mixed cropping showed higher GEY than sole crops (Table 2).

Cost and return analysis: Cost and return data are presented in Table 2. Gross return as well as gross margin was found higher in mixed crop cultivation in comparison to sole cropping. From cost and return analysis, it was documented that T₄ treatment (100% Groundnut + 40% lentil) made the highest gross margin Tk. 94659 ha⁻¹ followed by T₃ (Tk. 90369 ha⁻¹). The lowest gross margin (Tk. 80289 ha⁻¹) was obtained from sole groundnut.

Farmers' opinion: The farmers' got more yield from lentil and Groundnut as mixed cropping that is more profitable than the sole cropping. Risk of cultivation of one crop can be reduced by mixed cropping.

Table 1. Pod yield and yield attributes of groundnut as a mixed crop with lentil at the MLT site Bhuapur, Tangail during 2023-24

Treatments	Mature pod plant ⁻¹ (no.)	Kernel pod ⁻¹ (no.)	100-pod wt. (g)	Pod yield (t ha ⁻¹)
T ₁ = Sole groundnut	21.80	1.90	91.23	1.94
T ₂ = Groundnut (100%) + lentil (20%)	18.47	1.87	89.58	1.87
T ₃ = Groundnut (100%) + lentil (30%)	19.13	1.77	85.07	1.82
T ₄ = Groundnut (100%) + lentil (40%)	17.30	1.67	84.33	1.79
LSD (0.05)	2.72	0.25	NS	NS
CV (%)	7.50	7.00	7.90	10.30

Table 2. Groundnut equivalent yield, Cost and benefit analysis of groundnut as a mixed crop with lentil at the MLT site Bhuapur, Tangail during 2023-24.

Treatment	Groundnut yield (t ha ⁻¹)	Lentil yield (t ha ⁻¹)	Groundnut equivalent yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁ = Sole groundnut (100%)	1.94	0	1.94	174600	94311	80289
T ₂ = Groundnut (100%)+ lentil 20%)	1.87	0.251	2.12	190890	103011	87879
T ₃ = Groundnut (100%)+ lentil 30%)	1.82	0.377	2.20	197730	107361	90369
T ₄ = Groundnut (100%)+ lentil 40%)	1.79	0.503	2.29	206370	111711	94659

Price (Tk kg⁻¹): Groundnut= 90 and lentil = 80

Conclusion

Considering the yield and return it can be concluded that 100% Groundnut with 40% lentil showed higher profitable as compared to other treatment combinations when grown as a mixed crop. This is the first-year experiment, after second year trial conclusion may be drawn.

84. PERFORMANCE OF THE MIXED CROPPING SYSTEM OF LENTIL, MUSTARD, AND LINSEED UNDER AEZ-11

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Abstract

The field experiment was carried out at MLT site, Atghoria during the rabi season of 2023-24 to verify the performance of mustard and linseed as mixed cropping with lentil. The treatment compositions used for the experiment were T₁= Lentil (80%) + Linseed (20%), T₂= Lentil (80%) + Mustard (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%), T₄= Lentil (100%), T₅= Mustard (100%) and T₆= Linseed (100%). Sole linseed, lentil, and mixed cropping of lentil + linseed performed better than sole mustard and mixed cropping of all these three crops. Maximum lentil equivalent yield (LEY) (1.68 t ha⁻¹) was obtained from

sole linseed, which is identical to sole lentil, Lentil (80%) + Linseed (20%), and Lentil (80%) + Mustard (20%). LEY was minimum (1.22 t ha⁻¹) in sole lentil which was statistically similar to Lentil (75%) + Mustard (15%) + Linseed (10%). Sole linseed, lentil, and two-crop mixed cropping systems produced a higher economic return than sole mustard and three-crop-based mixed crop cultivation.

Introduction

Bangladesh faces a significant shortage of pulses and oilseeds to meet its demand. This deficit is primarily due to the lack of suitable high-yielding varieties of lentils, mustard, and linseed, as well as the occupation of land traditionally used for growing pulses and mustard by boro rice cultivation. In the Pabna area, as in other regions, farmers typically grow local varieties of lentils, mustard, and linseed after harvesting T. Aman rice. However, the yield potential of these local varieties is very low. Additionally, farmers often plant lentils and mustard late, after harvesting long-duration local T. Aman rice, which results in reduced yields. In many cases, this delay prevents them from growing boro rice altogether. To address these challenges, the Pulses Research Centre and the Oil Seed Research Centre of BARI have developed short-duration, high-yielding varieties of lentils, mustard, and linseed that can be successfully cultivated before boro transplanting. The objective to identify suitable mixed crop combinations of lentils, mustard, and linseed for higher yields.

Materials and Methods

The experiment was carried out at the MLT site, Atghoria, Pabna during the rabi season of 2023-24. The soils of the experimental areas belong to the High Ganges River Flood Plain under AEZ-11. The soils of the experimental plots were sandy clayey loam in texture. The experiments were laid out in a Randomized Complete Block design with six dispersed replications. It consisted of six treatments as follows: T₁= Lentil (80%) + Linseed (20%), T₂= Lentil (80%) + Mustard (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%), T₄= Lentil (100%), T₅= Mustard (100%) and T₆= Linseed (100%). Seeds of lentil (BARI Masur-8) mustard (BARI Sarisha-17) and linseed (Nila) were sown on 21 November 2023 as broadcast. The unit plot size was 30m² (5m x 6m). The lands were fertilized with 18.43-16- 20- 7-1.43- 1.36 kg N-P-K-S-Zn-B ha⁻¹ respectively. All the fertilizers were applied during final land preparation as basal in all the treatment combinations except Sole mustard and linseed as 1/3rd urea was used as a top dress at about 30 DAS on 20-25 December 2023. Data on yield and yield contributing characters were recorded and statistically analyzed. The land equivalent ratio (LER) index was used to evaluate mixed crop efficiencies concerning sole crops.

Result and Discussion

Yield and yield attributes of Lentil: The results indicated that most of the yield attributes of lentils were influenced by to mixed cropping system (Table 1). The maximum plant population (63.3) was recorded from sole lentils, while the minimum from three crop-based mixed cropping systems. The highest branches plant⁻¹, pods plant⁻¹ and 1000 seed weight (23.2 g) were found from Lentil (80%) + Linseed (20%) mixed cropping which were similar to Lentil (80%) + Mustard (20%), while minimum from sole lentil. The highest plant height was recorded from Lentils (80%) + Mustard (20%) and the lowest from sole lentil. Maximum grain yield and stover yield were obtained from sole lentils followed by two crop-based mixed cropping systems and minimum from three crop-based cropping systems.

Yield and yield attributes of mustard: Yield and yield attributes of mustard are presented in Table 2. Results indicated that yield and yield components varied significantly with variation of the cropping system. It was revealed that siliqua plant⁻¹ and grains siliqua⁻¹ were found maximum from Lentil (75%) + Mustard (15%) + Linseed (10%) followed by lentil (80%) + mustard (20%) and minimum from sol mustard. The highest plant population was recorded from sole mustard and the lowest from three crop-based mixed cropping. Grain and stover yield of mustard were maximum (1.61 and 1.12 t ha⁻¹ respectively) in the sole mustard system and the minimum (0.42 and 0.30 t ha⁻¹ respectively) in three crop-based mixed crop systems.

Yield and yield attributes of linseed: The yield and yield contributing characters as influenced by different cropping systems are presented in Table 3. All the parameters except 1000 grain weight are significantly influenced by different cropping systems. Maximum plant population was recorded from sole linseed compared to mixed cropping system. Branches plant⁻¹ was higher in Lentil (75%) + Mustard (15%) + Linseed (10%) followed by lentil (80%) + mustard (20%) and minimum from sole linseed. Plant height and pods plant⁻¹ were found greater in Lentil (80%) + Linseed (20%) and the latter one was identical to three crop-based mixed cropping systems. The highest grain and stover yield were found from sole linseed cropping and the minimum from three crop-based mixed cropping systems (Table 3).

Lentil equivalent yield: Two crop-based mixed crop treatments along with sole lentil and linseed provided higher lentil equivalent yield (LEY) than sole mustard and three crop-based mixed crop systems. The higher LEY was obtained from sole linseed which is identical to sole lentil and two crop-based mixed cropping systems. On the other hand, the lower LEY yield of 1.22 t ha⁻¹ was recorded from sole mustard which is similar to three crop-based mixed cropping systems.

Cost and Return Analysis: Cost and return data are presented in Table 5. Gross return as well as gross margin was found higher in sole lentil, sole linseed, and two crops-based mixed crop cultivation in comparison to sole mustard and three crop-based mixed cropping. From cost and return analysis, we observed that sole lentils provided the highest gross margin Tk 113505 ha⁻¹ followed by Lentil (80%) + Linseed (20%). The lowest gross margin (66635 Tk ha⁻¹) was obtained from sole mustard.

Farmers Opinion: As the farmers got the additional yield of linseed from the mixed crop with lentils, they were interested in growing linseed as a mixed crop with lentils.

Table 1 Yield and yield attributes of lentils obtained from mixed cropping with mustard and linseed during rabi season of 2023-24 at MLT site, Atghoria, Pabna

Treatments	Plants m ⁻² (no.)	Plant height (cm)	Branches plant ⁻¹ (no.)	Pods plant ⁻¹ (no.)	1000-seed wt (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁	54.33	37.4	5.11	60.7	23.2	1.19	0.65
T ₂	55.33	40.7	5.00	57.7	23.2	1.17	0.56
T ₃	51.67	38.3	4.93	54.2	23.0	0.77	0.34
T ₄	63.33	37.2	4.43	50.2	22.3	1.54	0.77
LSD (0.05)	2.64	1.60	0.38	3.22	0.64	0.11	0.09
CV (%)	3.36	3.97	3.9	3.89	1.4	4.71	7.73

T₁= Lentil (80%) + Linseed (20%), T₂= Lentil (80%) + Mustard (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%) and T₄= Lentil (100%)

Table 2 Yield and yield attributes of mustard obtained from mixed cropping with lentil and linseed during rabi season of 2023-24 at MLT site, Atghoria, Pabna

Treatments	Plants m ⁻² (no.)	Plant height (cm)	Branches plant ⁻¹ (no.)	Silique plant ⁻¹ (no.)	Grain silique ⁻¹ (no.)	1000- seed wt (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₂	10.93	109	4.67	33.0	35.7	3.20	0.44	0.34
T ₃	8.50	108	4.60	40.6	39.0	3.17	0.42	0.30
T ₅	55.67	105	4.53	29.6	32.5	3.07	1.61	1.12
LSD (0.05)	5.42	NS	NS	5.33	2.96	NS	0.04	0.07
CV (%)	9.56	2.17	3.81	6.84	1.51	2.49	3.52	4.90

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, ns = not significant [Legend: T₂= Lentil (80%) + Mustard (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%) and T₅= Mustard (100%)]

Table 3 Yield and yield attributes of linseed obtained from mixed cropping with lentil and mustard during rabi season of 2023-24 at MLT site, Atghoria, Pabna

Treatments	Plant m ⁻² (no.)	Plant height (cm)	Branches plant ⁻¹ (no.)	Pods plant ⁻¹ (no.)	1000-seed wt. (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁	10.1	82.4	4.31	85.0	3.10	0.23	0.14
T ₃	5.7	76.5	4.50	80.9a	2.93	0.14	0.09
T ₆	55.0	77.2	4.20	75.6	3.03	1.11	0.89
LSD (0.05)	6.19	3.37	0.18	5.45	NS	0.09	0.08
CV (%)	11.58	2.89	1.80	4.99	2.21	8.62	9.21

T₁= Lentil (80%) + Linseed (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%) and T₆= Linseed (100%)

Table 4 Lentil equivalent yield (t ha⁻¹) obtained from MLT site, Atghoria, Pabna during rabi season 2023-24.

Treatment Combination	Yield (t ha ⁻¹)						Lentil equivalent yield (t ha ⁻¹)
	Lentil		Linseed		Mustard		
	Grain	Strover	Grain	Strover	Grain	Strover	
T ₁	1.19	0.65	0.23	0.14	-	-	1.61a
T ₂	1.17	0.56	-	-	0.44	0.34	1.56a
T ₃	0.77	0.34	0.14	0.09	0.44	0.30	1.33b
T ₄	1.62	0.77	-	-	-	-	1.62a
T ₅	-	-	-	-	1.41	1.12	1.22b
T ₆	-	-	1.11	0.89	-	-	1.68a
LSD (0.05)	0.	0.09	0.09	0.08	0.04	0.07	0.12
CV (%)	5.69	7.73	8.62	9.21	3.52	4.90	4.79

[T₁= Lentil (80%) + Linseed (20%), T₂= Lentil (80%) + Mustard (20%), T₃= Lentil (75%) + Mustard (15%) + Linseed (10%), T₄= Lentil (100%), T₅= Mustard (100%) and T₆= Linseed (100%)]

Table 5 Cost and return analysis obtained from the experimentation conducted at MLT site Kashinathpur, Pabna Rabi season 2012-13

Treatment Combination	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁	161000	48165	112835
T ₂	156330	48165	108165
T ₃	133000	48165	84835
T ₄	161670	48165	113505
T ₅	122000	55365	66635
T ₆	168000	56365	111635

Market price: Lentil = 90 Tk kg⁻¹, Linseed = 120 Tk kg⁻¹ and Mustard = 80 Tk kg⁻¹

Conclusion

In the two-crop mixed cropping system, the lentil equivalent yield increased compared to the sole cropping and three-crop mixed cropping systems. Additionally, the two-crop mixed-crop combination resulted in better gross return and gross margin. Overall, two-crop mixed cropping is more profitable than sole cropping and three-crop mixed cropping.

85. MIXED CROPPING OF MAIZE WITH LEAFY VEGETABLES IN CHAR AREAS OF GAIBANDHA

M. J. ALAM AND A. A. MAHMUD

Abstract

The experiment was undertaken at Haldia Char, Saghata, Gaibandha during 2023-24 to get more yield and return from a single land as well as ensure nutritional security. The experiment was designed in a randomized complete block design with four replications. The

tested crops were Maize (Major), Lalshak (BARI Lalshak-1), Mulashak (BARI Mula-1) and coriander leaf (BARI dhania-1). Four treatments viz: T₁: Sole Maize, T₂: Maize+Lalshak, T₃: Maize+Mulashak and, T₄: Maize+ Coriander leaf was evaluated. The maximum Maize equivalent yield (18.71 t ha⁻¹), gross return (Tk. 467778 ha⁻¹) and gross margin (Tk. 331403 ha⁻¹) was recorded found from T₂ (Maize+Lalshak) treatment, followed by T₄ (Maize+Coriander leaf) and T₃ (Maize+Mulashak) treatment. The minimum Maize equivalent yield (10.91 t ha⁻¹), gross return (Tk.272778 ha⁻¹) and gross margin (Tk. 140403 ha⁻¹) was found from T₁ (Sole Maize)) treatment. The maximum MBCR was also recorded in T₂ treatment and the minimum MBCR was also recorded from sole Maize cultivation (T₁).

Introduction

The practice of planting two or more plants concurrently in the same field and interdigitating them so that they grow together is known as mixed cropping, sometimes referred to as polyculture, inter-cropping, or co-cultivation (Lizarazo et al., 2020). In general, the theory is that planting multiple crops at once saves space since crops in the same field might ripen at different seasons and provides a wealth of environmental benefits. Documented benefits of mixed cropping include the balance of input and outgo of soil nutrients, the suppression of weeds and insect pests, the resistance of climate extremes (wet, dry, hot, cold), the suppression of plant diseases, the increase in overall productivity, and the management of scarce resources (land) to the fullest degree (Sarker et al., 2022). Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. In char areas of Gaibandha, farmers usually practiced Maize solely. If we can grow some leafy vegetables like lalshak, mulashak and coriander leaf with maize together, can get more return from the same land. Keeping this view in mind, the present study has undertaken to get more yield and return from a single land as well as ensure nutritional security.

Materials and Methods

The field experiment was conducted at the farmer's field of Haldia char, Saghata, Gaibandha during the *rabi* season of 2023-24 to get more yield and return from a single land as well as ensure nutritional security. The experiment was laid out in a randomized complete block design with four replications. The unit plot size was 4.5 m x 5 m. There were four treatments combination viz., T₁: Maize (sole), T₂: Maize+Lalshak, T₃: Maize+Mulashak and T₄: Maize+coriander leaf. The tested crops were Maize (local hybrid), BARI Lalshak-1, BARI Mula-1 and BARI Dhania-1, respectively. Seeds of all crops were mixed and sown on 12 November 2013. The fertilizer doses were N-P-K-S-Zn-B @ 250-55-100-35-2-1 kg ha⁻¹, respectively in all the treatment. One-third of N and all of P, K, S, Zn and B were applied during final land preparation. The 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 hand weeding was done at 30-35 DAS to keep the plot weed free. The lalshak, mulashak and coriander leaf were harvested on 12 December 2023 and continued upto 5 January 2024. The Maize was harvested on 5 April 2024. Marginal Benefit Cost Ratio (MBCR) was calculated. Maize equivalent yield was calculated by converting the yield of lalshak, mulashak and coriander leaf based on the prevailing market prices. The data were analyzed statistically with open-source software CROPSTAT 7.2.

Results and Discussion

Maize Equivalent Yield (MEY): Maximum Maize equivalent yield was found in T₂ (18.71 t ha⁻¹) followed by T₄ (16.51 t ha⁻¹) and T₃ (16.27 t ha⁻¹) treatment (Table 1). The reason for the high MEY in T₂ treatment mainly due to the higher yield of lalshak as well as the similar maize yield of sole maize cultivation than the other treatment combinations. The lowest Maize equivalent yield (10.91 t ha⁻¹) was found from sole maize (T₁) cultivation.

Cost and return analysis: The highest gross return (Tk. 467778 ha⁻¹) and gross margin (Tk. 331403 ha⁻¹) was obtained from treatment T₂ (Maize+Lalshak) followed by T₄ (Maize+Coriander leaf) and T₃ (Maize+Mulashak) treatment due to the more yield of lalshak as well as get a good

market price. The lowest gross return (Tk. 272778 ha⁻¹) and gross margin (Tk. 140403 ha⁻¹) was obtained from treatment T₁ (Sole Maize).

Farmer's opinion: Farmer showed their interest for growing Maize with lalshak, mulashak and coriander leaf in a intermixed cropping system in char area of Gaibandha.

Table 1. Yield of different crops and Maize equivalent yield (MEY) during 2023-24.

Treatments	Maize yield (t ha ⁻¹)	Lalshak yield (t ha ⁻¹)	Mulashak yield (t ha ⁻¹)	Coriander leaf yield (t ha ⁻¹)	Maize equivalent yield (t ha ⁻¹)
T ₁ (Sole Maize)	10.91	0.00	0.00	0.00	10.91
T ₂ (Maize + Lalshak)	9.11	12.33	0.00	0.00	18.71
T ₃ (Maize + Mulashak)	8.89	0.00	9.22	0.00	16.27
T ₄ (Maize + Coriander leaf)	8.78	0.00	0.00	3.22	16.51
LSD _{0.05}	1.03	-	-	-	2.45
CV (%)	11.3	-	-	-	9.4

Table 2. Cost and return analysis of mixed cropping during the year of 2023-24.

Treatments	Chilli Equivalent Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
T ₁ (Sole Maize)	10.91	272778	132375	140403	-
T ₂ (Maize + Lalshak)	18.71	467778	136375	331403	48.8
T ₃ (Maize + Mulashak)	16.27	406667	136375	270292	33.5
T ₄ (Maize + Coriander leaf)	16.51	412778	135375	277403	46.7

Conclusion

The mixed cropping of maize with lalshak, mulashak and coriander leaf gave higher yield and economic returns than other sole maize cultivation.

86. EVALUATION OF APSIM MODEL FOR MAIZE GROWN UNDER DIFFERENT N RATES IN T. AMAN-CANOLA-MAIZE CROPPING SYSTEM

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Abstract

Maize is an important cereal grown in the sub-tropical environment of the Eastern Gangetic Plains (EGP) and its area of cultivation is expanding in Bangladesh over time due to its high yield potential and economic profit. Maize cultivation, including nitrogen (N) management and crop modelling provides numerous benefits, such as increased yield, resource use efficiency, climate resilience, research innovations and sustainable agriculture practices. In this aspect, a field experiment was conducted at the On-Farm Research Division (OFRD) research field, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur from October 2022 to April 2023. The experiment consisted of five levels of N viz., control, 125 Kg ha⁻¹, 250 Kg ha⁻¹, 375 Kg ha⁻¹ and 500 kg ha⁻¹. A robustly calibrated and validated model, when used from inputs of short-term experiments and long-term climate data, can help understand the risk of the crops grown and explore opportunities for agronomic interventions. We, therefore, aim to evaluate the performance of APSIM model for maize grown under different N rates in T. Aman – Canola – Maize cropping system. The simulated grain yield and biomass yield were found 12.44 t ha⁻¹ and 24.96 t ha⁻¹ with the recommended dose of N (250 Kg ha⁻¹). The high value of the correlation coefficient (R²) in validation for both maize yield (R² = 0.953) and biomass yield (R²=0.961) indicated a strong agreement between the observed and simulated data.

Introduction

Maize (*Zea mays* L.) comes in third behind rice and wheat as one of the most widely grown crops in the world in terms of overall output and planting area (Erenstein et al., 2022). In the Bangladesh context, farmers face several challenges in maize cultivation. Among different obstacles, nitrogen (N) is a key factor for determining the yield of maize. N management requires a multifaceted approach that addresses agronomic, environmental, and socio-economic factors. By conducting regular soil testing to assess nutrient levels and pH can help determine appropriate N application rates. Precision agriculture techniques can be implemented, such as variable rate N application, which can optimize fertilizer use efficiency and minimize N losses (Fiorentino et al., 2020).

Based on a field experiment, a maize simulation study is of significant practical value for rational industrial zoning and production management decision-making. Because of environmental and seasonal fluctuations, the majority of maize agronomic recommendations are based on limited sets of field trials that are rarely repeatable (Tsimba, 2011). Therefore, Agricultural simulation models (CSMs) are necessary to enable the use of less time-consuming and expensive system-based research methodologies to solve agricultural challenges (Soltani et al., 2003). Agricultural simulation models, such as the Agricultural Production Systems Simulator (APSIM) can convey agro-technology to farmers, policymakers, and planners (Keating et al., 2003). The APSIM model allows for a detailed description of the farming system, decision, and the simulation of associated soil water and salinity dynamics, together with the interactions between maize and other crops (Radanielson et al. 2018). In Asia, APSIM has undergone evaluations with various habitats, crops, and management scenarios. To ensure the validity of the model performances, the parameterization and calibration of the APSIM-Maize models are required for new cultivars, settings, and subsequent model evaluations (Ahmed et al., 2014). Considering the mentioned significance, the current research was undertaken with the following objectives:

- To evaluate the effect of N rates on the yield attributing parameters and yield of maize
- To estimate the variation of maize yield under different N rates using the APSIM-Maize model.
- To assess the capacity of the APSIM-Maize model for simulating maize crop performance

Materials and Methods

A robust procedure of model parameterisation, calibration, and validation was followed and then statistical analyses were undertaken to evaluate the model performance.

Description of the model used (APSIM v7.10): The APSIM software provides a dynamic farming systems modelling framework, which contains interconnected modules of key farming system components to be plugged in to simulate biophysical process in the systems (Holzworth et al., 2014; Keating et al., 2003; McCown et al., 1996). The model comprises biophysical modules, a flexible management module, and various data input-output modules connected to a central simulation engine that drives the simulation of the systems.

The key strength of APSIM is that it focuses on cropping systems rather than individual crops, and keeps soil dynamics and management in the central position over crop seasons. Soil state variables are simulated continuously with regards to weather and management and crops “come to the soil finding it in one state and leave it in another state” after completing its term (McCown et al., 1996). APSIM balances the supply and demand sides of the simulation as impacted by weather and management, rather than being focussed on demand like most crop models.

The generic plant model incorporated into APSIM (Wang et al., 2002) has now been able to simulate 30 different crops (Holzworth et al., 2014). The plant modules simulate key physiological processes on a daily time-step basis and simulate potential production which is constrained by the availability of resource supply (soil water, N), daily climate (solar radiation, maximum and minimum temperature, and rainfall) and management factors (sowing date, tillage type, irrigation, and N apply date, residue management, etc.) (Keating et al., 2003). Two model options are available for soil water balance simulation in APSIM - a cascading layer approach

(SOILWAT: simple one using “tipping bucket” approach) (Probert et al., 1998) and Richards equation method (APSWIM: using numerical solution) (Huth et al., 2012; Verburg et al., 1996). The surface organic matter (SURFACEOM) module has the function of addition, removal, incorporation, decomposition in situ, and soil cover (Probert et al., 1998; Thorburn et al., 2001). The soil N (SOILN) module simulates the processes of nitrification and denitrification in the soil, stubble/roots left from the previous crop, and thus N supply to the plant (Probert et al., 1998). SOILN also simulates the soil carbon balance. APSIM treats soil organic matter as a three pool system. The fresh organic matter (FOM) pool comprises the incorporated crop residues and roots. After decomposition of the FOM pool, the labile soil microbial biomass (BIOM) pool, and the more stable humus (HUM) pool are formed. The decomposition process of organic matter pools releases mineral N and the rates of mineralisation depend on soil temperature and water supply during the process (Probert et al., 1998). APSIM pond (POND) module simulates different biological and chemical processes occurring in the flooded rice field (Gaydon et al., 2012).

Experimental sites: The field experiment was established on experimental farms of the Bangladesh Agricultural Research Institute (BARI), Gazipur (23° 59' 08" N latitude and 90° 24' 36" E longitude) and it belongs to the Madhupur Tract agro-ecological zone (AEZ-28).

Description of the experimental datasets: The experiment was laid out in a randomized complete block (RCB) design with three replications. The size of each unit plot was 7 m × 3 m (21 m²). BARI hybrid maize-16 was used in this study. The Following treatments were included in the experiments:

- N₀- No nitrogen (control)
- N₁- Half of recommended nitrogen (125 kg N ha⁻¹)
- N₂- Recommended nitrogen (250 kg N ha⁻¹)
- N₃- 1.5 times of recommended nitrogen (375 kg N ha⁻¹)
- N₄- 2.0 times of recommended nitrogen (500 kg N ha⁻¹)

APSIM parameterisation: The APSIM model (version 7.5) was parameterised by supplying measured data to the model such as weather, soil properties, crop varieties, crop phenology, crop management practices followed and inputs supplied. *Weather data:* The weather data (daily maximum and minimum temperatures, rainfall, and sunshine hours) for Gazipur was collected from the weather records of the Bangladesh Meteorological Department (BMD). Solar radiation data were calculated from long-term interpolated sunshine hours data following the method used by Poulton (2010). These data were then used as weather inputs to APSIM.

Soils data: APSIM requires measurable soil physical parameters on a layer basis including bulk density, saturated water content, drained upper limit, lower limit (expressed in volumetric moisture content terms), soil water content (SWCON), and saturated hydraulic conductivity, and soil chemical parameters such as organic C, pH, and mineral N (NO₃⁻ and NH₄⁺). Details of soil data used in APSIM simulations were collected from Akhter et al. (2014).

APSIM calibration: Calibration was done by adjusting model parameters to improve the match between simulated and observed data, especially when discrepancies were identified during validation (Keating *et al.*, 2003). Optimization techniques, such as trial-and-error and more advanced algorithms were used to find parameter sets that minimized the difference between simulated and observed values (Holzworth *et al.*, 2014). Calibration was performed cautiously to avoid overfitting the model to specific datasets and the calibrated parameters were justified based on physiological and agronomic principles (Thorburn *et al.*, 2001). In the calibration process, the APSIM model was run with best possible guess values and then model outputs were compared with observed data (crop development stages, grain yield, biomass, soil water, soil NO₃-N) from the selected treatments and the process was repeated with re-estimated values until a satisfactory performance in simulating the output variables of interest (such as, yield) was achieved (Chaki *et al.* 2022).

Crop phenology: BARI hybrid maize-16 was used in this simulation study. The simulated (using

APSIM-Maize model) dates of sowing, emergence, flowering, physiological maturity, and harvest were compared with observed phenology dates for maize, and model parameters were adjusted until a good agreement was achieved. The APSIM-crop phenology coefficient values were varied iteratively to produce a close match between the observed and simulated phenology dates.

Grain and stover yield: Maize was harvested 3-5 days after physiological maturity, and grain and stover yield was measured by harvesting an area of 10 m² in the centre of each plot. The grain was threshed using a plot thresher and fresh grain weight was measured using a digital balance. Grain moisture content was determined by a grain moisture meter (model: GMK-303RS, Korea) for calculation of dry grain yield. The stover was dried in an oven at 70 °C for 3-5 days until the weight was constant.

APSIM validation: Validation was done by assessing the model's performance by comparing simulated results with observed data from independent field experiments (Holzworth *et al.*, 2014, Thorburn *et al.*, 2001). Statistical measures such as root mean square error (RMSE), coefficient of determination (R^2) were taken out from the simulated value and those were biased to evaluate the agreement between simulated and observed values. Validation ensured that the model accurately represented real-world processes and helped to identify areas for improvement (Robertson *et al.*, 2002). The well parameterized and calibrated APSIM model was validated against the experimental datasets to check the accuracy of the model's calibration.

Statistical tests used: The coefficient of determination (r^2), slope (α), and intercept (β) values from the linear regression of observed versus simulated data (1:1 graph) were used for the evaluation of the calibrated model.

Results and discussion

Crop phenology

APSIM-Maize crop module successfully simulated phenological development stages such as, sowing, emergence, end of juvenile, floral initiation, flowering, physiological maturity and harvest ripe. After calibration, there were good agreements between simulated and observed dates of phenological development stages for selected treatments. From the calibrated graph (Figure 1) it could be interpreted that the observed emergence occurred 9 days after sowing (DAS), however, the simulated emergence date was earlier. The observed end of juvenility occurred 1-2 days after the simulated stage and the simulated dates of the later three stages flowering, physiological maturity and harvest ripe were almost the same as observed.

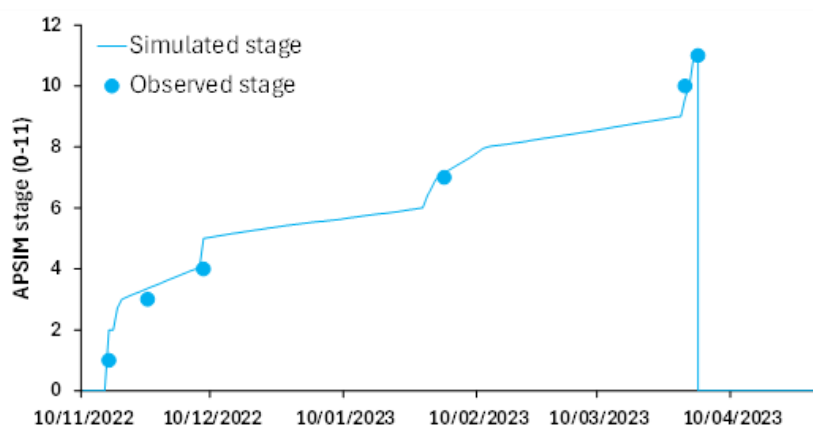


Figure 1. Simulating crop phenological development

Grain and biomass production

After an acceptable model performance in capturing the crop phenology, the next step was simulating grain and biomass production. As part of calibration and validation of crop production, the observed and simulated grain and biomass yields for each maize variety were compared. There was generally good agreement between simulated and observed grain yield and biomass

yield over time which was illustrated in Figure 2. The observed grain yield, $11.95 \pm 0.14 \text{ t ha}^{-1}$ (mean $\pm$ sd) and observed biomass yield, $24.62 \pm 0.68 \text{ t ha}^{-1}$ (mean $\pm$ sd) was closely associated with the simulated grain yield (12.44 t ha^{-1}) and simulated biomass yield (24.96 t ha^{-1}) respectively.

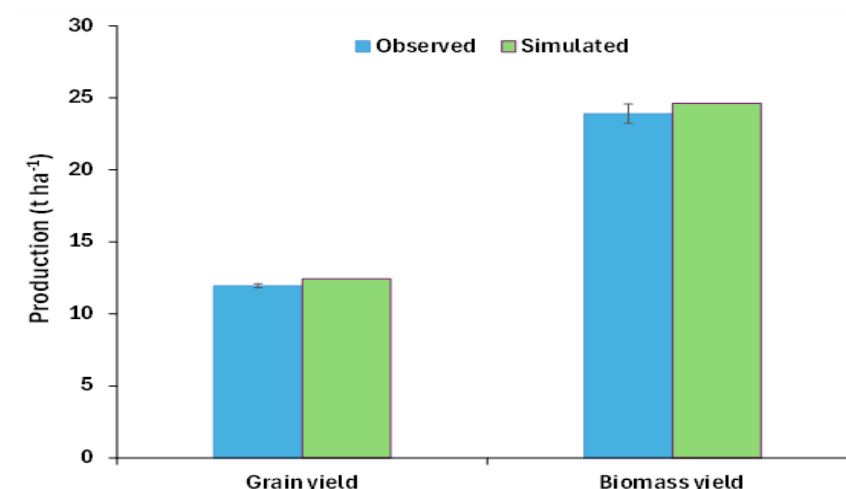


Figure 2. Comparison between observed and simulated grain and biomass yield

The overall model validation was performed using the statistical analysis tool Linear regression. It was initially used to compare paired data points for measured and simulated aboveground biomass and grain yield. The slope (α), intercept (β), and coefficient of correlation (R^2) of the linear regression were computed. The correlation coefficient (R^2) was high for both calibration and validation datasets of grain and biomass production (grain, $R^2 = 0.953$; biomass, $R^2 = 0.961$), indicating that there was a strong correlation between them (Figure 3).

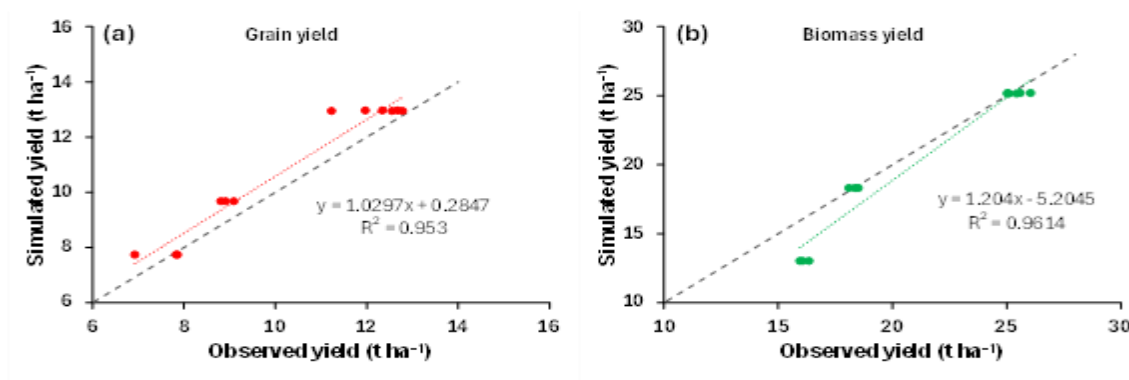


Figure 3. Overall validation performance of APSIM in simulating grain and biomass production across the rest of the treatments

Conclusions

Simulation models must be well-tested before being employed in scenario analyses. This research showed that APSIM performed in a statistically robust manner in simulating cropping system performance of maize over a wide range of N management practices. The calibration and validation process of the APSIM maize model has yielded promising results, demonstrating its proficiency in accurately simulating maize growth and yield under varying N rates. We think that the outcome of this study will help increase maize production by taking appropriate agronomic interventions.

Remarks: The analysis has not yet been completed. We have just presented our initial analysis incorporating maize data only (T. aman and canola simulation is underway) in this primary report. We think that a better conclusion can be made after the completion of the whole analysis.

87. YIELD PREDICTION OF LENTIL BY LINKING CROP CUTS WITH PHENOLOGICAL ANALYSIS OF SENTINEL-2 TIME SERIES

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Abstract

A study was conducted for two consecutive years (2021-22 and 2022-23) to predict the yield of lentil at Godagari Upazila of Barind, Rajshahi. The sample data was collected from 117 farmer fields in 2021-22 and 203 farmer fields in 2022-23 by the survey using the Kobo Toolbox to get information on cultivated lentil variety, planting and harvest time, and yield. The study revealed that BARI masur-8 was mostly grown by farmers. Using satellite-derived maximum NDVI and EVI were used to develop a model for yield prediction of lentils. However, a limited number of data was collected and analyzed, a best-performing model was tried to identify to predict the yield. The study noticed that the linear regression model predicted yield by 17-24% whereas the support vector model performed well during 2021-22 and the ensemble model performed well in 2022-23.

Introduction

Lentil (*Lens culinaris* L.) is an annual legume of the family Fabaceae. This pulse crop is a good source of protein; therefore, it is an important crop considering its food value and economic value. The production of lentils or any other crop is highly related to its vegetative growth. Nowadays, the phenology and growth of crops can be monitored from satellite imagery. The satellite-derived Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) are good indicators of vegetation greenness and activity (Peng et al, 2010; Cunha and Silva, 2020). It would be a good opportunity to use NDVI and EVI to understand lentils' phenology from satellite and monitor their growth. Besides this, lentil yield can also be predicted using early before harvest. The use of satellite remote sensing has become an effective way of making yield predictions due to its advantages of simple data acquisition, low cost, efficiency, wide spatial coverage, and short operating cycles (Peng et al. 2014; Zhang et al. 2019; Wang et al. 2020). The traditional agricultural yield forecasting methods mainly include agronomic forecasting methods (Feng and Wu, 2006), crop-growth models (Thorp et al, 2008), and meteorological statistics methods (Betbeder et al, 2016), and these are used to establish crop yield models based on different perspectives. These methods not only consume a lot of manpower and material resources; however, there are also spatial and temporal gaps in the results. Vegetation indices like NDVI and EVI have been widely used to predict crop yields over the past few decades (Jin et al, 2017; Kamir et al, 2020). However, these vegetation indices mainly reflect the greenness of vegetation and cannot fully capture environmental stresses on crops (Zhang et al, 2021). This means that the role of other vegetation indices such as the Normalized Difference Water Index (NDWI) (Gao, 1996), which reflects the crop water content, and the Red Edge Position Index (REP), which is sensitive to changes in chlorophyll concentration, should also be considered when making yield estimates.

The traditional method of estimating yields is the construction of linear regression models linking vegetation indices or climatic variables that track the evolution of crop canopy spectral reflectance patterns over the growing season and yields (He and He, 2013). However, although the calculations may be simple, the relationships involved are not simply linear, and these methods do not capture yield variations well. In the last few years, with the advent of the big data era, conditions have been created for machine-learning methods (Zhang et al, 2021), and more and more computer-dependent machine-learning models have been applied to crop yield estimation, usually outperforming traditional linear regression. Deep learning is an advanced Machine Learning method that uses multiple, stacked nonlinear layers, at each of which the original input data can be transformed into a higher and more abstract representation (Cai et al, 2019), such as Long Short-Term Memory (LSTM), deep Neural Network (DNN), Convolutional Neural Network (CNN), and Recurrent Neural Network (RNN), have produced higher accuracies across various regression and classification tasks (LeCun et al, 2015). Therefore, a study was designed with two research questions: (1) is it possible to identify and monitor the phenology of lentils from Sentinel-2 imagery using machine learning algorithms and TIMESAT software, and

(2) whether a model could be developed using machine learning techniques to predict the yield of lentil early before harvest.

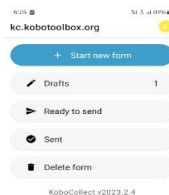
Materials and Methods

Study area: The study was conducted consecutive two years (2021-22 and 2022-23) at Godagari upazila of Rajshahi district covering the area under 24° 39'54" to 24° 6'15" N latitude and 88° 40'52" to 88° 48'54" E longitude during 2021-22 and 24° 38'27" to 24° 43'50" N latitude and 88° 39'51" to 88° 47'89" E longitude during 2022-23.

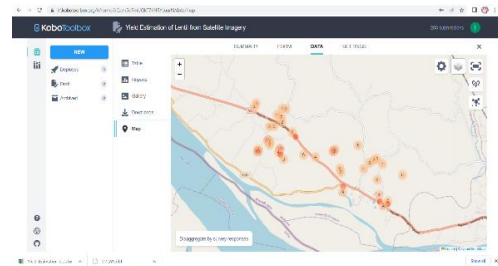
Data collection: This study obtained lentil data from plot-based manual surveys (Sun et al, 2020). The data on variety, soil type, planting, maturity and harvest dates, and yield of lentils were collected from the fields of 117 farmers in 2021-22 and 203 farmers in 2022-23 with GPS coordinates using the Kobo Toolbox.



Sample data collection from lentil fields by Kobo Toolbox installed in the mobile



Interface of Kobo Toolbox



View of the positions of the collected sample data in Kobo Toolbox

The sample data were collected by the Scientific assistants of OFRD, Barind, Rajshahi. The App of Kobo Toolbox was installed in their mobiles and their access was permitted to the lentil project having the pre-set questionnaire form. One lentil field is considered as one sample data point. After filling up information in the questionnaire form, all forms were submitted and the forms with the information were automatically saved in the server of Kobo Toolbox. From the server, the data were downloaded in an Excel file.

Data checking and pre-processing: After getting data into an Excel file, the data quality was checked at first following some techniques like visually checking data distribution or plotting the dataset in Box-plots. Then the abnormal or outlier data points were cleaned and again checked in QGIS. The data positions were corrected after checking in QGIS to minimize the error in getting EVI values. Then, the final corrected data was saved for final processing.

Data processing: The collected sample data were processed to get the phenology of lentils from satellite-derived EVI using Sentinel-2 time-series data and to develop a model for yield prediction. The multispectral data of Sentinel-2 imageries were extracted from the COPERNICUS/S2 hub. The Level-2 (atmospherically corrected) multispectral broadband and narrowband data were acquired for each collected sample data point at 5-day intervals and at 10 m resolution using Python codes in Google Earth Engine (GEE). The codes were run for two years separately in the GEE. For 2021-22, the number of collected Sentinel-2 images was 53 considering the period from 15 October 2021 to 31 March 2022. The image number was 59 from 15 October 2022 to 31 March 2023. The reflectance values of NIR, RED, and BLUE bands were considered to calculate the normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) at each sample point separately for the two years using the following equations.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$EVI = 2.5 \times \frac{NIR - RED}{1 + NIR + 6 \times RED - 7.5 \times BLUE}$$

Train and test models using Machine learning: Based on the relation of maximum NDVI ($NDVI_{max}$) and EVI (EVI_{max}) with yield, six machine learning models named Linear model (LM), RandomForest (RF) model, Support vector model (SVM), Gradient boost model, Artificial Neural Network, and the ensemble of RF, SVM, and Gradient boost models were run. Those models were

trained and tested with $NDVI_{max}$, EVI_{max} , and yield data at 80% and 20% ratios. The performance of the machine learning models was tested based on root mean square error (RMSE). Data were checked and cleaned again to improve the model. Lastly, we considered 105 cleaned data from 2021-22 and 159 data from 2022-23 for developing a good model for yield prediction.

Results and Discussion

Variety: The study found that the farmers of Godagari, Rajshahi grew mostly BARI lentil varieties (78% in 2021-22 and 92% in 2022-23). Among BARI lentil varieties, BARI masur-8 was cultivated by most of the farmers (Table 1).

Table 1: Cultivated lentil varieties with planting and harvest time in Godagari, Rajshahi during 2021-22 and 2022-23

Variety		Percentage of cultivation		Planting time	Harvest time
		2021-22	2022-23		
BARI variety	BARI masur-3	23	4.5	10 Nov' to 08 Dec' 2021 05 Nov' to 10 Dec' 2022	27 Feb' to 20 Mar' 2022 26 Feb' to 20 Mar' 2023
	BARI masur-6	12	3.5	09 Nov' to 07 Dec' 2021 28 Nov' to 04 Dec' 2022	26 Feb' to 20 Mar' 2022 06 to 17 Mar' 2023
	BARI masur-7	10	-	15 Nov' to 04 Dec' 2021	08 to 21 Mar' 2022
	BARI masur-8	33	92	12 Nov' to 08 Dec' 2021 13 Nov' to 08 Dec' 2022	08 to 20 Mar' 2022 27 Feb' to 21 Mar' 2023
		78	100		
Others		22	-	15 Nov' to 09 Dec' 2021	20 Feb' to 17 Mar' 2022

Planting and harvest date: Planting of all lentil varieties started from the 2nd week of November and continued up to the 2nd week of December. The harvest of the varieties was completed within 21 March (Table 1).

Maximum NDVI, and EVI, and their relation with yield of lentil: Before cleaning the data, the maximum NDVI values ranged from 0.341 to 0.828 in 2021-22 and 0.138 to 0.689 in 2022-23, the maximum EVI values ranged from 0.191 to 0.622 in 2021-22 and 0.116 to 0.715 in 2022-23, and the yields of lentils ranged from 0.54 to 2.52 t ha⁻¹ in 2021-22 and 0.56 to 2.40 t ha⁻¹ in 2022-23. After cleaning the data, the ranges of maximum NDVI values were 0.424 to 0.828 in 2021-22 and 0.343 to 0.674 in 2022-23, EVI values were 0.259 to 0.622 in 2021-22 and 0.256 to 0.685 in 2022-23, and the yields were 0.54 to 2.52 t ha⁻¹ in 2021-22 and 0.75 to 2.39 t ha⁻¹ in 2022-23.

The yield of lentils was strongly correlated with EVI_{max} (48% in 2021-22 and 37% in 2022-23) than $NDVI_{max}$ (40% in 2021-22 and 26% in 2022-23) (Table 2). The regression analysis results expressed that yields of lentils were highly dependent on EVI_{max} ($p < 1\%$ in 2021-22 and $p < 0.01\%$ in 2022-23) than $NDVI_{max}$ ($p = ns$ in 2021-22 and $p < 0.01$ in 2022-23) in both years (Table 3).

Table 2. Correlation matrix for $NDVI_{max}$, EVI_{max} and yield of lentil during 2021-22 and 2022-23

	Yield (t ha ⁻¹)	$NDVI_{max}$	EVI_{max}
Yield (t ha ⁻¹)	1		
$NDVI_{max}$	0.399 (2021-22); 0.279 (2022-23)	1	
EVI_{max}	0.475 (2021-22); 0.387 (2022-23)	0.687 (2021-22); 0.912 (2022-23)	1

Table 3. Linear regression model performance in 2021-22 and 2022-23

Independent variable	2021-22				2022-23			
	Default model		Improved model		Default model		Improved model	
	P-value	R ²	P-value	R ²	P-value	R ²	P-value	R ²
$NDVI_{max}$	0.423427	0.16	0.249536	0.24	0.000885	0.07	0.014445	0.17
EVI_{max}	0.026109		0.001852		0.000208		1.64E-05	

Performance of Linear regression model: The performance of the linear regression model was improved after cleaning the data. The results showed that the model was able to predict yield by

24% for 2021-22 and 17% for 2022-23 (Table 3). However, this model can be improved further, only needing a large number of datasets.

Performance of ML models: The best-performing machine learning model was the support vector model (SVM) in 2021-22 which could predict yield by 41% with the lowest RMSE (Table 4). On the contrary, the ensemble model performed well (28%) in 2022-23.

Table 4. Performance of machine learning models with RMSE

Sl. No.	Model	2021-22				2022-23			
		Default		Improved		Default		Improved	
		R ²	RMSE	R ²	RMSE	R ²	RMSE	R ²	RMSE
1.	Linear	-0.01	0.49	0.23	0.34	0.07	0.31	0.12	0.25
2.	SVM	0.02	0.50	0.41	0.31	0.08	0.30	-1.16	0.32
3.	Random Forest	-0.01	0.51	0.18	0.36	-0.04	0.32	-1.26	0.32
4.	Gradient Boosting	-0.02	0.51	0.002	0.40	-0.21	0.35	-1.55	0.34
5.	SGDRegressor	0.07	0.49	0.28	0.34	0.01	0.32	-0.17	0.23
6.	MLPRegressor (ANN)	0.03	0.50	0.17	0.37	-0.18	0.34	-0.86	0.29
7.	Ensemble	-0.22	0.56	-0.16	0.43	0.01	0.32	0.28	0.19

Conclusion

The study identified that farmers of Godagari, Rajshahi mostly grow BARI masur-8. The yield of lentils highly depended on the maximum EVI rather than the maximum NDVI. However, some other indices that could be more responsible for yield prediction need to be studied. Linear regression model could predict lentil yield by 17-24%. The best-performing machine learning model for 2021-22 was the support vector model (SVM) and the ensemble model performed best during 2022-23. The study should continue to get the best model for yield prediction of lentils with the large number dataset and in wider environments.

88. EFFECT OF NITROGEN FERTILIZER AND WEED MANAGEMENT ON WEED AND YIELD OF T. AMAN RICE-WHEAT-MUNGBEAN CROPPING PATTERN UNDER CONSERVATION AGRICULTURE SYSTEMS

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Abstract

Management of nitrogen and weed can play a significant role in yield improvement of T. Aman rice-wheat-mungbean cropping pattern under conservation agriculture systems. A study was designed and executed in three consecutive years (2022-24) to evaluate the effect of nitrogen and weed management on weed and crop yield of strip-tilled non-puddled T. Aman rice. and strip-planted wheat and also to optimize management of nitrogen and weed for achieving maximum yield. The study was initiated with strip-tilled non-puddled T. Aman rice in 2022 at the on-station field of On-Farm Research Division, BARI, Gazipur. Three nitrogen rates viz. no nitrogen fertilizer (0 kg N ha⁻¹), the recommended rate of nitrogen fertilizer (85 kg N ha⁻¹ for rice and 92 kg N ha⁻¹ for wheat), and double recommended nitrogen fertilizer rates (170 kg N ha⁻¹ for rice and 184 kg N ha⁻¹ for wheat); and four weed management treatments viz. no weeding control, weed-free control, application of one pre-emergence herbicide (pretilachlor for rice; pendimethalin for wheat) and application of pre-emergence followed by post-emergence herbicide (bispiribac-sodium for rice and carfentrazone-ethyl for wheat) were tested. The experiment was laid out in a factorial randomized complete block design with three replications. The study identified that nitrogen rate and weed management had significant effects on weed biomass and grain yields of strip-tilled un-puddled T. Aman rice and strip-tilled wheat. The study suggests application of the recommended rate of nitrogen (85 kg N ha⁻¹ for rice and 92 kg N ha⁻¹ for wheat) with the spray of pre-emergence followed

by post-emergence herbicides to control weeds of Aman rice and wheat most effectively and to obtain optimum grain yields.

Introduction

Heavy tillage and intensive crop cultivation are the main reasons for degradation of soil health and quality. To improve soil quality as well as soil health, conservation agricultural (CA) systems can be a better option (Bell and Haque, 2017). CA is a package of technologies that based on three principles: (i) minimum soil disturbance, (ii) crop residue retention and (iii) crop rotation (FAO, 2011). Minimum tillage helps to reduce soil erosion as well as reduces cultivation cost as it requires less fuel, labour and also less time (Hossain *et al.*, 2015). Minimum tillage also conserves soil moisture and keeps soil micro-environment cool (Salahin *et al.*, 2017). Addition of previous crop residue enriches soil quality through enhancing soil organic matter content. Moreover, crop performed better under conservation agricultural systems (Bell *et al.* 2017; Hossain *et al.*, 2014).

Nitrogen (N) is an essential nutrient for crop growth and yield (Xu *et al.*, 2012). Besides having an influence on crops, nitrogen has a significant influence on weeds. Booth *et al.* (2003) mentioned that weed germination is triggered by various factors like soil temperature, soil moisture, light, and N. Sweeney *et al.* (2008) and Travlos *et al.* (2018) reported that N fertilizer applications increase weed growth, but the influence of N on weed emergence is dependent on the weed species, seed source, and environmental condition. Blackshaw and Brandt (2017) evaluated the effect of N fertilizer rate on the competitive ability of weed species in wheat and identified a significantly high N-responsive weed species to the increased N fertilizer rate. Information regarding N fertilizer effects on crop-weed competitive interactions might be helpful in developing improved weed management programs. Moreover, weed management has a strong role for obtaining optimum yield of rice and wheat and even under conservation agriculture systems. Therefore, a study has been designed to evaluate the effect of nitrogen fertilizer and weed management on weed and yield of T. *Aman* rice and wheat in rice-wheat-mungbean cropping pattern under conservation agriculture systems.

Materials and Methods

The experiment was started with *Aman* rice in 2022 at the on-station field of the On-farm research division (OFRD), Bangladesh Agricultural Research Institute, Gazipur (23°59'13.2978" N and 90°24'36.33695" E). The experimental soil was sandy loam in texture having 55.28% sand, 38% silt and 6.72% clay. The status of the initial soil was analyzed and the chemical properties of soil are presented in Table 1.

Properties	pH	OM (%)	K (meq/100 ml)	Total N (%)	P	S	B	Zn
					ppm			
Value	6.8	1.86	0.174	0.10	54	27.4	0.22	1.95
Interpretation	Netural	M	M	L	VH	Opt	L	H

Two factors *viz.* rate of nitrogen fertilizer and weed management were considered as the treatments. The recommended rate of nitrogen fertilizer (85 kg N ha⁻¹) was tested with no nitrogen (0 kg N ha⁻¹) and double recommended nitrogen fertilizer rates (170 kg N ha⁻¹). In the case of weed management factor, four treatments were imposed *viz.* no weeding control, weed-free control, application of one pre-emergence herbicide (pendimethalin) and application of one pre-emergence herbicide (pendimethalin) followed by one post-emergence herbicide (bispiribac-sodium). The experiment was laid out in a factorial randomized complete block design with three replications. The unit plot size was 2.5 m × 4.0 m. The study field was cleaned from weeds by pre-planting application of Roundup (Glyphosate @ 80 mL L⁻¹) at 05 days before strip-tilled the field. Twenty-five days old seedlings of *Aman* rice cv. BRRI dhan87 were transplanted maintaining 15 cm × 20 cm spacing with 3 seedlings per hill. During the final land preparation, phosphorus, potassium and sulphur fertilizers @ 12, 53 and 12 kg ha⁻¹, respectively were broadcasted in the form of triple super phosphate (TSP), muriate of potash (MoP) and Gypsum. Nitrogen fertilizer as per the treatment requirement was applied into three splits: 10

days and 30 days after transplanting and during the panicle initiation stage. Shallow irrigation was provided for four times to ensure proper germination and growth of wheat. Crop protection measures were also taken as and when necessary. T. *Aman* rice was harvested at maturity. After rice, strip-planted wheat cv. BARI Gom33 was grown on 15 November 2022 in the same field following the same experimental design. Wheat seeds were sown within the strips apart by 20 cm at the rate of 150 kg ha⁻¹ with the help of a two-wheel tractor driven strip planter. Before strip till, the land was fertilized with phosphorus, potassium and sulphur in the form of triple super phosphate (TSP), muriate of potash (MoP) and Gypsum @ 160, 50 and 110 kg ha⁻¹, respectively. All fertilizers were broadcasted in the field just before seeding wheat. In wheat, three nitrogen rates (0, 92, and 184 kg per ha⁻¹) and four weed managements viz. no weeding, weed-free, application of pre-emergence herbicide (pendimethalin) and one pre-emergence (pendimethalin) followed by one post-emergence herbicide (carfentrazone-ethyl) were evaluated. Nitrogen fertilizer was applied in the form of Urea in two equal installments. The first installment of urea was applied at 15 days after sowing (DAS) and the second one was at the panicle initiation stage (PI). Pendimethalin (pre-emergence herbicide) was applied at 02 DAS and carfentrazone-ethyl plus isoproturon (late post-emergence herbicide) was applied at 25 DAS. Shallow irrigation was provided for four times to ensure proper germination and growth of wheat. Crop protection measures were also taken as and when necessary. Wheat was harvested at maturity and after that seeds of mungbean were sown at the rate of 35 kg ha⁻¹ within the strips apart by 20 cm. The crop is now at pod formation stage. The detail information on variety, date of planting and harvest of T. *Aman* rice, wheat and mungbean are provided in Table 2.

Table 2. Variety, date of planting and date of harvest of wheat, mungbean and T. *Aman* rice during 2017-2019 at Gazipur

Crop	Variety	Date of planting	Date of harvest
T. <i>Aman</i> rice	BRRI dhan87	27 July 2022	07 November 2022
		24 July 2023	09 November 2023
Wheat	BARI Gom-33	15 November 2022	12 March 2023
		16 November 2023	13 March 2024
Mungbean	BARI mung-6	19 March 2023	20 May 2023
		16 March 2023	03 may 2024

Weed density and biomass data were collected from randomly selected 50cm × 50cm quadrat spots. Weed species were identified and the weed populations of each species were counted from a 1m² area. The heights of wheat plants were measured at harvest from randomly selected ten plants. Data on yield contributing characters were recorded from randomly selected ten plants. Yield data were collected from the central 2m × 3m area of each plot and converted into t ha⁻¹. Collected data were analyzed by using a statistical package program 'RStudio' (version R 4.1.2).

Results and Discussion

T. *Aman* Rice

Weed biomass: The strip-tilled non-puddled field of T. *Aman* rice was infested by eleven (11) weed species among which five were grass weeds (*Cynodon dactylon*, *Echinochloa crus-galli*, *Echinochloa colona*, *Leersia hexandra* and *Paspalum comersoni*), one sedge weed (*Fimbristylis miliacea*) and five broadleaf weeds (*Ludwigia decurrens*, *Jussiaea repens*, *Monochoria vaginalis*, *Enhydra fluctuans* and *Alternanthera sessilis*). The most infested weed species was *Echinochloa crus-galli*.

The weed biomass was significantly affected by nitrogen rate and weed management and by their interaction effect (Table 3). The highest weed biomass was recorded from the unweeded plots with 170 kg N application ha⁻¹ (Table 4). Application of pre-emergence (pendimethalin) followed by post-emergence (bispyribac-sodium) herbicides with 85 kg N ha⁻¹ had the lowest weed biomass (Table 4).

Table 3. Effect of nitrogen rate and weed management on total weed biomass at 35 days after transplanting and grain yield of strip-tilled non-puddled T. *Aman* rice during 2022 and 2023 at Gazipur

Treatment	2022		2023	
	Total weed biomass	Grain yield	Total weed biomass	Grain yield
Nitrogen rate (N)	***	***	***	***
Weed management (W)	***	***	***	***
N×W	***	***	***	**

Here, fb = followed by, HW = hand weeding, CV = co-efficient of variance, *** = 0.1% level of significance

Grain yield: The grain yield of strip-tilled non-puddled T. *Aman* rice was significantly affected by nitrogen rate and weed management and by their interaction (Table 3). The highest grain yield (6.97 t ha⁻¹ in 2022 and 5.05 t ha⁻¹ in 2023) was obtained from the application of pre-emergence (pendimethalin) followed by post-emergence (bispiribac-sodium) herbicides with 85 kg N ha⁻¹ (Table 4). On the other hand, no weeding with no N fertilizer application produced the lowest grain yield (2.05 t ha⁻¹ in 2022 and 1.23 t ha⁻¹ in 2023).

Table 4. Interaction effect of nitrogen rate and weed management on total weed biomass at 35 days after transplanting and grain yield of strip-tilled non-puddled T. *Aman* rice during 2022 and 2023 at Gazipur

Treatment	2022		2023	
	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)
N ₀ W ₀	32.03 c	2.05 h	58.40 c	1.23 f
N ₀ W ₁	15.88 efg	3.55 f	24.07 ef	3.50 c
N ₀ W ₂	21.32 c-f	3.51 f	37.57 d	3.05 d
N ₀ W ₃	7.52 g	3.84 ef	30.93 e	3.43 cd
N ₁ W ₀	62.93 b	2.77 g	71.73 b	2.38 e
N ₁ W ₁	12.63 fg	5.07 d	26.40 e	3.90 b
N ₁ W ₂	30.24 c	5.22 d	29.87 e	4.02 b
N ₁ W ₃	21.68 c-f	6.74 ab	19.07 f	5.05 a
N ₂ W ₀	80.21 a	4.16 e	87.67 a	2.30 e
N ₂ W ₁	27.50 cde	5.63 c	30.67 e	4.71 a
N ₂ W ₂	28.67 cd	6.60 b	38.93 d	4.19 b
N ₂ W ₃	17.43 d-g	6.97 a	29.47 e	4.66 a
CV (%)	24.5	4.38	9.01	6.71

In a column, means with the similar letter(s) are identical as per LSD_{0.05}

Wheat

The strip-tilled wheat field was infested by fifteen (15) weed species among which four were grass weeds (*Cynodon dactylon*, *Echinochloa colona*, *Eleusine indica* and *Digitaria sanguinalis*), one sedge weed (*Cyperus rotundus*) and eleven broadleaf weeds (*Eclipta prostrata*, *Physalis heterophylla*, *Ludwigia decurrens*, *Jussiaea kabera*, *Gnaphalium album*, *Lindernia procumbens*, *Chenopodium album*, *Portulaca oleracea*, *Enhydra fluctuans*, and *Alternanthera sessilis*). The most infested weed species was *Echinochloa colona*.

The weed biomass was significantly affected by nitrogen rate and weed management and by their interaction effect (Table 5). The highest weed biomass was recorded from the unweeded plots with 192 kg N application ha⁻¹ (Table 6). Application of pre-emergence followed by post-emergence (carfentrazone-ethyl) herbicides with 184 kg N ha⁻¹ had the lowest weed biomass (Table 4).

Table 5. Effect of nitrogen rate and weed management on total weed biomass at 35 days after sowing and on grain yield of strip-tilled wheat during 2022-23 and 2023-24

	2022-23		2023-24	
Treatment	Total weed biomass	Grain yield	Total weed biomass	Grain yield
Nitrogen rate (N)	***	***	***	***
Weed management (W)	***	***	***	***
N×W	***	ns	***	ns

Here, fb = followed by, HW = hand weeding, CV = co-efficient of variance, *** = 0.1% level of significance

The grain yield of strip-planted wheat was also significantly affected by nitrogen rate and weed management and by their interaction (Table 5). The highest grain yield (3.62 t ha⁻¹ in 2022-23 and 4.00 t ha⁻¹ in 2023-24) was obtained from the application of pre-emergence followed by post-emergence (carfentrazone-ethyl) herbicides with 184 kg N ha⁻¹ (Table 6). On the other hand, no weeding with no N fertilizer application produced the lowest grain yield (1.30 t ha⁻¹ in 2022-23 and 0.65 t ha⁻¹ in 2023-24).

Table 6. Effects of nitrogen rate and weed management and their interaction on total weed biomass at 35 days after sowing and grain yield of strip-tilled wheat during 2022-23 and 2023-24 at Gazipur

Treatment	2022-23		2023-24	
	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)
0 kg N ha ⁻¹ + No weeding control	30.44 c	1.30 f	18.7 b	0.65 d
0 kg N ha ⁻¹ + Weed-free control	15.46 ef	2.27 d	3.9 g	1.67 c
0 kg N ha ⁻¹ + PRE herbicide	21.75 d	1.69 ef	12.4 cd	1.50 c
0 kg N ha ⁻¹ + PRE fb POST herbicides	19.33 de	1.77 e	12.5 cd	1.76 c
92 kg N ha ⁻¹ + No weeding control	42.16 b	2.37 d	22.0 b	1.09 cd
92 kg N ha ⁻¹ + Weed-free control	20.53 d	2.83 c	4.3 fg	3.09 b
92 kg N ha ⁻¹ + PRE herbicide	15.64 ef	2.82 c	9.5 de	2.96 b
92 kg N ha ⁻¹ + PRE fb POST herbicides	13.89 f	3.21 abc	5.6 fg	3.52 ab
184 kg N ha ⁻¹ + No weeding control	48.85 a	3.03 bc	43.9 a	1.45 cd
184 kg N ha ⁻¹ + Weed-free control	34.44 c	3.58 a	7.6 fg	3.50 ab
184 kg N ha ⁻¹ + PRE herbicide	31.07 c	3.36 ab	14.5 c	3.75 ab
184 kg N ha ⁻¹ + PRE fb POST herbicides	22.17 d	3.62 a	3.3 g	4.00 a
CV (%)	9.96	9.58	15.52	19.79

In a column, means with the similar letter(s) are identical as per LSD_{0.05}

Conclusion

The study identified that nitrogen application and weed management has significant effects on weed infestation and grain yields of T. *Aman* rice and wheat. The double rate application of nitrogen in no-weeding control plots had the highest weed biomass for both strip-tilled unpuddled T. *Aman* rice and strip-tilled wheat fields under rice-wheat-mungbean cropping pattern. The spray of pre-emergence herbicide followed by post-emergence herbicide with no nitrogen application or the recommended rate application offered the minimum weed infestation for rice and wheat. However, the maximum grain yields of T. *Aman* rice and wheat were mostly obtained from double-rate nitrogen application (170 kg N ha⁻¹ for rice and 184 kg N ha⁻¹ for wheat) with the spray of pre-emergence followed by post-emergence herbicides, the study suggests the recommended rate of nitrogen application (85 kg N ha⁻¹ for rice and 92 kg N ha⁻¹ for wheat) for getting similar higher yields of rice and wheat as the double-rate of nitrogen application.

89. GROWTH AND YIELD OF CHIA INFLUENCED BY SOWING TIME AND ROW SPACING AT DIFFERENT AEZS

M. N. A SIDDIQUIE, M. J. ISLAM, M. M. I. CHOWDHURY

Abstract

The study of growth and yield of chia influenced by sowing time and row spacing was conducted at On-station, OFRD Shyampur, Rajshahi during Rabi season of 2022-23 and 2023-24 in High Ganges River Flood Plain soil (AEZ-11) to determine the best sowing date and row spacing of chia for achieving higher yield. The experiment was laid out in RCB design with three replications. Four sowing time and two spacing was followed the experiment. The sowing times were D1= 15 November, D2= 30 November, D3= 15 December and S4= 30 December. The spacing was; S1= 30 cm X continuous in solid line and S2= 40 cm X continuous in solid line. The highest seed yield was found in the combination S2×D1 in both years. The combination S2×D1 indicated that 40 cm spacing (Line to Line) with 15 November seeding was the best combination for achieving a higher yield of Chia in the northwestern part of Bangladesh. However, higher to moderate seed yield can also be achieved by extending the seeding date up to 30 November following 30 cm or 40 cm spacing.

Introduction

Chia (*Salvia hispanica*) belongs to the mint family Lamiaceae. Chia seeds contain high amounts of omega-3 fatty acids, proteins, minerals and vitamins. Agronomic management is one of the most important aspects for the success of any crop with efficient use of all the resources. Studies on the agronomic management of Chia are limited as it is a newly introduced crop to Bangladesh. For higher yield and maximum profit, a maximum profit study on growth and responses towards inputs is very much essential. As Chia is a new crop, different aspects of sowing time and plant population of this crop are to be studied to harness the potential yield of this crop. Standardization of suitable location-specific agronomic practices concerning spacing and sowing time is essentially required to popularize this crop in Bangladesh. The sowing date is an extremely relevant variable, since it determines the duration of the development period of the crop due to variations in environmental temperature and day length to which it is exposed (Lobo *et al.*, 2011). Chia grows naturally in tropical and subtropical environments (Orozco *et al.*, 2014). It is intolerant to freezing in all development stages (Lobo *et al.*, 2011; Bochicchio *et al.*, 2015). Some studies have shown that the best row spacing range for the culture would be between 30 and 50 cm, with an amount of 5 kg of seed per hectare (Ayerza and Coates, 2009). Appropriate sowing time and row spacing are very effective to increase yield of chia. But information on this aspect is unavailable in Bangladesh. With this view in mind, this study was undertaken to determine the effect of climatic conditions in different regions on the growth and yield of chia in different regions. This study was also proposed to determine the most appropriate promising sowing date and row spacing in terms of growth and yield in chia in the different study areas.

Materials and Methods

This study was conducted at On-station, OFRD Shyampur, Rajshahi during Rabi season of 2022-23 and 2023-24 in High Ganges River Flood Plain soil (AEZ-11). Geographically the experimental field is located at 24°36.982' N. latitude and 88°66.256'E. longitude with an elevation of 21 m above sea level. The experiment was laid out in RCB design with three replications. Four sowing time and two spacing was followed the experiment. The sowing times were 15 November, 30 November, 15 December and 30 December. The spacings were 30 cm × continuous in solid line and 40 cm × continuous in solid line. The unit plot size was 6.0 m × 4.8 m, and the planting system was line sowing. The field was fertilized with **60-40-50-8-0.5-0.5** kg ha⁻¹ NPKSZn and B. One-third of N and all other fertilizers were applied as basal during final land preparation and the rest N was applied at 25 and 50 DAS in equal split followed by irrigation. Nitro @ 1 ml L⁻¹ water was sprayed 2 times at the vegetative stage to control leaf-feeding insects. Nativo @ 1 g L⁻¹ was sprayed 2 times to control fungal disease. Weeding, irrigation, and other intercultural operations were done as and when necessary. The crop was harvested on 05 March, 23 March, 09 April, and

16 April 2023. In 2024, the crop was harvested on 08 March, 31 March, and 10 April. All necessary data were collected and analyzed through Statistix 10 software.

Results and Discussion

Cropping Season 2022-23: Days to 1st flowering and days to harvest of Chia influenced by spacing and sowing dates were shown in Table 1. Early flowering was observed in early seeding in the combinations $S_1 \times D_1$ and $S_2 \times D_1$ (65 days in both spacings with 15 November seeding) and the combinations $S_1 \times D_4$ and $S_2 \times D_4$ found late in flowering (71 days in both spacings with 30 December seeding). The early harvest was found in the combinations $S_1 \times D_4$ and $S_2 \times D_4$. Yield and yield traits of Chia significantly affected by spacing and sowing dates were presented in Table 3. Plant height was significantly higher in $S_2 \times D_3$ combination (168.33 cm) which were similar to $S_1 \times D_3$ (162.9 cm), $S_1 \times D_2$ (161.9 cm) and $S_2 \times D_2$ (159.9 cm). Plants/m² found higher in $S_2 \times D_1$ (119.6) and $S_1 \times D_1$ (119.5) followed by $S_2 \times D_2$ (104.7), $S_1 \times D_2$ (96) and $S_1 \times D_3$ (94.4). The combination $S_2 \times D_4$ (21.13) produced the highest Inflorescences per Plant followed by statistically similar $S_1 \times D_4$ (17.9), $S_2 \times D_3$ (17.47) and $S_1 \times D_3$ (15.5) and rest of the combinations produced the lowest number of Inflorescences per Plant. The combinations $S_2 \times D_2$ (12.8 cm), $S_1 \times D_2$ (12.67 cm), $S_2 \times D_1$ (12.2 cm) and $S_1 \times D_1$ (11.93 cm) produced the highest and similar length of Inflorescence where the rest of combinations produced the lowest length of Inflorescence. Seeds/ Inflorescence was found higher in $S_1 \times D_1$ (442.3) which was like $S_2 \times D_2$ (422.5). The combination $S_2 \times D_2$ (422.5) also produced a similar number of seeds per Inflorescence with $S_1 \times D_2$ (397.4) and $S_2 \times D_1$ (396.7) where the rest of the combinations produced the lowest number of seeds per Inflorescence. The highest thousand weight (TSW) was produced by the combination $S_2 \times D_1$ (1.30g) followed by $S_2 \times D_4$ (1.15 g), $S_1 \times D_2$ (1.14 g) and $S_1 \times D_1$ (1.13g). The lowest number of inflorescence per plant produced the highest length of inflorescence with a higher number of seeds per inflorescence and higher TSW as well as the highest number of plants/m² resulting in the highest seed yield in the combination $S_2 \times D_1$ (1273 kg ha⁻¹). A similar trend was found in combinations $S_1 \times D_1$ (1010 kg ha⁻¹), $S_1 \times D_2$ (1010 kg ha⁻¹) and $S_2 \times D_2$ (893 kg ha⁻¹). The highest number of inflorescence per plant along with the lowest number of plants/m² produced the lowest length of inflorescence, lower number of seeds per inflorescence and lower TSW resulting in the lowest seed yield in the combination $S_2 \times D_4$ (167 kg ha⁻¹). Similarly, the lower seed yield trend was found in the combinations $S_1 \times D_4$ (216 g ha⁻¹), $S_2 \times D_3$ (501 kg ha⁻¹) and $S_1 \times D_3$ (525 kg ha⁻¹).

Cropping season 2023-24: Days to 1st flowering and days to harvest of Chia influenced by spacing and sowing dates were shown in Table 2. Early flowering was observed in early seeding in the combinations $S_1 \times D_1$ and $S_2 \times D_1$ (59 days in both spacing with 15 November seeding) and the combinations $S_1 \times D_4$ (73 days) and $S_2 \times D_3$ (74 days) were found late in flowering. The early harvest was found in the combinations $S_1 \times D_4$ and $S_2 \times D_4$ (112 days in both cases). Yield and yield traits of Chia significantly affected by spacing and sowing dates were presented in Table 4. Plant height was found to be non-significant indicating no effect of spacing and sowing dates on plant height. Plants/m² were found higher in $S_1 \times D_1$ (101.5 no) and $S_2 \times D_1$ (93.2 no) followed by $S_1 \times D_4$ (71.3 no). Inflorescences per Plant failed to produce any significant differences among all combinations of spacing and sowing dates. The combinations $S_2 \times D_1$ (13.7 cm) and $S_1 \times D_1$ (13.3 cm) produced the highest and similar lengths of Inflorescence whereas the rest combinations produced the lower length of Inflorescence. Seeds/ Inflorescence was found higher in $S_1 \times D_1$ (342) which was similar to $S_2 \times D_1$ (340) and $S_1 \times D_2$ (321) where the rest of the combinations produced the lowest number of seeds per Inflorescence. The highest thousand seed weight (TSW) was produced by the combination $S_1 \times D_2$ (1.47 g) which was similar to that of $S_2 \times D_2$ (1.42 g). The combinations $S_1 \times D_1$ (1.29 g) and $S_2 \times D_1$ (1.29 g) produced the moderate TSW. The highest length of inflorescence with a higher number of seeds per inflorescence and higher TSW as well as the highest number of plants/m² resulting in the highest seed yield in the combinations $S_2 \times D_1$ (1103 kg ha⁻¹) and $S_1 \times D_1$ (1095 kg ha⁻¹). The lower number of plants/m² produced the lowest length of inflorescence, the lower number of seeds per inflorescence, and lower TSW resulting in the lowest seed yield in the combination $S_2 \times D_3$ (618 kg ha⁻¹). Similarly, the lower seed yield trend was found in the combinations $S_2 \times D_4$ (626 g ha⁻¹) and $S_2 \times D_3$ (712 kg ha⁻¹).

Table 1. Days to 1st flowering and days to harvest of Chia influenced by spacing and sowing dates during 2022-23 & 2023-24

Treatment combinations	Days to 1 st flowering		Days to harvest	
	2022-23	2023-24	2022-23	2023-24
S ₁ ×D ₁	65	59	110	114
S ₁ ×D ₂	69	69	113	122
S ₁ ×D ₃	70	72	115	117
S ₁ ×D ₄	71	73	106	112
S ₂ ×D ₁	65	59	110	114
S ₂ ×D ₂	69	67	113	122
S ₂ ×D ₃	71	74	115	117
S ₂ ×D ₄	70	73	106	112

Table 2. Yield and yield attributes of Chia influenced by spacing and sowing dates, 2023-24

Treatment combinations	Plant height (cm)	Plants m ⁻²	Inflorescences plant ⁻¹	Length of Inflorescence (cm)	Seeds Inflorescence ⁻¹	1000-seed wt. (g)	Yield (kg ha ⁻¹)	
							2023-24	2022-23
S ₁ ×D ₁	127.3	101.5 a	13.8	13.3a	342a	1.29bc	1095a	1010b
S ₂ ×D ₁	136.9	93.2 a	14.8	13.7a	340a	1.29bc	1103a	1010b
S ₁ ×D ₂	133.1	58.7 b-d	13.9	11.5b	321a	1.47a	870b	525c
S ₂ ×D ₂	132.3	44.4 d	12.3	11.3b	272b	1.42ab	861b	216d
S ₁ ×D ₃	128.5	61.9 bc	11.2	10.2bc	214c	1.19cd	764bc	1273a
S ₂ ×D ₃	139.1	56.3 cd	11.8	10.7bc	244bc	1.28bc	712cd	893b
S ₁ ×D ₄	136.8	71.3 b	12.3	9.3c	218c	1.06d	618d	501c
S ₂ ×D ₄	131.3	52.3 cd	13.7	9.3c	212c	1.22cd	626d	167d
LSD (0.05)	NS	14.9	NS	1.73	48.6	0.18	123	124
CV (%)	6.5	12.66	11.89	8.83	10.26	7.86	8.46	10.12

S₁= 30 cm spacing, S₂= 40 cm spacing, D₁= 15 November seeding dates, D₂= 30 November seeding dates, D₃= 15 December seeding dates and D₄= 15 December seeding dates.

Conclusion

From the two years of results showed that the combination 40 cm spacing (Line to Line) with 15 November seeding was the best combination for achieving a higher yield of Chia in the northwestern part of Bangladesh. However, moderate seed yield can be achieved by extending the seeding date up to 30 November following 30 cm or 40 cm spacing.

90. EFFECT OF TILLAGE AND MULCH ON THE YIELD PERFORMANCE OF POTATO IN AEZ-11

M. S. RAHMAN, M. N. A. SIDDIQUE, M. J. ISLAM, AND M. M. I. CHOWDHURY

Abstract

The experiment was conducted both at an agricultural station and on farmers' fields, each with three replications and three treatments: (A) conventional tillage, (B) strip planting with straw mulch, and (C) strip planting with plastic mulch. The results showed that strip planting with high residue (both straw and plastic mulch) significantly improved potato yields compared to conventional tillage with low residue. On station, the highest yield was 44.2 t ha⁻¹ with plastic mulch, followed closely by 43.5 t ha⁻¹ with straw mulch. The conventional method produced the lowest yield of 34.6 t ha⁻¹. On the farmers' fields, the yields were not significantly different, with 43.1 t ha⁻¹ for strip planting with straw mulch, 40.1 t ha⁻¹ with plastic mulch, and 40.8 t ha⁻¹ with conventional tillage. Economically, strip planting with straw mulch provided the highest gross margin (Tk. 777,073 ha⁻¹ at the station and Tk. 767,073 ha⁻¹ on the farm) and the best benefit-cost ratio (BCR of 3.50 at on station and 3.47 on the farm). Overall, the results suggest that strip planting with straw mulch significantly boosts yield and profitability in rice-based intensive cropping systems.

Introduction

Bangladesh's agriculture sustains nearly 162 million people on 8.75 million hectares of land (Salam et al., 2014). The challenge of increasing food production while preserving natural resources is growing (Gathala et al., 2011). Rice-dryland cropping systems are critical in this context, balancing food production with population growth (Gathala et al., 2011). However, traditional rice cultivation on puddled soils with extensive tillage and residue removal negatively impacts subsequent dryland crops, requiring additional tillage and reducing farm profitability (Sharma et al., 2005). Conservation Agriculture (CA) offers a solution, combining strip planting and crop residue retention to enhance soil health and reduce reliance on inorganic fertilizers, benefiting both the environment and the economy (Tiwari, 2007). CA also improves crop yields with less labor, fuel, and water, lowering production costs and increasing farm profits (Choudhury et al., 2014; Bell et al., 2019; Haque et al., 2016). Innovations such as the Versatile Multi-crop Planter (VMP) have further accelerated CA adoption, especially in small farms of the Eastern Indo-Gangetic Plains (Bell et al., 2017). Efficient crop residue management, including retention, is crucial in halting long-term nutrient losses and sustaining productivity (Ghimire et al., 2017; Chauhan et al., 2012). CA, with full residue retention, has been shown to outperform traditional tillage methods in terms of production and economic returns (Laik et al., 2014). However, research on CA in Bangladesh remains limited, highlighting the need for further studies on its impact on crop productivity and profitability in key regions like the High Ganges River Floodplain.

Materials and Methods

The experiment was conducted at Shyampur farm and farmer's fields in Paba, Rajshahi, Bangladesh, on Calcareous Grey Floodplain soil (Typic Haplaquept, Arial/Sara soil series, USDA, 2014). The soil, classified as silt loam, was moderately well-drained. Basic soil properties are detailed in Table 1. The experiment followed an RCBD design with six replications. Treatments included T1=Conventional Tillage (CT), T2=Strip + Straw Mulch, and T3=Strip + Irish Polythene. Strip planting (SP) involved tilling a narrow strip for seeding while leaving inter-row areas undisturbed. Potatoes were planted in rows 60 cm apart, with 20 cm spacing between tubers. SP plots were mulched with rice straw at 5.5 t ha⁻¹, while CT plots were prepared with four rotary tiller passes. All management practices, including fertilizer application and pest control, followed FRG (2018) recommendations. Details of crop management are provided in Table 2.

Weeds were controlled with Roundup® herbicide, while insect pests were managed with Furadan and Malathion®. Fungicides, including Dithane M45 and Secure 600WG®, were applied to control late blight. The crop was harvested from designated plots, and yields were converted to t ha⁻¹. Grain and straw were sun-dried before final measurements. Production costs included land rental, seed, fertilizers, labor, and pest control. Gross return, gross margin, and benefit-cost ratio (BCR) were calculated to assess financial efficiency. ANOVA was used to evaluate treatment effects on crop productivity. Significant differences were identified using Duncan's Multiple Range Test (DMRT) at a 5% significance level (Statistics 10).

Table 1. Basic soil properties (at 0–30 cm soil depth) of study sites before starting the experiments

Soil properties	Potato field	On-farm		
	On station	Robi plot	Jahedul plot	Mostofa plot
pH (1:5 H ₂ O)	6.93	6.86	7.1	7.0
Total N (%)	0.11	0.12	0.09	0.12
Organic carbon (%)	0.47	0.48	4.10	4.90
Exch K (meq/100 g soil)	1.84	1.80	1.72	1.94
Extr P (ppm)	20.6	23.1	24.5	27.6
S (mg kg ⁻¹)	15.56	14.1	17.2	16.4
Bulk density (g cm ⁻³)	1.40	1.42	1.41	1.43

Table 2 Details of crop, variety, seed rate or seedlings/hill, row spacing, sowing and harvesting dates of Potato

Management factors	Potato
Variety	BARI Alu-7
Date of sowing/ Transplanting	27.11.23
Seed/tuber rate (kg ha ⁻¹)	1800
Spacing	60 cm × 20 cm
Recommended nutrient dose (kg ha ⁻¹)	N ₁₈₀ P ₂₀ K ₁₃₅ S ₁₅ Zn ₄ B _{0.8}
Basal: (N-P-K-S-Zn-B)	all fertilizers with 1/2N
top dress (DAT/DAS)	30
Irrigation (DAS/DAT)	30 and 47
Pest control	Curative
Date of harvest	12.03-2024

Results

Yield and yield attributes of Potato: In on-station trials, the treatments significantly influenced plant height, tuber count per plant, potato grade-A, tuber weight per plant, tuber yield, and dry yield, while grades B, C, and D remained unaffected. Strip planting with straw mulch compared to conventional planting resulted in a 22.5% increase in plant height and a 49.7% increase in tuber count per plant. It also achieved a 71.4% higher grade-A yield and a 23.7% increase in tuber weight per plant. Furthermore, tuber yields increased by 27.7% with polythene mulch and 25.7% with straw mulch, and dry matter yield improved by 34.3%. Conversely, on-farmer field trials showed no significant differences in any yield attributes or plant characteristics between the treatments.

Economic performances: The profitability of potato production at both sites is detailed in Tables 5 and 6. Across both locations, the combination of strip planting and straw mulch yielded the highest gross margin, with Tk. 777,073 and Tk. 767,073 per hectare, respectively, outperforming other treatment combinations. Furthermore, during both the on-station and on-farm harvest years, the highest Benefit-Cost Ratios (BCRs) were observed with the strip planting and straw mulch combination, registering values of 3.50 and 3.47, respectively, as compared to other combinations (Tables 5 and 6).

Table 3 Effects of tillage on plant height, tubers plant⁻¹, potato grades, tuber weight plant⁻¹, tuber yield and tuber dry matter of potato during 2023-24 (on station)

Treatments	Plant height (cm)	Potato hill ⁻¹	Grade				Tuber weight plant (g)	Tuber yield (t ha ⁻¹)	Dry weight (t ha ⁻¹)
			A=<25 mm	B=25-45 mm	C= 45-55 mm	D=> 55 mm			
Conventional	53.2	8.82	2.17	2.33	2.33	1.97	704	34.6	7.26
Strip + Straw mulch	58.8	13.2	3.72	3.67	2.83	3.03	871	43.5	9.75
Strip + Irish mulch	58.9	12.2	3.11	3.44	2.67	2.97	839	44.2	9.43
LSD (0.05)	3.82	3.37	0.9	-	-	-	126	3.68	0.92
CV (%)	3.61	13	13.2	-	-	-	6.89	3.98	4.59

Table 4 Effects of tillage on plant height, tubers plant⁻¹, potato grades, tuber weight plant⁻¹, tuber yield and tuber dry matter of potato during 2023-24 (on farm)

Treatments	Plant height (cm)	Potato hill ⁻¹	Grade				Tuber weight plant (g)	Tuber yield (t ha ⁻¹)	Dry weight (t ha ⁻¹)
			A=<25 mm	B=25-45 mm	C= 45-55 mm	D=> 55 mm			
Conventional	62.1	6.93	3.23	1.87	0.27	2.50	500	40.8	9.24
Strip + Straw mulch	69.1	7.63	2.30	2.60	0.60	2.20	612	43.1	10.1
Strip + Irish mulch	62.7	8.13	2.57	1.77	0.20	3.70	535	40.1	9.91
LSD (0.05)	-	-	-	-	-	-	-	-	-
CV (%)	-	-	-	-	-	-	-	-	-

Table 5 Profitability of potato production under different tillage practices on potatoes in on the station

Particulars	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
Conventional	34.6	865000	318746	546254	2.71
Strip + Straw mulch	43.5	1087500	310427	777073	3.50
Strip + Irish mulch	44.2	1105000	417306	687694	2.65

Table 6 Profitability of potato production under different tillage practices on potato in on farm

Particulars	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
Conventional	40.8	1020000	318746	701254	3.20
Strip + Straw mulch	43.1	1077500	310427	767073	3.47
Strip + Irish mulch	40.1	1002500	417306	585194	2.40

Conclusion

Conservation Agriculture (CA), characterized by minimal soil disturbance and high residue retention as mulch, has demonstrated significant benefits for cold-season crops in rice-based systems. Compared to conventional tillage, CA not only enhances all yield attributes but also substantially reduces expenses, particularly with one-pass sowing in strip planting. This practice supports sustainable and profitable crop production while preserving soil fertility. The study's findings suggest that CA with straw mulch is a highly effective strategy for boosting both productivity and profitability in agricultural systems.

91. EFFECT OF SOWING DATE ON THE PRODUCTIVITY OF MUSTARD (CANOLA) IN NORTH-WEST BANGLADESH

M. E. HAQUE, M. A. ALAM, M. Z. FERDOUS AND M. A. H. TALUKDER

Abstract

An experiment was set at the farmers' fields of Fatehpur, Vurarghat, Sadar upazila, Rangpur under OFRD, BARI, Rangpur during the rabi season of 2023-2024 to observe the performances of BARI Sarisha-18 sown at different sowing dates. The trial consisted of five sowing dates viz., 25-October, 05-November, 15-November, 25-November and 05-December. Flowering times varied slightly with the sowing date. The earliest flowering occurred on 05-Dec (39 days), while the latest was on 15-Nov (42.33 days). Maturity days decreased as sowing was delayed, with the earliest maturity at 95.33 days for 05-Dec sowing and the latest at 102 days for 25-Oct sowing. The number of pods per plant was significantly higher in the earliest sowing (134 on 25-Oct) compared to later dates, with a marked decrease observed for the last sowing date (91.80 on 05-Dec). The highest yields were observed on 25-Oct (2166.7a kg/ha), and the lowest on 05-Dec (1566.7 kg/ha). The earlier sowing dates lead to better performance across most parameters, including flowering and maturity rates, plant height, pod production, and overall yield.

Introduction

Mustard is one of the most important oil seed crops in Bangladesh. Its area coverage and production are increasing gradually due to the development of short-duration and high-yield potential varieties by BARI and Bangladesh Govt. initiatives. BARI has now released a canola-type healthy oil-seed variety (BARI Sarisha-18). The BARI Sarisha-18 has higher yield potential than the existing varieties. But it is a long-duration variety. In 2022-23, DAE of Northern Bangladesh reported that the seed yield of BARI Sarisha-18 has fluctuated (DAE, 2023). Delayed planting is one of the main reasons for that. Delayed planting encourages forced maturity because of

terminal heat. As a result, the seed yield of mustard goes down, small-sized seed produced and oil content is also reduced. Normally, farmers plant mustard after harvest of long duration T. Aman rice (Swarna) and mostly during late November to mid-December. As BARI Sarisha-18 is a long-duration variety, timely sowing is one of the alternatives for higher canola seed yield escaping terminal heat. Considering this fact, the experiment was proposed to find out the optimum sowing window for BARI Sarisha-18 in Northern Bangladesh.

Materials and Methods

The experiment was set at the farmers' field of Fatehpur, Vurarghat, Sadar upazila, Rangpur under OFRD, BARI, Rangpur during the rabi season of 2023-2024. Five sowing dates were starting from 25 October at an interval of 10 days used in the experimentation viz., 25-October, 05-November, 15-November, 25-November and 05-December. Mustard seeds were treated with Provax 200 and kept overnight at room temperature. Seeds were sown according to the treatment date maintaining the spacing of 30cm×5cm. ORC standard fertilizer doses were applied and standard intercultural management practices were followed in the trial plots. Orientation was also given to the farmers before and during the cropping season on improved crop production techniques as well as irrigation, disease management practices, etc. Farmers were also suggested to follow a routine spray schedule to control *Alternaria* blight infection. Data were recorded on days to 50 % flowering, days to maturity, plant height (cm), number of branches/plant, number of pods/plant, length of pod (cm), number of seeds/pod, plot yield (kg) and yield (kg ha⁻¹). Crops were harvested at 12% moisture content of tested crop seeds. The plot yield was converted to ton per hectare. The collected data were compiled and 't-Test' using 'Statistix-10' software.

Results

Flowering times varied slightly with the sowing date. The earliest flowering occurred on 05-Dec (39 days), while the latest was on 15-Nov (42 days). This indicates that earlier sowing generally leads to quicker flowering. Maturity days decreased as sowing was delayed, with the earliest maturity at 95.33 days for 05-Dec sowing and the latest at 102 days for 25-Oct sowing. Plant height decreased significantly with later sowing dates, from 165.50 cm on 25-Oct to 101.43 cm on 05-Dec. The earlier sowing results in taller plants ($p < 0.01$). The number of branches per plant was highest when sown on 15-Nov and lowest when sown on 25-Oct, indicating that mid-season sowing might encourage branch development. The number of pods per plant was significantly higher in the earliest sowing (134 on 25-Oct) compared to later dates, with a marked decrease observed for the last sowing date (91.80 on 05-Dec). Pod length varied significantly, with the longest pods at 7.43 cm for 25-Oct and the shortest at 6.23 cm for 25-Nov ($p < 0.01$), indicating that pod size can be influenced by sowing date. Seeds per pod also showed variation, with the highest number on 25-Oct (24.38) and the lowest on 25-Nov (19.23). Yields per hectare decreased significantly with later sowing dates. The highest yields were observed on 25-Oct (2166.7a kg ha⁻¹), and the lowest on 05-Dec (1566.7 kg ha⁻¹). These results strongly suggest that earlier sowing dates lead to higher yields ($p < 0.01$).

Table 1. Effect of sowing date on the productivity of Mustard (Canola) in North-West Bangladesh

Sowing time	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches/plant	Number of Pods/plant	Length of pod (cm)	Number of Seeds/pod	Yield (kg ha ⁻¹)
25-Oct	41.67ab	102.0a	165.50a	4.80c	134.0a	7.43a	24.38ab	2166.7a
05-Nov	40.67b	97.0bc	167.63a	5.0bc	129.67a	7.22ab	26.98a	2133.3ab
15-Nov	42.33a	99.0ab	149.50b	5.47a	89.53b	6.61ab	23.00bc	1988.9bc
25-Nov	41.33ab	97.67bc	135.13b	5.07abc	80.27b	6.23b	19.23d	1866.7c
05-Dec	39.00c	95.33c	101.43c	5.37ab	91.80b	6.47ab	21.00cd	1566.7d

Conclusion

It can be concluded that earlier sowing dates generally lead to better performance across most parameters, including flowering and maturity rates, plant height, pod production, and overall

yield. This information could be vital for mustard farmers in North-West Bangladesh in optimizing their planting schedules 25 October to 15 November for maximum productivity of Mustard (Canola).

92. EFFECT OF DIFFERENT MULCHING MATERIALS ON YIELD OF EGGPLANT

U. K. LAILY, M. Z. FERDOUS, M. K. ISLAM, M. U. S. KHATUN AND M. A. H. TALUKDER

Abstract

A field trial was carried out at the On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Rangpur in the Rabi season of 2023–24 to determine the impact of various mulching materials on eggplant production. Three different treatments were tested: T₁ = Polythene mulch, T₂ = Rice straw and T₃ = No mulch (control). The yield and yield components such as plant height, fruit length, fruit diameter, number of fruits plant⁻¹, single fruit weight and fruit yield were assessed for choosing the appropriate mulching materials. Among all the treatments, T₁ produced the highest number of fruits plant⁻¹ (9.8) and fruit yield (56.47 t ha⁻¹), whereas T₃ treatment had the lowest fruit yield (30.28 t ha⁻¹). The maximum gross margin (754600 Tk.ha⁻¹) was obtained from treatment T₁.

Introduction

Brinjal or Eggplant (*Solanum melongena* L.) is one of the most popular vegetable crop grown in Bangladesh (Saifullah *et al.* 2012). In term of consumption, brinjal ranks third after potato and rice (Ahsanuzzaman and David Zilberman, 2018). Crop production is controlled by several factors, variety, spacing, fertilization, water management, plant protection, weed management, etc. Brinjal has high water requirement. Water scarcity and weed infestation is the major problem for successful production of brinjal. Proper scheduling of irrigation is a must to maintain the soil moisture and aeration. Now-a-days different types of mulching is used as a important techniques or practices of covering the soil to make more favorable conditions for plant growth, development and efficient crop production and reduces the weed population. It also improves the microbial activity of the soil by improving the environment around the root zone. Organic mulches add nutrients to the soil when decomposed by microbes and help in addition to soil organic carbon and nitrogen. Mulched and irrigated treatments have been shown to induce higher root growth in comparison with un mulched and rain fed treatments (Kumara *et al.* 2011). Water is the single factor which directly affects the brinjal yield because it required especially at flowering, fruit set, and enlargement stage. But irrigation facilities are not sufficient in all the regions of the country. In Bangladesh, mulching was evaluated to many vegetables like tomato, onion, garlic but there was no record of research work on brinjal. Therefore, the present study was undertaken to investigate the suitable mulching materials for increasing the production and profit of eggplants.

Materials and Methods

The experiment was conducted at On-Farm Research Division (OFRD), BARI, Rangpur, from during Rabi season 2023-24. Geographical location of the station is Latitude: 25°43.258'N, Longitude: 089°15.732'E, with an elevation of 32.2 m from the sea level. The area mostly falls under high and medium-high land of the Tista Meander Floodplain (AEZ-3) (Anowar *et al.*, 2015; Ferdous *et al.*, 2016). Water holding capacity of the soil is good. The area receives an average annual rainfall of around 2160 mm with an average temperature of about 25°C (Ferdous *et al.*, 2016). There were three treatments viz. T₁= Polythene mulch, T₂= Rice straw and T₃= No mulch (Control). The experiment was laid out in RCB design with four replications. The unit plot size was 5m × 4.8 m. The tested crop was brinjal variety BARI Begun-12 was planted on 19 October 2023. All of the gypsum, boric acid and half of the compost, TSP were applied at the time of final land preparation. Seven days prior to planting, the remaining compost, TSP and one –third of MoP was added to the pits. Urea was applied in four equal installments at 20 DAP, at flowering stage and two times at fruiting stage and the remaining two-third of MoP was applied in three equal

installments at 20 DAP, at flowering stage and fruiting stage. The fruit harvesting season began on January 1st, 2024. After physiological maturity, five randomly selected plants from each plot were harvested and plant height, yield and yield components like fruit length, fruit diameter and single fruit weight of brinjal were measured. Plot yield of brinjal was determined plot wise and converted to yield on an area basis (t ha^{-1}). Production of brinjal included costs of field preparation, sowing, planting, irrigation and fertilizer, plant protection chemicals, and harvesting. White fly, Jasid, aphid and brinjal fruit and shoot borer infestation was observed that was well controlled by spraying of insecticides. Preventing wilting problems Kasumin 2% SL (kasugamycin) fungicide was used.

Gross return under a treatment was calculated by multiplying the gross amount of crop 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). Data were taken on different growth parameters like plant height, fruit length, fruit diameter, single fruit weight, number of fruits plant⁻¹ and fruit yield as cost and return analysis. Data were compiled and analyzed with Statistix10 software.

Result and Discussion

Yield and yield components of brinjal under different treatments are presented in Table 1. Results showed that the plant height, fruit length, number of fruits plant⁻¹ and fruit yield were significantly differed with the treatments but no statistical difference among the treatments in case of fruit diameter and single fruit weight. The highest plant height (90.33 cm), fruit length (25.46 cm), fruit diameter (9.98 cm), number of fruits plant⁻¹ (9.3) and single fruit weight (0.709 kg) were found from T₁ treatment. The highest fruit yield (56.47 t ha⁻¹) was also recorded from T₁ treatment which was statistically different with T₂ treatment (44.47 t ha⁻¹) and T₃ treatment (30.28 t ha⁻¹) (Table 1). In terms of cost and analysis revealed that the maximum gross return (1129600 Tk.ha⁻¹) and gross margin (754600 Tk.ha⁻¹) were recorded from treatment T₁ whereas the lowest gross return (605600 Tk.ha⁻¹) and gross margin (110100 Tk.ha⁻¹) from treatment T₃, respectively (Table 2).

Table 1. Effect of different mulching materials on yield and yield attributes of BARI Begun-12 at OFRD, BARI, Rangpur during 2023-24

Treatment	Plant height (cm)	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant ⁻¹	Single fruit weight (kg)	Fruit yield (t ha ⁻¹)
T ₁ = Polythene mulch	90.34	25.46	9.98	9.30	0.709	56.47
T ₂ = Rice Straw	87.25	24.91	9.46	7.53	0.694	44.47
T ₃ = No mulch (Control)	69.42	22.88	9.20	5.13	0.697	30.28
LSD (0.05)	11.90	2.16	0.85	2.27	0.072	15.64
CV (%)	8.35	5.13	5.16	17.92	5.88	20.38

Table 2. Cost and return of BARI Begun-12 at OFRD, BARI, Rangpur during 2023-24

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
T ₁ = Polythene mulch	1129600	375000	754600
T ₂ = Rice Straw	889200	364500	524700
T ₃ = No mulch (Control)	605600	495500	110100

Price (Tk./kg): Brinjal = 20

Conclusion

It may be concluded that the highest yield and gross return was found from Polythene mulch. This is the first year trial. For more confirmation, the experiment will be repeated in the next year.

93. ASSESSMENT OF ONION GROWING AREA IN CHARLAND OF GAIBANDHA THROUGH GEO-SPATIAL TECHNIQUES

A. A. MAHMUD, M. A. MOTTALIB, M. J. ALAM, M. R. ALAM AND M. S. H. MOLLA

Abstract

Accurate and faster estimation of crop area is very essential for projecting yearly agriculture production for formulating national budget and deciding agriculture policies. The present investigation deals with the estimation of onion crop acreage of charland area of Saghatta upazila of Gibandha district using satellite remote sensing technique. In this study single-season optical remote sensing data of Sentinel-2 satellite having a spatial resolution of 10 m was used to generate onion distribution map for Saghatta upazila. Cloud-free single-date Sentinel-2 satellite images were acquired during the onion growth stages. The investigation presented that the multi-temporal satellite imagery dataset was adequate to accurately identify the garlic cropped area with high accuracy. This study gives inspiration in selecting the remotely sensed data source, the band, and phenology for accurately extracting onion planting areas, which could be transferred to other sites with larger areas and similar agriculture structures. Besides, this research provides valuable insights for policymakers by providing near-real-time, earlier onion acreage estimates at the local level, facilitating informed decision-making in attaining sustainable agricultural development.

Keywords: satellite remote sensing, Onion cultivation, Charland, Gaibandha, Geo-spatial techniques, Geographic Information Systems (GIS), Remote Sensing.

Introduction

Onion (*Allium cepa* L.) is one of the essential profitable spice crops in Bangladesh, contributing significantly to the agricultural economy and food security of the country. In terms of production, onion is the first spice crop among all the spice crops (BBS, 2022). Onion is cultivated all over the country of Bangladesh extensively in Rabi (winter) season. To satisfy the demand of an ever-increasing population the area of onion production is increasing day by day. But there is an acute shortage of onion in relation to its requirement. In the last couple of years, the local production of onion almost remained static, causing a rise in imports of onion from neighboring and other countries to meet up the demand of its population (Haque et al., 2011). In order to fulfill the shortage of onion, both the area and production of the onion needs to be expanded horizontally and vertically. The accreted char land area exists much scope and opportunity to expand onion growing area after receding flood water. Charlands, which are riverine islands formed through the deposition of sediments in river channels, constitute a substantial portion of the country's landmass. According to EGIS (2000), char land areas are estimated to be 0.72 million hectares in Bangladesh which about 0.52 - 0.79 million hectares are cultivable. The combination of fertile soil, abundant water resources, favorable climate conditions, and traditional farming practices makes char areas suitable for crop production in Bangladesh. Besides, appropriate resource planning is needed with proper information management infrastructure related with onion cultivation, which requires a systematic effort towards proper agricultural planning. Assessing the extent and spatial distribution of onion cultivation in charlands is essential from the agricultural planning point of view. Accurate and timely spatial inventory and monitoring of onion is important for yield forecasting, loss assessment, land utilization dynamics and various aspects of agricultural planning. It would be helpful to stakeholders and policy makers for their advance planning of crop management, procurement, stock, availability and post harvesting decision and formulate policies related to food security. In Bangladesh, the annual agricultural statistical data on crop acreage, production and yield are derived by applying statistical projection techniques on the field information collected through sampled interviews adopted by the Department of Agriculture Extension (DAE) and Bangladesh Bureau of Statistics (BBS). This traditionally data acquiring approach is an extremely tedious job, including extensive travel and various interpolation methods based on the sample taken. This process is also time-consuming, labor-intensive, cost sensitive and lacking in spatial information (Ma et al.) and still suffers from risk of several anthropogenic errors. The advanced modern geo-spatial approaches such as

satellite remote sensing (RS) approach are proved to be an effective solution for assessing the extent and spatial distribution of crop area (Esch et al., 2014) and have been successfully implemented at regional-scale (Teluguntla et al., 2015) as well as at global scale (Salmon et al., 2015) in a short time with much accuracy and cost-effectively (Rahman et al., 2009). Satellite RS provides real time, georeferenced temporal datasets which are highly reliable and easy to handle. Several studies carried out for estimating cropland areas from satellite based remote sensing analysis under different crops in many countries show a near 90 percent accuracy level (Das, 2003). Faruk and Ahamed (2002) used remote sensing technique for cropping area assessment for the flood prone areas of Bangladesh. Mahboob (2007) used SPOT HRV multispectral imagery for detection and estimation of agro-forestry practices in the sal forest area. However, keeping in view the above related facts, the present study was undertaken to utilize satellite remote sensing and GIS applications to produce a thematic map of cropland and estimate onion producing area in charland of Gaibandha district. In this context, the following specific objectives of this study were developed: (i) to map crop land and types with precisely and accurately using satellite-based remote sensing techniques; (ii) to evaluate the accuracy and reliability of derived cropland map and (iii) to compare the area of derived from onion maps with the area statistics available from Year Book Statistics 2022, Government of Bangladesh. Using the information from satellite images which are collected in GIS databases information of geospatial technology in agriculture, specific crop-based cultivation and area are identified which help to promote the sustainable agriculture dissemination and adaptation program easily and rapidly. On the contrary, early availability of onion acreage data can be valuable for several purposes, one of these being the agricultural trade for export and estimating the revenue.

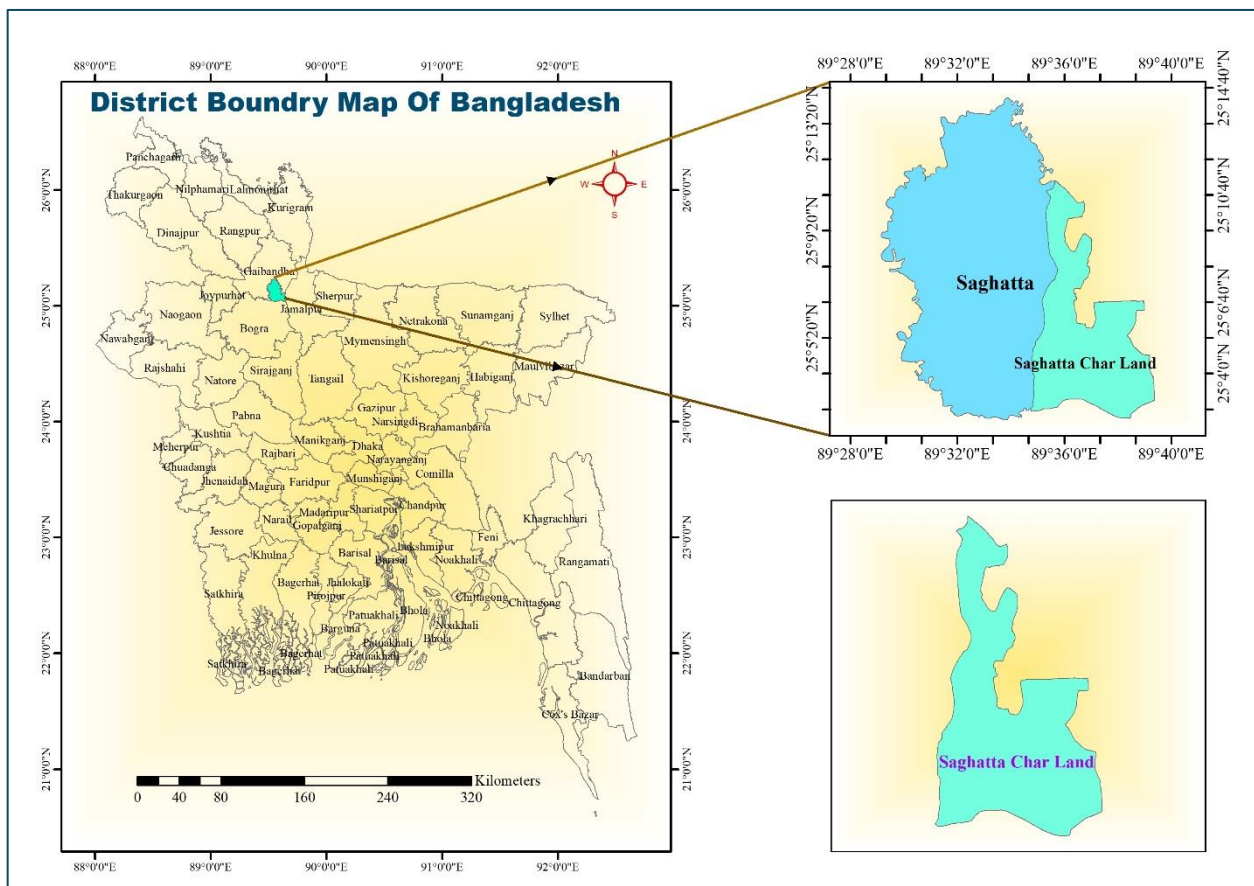


Figure 1. Location and boundary map of the study area

Materials and Methods

Explanation of the study area: The study focuses on charland area of Gaibandha district in Bangladesh which are growing Rabi crop specially onion prominently. The study areas were

purposively selected as the testing sites having a short visit to the area after discussion with the Department of Agricultural Extension (DAE) personnel for conducting this study. The study areas are characterized by mainly two cropping seasons i.e., Kharif (March–October, summer crops), and Rabi (October–March, winter crops). The onion is the most prominent and cash crop of Rabi season; however, rice is the major crop for the kharif season. The onion planting season starts between mid-November to mid-December, depending on the onset of the rainy season, whereas harvesting generally takes place at the end of March to April. The geographical location of study area is shown in Figure 1. The maximum coldness is observed in mid-December and January with minimum temperature of 5.8°C and maximum temperature of 23.4°C. The maximum sunshine is observed in June and July with maximum temperature 40°C and minimum temperature 24°C. Average annual rainfall of the study area is between 600-1000 mm. The texture of the soil is clay (sand 30%, silt 24%, clay 46%), with medium organic matter (1.83%), medium content in total N (1.16 g kg⁻¹), moderately alkaline (pH 7.61). The major cropping patterns of the selected areas are shown in Table 1.

Methodology: The methodology used in this study is aimed to identify and generate the thematic map of land use and land cover (LULC) map and then estimate onion growing area in the study area. As per the aims of the study, the methodological workflow essentially consisted of the following steps: (1) selection and collection of the datasets (2) data pre-processing (3) data classification (4) evaluation for assessing the classification accuracies and (5) generation of the output products. The detailed flowchart of the methodology is shown in Figure 3 for onion acreage estimation.

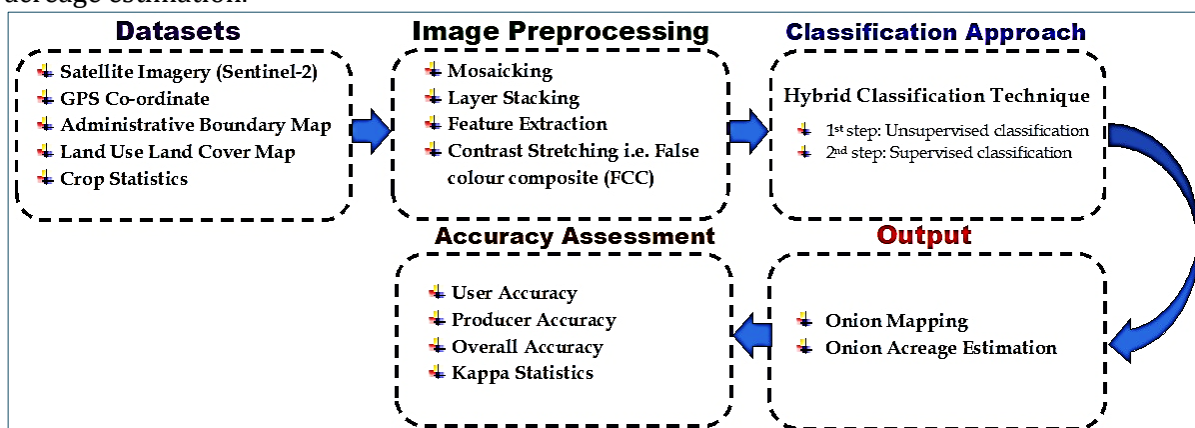


Figure 2 Illustrates the research methodology from the acquisition of the Sentinel-2 images to mapping cropland and crop types

Software's used: To achieve the above-mentioned methodological workflow, some different types of software were used for digital image acquisition, processing, analysis, data storage, statistical analysis, validation of work, etc. For example, Microsoft Office (version 2021) was used for database preparation, and ArcGIS software (version 10.7.) was used for spatial data composition, masking or sub-setting, image classification, thematic map generation, crop identification, and area estimation.

Data Collection

Satellite Imagery: High resolution Multispectral Instrument sensor (MIS) of Sentinel-2 (Level-1C) satellite data was used in this study. The freely available Sentinel-2 satellite images were downloaded from the European Space Agency's (ESA) Sentinel Scientific Data Hub (<https://dataspace.copernicus.eu/>) during the Rabi season. Single date satellite images were acquired in between February 2024 covering the entire onion growing season. Onion reaches its peak greenness in the mid-February to early March. In this context, Sentinel-2 satellite images was captured during this month for precise crop type mapping and or the optimum acreage calculations. However, predominant cloud-free (<10%) and unwanted shade free quality imagery were set as criteria during image selection. Details of images acquired with date of pass are given in Table 1. Table 2 shows Sentinel-2 satellite image acquisition dates with respective season of

study area. However, compared with Landsat and MODIS, Sentinel-2 is more popular due to its fine properties including increased number of bands (13 Band), shorter revisit time (5-10 days), and higher spatial resolution (10m ×10m). Only visible bands 2 (Blue), 3 (Green) and 4 (Red) and 8 (near-infrared) of Sentinel-2 data were used. The images were projected to a common Universal Transverse Mercator (UTM) Zone 45N coordinate system of World Geodetic System (WGS 84). Besides, yearly available of high-quality and accurately classified Sentinel 2 land use and land cover (LULC) map of 2024 with 10m spatial resolution was downloaded from the Environmental System Research Institute (ESRI) website.

Table 1. Detailed information of Sentinel-2 spectral bands used in this study

Satellite	Sensor	Path/ Row	Spatial Resolution (m)	Spectral Bands (μm)	Data sources
Sentinel 2A & 2B	MSIL2A	T45QYG	10 & 20	B2 (Blue): 0.492 B3 (Green): 0.560 B4 (Red): 0.665 B5 (Vegetation red edge): 0.705 B6 (Vegetation red edge):0.740 B7 (Vegetation red edge): 0.783 B8 (near-infrared (NIR)): 0.842 B8A (Narrow NIR): 0.865 B11 (SWIR): 0.1610 B12 (SWIR): 0.2202	https://dataspace.copernicus.eu/

Table 2. Satellite image acquisition dates with respective season of the study area

Location	Year	Date	Season
Saghatta, Gaibandha	2024	28-02-2024	Rabi (Winter)

Ground reference dataset: A ground reference dataset contains Geographical Positioning System (GPS) co-ordinates, pictures and visual observations. In a remotely sensed satellite image analysis, GPS co-ordinate data is to provide an unbiased reference necessary to determine sample plot's location of onion cultivation field, land cover types, interpret decisions, and assess accuracies of the results in image classification algorithms. In this study, ground truth data were collected for crop inventory at the peak vegetative stage of crops during the crop growing seasons from the study area. More than 80 GPS co-ordinates or geo-referenced points (training 70% and validation 30%) combination of all feature classes were collected from each study areas through field surveys for accuracy assessment, with a distance of 1-2 km. Smart phone with android operating system (Android version 5.1.1) with good quality camera was used for survey of GPS data collection. The collected GPS data samples was documented in the Microsoft Excel (version 2020) and converted into GIS database compatible format (.csv) so that the attribute data could be analyzed based on their spatial location. Subsequently, the integrated database was therefore identified checked and then minimized the position error by visual interpretation in high-resolution imagery using Google Earth pro. Likewise, GIS data like Bangladesh administrative boundary of GIS database was freely downloaded from the internet sources (<https://www.diva-gis.org/Data>). The boundary shape of Area of Interest (AOI) related to study area was then clipped from Bangladesh administrative boundary.

Additionally, ancillary data including soil type, elevation, rainfall patterns, cropping patterns, planting and harvesting dates, area coverage, and yield data of onion was collected through farmer interviews and discuss with Department of Agricultural Extension (DAE) personnel. The district-wise crop data (Crop statistics, 2022-23) released by the Department of Agricultural Extension and Bangladesh Bureau of Statistics (BBS); Government of Bangladesh was used as a guide for interpreting the outcomes of acreage estimation.

Image Preprocessing: Pre-processing of Sentinel-2 satellite images involves atmospheric correction, radiometric calibration, geometric corrections and image geo-referencing which is an integrated part of the process of Sentinel-2 satellite image processing when acquired. The

selected four bands from each image (blue, green, red, and NIR) were mosaicked and stacked together as one single layer to obtain a multispectral band composite image. Since they all have a similar spatial resolution of 10 m×10 m. All satellite images were then subset with clipped AOI administrative boundary (shape file) to extract feature data from imageries for covering only the study area to reduce computation and image analysis time (Figure 3).

At the final step of image pre-processing, contrast stretching was applied on R-G-B-NIR images to improve the visual interpretability of different objects on the imagery using on-screen digitizing and then a false colour composite (FCC) image was generated. This FCC was performed as a reference image during image classification in which the NIR-Red-Green band was projected as R-G-B color respectively. The FCC image clearly shows the water bodies in black, vegetation fields in pink to dark red and urban surface materials as light bluish.

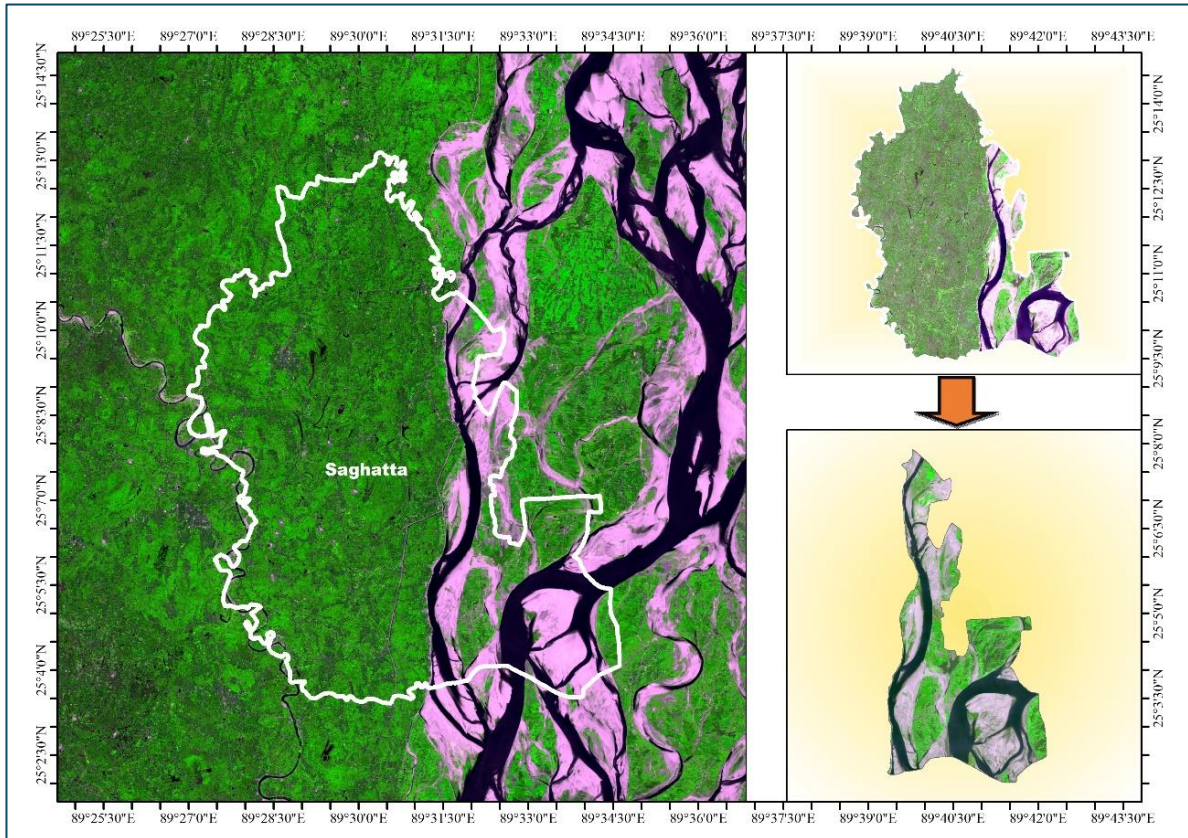


Figure 3. Spatial features data extraction using mouza boundary over composite band satellite datasets

Image classification approach: In this study, hybrid classification technique i.e. combination of unsupervised and supervised-based classification techniques was applied to illustrate thematic maps for depicting spatial distribution of onion cultivation in the study area. This classifier is cost-effective and successful in producing maps with high accuracy from satellite images (Güler et al. 2006) and generated more accurate classifications than the supervised classification techniques (Rozenstein and Karnieli, 2011). In this classification approach, initially, 20 spectrally homogenous classes grouped were created through an unsupervised (ISODATA) classification algorithm on single FCC image which provides an initial stratification of the study area. In the next step, each group of classes with similar spectral characteristics was merged into a single class through visual interpretation and ground reference data using a supervised technique. This procedure of labeling and class identification is called the spectral matching technique (SMTs) (Gumma et al., 2018). The classified image was then differentiated into five classes and assigned class names i.e., settlements, vegetation, cropland, water body and bare soil through a reclassification process which is described in Table 2.

Crop type identification and area estimation: This study was aimed to delineate the onion cultivation areas for the year of 2024. In this context, a spectral pattern profile based on remote sensing was employed to identify the cultivated areas of the different crops in the study area. The crop area identification process was done by using a classified output image and overlapped with a GPS-based ground truth point shape file on the classified image. The onion cultivation areas were then masked from other cropland and reclassified through visual interpretation. It should be noted that the spectral profiles of all crops were different because of their different phenological characteristics and profiles. The classified image was then converted into a polygon-based map and imported into a GIS for further validation. After classification, the onion cultivated area was computed from classified imagery pixel counting or sub-pixel analysis. The estimation of onion cultivation area was done as per the following mathematical formula (Gallego, 2004).

$$A_{ha} = \frac{N \times a}{10000} \quad (2)$$

Where, A_{ha} = each land cover class area in hectare, N = Number of pixels of each cover class and a = Resolution of the Sentinel-2 image area in square meter (10m×10m).

Accuracy assessment: An accuracy assessment is a crucial aspect of any classification. It is the comparison of a classification with ground-truth data to evaluate the reliability of the resultant land cover maps. In this study, an error matrix method was applied to assess the Sentinel-2 satellite derived image classification algorithms performance. The accuracies were evaluated in terms of overall accuracy, producer's accuracy, user's accuracy metrics, (Landerer and Swenson 2012) and kappa coefficient (Cohen 1960; Congalton 1991). The overall accuracy is the percentage of correctly classified samples (Thapa and Murayama 2009). The producer's accuracy represents the probability of pixels that a reference pixel has been correctly classified. The user's accuracy, on the other hand, describes the map reliability which provides information on how well a map represents within a specific class. Another common measure of accuracy is the Kappa statistics were also performed to measure the extent of classification accuracy. The following equations were considered to estimate overall accuracy, producer accuracy, user accuracy, and Kappa coefficient valuation.

producer's accuracy = Number correctly identified in ref. plots of a given class / Number actually in that reference class

overall accuracy

user's accuracy = Number correctly identified in a given map class / Number claimed to be in that map class

$\hat{\kappa}$ = observed accuracy - chance agreement

$$\text{Producer's accuracy} = \frac{\text{Number correctly identified in ref. plots of a given class}}{\text{Number actually in that reference class}} \times 100$$

$$\text{User's accuracy} = \frac{\text{Number correctly identified in a given map class}}{\text{Number claimed to be in that map class}} \times 100$$

$$\text{Overall accuracy} = \frac{\text{total numbers of correctly classified pixels}}{\text{Total number of reference pixels}} \times 100$$

$$\text{Kappa coefficient } \hat{\kappa} = \frac{\text{observed accuracy} - \text{chance agreement}}{1 - \text{chance agreement}}$$

Results

Based on the developed methodological procedure in the present study, the thematic map of study area was obtained for estimating onion cultivated area in cropping season of 2024. The different land use land cover (LULC) texture features produced from classification were computed is shown in Figure 3. The LULC class for the study areas was divided into the following theme classes is as shown in Table 4. Area statistics were extracted from map taking into account the pixel counted and estimated on the pixel grid cell method (Table 5). The area under onion crop was obtained by multiplying these number of pixels by resolution of the data i.e. 10 x10 m and converted into hectares. Identification and discrimination of onion from other land use and

land cover in the study area were carried out following digital hybrid (unsupervised and supervised) remote sensing image classification technique. On the classified image, green colour is assigned to the area of onion cultivation. The estimated onion area is given in Table 6.

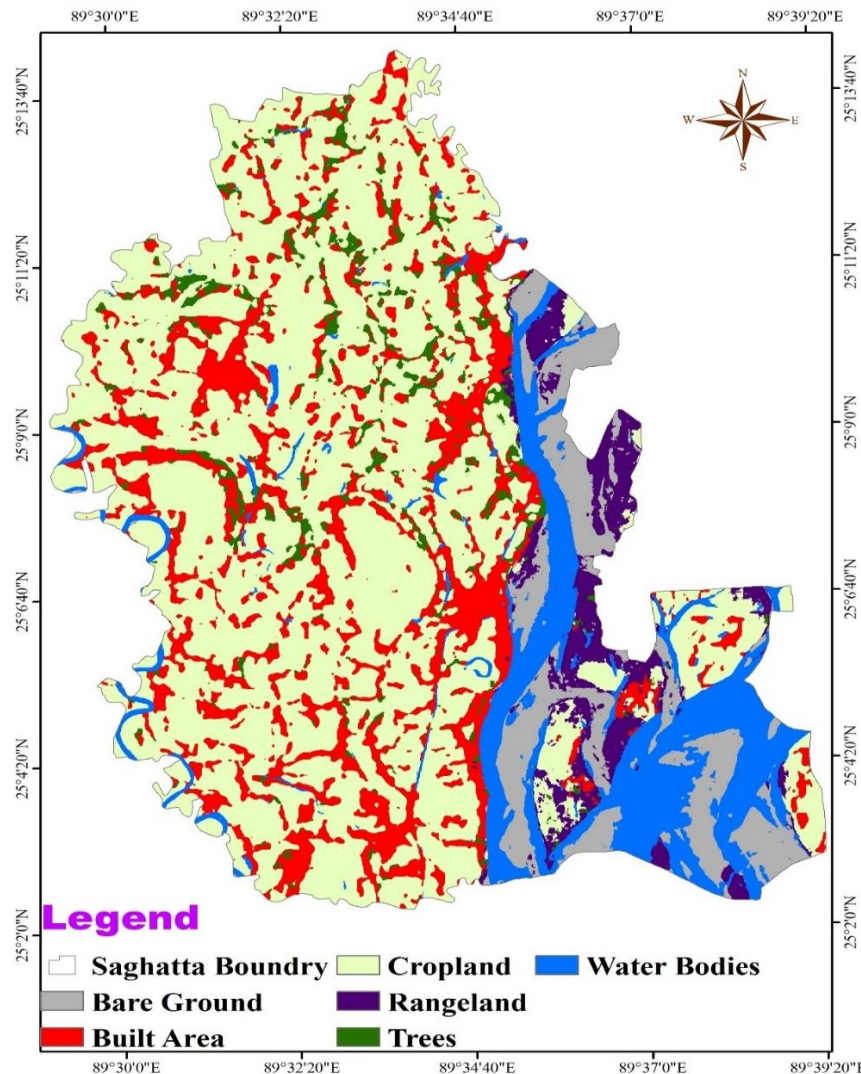


Figure 3. Land use cover land cover classes (LULC) of the study area

Table 4: Description of LULC classes

Classes	Description
Water Body	Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built-up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.
Trees	Any significant clustering of tall (~15-m or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense tall vegetation within savannas, plantations, swamp or mangroves (dense/tall vegetation with ephemeral water or canopy too thick to detect water underneath).
Cropland	Human planted/plotted cereals, grasses, and crops not at tree height; examples: maize, wheat, soybean, fallow plots of structured land.
Built Area	Human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples: houses, dense villages/towns/cities, paved roads, asphalt.

Bare ground	Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.
Rangeland	Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting (i.e., not a plotted field); examples: natural meadows and fields with sparse to no tree cover, open savanna with few to no trees, parks/golf courses/lawns, pastures. Mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are clearly not taller than trees; examples: moderate to sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse grasses, trees or other plants.

Table 5. LULC distribution with percentage covers

Feature Name	Area_ha	% Cover
Water Bodies	2621.56	11.55
Trees	835.4	3.68
Cropland	12472.56	54.95
Built Area	3914.86	17.25
Bare Ground	1814.55	7.99
Rangeland	1039.18	4.58
Total=	22698.11	100.00

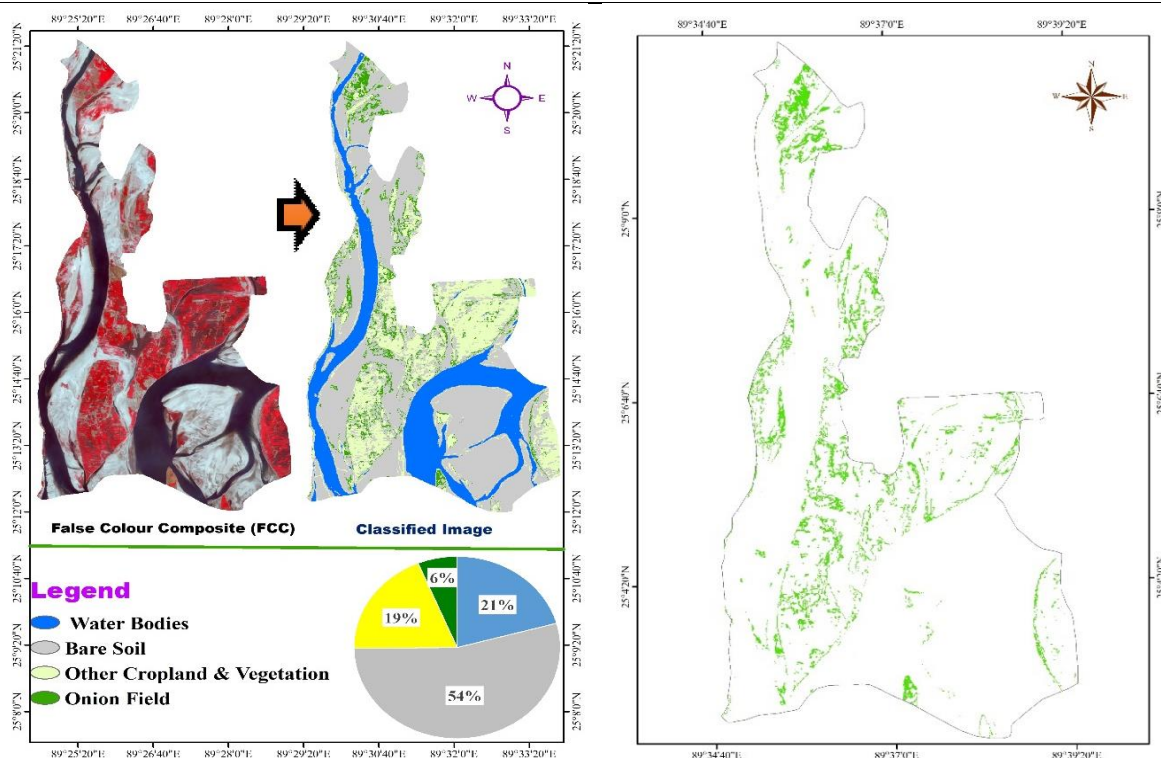


Figure 4. Mapping of spatial distribution of onion cultivated area

Table 6. Estimated onion area of Charland area in Saghatta upazila

Feature Name	Area_ha	% Area
Water Bodies	1282.97	21
Bare Soil	3351.83	54
Other Cropland & Vegetation	1177.34	19
Onion Field	382.77	6
Total=	6194.91	100

Accuracy accounting

The classification accuracy was assessed with the help of Kappa coefficient, overall accuracy, producers' accuracy and users' accuracy and presented as an error or confusion in the form of matrix table. The detailed information is shown in Table 7. The accusation value only shows the accuracy of onion cultivating area in performing classification based on differentiation and compatibility with the ground reference data. The ground reference data comprising of onion was overlaid on the classified image to test the accuracy. Result shows that the classified image obtained the highest overall accuracy of 81.54% with an estimated Kappa coefficient value of 0.78 over all the classes. The major reason for the lower accuracy of the image was misclassification or poor performance of the classification algorithm, overlapping, and errors in visual interpretation in distinguishing some LULC classes. Another reason was that the reference points were located in different areas for the assessments, i.e., many reference points were located in the border of two crop land when assessing the classified image, so it was hard to identify the desire cropland, which probably decreased the overall accuracy measure as well. Again, the high misclassification rate of the onion field was caused by the confusion with weeds, garlic cropland, grass and tree shadows as well as uneven onion planting time. However, this result indicates that remote sensing-based technique can be effectively used for acreage estimation of onion.

Table 7. Accuracy Assessment of onion area maps

Year	Producer's accuracy (%)	User's accuracy (%)	Overall accuracy (%)	Kappa Statistics
2024	70.5	84.3	81.54	0.78

Conclusion

In order to assess crop acreage estimation in mixed cropping region, it is essential to use advanced techniques of digital image processing algorithm. Remote sensing is a powerful technique for surveying, mapping monitoring and can be put to best use if it is incorporated with GIS. This research has investigated the spatial and temporal information contained in the satellite images in terms of onion cultivated acreage estimation at charland area of Saghatta upazila of Gibandha district. A hybrid technique based on unsupervised clustering and visual analysis was used for identifying onion crop and estimating its acreage. The resulting acreage was accurately identified in the current investigation with 81.54% overall accuracy and kappa coefficient of 0.78. This result demonstrates the possibility for using temporal Sentinel-2 satellite image to onion crop mapping framework at regional level. This study also shows that the early-season onion acreage estimation helps government policymakers, market traders, and farmers access timely and effectively land distribution information In the further research, a field survey in conjunction with statistical data in a large area and more high spatial resolution images i.e. IKONOS, Quick bird and Worldview-2 and similar type of satellites; along with machine learning image classification techniques should be adopted.

94. DETERMINATION OF SUITABLE SEED RATE OF PROSO MILLET IN CHAR LAND

M. S. ISLAM, M. R. A. MOLLAH AND M. T. HASAN

Abstract

The experiment was conducted in the farmer's field of Khatiamaria, Sonatola, Bogura during Rabi, 2023-2024 to find out the suitable seed rate of proso millet and to disseminate along with BARI Cheena varieties to the farmers of Char land areas. The treatments were $T_1=25 \text{ kg ha}^{-1}$, $T_2=50 \text{ kg ha}^{-1}$, $T_3=75 \text{ kg ha}^{-1}$, and $T_4= \text{Farmer's practice } 100 \text{ kg ha}^{-1}$. Maximum seed yield (1.54 t ha^{-1}) was recorded from the T_3 treatment that was statistically different from all other treatments. The highest gross return (Tk. 107100 ha^{-1}) amounted from T_3 treatment against the

cultivation cost of Tk. 29924 ha⁻¹ which together led to the higher gross margin (Tk. 77176 ha⁻¹). Lower gross return (Tk. 88900 ha⁻¹), as well as gross margin (Tk. 58576 ha⁻¹), was obtained from the T₄ (Farmer's practice) treatment. Therefore, the optimum seed rate of proso millet is 75 kg ha⁻¹ at Charland of Sonatola, Bogura.

Introduction

Proso millet is one of the important minor cereal crops in Bangladesh. It belongs to the family Poaceae and is used in various forms such as grain for human consumption and fodder for cattle, green manure, cover crop, and short-lived forage. Proso millet is a fast-growing, short-season, drought-tolerant, low-input crop (Gowda and Kaul 1982). It is a promising crop for Southeast Asia and its ecological suitability is wide. The national average yield of Proso millet in Bangladesh is low. This low yield may be due to the cultivation of the low-yielding local varieties, use high seed rates and lack of technical know-how, etc. BARI has developed some high yielding Proso millet varieties such as BARI Cheena-1 with several high-quality parameters. This variety has the potential to help generate farmers' income in a very short period. The present study evaluated the performance of different seed rates under farmer's field conditions and popularized them among the farmers to promote their adoption in the char land of Bogura.

Materials and Methods

The experiment was conducted in the farmer's field of Khatiamari, Sonatola, Bogura during *Rabi*, 2023-2024. One proso millet variety BARI Cheena-1 was tested in the experiment. Four treatments viz. T₁=25 kg ha⁻¹, T₂=50 kg ha⁻¹, T₃=75 kg ha⁻¹ and T₄= Farmer's practice 100 kg ha⁻¹. The experiments were laid out in an RCB design with three dispersed replications having a plot size of 40 m². One farmer is considered as each replication. Fertilizers were applied @ 60-21-42-8-0.75 kg of NPKSZn ha⁻¹. Total TSP, MOP, Gypsum, Zinc sulphate & half of urea as basal, and the rest half of Urea were applied after seedling establishment followed by irrigation. Seeds were sown on 26 December 2023. One irrigation was applied at 45 DAS. The crop was harvested on 15 April 2024. Tillers/plant¹, Panicle length, Seed panicle⁻¹, 1000 seed weight, and seed yield. Yield and yield attributes per plot was recorded and converted into yield per hectare. Data were analyzed statistically using statistics-10.

Results and Discussion

The yield and yield contributing performance of proso millet are presented in Table 1. Significant variation was found among the treatments of all characters except panicle length and 1000 seed weight. The highest plant height (65.67 cm) and panicle length was 10.80 cm in T₃ and the lowest (10.60 cm) from T₄. The highest weight of seed panicle⁻¹ (3.20 g) obtained from T₃ and the lowest (2.60 g) in T₄. The highest seed yield (1.54 t ha⁻¹) was found from T₃ and the lowest (1.27 t ha⁻¹) in T₄.

Farmers' opinion: Farmers of the area were cultivated local variety and use of high seed rate. They are very happy to see the new variety and interested to grow BARI Cheena-1 for its higher yield with 75 kg seed ha⁻¹.

Table 1. Yield and yield contributing characters of proso millet at Khatiamaria, Sonatola, Bogura during *Rabi*, 2023-24

Treatments	Plant height (cm)	Tillers plant ⁻¹	Panicle length (cm)	Seed weight panicle ⁻¹ (g)	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
T ₁	65.67a	2.53b	10.67	3.13a	4.33	1.31bc
T ₂	64.43ab	2.27c	10.67	2.86ab	4.33	1.36bc
T ₃	64.0b	2.76a	10.80	3.20a	4.66	1.54a
T ₄	62.03c	2.13d	10.60	2.60bc	4.33	1.27c
CV%	5.45	6.79	NS	12.16	NS	6.15

T₁=25 kg ha⁻¹ (BARI Rec. dose), T₂=50 kg ha⁻¹, T₃=75 kg ha⁻¹ and T₄= Farmer's practice 100 kg ha⁻¹ NS= Not significant

Conclusion

The treatment T₃ (75 kg seed ha⁻¹) gave higher yield in Char land of Khatiamaria, Sonatola, Bogura.

95. EFFECT OF PLANTING DATE ON YIELD OF SUMMER HYBRID TOMATO IN THE NORTHWEST BANGLADESH

M. T. HASAN AND M. S. ALAM

Abstract

The experiment was conducted at the OFRD, BARI, Bogura during 2022-23 and 2023-24 to find out the suitable planting time and increase production and economic return. BARI Hybrid Tomato-11 variety was considered as four sowing dates viz. S_1 = 5 August, S_2 = 20 August, S_3 = 5 September, S_4 = 20 September. The experiment was laid out in RCBD with three replications. The plant height, virus infestation and wt. of fruits per m² of tomato were significantly affected by different sowing dates. Significant influence on yield, 50% flowering, no. of fruits per plant and individual fruit weight because of climatic conditions such as rainfall, decreased and increased temperature of crop growing period.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables in Bangladesh, which is receiving an increase of growers and consumers and made its position within a few of the highest cultivated vegetables. It is an essential component of the human diet for the supply of vitamins, minerals and certain hormone precursors in addition to protein and energy. In Bangladesh, congenial atmosphere remains for tomato production during October to March. It is mainly grown in winter season. High temperature decreases flower production or to bud and flower drop. However, differences between varieties in fruit set under high temperature have been reported (FAO, 1990). Went assured that fruit set was abundant only when night temperature was between 15°C and 20°C, which might oversimplify the issue. The importance of temperature in fruit set was clearly evident. Carme reported that fruit set in certain varieties with temperatures as low (7.2°C) and with temperature as high (26.6°C) had created more flexible situation in respect of the variety temperature interactions. Climate change is a major threat for crop production not only Bangladesh but also all over the world. In some areas of the country the night temperature falls even sometimes go below 5-6°C which results tremendous yield loss in tomato (Haque et al., 1999). By this time BARI released a good number of tomato variety but their characteristics against tolerance to temperature injury has yet not been studied. Therefore, the present study was undertaken to find out the suitable planting date of summer hybrid tomato in different locations of North-West Bangladesh.

Materials and Methods

The experiment was conducted at On-Station, OFRD, BARI, Bogura during 2022-23 and 2023-24 in Karatoa Bangali Flood Plain soil (AEZ-4). Geographically the experimental field is located at 24°51'03.6"N latitude and 89°22'52.2"E longitude. BARI Hybrid Tomato-11 was used in this experiment. The experiment was laid out in RCB design with three replications. There were four treatments viz. S_1 = 5 August, S_2 = 20 August, S_3 = 5 September, S_4 = 20 September. The unit plot size was 1.2 m × 4 m with plant spacing of 60 cm × 40 cm. Twenty-five days old seedlings were transplanted on different sowing dates. The fertilizers were used 253-90-125-22-5.5-2 kg ha⁻¹ NPKSZnB and Cowdung 10 t ha⁻¹. Half of cowdung, half amount of P and entire amount of S and B were applied during final land preparation. The remaining half of cowdung and P were applied during pit preparation before a week of planting. The entire N and K were applied in 3 equal installments of 25, 40 and 55 days after seedling transplanting. Plant protection measures were taken as required. Other intercultural operations were done when necessary. Harvest of tomatoes was started on 01 October 2023 and continued up to 20 March 2024. At maturity, different data were collected accordingly and subjected to statistical analysis. The gross economic return was calculated based on the prevailing market price of the commodities.

Results and Discussion

Highest plant height (127.63 cm) was registered under S_2 treatment and lowest (125.27 cm) was S_4 treatment at harvest not significantly variation. The data regarding number of fruits per plant

were highest (41.45) from S₂ treatment and lowest (31.88) from S₄ treatment. A perusal of data revealed that the showed their significant influence on 50% flowering, no. of fruits per plant, individual fruit weight and yield because of climatic condition such as rainfall, decreased and increased temperature of crop growing period. Significantly highest 50% flowering (71.00) was recorded under S₄ treatment and lowest was S₁ treatment (53.00). Significantly highest individual fruit weight (62.17 g) was recorded under S₂ treatment while S₁ treatment was lowest (57.30 g). Significantly highest yield (65.51 t ha⁻¹) was registered under S₂ treatment while S₁ treatment was recorded the lowest (53.33 t ha⁻¹). Higher fruit yield contributed to the higher gross return (Tk 3275500 ha⁻¹) S₂ followed by S₄ (Tk 2930000 ha⁻¹), S₃ (Tk 2878500 ha⁻¹) and the lowest in S₁ (Tk 2666500 ha⁻¹). On the other hand, the highest gross margin (Tk 2615190 ha⁻¹) was recorded from S₂ followed by S₄ (Tk 2269690 ha⁻¹) and the lowest in S₁ (Tk 2006190 ha⁻¹).

Table 1. Average yield and yield attributes of BARI Hybrid Tomato-11 under different treatments at On-Station, OFRD, BARI, and Bogura during 2022-23 and 2023-24

Treatment	Plant height (cm)	50% flowering (days)	Virus infestation (%)	No. of fruits plant ⁻¹	Wt. of fruits plant ⁻¹ (kg)	Wt. of fruits m ⁻² (kg)	Individual fruit wt. (g)	Yield (t ha ⁻¹)
S ₁ (5 August)	126.80a	53.0d	12.68a	32.83b	2.11b	9.75a	57.30b	53.33b
S ₂ (20 August)	127.63a	59.33c	10.64a	41.45a	2.42a	11.30a	62.17a	65.51a
S ₃ (5 September)	125.40a	63.67b	11.81a	34.05b	2.32ab	11.12a	58.81ab	57.57ab
S ₄ (20 September)	125.27a	71.0a	9.95a	31.88b	2.27ab	10.82a	59.41ab	58.60ab
CV (%)	2.38	3.42	41.21	7.76	6.58	8.74	3.96	8.99

Conclusion

From the study was observed that the plant height, virus infestation, and wt. of fruits per m² of tomato were not significantly affected by different sowing dates. However, a significant influence on 50% flowering, no. of fruits per plant, individual fruit weight, and yield because of climatic conditions such as rainfall, decreased and increased temperature of crop growing period.

96. EFFECT OF PLANTING TIME ON YIELD OF BARI BEGUN-12 IN TANGAIL

M.A. RAHAMAN, S. ROY, T. TASMIMA, K. ROY AND G. PAUL

Abstract

An experiment was conducted at the MLT site, Bhuapur, Tangail during rabi 2023-24 to find out the optimum transplanting time of BARI Begun-12. Four transplanting dates such as, T₁= 15 October, T₂= 30 October, T₃= 15 November and T₄= 30 November, were tested in the experiment. BARI Begun-12 was used as planting materials. Transplanting on 15 October (T₁) produced significantly the highest yield (33.10 t ha⁻¹) while the 30 November planting gave the lowest yield (1.85 t ha⁻¹). Considering transplanting dates, the highest gross margin (1100240 Tk ha⁻¹) was obtained from the earliest planted (15 October) and no economic benefit was gained from 15 November and 30 November plantation.

Introduction

Eggplant (*Solanum melongena*) is widely cultivated in Bangladesh and is considered as the second major important vegetable crop after potato in its total production. It's grown widely round the year throughout the country. Considering its high nutritive value and export potentiality, it is imperative to make attempts for its successful cultivation in the country. We know that successful cultivation of any crop depends on several factors. Sowing date is one of the important aspects for the production system of different crops. Optimum sowing or planting time ensures proper growth and development of plants resulting in maximum yield of crop and economic use of land. During recent years Horticulture Research Centre (HRC) of BARI has developed some brinjal varieties among them the latest one is BARI Begun-12 which is high-

yielding and tolerant to pests and diseases. In Tangail region farmers face a huge problem in sowing this crop. They are unable to grow brinjal before the last week of October due to heavy rainfall every year. For this reason, it needs to adjust sowing time to avoid heavy rainfall and getting a higher yield. So, the present study was carried out to clarify the optimum sowing/planting time for BARI Begun-12 in Tangail region.

Materials and Methods

The experiment was conducted at the MLT site, Bhuapur, Tangail during the *Rabi* 2023-24. The experiment was laid out in RCB design with three replications. The unit plot size was 8m × 5m. The plant spacing was 100 cm × 80 cm. The treatments comprised with four transplanting date (T_1 = 15 October, T_2 = 30 October, T_3 = 15 November and T_4 = 30 November). BARI Begun-12 was used as planting materials. The plots were fertilized with 10 t ha⁻¹ cowdung, 139, 50, 100, 18, 1.7, kg ha⁻¹ N, P, K, S, and B, respectively. The entire quantity of cowdung, P, S, B, Zn, and one third amount of K were applied during final land preparation. Nitrogenous fertilizer was applied in four equal splits at 15-20 days after transplanting, flowering stage, fruiting stage and continuous fruiting stage. Rest amount of K was applied in three equal splits at 15-20 days after transplanting, flowering stage and fruiting stage followed by irrigation. Plant protection measures were taken as required. Weeding and all other intercultural operations were done as and when necessary. Harvesting of fruits was started from 16 December 2023 and continuous to 02 April 2024. Plants were infested with white fly and *Epilacna* beetle which was controlled successfully by spraying Admire (Imidacloprid 200 SL). Collected data related yield attributes and yield were analyzed statistically using CropStat analytical package. The gross economic return was calculated based on the prevailing market price of the commodities.

Results and Discussion

Effect of transplanting dates: The minimum days required for the first harvest (59) was recorded from 30 October transplanted plants (T_2) and the maximum days (66) needed to first harvest for 30 November transplanted plants (T_1), which was statistically significant among the transplanting date. In case of days to the last harvest, maximum days (171) was found on 15 October from T_1 while minimum (122) in T_4 . The transplanting date showed significant effect on the total duration of harvest, the maximum duration of harvest (111) was recorded from 15 October on the other hand the minimum duration of harvest (55) was recorded from 30 November. The highest plant (104 cm) was observed in the 15 October and the shortest plant (71 cm) in 30 November. The highest number of fruits plant⁻¹ (5.63) was recorded from 15 October transplantation which was at par with 30 October (4.77) transplanted plants. The lowest number of fruits plant⁻¹ (1.33) was recorded on 30 November. The highest weight of fruit plant⁻¹ (3.73 kg), individual fruit weight (662.67 g), length of fruit (25.20 cm) and breadth of fruit (24.73 cm) were found on 15 October which were statistically significant compared to other treatments. The lowest value 0.15 kg; 111.67 g; 11.13 cm and 6.07 cm were recorded in case of weight of fruit plant⁻¹, individual fruit weight, length of fruit and breadth of fruit from the delayed transplanted plot *e.i.* 30 November. Among the four transplanting date the highest yield (33.10 t ha⁻¹) was obtained from 15 October and the lowest yield (1.85 t ha⁻¹) was recorded from 30 November.

Table 1. Yield and yield attributes of BARI Begun-12 as influenced by date of transplanting at MLT site, Bhuapur, Tangail during Rabi 2023-24

Treatment	Days to 1 st harvest	Days to last harvest	Duration of harvest (days)	Plant height (cm)	Fruits plant ⁻¹ (no.)	Individual wt. of fruit (g)	Wt. Fruits plant ⁻¹ (kg)	Fruit length (cm)	Fruit breadth (cm)	Yield (t ha ⁻¹)
T_1	60.0	171	111	104	5.63	662.67	3.73	25.20	24.73	33.10
T_2	59.0	156	97.	92	4.77	591.0	2.81	22.07	21.60	28.48
T_3	61.67	139	78	78	2.33	248.33	0.58	15.60	10.80	7.09
T_4	66.33	122	55	71	1.33	111.67	0.15	11.13	6.07	1.85
LSD (0.05)	4.38	5.81	8.13	14.81	0.67	73.78	0.47	1.37	1.79	3.55
CV (%)	3.60	2.00	4.80	8.60	9.60	9.20	13.0	3.70	5.70	10.10

T_1 = 15 October, T_2 = 30 October, T_3 = 15 November, T_4 = 30 November

Farmers' opinion: Farmers are interested in transplanting vigor seedlings on 15 October to get maximum fruit yield and also the highest market price from BARI Begun-12.

Conclusion

It might be concluded that healthy seedlings transplanting on 15 October is the most suitable for producing BARI Begun-12 in Tangail region as it provides the highest fruit yield and economic returns. This is the results of first-year trial, for more confirmation the experiment may be repeated in the next year.

97. EFFECT OF SOWING TIME OF MUSTARD VARIETY IN EASTERN SURMA-KUSHIYARA FLOODPLAIN SOIL OF SYLHET

M. I. NAZRUL

Abstract

The present study was conducted at farming system research and development (FSRD) site under Sulhet and Multilocal Testing (MLT) site, Shaistagonj, Habigonj during consecutive years 2022-23 and 2023-24 to determine the effect of sowing date on flowering and seed yield of mustard (*Brassica juncea* L.). The studies were conducted in the mustard var. BARI Sarisha-18 by inducing the plant to flower early or late through different sowing dates viz. S₁: 15 November, S₂: 30 November, S₃: 15 December, S₄: 30 December, S₅: 15 January. Delay in sowing caused a significant reduction in the length of flowering period. The crop sown on S₁ had the longest flowering duration (42 days) followed by the crop sown on S₂ (40 days) and S₃ (35 days). In the present investigations, crops sown on S₁ took significantly more days from sowing to the flowering stage as compared to others. Delayed sowing of mustard resulted in the reduction of seed yields due to short flowering duration ultimately reducing the seed yield.

Introduction

Cultivation of low yielder local varieties late sowing are the major causes for poor yield of mustard in the country (Alam and Rahman, 2006). High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, BARI & BINA has developed a number of high yielding mustard varieties with yield potential up to 2.5 t ha⁻¹.

The low yield is due to lack of high yielding varieties and improper agronomic practices. An understanding of some morpho-physiological characters in mustard is necessary to make progress in genotypic improvement and for the management of the crop either to increase yield and quality or to reduce the cost of production (Mendham and Salisbury, 1985). Important physiological attributes such as plant height, number of leaves plant⁻¹, number of siliquea plant⁻¹, number of seed siliquea⁻¹, 1000 weight plot⁻¹ and yield plot⁻¹, leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and specific leaf weight (SLW) can address various constraints of a variety for increasing its' productivity (Tandale and Ubale, 2007). There is a great scope of increasing yield of mustard by selecting high yielding varieties and improving management practices. Time of sowing is very important for mustard production (Rahman et al., 1988, Mondal and Islam, 1993 and Mondal et al., 1999). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield. The seed yield and maturity of mustard plants are greatly influenced by environmental conditions regardless of proper sowing of times. Different sowing dates provide variable environmental conditions within the same location for growth & development of crops and yield stability (Pandey *et al.*, 1981). Decreasing crop yield in delayed sowing date has been reported by many workers (Kohn and Storrier, 1970, Doly and Marcellos, 1974, Degenhardt and Kondra, 1981, McDonald et al., 1983). Determining suitable planting date plays an important role in conformation of plant growth stages with desirable environmental conditions which results in maximum yield. Planting date

has a considerable effect on seed yield by influencing the yield components so that late planting decreases primary branches plant⁻¹ and silique plant⁻¹ and finally causes a remarkable reduction in seed yield (Thurling, 1974). A suitable planting date is very important for good agronomic performance of mustard. Therefore, the present study was undertaken to find out the optimum planting date for mustard seed production in the northern part of Bangladesh.

Materials and Methods

The experiment was conducted at farming system research and development (FSRD) site, kamalbazar, South-surma upozila under Sylhet and MLT site, Shaistagonj, Habigonj during consecutive years 2022-23 and 2023-24 April 2023. Geographically the experimental field was located at 24° 49' 16" N latitude and 91° 53' 25" E longitude at an average elevation of 22 m above the of sea level. The experimental site belongs to the Agro Ecological Zone (AEZ-20), which falls into puddled silty clay loam to clay in the top-soils and porous silt with mottled plastic clay at varying depth. Deep grey terrace soils and grey valley soils are major components of the general soil types of the area. General fertility status is moderate, having low status of organic matter. The experimental field was also a piece of well drained high land with moderately even topography. The variety of mustard was BARI Sarisha-18. The experimental treatments were 5 sowing dates viz. S₁: 15 November, S₂: 30 November, S₃: 15 December, S₄: 30 December, S₅: 15 January. The experimental design was Randomized Complete Block Design (RCBD) with 4 replications having unit plot size 5 m × 4 m. Seed were sown in properly prepared land. Recommended fertilizers were used at the rate of 250, 180, 90 150 kg and 6 kg per hectare of Urea, TSP, MoP, gypsum and Zinc sulphate, respectively. Half of the urea and the whole amount of all other fertilizers were applied at the time of final land preparation prior to sowing. The remaining half of the urea was applied as topdressing in 22 days after emergence of seedlings. Intercultural operations were done as and when necessary. The crop was harvested at proper maturity. Data were collected on flower bud development, duration of flowering, plant height, number of siliqua plant⁻¹, number of seed siliqua⁻¹, 1000 seed weight, and seed yield ha⁻¹. The collected data were analyzed using computer package MSTAT and mean differences were adjudged by using Duncan's Multiple Range Test.

Results and Discussion

Effect of sowing time on flower bud, flowering, and crop duration: Sowing dates greatly affects the flower bud development. The mean number of days for flower bud development was maximum on S₁ (15) followed by S₂ (14) and S₃ (12). Likewise, seed sown on S₁ (15 November) had the longest flowering duration of 41.50 days and minimum in S₅ (39.83 days). Delay in sowing caused a significant reduction in the length of the flowering period due to environmental conditions for plant growth were more favorable. However, delayed sowing plants tend to reach reproductive and seed production stage earlier due to little aberrant environmental conditions when crop was sown on S₃, S₄ and S₅. Temperature and photoperiod have been reported as the two most important environmental factors affecting phenological development (Ghersa and Holt, 1995; Patterson, 1995).

In the present investigations, crops sown on S₁ and S₂ took significantly more days from sowing to the flowering stage as compared to S₄ and S₅. Optimum temperature conditions in mustard crops sown on S₁ and S₂ and comparatively low temperature in the crop sown on S₄ and S₅ (Table 1) might have resulted in early flowering and seed set, resulting shorter crop duration. Rise in air temperature has also been reported to result beginning of growing season by Sparks et al. (2005); Chmielewski et al. (2004).

Plant Height: Plant height was not significant influenced by planting dates.

Plant population: Optimum sowing time, planting geometry and plant population are the important factors affecting the yield of mustard crops. Different sowing dates significantly affected plant populations m⁻². The number of plant populations decreased with the delayed sowing dates. Statistically similar plant population was observed in sowing dates on S₁, S₂ and S₃.

Number of siliquae: The highest number of siliqua plant⁻¹ (151.50) was obtained from 30 November which was statistically similar to the first (15 November) planting date but dissimilar to S₄ and S₅ planting date. This finding was in conformity with the findings of Mondal et al. (1999) who stated that the 30 October planting produced the highest number of siliqua plant⁻¹ and reduced in the late sowings. Aziz et al. (2011a) also reported the early planting recorded the higher number of siliqua (253.9).

Number of seeds per siliqua: The highest number of seeds siliqua⁻¹ (36.67) was produced on 15 November sowing, and it was statistically similar to those of 30 November. The lowest number of seeds siliqua⁻¹ (32.33) was found in the plants of 15 January which was statistically similar to S₄ (30 December) sowing. These results agree with the results of Mondal et al. (1999) and Shahidullah et al. (1997).

1000-seed weight: The highest 1000-seed weight (4.12 g) was recorded on 15 November which was statistically similar to those of 30 November and 15 December. 15 January sowing was recorded the lowest weight of 1000-seed indicating reduced test weight with each successive delay in sowing after 30 November. Mondal et al. (1999) stated that 1000-seed weight reduced with the delayed planting time.

Seed yield: A significant variation was observed among the different sowing time in respect of grain yield. The highest seed set was observed in S₁ (2.83 t ha⁻¹) as compared to S₄ and S₅ but statistically similar to that of S₂ (2.71 t ha⁻¹) and S₃ (2.30 t ha⁻¹). This shows an increase of seed yields under sowing dates on S₁ S₂, and S₃ over other sowing dates (S₄ and S₅); it could be due to the fact that delayed sowing resulted in reductions in seed yield due to reduction in the flowering period. These results are in agreement with those of Faraji (2003); Rahnama and Bakhshandeh (2005); Shamsi et al. (2012), who have also reported that delay in planting caused a significant reduction in the length of the flowering period of Brassica, and a positive and significant correlation was observed between the length of the flowering period and the components of seed yield. Delaying sowing time resulted in reduction in the seed yield and which might be due to variation in temperature in the late sown crop.

Table 1. Effect of planting dates on the yield and yield attributes of mustard (BARI Sarisha-18) as influenced by different dates of planting during rabi 2023-24.

Treatment	Duration (day)			Plant height (cm)	Plants m ⁻²	Siliquae plant ⁻¹	Seeds siliqua ⁻¹	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
	Flower bud	Flowering	Crop						
S ₁	15	42	95	111.33	42.33	150.83	36.67	4.12	2.83
S ₂	14	40	93	108.00	44.00	151.50	35.67	4.01	2.71
S ₃	12	35	88	103.33	42.67	147.50	35.00	4.07	2.30
S ₄	11	32	84	96.00	38.33	112.50	33.33	3.67	1.90
S ₅	12	31	84	95.33	36.67	112.83	32.33	3.63	1.90
LSD (0.05)	0.87	1.14	5.03	NS	4.43	14.47	2.78	NS	0.48
CV (%)	3.63	1.70	3.01	7.91	5.77	5.69	4.27	5.37	10.98

Note: S₁: 15 November, S₂: 30 November, S₃: 15 December, S₄: 30 December, S₅: 15 January.

Conclusion

From the above study, it may be concluded that the best sowing time of mustard (BARI Sarisha-18) is on 15 November in northeast part of Bangladesh.

98. EFFECT OF DIFFERENT APPLICATION TIMES OF ETHEPHON ON OFF-SEASON PINEAPPLE PRODUCTION IN BANDARBAN

M. T. ISLAM, I. HOSSAIN, M. F. HOSSAIN and M. M. ANOWAR

Abstract

An experiment was carried out at four locations of Bandarban Sadar during 2023-24 to find out the response of pineapple plants (cv. Giant Kew) to ethephon in early, uniform flowering and off-season production of fruits. Ethephon had a significant effect on flower induction and fruit development in pineapple. The treatments were: T₁= September forcing, T₂= October forcing, T₃= November, and T₀=Control. The experiment was carried out in a randomized complete block design with three replications. Plant hormone (ethephon) treated plot in November showed maximum flowering (78.65%) followed by in September (74.33%) and the lowest flowering percentage in October treated plants (54.45%). Natural flowering occurred in the remaining plants along with untreated plants in mid-February. The appearance of 1st inflorescence took 45 to 58 days to initiate after forcing. The off-season harvesting of pineapple was possible in the months of September and October with a yield of 22.20 and 16.12 t ha⁻¹, respectively.

Introduction

The total area of the Chittagong Hill Tracts is estimated to be around 13,237 sq. km, which is about one tenth of the country (Brammer, 1997). 15% of country's total fruit demand is met from hilly areas amounting to 8 lakh tonnes and the area under fruit cultivation is about 1 lakh hectares. 81% of the fruit produced in the hilly region comes from 6 fruits (mango, pineapple, banana, jackfruit, papaya and orange) with a production of 14,67,594 tonnes. Pineapple cultivation is a long-standing practice of hill peoples. Pineapple (*Ananas comusus* L.) is one of the major fruits of Bangladesh. It constitutes about 10% of the total fruit production of the country (Anon, 1994). Early, uniform and year-round production of pineapple is possible by the application of growth regulators especially ethephon (Ethrel) and calcicon carbide (Bose et al., 1983). Among three hill districts, a vast area of Rangamati and Khagrachhari is under commercial off-season pineapple production while Bandarban is lagging behind. To stagger the harvesting period of pineapple and to predict the appropriate time of hormone/regulator (ethrel) application to make availability of pineapple in the market during off-season and to evaluate the economic performance of off-season pineapple and effectiveness of ethrel to induce flowering, this experiment was undertaken.

Materials and Methods

Experiments were carried out at four locations of Bandarban Sadar during 2023-24 to find out the response of pineapple plants (cv. Giant Kew) to ethrel in early, uniform flowering and off-season production of fruits. The experiment was carried out in a randomized complete block design with three replications. Four treatments were as September forcing (15th September), October forcing (15th October), November forcing (15th November) with a control plot (No hormone). Plantation was made almost one year before the treatment application according to plant age for each year. The area of each plot was 8m x 5m. Pineapple plants were grown in 40 cm x 50 cm spacing. Variety was Giant Kew and one-year old plant was selected for treatment. The spray volume was made with Active ingredients of ethephon were 41%. Fertilizer was applied two times at mid-June and 1st week of October as a farmer's dose @ 55 kg (total) at 1:1:1 N, P, K/1000 plants. Ethephon was applied at 15th September, 15th October and 15th November, 2023 with a control plot. 1.25 mL/L water of the ethephon (41% a.i.) solution was applied and 50 mL of solution poured at the heart of each plant in the morning at 7 am to 9 am. Date of flowering, earliness and duration, flowering percentage, fruit yield and fruit related characters were recorded from all plants under the treatments.

Results and Discussions

Table 1: Effect of growth regulator (ethrel) on yield and yield related characters of off-season flowering of pineapple

Treatments	1 st inflorescence after forcing (days)	Flowering (%)	Ripening (days)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight with crown (kg)	Number of leaves/plant	Fruit yield (t ha ⁻¹)
T ₁	45	74.33	225	11.85	5.98	1.42	38	22.20
T ₂	48	54.45	234	12.13	6.21	1.36	37	16.12
T ₃	53	78.65	-	-	-	-	39	-
T ₀	No hormone (Mid-February)	91.43	-	-	-	-	37	-

99. EFFECT OF DRIP IRRIGATION ON YIELD OF ROBUSTA COFFEE IN CHITTAGONG HILL TRACTS

M. T. ISLAM, I. HOSSAIN, N. U. AHMED, F. ARSHAD, M. F. HOSSAIN, M. M. ANOWAR and M. A. HOSSAIN

Abstract

Field experiments were conducted at Bandarban Sadar and Hill Agricultural Research Station, Raikhali, Rangamati during January 2024 to evaluate the influence of drip irrigation on the growth and yield of coffee robusta. Four treatments viz. T₁= 75% of the recommended dose of water; T₂= 50% of the recommended dose of water; T₃= 25% of the recommended dose of water; and T₀= Control (No water). The experiment was outlined in a Randomized Complete Block Design with five replications. Significant variation was found with the treatments. In Raikhali, maximum canopy size (5.85 m), tree volume (14.20 m³), and length of flower branch (94.4 cm) was found in T₂ treatment. The highest plant height (3.17 m), no. of the flowering branch (61) and no. of node/branch (16.26) was found in T₃. T₀ gave the minimum result in all growth and yield-related parameters. In Bandarban sadar, the highest plant height (3.20 m), maximum canopy size (5.51 m), tree volume (12.82 m³), no. of flowering branch (58.8), length of flower branch (91.4 cm) and no. of node/branch (7.86) were found in T₂ treatment. The lowest was found in T₀ (2m, 3.21m, 2.76m³, 11.8, 50cm, and 4.63 respectively).

Introduction

Coffee (*Coffea spp*) is one of the most important commercial crops grown worldwide in over 50 countries. There are several varieties of coffee, but only two varieties, *Coffea arabica*, and *C. robusta*, are grown commercially. Coffee plants, being perennial in nature, have the dual function of nurturing the developing berries and producing fresh wood for the succeeding crop. In normal management, Coffee plants remain productive for nearly 35-40 years. Therefore, establishing vigorous and healthy plants in the early years is essential for the longevity of the plantations. Since coffee is primarily grown as a rain-fed crop, the irrigation requirement is the same as that of the amount of rainfall received (Goodyear, 2004). Rainfall variability and distribution make irrigation essential to produce quality coffee in the agro-forest ecosystem in Bangladesh. Water stress and inadequate nutrition predispose coffee plants to die back, affecting yields and bean quality. Improper management of irrigation in coffee plantations will limit the expansion of the coffee industry unless water is used at its optimum efficiency. Robusta coffee is more susceptible to drought and responds well to irrigation than Arabica coffee. The most important factor limiting coffee production, even in well-managed estates, is the long dry period. Besides this, if blossom rains are delayed beyond March, then the production of coffee receives a major setback. Drip irrigation is an efficient method of providing irrigation water directly into the soil at the root zone of plants. It minimizes conventional losses such as deep percolation, runoff, and soil erosion, especially in water-scarce areas having undulated topography, shallow soils, and wide-spaced high-value crops. It also permits the utilization of fertilizers, pesticides, and other water-soluble chemicals along with irrigation water, resulting in higher yields and better-quality produce.

Hence, a drip irrigation system is considered a panacea for many of the problems in drought-prone areas (Carr, 2001 and Silva *et al.*, 2008). For coffee producers, a further advantage attributed to the irrigation method is the possibility of implementing drip fertigation, which may result in substantial fertilizer savings (Muaralidhara *et al.*, 2006 and Guimaraes *et al.*, 2010). Several research evidence showed that drip irrigation in coffee resulted in substantial savings in fertilizer and increased by 27% of productivity (Serra *et al.*, 2013). Keeping all these in view, the present experiment was, therefore, undertaken to explore the influence of drip irrigation on robusta coffee's yield parameters, especially during the flowering stages, which are more vulnerable to water stress.

Materials and Methods

Field experiments were conducted at Bandarban Sadar and Hill Agricultural Research Station, Raikhali, Rangamati, from January 2024 to the present to evaluate the influence of drip irrigation on the growth and yield of coffee robusta. The experiment was carried out in a randomized complete block design (RCBD) with five replications. In this experiment, coffee plants that were 5 years old, spaced 2 m apart in lines and 2 m apart, were used.

Installing components of drip irrigation system and work principle: A water tanker with a capacity of 220 L built at a head of 1m above the ground feeds a supply line made of HDP Pipe with a 32 mm diameter. Ball valves were installed and used to control the water flow out of the tanker. Screen filters were installed below ball valves to prevent the introduction of sand and other debris. After the screen filters, elbows have been added to connect the main lines to the risers. End caps were fitted to prevent water from seeping out of one end of the pipeline. The line is attached to a ball valve and a main filter. Using elbows, the main lateral and the extension pipes were connected. Laterals with online emitters spaced at 100 cm along the mainline began to appear. Elbows were used to connect the extension pipes to the main lateral. 100 cm-spaced laterals with on-line emitters started to appear along the mainline. Drip holes on HDP Pipe with a diameter of 2 mm were built at a spacing of 2 m based on the distance for growing coffee. The hydraulic parameters of the installed system, including the emitter flow rate, emitter flow rate variation, uniformity coefficient, and emission uniformity, were evaluated.

Emitter flow rate: From plots where catch cans were arbitrarily assigned plots and amounts of flow were captured over time, the average flow rate of the emitters used in the experiment was determined. Thus, the discharge or flow rate from a single output emitter at a given head was calculated as;

$q = v/t$, Where, q = single emitter discharge (litre/hour); V = volume of water collected from the emitter (litres) and t = time duration of discharge collection (hour). The emitter discharge rate was 6L/dripper/hour. Three digital timers were used to maintain different treatments according to CROPWAT 8.0 value.

Irrigation requirement and crop water requirement of coffee: Meteorological data has been collected from the SRDI, Bandarban, to assess the crop water and irrigation needs of coffee. Using the FAO CROPWAT version_8 software, the reference evapotranspiration (ET₀) of the experimental site was estimated using a modified FAO Penman-Monteith equation (Allen *et al.*, 1998). Coffee crop K_c values range from 0.9 to 1.1, and reference evapotranspiration (ET₀) is required to calculate the quantity of water required to make up for water lost through evapotranspiration (ET_c) (Allen *et al.*, 1998). In this study, 5-year-old coffee crop with an average crop coefficient of 1.1 was used (Doorenbos and Pruitt, 1977; Silva *et al.*, 2008). According to the crop ground cover factor K_r, the crop water requirements for drip irrigation are lower than those of conventional agricultural water. According to Savva and Frenken (2002), a ground cover of 80% was chosen for mature coffee trees. To calculate the amount of irrigation water needed for assessment purposes, the value of K_r based on Keller and Karmeli (1975) equal to 0.94 was selected.

Crop water needs and irrigation requirements for coffee: All the climatic data were calculated by CLIMWAT 2.0, a computer software developed by FAO. CLIMWAT is a climatic database to be used in combination with the computer program CROPWAT 8.0 and allows the calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide. Monthly reference crop evapotranspiration (ET_0) for each year of climatic record was calculated based on the modified FAO Penman menthieth equation (Allen *et al.*, 1998) using FAO CROPWAT software.

Net crop water requirement was calculated by 'CROPWAT 8.0' based on the various growth stages of the coffee plant (Table 1). CROPWAT 8.0 is a computer program developed by the Land and Water Development Division of FAO. CROPWAT 8.0 for Windows is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data.

Table 1. Crop water requirement for coffee robusta calculated by CROPWAT 8.0

Month	Decade	Stage	Kc	ETc	ETc	Eff. rain	Irr. Req.
			coeff.	mm/day	mm/dec	mm/dec	mm/dec
Jan	1	Init	0.9	1.9	18.7	0.0	18.7
Jan	2	Init	0.9	1.9	19.0	0.0	19.0
Jan	3	Init	0.9	2.1	23.1	0.0	23.1
Feb	1	Init	0.9	2.3	23.0	0.0	23.0
Feb	2	Init	0.9	2.5	25.0	0.0	25.0
Feb	3	Init	0.9	2.7	21.6	0.1	21.5
Mar	1	Init	0.9	2.9	29.1	0.6	28.5
Mar	2	Init	0.9	3.1	31.1	0.9	30.2
Mar	3	Init	0.9	3.3	35.6	4.3	31.3
Apr	1	Deve	0.9	3.4	34.0	4.0	30.0
Apr	2	Deve	0.9	3.6	34.1	5.1	31.0
Apr	3	Deve	1.0	3.7	36.1	24.2	12.9
May	1	Deve	1.0	3.8	38.2	45.2	0.0
May	2	Deve	1.0	3.9	39.3	62.2	0.0
May	3	Deve	1.0	3.7	41.1	79.2	0.0
Jun	1	Deve	1.0	3.5	35.4	101.1	0.0
Jun	2	Deve	1.1	3.3	33.2	120.5	0.0
Jun	3	Deve	1.1	3.4	33.6	121.9	0.0
Jul	1	Mid	1.1	3.4	33.9	123.0	0.0
Jul	2	Mid	1.1	3.4	33.7	127.2	0.0
Jul	3	Mid	1.1	3.3	36.6	123.9	0.0
Aug	1	Mid	1.1	3.3	32.9	122.4	0.0
Aug	2	Mid	1.1	3.3	32.5	121.2	0.0
Aug	3	Mid	1.1	3.3	36.8	108.3	0.0
Sep	1	Mid	1.1	3.4	34.4	94.9	0.0
Sep	2	Mid	1.1	3.5	35.3	83.6	0.0
Sep	3	Mid	1.1	3.4	33.6	69.3	0.0
Oct	1	Late	1.1	3.2	31.7	54.2	0.0
Oct	2	Late	1.1	3.0	29.5	40.0	0.0
Oct	3	Late	1.1	2.8	30.5	27.5	3.0
Nov	1	Late	1.0	2.6	26.0	7.8	18.2
Nov	2	Late	1.0	2.4	24.3	0.0	24.3
Nov	3	Late	1.0	2.3	22.5	0.0	22.5
Dec	1	Late	1.0	2.1	20.7	0.1	20.5
Dec	2	Late	0.9	1.9	18.9	0.0	18.9
Dec	3	Late	0.9	1.9	20.6	0.0	20.6
Total					1085.6	1672.7	422.2

Results and Discussion

Raikhali, Rangamati: Significant variation was found among the treatments. The maximum canopy size (5.85 m), tree volume (14.20 m³), and length of flower branch (94.4 cm) were found in the T₂ treatment. The highest plant height (3.17 m), no. of flowering branch (61), and no. of node/branch (16.26) was found in T₃. T₀ gave the minimum result in plant height (2.19m), canopy

development (4.46m), tree volume (5.75m³), flowering branch (39.8), length of flowering branch (73.8 cm), and no. of node/branch (12.20).

Bandarban sadar, Bandarban: In Bandarban sadar, significant variations were found among the treatments. The highest plant height (3.20 m), maximum canopy size (5.51 m), tree volume (12.82 m³), no. of flowering branch (58.8), length of flower branch (91.4 cm), and no. of node/branch (7.86) were found in T₂ treatment. The lowest was found in T₀ (2m, 3.21m, 2.76 m³, 11.8, 50cm, and 4.63, respectively).

Table 2. Growth and yield characteristics of coffee robusta in Raikhali during 2023-24

Treatments	Plant height(m)	Canopy(m) (E+W+N+S)	Tree volume (m ³)	No. of flowering Branch	Length of flowering branch(cm)	No. of node/ branch
T ₁	2.66	4.79	8.10	45.20	93.2	14.87
T ₂	3.01	5.85	14.20	47.00	94.4	12.43
T ₃	3.17	5.38	11.42	61.00	82.0	16.26
T ₀	2.19	4.46	5.75	39.80	73.8	12.20
CV%	14.14	8.85	13.80	15.80	16.36	20.54
LSD (0.05)	0.54	0.62	3.23	10.50	19.35	3.95

Table 3. Growth and yield characteristics of coffee robusta in Bandarban during 2023-24

Treatment s	Plant height (m)	Canopy(m) (E+W+N+S)	Tree volume (m ³)	No. of flowering Branch	Length of flowering branch(cm)	No. of node/ branch
T1	2.678	4.268	6.467	30.8	70.8	6.632
T2	3.204	5.51	12.819	58.8	91.4	7.86
T3	2.912	4.458	7.591	42.8	69.4	4.998
T0	2	3.208	2.755	11.8	50	4.634
CV%	9.63	7.95	16.53	17.69	12.89	12.45
LSD(0.05)	0.36	0.48	1.99	8.79	12.51	1.03

100.EFFECT OF DIFFERENT SOWING DATES ON THE YIELD OF MUNGBEAN IN COASTAL AREA

M. M. ISLAM H. M. K. BASHAR AND M. S. I. KHAN

Abstract

The experiment was conducted at Badarpur, Patuakhali sadar, Patuakhali during late rabi season of 2023-24. Mungbean variety viz. BARI Mung-6 was sown at 10 days interval starting from 20 January to 10 February. Plots consisted of three sowing dates (20 January, 30 January and 10 February). The yield and yield contributing characters of mungbean plant was significantly affected by the different sowing dates. 30 January sowing seeds produced maximum number of pods/plant (18.96), number of seeds/pod (10.67). pod length (10.19cm), 1000-seed weight (52.68 g) and yield (1.89 t ha⁻¹). The seed yield decreased 21.15% when seed sown late (10 February) due to production of lower yield components. Comparing different sowing dates yield and yield contributing characters 30 January performed better. The maximum gross return (Tk. 151200 ha⁻¹) was obtained from T₂ as well as gross margin (Tk. 92700 ha⁻¹) and BCR (2.58) was recorded from 30 January sowing. The lowest economic return was recorded from T₃ (Tk. 124800 ha⁻¹) and BCR (2.13).

Introduction

Effort was made to introduce mungbean in the late rabi season in southern Bangladesh from the early nineties. It has now been established as a major season. Mungbean (*Vigna radiata* L.) is an important cash crop which can be successfully cultivated under rainfed conditions during late Rabi season in the coastal areas of Bangladesh. After harvesting T-Aman, there is a huge potential

for the expansion mungbean in this region. However, various factors responsible for the successful yield of mungbean at farmer's field are: awareness of farmer about sowing date, using high yielding variety, proper planting pattern, proper plant protection measures and balanced application of fertilizers. Among the various agronomic practices, sowing date is the most important factor influencing the yield of mungbean. It affects duration of the vegetative, reproductive and maturity period of mungbean (Soomro and Khan 2003). Sowing date adjustment may help to overcome the problem of increasing the yield of the crop partially. Mungbean is also drought tolerant and can grow with a minimum supply of nutrients. However farmers are still using traditional variety, no fertilizer use, no weeding, no insect control measure etc. as a result their yields are low. As ecology of southern region of Bangladesh is different from other parts of the country so optimum sowing date for mungbean need to be identified for getting higher yield. Considering the above facts, the present experiment was undertaken to find out the optimum sowing date as well as ensure higher yield in coastal area.

Materials and Methods

The experiment was conducted at Badarpur, Patuakhali Sadar during late Rabi season of 2023-24 in farmer's field. The treatment comprised of three dates of sowing time i.e. 20 January (T_1), 30 January (T_2) and 10 February (T_3). BARI Mung-6 was used as experimental material. The seeds @ 30 kg ha⁻¹ was used. The experiment was laid out in RCB design with 3 replications having unit plot size 8 m x 5 m. Seeds were sown according to plots in line 30 cm apart. The land was fertilized with N₂₃, P₁₇, K_{17.5} and B₂ kg ha⁻¹ at the time of final land preparation. Weeding was done at 15 days after sowing followed by thinning to keep plant to plant distance of 10 cm. Other intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml L⁻¹ to control insect pests such as thrips and pod borers, respectively. The crops of 1m² (1m x 1m) in each plot were harvested by hand picking of pods at different dates as per maturity. Seed yield was recorded at 10-12% moisture content. The yield and other relevant data were recorded and analyzed statistically. The data were statistically analyzed and means were separated by LSD values at 5% level of significance.

Results and Discussion

Significant variation was found in case of plant height among the different days of sowing. Plant height ranged from 41.55 to 45.27 cm. The tallest plant (45.27cm) was recorded in T_1 (20 January) which was statistically identical to T_2 (30 January). The shortest plant (41.55cm) was recorded in T_3 (10 February). It seems that plant height reduced with reducing of soil moisture in the field. Seed yield of mungbean was significantly influenced by sowing date (Table I). Results revealed that T_2 (30 January) sowing produced the highest seed yield (1.89 t ha⁻¹), which resulted from the highest number of pods/plant (18.96), seeds/pod (10.67) and 1000-seed weight (52.68 g) than the other sowing dates. The T_3 (10 February) treatment gave significantly lower yields and showed lower yield contributing traits. The highest seed yield obtained from sowing on 30 January might be due to suitable temperature which enhanced the vegetative as well as reproductive growth of the crop. Seed yield was significantly higher with 30 January (1.89 t ha⁻¹) than other treatments (T_1 = 1.80 t ha⁻¹ and T_3 = 1.56 t ha⁻¹). The number of days required for first flowering was reduced with delay sowing due to increased temperature. Crop sown on 20 January required 48 days to reach first flowering stage. Crop sown on 10 February attained the same stage in 42 days only. Days required for first harvesting also followed the similar trend. The last sown crop took only 75 days to first harvesting, which was mainly due to earliest flowering. On the other hand, the crop sown earliest required more than 84 days for first harvesting this might be due to delayed flowering. In delay planting forced maturity comes due to rising temperature with time.

Farmers' opinion: Farmers are very much interested to grow mungbean var. BARI Mung-6 and they were happy to see the performance of mungbean variety with different sowing dates and opined that seed will be sown on 30 January next year for higher yield.

Table 1. Yield contributing characters and seed yield of mungbean as influenced by sowing date during rabi 2023-24

Treat.	Plant height (cm)	Days to first flowering	Days to first harvesting	Number of pods plant ⁻¹	Pods length (cm)	Number of seeds pod ⁻¹	1000-seed wt. (g)	Seed yield (t ha ⁻¹)	
								2023-24	2022-23
T ₁ = 20 January	45 a	48 a	84 a	17.72a	8.39b	9.21b	51.68ab	1.80a	1.79a
T ₂ = 30 January	44 ab	45 b	79 b	18.96a	10.19a	10.67a	52.68a	1.89a	1.87a
T ₃ = 10 February	42 b	43 c	75 c	14.57b	7.58b	10.02a	47.42b	1.56b	1.16b
CV (%)	7.45	2.73	5.85	3.75	7.76	4.62	10.68	2.78	4.27

Conclusion

From the result of two consecutive years it can be concluded mungbean seed should be sown around the 30 January to obtain the highest in coastal region. In this time soil comes at a level that helps to germinate mungbean seeds properly. Before 30 January soil moisture remain high and after 30 January soil moisture reduced rapidly due to rising temperature, both the situation hamper land preparation and reduce germination in mungbean. So, 30 January +/- 5 days might be considered as optimum sowing time of mungbean at coastal region.

101.EFFECT OF VARIETY AND SOWING DATES ON SUNFLOWER VARIETIES IN SOUTHERN REGION

M. M. ISLAM H. M. K. BASHAR AND M. S. I. KHAN

Abstract

The experiment was conducted at Patuakhali and Barguna district with different locations during 2023-24 with different sunflower to determine appropriate sowing time in coastal region for improving their yield. The experiment was design randomized complete block design (RCBD) with 6 dispersed replications. Three sowing date (15 December, 30 December and 15 January) and three sunflower cultivars (BARI Surjomukhi-2, BARI Surjomukhi-3 and local hybrid Hysun-33) were used. The effect of sowing date was significant difference for thousand-grain weight and number of grains per head, so that delays in planting decrease fruit yield. The highest plant height (136.44 & 135.37 cm), head diameter (61.26 & 58.64 cm), number of seeds per head (416.53 & 410.53) and seed yield (1.82 & 1.79 ton ha⁻¹) was observed when sowing on 15th of December both the location. At the interaction between sowing dates and varieties the highest days to maturity (113 & 114), plant height (138.1 & 134.01 cm), head diameter (57.41 & 55.31 cm), number of seeds per head (428.69 & 444.87), 1000 seed weight (77.79 & 79.12 g) and seed yield (1.84 t ha⁻¹) was obtained from BARI Surjomukhi-2 with 15 December sowing at Kuakata, Patuakhali and Barguna sadar, Barguna. Higher salinity observed in Kuakata and ranges 0.47 to 9.79 dS/m.

Introduction

Sunflower is one of the major oilseed crops in south central coastal region of Bangladesh. Traditionally, farmers prefer hybrid sunflower varieties e.g. Hysun-33 for its large head and higher productivity. Hybrid variety seed cost is comparatively higher than BARI developed composite varieties. Therefore, input cost for cultivation of hybrids minimizes the cost benefit ratio. Moreover, the performance of BARI developed composite varieties in different sowing dates yet not justified. Therefore, a comparative study on performance of BARI developed sunflower with the commercial one (Hysun-33) under different sowing dates is time demanding.

In sunflower, yield is determined by the proportions of the various components. Recognition the share and state of formation in each component are important in plant yield. Yield components of sunflower include number of heads per unit area, number of grains per head and average grain weight . Sowing date under irrigated and rainfed cultivation are one of the most important in

farming operations, which affect on yield and other characteristics of the crop. Determine the sowing date for a crop depending on prevailing conditions and climatic region . Ishida et al., and Hadjichristodoulou reported that in sunflower with delay in planting decreased grain yield. Tanimu et al., and Dixon and Lutman pointed out that delay in sowing reduced the morphological characteristics of the plant, including plant height, stem and head diameter, but its effect on grain yield is not significant. Although many studies have been done on all sunflower cultivars particularly planting date, however, few studies on planting (especially in the case of studied cultivars) has been in the region. Therefore, this study carried out to determine the best sowing date of sunflower cultivars, according to the weather conditions in coastal district.

Materials and Methods

The experiment was conducted at Kalapara, Patuakhali and Barguna sadar, Barguna during late Rabi season of 2023-24 in farmer's field. The treatment comprised of three dates of sowing time i.e. 15 December (T_1), 30 December (T_2) and 15 January (T_3) consists factor A. BARI Surjomukhi-2, BARI Surjomukhi-3 and local hybrid Hysun-33 consists factor B. The seeds @ 10 kg ha⁻¹ was used. The experiment was laid out in RCB design two factors with 3 replications having unit plot size 8 m x 5 m. Seeds were sown in line 50 cm apart. Contrary 75cm x 40cm followed Hysun-33. The land was fertilized with N₁₂₃, P₃₇, K₁₀₀, S₃₀ and B₂ kg ha⁻¹ at the time of final land preparation. Weeding was done at 15 days after sowing followed by thinning to keep plant to plant distance of 25 cm. Other intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. Seed yield was recorded at 10-12% moisture content. The data were statistically analyzed and means were separated by LSD values at 5% level of significance.

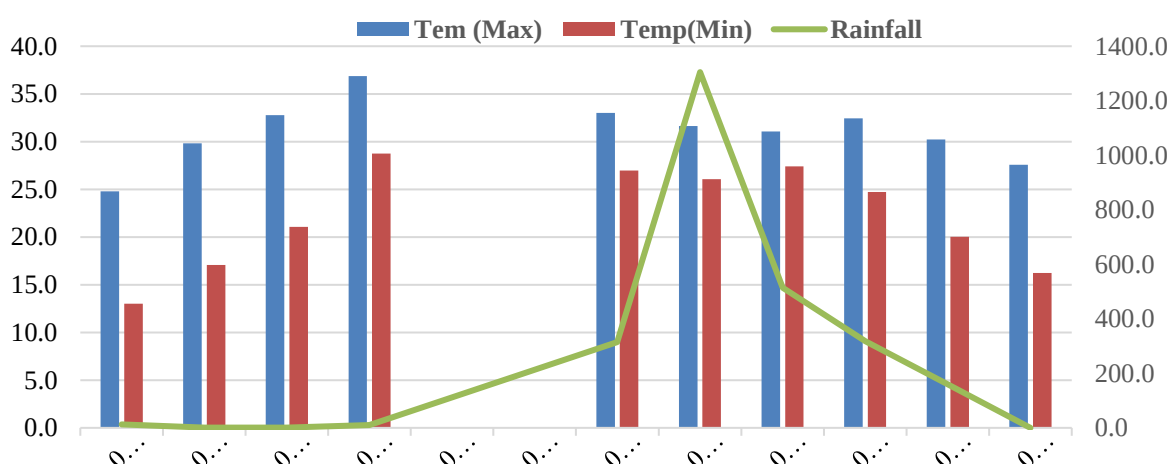


Figure 1: Weather scenario during trial period from May 2023 to June 2024.

Result and discussion

Sowing date effects: There were significant responses for all studied traits to climate changes when sowing date shifted from one to another. This may be due to the effective role of climatic changes relating to temperature, rainfall and relative humidity.

Delaying in sowing date from 15th of December to 15th of January was associated with a highly significant respective decrease in number of days to physiological maturity due to adverse climatic conditions relating to high temperature. This could be attributed to late sown plants were more exposed to higher temperature than early one, which was responsible for shortening of their life cycle. Highest seed yield was observed 1.82 t ha⁻¹ in kuakata and 1.79 t ha⁻¹ in Barguna sadar when seeds were sown on 15 December 2023. The yield was decreased when planting delay.

The shortest plants (136.44 & 128.49 cm) were associated with delaying sowing date on 15th of January with compared to early sowing date on 15th of December. This may be due to early

sowing date on 15th December which might have provided plants with relatively cooler period compared to the latter three sowings, that leading to stimulate cytokine and gibberellins accumulation, modifying the hormonal balance and leading the plant to increase the plant development and which reflected on elongation of main stalk.

Head diameter and 1000-seed weight, as two important components that related to yield components followed the same trend of the previous traits. Where, a gradual decrease in head diameter could be observed due to delaying sowing date on 15th of January, 30 December respectively in comparison with early sowing on 15th of December. These results are in accordance with those obtained by Mahmood (2013) and Aziz and Salih (2014). This may be due to plants were early sown on 15th of December had the largest vegetative growth period which allowed plants to receive the highest degrees of heat unit with their ability to effectively absorption of water and soil nutrients, hence increasing the photo-assimilates in the leaves which movement from vegetative organs to head and seed represent a sink, which might had the positive influence on head diameter and 1000-seed weight. Expression of higher maturity time, highest head diameter, higher number of seeds per head and 1000 seed weight leads to higher seed yield (1.82 & 1.79 t ha⁻¹) from early sunflower seed sowing next to 30 December seed sowing. The lowest seed yield (1.53 & 1.48 ton ha⁻¹) obtained from delay seed sowing ie. 15 January of 2024 from Patuakhali and Barguna, respectively.

Varietal effect: Among the varieties flowering started earlier in BARI Surjamukhi-3 and also matured 14 days earlier than BARI Surjomukhi-2. Hysan 33 took the highest times (124 days) to be matured at Kuakata, Patuakhali. Maximum plants were found in BARI Surjamukhi-2 (139.76 & 142.65 cm) that was statistically similar with Hysun 33 (135.45 cm) from both the location. The variety Hysun -33 produced the biggest size head (53.55 & 51.98 cm) with the highest number of seeds (440.84 & 475.34) but 1000 seed weight was lower than BARI Surjomukhi-2. The highest yield was observed in BARI Surjomukhi-2 (1.85 & 1.76 t ha⁻¹) and similar to Hysun-33 (1.79 & 1.71 t ha⁻¹) and lowest yield in BARI Surjomukhi-3 (1.48 & 1.43 t ha⁻¹) from Patuakhali and Barguna, respectively.

Interaction effect: The interaction effect of sowing dates with sunflower varieties was highly significant for all studied traits. The highest days to maturity was acquired from early sowing with hybrid variety. The shortest plants (125.20 cm) were observed in BARI Surjomukhi-3 when sowing on 15th of January due to shortened the vegetative growth period. However, the best variety was detected in BARI Surjomukhi-2 for plant height (138.10 & 138.82 cm), head diameter (56.15 & 55.31 cm), number of seeds per head (424.49 & 444.87), 1000 seed weight (77.79 & 79.12 gm) and seed yield (1.84 & 1.77 t ha⁻¹) when sowing on 15th of December.

Effect on salinity: Salinity level of the experimental plots was (0.47 & 0.24) dS/m during plantation then it increased with time up to (9.79 & 6.72) dS/m throughout the growing season of Patuakhali and Barguna (Fig. 1). Higher Salinity observed in Patukhali (9.79dS/m) compare to Barguna (6.72 dS/m).

Table 1. The effects of sowing dates on yield and yield components of sunflower cultivars at Kuakata, Patuakhali during robi 2023-24

Sowing date	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/ head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
T1-15 December	115	136.44	61.26	416.53	75.34	1.82
T2-30 December	103	132.49	58.33	403.00	73.00	1.69
T3-15 January	112	129.66	55.76	372.34	69.15	1.53
CV (%)	2.78	4.15	14.63	13.71	10.82	5.61
LSD 5%	1.5	1.44	0.78	6.75	0.58	1.36

Table 2. The effects of sowing dates on yield and yield components of sunflower cultivars at Barguna Sadar Sadar, Barguna during rabi season, 2023-24

Sowing date	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
T1-15 December	116	135.37	58.64	410.53	73.98	1.79
T2-30 December	105	130.98	54.89	400.57	71.15	1.68
T3-15 January	110	128.49	52.79	383.49	74.67	1.48
CV (%)	2.68	5.64	11.47	8.64	8.64	4.38
LSD 5%	1.73	2.08	1.98	7.97	1.69	1.37

Table 3. The effects of different sowing dates on sunflower yield and yield components at Kuakata, Patuakhali during rabi season, 2023-24

Sowing date	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
T1- 15 December	110	139.76	51.05	432.45	80.24	1.85
T2- 30 December	96	120.74	50.16	375.80	75.24	1.48
T3- 15 January	124	137.68	53.55	440.84	78.17	1.79
CV (%)	3.58	4.15	14.63	13.71	10.82	5.61
LSD 5%	1.47	1.36	3.21	13.17	1.22	0.76

Table 4. The effects of cultivars of sunflower on yield and yield components at different sowing dates at Barguna Sadar Sadar, Barguna during robi 2023-24

Varieties /lines	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
V1-BARI Surjomukhi 2	112	142.65	50.24	426.74	83.57	1.76
V2-BARI Surjomukhi-3	97	123.47	43.25	360.45	78.45	1.43
V3-Hysun 33	118	135.45	51.98	475.34	72.67	1.71
CV (%)	12.64	4.15	1.69	5.49	11.89	4.98
LSD 5%	3.94	1.36	0.75	3.48	0.78	2.56

Table 5. Effect of sowing date interaction with three sunflower genotypes on seed yield and yield- attributes at Kuakata, Patuakhali during robi 2023-24

Interaction (TXV)	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
T ₁ V ₁	113	138.10	56.15	424.49	77.79	1.84
T ₁ V ₂	106	128.59	55.71	396.16	75.29	1.65
T ₁ V ₃	120	137.06	57.41	428.69	76.75	1.76
T ₂ V ₁	107	136.13	54.74	417.68	76.62	1.77
T ₂ V ₂	99	126.61	54.25	389.40	74.12	1.59
T ₂ V ₃	114	135.09	55.94	421.92	75.59	1.74
T ₃ V ₁	111	134.71	53.40	402.39	74.69	1.69
T ₃ V ₂	104	125.20	52.96	374.07	72.19	1.51
T ₃ V ₃	118	133.67	54.65	406.54	73.66	1.66
CV (%)	5.36	4.15	14.63	13.71	10.82	5.61
LSD 5%	2.95	6.71	2.41	26.34	2.43	1.51

T₁-15 December, T₂-30 December, T₃-15 January: V₁-BARI Surjomukhi 2, V₂-BARI Surjomukhi-3 and V₃-Hysun 33

Table 6. Effect of sowing date interaction with three sunflower genotypes on seed yield and yield- attributes at Barguna, Sadar, Barguna during robi 2023-24

Interaction (TXV)	Days to maturity	Plant height (cm)	Head diameter (cm)	No of seed/ head	1000 seed wt. (g)	Seed yield (t ha ⁻¹)
T ₁ V ₁	114	134.01	54.39	418.45	78.77	1.77
T ₁ V ₂	106	129.42	50.95	385.96	76.22	1.61
T ₁ V ₃	117	135.41	55.31	444.87	73.32	1.75
T ₂ V ₁	108	138.82	52.53	413.39	77.36	1.72
T ₂ V ₂	101	127.23	49.07	380.45	74.80	1.56
T ₂ V ₃	112	133.22	53.44	437.73	71.91	1.69
T ₃ V ₁	111	135.57	51.52	405.12	79.12	1.62
T ₃ V ₂	104	125.98	48.02	371.97	76.56	1.46
T ₃ V ₃	114	131.97	52.38	429.42	73.67	1.60
CV (%)	7.64	4.78	9.24	7.71	9.47	7.48
LSD 5%	3.07	6.71	3.47	11.34	4.57	3.67

T₁-15 December, T₂-30 December, T₃-15 January: V₁-BARI Surjomukhi 2, V₂-BARI Surjomukhi-3 and V₃-Hysun 33

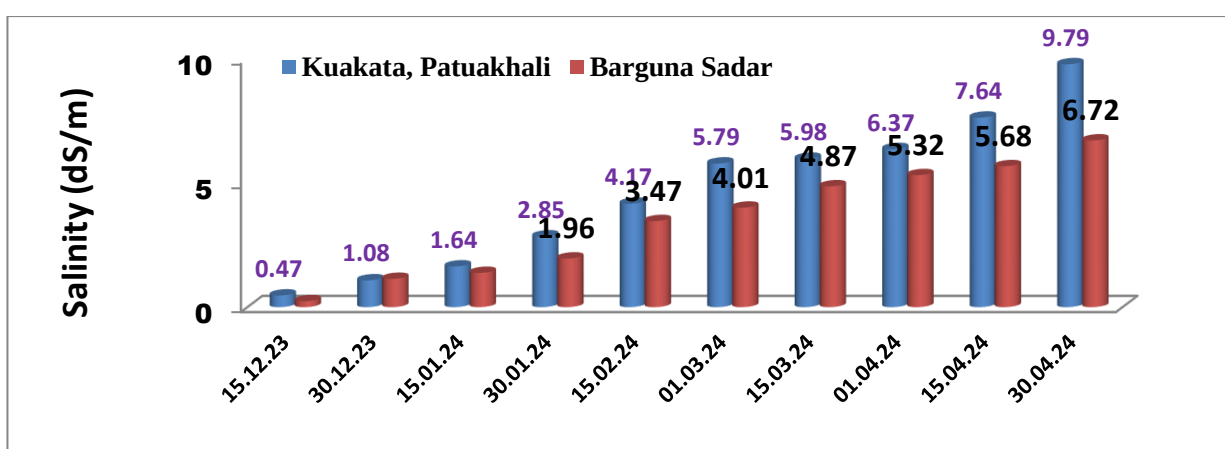


Fig-1: Salinity level of different location

Conclusion

It can be concluded from above mentioned results that early sown plants on 15th of December had high yield potential could be due to the extent of the plants life cycle with time which allowed them to form a sufficient amount of photo-assimilates through photosynthetic process and increasing the seed yield. From the salinity graph higher salinity is not a factor for sunflower production in coastal region. On the other hand Farmers can easily store the seeds of BARI Surjomukhi-2 and 3 for next year cultivation. However, this was the first year result, it should be repeated next year for more confirmation.

102. PERFORMANCE OF SUNFLOWER AS INFLUENCED BY SOWING DATES

R. UDDIN AND B.C. KUNDU

Abstract

Sunflower sowing at south central coastal region of Bangladesh is varies from region to region depending upon soil moisture condition after T. Aman rice harvesting. Optimum date of sowing for sunflower in different regimes of southern belt still not investigated. A field study was carried out at RARS, Rahmatpur, Barishal during Rabi season of 2023-24 to observe the effect of different sowing dates on sunflower cultivation.. *The experiment* was carried out with three sowing dates i) December 31 (ii) January 15 and (iii) January 30 and three variety/cultivars e.g. i) BARI Surjomukhi-2 ii) BARI Surjomukhi -3 and iii) Hysun-33 under factorial randomized complete block design with three replications. Results revealed that,

optimum sowing contributed to the maximum seed yield, the commercial cultivar Hysun-33 has the late sown potentiality in respect of seed yield and Hysun-33 sown at December 31 gave the maximum seed yield (1776.7 kg ha⁻¹) whereas the minimum seed yield from BARI Surjomukhi-3 at varying sowing dates.

Introduction

Sunflower is one of the major oilseed crops in south central coastal region of Bangladesh. Traditionally, farmers prefer hybrid sunflower varieties *e.g.* Hysun-33 for its large head and higher productivity. Hybrid variety seed cost is comparatively higher than BARI developed composite varieties. Therefore, input cost for cultivation of hybrids minimizes the cost benefit ratio. Moreover, performance of BARI developed composite varieties in different sowing dates yet not justified. Therefore, a comparative study on performance of BARI developed sunflower with the commercial one under different sowing dates is time demanding. Therefore, the study was undertaken to evaluate the performance of sunflower varieties/cultivar influenced by different date of sowing.

Materials and Methods

The experiment was conducted at RARS, Rahmatpur, Barishal in two factor randomized complete block design with three replications. The unit plot size was 3m × 5m with 4 replications. Line to line distance was 50 cm and plant to plant distance was 10-15 cm. The experimental field was fertilized with @40-80-40-20 kg ha⁻¹ of NPKS as basal dose. The treatments were as follows: Factor 1. Variety/cultivar- (i) BARI Surjomukhi-2 (V₁) (ii) BARI Surjomukhi-3 (V₂) and (iii) Hysun-33 (V₃) and Factor 2. Sowing Dates: (i) Sowing at December 30 (S₁) (ii) Sowing at January 15 (S₂) and (iii) Sowing at January 30 (S₃). The collected data were analyzed by the statistical software R and the least significant differences were calculated at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

The results revealed that the number of seed/heads (310.4), thousand seed weight (36.86 g) and seed yield (1276.7 kg ha⁻¹) of sunflower was maximum at early sowing whereas minimum seed yield from late seeding (30 January). The number of seeds/heads was maximum in Hysun-33 (332.33) with the highest thousand seed weight from Hysun-33 (82.38 g) and subsequently maximum seed yield (1497.2 kg ha⁻¹). The number of head m⁻² was maximum in BARI Surjomukhi-3 and Hysun-33 in 30 January sowing. Number of seeds/heads was maximum (358) in December 31 sowing for Hysun-33 whereas the minimum from BARI Surjomukhi-3 at January 30 Sowing (153). Thousand seed weight differed significantly among the treatment combinations. The maximum seed weight (91.79 g) can be observed from Hysun-33 at December 31 sowing. The minimum thousand seed weight (41.79) can be obtained from BARI Surjomukhi-3 at January 30 sowing. Seed yield of sunflower differed significantly among the treatment combinations. Maximum seed yield at different sowing dates from Hysun-33 followed by BARI Surjomukhi-2 and BARI Surjomukhi-3, respectively. Maximum seed yield from Hysun-33 on December 31 sowing (1776.7 kg ha⁻¹), January 15 sowing (1578.3 kg ha⁻¹) and January 30 sowing (1136.7 kg ha⁻¹) whereas the lowest seed yield from BARI Surjomukhi-3 at varying sowing dates.

Farmers opinion: Farmers commented that sunflower sown in proper time gave higher seed yield than late sown crop. They also said, hysun-33 sunflower has more late seeded potentiality than BARI released sunflower.

Table 1. Seed yield and yield contributing characters of sunflower as influenced by sowing dates during 2023-24

Sowing Dates	Plant Height (cm)	Head/m ² (No.)	Seed/Head (No.)	TSW (g)	Seed Yield (Kg ha ⁻¹)
S ₁	149.17	11.9	310.4a	36.86a	1276.7a
S ₂	137	11.8	282.83b	25.62c	1196.3a
S ₃	134.7	12.1	230c	34.9b	890.8b
CV (%)	13.47	11.57	7	4.70	6.11

Table 2. Seed yield and yield contributing characters of sunflower as influenced by variety during 2023-24

Variety	Plant Height (cm)	Head/m ² (No.)	Seed/Head (No.)	TSW (g)	Seed Yield (Kg ha ⁻¹)
V ₁	148.33 a	10.2 b	286.33 b	35.58 b	1101.7 b
V ₂	109.83 b	13.3 a	208.56 c	29.52 c	764.9 c
V ₃	162.67 a	12.1 a	332.33 a	42.38 a	1497.2 a
CV (%)	13.47	11.57	7	4.70	6.11

Table 3. Interaction effect of variety and sowing dates on sunflower during Rabi 2023-24

Interactions	Plant height (cm)	Head/m ² (No.)	Seed/Head (No.)	1000-seed wt. (g)	Seed yield (kg ha ⁻¹)
V ₁ S ₁	146	10.3 c	317 ab	33.53 b	1260.0 c
V ₂ S ₁	112.5	12.6 a-c	256.16 c	39.26 b-d	793.3 d
V ₃ S ₁	189	12.7 a-c	358 a	41.79 a	1776.7 a
V ₁ S ₂	169	10.4 bc	302 b	34.97 c-e	1118.3 c
V ₂ S ₂	101	13.53 ab	216 c	29.03 e	892.3 d
V ₃ S ₂	141	11.33 a-c	330 ab	32.86 bc	1578.3 b
V ₁ S ₃	130	9.83 c	240 c	28.24 ef	926.7 d
V ₂ S ₃	116	14 a	153 d	20.27 f	609 e
V ₃ S ₃	158	12.4 a-c	309 b	32.48 de	1136.7 c
CV (%)	13.47	11.57	7	4.70	6.11
Level of Sig.	NS	*	*	*	**

Conclusion

The commercial cultivar Hysun -33 gave significantly higher yield than BARI Surjomukhi-2 and BARI Surjomukhi-3 in respect of yield and yield contributing characters. Hysun-33 has late seeded yield potentiality.

103. INTEGRATED MANAGEMENT OF FOOT ROT DISEASE OF GROUNDNUT WITH SEED AND SOIL TREATMENTS

M.Y.H. RAYHAN

Abstract

An experiment was executed at the MLT site Nikli during 2023-2024 to assess the effect of integrated diseases management modules with chemical treatments, organic amendments, and bio-control agents on diseases incidence and yield of groundnut in comparison with untreated control. Five different treatments were taken. T₂ treatment (liming (1 tha⁻¹) and seed treatment with Provex 2.5 kg⁻¹) significantly gave the highest nut yield (2.64 tha⁻¹), with the lowest foot rot (5%) infection of ground nut production. The highest gross return (Tk. 290400 ha⁻¹), gross margin (Tk. 174718 ha⁻¹) and BCR (2.51) were calculated from treatment and the lowest gross return (233200 Tk ha⁻¹), gross margin (Tk.119635 ha⁻¹) and BCR (2.05) were from treatment T₅ (farmers practice).

Introduction

Groundnut is a major legume and an important oil seed crop throughout the world as well as in Bangladesh. Numerous issues are accountable for low productivity among which diseases like leaf spot, collar rot, stem rot, bud necrosis, etc are very important. Out of all, foot rot caused by *Sclerotium rolfsii* is a major problem and is an economically important soil-borne pathogen. The huge number of sclerotia produced by *S. rolfsii* and their ability to persist in the soil for several years, as well as the abundant growth rate of the fungus make it well matched facultative parasite and a pathogen of major importance throughout the world (Punja, 1988). Different methods for the control of foot rot of ground nut were suggested worldwide, including the use of resistant cultivars (Butzler et al., 1998), cultural practices (El-Deeb and Ibrahim, 1998), biological and

chemical control (Siddiqui et al., 2002; Cilliers et al., 2003). All of these control measures is an important means in checking foot rot of groundnut (Helal et al., 1994). Therefore, an attempt will be taken to assess the effect of integrated diseases management modules with chemical treatments, organic amendments, and bio control agents on diseases incidence and yield of groundnut in comparison with untreated control.

Materials and methods

A series of field experiments were conducted at the MLT site Nikli, Kishoreganj during 2023-24 to assess the effect of integrated disease management modules with chemical treatments, organic amendments, and biocontrol agents on disease incidence and yield of groundnut in comparison with untreated control. Seed was sown 22 January 2024. Three replicate plots (6 m × 5 m) with a spacing 40 cm × 15 cm for each treatment were prepared and arranged in a completely randomized block design. Groundnut variety BARI china badam-9 was used as planting material in this experiment. Five single treatments were, T₁= Liming (1 t ha⁻¹), T₂= Liming (1 t ha⁻¹) and seed treatment with Provex 2.5 gkg⁻¹, T₃= Liming (1 t ha⁻¹) and soil treated by Trichoderma 2.5 tha⁻¹, T₄=Seed treatment with Provex 2.5 gkg⁻¹ and soil treated with Trichoderma 2.5 tha⁻¹, T₅= Farmers practice. All agronomic activities including sowing 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. The economic indices like gross return, gross margin were also calculated based on prevailing market price of the inputs and outputs (produces). BARI Chinabadam-9 was harvested at 7 May 2024 Crop cut was done from an area of 1m² at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot-wise and stated in table 1.

Results and Discussions

All Integrated Disease Management (IDM) modules were found to be superior over untreated farmers practice in reducing the diseases incidence and increasing nut yield during 2023-24 presented in the figures. The experiment indicated the Liming (1 t ha⁻¹) and soil treated by Trichoderma 2.5 tha⁻¹ was found to be significantly effective by recording the Maximum no. of mature nut/m² (331) and maximum germination (91%). T₂ treatment (liming (1 t ha⁻¹) and seed treatment with Provex 2.5 gkg⁻¹) significantly gave highest nut yield (2.64 tha⁻¹), with lowest foot rot (5%) infection of ground nut production. The highest gross return (290400Tk ha⁻¹), gross margin (174718 Tk ha⁻¹) and BCR (2.51) was calculated from treatment T₂ and the lowest gross return (233200 Tk ha⁻¹), gross margin (119635 Tk ha⁻¹) and BCR (2.05) were from treatment T₅ (Table 2).

Table1. Effect of different management practices on the percentage of germination, No. of plants m⁻², No. of mature nuts m⁻² and % foot rot infection of groundnut seedling, 2023-24

Treatment	% of germination	Number of plant/m ²	Number of mature nut/m ²	% of foot rot
T ₁	87	30	304	8
T ₂	89	32	317	5
T ₃	91	29	331	10
T ₄	85	28	281	9
T ₅	81	27	272	14

Here, T₁= Liming (1 t ha⁻¹), T₂= Liming (1 t ha⁻¹) and seed treatment with Provex 2.5 gkg⁻¹, T₃= Liming (1 t ha⁻¹) and soil treated by Trichoderma 2.5 tha⁻¹, T₄=Seed treatment with Provex 2.5 gkg⁻¹ and soil treated with Trichoderma 2.5 tha⁻¹, T₅= Farmers practice.

Table 2. Yield and economic analysis of groundnut during 2023-24

Treatment	Yield (t ha ⁻¹)	Gross return (Tk)	TVC (Tk)	Gross margin (Tk)	BCR
T ₁	2.47	271700	110325	161375	2.46
T ₂	2.64	290400	115682	174718	2.51
T ₃	2.43	267300	118535	148765	2.25
T ₄	2.32	255200	119352	135848	2.13
T ₅	2.12	233200	113565	119635	2.05

Price of groundnut= Tk.110kg⁻¹.

104. INTEGRATED MANAGEMENT APPROACH OF THRIPS, WHITE FLY, JASSID AND FRUIT BORER COMPLEX IN CHILLI AT BOGURA REGION

Abstract

An experiment was conducted at the MLT site, Sariakandi, Bogura during 2023-24 to observe the performance of integrated management practice against thrips, white fly and jassid complex in chilli under char land conditions. Crops under T₂ (cover crops with 60 mesh net) resulted in comparatively lower fruit damage and produced higher yields than T₁ (Blue + Yellow + white sticky trap + Use of pheromone mask trap + Success) and T₃ (farmers practice with insecticide). Cover crops with net insects cannot be in the field. So, the insect infestation percentage is lower than the other treatments.

Introduction

Chilli is one of the most important spice crops in Bangladesh. The crop is commercially cultivated in Bogura districts. Unfortunately, the crop is attacked by white flies, aphids, jassid and thrips. The pests attack the crop in leaves, flowers, fruits and cause considerable losses. However, in Bangladesh, very little information is available about their incidence. So, it is necessary to document the pests to develop appropriate management strategies. Chemical control is a popular management tactic in Bangladesh, but this has led to many problems, e.g. the resistance of insects to traditional insecticides, environmental pollution, human health impacts, and injury to beneficial species, etc. However, BARI scientists have already developed an integrated management approach that significantly reduced the field's thrips, whitefly and jassid populations. The present study was undertaken to observe the performance of this approach on a large scale among the farm community.

Materials and Methods

The trial was carried out at the farmer's chilli field of the MLT site, Sariakandi, Bogura during 2013-24. The experiment was laid out with six dispersed replications. The unit plot size was 0.5 bigha. There were two treatments viz. T₁: IPM Approach (Blue+Yellow + white sticky trap + Use of pheromone mask trap + Success) T₂: cover crops with 60 mesh net and T₃: Farmers practice (with insecticide- Imidacloprid) @ 0.5 ml/L of water, 22 times spray at 7 days interval). Traps were placed uniformly throughout each field with equal spacing of 20m × 20m between traps. The seedlings (variety: Bizli plus) were sown from 30 August to 15 September 2023. The trap was set on 03 December 2023. For the fulfillment of the scientific condition of the sex, pheromone was placed in the experimental plot. The harvesting started on 1st November 2023 and continued until 28th April 2024. All data were collected accordingly and subjected to statistical analysis. The gross economic return was calculated based on the prevailing market price of the commodities.

Preparation of sex pheromone and sticky trap

The pheromone bait trap comprises the pheromone lure and the locally fabricated water trough. The whole system consists of a 5-liter capacity, 22 cm tall rectangular or round clear plastic container. A triangular opening was cut in any two opposite sides starting 3-4cm from the bottom. Soapy water of 3-4cm height was maintained inside the container (trap) throughout the season. The pheromone tube was hanged through the center of the lid of the plastic container by means of a thin wire in such a way that the bait remains 3-4cm above the soapy water. The pheromone and sticky traps were then placed just above the crop canopy by means of a bamboo support.

Results and Discussion

The lowest percent of infested fruit (1.32), and highest yield (14.83 tha⁻¹) were obtained from the treatment T₂ compared to the integrated approach and farmer's practice. Highest gross return (Tk. 1038100 ha⁻¹) and gross margin (Tk. 995775 ha⁻¹) were also recorded from the treatment (Table 2). In the study, cover crops with net had lower infestation than integrated and farmer's practice (with insecticide). Though yield did not vary significantly in T₂ and T₁ treatment, but highest gross margin was obtained from cover crops, because cost of pest management of

farmer's practice is higher than cover crops and integrated Approach. Moreover, Cover crops and integrated Approach offered pesticide residue free fresh fruits.

Farmers' opinion: Farmers are very much interested to use cover crops and integrated approach for higher yield and economic return but cover crops is preferable for net available in the local market. This technology is poison-free and easily applicable.

Table 1. Effect of Integrated management approach of thrips, white fly, jassid, and fruit borer complex in chili at the MLT site, Sariakandi, Bogura during 2023-24

Treatment	Infested fruit (by wt.) (%)	Yield of un-infested fruit (t ha ⁻¹)	Yield of infested fruit (t ha ⁻¹)	Insect captured/trap (no)/week
T ₁	5.10b	14.27ab	0.77b	12.28 (Blue), 20.34 (yellow), 16.58 (white) and 5.24 (pheromone)
T ₂	1.32c	14.83a	0.23c	
T ₃	14.83a	11.82b	1.97a	
LSD (0.05)	1.99	2.99	0.31	
CV (%)	12.38	9.67	13.78	

T₁: Integrated Approach (Blue +Yellow + white sticky trap + Pheromone mask trap + Success), T₂: cover crops with 60 mesh net and T₃: Farmers practice (with insecticide)

Table 2. Cost and return analysis of chili in different management approaches at the MLT site, Sariakandi, Bogura during 2023-24

Treatment	Gross return (Tk.ha ⁻¹)	Cost of pest management (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
T ₁	998900	40505	958395
T ₂	1038100	42325	995775
T ₃	827400	120820	706580

The market price of chili @ Tk 70/kg

Notes: Spray volume 650 L ha⁻¹; 3 labor required for per ha spray; Cost of labor @ Tk 500/labor/day; Admire @ Tk 270/25 ml, pheromone trap@ Tk 150 per trap, 1 labor required for 1 ha pheromone trap setting, yellow and white sticky trap@ Tk 80 per trap and cover net @ Tk 7 per fit.

105. MANAGEMENT OF GUMMOSIS DISEASE OF CITRUS AT SHIBPUR, NARSINGDI

M. M. ALAM, M. AHMAD AND M.H. RAHMAN

Abstracts

The experiment was conducted with Colombo lebu at Dattergaon and Joymongal, Shibpur, Norsingdi during 1st week of March 2023. The experimental was laid out randomized complete block design with three replications. Five to eight years aged, 20 disease infected plants were selected for the experiment and five tree was considered one replication. Treatments were (i) Ridomil gold pest. (ii) Bordeaux mixture (iii) Alkatra (iv) control. Clean the wounded portion and applied redomil pest and spray four times 5gm L⁻¹ after 15 days' interval. Length and diameter of lesion was measured and remarkable reduction was observed after thrice application. The length and diameter reduced about 61.86 and 71.94% respectively in Redomil gold treatment. While it reduced about 51.20 and 63.24% respectively in Bordeaux mixture treatment and 52.31 and 73.16%, respectively in Alkatra treatment.

Introduction

Citrus is an important and popular fruit crop in Bangladesh. Citrus fruits are known as citron (Jaralebu), Colombo lebu, Lemon (Elachilebu), Pummelo, Satkara, Adazamir. It covers 20-25 percent of among the exported horticultural crops. Gummosis is a major fungal disease of citrus especially lemon and Colombo lebu. Gum formation on the trunk or branches is a characteristic symptom. Gum exudes from blisters containing gum pockets, usually located on the trunk. The wood beneath the blister shows a pink-orange color disease caused by *Phytophthora citrophthora*. However, *Diplodia* sp. also identified form infected disease areas. The disease can

affect the root system, the trunk below and above ground, branches, leaves, blossoms and fruit. The infected area becomes cracked and gummy substances come out from the stem. It is especially troublesome during prolonged rainy periods. Trees with the bud union beneath or close to the soil and trees in poorly-drained locations are highly susceptible. Fungus of gummy stem blight can easily be transmitted to a new area with infected soil. Plants are more susceptible at older stage; chlorosis or necrosis symptoms appear in case of severe attack. The infected plant may be died due to the infection of gummy blight (Agrios, 1997; Kucharek and Schenck, 1999). Elaborate research work on gummosis not been undertaken yet. So this experiment will be conducted to develop appropriate technology for management of gummosis disease of citrus.

Materials and Methods

The experiment was conducted with Colombo lebu at datergaon and Joymongal, Shibpur, Norsingdi during 1st week of March, 2023. The experimental design laid out RCB with three replications. Five to eight years' plants were selected for the experiment and five tree was considered one replication. Treatments were (i) T₁= Ridomil gold paste (ii) T₂= Bordeaux mixture [Ca(OH)₂:CuSO₄:H₂O= 1:1:100]; (iii) T₃= Alkatra and (iv) T₄= control. Disease area was scoped with sharp knife or chiseled and removed all infected plant parts. The scoped area was treated with Redomil gold, Bordeaux paste and Alkatra with covering the stem base. Redomil gold was sprayed on stem four times 2gm L⁻¹ after 15 days' interval removing the infected parts. The control treatment was maintained to keep the scoped area without any organic amendment or fungicide treatments. Area (length & diameter) was measured before and after treatment application. Treatment was applied at 30 days' interval thrice times. Data on diseases area were recorded 15 days' interval.

Results and Discussion

Result revealed that application of different treatments reduced disease infected areas. Length and diameter of lesion reduced gradually in size after treatment applications. The treatment application was significantly affected up to once or twice applications. However, after thrice application the lesion area recovered distinctly. In control treatment, disease area was not recovered compared to initial infection because of lack of treatment application (Table 1.). After thrice treatment application, lesion length and diameter reduced about 61.86 and 71.94%, respectively in Ridomil gold paste treatment. While it reduced about 51.20 and 63.24%, respectively in Bordeaux paste treatment and 52.31 and 73.16% respectively in Alkatra (Table 2.).

Table 1. Effect of different treatment in controlling gummosis of Colombo lebu

Treatment	Application before treatment		After once application		After twice application		After thrice application	
	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)
T ₁	16.28a	5.56c	13.75a	4.05c	10.13b	3.04c	6.21c	1.56c
T ₂	15.00b	5.55c	12.71b	3.91d	9.32c	2.10d	7.32b	2.04b
T ₃	15.16b	7.19a	13.27ab	4.88b	10.11b	3.31b	7.23b	1.93b
T ₀	13.05c	6.05b	13.03b	6.05a	13.15a	6.13a	13.22a	6.32a
CV (%)	1.21	1.96	0.934	0.96	1.63	2.42	0.56	3.96

Table 2. Effect of different treatment on lesion size of gummosis of Colombo lebu

Treatment	Lesion length reduced over control (%)	Lesion diameter reduced over control (%)
T ₁	61.86	71.94
T ₂	51.2	63.24
T ₃	52.31	73.16
T ₀	-	-

Conclusion: Redomil gold paste gave the best results. However, the experiment is ongoing.

106.PERFORMANCE OF DIFFERENT SPICES INTERCROPPING WITHIN BETEL NUT ORCHARD

G N HASAN, R H ANIK & M ISLAM

Abstract

The trial was conducted at Bhola sadar and Doulatkhan under Bhola districts during rabi season of 2023-24 in farmer's field to select suitable variety of spices in betelnut orchard as well as to increase farmer's income. A total of 4 different spices ginger (BARI Ada-1), turmeric (BARI Holud-4), black pepper (BARI Golmorich-1) and chuijhal (local) were tested. Among the spices BARI Golmorich-1 and Chuijhal were in growing stage and for that yield and yield contributing data of those two spices were not tabulated in 2023-24. The rhizome yield of BARI Ada-1 and Bari Holud-4 were 6.49 and 7.10 t ha⁻¹ respectively. The gross return and gross margin of BARI Ada-1 was 973500 and 639760 Tk. ha⁻¹ respectively whereas the gross return and gross margin of BARI Holud-4 was 248500 and 124460 Tk. ha⁻¹ respectively.

Introduction

Betel nut (*Areca catechu*) is a common palm in Bangladesh, especially in the coastal areas. Each and every homestead has few to thousands of betel nut trees in the coastal areas. It is not only a crop for family consumption but also a cash crop in this area. Many farmers have betel nut plants like orchard. They grow it without proper care especially manure or fertilizer application. In the recent years, emphasis has been given on increasing cropping intensity to meet increasing demand of food in the country. At present area under betel nut in Bhola district is 8150 ha (DAE, 2020). The inter space of betel nut orchard remains fallow round the year. So, there is an opportunity to verify different spices and aroid intercrop within betel nut orchard. It will increase total productivity as well as farmer's income. Therefore, the proposed study was undertaken to include spices and aroids intercrop within orchard for increasing productivity and farmers' income.

Materials and Methods

The trial was conducted at Bhola sadar and Doulatkhan under Bhola districts during rabi season of 2023-24 in farmer's field to select suitable variety of spices which can be produced in betel nut orchard as well as to increase farmer's income. A total of 4 different spices ginger (BARI Ada-1), turmeric (BARI Holud-4), black pepper (BARI Golmorich-1) and chuijhal (local) were tested. Unit plot size was 20m x 2 m with 3 Replications. Spacing of turmeric and ginger were 50 cm (row to row) and 25 cm (rhizome to rhizome). Rhizomes were transplanted on 11 April to 10 June, 2023 within the rows of betel nuts (1 m) in orchard under partial shade condition. Fertilizer and other management practices were done following BARI *Krishi Projukti Hatboi* 2019. Fertilizer rate of ginger was @139-53-139-4.5-20 kg ha⁻¹ N-P-K-Zn-S and turmeric was @ 101-25-130-17.6-0.5 kg ha⁻¹ N-P-K-S-B. 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 and ginger. Mancozeb and Autostin were applied to control leaf blotch and rhizome rot of Turmeric. The crops were harvested on 07 January to 01 February, 2024. Data on yield and yield contributing characters were recorded properly.

Results and Discussion

The yield and yield attributes of different spices within betel nut orchard are presented in Table 1. Among the spices BARI Golmorich-1 and Chuijhal were in growing stage and for that yield and yield contributing data of those two spices were not tabulated in 2023-24. Weight of rhizome per plant of BARI Ada-1 and BARI Holud-4 were 180g and 215g respectively. The rhizome yield of BARI Ada-1 and Bari Holud-4 were 6.49 and 7.10 t ha⁻¹ respectively.

Cost and return analysis: Maximum rhizome yield (7.10 t ha⁻¹) was obtained from BARI Holud-4 compared to the yield of 6.49 t ha⁻¹ from BARI Ada-1. The gross return and gross margin of BARI

Ada-1 was 973500 and 639760 Tk. ha⁻¹ respectively whereas the gross return and gross margin of BARI Holud-4 was 248500 and 124460 Tk. ha⁻¹ respectively.

Farmer s Opinion: Farmers are very much interested in cultivating this kinds of partial shade loving spices within their betel nut orchard as they can utilize their fallow space and increase their income.

Table 1. Yield and yield attributes of different spices intercropping within betel nut orchard in Bhola during 2023-24 cropping season

Spices/verities	Plant Population/40 m ²	Weight of rhizome (g)/plant	Rhizome yield (t ha ⁻¹)
BARI Ada-1	145	180	6.49
BARI Holud-4	133	215	7.10
BARI Golmorch-1	On going	On going	On going
Chujhal (Local)	On going	On going	On going

Table 2. Cost and return analysis of different spices intercropping within betel nut orchard in Bhola during 2023-24 cropping season

Spices/verities	Rhizome yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI Ada-1	6.49	973500	333740	639760	2.92
BARI Holud-4	7.10	248500	124460	124040	2.00
BARI Golmorch-1	On going	On going	On going	On going	On going
Chujhal (Local)	On going	On going	On going	On going	On going

Note: Price of ginger @150 Tk/kg, and turmeric @35 Tk/kg

Conclusion

BARI Ada-1 and BARI Holud-4 are profitable to the farmers, but conclusion would be made after harvest of Chujhal.

107.PERFORMANCE OF MIXED VEGETABLES IN NEWLY ESTABLISHED MANGO ORCHARD IN CUMILLA

M. JAMAL UDDIN

Abstract

The experiment was conducted at the 1-3 years old mango gardens of the farmers' field of Barura, Chandina and Debidwer of Cumilla during 2023-24. Average spacing of mango trees were 8m×6m, clean bole height was 1.5m, canopy spread was 1.5m×1.5m and tree height was 1.5-3m. So, there was some gaps between the tree canopy in the garden, where direct sunlight may reach to the under-storey crops. Vegetables varieties were cabbage (Hybrid Quiker), Cauliflower (Hybrid Snow white), Sweetgourd (BARI Mistikumra-2), tomato (BARI Tomato-17) and Garden pea (BARI Motorshuti-3) were used as under storey crop in this experiment. The treatments were designed as Mango+Cabbage (T₁), Mango+Cauliflower (T₂); Mango+Sweet gourd (T₃), Mango+Tomato (T₄) and Mango+Garden pea (T₅). Highest yield (55.43 t ha⁻¹) was found from cabbage (Hybrid Quiker) followed by cauliflower(Hybrid Snow white) (31.87 t ha⁻¹). Garden pea (BARI Motorshuti-3) produced the lowest yield (1.1 t ha⁻¹) when grown in an agroforestry system. Gross return, gross margin and BCR also found higher in cabbage (1.72) followed by tomato (1.44) and calliflower (1.42). This agroforestry system provided additional care to mango orchards along with additional income.

Introduction

The limited land resource has been engaged in producing food requirements for the people. Therefore, less emphasis has been provided for other production systems including fruit and minor crop production, which are also important for food and nutrition security of the country.

The minimum dietary requirement of fruits per day per capita is 85 g, whereas the availability is only 34.28 g (Helen Keller International, 2001) or 07 g (BIDS survey report, 2008). In view of the fact, fruits are the important source of vitamins and minerals. However, due to high price of fruits, the majority of people can't afford to buy them. As a result, many people especially children have been suffering from malnutrition and blindness in the country. On the other hand, Bangladesh is also 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 their acreage and production is far below then our needs. So, we should increase their production in the country. Recently DAE have some fruit garden establishment program. Deputy Director of DAE, B. Baria requested to take initiative to intensify the fruit garden by agroforestry system. Agroforestry is a new name of an age old practice. 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- (i) to observe the performance of under storey vegetables in the newly established mango orchard in agroforestry system and to increase production and additional return from the orchard.

Materials and Methods

The experiment was conducted at the 1-3 years old mango gardens of the farmers' field of Barura, Chandina and Debidwer of Cumilla during 2023-24. Average spacing of mango trees were 8m×6m, clean bole height was 1.5m, canopy spread was 1.5m×1.5m and tree height was 1.5-3m. So, there was some gaps between the tree canopy in the garden, where direct sunlight may reach to the under-storey crops. Vegetables varieties were cabbage (Hybrid Quiker), Cauliflower (Hybrid Snow white), Sweet gourd (BARI Mistikumra-2), tomato (BARI Tomato-17) and Garden pea (BARI Motorshuti-3) were used as under storey crop in this experiment. The experiment was laid out in Randomized Complete Block (RCB) Design with five dispersed replications. The unit plot size was 6m × 4m. The spacing were 60cm×45cm for cabbage & cauliflower, 60cm×40cm for tomato, 3m×2.4m for sweet gourd and 30cm×15cm for garden pea. Land was prepared by three times ploughing followed by laddering. Hence, the treatments was designed as Mango+Cabbage (T₁), Mango+Cauliflower (T₂); Mango+Sweet gourd (T₃), Mango+Tomato (T₄) and Mango+Garden pea (T₅). The seeds/seedlings of vegetables were planted on 8-15 November 2023, depending on crop and location. Due to heavy rain garden pea field was damaged in three replications. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Cabbage was harvested during 5/02/2024 to 15/02/2023. Cauliflower was harvested from 15/02/2024 to 18/2/2024. Sweet gourd was harvested from 29/02/2024 to 11/03/2024, Tomato was harvested during 16-28/02/2024 and garden pea on 14/01/2024. Necessary data were recorded and analyzed by using Statistic 10 computer program.

Results and Discussion: Average yield of cabbage, cauliflower, sweet gourd, tomato and garden pea in a new established mango orchard in Cumilla is presented in Table 1. Highest yield (55.43 t ha⁻¹) was found from cabbage (Hybrid Quiker) followed by cauliflower (Hybrid Snow white) (31.87 t ha⁻¹). Lowest yield (1.1 t ha⁻¹) was found from Garden pea (BARI Motorshuti-3) under agroforestry system. Due to effect of Mighjaon and Midhili, the garden pea was damaged all most all replications. Gross return, gross margin and BCR also found higher in cabbage (1.72) followed by tomato and cauliflower.

Farmer's Reaction: Cultivation of vegetables in new mango orchards gives additional care to mango orchards and additional earn additional income. Farmers can meet their family requirement of vegetables. They can fulfill their nutritional security. Farmers particularly small and marginal farmers are very much interested to grow vegetables at their newly established mango orchard

Table 1: Average yield of mixed vegetables cultivation in newly established mango orchard in Cumilla during 2023-24

Treatments	Plants plot ⁻¹	Individual weight (g)	Yield/plot (kg)	Yield (t ha ⁻¹)	Field duration (day)
Mango+Cabbage (T ₁)	93.75	1.5	171.2	55.43	92.75
Mango+Cauliflower (T ₂)	92	1.23	103.4	31.87	97.5
Mango+Sweet gourd (T ₃)	6.75	1.48	25.65	9.16	111.5
Mango+Tomato (T ₄)	125	0.265	108	25.7	1115
Mango+Garden pea (T ₅)	-	-	4.8	1.1	63

Table 2: Cost-return of mixed vegetables cultivation in newly established mango orchard in Cumilla during 2023-24

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Mango+Cabbage (T ₁)	864708	502500	362208	1.72
Mango+Cauliflower (T ₂)	701140	495270	205870	1.42
Mango+Sweet gourd(T ₃)	174040	158962	15078	1.09
Mango+Tomato (T ₄)	771000	535249	235751	1.44
Mango+Garden pea (T ₅)	44000	41150	2850	1.07

Note: Market price of Cabbage @Tk.15.6/kg; Cauliflower@ Tk. 22.07; Sweet gourd @Tk.19.00; Tomato @Tk. 30 and Garden pea@Tk.40/kg

Conclusion

It might be concluded that cabbage (Hybrid Quiker) performed better followed by Tomato (BARI Tomato-17) and Cauliflower (Hybrid Snow white) among the five tested vegetables in the newly established garden of mango.

108.INTEGRATED NUTRIENT MANAGEMENT FOR CABBAGE UNDER AGRO-FORESTRY SYSTEM

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Abstract

An experiment was carried out at the FSRD site, Ganggarampur, Pabna during the rabi season of 2023-24 to evaluate the performance of different nutrient management options in mango-based agroforestry system. Four nutrient management practices viz. recommended dose (FRG-18), IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost along with farmers practice were evaluated in this study. The IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost exhibited significantly higher card yield which were 21% and 18% higher than recommended dose, respectively. Regarding economic return higher gross margin (Tk. 431340 ha⁻¹) was also attained from IPNS + 5 t ha⁻¹ cowdung.

Introduction

In Bangladesh, fruit orchard especially Ber, Litchi, Guava and Mango orchard increasing considerably in last few years. A vast area is going under orchard every year so, it is possible to produce some vegetable crops such as cabbage and tomato under agroforestry system will be a good option for producing vegetable from the same land. In the tropics and sub-tropics rapid degradation of organic matter is the major problem, where through vegetable production, there has a less chance to add biomass in the soil. So, from the view of sustainable productivity of soil, addition of organic matter through integrated nutrient management system may be helpful. Trees on farms can enhance coping capacity of small farmers to risks through crop and income diversification, soil and water conservation and efficient nutrient cycling and conservation. A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required.

Materials and Methods

The experiment was carried out at FSRD site, Ganggarampur, Pabna during the rabi season of 2023-24. Four nutrient management practices viz. recommended dose (FRG-18), IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost along with farmers practice were evaluated in this study. The experiment was laid out in RCB design with four replications having a unit plot size 6m x 5m. The seedlings of cabbage (Atlas-70) were transplanted on 3 November 2023. The land was fertilized according to the treatment composition presented in Table 1. 1/3 of N and the entire amount of P, K, S, Zn, B, well decomposed cowdung and vermicompost were applied as basal during final land preparation. Remaining N was applied in two equal splits as top dress after 22 and 55 DAT (days after transplanting) on 25 November 2023 and 5 January, 2024 followed by an irrigation. Weeding was done two times on 5 December, 2023 and 10 January, 2024 to control weeds. Insecticide Nitro, Regent and Abamectin were applied alternately three times on 20 November, 2023; 1 December, 2023 and 10 December, 2023 to control Spodoptera insect. The harvesting of crops was started on 2 February and continued up to 25 February, 2024. All the relevant data were recorded carefully and analyzed statistically.

Table 1 Nutrient composition under different management practices for cabbage under mango-based agroforestry system

Treatments	N	P	K	S	Zn	B	Cowdung	Vermicompost
Recommended dose	120	36	30	12	2.5	1	-	-
IPNS with 5 t ha ⁻¹ cowdung	105	31.5	23.1	12	2.5	1	5 t	-
IPNS with 3 t ha ⁻¹ vermicompost	85	20	15	12	2.5	1	-	3 t
Farmers Practice	253	90	125	22	5.5	1.9	-	-

Results and Discussion

Data on yield contributing characters and yield are presented in Table 1. Card length, card diameter, individual card weight and yield varied significantly due to different nutrient management options. The IPNS + 5 t ha⁻¹ cowdung provided maximum card length, card diameter and individual card weight which was identical with IPNS + 3 t ha⁻¹ vermicompost. While, minimum card length, card diameter and individual card weight was recorded from recommended dose. The highest yield was obtained from IPNS + 5 t ha⁻¹ cowdung which is statistically similar to IPNS + 3 t ha⁻¹ vermicompost and first one was 21% and second one was 18% higher than recommended dose, respectively. However, the lowest yield was recorded from recommended dose which is identical to farmers practice. Maximum yield in IPNS + 5 t ha⁻¹ cowdung and IPNS + 3 t ha⁻¹ vermicompost may be due to higher card diameter and individual card weight.

Regarding economic benefit, maximum gross return (Tk. 591750 ha⁻¹) and gross margin (Tk. 431340 ha⁻¹) was obtained from IPNS + 5 t ha⁻¹ cowdung which was followed by IPNS + 3 t ha⁻¹ vermicompost. However, minimum gross return (Tk. 488750 ha⁻¹) and gross margin (Tk. 333340 ha⁻¹) was recorded from recommended dose.

Table 1. Yield and yield contributing characters of cabbage under different nutrient management options at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2023-24.

Treatments	Curd length (cm)	Curd diameter (cm)	Individual card weight (kg)	Head yield (t ha ⁻¹)
Recommended dose	25.2	62.3	1.57	48.9
IPNS with 5 t ha ⁻¹ cowdung	28.2	66.6	1.89	59.2
IPNS with 3 t ha ⁻¹ vermicompost	26.9	65.5	1.82	57.6
Farmers Practice	26.3	64.2	1.74	54.9
LSD(0.05)	1.43	1.13	0.23	9.28
CV (%)	3.35	3.09	8.32	7.28

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, ns = not significant

Table 2 Cost and return analysis from cabbage under different nutrient management at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2023-24.

Treatments	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Recommended dose	488750	155410	333340
IPNS with 5 t ha ⁻¹ cowdung	591750	160410	431340
IPNS with 3 t ha ⁻¹ vermicompost	576000	185410	390590
Farmers Practice	546250	162040	384210

Price: 10.00 Tk kg⁻¹

Farmers expressed their satisfaction to see higher yield performance of cabbage and economic return from IPNS with 5 t ha⁻¹ cowdung. They also preferred IPNS with 3 t ha⁻¹ vermicompost also showed satisfactory yield and return.

Conclusion

IPNS with 5 t ha⁻¹ cowdung and IPNS with 3 t ha⁻¹ vermicompost provided significantly higher yield than recommended dose and farmer's practice.

109. PERFORMANCE OF HIGH VALUE CROPS IN MANGO BASED AGROFORESTRY SYSTEMS

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Abstract

Fruit orchard are the principal agricultural crops that generate sustainable economic income to the farmers in Rajshahi. The experiment was conducted at farmers' field under MLT site, Shibpur and Paba, Rajshahi during 2023-24 to assess the performance of mango-based agroforestry with high value crops to increase cropping intensity and productivity. Four crops i.e. potato, cabbage, cauliflower and tomato were evaluated in mango orchard. The mango + tomato system recorded the highest mango equivalent yield (MEY) (28.51 t ha⁻¹) followed by mango+ cabbage (27.28 t ha⁻¹), mango+ cauliflower (26.54 t ha⁻¹) and mango+ potato (22.71 t ha⁻¹). However, the sole mango system (18.9 t ha⁻¹) recorded the lowest MEY. Similarly mango+ tomato (Tk. 1557843 ha⁻¹) had maximum gross margin followed by mango+ cabbage (Tk. 1557753 ha⁻¹), mango+ cauliflower (Tk. 1480858 ha⁻¹), sole mango system (Tk. 1131795 ha⁻¹) whereas the mango + potato system (Tk. 1103214 ha⁻¹) had the lowest gross margin.

Introduction

In Rajshahi district, farmers have been establishing orchards of different fruits at the field. Fruit orchard is one of the most prominent practice. Farmers obtained 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 6-7 years of planting saplings, the land space between two rows of trees can be utilized for growing short duration crops but thereafter the growing tree canopy make substantial shading on the ground. In these circumstances, the ground land remains totally unutilized or partially utilized with traditional spice crops. So, cultivation of some high value vegetable crops such as, potato, cabbage, cauliflower, tomato in agro forestry system may be good options for the farmers to generate additional income from these fruit gardens. Considering the facts, the present experiment has been undertaken to find out the performance of different cropping pattern under Mango based agro-forestry systems and increase productivity and income of the agro-forestry systems.

Materials and Methods

The experiment was conducted at the farmers' field under the multilocation testing (MLT) site, Shibpur & Paba, Rajshahi during 2023-24 in High Ganges River Flood plain soils. 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 high value crops named, Potato (BARI Alu-90),

Cabbage(Atlus-70), Cauliflower (Victoria M) and Tomato (BARI Tomato-19) were tested in the mango orchard. The experiment was laid out in a Randomized Complete Block Design with six replications. The plot size was 3.30m x 2.60m. The spacing was 60cm x 40cm for tomato, 60cm x 45cm for cabbage, 60cm x 45cm for cauliflower and 60 cm x 25 cm for potato. The crops were sown/ transplanted on 15-16 December, 2023. Fertilizers were applied as per recommendation of fertilizer recommendation guide (FRG'18) for each vegetable crop. Earthing of potato was done on 27 December, 2024. Other intercultural operations were done as and when required. The harvesting of cauliflower, cabbage, tomato and potato was recorded on 24-27 January, 15-28 February, 4 February to 24 March, 13 February, 2024, respectively. The harvesting of mango was recorded on 25-30 June, 2024. The relevant data on different parameters of vegetables and fruits were measured at respective stage.

Results and Discussion

For comparison of different high value crops in mango-based agroforestry system, all the yield component crops was converted to mango equivalent yield (MEY) and system productivity was considered as MEY (Table 1). From this table it was observed that mango tomato recorded the highest MEY (28.51 t ha⁻¹) followed by mango+ cabbage(27.28 t ha⁻¹), mango+ cauliflower(26.54 t ha⁻¹) and mango+ potato(22.71 t ha⁻¹). However, the sole mango system(18.9 t ha⁻¹) recorded the lowest MEY during this study year. Mango based agroforestry system attributed a significant impact on cost of cultivation, gross return, gross margin and benefit cost ratio (MBCR) in the study year (Table 1). In general, inclusion of the second crop in agroforestry system markedly enhanced the cost of production. Among the different system mango+ potato (Tk. 486486 ha⁻¹) had maximum cost of production followed by mango+ tomato (Tk. 437857 ha⁻¹), mango+ cauliflower (Tk. 376942 ha⁻¹), mango+ cabbage (Tk. 351847 ha⁻¹) whereas the sole mango system (Tk. 191205 ha⁻¹) had the lowest cost of production. On the other hand, among different system mango+ tomato (Tk. 1995700 ha⁻¹) had maximum gross return followed by mango+ cabbage (Tk. 1909600 ha⁻¹), mango+ cauliflower (Tk. 1857800 ha⁻¹), mango+ potato (Tk. 1589700 ha⁻¹) whereas the sole mango system (Tk. 1323000 ha⁻¹) had the lowest gross return. Similarly, mango+ tomato (Tk. 1557843 ha⁻¹) had maximum gross margin followed by mango+ cabbage (Tk. 1557753 ha⁻¹), mango+ cauliflower (Tk. 1480858 ha⁻¹), sole mango system (Tk. 1131795 ha⁻¹) whereas the mango + potato system (Tk. 1103214 ha⁻¹) had the lowest gross margin. On the other hand the highest MBCR was observed in mango+ cabbage (3.65) followed by mango+ cauliflower (2.87), mango+ tomato (2.72) and lowest was observed in mango + potato system (0.90).

Farmers reaction: Farmers' are interested to grow cabbage in mango based agroforestry system due to it's higher economic benefit . Neighboring farmers visited the field and impressed to see the crop performance.

Table 1. Yield of different high value crops in mango-based agroforestry system at Paba & Shibpur MLT sites, Rajshahi during 2023-24.

Crops	Mango yield (t ha ⁻¹)	High value crops 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+ Potato	18	10.99	22.71	1589700	486486	1103214	0.90
Mango+ Cabbage	18.6	40.55	27.28	1909600	351847	1557753	3.65
Mango+ Cauliflower	17.4	16.01	26.54	1857800	376942	1480858	2.87
Mango+ Tomato	18.3	28.61	28.51	1995700	437857	1557843	2.72
Mango	18.9	-	18.9	1323000	191205	1131795	-

Output: Cauliflower: 40Tk kg⁻¹, Cabbage: 15Tk kg⁻¹, Tomato: 25Tk kg⁻¹, Potato: 30Tk kg⁻¹ and Mango: 70Tk kg⁻¹

Conclusion

It was concluded that cabbage is most suitable crop to grow in mango basd agro-forestry system at AEZ-11 in respect of economic point of view. However, for concrete conclusion it should be repeated further.

On-Farm Trials with Advanced lines and Technologies

110. ADAPTIVE TRIAL WITH NEWLY RELEASED POTATO VARIETIES IN DIFFERENT LOCATIONS

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Abstract

Two sets of trials were carried out at farmers' fields in 7 (Seven) locations under two ecosystems, viz low land and plain land ecosystem during the rabi season of 2023–2024 to assess the performance of high-yielding potato varieties and learn about farmers' preferences regarding the varieties. Considering the low land ecosystem, the average tuber yield varied from 25.13 to 35.28 across different testing locations. Sylhet was identified as the most favorable environment for potato production, with an average yield of 35.28 tons per hectare, followed by Manikganj with 32.81 tons per hectare. On the other hand, the environmental conditions in Cumilla were less conducive to potato cultivation, resulting in an average yield of 24.40 tons per hectare. Again, in plain land ecosystem, the average potato yield varied between 37.50 and 39.08 across different locations. The Gopalganj region was identified as the most favorable environment for potato production, with a yield of 39.08 tons per hectare, followed by Rangpur with a yield of 37.50 tons per hectare. In contrast, Tangail was found to be less productive with a yield of 37.45 tons per hectare. The choices made by farmers for potato variety selection varied based on tuber shape and size, skin color, plant growth, yield potential, and market price. This variation was observed across different locations. However, in lowland and haor ecosystems, BARI Alu-47, BARI Alu-62, BARI Alu-87, and BARI Alu-88 were found to be the best-performing potato varieties. For plain land ecosystems, BARI Alu-62, BARI Alu-79, BARI Alu-87, BARI Alu-88, and BARI Alu-91 were the top performers. Considering both ecosystems, BARI Alu-62, BARI Alu-87, and BARI Alu-88 are suitable for cultivation and may be recommended for growing nationwide.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most significant food crops in Bangladesh. In terms of potato production, Bangladesh is second in the nation and eighth worldwide (FAOSTAT, 2018). Currently about 10.14 million tons (Mt) of potato is being produced from an area of 0.46 million hectares (Mha) of land with an average yield of 21.84 t ha⁻¹ (BBS, 2022). To feed the country's growing population, there is an increasing demand for potato production. By 2030, the government must boost its potato yield from 20.43 t ha⁻¹ to 41.50 t ha⁻¹ to achieve food and nutrition security. Several potato varieties have been developed by the Tuber Crop Research Center (TCRC), BARI. These varieties need to be assessed for their performance in various ecological zones in terms of yield performance as well as to learn the farmers' perceptions of these varieties in different parts of Bangladesh.

Materials and Methods

During the *rabi* season of 2023-24, the adaptive trial with newly released potato varieties were designed for two ecosystem such as low landha-or ecosystem and plain land ecosystem. Under low land ecosystem trials were set up in three locations viz Kishoreganj (18 potato varieties); Manikganj (16 potato varieties) and Sylhet (18 potato varieties) (Table 1.), where seed tubers were planted from 27 November to 5 December 2023 in low land ecosystem and with a spacing of 60 cm × 25 cm. Again, under the plainland ecosystem, trials were conducted in three locations, viz Rangpur, Tangail and Gopalganj with 10 potato varieties. where seed tubers were planted from 3-6 December 2023 in plainland ecosystem following 60 cm × 25 cm spacing. The unit plot size was at least 1000m², however it varied in the trial locations. Trial plots were fertilized following FRG, 2018. The crop was sprayed 3 times with Indofil (18-19, 33-35, and 46-48 DAP) and secure (63-64 DAP) for controlling Late blight infection. The haulm was pulled out at 85-86 DAP. The tubers were harvested after 8-10 days after haulm pulling, started from 22 February to 15 March 2024 in lowland ecosystem and 28 February to 15 March 2024 in plainland ecosystem.

As the trial was non-replicated farmers field trial, so collected yield data was not analyzed statistically, only mean value and yield range data was presented in the table.

Table 1 Details of the trials conducted in different locations.

Ecosystem	Location	Variety
Low land ecosystem	Sylhet, Cumilla and Kishoreganj	BARI Alu-25, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-50, BARI Alu-53, BARI Alu-62, BARI Alu-63, BARI Alu-77, BARI Alu-78, BARI Alu-79, BARI Alu-87, BARI Alu-88, BARI Alu-90, BARI Alu-91
	Manikganj	BARI Alu-25, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-53, BARI Alu-62, BARI Alu-63, BARI Alu-77, BARI Alu-78, BARI Alu-79, BARI Alu-87, BARI Alu-88, BARI Alu-90,
Plainland ecosystem	Rangpur, Tangail and Gopalganj	BARI Alu-25, BARI Alu-37, BARI Alu-62, BARI Alu-78, BARI Alu-79, BARI Alu-81, BARI Alu-87, BARI Alu-88, BARI Alu-90, BARI Alu-91

Results and Discussions

i) Low landha₁or ecosystem (Sylhet, Kishoreganj and Manikganj): Under the low land ecosystem, the high yield of the potato varieties with the evaluated record was preferred by the growers. Tuber yield among the varieties across the locations ranged from 15.28 to 40.40 t ha⁻¹ (Table 2), where the highest and the lowest yields obtained from BARI Alu-88 (40.40 t ha⁻¹) and BARI Alu-53 (15.28 t ha⁻¹) in Kishoreganj. Among the locations the average tuber yield ranged from 25.13–35.28. The environment of Sylhet was found the most suitable for potato production (range 21.00–43.00; average yield of 35.28 t ha⁻¹) followed by Manikganj (range 20.78–40.40, 32.81 t ha⁻¹) and Kishoreganj (range 15.28– 31.24; average 25.13 t ha⁻¹). While the environmental condition of Cumilla was less productive for potato cultivation (range 16.87–32.36; average 24.40 t ha⁻¹) Among these genotype, BARI Alu- 47 was the average highest yielder (35.03 t ha⁻¹), BARI Alu 62 was the average 2nd highest yielder (32.60 t ha⁻¹) and BARI Alu-87 was the average 3rd highest yielder (32.52 t ha⁻¹), While, BARI Alu-25 was the average lowest yielder (21.18 t ha⁻¹).

Considering the potato varieties, BARI Alu-47 showed the average highest gross return (789069 Tk. ha⁻¹) and gross margin (577055 Tk. ha⁻¹) followed by BARI Alu-62, BARI Alu-88 and BARI Alu-87. On the contrary, the average lowest gross return (462888 Tk. ha⁻¹) and gross margin (250874 Tk. ha⁻¹) were found in BARI Alu-91 and this difference is due to variation in potato yields and local market prices across different locations (Table 2).

ii) Plainland ecosystem (Rangpur, Tangail and Gopalganj): Tuber yield among the varieties across the locations ranged from 26.16 to 47.15 t ha⁻¹ (Table 3), where BARI Alu-79 (47.15 t ha⁻¹) produced the highest tuber yield in Gopalganj and BARI Alu-25 26.16 t ha⁻¹) produced the lowest tuber yield in Tangail. Among the locations the average tuber yield ranged from 37.50– 39.08. The environment of Gopalganj was found to be the most suitable for potato production (range 32.11–47.15; average yield of **39.08** t ha⁻¹) followed by Rangpur (range 31.25–44.50, 37.50 t ha⁻¹). While the environmental condition of Tangail was recorded comparatively less productive (range 26.16–43.89; 37.45 t ha⁻¹) Among these genotype, BARI Alu- 62 was the average highest yielder (43.87 t ha⁻¹), BARI Alu 87 was the average 2nd highest yielder (43.01 t ha⁻¹) and BARI Alu-87 was the average 3rd highest yielder (39.50 t ha⁻¹), While, BARI Alu-37 was the average lowest yielder (33.46 t ha⁻¹).

Considering the mean yield, the reasons for the yield variation in different locations are mainly due to the different soil types and agro-climatic conditions. Therefore, the genotype-environment interaction impacts expressed that the potato varieties reacted in a different way to the difference in ecological environments of locations, which suggested the requirement of checking potato genotypes/varieties in different locations. This also highlights the complexities that plant breeders face when selecting new potato varieties for release and distribution.

Considering cost and return analysis, BARI Alu-62 showed the average highest gross return (987075 Tk. ha⁻¹) and gross margin (760698 Tk. ha⁻¹) followed by BARI Alu-87 and BARI Alu-79. On the contrary, the average lowest gross return (Tk. 766125 ha⁻¹) and gross margin (539748 Tk. ha⁻¹) were found in BARI Alu-25 and this difference is mainly due to variation in potato yields and local market prices across different locations (Table 5).

Farmers' opinion: Farmer's choices regarding variety selection 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 and varied from location to location. However, BARI Alu-47, BARI Alu-62, BARI Alu-87 and BARI Alu-88 were the best-performing potato varieties for low landha_{10r} ecosystems. Again, BARI Alu-62, BARI Alu-87, BARI Alu-79, BARI Alu-88 and BARI Alu-91 were the best-performing potato varieties for the plain land ecosystem. Considering both ecosystems, BARI Alu-62, BARI Alu-87 and BARI Alu-88 are suitable for cultivation and may be considered for dissemination all over the country.

Table 2. Yield of different Potato varieties in Haor ecosystem of different locations, 2023-24.

Varieties	Tuber yield (t ha ⁻¹)				Mean
	Sylhet	Manikganj	Kishoreganj	Cumilla	
BARI Alu-25	21.00	20.78	21.22	21.73	21.18
BARI Alu-40	40.00	32.18	21.42	32.36	31.49
BARI Alu-41	40.00	35.84	27.52	23.26	31.66
BARI Alu-46	25.00	30.83	21.21	29.98	26.76
BARI Alu-47	43.00	35.81	30.53	30.79	35.03
BARI Alu-48	38.00	27.03	26.75	23.98	28.94
BARI Alu-49	37.00	30.20	21.61	27.82	29.16
BARI Alu-50	41.00	-	17.78	18.88	25.89
BARI Alu-53	28.00	29.49	15.28	24.17	24.24
BARI Alu-62	37.00	37.17	30.52	25.70	32.60
BARI Alu-63	36.00	31.49	25.55	22.58	28.91
BARI Alu-77	33.00	26.63	29.05	22.58	27.82
BARI Alu-78	37.00	33.62	31.24	24.53	31.60
BARI Alu-79	35.00	37.29	30.20	20.58	30.77
BARI Alu-87	43.00	40.20	22.92	22.11	32.06
BARI Alu-88	34.00	40.40	30.76	24.92	32.52
BARI Alu-90	35.00	35.97	27.40	26.38	31.19
BARI Alu-91	32.00	-	21.35	16.87	23.41
Range	21.00-43.00	20.78-40.40	15.28-31.24	16.87-32.36	-
Mean	35.28	32.81	25.13	24.40	-

Table 3. Economics of different potato varieties haor ecosystem during 2023-24 (average of all locations).

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Alu-25	462888	212013	250874
BARI Alu-40	716413	212013	504399
BARI Alu-41	715900	212013	503887
BARI Alu-46	584344	212013	372330
BARI Alu-47	789069	212013	577055
BARI Alu-48	657081	212013	445068
BARI Alu-49	662144	212013	450130
BARI Alu-50	639583	212013	427570
BARI Alu-53	545150	212013	333137
BARI Alu-62	725375	212013	513362
BARI Alu-63	652131	212013	440118
BARI Alu-77	620644	212013	408630
BARI Alu-78	704925	212013	492912
BARI Alu-79	683975	212013	471962

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Alu-87	734325	212013	522312
BARI Alu-88	716175	212013	504162
BARI Alu-90	694125	212013	482112
BARI Alu-91	557008	212013	344995
Mean	658959	212013	446945

Average price of potato: 23.00 Tk. kg⁻¹ (average of the 3 trial sites)

Table 4. Yield (t ha⁻¹) of different Potato varieties in Plainland ecosystem of different locations during 2023-24.

Varieties	Tuber yield (t ha ⁻¹)			Mean
	Rangpur	Tangail	Gopalganj	
BARI Alu-25	31.25	26.16	44.74	34.05
BARI Alu-37	31.25	33.59	35.53	33.46
BARI Alu-62	44.50	43.29	43.82	43.87
BARI Alu-78	34.50	39.22	32.73	35.48
BARI Alu-79	35.75	35.59	47.15	39.50
BARI Alu-81	36.25	33.31	39.92	36.49
BARI Alu-87	39.00	43.89	46.14	43.01
BARI Alu-88	39.25	39.64	36.27	38.39
BARI Alu-90	41.50	39.24	32.47	37.74
BARI Alu-91	41.75	40.57	32.11	38.14
Range	31.25-44.50	26.16-43.89	32.11-47.15	
Mean	37.50	37.45	39.08	

Table 5 Economics of different potato varieties in plainland ecosystem during 2023-24 (average of all locations).

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Alu-25	766125	226378	539748
BARI Alu-37	752775	226378	526398
BARI Alu-62	987075	226378	760698
BARI Alu-78	798375	226378	571998
BARI Alu-79	888675	226378	662298
BARI Alu-81	821100	226378	594723
BARI Alu-87	967725	226378	741348
BARI Alu-88	863700	226378	637323
BARI Alu-90	849075	226378	622698
BARI Alu-91	858225	226378	631848
Mean	855285	226378	628908

Average price of potato: 22.50 Tk. kg⁻¹ (average of 3 locations)

Conclusion

BARI Alu-41, BARI Alu-47, BARI Alu-62, BARI Alu-82, and BARI Alu-88 have emerged as the top-performing potato varieties in low land ecosystems. Similarly, BARI Alu-42, BARI Alu-87, BARI Alu-79, BARI Alu-88, and BARI Alu-91 have excelled in plain land ecosystems. BARI Alu-62, BARI Alu-87 and BARI Alu-88, in particular, are well-suited for both ecosystems and are recommended for widespread cultivation across the country.

111. SELECTION AND DISSEMINATION OF DROUGHT RESISTANT POTATO VARIETIES FOR CHAR LAND AREAS FROM EXISTING MEGA VARIETIES

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Abstract

These trials were conducted at farmers' fields of Gaibandha, Brahmanbaria, Manikgonj and Kurigram charland area during the rabi season of 2023-24 to select the suitable potato varieties suitable to char areas. Eight potato varieties viz. BARI Alu-7, BARI Alu-13 BARI Alu-25, BARI Alu-62, BARI Alu-72, BARI Alu-73, BARI Alu-78 and BARI Alu-79. Among the tested potato varieties BARI Alu-62, BARI Alu-72, BARI Alu-78 and BARI Alu-79 performed better in char areas of different districts. The average highest tuber yield recorded from BARI Alu-79 (33.51 t ha^{-1}) followed by BARI Alu-62 (28.80 t ha^{-1}) and BARI Alu-78 (28.25 t ha^{-1}) whereas the lowest was from BARI Alu-25 (20.68 t ha^{-1}).

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops in Bangladesh and is being cultivated throughout the country. In Bangladesh, the crop is the third most important crop in Bangladesh next to rice and wheat. Bangladesh ranks in 8th position in production in the world and 2nd in the country (FAOSTAT, 2021). Currently, 9.89 million tons (Mt) of potatoes were produced from around 0.47 million hectares (Mha) of land and the average yield was 20.41 t ha^{-1} (FAOSTAT 2021). Over the two decades, total potato production has reached from 1.55 Mt to 9.89 Mt, in an area of 0.47 Mha from 0.14 Mha. The demand for potato production in the country is increasing to feed the ever-increasing population and by 2030 the country needs to increase its yield from 20.43 t ha^{-1} to 41.50 t ha^{-1} of potatoes to attain food and nutrition security also. 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. Char areas have harsh environment due to lack of irrigation facilities, that hamper crop production. 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 insects' pests and diseases. Our main objective was to select the suitable potato varieties grown in char land area. Therefore, this trial was conducted to evaluate their yield performance in char area as well as select the most promising potato varieties especially for charland areas.

Materials and Methods

The experiment was carried out a farmer field of Char area in Gaibandha, Brahmanbaria, Manikgonj and Kurigram during rabi season 2023-24. Potato varieties viz. BARI Alu-7, BARI Alu-13 BARI Alu-25, BARI Alu-62, BARI Alu-72, BARI Alu-73, BARI Alu-78 and BARI Alu-79 were used in the trial. The unit plot size was $8 \text{ m} \times 4.8 \text{ m}$. Seed tubers were planted on 20 November-27 December 2023 maintaining $60 \text{ cm} \times 25 \text{ cm}$ spacing. The crop was fertilized with 143-18-45-3-15-1.33-0.5 kg N-P-K-S-Mg-Zn-B ha^{-1} . The entire amount of P, K, S, Mg, Zn and half of N were applied during final land preparation. The rest of nitrogen was top dressed at 35 DAP. Earthing up was done twice at 35 and 50 DAP. The crop was irrigated thrice at 35, 55 and 70 DAP. Different groups of fungicides viz. Dithane M-45 @ 2 g L^{-1} water, Secure 2 g L^{-1} , Metaryl 72 WP @ 2 g L^{-1} water and Acrobet MZ @ 2 g L^{-1} water was sprayed 4 times to control late blight disease of potato. Insecticide (Nitro @ 2 ml L^{-1} water was sprayed to control cut worm and other leaf feeder insects to support normal growth of plant. The tubers were harvested on 4-13 March 2024.

Results and Discussions

The tuber yield (t ha^{-1}) across the locations ranged from 15.60 - 41.76 t ha^{-1} , where BARI Alu-79 (41.76 t ha^{-1}) produced the highest tuber yield in Manikgonj, followed by BARI Alu-78 (40.65 t ha^{-1}) in Kurigram and the lowest observed from BARI Alu-25 (15.60 t ha^{-1}) in Brahmanbaria. Considering the locations, the average maximum tuber yield was produced in Kurigram (30.18 t ha^{-1}), followed by Manikgonj (27.37 t ha^{-1}) and Gaibandha (24.33 t ha^{-1}) whereas the average minimum tuber yield was recorded in B. Baria (19.61 t ha^{-1}). Among the varieties, the average

maximum tuber yield was produced by BARI Alu-79 (33.51 t ha⁻¹), followed by BARI Alu-62 (28.80 t ha⁻¹), BARI Alu-78 (28.25 t ha⁻¹) and BARI Alu-72 (26.49 t ha⁻¹) whereas the lowest was observed from BARI Alu-25 (20.68 t ha⁻¹).

The cost and return analysis (Table 2) showed that the highest gross return was obtained from BARI-79 (Tk. 806138 ha⁻¹) followed by BARI Alu-62 (Tk. 680638). Similar trends were also observed in the gross margin. The average cultivation cost was Tk. 222196 ha⁻¹.

Table 1. Yield Performance of eight potato varieties at different char areas during 2023-24.

Variety	Brahmanbabaria	Manikganj	Gaibandha	Kurigram	Mean
BARI Alu-7	16.95	22.37	21.58	28.45	22.34
BARI Alu-13	21.57	23.37	21.35	22.25	22.14
BARI Alu-25	15.60	22.19	19.16	25.76	20.68
BARI Alu-62	23.41	30.19	28.08	33.50	28.80
BARI Alu-72	19.41	24.88	32.06	29.60	26.49
BARI Alu-73	16.62	18.18	22.60	25.77	20.79
BARI Alu-78	18.06	36.03	18.27	40.65	28.25
BARI Alu-79	25.27	41.76	31.54	35.46	33.51
Mean	19.61	27.37	24.33	30.18	

Table 2. Benefit-cost of eight potato varieties during the year 2023-24 (average of all locations).

Variety	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Alu-7	523863	222196	301666
BARI Alu-13	528088	222196	305891
BARI Alu-25	488525	222196	266329
BARI Alu-62	680638	222196	458441
BARI Alu-72	616213	222196	394016
BARI Alu-73	482075	222196	259879
BARI Alu-78	677700	222196	455504
BARI Alu-79	806138	222196	583941
Mean	600405	222196	378208

*Potato price at harvest: Tk. 20-30 kg⁻¹

Conclusion

Among the tested potato varieties, BARI Alu-62, BARI Alu-72, BARI Alu-78, and BARI Alu-79 performed well in terms of yield with higher financial return in the char areas. Farmers in the char areas have expressed interest in growing these potato varieties next year and promotional works should be taken to disseminate these varieties in coastal regions.

112. PROMOTION AND DISSEMINATION OF NEWLY RELEASED CLIMATE-SMART (HEAT AND SALT TOLERANT) POTATO VARIETIES IN THE COASTAL AREAS OF BANGLADESH

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Abstract

Three climate-smart (heat and salt tolerant) potato varieties BARI Alu-72, BARI Alu-73, and BARI Alu-78 were evaluated at the farmer's field in three locations. The tuber yield ranged from 20.40-33.60 t ha⁻¹, where the highest yield was recorded from BARI Alu-78 (33.60 t ha⁻¹) in Cox's Bazar and the lowest from BARI Alu-7 in the same location. Considering the varieties, the maximum tuber was produced by BARI Alu-78 (29.98 t ha⁻¹), followed by BARI Alu-72 (28.28 t ha⁻¹). Among the three locations, the average maximum tuber yield was produced in Cox's Bazar (26.38 t ha⁻¹) and the minimum was in Patuakhali (24.86 t ha⁻¹).

Introduction

The coastal area includes 32% of the cultivable land in Bangladesh (Haque, 2006). About 1.06 Mha out of 2.86 Mha of coastal and off-shore cultivable lands in Bangladesh, are affected by varying degrees (>2 to 16 dS m^{-1}) of salinity (SRDI, 2010). During the *rabi* season, the soil salinity levels increase through capillary movement. It is a major production constraint in the saline coastal region. The lack of high-yielding salt-tolerant variety, soil salinity, and lack of irrigation facilities are the major challenges for potato cultivation in this area. Potato has the capacity of producing more calories and proteins per unit of land area with minimum time than most other major food crops (Azimuddin *et al.*, 2009). Recently, BARI has developed three climate-smart potato varieties, BARI Alu-72 (Heat & Salt tolerant), BARI Alu-73 (Heat Tolerant), and BARI Alu-78 (Salt tolerant) to expand potato cultivation for un-favorable ecosystem (heat and salinity problem) areas. The field performance of these three varieties needs to be evaluated at the farmers field condition before the expansion of potato cultivation in these areas and keeping this view in mind, the experiment was undertaken.

Materials and Methods

A trial with BARI Alu-72, BARI Alu-73 and BARI Alu-78 and BARI Alu-7 (check) was conducted at Khulna, Cox's Bazar and Patuakhali during Rabi season 2023-24 to observe its performance in the coastal saline area. The unit plot size was 05 decimals for each farmer. The experimental plots were fertilized with $174\text{-}92\text{-}125\text{-}21.6\text{-}1.7\text{-}1.0 \text{ kg ha}^{-1}$ N-P-K-S-Zn-B in the form of Urea-DAP-MoP-Gypsum- $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and Boric acid, respectively. Total amount of all fertilizers and half of the total urea was applied as basal during final land preparation. Rest of the urea was applied at 20 and 45 DAP as top dressing. Seed tubers were planted on 02-04 December 2023 maintaining $60 \text{ cm} \times 25 \text{ cm}$ spacing and seed rate of 1.5 t ha^{-1} . The crop was irrigated two times, weeding and earthing up were done once. Aphids were controlled by spraying Emitaf @ 1 ml L^{-1} and Admire @ 0.5 ml L^{-1} of water. To control Late Blight, crop was sprayed 4 times with Mancozeb @ 2 g L^{-1} of water at 10 days interval. The crop was harvested on 26-29 February 2024. Soil salinity gradually increased up to maturity stage of the crop. The salinity level was $2.50\text{-}3.22 \text{ (dS/m)}$ at germination stage, $4.17\text{-}5.28 \text{ (dS/m)}$ vegetative stage, $5.45\text{-}6.48 \text{ (dS/m)}$ tuber formation stage and it reached up to 8.35 (dS/m) at maturity stage. Production costs of potato included the cost of all operations (e.g., land preparation, seed, planting, irrigation, application of organic manure and chemical fertilizers, spraying of insecticides and fungicides and harvesting). Data on yield and yield attributes, and disease and insect incidence were collected and analyzed statistically.

Results and Discussion

The mean yield of the three climate smart potato varieties across the locations ranged from 20.40 to 33.60 t ha^{-1} , where the maximum tuber yield was recorded from BARI Alu-78 (33.60 t ha^{-1}) in Cox's Bazar, followed by BARI Alu-72 (29.40 t ha^{-1}) and the minimum was observed from BARI Alu-7 (20.40 t ha^{-1}) in the same location. Among the varieties, BARI Alu-78 (29.98 t ha^{-1}) was the highest yielder followed by BARI Alu-72 (28.28 t ha^{-1}) (Table 1). Considering the locations, the average maximum tuber yield was produced in Cox's Bazar (26.38 t ha^{-1}) and the minimum was in Patuakhali (24.86 t ha^{-1}).

The maximum average gross return and gross margin obtained from BARI Alu-78 accounted for Tk. 815250 ha^{-1} , and Tk. 603217 ha^{-1} followed by BARI Alu-72 (gross return and gross margins were Tk. 753417 ha^{-1} and Tk. 541383 ha^{-1}). The average lowest gross return and gross margin were accounted for in BARI Alu-13 (Tk. 601267 ha^{-1} and Tk. 389233 ha^{-1}) (Table 2). The reason for the higher gross return as well as gross margin was mainly due to the higher tuber yield and market price.:

Farmers' opinion

Farmers of Patuakhali preferred BARI Alu-72 and farmers of Khulna and Cox's Bazar preferred BARI Alu-72 and BARI Alu-78 due to higher yield and suitable for cultivation under salinity stress conditions.

Table 1. Yield performance of climate-smart potato varieties in Khulna, Cox's Bazar and Patuakhali during the year 2023-24.

Variety	Khulna	Cox's Bazar	Patuakhali	Mean	% increase over check
BARI Alu-7 Check)	22.01	20.40	25.34	22.58	-
BARI Alu-72	27.85	29.40	27.59	28.28	25.2
BARI Alu-73	-	22.10	21.65	21.88	-3.1
BARI Alu-78	26.35	33.60	-	29.98	32.7
Mean	25.40	26.38	24.86	-	-
LSD _{0.05}	1.63	1.63	-	-	-
CV (%)	5.16	8.72	-	-	-

Table 2. Economic analysis of climate smart potato varieties during 2023-24 (average of all locations).

Varieties	Gross Return (Tk.ha ⁻¹)	Total Variable Cost (Tk.ha ⁻¹)	Gross Margin (Tk.ha ⁻¹)
BARI Alu-7 Check)	601267	212033	389233
BARI Alu-72	753417	212033	541383
BARI Alu-73	546875	212033	334842
BARI Alu-78	815250	212033	603217
Mean	679202	212033	467169

*Price of Potato: Tk. 25-30 kg⁻¹ across the locations.

Conclusion

Potato var. BARI Alu-72 and BARI Alu-78 suited for cultivation under saline ecosystem and produced satisfactory yield in all locations. So, promotional works should be taken to disseminate these varieties in coastal regions.

113.ON FARM TRIAL OF SWEET POTATO VARIETIES IN DIFFERENT LOCATIONS

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Abstract

The field trial was conducted with seven sweet potato varieties at four different sites in 2023-2024 to compare the performance of each variety and get farmers' choice. The root yield of sweet potato varieties ranged from 10.83 to 42.10 t ha⁻¹, where BARI Mistialu-14 produced the maximum root yield (42.10 t ha⁻¹) in Gopalganj whereas BARI Mistialu-8 produced the lowest root yield (10.83 t ha⁻¹) in Rajbari. Considering location, Gopalganj showed the maximum mean root yield (38.43 t ha⁻¹), followed by Mymensingh (25.96 t ha⁻¹) and Jamalpur (20.21 t ha⁻¹) while Rajbari showed the minimum (14.68 t ha⁻¹).

Introduction

Sweet potato (*Ipomoea batatas*) is the fourth significant food crop in Bangladesh, which has excellent agronomic properties for growing in a diverse environment (Islam et al., 2003, 2006, and Ndolo et al. 2001). Sweet potatoes can be crucial in helping Bangladesh's poor people satisfy their food demands in times of crisis (Rafiq et al. 2015). Currently, about 304 t sweet potato is being produced from an area of 29150 acre of land (BBS, 2022). Orange-fleshed sweet potatoes (OFSP) can be one of the remedies for vitamin A insufficiency. High-yielding sweet potato cultivars have been released by TCRC, BARI, however, there aren't any promotions to get the word out to farmers. For this reason, farmers' fields have been used for adaptive trials to locate acceptable cultivars in various regions of Bangladesh and to encourage farmer participation.

Materials and Methods

The trials were conducted at farmers' field of MLT site Rajbari, Jamalpur, Mymensingh and Gopalganj during the rabi season of 2023-24. The trials were set up in a RCBD with three to six

dispersed replications. Planting of vines was started on 5 November 2023 and continued up to 17 December 2023 with a spacing of 60 cm × 30 cm. The unit plot size varied from location to location. Manures and fertilizers were applied at the rate of 10 t ha⁻¹ cowdung and 105-45-105-15-2-1 Kg of N-P-K-S-Zn-B ha⁻¹, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty per cent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizers were applied at 35 DAP. Intercultural operations and plant protection measures were made as and when necessary. Harvesting started on 10 March 2024 and continued up to 2 May 2024.

Results and Discussion

The sweet potato root yield ranged from 10.83 to 42.10 t ha⁻¹ across the locations. The maximum root yield was observed from BARI Mistialu-14 (42.10 t ha⁻¹) in Gopalganj whereas the minimum root yield (10.83 t ha⁻¹) was recorded from BARI Mistialu-8 in Rajbari (Table 1). This may be due to the different soil and climatic conditions among the locations. Among the four locations, the average maximum root yield was recorded in Gopalganj (38.43 t ha⁻¹), followed by Mymensingh (25.96 t ha⁻¹) and Jamalpur (20.21 t ha⁻¹) whereas the minimum (14.68 t ha⁻¹) was in Rajbari.

The average maximum gross return (Tk. 608800 ha⁻¹) was observed by BARI Mistialu-15, followed by BARI Mistialu-17 (Tk. 606217 ha⁻¹) and the minimum was from BARI Mistialu-8 (Tk. 270750 ha⁻¹). The maximum gross margin (Tk. 422647 ha⁻¹) was found from BARI Mistialu-17, followed by BARI Mistialu-16 and BARI Mistialu-15. The variation of gross return and gross margin was mainly due to market various market price depending on locations (Table 2).

Farmer's opinion: Farmers have shown interest in BARI Mistialu-17 in all the locations except Gopalganj because of their higher root yield, and nutritional value. In addition, Farmers also preferred BARI Alu-12, 14, 15 and 16 that varied from location to location. They also showed interest in cultivating these varieties in the upcoming year.

Table 1. Root yield (t ha⁻¹) of sweet potato varieties in different locations, 2023-24.

Variety	Root yield (t ha ⁻¹)			Gopalganj
	Jamalpur	Rajbari	Mymensingh	
BARI Mistialu-8		10.83	-	
BARI Mistialu-12	19.60		-	36.85
BARI Mistialu-14	19.56	14.61	-	42.10
BARI Mistialu-15	21.36	-	-	36.85
BARI Mistialu-16	18.19	-	25.18	37.90
BARI Mistialu-17	22.34	20.32	32.32	-
Local		12.96	20.38	-
Mean	20.21	14.68	25.96	38.43
LSD (0.05)	1.02	5.71	4.50	5.03
CV (%)	2.67	13.31	9.52	5.30

Table 2. Cost and return analysis of sweet potato varieties in different locations during the year 2023-24 (average of all locations)

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Mistialu-8	270750	185640	85110
BARI Mistialu-12	589000	253660	335340
BARI Mistialu-14	549117	230987	318130
BARI Mistialu-15	608800	253660	355140
BARI Mistialu-16	598925	215857	383068
BARI Mistialu-17	606217	183570	422647
Local	384350	162945	221405
Mean	515308	212331	302977

*Price of BARI sweet potato 22.5-25 and local 20 Tk. kg⁻¹ in different locations.

Conclusion

Due to their excellent production and gross profit, the evaluated sweet potato types of BARI Mistialu-12, BARI Mistialu-14, BARI Mistialu-15, BARI Mistialu-16 and BARI Mistialu-17 performed well. However, awareness should build up among the growers and consumers about the nutritional status of these sweet potato varieties.

114.ON-FARM TRIAL OF BARI RELEASED VARIETIES OF MUKHIKACHU IN DIFFERENT LOCATIONS

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Abstract

The experiment was carried out at seven different places with three different Mukhikachu varieties during kharif season of 2023 to assess their performed in farmers' fields and to gain popularity among them. The corm yield varied from 15.32 to 30.53 t ha⁻¹ across the locations where the maximum yield (30.53 t ha⁻¹) was recorded from BARI Mukhikachu-1 in Sylhet and the lowest (15.32 t ha⁻¹) was recorded from local cultivar in Narsingdi. According to location, Cumilla had the highest average corm yield (27.87 t ha⁻¹), followed by Gaibandha (26.79 t ha⁻¹) and Sylhet (25.74 t ha⁻¹) whereas Rajshahi had the lowest average corm yield (18.46 t ha⁻¹). Among the varieties, the average maximum yield observed in BARI Mukhikachu-1 (25.71 t ha⁻¹), similar to BARI Mukhikachu-2 (25.31 t ha⁻¹).

Introduction

Mukhikachu (*Calocassia esculenta* var. antiquorum) is one of the significant tuber crops grown in Bangladesh during the Kharif season. It is regarded as a significant vegetable, a source of iron, protein, carbohydrates, and vitamin 'A'. Now about 122995 t Mukhikachu is being produced from an area of 9708 ha of land (BBS 2022). Two Mukhikachu varieties have been developed by BARI's Tuber Crops Research Center (TCRC), which have great yield potential and are less prone to diseases and pests. Farmers are also cultivating some native types. They are not too familiar with the recently released variety. Thus, the trials were conducted to assess this variety's performance and to popularize and disseminate it throughout the nation.

Materials and Methods

The experiment was conducted at seven different locations namely, Tangail, Sylhet, Sherpur, Rajshahi, Cumilla, Narsingdi and Gaibandha during the kharif season of 2023 to evaluate the performance of the two mukhikachu varieties (BARI Mukhikachu-1 and BARI Mukhikachu-2) along with the local cultivar and to popularize among the farmers. The experiment was laid out in RCBD with three dispersed replications. The unit plot size was 13.5-144. The land was fertilized with 275-150-225-125-14-10 kg ha⁻¹ in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid, respectively with 10 tha⁻¹ of cowdung. The full amount of cowdung, TSP, and half of MOP were applied at the final land preparation. The rest half of MOP and 1/6th of urea was applied at 45-60 Days after planting (DAP). The remaining 1/5th urea was applied at 15 days intervals. The seedlings of Mukhikachu were planted on 4 March-3 April 2023 with a spacing of 60 cm x 35 cm. The crop was slightly infested with leaf spot disease, and it was controlled by spraying several times with Ridomil Gold- 72 @ 2 ml L⁻¹ water. No other significant diseases and pest infestation were observed in the plots. The corm was harvested on 3 October 2023 and continued up to 16 November 2023. Data were collected and analyzed statistically, and the means were separated using least significant difference (LSD) at the 5% level of significance (p < 0.05).

Results and Discussion

The corm yield ranged from 15.32 to 30.53 t ha⁻¹ across the location where the highest yield (30.53 t ha⁻¹) recorded from BARI Mukhikachu-1 in Sylhet and the lowest (15.32 t ha⁻¹) recorded by local cultivar in Narsingdi (Table 1). Considering the locations, the average highest corm yield was found in Cumilla (27.87 t ha⁻¹), followed by Gaibandha (26.79 t ha⁻¹) and Sylhet (25.74 t ha⁻¹) and the minimum corm yield observed in Rajshahi (18.46 t ha⁻¹). Considering the varieties, the average highest yield was recorded from BARI Mukhikachu-1 (25.71 t ha⁻¹), similar to BARI Mukhikachu-2 (25.31 t ha⁻¹) whereas the lowest was in the local cultivar with a value of 18.72 t ha⁻¹.

The average highest gross return (Tk. 854189 ha⁻¹) and gross margin (Tk. 618604 ha⁻¹) were found from BARI Mukhikachu-1 due to the maximum corm yield and the lowest gross return (Tk. 568410 ha⁻¹) and gross margin (Tk. 346607 ha⁻¹) were from the local cultivar (Table 2).

Farmers' opinion

Farmers were very happy to see the yield of BARI Mukhikachu-1 and BARI Mukhikachu-2. They also preferred these varieties and showed their interest to grow in future.

Table 1. Yield (t ha⁻¹) of Mukhikachu varieties in different locations during the year 2023.

Varieties	Tangail	Sylhet	Sherpur	Rajshahi	Cumilla	Narsingdi	Gaibandha
BARI Mukhikachu-1	24.54	30.53	25.50	20.24	29.40	24.25	25.52
BARI Mukhikachu-2	26.37	28.10	21.70	18.87	26.33	27.77	28.06
Local	24.69	18.60	-	16.26	-	15.32	-
Mean	25.20	25.74	23.60	18.46	27.87	22.45	26.79
LSD	1.47	2.18	-	0.91	-	4.52	-
CV (%)	11.49	3.73	-	7.82	-	3.49	-

Table 2. Cost and analysis of Mukhikachu varieties at different locations during 2023 (average of all locations).

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Mukhikachu-1	854189	235584	618604
BARI Mukhikachu-2	823004	235584	587420
Local	568410	221803	346607
Mean	748534	230991	517544

*Price of corm: Tk. 18-43 kg⁻¹ varied on the locations

Conclusion

From the results, it may be concluded that BARI Mukhikachu-1 and BARI Mukhikachu-2 were found best for corm production in all locations.

115. ON-FARM TRIAL OF BARI RELEASED VARIETIES OF PANIKACHU IN DIFFERENT LOCATIONS

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Abstract

The experiment was carried out in six distinct places during the kharif season of 2022-2023 to assess the performance of Panikachu varieties. The stolon yield of the Panikachu varieties ranged from 5.87 to 32.40 t ha⁻¹, where BARI Panikachu-1 in Cumilla recorded the highest yield (32.40 t ha⁻¹) and BARI Panikachu-5 in Gaibandha recorded the lowest (5.87 t ha⁻¹). On the other hand, the rhizome yield varied from 8.00 to 77.87 t ha⁻¹, with BARI

Panikachu-6 in Mymensingh recorded the highest yield (77.87 t ha⁻¹) and BARI Panikachu-1 in Tangail recorded the lowest (8.00 t ha⁻¹). Considering the locations, the average maximum stolon (22.46 t ha⁻¹) and rhizome (39.37 t ha⁻¹) were produced in Cumilla and Mymensingh whereas the average minimum stolon (11.80 t ha⁻¹) and rhizome (8.45 t ha⁻¹) were produced in Gaibandha and Tangail, respectively.

Introduction

Panikachu is one of the most important tuber crops in Bangladesh. Panikachu is being produced on 5734 ha of land, yielding roughly 65150 t (BBS, 2022). The stolon, leaf blade, and leaf stem are extremely nutrient-dense parts of this crop. Seven improved Panikachu cultivars, all of which are excellent yielders and resistant to pests and diseases, have been made available by BARI. The farmers have taken a liking to only BARI Panikachu-1 (Latiraj). The growers are additionally cultivating a few regional types. They are unfamiliar with the most recent variety. Therefore, a trial was carried out to assess the performance of the aroid varieties and promote and propagate them throughout the nation.

Materials and Methods

The experiment was conducted at five locations of Tangail, Sherpur, Cumilla, Kishoregonj, Gaibandha and Mymensingh during the kharif season of 2022-23 to evaluate the performance of Panikachu varieties; BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6, BARI Panikachu-7 under farmers' field and to popularize among the farmers. Six dispersed replications were used in the trial's design by RCB. The unit plot size was 10.8 to 40.5 m². The seedlings were planted from 26 November 2022 to 2 February 2023 maintaining 60 cm x 45 cm spacing. The crop was fertilized with a dose of N₁₅₂ P₃₄ K₁₈₀ S₂₀ Zn_{4.3} B_{1.7} kg⁻¹ respectively. The full amount of cowdung, TSP and half of MOP was applied at the final land preparation. The remaining half of MOP and 1/6th of urea was applied at 45-60 Days after planting (DAP). The remaining 1/5th urea was applied at 15 days intervals. The crop had a little amount of the leaf spot disease, which was controlled by repeatedly spraying Ridomil Gold-72 @ 2 ml L⁻¹ water on the crop. No additional serious diseases or evidence of a pest infestation was found in the plots. The stolon was harvested from 20 March to 16 August 2023 and rhizome was harvested from July to September 2023.

Results and Discussion

The Panikachu varieties' stolon yields ranged from 5.87 to 32.40 t ha⁻¹, with BARI Panikachu-1 in Cumilla showing the highest yield (32.40 t ha⁻¹) and BARI Panikachu-5 in Gaibandha showed the lowest (5.87 t ha⁻¹) (Table 1). The rhizome yield varied from 8.00 to 77.87 t ha⁻¹, with BARI Panikachu-6 in Mymensingh showing the highest yield (77.87 t ha⁻¹) and BARI Panikachu-1 in Tangail showed the lowest (8.00 t ha⁻¹) (Table 2). The yield varied among the locations due to soil and climatic variability. Among the locations, the average maximum stolon (22.46 t ha⁻¹) and rhizome (39.37 t ha⁻¹) were produced in Cumilla and Mymensingh whereas the average minimum stolon (11.80 t ha⁻¹) and rhizome (8.45 t ha⁻¹) were produced in Gaibandha and Tangail, respectively

On an average, the highest gross return (923058 Tk. ha⁻¹) and gross margin (660696 Tk. ha⁻¹) was obtained from BARI Panikachu-1 due to the more stolon and rhizome yield compared to the others, next to BARI Panikachu-2 and BARI Panikachu-7, respectively. The lowest gross return (Tk. 455130 ha⁻¹) and gross margin (Tk. 183599 ha⁻¹) was obtained from BARI Panikachu-5 (Table 3).

Farmers' reaction: Farmers preferred BARI Panikachu-1 and BARI Panikachu-2 for stolon and BARI Panikachu-5, BARI Panikachu-6, and BARI Panikachu-7 for cards (rhizomes) depending on locations. In the future, they would like to grow these varieties.

Table 1. Stolon yield of Panikachu varieties at different locations during the year of 2022-23.

Variety	Stolon yield (t ha ⁻¹)					
	Tangail	Sherpur	Cumilla	Kishoreganj	Gaibandha	Mymensingh
BARI Panikachu-1	17.57	23.10	32.40	25.40	21.44	-
BARI Panikachu-2	16.22	19.20	26.20	20.25	22.48	19.80
BARI Panikachu-3	-	13.50	-	7.15	8.72	11.48
BARI Panikachu-4	-	8.85	-	9.10	6.05	-
BARI Panikachu-5	-	5.89	-	8.40	5.87	8.18
BARI Panikachu-6	-	7.50	12.09	7.48	6.22	7.19
BARI Panikachu-7	-	-	12.20	7.10	-	7.52
Local	-	-	29.40	-	-	19.48
Mean	16.90	13.01	22.46	12.13	11.80	12.28
LSD	-	-	13.16	-	-	0.70
CV (%)	-	-	4.45	-	-	2.03

Table 2. Rhizome yield of Panikachu varieties at different locations during the year 2022-23.

Variety	Rhizome yield (t ha ⁻¹)					
	Tangail	Sherpur	Cumilla	Kishoreganj	Gaibandha	Mymensingh
BARI Panikachu-1	8.00	34.04	22.20	17.55	15.67	-
BARI Panikachu-2	8.90	32.30	36.50	18.20	18.76	18.93
BARI Panikachu-3	-	34.70	-	30.20	22.77	22.83
BARI Panikachu-4	-	37.11	-	27.50	28.59	-
BARI Panikachu-5	-	21.70	-	26.20	34.77	23.76
BARI Panikachu-6	-	17.13	39.50	41.21	41.06	77.87
BARI Panikachu-7	-	-	48.90	27.35	-	72.90
Local	-	-	18.50	-	-	19.95
Mean	8.45	29.50	33.12	26.89	26.94	39.37
LSD	-	-	0.60	-	-	-
CV (%)	-	-	5.47	-	-	-

Table 3. Cost and return analysis of different Panikachu varieties at different locations during the year of 2022-2023 (average of all locations).

Varieties	Gross Return (Tk. ha ⁻¹)	Total Variable Cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Panikachu-1	923058	271531	651527
BARI Panikachu-2	881562	271531	610031
BARI Panikachu-3	557578	271531	286047
BARI Panikachu-4	500407	271531	228876
BARI Panikachu-5	455130	271531	183599
BARI Panikachu-6	712124	271531	440593
BARI Panikachu-7	843600	271531	572069
Mean	696208	271531	424677

*Price of stolon (Tk. 15-38kg⁻¹) and rhizome (Tk. 10-12 kg⁻¹)

Conclusion

BARI Panikachu-1 and BARI Panikachu-2 were suitable for stolon production in all the locations with some exception in local cultivar that produced a good stolon (29.40 and 19.48 t ha⁻¹ in Cumilla and Mymensingh). In case of rhizome production, BARI Panikachu-3 and BARI Panikachu-4 performed best in Sherpur, BARI Panikachu-5, BARI Panikachu-6 and BARI Panikachu-7 performed best in Cumilla, Kishoregonj, Gaibandha and Mymensingh.

116. ON-FARM TRIAL OF BARI RELEASED VARIETIES OF ELEPHANT FOOT YAM

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Abstract

The field trial was executed at Sadar upazila of Kishoreganj during the year 2022-23 to know the performance of BARI released Ol kachu varieties in the study area. Three varieties were selected for this experiment viz; BARI Olkachu-1, BARI Ol kachu-2 and local. The highest rhizome yield was obtained from BARI Olkachu-1 (30.32 t ha⁻¹) and the lowest from local variety (25.31 t ha⁻¹). The highest gross return (303200 Tk. ha⁻¹) gross margin (116620 Tk. ha⁻¹) was calculated from BARI Olkachu-1 and the lowest from local variety (Gross return 253700 Tk. ha⁻¹ and gross margin 67120 Tk. ha⁻¹).

Introduction

Elephant foot yam is a tropical tuber crop that offers excellent scope for adoption in the tropical countries as a cash crop due to its production potential and popularity as a vegetable in various delicious cuisines. It is a crop of southeast Asian origin, and grows in wild form in the Philippines, Malaysia, Indonesia, Bangladesh and south-east Asian countries. Many indigenous ayurvedic and unani medicinal preparations are also made using its tubers. The tubers are believed to have blood purifying characteristics and are used in medicines for the treatment of piles, asthma, dysentery and other abdominal disorders. However, some farmers of different regions of the country like Jashore, Satkhira, Narsingdi, Kishoreganj along with Hill Tracts cultivate it commercially. It is important for its nutrients content and medicinal values though it is used as vegetable. BARI released two varieties of yam as BARI Olkachu-1 and BARI Olkachu-2. The Farmers of Kishoreganj usually cultivate local variety of Ol kachu which give low yield as well as low returns. They do not know about BARI developed high yielding, disease and insect resistant variety. So, if these varieties are introduced in this area then farmer will be benefited. Thus, this experiment was taken in this area.

Materials and Methods

The experiment was conducted in Kishoreganj during the year 2022-23 to know the performance of BARI released Ol kachu varieties in that area. The design was RCBD with three replications. Varieties were BARI Ol kachu-1, BARI Ol kachu-2 and local variety. The unit plot sizes were 9 m × 4.5 m². Spacing was followed by 60 cm × 45 cm. Ol kachu were sown on 26 February 2023 to 28 March 2023. The recommended fertilizer doses were applied as N₁₃₂ P₃₄ K₁₈₀ S₂₀ Zn_{4.3} B_{1.7} kg⁻¹ 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 45 & 60 DAS. Harvesting of rhizome started from 21st October 2023 and ended at 26th November 2023. Data on yield and yield contributing characters were recorded and analyzed for report writing.

Result and Discussion

Yield and economic analysis are shown table 1. The highest yield was found from BARI Ol kachu-1 (30.32 t ha⁻¹) and the lowest from local variety (25.37 t ha⁻¹) (Table 1). The highest gross return (303200 Tk ha⁻¹) and gross margin (116620 Tk. ha⁻¹) were calculated from BARI Ol kachu-1 and the lowest from local variety (253700 Tk ha⁻¹ and 67120 Tk ha⁻¹).

Farmers' opinion: Farmers prefer BARI Ol kachu-1 for higher yield potential with market demand and price.

Table 1. Yield and economic analysis of Ol kachu in Kishoreganj during 2022-23

Varieties	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC(Tk. ha ⁻¹)	Gross marginal (Tk. ha ⁻¹)
BARI Olkachu-1	30.32	303200	186580	116620
BAR Olkachu -2	27.23	272300	186580	85720
Local variety	25.37	253700	186580	67120

* TVC includes land preparation, labour, seed, fertilizers and insecticides, Ol kachu= Tk. 10 kg⁻¹

Conclusion

The unavailability of good quality rhizome during the growing season was the major problem in this area. So, Purpose of more dissemination and meet up vegetable crisis rhizome must be available in time at farmers' level.

117.ON-FARM TRIAL OF BARI HYBRID TOMATO VARIETIES DURING WINTER SEASON

Abstract

The experiment was conducted at Noyadingi village under Saturia upazila, Boinna village under Ghior upazila of Manikganj; Panchbaria, Shercol, Singra of Natore; Shibpur of Narsingdi; and FSRD site, Gopalganj Sadar and Tungipara of Gopalganj district during Rabi season of 2023-24 to evaluate the performance of BARI released winter hybrid tomato varieties in the farmers' field. Different BARI winter hybrid tomato varieties, viz. BARI hybrid Tomato-5, BARI hybrid Tomato-7 and BARI hybrid Tomato-9 along with commercial hybrids were evaluated in Manikganj and Narsingdi district. Moreover, two varieties viz. BARI Tomato-19 and BARI Tomato-21, and four varieties viz. BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and BARI Tomato-21 were evaluated in Natore and Gopalganj, respectively. The highest fruit yield (67.16 t ha^{-1}) was recorded in Bahuboli hybrid followed by BARI hybrid tomato-5 (62.62 t ha^{-1}) and BARI hybrid tomato-9 (62.14 t ha^{-1}) in Manikganj. BARI Hybrid Tomato-5 produced the highest fruit yield 95.20 t ha^{-1} in Narsingdi. Among the two varieties, BARI Tomato-21 produced the higher yield (61.72 t ha^{-1}) in Natore, and BARI tomato-15 produced significantly highest fruit yield (78.40 t ha^{-1}) over BARI Tomato-21 in Gopalganj farmer's field.

Introduction

Tomato (*Lycopersicon esculentum*) is the most important vegetable crop in our country cultivated mostly during rabi season. The area of tested locations is low and total production is also low. Farmers use the traditional varieties which is low yielding and susceptible to disease and pests. As a result, yield is decreasing day by day. 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. Some advanced farmers grow commercial hybrid variety but the seeds are very costly that causes economic loss of the farmers. Horticulture Research Centre of BARI has developed some winter hybrid varieties of tomato which are supposed to be higher yielder and less susceptible to pests 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 variety among the farmers to promote their adoption.

Materials and Methods

The experiment was conducted at four different locations during Rabi season of 2023-24. Locations, varieties and agronomic management were presented in Table 1. The experiment was laid out in a randomized complete block design with six and/ or three dispersed replications. 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 DAS. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Fruits were harvested from 20 January to 30 March 2024. Data on yield and yield attributes were collected and analyzed statistically following SPSS/ R/ Statistix 10 program.

Table 1. Crop management of BARI developed winter hybrid tomato varieties

Locations	Varieties	Dates of transplanting	Unit plot size	Spacing	Fertilizer dose N-P-K-S-Zn-B (kg ha ⁻¹)	Harvesting date
Saturia and Ghior, Manikganj	BARI Hybrid Tomato-5, BARI Hybrid Tomato-7, BARI Hybrid Tomato-9, Hybrid (Bahuboli)	25 November to 04 December, 2023	10 m × 10 m	60cm × 40cm	275-105-150-22-2.5-1 kg ha ⁻¹ N-P-K-S-Zn-B + 5 ton CD ha ⁻¹	20 January to 30 March, 2024
Panchbaria, Shercol and Singra, Natore	BARI Tomato-19, BARI Tomato-21	04 November 2023	4 m × 1 m	60cm × 40cm	253-90-125-22-6-2 N-P-K-S-Zn-B kg ha ⁻¹ + 10 ton CD ha ⁻¹	14 January to 15 April 2024
Shibpur, Narsingdi	BARI Hybrid Tomato-5, BARI Hybrid Tomato-7, BARI Hybrid Tomato-9, Hybrid (Surma)	15-20 December 2023	5m × 4m	60cm × 40cm.	250-90-125-22-1-1 kg ha ⁻¹ N-P-K-S-Zn-B + 5 ton CD ha ⁻¹	25-30 March 2024
Gopalganj Sadar and Tungipara, Gopalganj	BARI Tomato-15, BARI Tomato-16, BARI Tomato-18, BARI Tomato-21	28 November, 2023	4m × 1 m	60cm × 40 cm	102-38-63-22-2-1 kg ha ⁻¹ + 10 ton CD ha ⁻¹	7 Feb. to 24 March 2024

Pest Infestation

Manikganj: Autostin @ 2g L⁻¹ water was sprayed to control root rot disease of seedling and Confidor @ 2g /10L water was sprayed to control small insects. Pyrifin @ 2 ml L⁻¹ water was sprayed to control white fly insect. Some plants were infected by leaf curl virus and were uprooted from the plot.

Natore: Pesticides like *confidor*, *rovral* and *dithene M 45* were sprayed seven times to control the pest.

Narsingdi: In the farmer's field plants were infected by leaf blight and successfully controlled by applying Ridomil Gold @ 5 gL⁻¹ of water. White fly infestation was controlled by spraying Subicron @ 2 ml L⁻¹ of water. Experimental plots were sprayed with Indofil M-45 to control root rot disease old seedlings and Karate @ 2 ml L⁻¹ of water to control cut worm. Some plants were infected by leaf curl virus and were uprooted from the plot.

Results and Discussion

Yield and yield attributes recorded from winter hybrid tomato were presented in Table 2. The highest weight of fruit plant⁻¹ (3.85 to 3.95 kg) was recorded in Bahuboli hybrid followed by BARI Hybrid Tomato-7 (3.93 to 4.07 kg plant⁻¹) and BARI Hybrid Tomato-5 (3.87 to 4.53 kg plant⁻¹) in Manikganj. BARI Tomato-21 produced significantly higher fruit weight per plant (3.55 kg) than BARI Tomato-19 (2.96 kg) in Natore. Moreover, in Gopalganj, the maximum fruit yield plant⁻¹ 3.24 kg was found from BARI Tomato-15 and minimum 2.51 kg plant⁻¹ was recorded from BARI Tomato-16.

The highest fruit yield (67.16 t ha⁻¹) was recorded from Bahuboli hybrid followed by BARI hybrid tomato-5 (62.62 t ha⁻¹) and BARI hybrid tomato-9 (62.14 t ha⁻¹) in Manikganj. The higher yield was found in BARI Tomato-21 (61.72 t ha⁻¹) than BARI Tomato-19 (57.47 t ha⁻¹) in case of Natore locations. On the other hand, in Narsingdi, BARI Hybrid Tomato-5 produced the highest fruit yield 95.20 t ha⁻¹ followed by BARI Hybrid Tomato-9 (82.60 t ha⁻¹). Besides, in Gopalganj, the highest fruit yield 78.40 t ha⁻¹ found by BARI Tomato-15 may be due to its highest single fruit wt. and yield plant⁻¹.

Cost and return analysis revealed that the higher gross return (Tk 1343200 ha⁻¹) and gross margin (Tk. 1054994 ha⁻¹) was obtained from Bahuboli hybrid variety in Manikganj. From the economic analysis (Table 3) of Natore, it was revealed that the higher gross return (Tk. 1851600

ha⁻¹) and gross margin (Tk. 1245500 ha⁻¹) was recorded from BARI Tomato-21 followed by BARI Tomato-19 (Tk. 1724100 ha⁻¹ and Tk. 1118600 ha⁻¹). The highest gross return (Tk. 1142400 ha⁻¹) and gross margin (Tk. 931840 ha⁻¹) was found from BARI Hybrid Tomato-5 in Narsingdi. Also, from Gopalganj, the highest gross return (Tk.1960000 ha⁻¹) was found from BARI Tomato-15 followed by BARI Tomato-21 (Tk. 1881000 ha⁻¹).

Farmers' opinion:

Manikganj: Farmers both at Saturia and Ghior preferred BARI Hybrid Tomato-5 and 7 due to their high yield and higher market demand.

Natore: Farmers were very happy to observe the performance of the varieties. They prefer BARI Tomato-21 due to it's higher yield, comparatively hard fruit skin and longer harvesting period than BARI Tomato-19.

Narsingdi: Farmers of Shibpur were interested to grow BARI Hybrid Tomato varieties for the higher yield, uniform size, and higher economic return. Farmers opined that keeping quality of BARI varieties were better than locally available hybrid Tomato variety. They demanded seeds of BARI Hybrid Tomato-5 for next growing season due to higher yield, fruit size and attractive color.

Gopalganj: Farmers became interested to cultivate BARI Tomato-15 and BARI Tomato-21 for their higher yield and gross return.

Table 2. Yield and yield attributes of winter hybrid tomato varieties grown in Manikganj, Natore, Narsingdi and Gopalganj during Rabi season of 2023-24.

Location	Treatment	Fruits plant ⁻¹ (no.)	Wt. of single fruit (g)	Wt. of fruits plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
Manikganj	BARI Hybrid Tomato-5	97	43.68	4.23	62.62
	BARI Hybrid Tomato-7	86	46.3	3.98	58.61
	BARI Hybrid Tomato-9	48	70.89	3.59	62.14
	Local hybrid (Bahuboli)	57	70.7	3.81	67.16
	LSD _(0.05)	10.00	5.93	0.571	6.20
	CV (%)	6.98	7.28	7.31	4.92
Natore	BARI Tomato-19	50.8 a	-	2.96 b	57.47 a
	BARI Tomato-21	45.2 b	-	3.55 a	61.72 a
	LSD	8.67	-	10.34	4.30
	CV (%)	2.55	-	8.03	9.11
Narsingdi	BARI Hybrid Tomato-5	38.67bc	86.67b	3.17a	95.20a
	BARI Hybrid Tomato-7	44.33b	57.33c	2.55b	76.60b
	BARI hybrid Tomato-9	28.67c	97.00a	2.75b	82.60b
	Local Hybrid (Surma)	110.33a	21.00d	2.11c	63.40c
	CV (%)	15.51	4.80	6.69	6.69
Gopalganj	BARI Tomato-15	45.40ab	65.28a	3.24a	78.40a
	BARI Tomato-16	42.50b	57.40b	2.51b	66.26b
	BARI Tomato-18	45.68ab	60.60ab	3.12a	73.30ab
	BARI Tomato-21	47.20a	59.17ab	3.15a	75.24a
	CV (%)	5.10	6.32	9.71	8.16
	Lsd (0.05)	3.50	5.27	0.5258	6.10

Table 3. Cost and return analysis of winter hybrid tomato varieties grown in Manikganj, Natore, Narsingdi and Gopalganj during Rabi season of 2023-24.

Location	Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Manikganj	BARI Hybrid Tomato-5	1252400	269456	982944
	BARI Hybrid Tomato-7	1172200	269456	902744
	BARI Hybrid Tomato-9	1242800	269456	973344
	Bahuboli hybrid	1343200	288206	1054994
Natore	BARI Tomato-19	1724100	605500	1118600

Location	Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
	BARI Tomato-21	1851600	606100	1245500
Narsingdi	BARI Hybrid Tomato-5	1142400	210560	931840
	BARI Hybrid Tomato-7	919200	210560	708640
	BARI Hybrid Tomato-9	991200	210560	780640
	Local Hybrid (Surma)	760800	210560	550240
Gopalganj	BARI Tomato-15	1960000	571650	1388350
	BARI Tomato-16	1651500	571650	1079850
	BARI Tomato-18	1832500	571650	1260850
	BARI Tomato-21	1881000	571650	1309350

Cost of seed: BARI hybrid Tomato-5, 7, 9 (Tk. 30000 kg⁻¹) and Bahuboli hybrid (Tk.100000.00 kg⁻¹). Price of tomato Tk. 20.00 kg⁻¹ (Manikganj); Tk. 30 kg⁻¹ (Natore); Tk. 12 kg⁻¹ (Narsingdi); 25 Tk. Kg⁻¹ (Gopalganj).

Conclusion

BARI released winter hybrid tomato var. BARI Hybrid Tomato-5, BARI Hybrid Tomato-7, BARI Hybrid Tomato-9, BARI Tomato-15 and BARI Tomato-21 was found high yielding in the study areas. Therefore, these varieties could be extended in the farmers' field in every location. The experiment need to be repeated in the next year for conformation the results.

118.ON FARM TRIAL OF BARI DEVELOPED SUMMER HYBRID TOMATO VARITIES

Abstract

The experiment was conducted at Katigram village under Manikganj Sadar upazila and Banglabazar, Cox'sbazar sadar during Kharif season of 2023. Two summer hybrid tomato varieties viz. BARI Hybrid Tomato-8 and BARI Hybrid Tomato-11 along with local cultivar were evaluated in the study. BARI Hybrid Tomato-11 (14.30 t ha⁻¹) gave 18.64% higher yield compared to BARI Hybrid Tomato-8 (11.21 t ha⁻¹) in Manikganj. In contrast, BARI Hybrid Tomato-8 produced 11% higher fruit yield (48.40 t ha⁻¹) than BARI Hybrid Tomato-11 (43.56 t ha⁻¹) in Cox'sBazar. Higher gross margin (Tk. 379105 ha⁻¹) and BCR (2.12) was also obtained from BARI Hybrid Tomato-11 than BARI Hybrid Tomato-8 with gross margin Tk. 224605 ha⁻¹ and BCR (1.66) in Manikganj.

Introduction

Tomato (*Lycopersicon esculentum* L.) is a high value cash crop grown throughout the country. It is also most nutritious and popular winter vegetable in Bangladesh. Tomato is rich in vitamin C and is usually grown as a winter vegetable in the country. The crop is sown mainly from October to November and becomes available for consumption from February to April. For better market value, few producers sow tomato from August to September and from December to January for early and late production, respectively. Both early and late sowing tomatoes suffer from bacterial wilt and high rainfall. From March through September, tomatoes are practically not grown in Bangladesh due to the adverse weather conditions of summer. During this period, the temperature (both day and night), humidity, rainfall and light intensity, which are actually the basic limiting factors of tomato production in the tropics, remain very high. At higher temperature, the probability of floral abscission is high after anthesis. High day and night temperatures above 32°C and 21°C, respectively, were reported as limiting fruit-set due to an impaired complex of physiological process in the pistil, which results in floral or fruit abscission. High temperature associated with high night temperature during summer affects fruit-set of tomatoes in the country. Hybrid tomato varieties have many advantages compared to open-pollinated varieties. Hybrids usually produce higher yields. They generally mature earlier and more uniformly. Many hybrids have better fruit quality and disease resistance. Summer tomato production in Bangladesh is gaining popularity day by day. In some tomato growing countries, attempts have been made in developing heat-tolerant varieties and in generating technology for summer production of tomato. A number of high yielding summer tomato varieties have been

developed by Horticultural Research Centre, BARI and these needs to popularize in the farmer's field. So, this trial has been under taken to evaluate the performance and to popularize BARI released summer tomato varieties in farmer's field.

Materials and Methods

The adaptive trial was conducted in the famers' field at Katigarm village under Manikganj Sadar upazila and Banglabazar, Cox'sbazar sadar during *Kharif* season of 2023. The experiment was laid out in Randomized Complete Block Design with six (Manikganj) and three (Cox'sbazar) dispersed replications.. The trial was layout in RCB design with six replications. Varieties and agronomic management were presented in Table 1. 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 instalments at 20, 40 and 60 days after transplanting (Manikganj) and at 12, 27 and 46 days after transplanting (Cox'sBazar). Black polythene mulch was used to maintain adequate soil moisture during hot summer. Bamboo frame, rope and other materials were used to protect the plant from lodging. Flowering hormone Tomatoton (2%) and/ or Flora 3 ml L⁻¹ was sprayed on plants at anthesis stage 30-35 days after transplanting for every 7 or 15 day interval. Intercultural operations and plant protection measures were taken as and when required. The tomato was started to harvest during 55-65 days after transplanting. Data on different plant characters and yield were collected and analyzed statistically.

Table 1. Agronomic management of Summer Tomato in Manikganj and Cox'zBazar

Locations	Varieties	Date of transplanting	Plot size	Spacing	Fertilizer dose N-P-K-S-Zn-B (kg ha ⁻¹)	Harvesting date
Katigarm Manikganj	BARI Hybrid Tomato-8 BARI Hybrid Tomato-11	16 July, 2023	20 m × 20 m	80cm × 60cm (50cm drain)	90-36-45-16-2.5-1.19-5000 kg ha ⁻¹ N-P-K-S-Zn-B + 5 ton CD ha ⁻¹	10 September to 15 October, 2023
Banglabazar Cox'sbazar	BARI Hybrid Tomato-8 BARI Hybrid Tomato-11 Local (Bahubali)	11 August, 2023	250 deci.	60cm × 40cm (1 m drain)	97-10-37.5 kg ha ⁻¹ N-P-K + 10 ton CD ha ⁻¹	02 October to 20 November, 2023

Disease and pest incidence: In the field of Manikganj, white fly infestation was observed at seedling stage and was controlled spraying with Tundra @ 2.0 ml L⁻¹ water and Confidor @ 2.0 ml L⁻¹ water. Fungicide Indofil M-45 @ 2.0 ml L⁻¹ water and Ridomil gold @ 2.0 ml L⁻¹ water were sprayed to control fungal diseases. Some plants of each variety at flowering stage were affected with leaf curl virus and growth was severely stunted. In Cox'sbazar, for controlling pest and disease, Bavistin, Dithane M-45@ 2.5 ml L⁻¹, Emitaph @ 0.25 ml L⁻¹ and Admire@ 1.0 ml L⁻¹ of water were sprayed.

Results and Discussion

The yield and yield contributing characters of summer hybrid tomato varieties is shown in Table 2. In Manikganj, the significant variation was observed in weight of fruit plant⁻¹ and fruit yield but other characters did not differ significantly between the varieties. The weight of fruit plant⁻¹ was statistically higher (622.80g) in BARI Hybrid Tomato-11 and lower in BARI Hybrid Tomato-8 (495.22 g). The fruit yield between the varieties differs statistically. BARI Hybrid Tomato-11 gave higher yield (14.30 t ha⁻¹) compared to BARI Hybrid Tomato-8 (11.21 t ha⁻¹). On the other hand, in Cox'sbazar, the maximum number of tomato fruits per plant was recorded from BARI Hybrid Tomato-8 (23.7). The highest (56 g) individual fruit yield and fruit yield per hectare (48.40 t) was recorded from BARI Hybrid Tomato-8 (Table 2). Local variety showed the lowest yield of fruit (37.74 t ha⁻¹) because of the lowest individual fruit weight (37 g).

Cost and return: The economic analysis of summer tomato grown at Manikganj is shown in Table 3. The maximum gross return was obtained from BARI Hybrid Tomato-11 (Tk. 715000 ha⁻¹) and BARI Hybrid Tomato-8 (Tk. 560500 ha⁻¹). The variable cost (Tk. 335895 ha⁻¹) includes cost of plot preparation and layout, cost of tunnel making with bamboo, rope, polythene etc., cost of fertilizers and pesticides, labour cost of intercultural operations etc. The maximum gross margin (Tk. 379105 ha⁻¹) was recorded in BARI Hybrid Tomato-11 and lower gross margin (Tk. 224605 ha⁻¹) from BARI Hybrid Tomato-8. The variation in gross margin was due to the variation of yield between the two varieties. The maximum gross return from Cox'sbazar was obtained from BARI Hybrid Tomato-8 (Tk. 4840000 ha⁻¹) and BARI Hybrid Tomato-11 (Tk. 4356000 ha⁻¹) due to high market price they offered.

Farmer's opinion: Farmer opined that summer tomato is a new crop in the locality and they were quite interested to see the results of this observation trial. From the result, farmers reacted that this is a risky enterprise. The fruit yield was too low as expected by the farmer but intensive care and extra laborer are required compared to winter tomato production. Nonetheless, farmers of Cox'sbazar are highly interested in growing BARI Hybrid Tomato-8 in this region in summer season.

Table 2. Yield and yield contributing characters of hybrid summer tomato varieties in Manikganj and Cox'sbazar Kharif season of 2023

Variety	Plant height (cm)	Fruits plant ⁻¹ (no.)	Single fruit wt. (g)	Wt. of fruit plant ⁻¹	Yield (t ha ⁻¹)
Manikganj					
BARI Hybrid Tomato-8	110.4	10.40	48.20	495.22	11.21
BARI Hybrid Tomato-11	112.2	12.13	54.40	622.80	14.30
T-value	-0.56	-0.25	-1.74	2.12	1.13
Level of sig.	ns	ns	ns	*	*
Cox'sbazar					
BARI Hybrid Tomato-8	109	23.7	56	-	48.40
BARI Hybrid Tomato-11	107	22.3	47	-	43.56
Local (Bahubali)	110	20.3	37	-	37.74
CV (%)	8.2	6.2	7.6	-	6.53
Level of significant	ns	*	**	-	**

Table 3. Cost and return from summer hybrid tomato varieties in at Katigram under Manikganj Sadar upazila and Cox'sbazar during Kharif season of 2023

Location	Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Manikganj	BARI Hybrid Tomato-8	560500	335895	224605
	BARI Hybrid Tomato-11	715000	335895	379105
Cox'sbazar	BARI Hybrid Tomato-8	4840000	2353800	2486200
	BARI Hybrid Tomato-11	4356000	2353800	2002200
	Local (Bahuboli)	3774000	2353800	1420200

Price of summer tomato: Tk. 50.00 kg⁻¹ (Manikganj) and Tk. 100.00 kg⁻¹ (Cox'sbazar)

Conclusion

Considering the above-mentioned results from two locations, summer hybrid tomato var. BARI Hybrid Tomato-8 and BARI Hybrid Tomato-11 were found to be promising in respect of yield and economics for summer season. However, cultivation of summer tomato was hampered due to high air temperature and leaf curl virus infestation. This trial may be repeated in the next year for confirmation.

119.ON-FARM TRAIL OF BARI HYBRID BRINJAL VARIETIES

Abstract

An on-farm trial was conducted at Gopalganj Sadar and Tungipara under Gopalganj district, Noyadingi,, Kamta and Mohishaloha village under Saturia upazila of Manikganj, and MLT site Bhuapur Tangail during Rabi season of 2023-24 to evaluate the performance of BARI released hybrid brinjal varieties at farmers' field. There are three hybrid Brinjal varieties like BARI Hybrid Begun-4, BARI Hybrid Begun-6 and Super Singnath (check) in Gopalganj; BARI hybrid begun-4, BARI hybrid begun-5, BARI hybrid begun-6 and Lalteer hybrid in Manikganj district; and BARI Begun-12 and local as check were evaluated in Tangail. In Gopalganj, BARI Hybrid Begun-6 gave highest yield 36.5t ha⁻¹ and lowest yield 24.85t ha⁻¹ was recorded by Super Singnath (check). In Manikganj, higher yield was obtained from BARI hybrid begun-5 (35.00 to 43.32 t ha⁻¹) followed by BARI hybrid begun-6 (38.04 to 40.03 t ha⁻¹), BARI hybrid begun-4 (30.82 to 33.63 t ha⁻¹ and the lowest yield was recorded in Lalteer hybrid (26.50 to 30.47 t ha⁻¹). At Tangail, BARI Begun-12 produced the highest yield (31.93 t ha⁻¹) whereas local variety produced the lowest yield (22.40 t ha⁻¹).

Introduction

Brinjal (*Lycopersicon esculentum*) is the most important vegetable crop in our country cultivated mostly during Rabi season. The area of brinjal in Gopalganj, Manikganj and Tangail district is low 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 use local variety of brinjal which is low yielder and susceptible to disease. Some advance farmers grow commercial hybrid varieties but the seeds are very costly that cause economic loss of the farmers. Horticulture Research Centre of BARI has developed some winter hybrid varieties of brinjal those are supposed to be higher yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI hybrid brinjal varieties in the farmers' field of Gopalganj, Manikganj and Tangail and to popularize the varieties among the farmers to promote its adoption.

Materials and Methods

The adaptive trial was conducted in the farmers' field at Gopalganj Sadar and Tungipara under Gopalganj district, and Noyadingi, Kamta and Mohishaloha village under Saturia upazila of Manikganj district, and Tangail during Rabi season of 2023-24 to evaluate the performance of BARI released hybrid brinjal varieties. The trial was laid out in RCB design with six and/ or three dispersed replications The crop management of brinjal at different locations are given in table 1.

Table 1. Crop management practices of brinjal in different locations

Locations	Tested varieties	Date of transplanting	Plot size	Spacing	Fertilizer dose (N-P-K-S-B-CD kg ha ⁻¹)	Date of harvesting
Gopalganj	BARI Hybrid Begun-4, BARI Hybrid Begun-6, Singnath (check)	14 Oct 2023	10 m x 10 m	100 cm x 70 cm	140-50-100-20-1-1.5-5000	25 Jan- 5 April 2023
Manikganj	BARI hybrid begun-4, BARI hybrid begun-5, BARI hybrid begun-6, Lalteer hybrid	20 Nov to 6 Dec, 2023	10m x10m	100cmx80cm	140-50-100-20-2-1.5	10 Feb – 15 April 2024
Tangail	BARI Begun-12, local variety	12 Oct 2023	8 m x 5 m	100 cm x 75 cm	170-60-125-18-4.3-1.7-10000	10 Feb – 26 March 2023

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 four equal splits at 30, 45, 60 and 75 DAS. Potash was applied in two equal splits at 45 and 60 DAS. Irrigation was

provided three times at 15 and 25, 50 days after planting. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Data on yield and yield attributes were collected and analyzed statistically.

Results and Discussion

In Gopalganj, there was a significant difference found in tested hybrid brinjal varieties in respect of yield and yield contributing characters (Table 2). Among the varieties BARI Hybrid Begun-6 gave highest yield 36.50 t ha⁻¹ may be due to its highest fruit weight plant⁻¹ (3.45 kg) and single fruit wt. (120.40g) and it followed by BARI Hybrid Begun-4 with yield 31.70 t ha⁻¹. At the same time, the lowest yield 24.85 t ha⁻¹ was recorded by local variety Super Singnath (check) may be due to its lowest single fruit wt. (85.50g) and fruit weight plant⁻¹ (2.47 kg).

In Manikganj, the number of fruit plant⁻¹ ranged from 23 to 35 in BARI Hybrid Begun-4, 23 to 33 in BARI Hybrid Begun-5, 20 to 25 in BARI Hybrid begun-6 and 34 to 45 in Lalteer hybrid in different tested locations. The single fruit weight was maximum 149.12 to 177.50g in BARI Hybrid begun-5 followed by BARI Hybrid begun-6 (138.92 to 161.23g), BARI Hybrid Begun-4 (93.80 to 112.00g). The lowest weight of single fruit 57.58 to 65.50g was recorded in Lalteer hybrid. The average weight of fruits plant⁻¹ was recorded and maximum weight was found in BARI Hybrid Begun-5 (3.31 to 3.62 kg plant⁻¹) followed BARI Hybrid begun-6 (3.15 to 3.43 kg plant⁻¹) and BARI Hybrid begun-4 (2.70 to 2.83 kg plant⁻¹). The lowest fruit weight plant⁻¹ 2.34 to 2.66 kg plant⁻¹ was obtained from Lalteer hybrid. The highest fruit yield was recorded in BARI Hybrid begun-5 (35.00 to 43.32 t ha⁻¹) followed by BARI Hybrid begun-6 (38.04 to 40.03 t ha⁻¹), BARI Hybrid begun-4 (30.82 to 33.63 t ha⁻¹). The lowest yield 26.501 to 30.47 t ha⁻¹ was obtained from Lalteer hybrid. The yield performance was comparatively better in the farmers' field at Kamta-Golara than Noyadingi and Mohishjalohavillage of Saturiaupazila of Manikganj.

In Tangail, yield and yield contributing characters varied significantly between BARI Begun-12 and Local varieties. Higher plant height was observed in BARI Begun 12 (115.00 cm) and lower one was observed in local (92.33 cm). Higher number of fruits plant⁻¹ was found in Local variety (18.60) whereas lowers number of fruits in BARI Begun-12 (5.53). Individual fruit weight plant⁻¹ was higher in BARI Begun-12 (576.00 g) whereas the lowest in Local (113.67 g). The highest weight of fruit plant⁻¹ (3.19 kg) in BARI Begun-12 whereas the lowest was in local variety (2.23 kg). The highest individual fruit weight results in maximum yield in BARI Begun-12 (31.93 t ha⁻¹).

In Gopalganj, the highest gross return (Tk. 1277500 ha⁻¹), and gross margin (Tk. 770250 ha⁻¹) were found from the BARI Hybrid Begun-6 which gave highest yield. In Manikganj, cost and return analysis revealed that the higher gross return (Tk. 836880 to 880660ha⁻¹) and gross margin (Tk. 609300 to 653080 ha⁻¹) was obtained from BARI Hybrid begun-6 followed by BARI Hybrid begun-5 with gross return Tk. 700000 to 866400 ha⁻¹ and gross margin Tk. 472420 to 638820 ha⁻¹. Gross return Tk.616400 to 672600 and gross margin Tk. 388820 to 445020 ha⁻¹ was obtained from BARI Hybrid begun-4. In Tangail, the highest gross return (Tk. 1277200 ha⁻¹) and gross margin (Tk. 1021630 ha⁻¹) were found from BARI Begun-12 (Table 3).

Farmer's opinion: Farmers and neighbors of Gopalganj choose BARI hybrid Begun-6 due to its higher yield and market price than BARI Hybrid Begun-4. Farmers of Manikganj choose BARI Hybrid Begun-5 and BARI Hybrid Begun-6 due to their high yield potentiality, market demand than other hybrid varieties. The market price of BARI Hybrid Begun-6 was higher due to its attractive colour compared to other brinjal varieties. Farmers of Tangail prefer BARI Begun-12 as the market price of this variety was higher as compared to local varieties. They are highly interested to grow BARI Begun-12 instead of local one.

Table 2. Yield and yield attributes of hybrid brinjal varieties in Gopalganj, Manikganj and Tangail during *Rabi* season of 2023-24.

Location	Varieties	Fruit plant ⁻¹ (No.)	Wt. of single fruit (g)	Yield plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
Gopalganj	BARI Hybrid Begun-4	26.4	115.4	2.9	31.7
	BARI Hybrid Begun-6	28.3	120.4	3.5	36.5
	Super Singnath (Check)	30.8	85.5	2.5	24.9
	LSD (0.05)	4.3	7.9	0.5	4.1
	CV (%)	9.3	7.37	10.8	12.8
Manikganj					
Saturia (Noyadingi)	BARI Hybrid Begun-4	26	93.80	2.83	33.63
	BARI Hybrid Begun-5	23	177.50	3.31	35.00
	BARI Hybrid Begun-6	24	150.60	3.43	38.88
	Lalteer Hybrid	45	65.50	2.66	30.47
	LSD (0.05)	6.13	10.33	0.53	5.35
	CV (%)	10.4	4.24	8.63	7.76
Saturia (Kamta)	BARI Hybrid Begun-4	35	112.00	2.70	30.82
	BARI Hybrid Begun-5	33	149.12	3.62	43.32
	BARI Hybrid Begun-6	20	161.23	3.15	40.03
	Lalteer Hybrid	38	57.58	2.40	26.50
	LSD (0.05)	6.02	13.84	0.396	6.67
	CV (%)	9.57	5.78	6.63	9.5
Saturia (Mohishaloha)	BARI Hybrid Begun-4	23	110.40	2.72	32.57
	BARI Hybrid Begun-5	28	168.38	3.57	40.97
	BARI Hybrid Begun-6	25	138.92	3.23	38.04
	Lalteer Hybrid	34	61.99	2.34	28.25
	LSD (0.05)	7.89	14.00	0.53	6.97
	CV (%)	14.35	5.8	9.01	9.99
Tangail	BARI Begun-12	5.5	576.0	3.2	31.9
	Local	19.6	113.7	2.2	22.4
	T test	*	*	*	*

Table 3: Cost and return analysis of different hybrid brinjal varieties, *Rabi* season of 2023-24

Location	Variety	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
Gopalganj	BARI Hybrid Begun-4	1109500	507250	602250
	BARI Hybrid Begun-6	1277500	507250	770250
	Super Singnath (Check)	869750	507250	362500
Manikganj				
Noyadingi	BARI Hybrid Begun-4	672600	227580	445020
	BARI Hybrid Begun-5	700000	227580	472420
	BARI Hybrid Begun-6	855360	227580	627780
	Lalteer Hybrid	609400	247580	361820
Kamta	BARI Hybrid Begun-4	616400	227580	388820
	BARI Hybrid Begun-5	866400	227580	638820
	BARI Hybrid Begun-6	880660	227580	653080
	Lalteer Hybrid	530000	247580	282420
Mohishaloha	BARI Hybrid Begun-4	651400	227580	423820
	BARI Hybrid Begun-5	819400	227580	591820
	BARI Hybrid Begun-6	836880	227580	609300
	Lalteer Hybrid	565000	247580	317420
Tangail	BARI Begun-12	1277200	255570	1021630
	Local	448000	255570	304430

In Gopalganj, price (Tk. kg⁻¹) = BARI Hybrid Begun-4 = 35 Tk., BARI Hybrid Begun-6=35 Tk., Singnath (Check)=30 Tk. and GR=Gross Return, TVC= Total Variable Cost, GM= Gross Margin and BCR= Benefit Cost Ratio; In Maikganj, Price of BARI hybrid begun-4, 5 and Lalteer hybrid Tk. 20.00 kg⁻¹ BARI hybrid begun-6: Tk. 22 kg⁻¹, Cost of seed: BARI hybrid begun-4, 5,6 (Tk. 10000.00 kg⁻¹) and Lalteerhybrid (Tk.100000.00 kg⁻¹). In Tangail, the sale price of brinjal: BARI Begun-12= Tk. 40 kg⁻¹, Local Begun=Tk. 25 kg⁻¹

Conclusion

BARI hybrid Begun-6 gave highest yield in Gopalganj district whereas the BARI Hybrid Begun-5 and BARI Hybrid Begun-6 were best in Manikganj due to its high yield potentiality, market demand than other hybrid varieties. Moreover, the yield of BARI Begun-12 was higher than other varieties at Tangail. However, this was the first year experiment; the experiment needs to be repeated in next year to draw a concrete decision.

120. ON-FARM TRIAL OF BARI DEVELOPED SWEET PEPPER VARIETIES

Abstract

An On-Farm trial of sweet pepper varieties was conducted at Reicha and Sualok of Bandarban Sadar and FSRD site Atia, Tangail under two different technologies (Net and Without net) during Rabi season of 2023-24. The capsicum varieties T₁= BARI Mistimorich-1, T₂= BARI Mistimorich-2, T₃= Astha Mistimorich, and T₄= Green Cape were used in Bandarban hilly areas, and BARI Mistimorich-1 and BARI Mistimorich-2 were evaluated in Tangail. The experiment was conducted in RCB design with three replications. In both open field (without net) and protective condition of Bandarban, the highest average fruit yield 21.65 t ha⁻¹ and 25.84 t ha⁻¹, respectively were found from Green Cape and the lowest from BARI Mistimorich-1 (12.96 t ha⁻¹ and 17.18 t ha⁻¹). Maximum pest infestation was found in Astha mistimorich (20.83%) in open fields. In Tangail, the highest fruit yield (14.18 t ha⁻¹) was recorded from the variety BARI Mistimorich-1 compare to BARI Mistimorich-2 (13.40 t ha⁻¹).

Introduction

Sweet pepper (*Capsicum annuum* L.) belongs to the family Solanaceae is an important nutritious vegetable grown extensively in almost every country especially temperate countries of the world (Greenleaf, 1986). Sweet pepper is popularly known as capsicum and may be eaten as cooked, raw as well as salad. Capsicum is rich in vitamin A, vitamin C, carbohydrates, proteins, fiber, and unsaturated fatty acid and for having capsaicin, capsanthin, carotenoids, and antioxidantal properties it has great medicinal value (Aminifard *et al.*, 2012). This crop is well adapted to temperature ranged from 16-25°C. This is very sensitive to environmental factors viz. both biotic and abiotic factors (Bhatt *et al.*, 1992). Fruit setting is largely affected by high temperature at night than day temperature. On the contrary, blossom dropping also occurred at below 16° C night temperature and above 32° C day temperature (Rylski and Spigelman, 1982; Boswell, 1964). In Bandarban, from December to January night temperatures usually don't go below 10° C or less which is detrimental to both the vegetative and fruiting stage of sweet pepper. So, there might be a large potentiality of growing sweet pepper in this area. Again, the prevalence of severe powdery mildew and mite infestation in plants is common when there are longer periods of temperatures between 10 to 15°C and daytime RH between 85 to 95% (Elad *et al.*, 2007). So, these environmental factors need to be considered seriously. On the other hand, the demand of high value crops like sweet is increasing day by day in tourist places like Bandarban. But to meet the local demand, consumers and vegetable sellers have to be dependent on other districts. In the near past, no intervention was taken to evaluate sweet pepper varieties or production technologies in the Bandarban region. However, farmers of Tangail region usually grow the locally available capsicum variety which is low yielding and susceptible to diseases and pest. Considering these facts, the present study was undertaken to evaluate BARI-released promising sweet pepper varieties.

Materials and Methods

The On-Farm evaluation of sweet pepper was done at Shwarnamondir, Reicha and Sualok of Bandarban Sadar under two different technologies (Net and without net) and FSRD site, Atia, Delduar, Tangail. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In Bandarban, for net-protected structures, the height of the structure was 1.0

meter above the soil surface. White-colored polythene of 0.5mm thickness and 120 mesh white nylon net were used to place over the structure for covering the plants. Varieties and agronomic management were presented in Table 1. Full amount of cowdung 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. Intercultural operations such as watering, weeding, gap filling, earthing up etc. were done as and when necessary. Harvesting of the green fruits was done when they were relatively firm and crispy. Data were collected and analysed statistically with the help of STATISTIX-10 software.

Table 1. Crop management of Sweet Pepper in of Bandarban and Tangail

Locations	Varieties	Date of transplanting	Unit plot size	Spacing	Fertilizer dose N-P-K-S-Zn-B (kg ha ⁻¹)
Bandarban	BARI Mistimorich-1, BARI Mistimorich-2, Astha Mistimorich Green Cape	13 November, 2023	3.2 m × 1.0 m	60 cm × 40 cm	115-69-125-17-1.7 kg ha ⁻¹ + 5 t CD ha ⁻¹
Tangail	BARI Mistrimorich-1 BARI Mistrimorich-2	30 November, 2023	5m x 4m	45 cm x 45 cm	115-69-125-17-1.7 kg ha ⁻¹ + 10 t CD ha ⁻¹

In Tangail, plants were infected by leaf blight and root rot which were controlled by applying Ridomil Gold 2 g/L and Amistar Top @ 2 m/L water and white fly infestation was controlled by spraying subicron @ 2ml/L water in three times after 15 days interval.

Results and Discussion

Open field condition: In Bandarban, yield and yield attributing characteristics of sweet pepper varieties are presented in Table 2. The highest individual fruit weight (164.92 g) and average fruit yield (21.65 t ha⁻¹) were found from Green Cape and the lowest from BARI Mistimorich-1 (115.90 g, 12.96 t ha⁻¹). Maximum pest infestation was found in Astha mistimorich (20.83%) in the open field. However, in Tangail, the results observed that there was no significant different between the tested varieties in case of fruits plant⁻¹. The result was observed that the maximum individual fruit weight (73.07 g) was recorded from BARI Mistimorich-2 variety where minimum individual fruit weight (66.80 g) was found in BARI Mistimorich-1. The maximum fruit yield (14.18 tha⁻¹) was recorded from the variety BARI Mistimorich-1 and BARI Mistimorich-2 produce minimum fruit yield (13.40 tha⁻¹) (Table 2).

Protective condition (Net house): Significant variation was observed among the treatments for all the parameters observed in this experiment (Table 3). Yield and yield attributing characteristics of sweet pepper varieties are presented in Table 3. The highest individual fruit weight (171.32 g) and average fruit yield (25.84 t ha⁻¹) were found from Green Cape and the lowest from BARI Mistimorich-1 (120.23 g, 17.18 t ha⁻¹). Maximum pest infestation was found in BARI Mistimorich-1 (15.28%) in the net house.

In Tangail, the highest gross margin Tk. 1251130 ha⁻¹ was obtained from variety BARI Mistimorich-1 compared to BARI Mistimorich-2 (Tk.1181130 ha⁻¹) (Table 4). Open field condition of hill valleys of Bandarban, the highest gross return was found from Green cape (Tk.1299000ha⁻¹) (Table 5). The lowest gross return (Tk. 777600 ha⁻¹) was found from BARI Mistimorich-1. Whereas, in protective System (with net), the highest gross return was found from Green cape (Tk. 1550400 ha⁻¹) and the lowest (Tk. 1030800 ha⁻¹) from BARI Mistimorich-1.

Farmer's opinion: Farmers of Bandarban expressed their satisfaction with the higher yield, individual fruit weight, and attractive color of capsicum varieties. An unstable marketing channel made them suffer as the price was low in this season. Farmers of Tangail opined that BARI released capsicum varieties are less susceptible to bacterial wilt and leaf curl virus than existing capsicum variety. They are interested to grow BARI released capsicum variety. They also passing their opinion, seeds of BARI released capsicum varieties are not available in market.

Table 2. Yield and yield attributing characteristics of sweet pepper varieties in hill valleys of Bandarban and Tangail at open field condition

Varieties	Plant height (cm)	Fruits plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Infected plant (%)	Fruit yield (t ha ⁻¹)
Bandarban							
BARI Mistimorich-1	49.69	5.61	7.79	6.57	115.90	19.45	12.96
BARI Mistimorich-2	47.98	6.67	8.41	6.86	123.15	13.89	18.19
Astha Mistimorich	51.97	6.69	8.45	7.1	152.25	20.83	19.80
Green Cape	48.44	5.25	9.36	7.61	164.92	19.45	21.65
CV%	4.16	7.57	3.81	2.24	3.18	15.56	5.05
LSD (0.05)	4.11	0.92	0.65	0.32	8.84	5.72	1.83
Tangail							
BARI Mistimorich-1	83.73	7.73	-	-	66.80	-	14.18
BARI Mistimorich-2	90.60	6.13	-	-	73.07	-	13.40
T test	NS	NS	-	-	*	-	*

Table 3. Yield and yield attributing characteristics of sweet pepper varieties in hill valleys of Bandarban in the Net house

Varieties	Plant height (cm)	Fruits plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Infected plant (%)	Fruit yield (t ha ⁻¹)
BARI Mistimorich-1	53.8	6.17	8.82	6.81	120.23	15.28	17.18
BARI Mistimorich-2	52.26	7.04	9.58	6.85	125.83	11.11	20.84
Astha Mistimorich	56.71	5.75	9.44	8.68	160.68	13.89	24.25
Green Cape	58.42	6.02	9.4	7.85	171.32	8.33	25.84
CV%	2.08	5.63	1.34	3.06	6.62	15.67	3.48
LSD (0.05)	2.3	0.7	0.25	0.46	19.11	6.21	1.53

Table 4. Cost and return analysis of BARI released Capsicum varieties at FSRD Site, Tangail during Rabi 2023-24

Variety	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI MistiMorich-1	1410000	158870	1251130
BARI MistiMorich-2	1340000	158870	1181130

Market price: Capsicum = Tk.100 kg⁻¹, Urea = Tk.22, TSP = Tk. 22, MoP = Tk. 15, Gypsum =Tk. 12, Zinc sulphate = Tk. 500 kg⁻¹, Cowdung= Tk. 2 kg⁻¹, Labour = Tk. 500 day⁻¹ person

Table 5. Cost-return analysis of capsicum varieties for the crop year 2023-24 at hill valleys of Bandarban

Condition	Treatments	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Open field	T ₁ =BARI Mistimorich-1	777600	315000	462600
	T ₂ =BARI Mistimorich-2	1091400	315000	776400
	T ₃ = AsthaMistimorich	1188000	348500	839500
	T ₄ = Green Cape	1299000	348500	950500
Protected	T ₁ =BARI Mistimorich-1	1030800	365500	665300
	T ₂ =BARI Mistimorich-2	1250400	365500	884900
	T ₃ = AsthaMistimorich	1455000	395500	1059500
	T ₄ = Green Cape	1550400	395500	1154900

Unit price: 60tk/kg

Conclusion

Capsicum is a high-value vegetable crop in which protected cultivation is always advantageous over open-field cultivation. Protected cultivation (with net) endorses maximum yield and least pest and disease infestation. Green cape and Astha mistimorich performed well under both conditions. Further trial may continue with these two sweet pepper varieties under net protection systems in the Bandarban region. However, in case of Tangail, considering yield and economic point of view, BARI released capsicum varieties could be promising.

121. ON-FARM TRIAL OF BARI DEVELOPED STEM AMARANTH VARIETIES

Abstract

An on-farm trial was conducted with three amaranth varieties during rabi season of 2023-24 to find out the performance of new released amaranth varieties among the farmer's at FSRD Site, Tarakandi, Sherpur sadar, Sherpur. Three amaranth varieties viz., BARI Danta-3, BARI Danta-4, and Local one were included in this trial. Results obtained from the study indicated that the highest stem yield (48.55 t ha^{-1}) was recorded from BARI Danta-3 which was followed by BARI Danta-4 (41.02 t ha^{-1}) and local one produced the lowest stem yield (25.70 t ha^{-1}). The highest gross return (Tk. 7,28,250 ha^{-1}) and gross margin (Tk. 6,00,375 ha^{-1}) was recorded from BARI Danta-3 and local one gave the lowest gross return (Tk. 3,85,500 ha^{-1}) and gross margin (Tk. 2,57,225 ha^{-1}).

Introduction

As one of the nutritious and delicious vegetables, stem amaranth (*Amaranthus tricolor*) is a popular vegetable in Bangladesh because of its cheapest price, quick growing character and higher yield potential. Additionally it is considered as a potential subsidiary food crop (Tutonic and Knorr, 1995). Stem amaranth (*Amaranthus tricolor* L.) belongs to the family Amaranthaceae. The genus *Amaranthus* consists of around 60 species which can be broadly categorized into grain, green leafy vegetables and weed types. The amaranth is said to be native of India (Nath, 1976). At present amaranth is cultivated in an area of 8647.77 ha with a total production 58095 tone of green amaranth (BBS, 2020) which is lower than other amaranth producing countries (Talukder, 1999). This low yield is mainly attributed to the use of low yielding cultivars and lack of proper cultural practices like optimum spacing, fertilization, irrigation etc. The leaves and tender stem of amaranth are rich in protein (0.90g), fiber(1.2g), fat(0.10g), calcium, riboflavin, sodium, iron, ascorbic acid than any other common vegetables. BARI has developed four stem amaranth varieties so it is need to find the suitability of those variety in this region. From that point of view this experiment was carried out.

Materials and Method

The trial was conducted at farmer field under FSRD, OFRD, Sherpur during December, 12, 2023 to April, 8, 2024. Three stem amaranth varieties viz. BARI Danta-3, BARI Danta-4, and Local one were included in this trial. The experiment was laid out in RCB design with four replications. The unit plot size was $4.0 \text{ m} \times 2.4 \text{ m}$. After final land preparation, the seeds were drilled by hand, mixed with some sand to allow uniform sowing in row. As the amaranth seeds are small, so it is covered by a thin layer of loose fertile sandy loam soil. Distance between two row was 30 cm. Manures and fertilizer were applied at the rate of cowdung 20 tha^{-1} , urea 200 kg ha^{-1} , TSP 100 kg ha^{-1} , MOP 200 kg ha^{-1} . The entire quantity of cowdung, MOP and TSP were applied during final land preparation. Urea was top dressed in three equal splits. The first, second, third top dressing was done at 15 days, 21 days, and 28 days after sowing respectively. Irrigation and other intercultural operation were done as and when necessary. Data were collected on yield and yield contributing characters and were calculated by STAR.

Results and Discussion

Results of experiment for different characters are presented in table 1. The maximum stem weight (151.50 g/plant) was contributed by BARI Danta-3 followed by BARI Danta-4 (124.25 g). The minimum stem weight (75.50 g/plant) was contributed by local one. The highest stem diameter was produced by the BARI Danta-3 37.83 cm that leads to the higher stem yield. The local requires 58.50 days to first flowering that decrease stem production. The results of the experiment revealed that yield was mainly contributed by plant height, stem weight, stem diameter etc. The stem weight and stem diameter had maximum direct effect on yield. BARI Danta-3 performed best (48.55 t ha^{-1}) whereas yield was minimum in Local one (25.70 t ha^{-1}). The highest gross return (Tk. 7,28,250 ha^{-1}) and gross margin (Tk. 6,00,375 ha^{-1}) was recorded from BARI Danta-3 and local one gave the lowest gross return (Tk. 3,85,500 ha^{-1}) and gross margin (Tk. 2,57,225 ha^{-1}).

Table 1. Yield and yield contributing characters of Danta varieties at FSRD site, Sherpur during 2023-24

Varieties	Plant height (cm)	Stem diameter (cm)	Duration (day)	Self-life (day)	Days to flowering	Single plant wt. (g)	Yield (t ha ⁻¹)	Insect infestation
BARI Danta-3	87.01 b	7.83 a	114 a	4.0	99.75 a	151.50 a	48.55 a	Not Occurred
BARI Danta-4	94.53 a	6.76 b	108 b	3.0	93.50 b	124.25 b	41.02 b	Not Occurred
Local	63.73 c	4.25 c	91.25 c	3.0	58.50 c	75.50 c	25.70 c	Not Occurred
LSD _{0.05}	0.001	0.002	0.001	NS	0.002	0.003	0.001	
CV %	0.54	0.69	1.40	2.0	1.94	0.47	3.44	

Farmer's opinion: Farmers are happy to get higher yield from the BARI Danta-3. No pest attack was observed in the experiment.

Conclusion: BARI Danta-3 performed better in respect of yield, test, and economic return.

122. ON-FARM TRIAL OF YARD LONG BEAN VARIETIES

Abstract

The experiment was conducted in the farmer's field at Trishal Upazila, Mymensingh during the summer of 2022-2023 to evaluate the performance of yard long bean varieties. The BARI Borboti-1 performed better in the tested location. BARI Borboti-1 gave the highest yield (17t ha⁻¹), followed by the local cultivar Toki (13.9 t ha⁻¹). The highest gross return (766,350 Tk ha⁻¹) and gross margin (578,400 Tk ha⁻¹) were recorded from BARI Borboti-1 while BARI Borboti-2 gave the lowest gross return (547,200Tk ha⁻¹) and gross margin (409,250 Tk. ha⁻¹).

Introduction

The yardlong bean, scientifically termed *Vigna unguiculata*, is a rapidly growing summer vegetable. It is prominent among leguminous vegetables, flourishing abundantly in Bangladesh during the summer months and locally known as Borboti. Originating from southwest China, this annual legume crop belongs to the Leguminaceae family, as noted by Suma *et al.* in 2021. Yard long beans hold significant importance in Bangladesh. Firstly, they are a valuable source of nutrition, providing essential vitamins, minerals, and dietary fiber. Secondly, they contribute to food security by offering a reliable and abundant summer crop. Additionally, yardlong beans are versatile in culinary use, featuring prominently in traditional Bangladeshi dishes. Moreover, its cultivation provides income opportunities for farmers, supporting livelihoods and rural economies. BARI has developed two varieties of yard long bean need to disseminate and popularize among the farmers. Therefore, this experiment was undertaken to popularize the yard long bean variety in the summer season.

Materials and Methods

The experiment was conducted at the farmer's field in Trishal, Mymensingh during the summer season of 2023. Two BARI released varieties (BARI Borboti-1 and BARI Borboti-2) and the local cultivar Toki were cultivated. The experiment was laid out in RCB design with three replications. The unit plot size was 6m x 1m maintaining a spacing of 50 cm x 50cm. Seeds were sown on 4 March 2023. The land was fertilized with fertilizer-N-P-K- S-Zn-B @5t-67-30-75-18-4.3-1.8 kg per hectare, respectively. The entire amount of cowdung P, S, Zn, B, and half of K was applied during final land preparation as basal dose. The rest of K and the entire amount of N were applied in 2 installments, starting first after 15 days of germination and the second installment at 40 days after sowing. Intercultural operations, gap filling, weed, and its management, irrigation, drainage, staking, pruning, and crop protection were done as and when necessary. Yard long bean was infested by the pod borer at the pod bearing stage. To control this infestation 77 Tafgor 40 EC was

sprayed @ 2 ml L⁻¹, 2 times at 7 days intervals. The crop was harvested on 26 April to 14 June 2023. Data was collected from randomly selected 10 plants per plot for the following traits: days to first flowering, pod length (cm), individual pod weight, number of pods per plant, and pod yield (tha⁻¹). The collected data were statistically analyzed using Statistix-10 Software.

Results and Discussion

The yield and yield contributing characters of three yard long bean varieties have been presented in Table 1. Significant variations were found in all parameters. Local cultivar Toki took a maximum of days in flowering (53.3) whereas BARI Borboti-2 took a minimum of days (43.6). The range of pod length and individual pod weight were 34.13-47.40 cm and 10.23-14.26g respectively. The number of pods per plant was maximum in BARI Borboti-1 (41.3) and minimum in Toki (30.3). The range of yield per plant and yield per plot were 304.6-427.0 (g) and 7.4-10.3 (kg) respectively. The highest pod yield was recorded in BARI Borboti-1 (17 tha⁻¹) and BARI Borboti-2 gave the lowest pod yield (12.1 tha⁻¹).

From Table 2, it was observed that the highest gross return (Tk. 766,350 ha⁻¹) and gross margin (Tk. 578,400 ha⁻¹) was calculated from BARI Borboti-1 followed by local cultivar (Tk. 626,850 ha⁻¹ and 438,900 Tk ha⁻¹ respectively). The lowest gross return (Tk. 626,850 ha⁻¹) and gross margin (Tk. 438,900 ha⁻¹) were recorded from BARI Borboti-2.

Farmers' opinion: Farmers express their satisfaction with the higher yield of BARI Borboti-1. They showed their keen interest in growing Borboti-2 because of its shortest statured which can be easily grown without a trellis.

Table 1. Average yield and yield attributes of BARI Yard long bean varieties at Trishal, Mymensingh during 2022-2023

Variety	Days to first flowering	Pod length (cm)	Individual pod weight (g)	Number of pods per plant	Pod yield per plant (g)	Pod yield (t ha ⁻¹)
BARI Borboti-1	50.67	42.43	10.23	41.3	427.0	17.03
BARI Borboti -2	43.67	34.13	12.03	25.0	304.6	12.16
Local cultivar (Toki)	53.33	47.40	14.26	30.3	348.0	13.93
LSD (0.05)	6.32	6.49	0.890	5.90	74.1	2.75
CV (%)	5.67	6.93	3.23	8.61	9.09	8.46

NS= Non-Significant, * =Significant at 5% level and ** =Significant at 1% level of probability

Table 2. Average cost and return analysis of BARI Yard long bean varieties at Trishal, Mymensingh during 2022-2023

Variety	Gross return (Tk ha ⁻¹)	Variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
BARI Borboti -1	766,350	187950	578,400
BARI Borboti -2	547,200	137950	409,250
Local Cultivar (Toki)	626,850	187950	438,900

Price of input and output: Urea: 17 Tk kg⁻¹, TSP 24 Tk kg⁻¹, MoP 16 Tk kg⁻¹, Gypsum 10 Tk kg⁻¹, Zinc sulphate 130 Tk kg⁻¹, Boric acid 300 Tk kg⁻¹, Cowdung 1 Tk kg⁻¹. Selling price: 45 Tk kg⁻¹

Conclusion

The BARI released yard long bean varieties were preferred to cultivate at the experimental location. To disseminate the variety, further experimentation is needed.

123.ON-FARM TRIAL OF BARI DEVELOPED WINTER COUNTRY BEAN VARIETIES IN HILLY AREAS OF BANDARBAN

Abstract

An On-Farm trial was conducted at hill valleys of Bandarban sadar during the rabi season, 2023-24 to evaluate the performance of BARI-developed winter Country bean varieties in farmers' fields. The treatments were T₁= BARI Sheem-1, T₂= BARI Sheem-6, T₃= BARI Sheem-10, and T₄=Local variety as check. The experiment was laid out in RCB design with three dispersed replications. BARI Sheem-6 gave the highest fruit length, individual fruit weight, and yield (18.53 cm, 13.05 g, and 16.73 t ha⁻¹) whereas the local variety gave the lowest yield (13.12 t ha⁻¹). From the cost-return analysis it was found that the highest gross return was found from BARI Sheem-6 (Tk.585550 ha⁻¹) with BCR of 3.71 followed by BARI Sheem-1 (Tk.505750 ha⁻¹ and 3.20). The lowest gross return (Tk.419840 ha⁻¹) and BCR (2.66) were found from the local sheem.

Introduction

Country bean botanically known as *Lablab purpureus* L. which is a legume species. It is a self-pollinated crop belonging to the family Fabaceae. It is the third most important vegetable in the central and southwestern parts of Bangladesh after eggplant and taro (Rashid *et al.*, 2007). In Bangladesh, it is popularly known as 'Sheem'. Country bean is one of the important vegetables of Bangladesh. Its cultivation is a century-old practice for Bangladeshi farmers. Around 12,000 ha of land are cultivated and 50,000 metric tons of pods are produced every year. The crop is commonly used for pulse, vegetables, and fodder. It is generally grown for pods as edible vegetables and dry seeds as a pulse which is rich in protein, fiber, vitamins, and minerals (Asaduzzaman *et al.*, 2015). Country bean is very popular pulse and is normally grown in rabi or winter season in Bangladesh. The country bean grows well in Bandarban as well. Farmers normally use local imported varieties. However, the traditional local varieties have a prolonged vegetative period and poor yield potential and are often infected with mosaic virus disease. To minimize this problem Olericulture division of Bangladesh Agricultural Research Institute has successfully developed some high-yielding and disease resistant country bean varieties. The varieties have been popularized in some areas of the country. Therefore, it is necessary to observe the adaptability of this variety and thus the on-farm trial will be undertaken to evaluate the performance of BARI-released Sheem varieties in hilly areas of Bandarban.

Materials and Methods

The trial was conducted in the three farmer's fields of hill valleys of Bandarban sadar during the Rabi season of 2023-2024 to evaluate the performance of BARI Sheem-1, BARI Sheem-6, and BARI Sheem-10. A local variety of country bean was used as a check. The experiment was laid out in RCB design with three dispersed replications. Seeds were sown in the pits on 12 September, 2023 with the spacing 1.5 m × 1.5 m. The unit plot size was 18 m x 2.5 m. The amounts of fertilizer applied (kg/ha.) were as follows- Urea: 25; TSP: 90; MoP: 60; Gypsum: 60; Boron: 5. Total amount of cowdung, TSP, gypsum, and boric acid were applied in the plot during final land preparation. Urea and MoP were applied in three equal installments at 15, 30, and 45 days after planting. Irrigations were applied when necessary. Three weeding was also done after planting. Ten plants were selected randomly for data collection from each treatment and each plot. Harvesting of the trials was started on 15 January 2024 and completed on 26 March 2024. Flowers/cluster, Pod/cluster, Pod length (cm), Fruit width (cm), Individual fruit weight (g), Yield/plot (kg), and total yield were recorded. The collected data were analyzed statistically and the means were separated by LSD.

Results and discussion

Number of flowers per cluster: The maximum number of flowers per cluster was observed in BARI Sheem-10 (20.23) followed by BARI Sheem-6 (17.76) whereas the minimum was in the local variety (16.87) (Table 1).

Number of pods per cluster: The maximum number of pods per cluster was obtained from BARI Sheem-10 (7.95) and the minimum from Local variety (6.92) (Table 1).

Pod length (cm): BARI Sheem-6 gave the longest pod length (18.53 cm) whereas the shortest in the local variety (8.91) (Table 1).

Pod width (cm): The longest pod width was observed in BARI Sheem-10 (2.61) and the shortest in BARI Sheem-6 (1.52) (Table 1).

Individual pod weight: In terms of individual pod weight, the highest pod weight was obtained from BARI Sheem-6 (13.05) whereas the lowest was from local variety (9.44) (Table 1).

Pod yield: BARI Sheem-6 produced the highest yield (16.73 t ha⁻¹) among all varieties followed by BARI Sheem-1 (14.45 t ha⁻¹) and the lowest from the local variety (13.12 t ha⁻¹) (Table 1).

The highest gross return was found from BARI Sheem-6 (Tk.585550 ha⁻¹) with BCR of 3.71 followed by BARI Sheem-1 (Tk.505750 ha⁻¹ and 3.20). The lowest gross return (Tk.419840 ha⁻¹) and BCR (2.66) were found from local sheem.

Farmer's opinion

Farmers expressed their satisfaction with the higher yield, attractive color, price, and demand of BARI Sheem- 6 and BARI Sheem-1. They also preferred the bold-seeded nature of BARI Sheem-10 because of market demand.

Table 1. Performance of BARI-developed country bean varieties at hill valleys of Bandarban sadar during Rabi season of 2023-24.

Treatment	Flowers cluster ⁻¹	Pods cluster ⁻¹	Pod length (cm)	Pod width (cm)	Individual fruit weight (g)	Fruit yield (t ha ⁻¹)
T ₁ = BARI Sheem-1	17.26	7.74	10.51	2.39	9.66	14.45
T ₂ = BARI Sheem-6	17.76	7.66	18.53	1.52	13.05	16.73
T ₃ = BARI Sheem-10	20.23	7.95	11.24	2.61	12.56	13.42
T ₄ = Local	16.87	6.92	8.91	2.27	9.44	13.12
LSD (0.05)	4.17	0.99	1.56	0.34	1.61	1.8
CV (%)	11.56	6.57	6.33	7.73	7.23	6.22

Table 2. Cost-return analysis of country bean varieties for the crop year 2023-24 at hill valleys of Bandarban sadar.

Treatments	Gross return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
T ₁ = BARI Sheem-1	505750	158000	347750
T ₂ = BARI Sheem-6	585550	158000	427550
T ₃ = BARI Sheem-10	469700	158000	311700
T ₄ = Local	419840	158000	261840

Price (per kg): BARI Sheem- 35 tk, Local- 32 tk.

124. ON-FARM TRIAL OF BARI DEVELOPED HYBRID SWEET GOURD VARIETY

Abstract

The trial of hybrid sweet gourd varieties was conducted at the MLT site, Madhupur, Tangail during the Rabi season of 2023-24 to evaluate the performance of BARI developed sweet gourd varieties in the farmers' field. BARI released hybrid sweet gourd varieties viz. BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3 were tested against locally available hybrid namely sweet ball. The experiment was laid out in RCB design with five replications. BARI Hybrid Mistikumra-2 produced the highest fruit yield (45.97 t ha⁻¹) resulting in a maximum gross margin (Tk. 543093 ha⁻¹) whereas the lowest fruit yield (Tk. 35.90 t ha⁻¹) and gross margin (Tk. 392043 ha⁻¹) obtained from sweet ball.

Introduction

Pumpkin is a nutritious and popular vegetable in Bangladesh. 100 g pumpkin contains 89.1 g moisture, 1.4 g phosphorus, 0.1 g fat, 0.6 g minerals, 7 g crude fiber, 4.6 g carbohydrate, 25 kcal energy, 10 mg calcium, 30 mg phosphorus, 0.44 mg iron (Gopalan et al., 1989). Bangladesh Agricultural Research Institute has developed three hybrid pumpkin varieties that need to be popularized among farmers. On-farm trials will help popularize the variety among the farmers. This adaptive trial has been undertaken to evaluate the performance of the BARI developed pumpkin variety in the farmer's field and to popularize, disseminate and the productivity of BARI developed pumpkin varieties in the Tangail region.

Materials and Methods

The experiment was conducted at the MLT site, Madhupur, Tangail during the Rabi season of 2023-24. BARI developed BARI Hybrid Mistikumra-2 and BARI Hybrid Mistikumra-3 were evaluated. The seeds were sowed on 30 November 2023 maintaining 2 m x 2 m spacing. The crop was fertilized with 80-35-76-15-4-2 kg N-P-K-S-Zn-B ha⁻¹, respectively along with 5 t ha⁻¹ cowdung. The total amount of cowdung, one-third of MoP, and all other fertilizers except N were applied in the pit 7 days before seed sowing. Rest K was applied twice at 20-day intervals and N was applied in four equal installments at 15, 35, 55, and 75 DAP. Intercultural operations like watering and weeding were done as and when required. Ridomil Gold, Thiovit @ 2 g L⁻¹ water was applied to control the powdery mildew. The pheromone trap was also used at 12 m distance in the plot to control fruit fly insects as well. The fruits were harvested on 10 February to 15 March 2024. Fruit yield and yield contributing components were collected and analyzed using CropStat analytical software.

Results and Discussion

The fruit yield and yield characteristics varied significantly among the sweet gourd varieties except for fruit length and breadth. The number of fruits plant⁻¹ ranged from 4-6 in different sweet gourd varieties and BARI Hybrid Mistikumra-2 produced the maximum number of fruits plant⁻¹ (7). The maximum individual fruit yield of 2.80 kg was found in BARI Hybrid Mistikumra-2 followed by BARI Hybrid Mistikumra-3 (2.73 kg) whereas the lowest was in sweet ball (2.57 kg). BARI Hybrid Mistikumra-2 produced the highest fruit yield (45.97 t ha⁻¹) followed by BARI Hybrid Mistikumra-3 (39.63 t ha⁻¹) and the lowest yield was observed in sweet ball (35.30 t ha⁻¹) (Table 1).

The maximum gross return (Tk. 689550 ha⁻¹) and gross margin (Tk. 543093 ha⁻¹) were observed in BARI Hybrid Mistikumra-2 whereas the lowest gross return (Tk. 538500 ha⁻¹) and gross margin (Tk. 392043 ha⁻¹) were observed in sweet ball.

Farmers' opinion: Farmers prefer BARI Mistikurma-2 for higher yield. The highest yield of BARI Hybrid Mistikumra-2 provides the maximum gross return and gross margin. Seeds of BARI Mistikurma-2 and BARI Mistikurma-3 should be available in the market for large scale production.

Table 1. Yield and yield attributes of sweet gourd varieties at MLT site, Madhupur, Tangail during the Rabi season of 2023-24

Treatment	Fruits plant ⁻¹	Individual fruit weight (kg)	Fruit length (cm)	Fruit breadth (cm)	Fruit yield (t ha ⁻¹)
BARI Hybrid Mistikumra-2	7	2.80	43.87	48.47	45.97
BARI Hybrid Mistikumra-3	6	2.73	42.27	48.20	39.63
Sweet ball	6	2.57	40.73	48.07	35.90
LSD _{0.05}	0.42	0.13	NS	NS	4.03
CV (%)	3.10	2.10	6.60	4.00	4.40

Table 2. Cost and return analysis of sweet gourd varieties at MLT site, Madhupur, Tangail during the Rabi season of 2023-24

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Hybrid Mistikumra-2	689550	146457	543093
BARI Hybrid Mistikumra-3	594450	146457	447993
Sweet ball	538500	146457	392043

Farm gate price of sweet gourds (Tk kg⁻¹): 15

Conclusion

Sweet gourd var. BARI Hybrid Mistikurma-2 provides the maximum fresh fruit yield as well as the highest gross return and gross margin. This is the first-year result, the trial should be repeated in next year.

125. ON-FARM TRIAL OF BARI HYBRID BITTER GOURD VARIETIES AT MANIKGANJ

Abstract

The experiment was conducted at Kamta village under Saturiapazila and Ramnagar village under Shibaloya upazila of Manikganj district during Kharif-I season of 2023-24. The experiment was laid out in RCB design with six dispersed replications. Two BARI varieties viz. BARI Hybrid Korola-2, BARI Hybrid Korola-3 were evaluated with a locally available hybrid (Glory hybrid) as check. Higher yield was obtained from BARI Hybrid Korola-2 (25.10 to 26.16 t ha⁻¹) followed by glory hybrid (21.70 to 22.26 t ha⁻¹) and the lowest yield were recorded in BARI Hybrid Korola-3 (19.22 to 19.55 t ha⁻¹). Higher gross margin (Tk. 919790 to 877390 ha⁻¹) and BCR (8.27 to 7.92) were also obtained from BARI Hybrid Korola-2 and gross margin (Tk. 763790 to 741390 ha⁻¹) with BCR (6.84 to 7.04) from Glory hybrid. The lowest gross margin (Tk. 642190 to 655390 ha⁻¹) with lower BCR (6.08 to 6.18) was obtained from BARI Hybrid Korola-3.

Introduction

Bitter gourd (*Momordica charantia*) is one of the most popular vegetable crops in our country cultivated mostly during Kharif season. During the rainy season its market price is 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 commercial variety from the seeds traders. Some advance farmers grow commercial hybrid variety, but the seeds are very costly that causes economic loss of 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 variety among the farmers.

Materials and Methods

The experiment was conducted at Kamta village under Saturiapazila and Ramnagar village under Shibaloya upazila of Manikganj district during Kharif-I season of 2023-24. BARI Hybrid Korola-2, BARI Hybrid Korola-3 and locally available hybrid (Glory hybrid) as check were evaluated. The seeds were directly sown on the pit of main field on 15 to 18 March, 2024. The experiment was layout in a randomized complete block design with six dispersed replications. The unit plot size was 10m×10m and spacing was maintained 1.5cm×1.5cm. Recommended fertilizer as per FRG, 2018i.e. 80-35-75-18-5-1.8 kg, N-P-K-S-Zn-B ha⁻¹ plus 5 tha⁻¹ of CD. 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 seed sowing. The remaining amount of urea and MoP were

applied two equal splits at 25 and 40 DAS. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Autostin @ 2 g L⁻¹ water was sprayed to control root rot disease of seedling and Confidor @ 2 g 10 L⁻¹ water was sprayed to control small insects. Natio @ 2 g L⁻¹ water was sprayed to control fungal diseases. Fruits were harvested from 15 May to 25 June, 2024. Data on yield and yield attributes were collected and analyzed statistically.

Results and Discussion

The yield and yield contributing of hybrid bitter gourd varieties is shown in Table 1. The number of fruit plant⁻¹ ranged from 38.40 to 53.20 in different Hybrid bitter gourd varieties among which 49.80 to 53.20 in Glory hybrid followed by 41.98 to 45.28 in BARI Hybrid Korola-2 and the lowest 38.40 to 36.25 in BARI Hybrid Korola-3 in different tested locations. The weight of single fruit was maximum 138.25 to 140.92g in BARI Hybrid Korola-2 followed by BARI Hybrid Korola-3 (110.90 to 112.05g) and the lowest weight of single fruit 90.55 to 92.28g was recorded in Glory hybrid. The average weight of fruits plant⁻¹ was recorded and maximum weight was found in BARI Hybrid Korola-2 (5.65 to 6.00 kg plant⁻¹) followed by Glory hybrid (4.50 to 4.56 kg plant⁻¹) and the lowest fruit weight plant⁻¹ (4.00 to 4.10 kg plant⁻¹) was obtained from BARI Hybrid Korola-3. The highest fruit yield was recorded in BARI Hybrid Korola-2 (25.10 to 26.16 t ha⁻¹) followed by followed by Glory hybrid (21.70 to 22.26 t ha⁻¹) and the lowest yield (19.22 to 19.55 t ha⁻¹) was obtained from BARI Hybrid Korola-3.

The cost and return analysis is shown in Table 2. Cost and return analysis revealed that the higher gross return (Tk. 1046400 to 1004000ha⁻¹) and gross margin (Tk. 919790 to 877390 ha⁻¹) was obtained from BARI Hybrid Korola-2 with BCR 7.92 to 8.27 followed by Glory hybrid with gross return Tk. 890400 to 86800 ha⁻¹ and gross margin (Tk. 741390 to 763790ha⁻¹) with BCR 6.84 to 7.04. The lowest gross return (Tk. 768800 to 782000 ha⁻¹) and gross margin (Tk. 642190 to 655390 ha⁻¹) with lower BCR (6.08 to 6.18) was found from BARI Hybrid Korola-3.

Table 1. Yield and yield attributes of hybrid bitter gourd varieties grown at Saturia and Shibaloyaupazila of Manikganj during Rabi season of 2023-24.

Location	Treatment	Fruits plant ⁻¹ (no.)	Wt. of single fruit (g)	Wt. of fruit plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
Saturia	BARI Hybrid Korola-2	45.28 b	140.92 a	6.00 a	26.16 a
	BARI Hybrid Korola-3	38.40 c	110.90 b	4.10 b	19.22 c
	Glory hybrid	53.20 a	90.55 c	4.56 b	22.26 b
	LSD (0.05)	4.98	15.75	1.40	1.95
	CV (%)	8.95	4.45	9.35	7.50
Shibaloya	BARI Hybrid Korola-2	41.98 b	138.25 a	5.65 a	25.10 a
	BARI Hybrid Korola-3	36.25 c	112.05 b	4.00 b	19.55 b
	Glory hybrid	49.80 a	92.28 c	4.50 b	21.70 b
	LSD (0.05)	5.65	17.20	1.10	2.37
	CV (%)	9.20	6.34	9.10	8.22

Table 2. Cost and return of hybrid bitter gourd varieties grown at Saturia and Shibaloya upazila of Manikganj during Rabi season of 2023-24.

Location	Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Saturia	BARI Hybrid Korola-2	1046400	126610	919790
	BARI Hybrid Korola-3	768800	126610	642190
	Glory hybrid	890400	126610	763790
Shibaloya	BARI Hybrid Korola-2	1004000	126610	877390
	BARI Hybrid Korola-3	782000	126610	655390
	Glory hybrid	868000	126610	741390

Price of BARI Hybrid Korola-2 and BARI Hybrid Korola-3 Tk.40.00 kg⁻¹

Farmers' opinion: Farmers choose BARI Hybrid Korola-3 due to its higher yield potentiality than other hybrid varieties. They reacted those seeds of BARI hybrid bitter gourd varieties is not available in the local market.

Conclusion

Hybrid bitter gourd var. BARI Hybrid Korola-2 and BARI Hybrid Korola-3 was found high yielding in the study locations.

126. ON FARM TRIAL OF WATERMELON VARIETIES IN JOYPURHAT AND FARIDPUR

Abstract

The experiment was carried out at the MLT site, Joypurhat and FSRD site, Faridpur during the kharif II season of 2023, to observe the performance of two promising BARI watermelon varieties, i.e., BARI Tarmuj-1, BARI Tarmuj-2 among the farmers regarding its yield potentiality. The experimentation consisted of three treatments, i.e., BARI Tarmuj-1, BARI Tarmuj-2 and Bangla Link and/ or Sugar king (local). The highest yield of was recorded from BARI Tarmuj-1 and it was 36.18 t ha⁻¹ in Joypurhut and 25.17 t ha⁻¹ in Faridpur. The highest market price contributed to the highest gross return Tk 1548450 ha⁻¹ (Joypurhut) obtained from Bangla Link.

Introduction

Watermelon (*Citrullus lanatus*) is one of the most widely cultivated crops in the world at large. According to FAO (2014) statistics, China is the world's leading producer of watermelon. The top twenty leading producers of watermelon produced a collective volume of approximately 111 million metric tons in 2011, of which China produced 67.4%. Turkey, Iran and Brazil commanded a production share (of the 20 leading producers) of 3.5%, 3.2% and 2% respectively in 2014 (FAO, 2014). In Bangladesh, like many other parts of the world watermelon is highly relished as a fresh fruit because of its thirst-quenching attribute in addition to many other identified characteristics like size, color, sweetness, nutritional values and advantages. Farmers of Bangladesh, especially in sandy lands of coastal islands, are getting encouraged to cultivate watermelon on more areas of land as the popular summer fruit brings more profit than traditional crops including paddy. In Bangladesh, Gopalganj, Panchagar, Thakurgaon, Nator, Patuakhali, Khulna, Barishal, Noakhali and Rangamati are well known as watermelon cultivation area. Recently farmers would like to cultivate in Joypurhat and Faridpur region as a new cultivation zone. Watermelon fields should have suitable cultivable soil, weather condition, and availability of irrigation water. On the other hand, watermelon is known for its refreshing quality, though its sensory attributes have never been related to its perceived refreshment. Fruit intake could be improved by interventions that target consumer food choice motives, one of which is the sensory appeal of the product. As consumers desire a refreshing watermelon, it is necessary to determine flavor attributes associated with refreshment to inform watermelon breeding practices and better meet the expectations of the market. Watermelon is composed of 94% water (Olayinka & Etejere, 2018) and contains simple sugars like sucrose, fructose, and glucose, with relatively low amounts of ascorbic acid (Yoo, Bang, Lee, Crosby, & Patil, 2012). Most of the farmers using hybrid seed to cultivate watermelon. So, Production cost is very high due to hybrid seed cost is very high in local market. For this reason, the study was undertaken to evaluate the BARI released water melon varieties under farmer's field condition and popularize them among the farmers of Joypurhat and Faridpur.

Materials and Methods

The experiment was conducted at the MLT site, Joypurhat and Faridpur during kharif II, 2023. The seeds of two BARI varieties and one variety of mini watermelon were collected from Bangladesh Agriculture Research Institute (BARI), Joydebpur, Gazipur-1701, Bangladesh and Lal

teer Company and/ or Hyjen Biotech, respectively which were denoted by different accession number viz. BARI Tarmuj-1, BARI Tarmuj-2 and Bangla Link and/or Sugar King. Fresh, healthy and mature seeds were soaked in water for 3 hours and sown on 12 June 2023 in main research field following randomized complete block design (RCBD) replicated six with ten plants in each replication following a spacing of 1 x1 m² in Joypurhut. In case of Faridpur, unit plot size was 45 m² (10 m x 4.5m), plant to plant distance was 1.5 m and number of seedling/hill was 1-2. Uniform size, healthy 17 days old seedlings of watermelon were transplanted in the field on 09 July, 2023. The plants at their subsequent growing stages were fertilized with proper doses of manures and fertilizers following Fertilizer Recommendation Guide of Bangladesh (FRG, 2018). The fertilizer dose was N₁₁₅P₅₀K₁₀₀S₁₈Zn_{3.5}B_{2.3} kg ha⁻¹ + 10 t ha⁻¹ cowdung was also applied. Half of K and all of CD, P, S, Zn and B were applied as basal dose during final land preparation. Rest N and half of K used as topdressing in four equal splits at 15 days of interval. Intercultural operations such as weeding, irrigation, mulching, trellising, pheromone trap setting, pesticide and fungicide spraying, etc. were done as per requirements. In Faridpur, fruits were harvested after 65-74 days of planting during 10-19 Sep. 2023.

Results and Discussion

The quality of fruit is a major aspect from the point of view of consumers which is determined by both physical and biochemical properties. Physical properties include size, shape and color of fruit which are immediate preference in the market for visual attractions (Usharani et al., 2022). Table 1 revealed that mini watermelon genotypes expressed noticeable variations for their fruit morphological characteristics. In terms of fruit shape, it was found different among the mini watermelon genotypes. Two different types of fruit shapes were noticed during evaluation viz. round (BARI Tarmuj -1) and oval (BARI Tarmuj -2 and Bangla Link). Watermelon fruit shape can be elongated, oval, round based on the fruit length to width ratio (Lou and Wehmer, 2016). Divergent rind color and patterns in watermelon are preference of consumers that makes it commercially important and considerable importance has also been given to its esthetic value (Kayesh et al., 2013). The color of the watermelon rind generally varies from light to dark green (solid or striped) and yellow (Gusmini and Wehner, 2007; Dou et al., 2018). In our study, fruits of BARI Tarmuj -1, BARI Tarmuj -2, Bangla Link and Sugar king genotypes had blackish, light and light with dark green rind, respectively. Watermelon flesh color is another vital appearance quality closely related to consumers' preferences (Yuan et al., 2021). Watermelon flesh colors include coral red, scarlet red, canary yellow, orange, and white flesh. These different colors of watermelon not only provide visual diversity but are important from a nutritional perspective, as they are based on the carotenoid composition and content (Song et al., 2023). Among the tested varieties, fruits of BARI Tarmuj -1 and Sugar king had red flesh; yellow color was noticed in BARI Tarmuj -2 and Bangla Link flesh. Different type and content of carotenoids contributed to this variation in flesh color of watermelon (Song et al., 2023). Fruit flesh texture properties, especially flesh firmness, influence sensory quality and affect taste, flavor, and the shelf life of ripened watermelon fruit (Gao et al., 2020; Sun et al., 2020). A hard flesh results in reduced juice and poor flavor, whereas a soft flesh shows poor eating quality, storage and reduced shelf life (Gao et al., 2020). During evaluation, juicy compact flesh texture was recorded in BARI Tarmuj -2 and Bangla Link varieties. Meanwhile, crispy flesh was noticed for BARI Tarmuj -1 variety.

Fruits in terms of fruit length, fruit weight and yield were found non-significant variation while fruit diameter and rind thickness showed significant variation ($p < 0.05$) among them (Table 2). Fruit length along with diameter is a good indicator of better-quality watermelon. The measure of fruit equatorial diameter decides the shape of the fruit. Lesser its value, more is the fruit shape towards the cylindrical shape (Tamil selvi et al., 2012). In the current study, the length of the fruit was measured within the range of 14.82 to 15.14 cm and the longest fruit was produced by BARI Tarmuj-1 variety whereas BARI Tarmuj -2 variety had the shortest one (14.82 cm). In terms of fruit diameter, it was also found maximum (12.13 cm) in BARI Tarmuj-1 variety and lowest was observed by BARI Tarmuj-2 variety. In a study, Sari et al. (2016) found fruit length varied from 14.53 to 23.67 cm and fruit diameter from 11.71 to 17.94 cm in 38 mini watermelon lines. These

findings were in close conformity with our results. Rind thickness in watermelon fruits is an important feature for packaging. Fruits with very thin rind require greater care in transport to the final destination and have a shorter shelf life, an undesirable characteristic for both the trader and the final consumer (Rouphael et al., 2010). Present study revealed that the thickest rind (1.55 cm) was found in BARI Tarmuj-1 variety and the thinnest (0.99 cm) was traced in the fruit of BARI Tarmuj-2 variety. Our range of rind thickness was found higher than that of reported by Sari et al., (2016). Fruit weight in watermelon production is an important descriptor of fruit type, although it can also be considered as a yield component (Gusmini and Wehner, 2007). Average fruit weight of the studied varieties was recorded within 4.01 to 4.11 kg and the lightest fruit (4.01 kg) was harvested from BARI Tarmuj-2 variety. The highest yield was observed in BARI Tarmuj-1 variety and lowest was found in BARI Tarmuj-2 variety. Nonetheless, in case of Faridpur, the higher single fruit weight was obtained from BARI Tormuj-1 (2.35kg) and the lowest from Sugar king (1.70 kg). The fruit yield was 25.17, 21.78 and 20.69 t ha⁻¹ of BARI Tormuj-1, BARI Tormuj-2 and Sugar king as local, respectively.

Cost and return analysis from Table 3 indicated that the highest gross return Tk. 1548450 ha⁻¹ was obtained from Bangla Link followed by BARI Tarmuj -1 (Tk. 1447200 ha⁻¹) and the lowest gross return, Tk. 1328400 ha⁻¹ was from BARI Tarmuj-2. Higher gross return contributed to the higher gross margin in Bangla Link (Tk. 1248050 ha⁻¹) and lowest in BARI Tarmuj-2 (Tk. 1028000 ha⁻¹) against the cultivation cost Tk. 300400 ha⁻¹.

Farmers' Opinion: Faridpur: Farmers were satisfied for off-season cultivating of watermelon for the first time. They got high market price as it's highly demandable to the customers due to fresh and family sized fruit.

Table 1. Fruit morphological attributes of three mini watermelon varieties

Varieties	Fruit shape	Rind color	Flesh color	Flesh texture
BARI Tarmuj -1	Round	Blackish green	Red	Crispy
BARI Tarmuj -2	Oval	Light green	Yellow	Juicy compact
Bangla Link	Oval	Light green with dark green stripe	Yellow	Juicy compact
Sugar king	Oblong	Blackish green	Red	Crispy

Table 2. Fruit length, diameter, rind thickness and fruit weight of watermelon varieties

Locations	Varieties	No of fruits plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)	Rind thickness (cm)	Average fruit weight (kg)	Average yield (t ha ⁻¹)
Joypurhut	BARI Tarmuj-1	-	15.14	12.13a	1.55a	4.22	36.18
	BARI Tarmuj-2	-	14.82	10.92b	0.99c	4.01	33.21
	Bangla Link	-	15.10	11.33b	1.22b	4.11	34.41
	CV (%)	-	2.33	2.57	6.90	7.11	5.97
Faridpur	BARI Tormuj-1	2.68a	-	-	-	2.35a	25.17
	BARI Tormuj-2	2.57a	-	-	-	2.09a	21.78
	Sugar king	2.65 a	-	-	-	1.70b	20.69
	CV (%)	3.03	-	-	-	14.44	1.83

Table 3. Cost and return analysis of different watermelon varieties obtained from experimentation conducted during the Kharif season, 2023

Location	Varieties	Gross return (Tk. ha ⁻¹)	Total cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Joypurhut	BARI Tarmuj-1	1447200	300400	1146800
	BARI Tarmuj-2	1328400	300400	1028000
	Bangla Link	1548450	300400	1248050

* Joypurhut: BARI Tarmuj -1 and BARI Tarmuj -2 = 40 Tk kg⁻¹, Bangla Link= 45 Tk kg⁻¹, Faridpur: Fruit 50 Tk kg⁻¹

Conclusion

In Joypurhut, Watermelon var. BARI Tarmuj-1 was the highest yield than BARI Tarmuj-2 and Bangla Link but gross return was the highest in Bangla Link because of high market price. Bangla Link variety looks very attractive color and the farmers are getting more price than any other variety in the market. At Faridpur, Watermelon var. BARI developed showed satisfactory performance. For further verification, the trial may be repeated in the next year.

127. ON FARM TRIAL OF BARI GLADIOLUS VARIETIES IN MYMENSINGH REGION

Abstract

A trial on gladiolus was conducted at Mymensingh and Sherpur region under close supervision of On Farm Research Division of Bangladesh Agricultural Research Institute, Mymensingh and Sherpur during 2023-2024 to evaluate the comparative performance and to disseminate the BARI released gladiolus varieties at farmers' field. The trial consisted of three gladiolus varieties viz. BARI Gladiolus-2, BARI Gladiolus-3 and local for Mymensingh region, and BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-5 for Sherpur region. The yield performance of those varieties appeared to be promising in these regions. In Mymensingh, significantly the highest spike yield was obtained from BARI Gladiolus-3 (219000 spike ha⁻¹) followed by BARI Gladiolus-2 (165000 spike ha⁻¹) and in Sherpur, The highest spike yield was obtained from BARI Gladiolus-4 (232933 spike ha⁻¹) followed by BARI Gladiolus-5 (225666 spike ha⁻¹). The lowest yield of gladiolus as per spike was recorded from local (163667 spike ha⁻¹, in Mymensingh) and BARI Gladiolus-3 (215733 spike ha⁻¹, in Sherpur). From the study in Mymensingh region, the highest gross return (Tk.2847000 ha⁻¹) was estimated from BARI Gladiolus-3 followed by BARI Gladiolus-2 (Tk. 2145000 ha⁻¹). Maximum gross return (Tk.3139330 ha⁻¹) was estimated from BARI Gladiolus-4 in Sherpur. Considering the yield potentiality, disease and insect infestation, BARI Gladiolus-3 and BARI Gladiolus-2 might have been chosen for promotion and dissemination in Mymensingh region.

Introduction

Gladiolus (*Gladiolus grandiflora* L.) is the most worldwide cultivated economically important herbaceous perennial plant. It belongs to the family Iridaceae. Gladiolus is known as queen of the bulbous plants which is very popular as a cut flower, both the consumer and the florist alike because of its many spike forms, colors and color combinations (Bushman 1990). It is becoming popular day by day in Bangladesh. Its demand is increasing in country for aristocracy and modernization of Bangladesh as well as to earn foreign currency. Commercial cultivation of gladiolus is gaining popularity due to export potential and prevalence of favorable growing conditions in different parts of the country. These ornamental plants exhibit great diversity in their morphology, physiological responses to environmental factors, growth and developmental biology. Negi *et. al* (1978a) stated that in gladiolus the maximum variability was observed for plant height, corm number and flower yield. In addition to genotypic factors, the morphological character of gladiolus is directly or indirectly influenced by some environmental factors like temperature, humidity, rainfall, fog/dew, wind speed, soil texture and soil topography. Owing to the above said facts and environmental factors, the present study was undertaken to compare the variability among the genotypes and to find out the suitable genotypes of gladiolus flower for increasing the production of flower, corm and cornel of gladiolus. BARI has developed several gladiolus varieties which need to adaptation and popularization among the farmer' in different Agro-Ecological Zone. Considering the above fact, the adaptation trial of BARI released gladiolus varieties have been undertaken at farmers' field to find out a suitable variety for AEZ-9 and to finding about the yield, economic return and recognition by the farmers and customers of Bangladesh.

Materials and Methods

The experiment was initiated at Gouripur upazilla of Mymensingh district Jhinaigati and Nalitabari of Sherpur district during the cropping season 2023-2024 under the farmer's field condition. Three different gladiolus varieties were evaluated in randomized complete block design. Varieties and agronomic management were presented in Table 1. Manures and fertilizers were applied in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, cowdung as manure. Entire quantity of CD, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid were applied during final land preparation. The full doses of urea were applied at 30, 45 and 60 days after planting. Irrigation was done 20 Days After Planting, 30 DAP and 45 DAP, respectively. Ear thing up and weeding were done after one month of age. At one month age an infestation of sucking insect and mite were observed and it was controlled by applying Karate 2 m IL⁻¹ and Theovit 3 g L⁻¹ at two times of seven days interval. At early stage, mite infestation on leaf was observed and it was controlled spraying with Vertimec @ 2ml L⁻¹ water. Data on yield and yield contributing characters were recorded and analyzed statistically following SPSS program.

Table 1. Agronomic management of Gladiolus in Mymensingh and Sherpur region

Locations	Varieties	Sowing date of corm	Unit plot size	Spacing	Fertilizer dose N-P-K-S-Zn-B (kg ha ⁻¹)	Harvesting date
Gouripur, Mymensingh	BARI Gladiolus-2 BARI Gladiolus-3 Local	15 th November, 2023	8.0m × 5.0m	20cm × 20cm (30 cm drain)	240-90-90-25-4-2 kg NPKSZn and B ha ⁻¹ + 5 ton CD ha ⁻¹	07 to 25 February, 2023-24
Jhinaigati & Nalitabari, Sherpur	BARI Gladiolus-3 BARI Gladiolus-4 BARI Gladiolus-5	5 th November, 2023	2.4m × 3.0m	20cm × 20cm (30cm drain)	240-90-90-25-4-2 kg NPKSZnB ha ⁻¹ + 5 ton CD ha ⁻¹	07 to 20 February, 2024

Results and Discussions

The yield and yield contributing characters of different gladiolus varieties showed significant different (Table 1). In Mymensingh, the days takes 60 days for 50% flower initiation in BARI Gladiolus-2 whereas it showed 65 days for BARI Gladiolus-3 and local variety showed 62 days. However, in Sherpur, BARI Gladiolus-4 took 77 days for 50% flower initiation whereas BARI Gladiolus-5 took 79 days for 50% flowering. The tallest plant was recorded from BARI Gladiolus-3 in both the region and the height was 72.63 cm (Mymensingh) and 85.66 cm (Sherpur). The results from Mymensingh also revealed that spike per hill did not differ significantly although the highest number of spike (1.4) was observed in BARI Gladiolus-3. In case of Mymensingh region, the local variety produced the highest number of corm and cormel (1.8 and 62) which will be used for gladiolus production. However, in Sherpur, BARI Gladiolus-4 produced the highest number of cormel plant⁻¹ (46.99) and the lowest was recorded in BARI Gladiolus-3 (34.22). Moreover, in Mymensingh, BARI Gladiolus-3 produced the highest spikes (219000 spikes ha⁻¹) followed by BARI Gladiolus-2 (165000 spikes ha⁻¹). The lowest number of spikes per hectare was recorded from local variety (163667 spikes ha⁻¹). In Sherpur, BARI Gladiolus-4 produced the highest number of spike (232933 spike ha⁻¹) followed by BARI Gladiolus-5 (225666 spike ha⁻¹). The lowest number of spike (215733 spike ha⁻¹) was recorded in BARI Gladiolus-5.

In case of Mymensingh region, the highest gross return (Tk.2847000 ha⁻¹) and gross margin (Tk. 1938680 ha⁻¹) has been observed in BARI Gladiolus-3 followed by BARI Gladiolus-2 (Tk.2145000 ha⁻¹ and Tk.1236680 ha⁻¹, respectively). This might be due to higher yield potentiality. Whilst the lowest gross return (Tk. 2127671 ha⁻¹) and gross margin (Tk. 1219351 ha⁻¹) were calculated from local cultivar due to its lowest yield. In the event of Sherpur, the highest gross return (Tk. 3139330 ha⁻¹) and gross margin (Tk.2231050 ha⁻¹) was observed in BARI Gladiolus-4 followed by BARI Gladiolus-5 (Tk. 2988660 ha⁻¹ and Tk.2080380 ha⁻¹), respectively. The lowest gross return (Tk 2889330 ha⁻¹) and gross margin (Tk 1981050 ha⁻¹) was obtained from BARI Gladiolus-3.

Farmers' opinion:

Mymensingh: Generally, all varieties are liked and preferred by farmers due to yield potentiality and less insect and disease infestation, attractive colour and hike market price.

Sherpur: Farmers are happy to get higher yield from the BARI Gladiolus-4 and BARI Gladiolus-5 and BARI Gladiolus-3.

Table 2a. Yield and yield contributing characters of Gladiolus at Mymensingh during 2023-24.

Varieties	50% spike initiation (day)	Plant height (cm)	Leaves pl ⁻¹ (no)	Leaf length (cm)	Spike hill ⁻¹ (no)	Flower length (cm)	Spike length (cm)	Rachis length (cm)	Corm pl ⁻¹ (no)	Cormel pl ⁻¹ (g)	Yield (spike ha ⁻¹)
BARI Gladiolus-2	60	70.80	8.07	42.67a	1.0	11.5	51.53	45.83b	1.2	39.9c	165000b
BARI Gladiolus-3	65	72.63	6.97	38.43c	1.4	11.6	61.93	49.73a	1.0	50.7b	219000a
local	62	69.03	7.03	39.90b	1.0	11.3	55.77	47.20ab	1.8	62.0a	163667b
CV (%)	-	3.99	6.61	5.60	10.54	6.08	6.22	4.21	10.47	7.55	3.02

Table 2b. Yield and yield contributing characters of Gladiolus at Sherpur during 2023-24.

Sherpur	50% spike initiation (days)	Plant height (cm)	Spikelet/ spike	Spike length (cm)	Corm pl ⁻¹ (no)	Cormel pl ⁻¹ (g)	Yield (spike ha ⁻¹)
BARI Gladiolus-3	76	85.66a	9.64	58.50b	1.22	34.22c	215733c
BARI Gladiolus-4	75	85.03a	9.50	60.40a	1.35	46.99a	232933a
BARI Gladiolus-5	79	76.19b	10.5	58.31b	1.14	38.50b	225666b
LSD (0.05)	0.16	0.001	0.35	0.04	0.28	0.002	
CV (%)	2.31	1.60	8.65	1.26	12.9	4.49	

Table 3. Cost and return analysis of gladiolus varieties at farmers' field of Mymensingh and Sherpur during 2023-2024.

Varieties		Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Mymensingh	BARI Gladiolus-2	2145000	908320	1236680
	BARI Gladiolus-3	2847000	908320	1938680
	Local	2127671	908320	1219351
Sherpur	BARI Gladiolus-3	288933	908280	1981050
	BARI Gladiolus-4	3139330	908280	2231050
	BARI Gladiolus-5	2988660	908280	2080380

Price of input and output (Tk kg⁻¹): Urea: 22.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc sulphate: 180.00, Boric acid: 220.00, Seed gladiolus (Tk/corm): 4.00 (Mymensingh), 3.00 (Sherpur); Gladiolus (selling price): 13.00 (Mymensingh), 10.00/stick (Sherpur)

Conclusion

Considering the yield potentiality, disease and insect pest incidence and as of economic return all the varieties appeared to be promising in both the region. However, BARI Gladiolus-2 and BARI Gladiolus-3 in Mymensingh region and Gladiolus-4 and BARI Gladiolus-5 in Sherpur region could be promoted and disseminated.

128.ON-FARM TRIAL OF SHORT DURATION MUSTARD VARIETIES IN DIFFERENT LOCATION OF BANGLADESH

Abstract

An on-farm trial was conducted at Char Komorpur, Pabna, Barind, Rajshahi, Bholasadar and Doulatkhan under Bhola district, Chokoria under Coxsbazar district and Bandarban during the Rabi season of 2023-24 to assess the performance of short duration mustard varieties in different ecosystems. Six varieties (viz. BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-20, Binasarisha-9, Binasarisha-11 and Tori-7), four varieties (viz. BARI Sarisha-14, BARI Sarisha-

17, BARI Sarisha-20 and BinaSarisha-9), three varieties (viz. BARI Sarisha-17, BARI Sarisha-18 and BARI Sarisha-20), four varieties (viz. BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-17 and local) and three varieties (viz. BARI Sarisha-14, BARI Sarisha-19 and local) were used for the trial in Pabna, Bhola, Barind, Bandarban and Coxsbazar respectively. Different varieties performed better in different locations. All tested BARI varieties of Mustard produced significantly higher yield ranging from 20-71% in every locations against local check varieties. Maximum grain yield (1.88 t ha⁻¹) was obtained from BARI Sarisha-20 in Pabna, BARI Sarisha-18 (1.93 tha⁻¹) in Barind, BARI Sarisha-17 (1.41 tha⁻¹) in Bhola, BARI Sarisha-14 (1.46 tha⁻¹) in Bandarban and BARI Sarisha-19 (1.93 tha⁻¹) in Coxsbazar. Obviously, the gross margin was maximum in the BARI developed varieties against check variety due to the highest yield potentiality and similar market price.

Introduction

Mustard is an important oilseed crop in Bangladesh and traditionally farmers used to cultivate it after harvesting of short duration T. Aman rice in residual soil moisture. Annual requirement of edible oil is 5 lakh metric tons. That is, the internal production of edible oil can meet up only less than one-third of the annual requirement (Mondal and Wahhab, 2001). It covers about 78% of the total oilseeds acreage and 62% of the total production (BBS, 2020). The oilseed crop occupies 5% of the total cropped area. Out of this, 73% is covered by rapeseed and mustard, 18% by sesame and 9% by groundnut (BBS, 2020). Total production of rapeseed and mustard was 311740 M tons from 667242 acres (BBS, 2020). However, this production is very small in contrast to the massive national demand. About 80 to 90% of edible oil is refined and processed domestically for consumption in Bangladesh after crude oil is imported (Ebata *et al.*, 2021). Increasing area coverage of oilseeds is the key to curb the import and attain self-sufficiency in edible oil production. So, there is a great scope of increasing yield of mustard by introducing high yielding varieties in traditional and non-traditional areas. BARI and BINA have already developed some high yielding short varieties with good quality and yield. Therefore, it is necessary to select suitable variety for upscaling in different ecosystems.

Materials and Methods

An on-farm trial was conducted at Char Komorpur, Pabna, Barind, Rajshahi, Bholasadar and Doulatkhan under Bhola district, Chokoria under Coxsbazar district and Bandarban during the *Rabi* season of 2023-24 to assess the performance of short duration mustard varieties in different ecosystems. Six varieties (viz. BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-20, BinaSarisha-9, BinaSarisha-11 and Tori-7), four varieties (viz. BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-20 and BinaSarisha-9), three varieties (viz. BARI Sarisha-17, BARI Sarisha-18 and BARI Sarisha-20), four varieties (viz. BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-17 and local) and three varieties (viz. BARI Sarisha-14, BARI Sarisha-19 and local) were used for the trial in Pabna, Bhola, Barind, Bandarban and Coxsbazar respectively. The experiment was laid out in Randomized Complete Block Design with four dispersed replications. Some crop management practices were shown in Table 1. In fertilizer application method, total amount of fertilizers except urea was applied during the final land preparation. Urea was applied in two instalments. Two-third of the urea was applied as basal and the remaining one-third was applied as top dress at 22-25 DAS (days after sowing) followed by an irrigation. Weeding was done at 20-21 DAS before urea top dressing. The fields were infested with aphid and *Alternaria* blight disease. Imitaf® 20 SL (Imidacloprid) and Rovral® 50 WP (Iprodione) were applied as insecticide and fungicide, respectively. Based on the severity, insecticide and fungicide were applied throughout January 2024. Mustard was harvested at different locations based on the maturity of the respective varieties. 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.

Table 1. Crop management practices used in mustard at different locations during 2023-24

Location	Date of Sowing	Date of Harvest	Fertilizer dose (N-P-K-S-Zn-B-CD) kg ha ⁻¹
Pabna	10November, 2023	20-24February, 2024	120-34-45-29-2-2-0
Barind, Rajshahi	14 November, 2023	12-23 February, 2024	115-35-35-30-0-1-0
Bhola	04-13 December,2023	24 February-11March, 2024	120-34-45-29-2-2-10000
Coxbazar	12-18 November,2023	14 February-22 March, 2024	120-70-50-30-3-1-0
Bandarban	12 December,2023	05 March, 2024	140-36-50-32-1.5-2-0

Results and Discussion

Pabna: Yield and yield contributing characters are presented in Table 2. The tallest plant was BARI Sarisha-20 which is statistically similar to BinaSarisha-11 and the shortest was Tori-7. Tori-7 provided maximum siliqua plant⁻¹ compared to all other varieties. The 1000 seed weight and stover yield were found maximum from BinaSarish-11 which is identical to BARI Sarisha-17, BARI Sarisha-14 and BinaSarisha-9. The highest seeds siliqua⁻¹ and grain yield was found from BARI Sarisha-20 which is identical to BARI Sarisha-17 and lowest seeds siliqua⁻¹ and grain yield was recorded from Tori-7. Cost and return analysis is shown in Table 3. BARI Sarisha-20 showed the highest gross return (Tk. 148355 ha⁻¹) and gross margin (Tk. 79445 ha⁻¹) followed by BARI Sarisha-17. The lowest gross return (Tk. 85048 ha⁻¹) and gross margin (Tk. 16138 ha⁻¹) was found from Tori-7. Therefore, BARI Sarisha-20 was found the most profitable variety for the farmers.

Barind: The yield and yield attributes of mustard were presented in Table 4. The BARI Sarisha-20 took its flowering with earliest time (30 days) followed by BARI Sarisha-17 (35.33 days) and the BARI Sarisha-18 acquired the maximum time (44.33 days). Similarly, the minimum days to maturity were recorded from BARI Sarisha-20 (83.33 days) followed by BARI Sarisha-17(84.66 days)and maximum maturitydays were recorded for BARI Sharisha-18 (95 days). The maximum plant height was found in BARI Sharisha-18 (181.99 cm) and minimum in BARI Sharisha-20 (89.99 cm). The maximum siliqua plant⁻¹ (125.52), 1000-seed weight (3.77 g) and seed yield (1.83 t ha⁻¹) were found in BARI Sarisha-18. The BARI Sarisha-17 gave second highest and identical seed yield (1.65 t ha⁻¹) with BARI Sarisha-18. The seed yield was the minimum in BARI Sarisha-20 (1.47 t ha⁻¹). The maximum straw yield was also found in BARI Sharisha-18 (2.78 t ha⁻¹) and minimum was found in BARI Sarisha-20 (1.73 t ha⁻¹).

Bhola: The yield and yield attributes of mustard varieties are presented in Table 5. BINA Sharisha-9 (95 days) took longer time to floweramong all varieties and the lowest days to flower was found in BARI Sharisha-14 (82 days). The maximum plant height was observed in BINA Sarisha-9 (117.52 cm) and minimum plant height was observed from BARI Sarisha-14(92.65 cm).The maximum siliqua plant⁻¹ (72) was obtained from BARI Sorisha-14 which was statistically significance than other varieties. Number of seeds per siliqua (34 & 33) was higher in BINA Sarisha -9 and BARI Sorisha-14. Thousand seed weightfailed to produce any significant differences among the varieties.The highest yield (1.41 tha⁻¹) was recorded from BARI Sorisha-17 followed by BINA Sharisha-9 (1.37 tha⁻¹) and the lowest was obtained from BARI Sorisha-20 (1.24 tha⁻¹).The highest gross return (119850Tk ha⁻¹) and gross margin (73000Tk ha⁻¹) was also obtained from BARI Sharisha-17(Table 6).

Coxsbazar: The yield and yield attributes of mustard varieties are presented in Table 7. Local variety took the maximum days to maturity (120 days) while BARI sarisha-14 attained maturity with the minimum days (82 days). The highest plant height was observed in BARI sarisha-19 (100.95 cm) while the lowest was recorded in the Local variety (94.17 cm). The highest number of branches plant⁻¹ was recorded from BARI sarisha-19 (5.84) and Local variety gave the lowest number of branches plant⁻¹ (3.40). The highest number of siliqua plant⁻¹ was recorded from BARI sarisha-19 (100.74) and the lowest was in Local (86.33). Maximum number of seeds siliqua⁻¹ was observed in BARI sarisha-19 (16.89). Local variety attributed to minimum number of seeds siliqua⁻¹ (13.16). The maximum weight of 1000 seeds was recorded in BARI sarisha-19 (3.88 g).

The highest seed yield was obtained from BARI sarisha-19 (1.93 t ha⁻¹) and it was significantly different with other varieties.

Bandarban: The yield and yield attributes of mustard varieties are presented in Table 8. The tallest plant height (103.17 cm) was obtained from BARI Sarisha-14 and the shortest from local (91.20 cm). The maximum number of branches per plant was found in BARI Sarisha-14 (7.50) whereas the minimum was in the local Sarisha (5.13). BARI Sarisha-14 (109.35) gave the maximum number of siliqua plant⁻¹ over other varieties and the lowest was observed in local (58.56). The maximum number of seeds per siliqua was recorded in BARI Sarisha-14 (30.28) followed by BARI Sarisha-15 (24.04), BARI Sarisha-17 (22.72), and the minimum was found in local variety (22.38). In terms of yield, BARI Sarisha-14 (1.46 tha⁻¹) gave the highest result over other varieties followed by BARI Sarisha-15 (1.33) and the lowest was found in Local (1.22). The highest gross margin (Table 9) was found from BARI Sarisha-14 (Tk.78300 ha⁻¹) and the lowest was found from the local one (Tk.59100 ha⁻¹).

Farmer's reaction

Pabna: Farmers preferred BARI Sarisha-20 and BARI Sarisha-17 simultaneously due to their higher yield and shorter life cycle.

Barind: Farmers chose BARI Sarisaha-17 for early maturity. They did not like BARI Sarisha-18 due to late maturity and shattering loss.

Bhola: Though yield performance of BARI Sharisha-17 is higher compared to other varieties but BARI Sarisha-14 and BARI Sarisha-20 are short durated. Farmers are interested to cultivate BARI varieties. It can be easily fitted in case of Boro cultivation and also one another crop can be cultivated after harvesting of mustard.

Coxsbazar: The performance of BARI sarisha-19 is good. Farmers reacted very positively and were satisfied with that variety for its high yield. They also preferred BARI sarisha-14, because of short life cycle. This short duration was fitted in Mustard-Boro-T.aman cropping pattern.

Bandarban: Farmers of the Bandarban region are very much interested in cultivating high-yielding mustard varieties so that they can earn maximum benefit. They are optimistic that BARI Sarisha-14 will ensure more income and can change their socio-economic condition.

Table 2. Yield and yield attributes of the short duration mustard varieties in Pabna, 2023-24.

Treatment	Plant height (cm)	Siliqua plant ⁻¹	Seeds siliqua ⁻¹	1000 seed weight (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
BARI Sarisha-14	93.9c	58.7b	31.5ab	3.48ab	1.78bc	3.54a
BARI Sarisha-17	98.8bc	59.4b	33.4a	3.58a	1.83ab	3.69a
BARI Sarisha-20	105a	62.3b	32.2ab	3.35b	1.88a	3.68a
BinaSarisha-9	94.5c	58.1b	25.5c	3.57a	1.70d	3.56a
BinaSarisha-11	101ab	60.9b	29.8b	3.63a	1.76cd	3.68a
Tori-7	79.1d	79.8a	18.3d	2.79c	1.10e	1.18b
LSD (0.05)	5.09	3.21	3.11	0.19	0.07	0.28
CV (%)	3.54	7.02	7.26	3.8	3.62	5.78

Table 3. Cost and return analysis of the short duration mustard varieties in Pabna, 2023-24.

Treatment	Gross return (Tk.ha ⁻¹)	Total variable cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
BARI Sarisha-14	140200	68910	71290
BARI Sarisha-17	144260	68910	75350
BARI Sarisha-20	148355	68910	79445
BinaSarisha-9	134803	68910	65893
BinaSarisha-11	138990	68910	70080
Tori-7	85048	68910	16138

Local market price: grain = 75.00 Tk. kg⁻¹, straw = 2.00 Tk. kg⁻¹

Table 4. Yield and yield attributes of Mustard varieties at Godagari, HBT, Rajshahi, 2023-24

Variety	Days to Flowering	Days of maturity	Plant height (cm)	Plants m ²	Siliqua plant ⁻¹ (no.)	Seeds siliqua ⁻¹ (no.)	1000-seed wt. (g)	Seed yield (t ha ⁻¹)	Straw Yield (t ha ⁻¹)
BARI Sharisha-17	35.33 b	84.66 b	101.21 b	61.00 a	90.95 ab	33.20 a	3.10 b	1.65 ab	2.33 ab
BARI Sharisha-18	44.33 a	95.00 a	181.99 a	50.33 b	125.52 a	25.76 a	3.77 a	1.83 a	2.78 a
BARI Sharisha-20	30.00 c	83.33 b	89.99 b	57.33 a	86.73 b	26.43 a	3.08 b	1.47 b	1.73 b
LSD (0.05)	2.56	3.33	19.56	5.97	34.97	7.97	0.29	0.24	0.67
CV (%)	3.09	1.67	6.93	4.68	15.16	12.35	3.86	6.43	12.99

*LSD=least significant difference, CV= co-efficient of variation,

Table 5. Yield and yield attributes of Mustard varieties in Bhola during 2023-24 cropping season.

Varieties	Days to maturity	Plant height (cm)	Plants m ⁻² (no)	Siliqua plant ⁻¹ (no)	Seeds Siliqua ⁻¹ (no.)	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
BARI Sharisha-14	82	92.65	55.17	7 2	33	3.16	1.32
BARI Sharisha-17	85	106.70	57.50	68	32	3.23	1.41
BARI Sharisha-20	87	98.73	56.38	63	27	3.12	1.24
BINA Sharisha-9	95	117.52	59.80	60	34	3.21	1.37
LSD (0.05)	2.95	4.92	NS	3.24	3.11	NS	0.09
CV (%)	8.41	2.67	7.81	7.23	10.89	7.87	6.94

Table 6. Cost and return analysis of Mustard varieties in Bhola during 2023-24 cropping season

Treatment/varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Sharisha-14	112200	46850	65350
BARI Sharisha-17	119850	46850	73000
BARI Sharisha-20	105400	46850	58550
BINA Sharisha-9	116450	46850	69600

Note: Price of Mustard @ 85 Tk/kg

Table 7. Yield and yield contributing characters of mustard varieties at Coxsbazar, 2023-2024

Varieties	Days to maturity	Plant height (cm)	No. of branches plant ⁻¹	Siliqua plant ⁻¹	Seeds siliqua ⁻¹	1000-seed wt. (g)	Seed yield (t ha ⁻¹)
BARI sarisha-14	82	96.54	4.05	92.25	14.24	3.14	1.38
BARI sarisha-19	108	100.95	5.84	100.74	16.89	3.88	1.93
Local	120	94.17	3.40	86.33	13.16	2.56	1.15
CV (%)	4.56	5.67	4.18	9.42	4.58	6.35	3.40

Table 8. Yield and yield attributes of Mustard varieties in hilly areas of Bandarban, 2023-2024

Varieties	Plant height (cm)	Branches plant ⁻¹	Siliqua plant ⁻¹	Seeds siliqua ⁻¹	Seed yield (t ha ⁻¹)
BARI Sarisha-14	103.17	7.50	109.35	30.28	1.46
BARI Sarisha-15	95.87	6.13	77.72	24.04	1.33
BARI Sarisha-17	91.87	5.81	66.82	22.72	1.27
Local	91.20	5.13	58.56	22.38	1.22
LSD (0.05)	9.61	0.99	8.05	2.72	0.11
CV%	5.03	8.11	5.76	5.48	2.7

Table 9. Cost-return analysis of BARI released short-duration mustard varieties at hill valleys of Bandarban Sadar during, 2023-24

Varieties	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Sarisha-14	116800	38500	78300
BARI Sarisha-15	106400	38500	67900
BARI Sarisha-17	101600	38500	63100
Local	97600	38500	59100

Price (Tk/kg): 80

Conclusion

Pabna: BARI Sarisha-20 found the most profitable variety among the short duration varieties due to its satisfactory yield and the highest gross margin. This variety had lodging tendency subsequent yield loss. BARI Sarisha-17 was also found a promising variety in terms of yield, shorter plant height and duration.

Barind: The performance of BARI Sarisha-18 was the best among the mustard varieties. But farmers did not like it due to long duration at Basantapur, Godagari, Rajshahi of High Barind Tract.

Bhola: BARI Sarisha varieties 14, 17 & 20 cultivation is profitable to the farmers due to its short duration and acceptable yield.

Coxsbazar: The performance of BARI sarisha-19 is better than local variety due to its lower days to maturity and higher yield.

Bandarban: The performance of BARI Sarisha-14 and BARI Sarisha-15 were the best among the mustard varieties. Those varieties can be a good option for replacing local variety.

129.ON FARM TRIAL OF SESAME VARIETIES IN DIFFERENT LOCATIONS IN BANGLADESH

Abstract

The on-farm trial was conducted in charland situation at the MLT site Bhuapur, Tangail and at farmers' field of Rajendrapur, Netrokona during the Kharif 2023 to test the performance of newly developed BARI sesame varieties and to popularize them among the farmers. The trial was laid out in RCB design in three farmers' fields considered as three replications in Bhuapur, Tangail and six replications in Rajendrapur, Netrokona. Three varieties viz., BARI Til-4, BARI Til-5, and BARI Til-6 variety were tested in Bhuapur, Tangail and four varieties viz., BARI Til-2, BARI Til-4, BARI Til-6 and local cultivar in Rajendrapur, Netrokona. The highest numerical seed yield was observed in BARI Til-4 (1.46 t ha⁻¹) in Bhuapur, Tangail and the highest seed yield was also found in BARI Til-6 (1.38 t ha⁻¹) in Rajendrapur, Netrokona. Obviously, the gross margin was maximum in BARI Til-4 and BARI Til-6 varieties against check variety due to their highest yield potentiality.

Introduction

Sesame (*Sesamum indicum*) is one of the important oil seed crop grown during kharif season specially kharif-I in Bangladesh. It is cultivated in almost everywhere of the country. It is second major oil producing crop in the country. Abundant unsaturated fatty acids, proteins, and antioxidants in sesame seeds attract the worldwide consumption of sesame products. Sesame is highly tolerant of drought and poor soil condition (Zhang *et al.*, 2019). Seed contain 42-45% oil and 20% protein. Average sesame yield of Bangladesh is about 957 kg per ha. Currently, about 38,923 ha of land are under sesame cultivation and annual production is about 37,260 m tons. Due to high competition among different high value crops over the years, the acreage and production decrease in our country. In addition, lack of suitable varieties and genotypes with adaptation to local condition is also a factor that affects the yield of sesame. Bangladesh Agricultural Research Institute has developed high yielding and less disease and pest susceptible sesame varieties but farmers are not familiar with BARI sesame varieties. Therefore, the adaptive trial was conducted to evaluate the performance of those varieties to increase popularities among the farmers and economic return.

Materials and Methods

The trial was conducted in charland situation at the MLT site Bhuapur, Tangail and at farmers' field of Rajendrapur, Netrokonaduring the *Kharif*2023 to test the performance of newly developed BARI sesame varieties and to popularize them among the farmers. The trial was laid out in RCB design in three farmers' fields considered as three replications in Bhuapur, Tangail

and six replications in Rajendrapur, Netrokona. The unit plot size was 8 m x 5 m in both places. Three varieties viz., BARI Til-4, BARI Til-5, and BARI Til-6 variety were tested in Bhuapur, Tangail and four varieties viz., BARI Til-2, BARI Til-4, BARI Til-6 and local cultivar in Rajendrapur, Netrokona. Seeds were sown on 30 March 2023 as line sowing (row to row distance 30 cm continuous sowing) method @ 8 kg ha⁻¹ seed in Bhuapur, Tangail. In Rajendrapur, Netrokona, the seeds were sown on 04 Oct. 2023 as a broadcast method and seed rate was 7.5 kg ha⁻¹. The land was fertilized with 100-60-40 kg ha⁻¹ of NPK in Bhuapur, Tangail and 45-60-30-15 kg ha⁻¹ of N-P-K-S, respectively in Rajendrapur, Netrokona. Half of N and entire other fertilizers were applied as basal during final land preparation. Rest amount of N were applied after 25-30 DAS. Intercultural operations viz., weeding, and thinning were done when necessary. The crop was harvested on 27 July 2023 in Bhuapur, Tangail and 14-18 January in Rajendrapur, Netrokona. The data on different yield and yield components were recorded by having crop cuts (3 m x 2 m) randomly selected in each plot. The cost and return were calculated on the basis of prevailing market price of the commodities. Collected data were analyzed statistically using statistical analytical tool.

Results and Discussion

Bhuapur, Tangail: Yield and yield attributes of barley varieties are presented in Table 1. The minimum days to maturity was observed in BARI Til-5 (107 days) followed by BARI Til-4 (117) and BARI Til-6 (127 days) took the longest time to mature. The tallest plant was found in the BARI Til-5 (118 cm) whereas the shortest plant was found in BARI Til-6 (104 cm). The number of pod plant⁻¹, 1000-seed weight and seed yield failed to produce any significant difference among the varieties. However, the numerical highest seed yield was observed in BARI Til-4 (1.46 t ha⁻¹) followed by BARI Til-6 (1.35 t ha⁻¹) and BARI Til-5 (1.22 t ha⁻¹). The cost and return analysis was observed that the highest gross margin (Tk. 73504 ha⁻¹) was calculated from BARI Til-4 due to higher yield (Table 2). The lowest gross margin (Tk. 53104 ha⁻¹) was obtained from BARI Til-5.

Rajendrapur, Netrakona: The yield and yield attributes of tested materials were differed significantly (Table 3). The tallest plant was obtained from BARI Til-4 (101.33 cm) followed by BARI Til-2 (93.80 cm) whereas the shortest plant was recorded from local cultivar (76.53 cm). The number of branch per plant and pod per plant failed to produce any significant differences among the varieties. Seed per pod was found highest in BARI Til-4 (88.40) and lowest from BARI Til-2 (57.83) and local check (61.93), respectively. The highest seed weight was obtained from BARI Til-6 (2.90 g) whereas local check gave the lowest weight (1.60 g). The highest seed yield was recorded from BARI Til-6 (1.38 t ha⁻¹) which was statistically similar with BARI Til-4 (1.32 t ha⁻¹) and the lowest seed yield was obtained from local check (1.08 t ha⁻¹). The gross return and gross margin were varied among the tested materials (Table 4). Out of four varieties, the calculated highest gross return (Tk. 235166 ha⁻¹) and gross margin (Tk. 183766 ha⁻¹) was recorded from BARI Til-6 might be due to higher yield and market price. The BARI Til-2 gave lowest gross return (Tk. 113333) and gross margin (Tk. 61933 ha⁻¹), respectively.

Farmers' opinion

Tangail: Farmers showed their keen interest in the BARI Til-4 and BARI Til-6 due to their higher yield potentialities and less disease and pest infestation. They are interested to have an available seed supply during the growing season.

Netrakona: Farmers' are interested to grow BARI Til-6 for higher yield and market price. Behind reason of high price is BARI Til-6 is black colour which was local demand.

Conclusion

Tangail: BARI Til-4 and BARI Til-6 are promising varieties that BARI Til-4 in char areas of Tangail.

Netrokona: The performance of BARI Til-6 was found better in terms of higher price and yield potentiality.

Table 1. Yield and yield contributing characters of BARI Sesame varieties at Charland under MLT site, Bhuapur, Tangail during the Kharif 2023.

Variety	Days to maturity	Plant height (cm)	Pods plant ⁻¹ (no.)	1000-seed weight (g)	Seed yield (t ha ⁻¹)
BARI Til-4	117	111	26.26	2.72	1.46
BARI Til-5	107	118	24.13	2.16	1.22
BARI Til-6	127	104	25.63	2.43	1.35
LSD _{0.05}	1.00	3	NS	NS	NS
CV (%)	5.27	11.67	12.27	8.79	9.21

Table 2. Mean yield and cost-return analysis of BARI sesame varieties at Charland areas of Bhuapur, Tangail during the Kharif 2023.

Variety	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Sesame-4	124100	50596	73504
BARI Sesame-5	103700	50596	53104
BARI Sesame-6	114750	50596	64154

Farm gate price of grain (Tk. kg⁻¹): 85

Table 3. Yield and yield attributes of sesame varieties at farmer field of Rajendrapur, Netrakona during Kharif-II season of 2023.

Variety	Plant height (cm)	Branch plant ⁻¹ (no.)	Pod plant ⁻¹ (no.)	Seed pod ⁻¹ (no.)	1000-grain weight (g)	Seed yield (t ha ⁻¹)
BARI Til-2	93.80	3.70	57.53	57.83	1.80	1.13
BARI Til-4	101.33	3.63	74.57	88.40	2.25	1.32
BARI Til-6	91.37	3.80	80.23	79.33	2.90	1.38
Local cultivar	76.53	3.13	63.73	61.93	1.60	1.08
LSD (0.05)	13.38	ns	ns	12.66	0.53	0.19
CV (%)	7.38	9.66	14.07	8.82	12.54	8.14

Table 4. Cost and return analysis of sesame varieties at farmers' field of Netrakona during Kharif-II season of 2023

Lines/variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Til-2	113333.00	51400.00	61933.00
BARI Til-4	131666.00	51400.00	80266.00
BARI Til-6	235166.00	51400.00	183766.00
Local cultivar	184166.00	51400.00	132766.00

Price of input and output (Tk. kg⁻¹): Urea: 27.00, TSP: 27.00, MoP: 20.00, Gypsum: 12.00, Rovral: 3750.00, Sesame (selling price): Market price (Tk. kg⁻¹): 100/- (BARI Till-2, 4) and 170/- (BARI Till-6 and local black coated)

130. ON-FARM TRIAL OF GROUNDNUT VARIETIES IN DIFFERENT LOCATIONS IN BANGLADESH

Abstract

On-Farm trial of groundnut was conducted in farmer's field at Gopalgon sadar, Pirojour sadar and Chilmari, Kurigram during Rabi season of 2023-24 to find out the suitable groundnut variety(s) for different locations. Four BARI developed groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 and BARI Chinabadam-11 were evaluated in Chilmari, Kurigram and BARI Chinabadam-8, BARI Chinabadam-9 at Gopalgon sadar and Pirojour sadar in the study. In every location Chinabadam Dhaka-1 was used as check. All tested BARI varieties of groundnut produced significantly higher yield ranging from 21-61% in every locations against local check variety Dhaka-1. Among the locations, BARI Chinabadam-9 produced the highest nut yield in all tested locations where 2.49 t ha⁻¹ was produced in Gopalganj sadar and Pirojpur sadar and 2.36 t ha⁻¹ in Chilmari, Kurigram.

Obviously, the gross margin was maximum in the BARI developed varieties against check variety due to the highest yield potentiality and similar market price. Thus BARI varieties can be extended in tested areas by replacing local check variety to boost up groundnut production in Bangladesh.

Introduction

Groundnut (*Arachishypogaea*) is an important leguminous oilseed crop. It is cultivated during *rabi* and *kharif* seasons under rainfed condition in Bangladesh. It is very rich in protein and quality oil (Gohari *et al.* 2014; Gohari and Niyaki, 2010). Each of 100 g edible portion of groundnut contain 3.0 g moisture, protein 25.3 g, fat 40.1 g, minerals 2.4 g, crude fiber 3.1 g, carbohydrates 26.1 g, energy 567 Kcal, calcium 90 mg, phosphorus 350 mg, iron 2.5 mg (Gopalan *et al.*, 1989). *Bradyrhizobium* bacteria form nodules in the roots of groundnut plant which fixes atmospheric nitrogen. Groundnut is an important warm-season oilseed crop and is one of the most important oil producing crops in Bangladesh and ranking second in area and production. 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. Traditionally, the farmers of different region of Bangladesh grow groundnut by using old variety that reasons they are often deprived from expected yield and quality. But there is a lot of scope to cultivate the BARI released HYV of groundnut in groundnut producing areas and can be expanded in northern char and southern coastal belt of Bangladesh. Hence, the study was undertaken to find out a suitable groundnut variety for char land, coastal and other region to popularize the variety (ies) among the farmers of different Agro-Ecological Zones in Bangladesh.

Materials and Method

The experiment was conducted at Pirojpur and Gopalganj sadar, and at charland of Chilmari, Kurigram during Rabi season of 2023-24 to find out the suitable groundnut variety(s) for different AEZs. Four BARI developed groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10, and BARI Chinabadam-11 were evaluated in Chilmari, Kurigram; BARI Chinabadam-8 and BARI Chinabadam-9 in Gopalganj sadar and Pirojpur under this experiment. In every location Chinabadam Dhaka-1 was used as check. The experiment was laid out in RCB design with four dispersed replications except Chilmari, Kurigram where three compact replications were employed. Seeds were sown maintaining a spacing of 30 cm × 15 cm. Some crop management practices were shown in Table 1. In fertilizer application method, 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. Cowdung (CD) was also applied at the rate of 5000 kg ha⁻¹ before final land preparation and incorporated in the soil properly. Before sowing, seeds were treated with provex @ 0.2% to prevent seed and soil born diseases. One hand weeding was done at 45-65 DAS depending on weed infestation at different locations. 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.

Table 1. Crop management practices used in Groundnut at different locations during 2023-24

Location	Date of Sowing	Date of Harvest	Fertilizer dose (N-P-K-S-Zn-B-CD) kg ha ⁻¹
Gopalganj and Pirojpur	22-27 February, 2023	5-8 June 2024	12-32-43-54-0-1.7-5000
Chilmari, Kurigram	04-12 October, 2023	25 February-04 March, 2024	12-32-43-54-0-1.7-5000

Results and Discussion

Chilmari, Kurigram: A significant variation was observed among the varieties on the yield and most of the yield contributing parameters (Table 2). Among the tested varieties, BARI

Chinabadam-9 (2.36 t ha⁻¹) gave maximum pod yield. BARI Chinabadam-8 (2.01 t ha⁻¹), BARI Chinabadam-10 (2.04 t ha⁻¹) and BARI Chinabadam-11 (2.08 t ha⁻¹) gave the 2nd highest yield, which are statistically similar. Dhaka-1 gave minimum yield (1.77 t ha⁻¹). Maximum number of pods plant⁻¹ was recorded from BARI Chinabadam-9 (19.73) and BARI Chinabadam-10 (19.30) followed by BARI Chinabadam-11 (18.67) which are statistically similar. The highest 100 seeds weight (54.33 g) was recorded from BARI Chinabadam-8 and maximum plant height was observed in BARI Chinabadam-10 (41.03 cm). The maximum gross return (306800 Tk. ha⁻¹) and gross margin (146957 Tk. ha⁻¹) was obtained from BARI Chinabadam-9 (Table 3).

Gopalganj Sadar and Prioipjur Sadar: All the yield and yield contributing characters showed significant difference among the tested varieties (Table 4). The highest plant height (53.32cm) was obtained from BARI Chinabadam-9 and the lowest from local (47.92 cm). The maximum number of mature pods plant⁻¹ (20.56) was recorded from BARI Chinabadam-9 and the lowest number of mature pods plant⁻¹ (17.67) was found from local chinabadam. The maximum 1000 pod weight was recorded from BARI Chinabadam-9 (449.75 g) followed by BARI Chinabadam-8 (445.75 g) lowest 1000 pod weight (382.25g) was recorded from local chinabadam. The highest average nut yield (2.49 t ha⁻¹) was recorded in BARI Chinabadam-9 which was significantly similar to yield of BARI Chinabadam-8 (2.15 t ha⁻¹) among the tested varieties lowest nut yield (1.54 t ha⁻¹) was recorded from local variety. In case of economic return, higher gross margin was obtained from BARI Chinabadam-9 Tk. 163800 ha⁻¹ followed by BARI Chinabadam-8 Tk. 123000 ha⁻¹ and lowest gross margin found from the local variety Tk. 49800 ha⁻¹ (Table 5).

Farmer's opinion

Kurigram: Farmers are opined that obtaining higher yield of groundnut. It planted during September. Farmers are preferred BARI Chinabadam-9 on its high yield for Charland area and BARI Chinabadam-10 and BARI Chinabadam-11 also performed better as a new variety. They also observed that pest attack was relatively lower in charland condition.

GopalganjSadar and PrioipjurSadar: Farmers and their neighbors choose BARI Chinabadam-9 for its higher yield and gross margin. They showed their interested to cultivate BARI Chinabadam-9 in future.

Table 2. Yield and yield attributes of groundnut varieties at Chilmari, Kurigram during 2023-24

Treatment	Plant height (cm)	Number of pods plant ⁻¹	Weight of pods plant ⁻¹ (g)	Weight of 100-kernels (g)	Nut yield (t ha ⁻¹)
BARI Chinabadam-8	26.80c	15.97b	20.17b	54.33a	2.01b
BARI Chinabadam-9	29.17b	19.73a	21.33a	45.0b	2.36a
BARI Chinabadam-10	41.03a	19.30a	20.33ab	44.33b	2.04b
BARI Chinabadam-11	24.97cd	18.60a	19.83b	43.33b	2.08b
Dhaka-1	24.77d	13.87c	17.50c	31.50c	1.66c
LSD (0.05)	1.918	1.752	1.119	3.013	0.187
CV (%)	5.43	8.32	4.68	5.73	7.65

Table 3. Cost and return of groundnut varieties at Chilmari, Kurigram during 2023-24

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Chinabadam-8	261300	159843	101457
BARI Chinabadam-9	306800	159843	146957
BARI Chinabadam-10	265200	159843	105357
BARI Chinabadam-11	270400	159843	110557
Dhaka-1	215800	144369	71431

Price (Tk./kg): Groundnut=130

Table 4. Yield and yield attributes of groundnut varieties at Gopalganj Sadar and Pirojpur, Sadar during 2023-24

Treatment	Plant height(cm)	Pods plant ⁻¹ (no.)	100 pod wt. (g)	Nut yield (t ha ⁻¹)
BARI Chinabadam-8	49.47b	19.85a	445.75ab	2.15a
BARI Chinabadam-9	53.32a	21.56a	449.75a	2.49a
Local (Dhaka-1)	47.97b	17.47b	382.25b	1.54b
LSD _{0.05}	2.37	2.16	16.12	0.34
CV (%)	2.73	8.55	8.76	9.77

Table 5. Economic analysis of groundnut varieties at different location of Gopalganj and Pirojpur district during *rabi* season of 2023-24

Varieties	Gross return (Taka ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Chinabadam-8	258000	135000	123000
BARI Chinabadam-9	298800	135000	163800
Local (Dhaka-1)	184800	135000	49800

Market price of Groundnut = Tk. 120 kg⁻¹

Conclusion

Kurigram: The performance of variety BARI Chinabadam-9 appeared to be promising among the varieties tested at Charland area of Bongram, Chilmari, Kurigram during the study period. BARI Chinabadam-10 and BARI Chinabadam-11 also appeared to be promising among the tested varieties.

Gopalganj and Pirojpur: Results indicated that BARI Chinabadam-9 gave highest yield at Gopalganj and Pirojpur district.

131. ON-FARM TRIAL OF SOYBEAN VARIETIES IN SALINE AREA

Abstract

The experiment was conducted in the farmer's field of Noakhali and khulna region during Rabi season of 2023-2024 to select suitable soybean variety(s) for saline condition. The experiment was laid out in RCB design with six dispersed replications. Twelve soybean varieties developed by different research organizations and universities were used in the experiment in Noakhali and four soybean varieties were included in the experiment in Khulna. In Noakhali, the highest seed yield was obtained from BARI Soybean-6 (3.26 t ha⁻¹) which was at par with that of BU Soybean-2 (3.11 t ha⁻¹) and the lowest yield (1.92 t ha⁻¹) was obtained from Shohag. BARI Soybean-6 gave the highest gross margin (Tk. 145850 ha⁻¹) next to BU soybean 2 (Tk. 136850 ha⁻¹). On the other hand, the highest seed yield was produced by BARI Soybean-7 (2.13t ha⁻¹) and BARI Soybean-6 (1.91 t ha⁻¹) and got farmers preferences in Khulna.

Introduction

Soybean (*Glycine max* (L.) Merrill) accounts for approximately 50% of the total production of global oilseed crops. It has exceptional nutritional value, provides the richest source of protein of any crop (similar to levels found in cow's milk and meat, fish or poultry) and is able to serve as the core protein supplement to human diets. Soybean, including processed soybean products like tofu, constitutes good nutritional quality for adult humans, containing a high amount of protein (40%–50%), lipids (20%–30%) and carbohydrates (26%–30%), with more than 85% of its protein content made up of β -conglycinin and glycinin. Soybean oil has gained popularity in modern day cooking in Bangladesh. In Bangladesh, total annual production is 98646.06 M. tons from a cultivated area of 144712.75 acre at 1.54 tonsha⁻¹, this is much lower than the world average of 2.79 tonsha⁻¹. Soybean is tolerant to 4-10 dS m of soil salinity and the soybean production may be limited by soil salinity stresses or damaged when the salinity level was >16.78 dS m. The yield per unit area of soybean at farmers' level much below than the potential yield.

The reasons for low yield of soybean are mainly associated with lack of use of improved varieties. 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 saline region.

Materials and Methods

The experiment was conducted in the farmer's field of Noakhali and khulna region during Rabi season of 2023-2024 to select suitable soybean variety(s) for saline condition. The experiment was laid out in RCB design with six dispersed replications. Twelve soybean varieties developed by different research organizations and universities namely: Binasoybean-2, Binasoybean-3, Binasoybean-5, Binasoybean-6, Binasoybean-7, BU soybean 1, BU soybean 2, BARI Soybean-5, BARI Soybean-6, BARI Soybean-7, BD-4 and shohag were used in the experiment in Noakhali. Four (04) soybean varieties namely: BARI Soybean-4, BARI Soybean-5, BARI Soybean-6 and BARI Soybean-7 were included in the experiment in Khulna. Some crop management practices were shown in Table 1. The seeds were sown @ 50 kg ha⁻¹ in both locations. 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. Ripcord 10 EC @ 2 ml/L was sprayed twice at 42 and 56 DAS to control insects. Different intercultural operations and plant protection measures were taken as and when necessary to raise healthy crops. Data on different yield and yield contributing characters were recorded. The collected data were analyzed by the statistical software program.

Table 1. Crop management practices used in Soybean at different locations during 2023-24

Location	Date of Sowing	Date of Harvest	Unit plot size	Spacing (cm)	Fertilizer dose (N-P-K-S) kg ha ⁻¹
Noakhali	15 January, 2023	23-29 April, 2024	5m ×8m	40 cm×10cm	25-33-55-18
Khulna	12 December, 2023	15 April, 2024	3.6m×5 m	30cm×5cm	25-25-55-10

Results and Discussions

Noakhali: Yield and yield contributing characters of twelve soybean varieties were presented in Table 2. Yield and yield contributing characters were differed significantly. The result revealed that BARI Soybean-6 was the tallest variety (73.9 cm) which was at par with that of Shohag, Binasoybean-5, Binasoybean-5, BD-4, Binasoybean-3 and Binasoybean-2. BU soybean 1 was the shortest variety (37.4). BD-4 produced the highest number of branches plant⁻¹ (4.03) which was statistically identical to that of BARI Soybean-6 and Binasoybean-3 whereas BU soybean 1 showed the poorest number of branches plant⁻¹ (1.93). There was a huge variation in number of pods plant⁻¹. BD-4 showed the highest pods plant⁻¹ (101.6) and BU soybean-1 produced the lowest pods plant⁻¹ (44.8). All the tested varieties produced more than two seeds pod⁻¹. The highest number of seeds pod⁻¹ (2.70) was obtained from Binasoybean-5 which was statistically identical to that of BARI Soybean-6, BARI Soybean-7, Binasoybean-3, Binasoybean-7 and Binasoybean-6. The lowest number of seeds pod⁻¹ (2.23) was observed from Shohag. Days to maturity also varied but limited to one week variation. BU soybean 2 (16.3 g) was the bold seeded among the tested varieties, BD-4 showed the lowest 100-seed weight (7.7 g). The result revealed that BARI Soybean-6 produced the highest seed yield (3.25 t ha⁻¹) which was statistically identical to that of BU soybean 2 followed by Binasoybean-2. The lowest seed yield was obtained from Shohag (1.92 t ha⁻¹), still a good yield to produce a handsome return. The top gross margin was observed from BARI Soybean-6 (Tk. 145850 ha⁻¹) next to BU soybean 2 (Tk. 136850 ha⁻¹). Although Shohag produced the lowest gross margin (Tk. 65450 ha⁻¹) it was a good considerable return (Table 3).

Khulna: A significant variation was observed in grain yield and yield contributing characters of soybean varieties (Table 4). Plant height of soybean varieties ranged from 51.67 to 85.00 cm. The tallest plant was found in BARI Soybean-6 (85.00 cm) and lower in BARI Soybean-4 (51.67 cm).

Among the four varieties, the earliest flowering was BARI Soybean-7 (41.67) and others three varieties were statistically similar result at days to flowering (55.67 to 56.33 days). The maximum number of pods plant⁻¹ (86) was recorded from BARI soybean-7 and the minimum number of pods plant⁻¹ was found in BARI Soybean-4 (70). Non-significant variation was observed in number of seed pod⁻¹. Maximum hundred seed weight was found from BARI Soybean-7 (12.50 g) and the minimum hundred seed weight was found from BARI Soybean-4 (8.72 g). The highest seed yield (2.13 t ha⁻¹) was obtained in BARI Soybean-7 while the lowest yield | (1.44 t ha⁻¹) was found in BARI soybean-4.

Table 2. Yield and yield contributing characters of soybean varieties at Noakhali during Rabi season of 2023-24

Variety	Plant height (cm)	Plants m ⁻² (no.)	Branches plant ⁻¹ (no.)	Pods plant ⁻¹ (no.)	Seeds pod ⁻¹ (no.)	Days to Maturity	100-seed wt. (g)	Seed yield (t ha ⁻¹)*
Binasoybean-2	61.1 abc	13.8 def	2.90 bcd	72.6 bc	2.33 bc	103 ab	10.9 e	2.77 bc
Binasoybean-3	63.2 abc	18.0 ab	3.10 abc	69.3 c	2.43 abc	101 bc	9.9 f	2.32 de
Binasoybean-5	67.3 ab	14.3 def	2.57 bcd	72 bc	2.70 a	103 abc	10.7 ef	2.63cde
Binasoybean-6	57.5 bcd	14.7 cde	2.33 cd	64.4 cd	2.37 abc	102 abc	11.9 cd	2.55 cde
Binasoybean-7	43.7 de	13.5 ef	2.47 cd	52.6 de	2.43 abc	103 abc	13.2 b	2.32 e
BU soybean 1	37.4 e	11.7 f	1.93 d	44.8 e	2.27 bc	102 abc	11.3 de	2.66 cd
BU soybean 2	50.8 cde	13.7 def	2.10 cd	54.2 de	2.33 bc	104 a	16.3 a	3.11 ab
BARI Soybean-5	56.1 bcd	17.2 abc	2.50 cd	62.6 cd	2.50 abc	101 bc	13.4 b	2.51 cde
BARI Soybean-6	73.9 a	14.0 def	3.64 ab	83.7 b	2.60 ab	102 abc	10.5ef	3.26 a
BARI Soybean-7	44.1 de	16.3 bcd	2.80 bcd	60.8 cde	2.53abc	102 abc	12.7 bc	2.37 de
BD-4	64.8 abc	15.7 bcde	4.03 a	101.6 a	2.33 bc	103 abc	7.7 g	2.56 cde
Shohag	67.9 ab	19.2 a	2.90 bcd	70.8 c	2.23 c	100 c	10.5 ef	1.92ef
LSD (0.05)	15.9	2.67	1.10	12.64	0.36	2.86	0.92	0.34
CV (%)	14.15	8.95	20.09	9.76	7.49	1.43	4.06	11.31

*Plant population adjusted.

Table 3. Cost and return analysis of soybean varieties at Noakhali during Rabi season of 2023-24

Variety	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Binasoybean-2	166200	46750	119450
Binasoybean-3	139200	46750	92450
Binasoybean-5	157800	46750	111050
Binasoybean-6	153000	46750	106250
Binasoybean-7	139200	46750	92450
BU soybean 1	159600	46750	112850
BU soybean 2	186600	46750	139850
BARI Soybean-5	150600	46750	103850
BARI Soybean-6	195600	46750	148850
BARI Soybean-7	142200	46750	95450
BD-4	153600	46750	106850
Shohag	115200	46750	68450

*TVC included labor, land preparation, seed, fertilizers and Insecticides, Price: soybean = Tk. 60 kg⁻¹

Table 4. Seed yield and yield attribute Soybean varieties at on-station, BARI, Khulna during the Rabi season 2023-24

Variety	Plant height (cm)	Days to flowering	No. of pod plant ⁻¹	No of seed pod ⁻¹	100-seed weight (g)	Seed yield (t ha ⁻¹)
BARI Soybean-4	51.67 d	56 a	70.00 c	2.33	8.72 c	1.44 d
BARI Soybean-5	56.00 c	56 a	72.33 bc	2.67	10.78 b	1.71 c
BARI Soybean-6	85.00 a	56 a	77.67 b	3.00	11.48 b	1.91 b
BARI Soybean-7	66.00 b	42 b	86.00 a	3.00	12.50 a	2.13 a
LSD (0.05)	3.51	3.37	564	NS	0.84	0.16
CV (%)	2.72	3.07	3.69	13.55	3.91	4.65

Farmers; opinion

Noakhali: Farmers preferred bold seeded and bright colored variety because of its market preference

Khulna: Farmers preferred BARI Soybean-7 and BARI soybean-6 varieties due to their higher yield & almost similar maturity period with popular check variety.

Conclusion

Noakhali: 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 land areas. The result that showed Soybean var. BARI Soybean-7 followed by BAU Soybean-2 gave higher yield but 2 days varied is duration.

Khulna: The yield performance of BARI Soybean-7 is higher than other varieties. The second highest yield was found in BARI Soybean-6. Therefore, these varieties could be extended in the farmers field in the tested location according to yield performance and farmers choice.

132. ON-FARM TRIAL OF LENTIL VARIETIES IN HIGH BARIND TRACT

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

An experiment was carried out at FSRD site Basantapur under FSRD site, Godagari, Rajshahi during rabi season of 2023-24. Six treatments viz. E₁=BLX-09015, E₂= BLX-05002-3, E₃= LRIL-21-1-1-1-1, E₄= LRIL-21-1-1-1-1-6, E₅= BLX-05002-6, E₆= BARI Masur-8 were used in the experiment. The experiment was laid out in RCB design with 6 replications. The highest yield (1.85 t ha⁻¹) was obtained from BARI Masur-8 followed by E₂ = BLX-05002-3 (1.76 t ha⁻¹) and the lowest was recorded from E₄= LRIL-21-1-1-1-1-6 (1.40 t ha⁻¹).

Introduction

Lentil (*Lens culinaris* L.) occupies the topmost position in terms of popularity and is placed second in terms of area (1.46 lac hectare) and is placed 3rd in terms of production (1.85 lac ton) in Bangladesh (Yearbook of Agricultural Statistics, 2021). The interaction between legumes and *Rhizobium* is a paradigm of mutualism found in ecology where symbiotically fixed N comes from the atmosphere and this fixation represents it's one of the major renewable sources for agriculture (Friesen, 2012; Zahran, 1999). *Rhizobium* assists nodule formation on their host's roots or stems, in which atmospheric N is fixated and made available to the plant (Sessitsch *et al.*, 2002). Lentil yield in Bangladesh is much lower than its potential yield due to many factors. Lack of effective *Rhizobium* symbiosis with lentil is one of the important reasons for low yield of this crop. Response of *Rhizobium* inoculation to lentil depends on the soil type and crop cultivars. Judicious matching of *Rhizobium* strains or its mixture with host plant and suitable soil type is the only way to attain maximum nitrogen fixation and yield of leguminous crops (Haque *et al.*, 2014). 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, Jessore, Rajshahi and Pabna districts. The yield of lentil is lower in Bangladesh. The major constraints responsible for low yield of lentil are using of local old variety and climatic factor like unexpected rainfall. Recently, BARI has developed a good number of high yielding lentil varieties. So there is a scope to produce and expand modern lentil variety in Barind area. For this reason, some varieties were evaluated to find out the suitable one for Barind.

Materials and Methods

An experiment was carried out in FSRD site, Godagari, Rajshahi during the *rabi* season of 2023-24. Three treatments viz. T₁= BARI Masur-7, T₂= BARI Masur-8, T₃= BARI Masur-3 were used in the experiment. The experiment was laid out in RCB design with 6 replications. Unit plot size was

6m×5m. Seeds of lentil were broadcast on 29-30 November 2022. Fertilizers were applied @ 28-24-14-9-2-2 kgha⁻¹ N-P-K-S-Zn-B. Weeding, irrigation and other intercultural operations were done properly. Fungicide was sprayed at 64-68 DAS. Masur was harvested during 8-13 March 2023. Data on yield and yield contributing characters were recorded and analyzed statistically with R software.

Results and Discussion

The highest yield (1.85 t ha⁻¹) was obtained from BARI Masur-8 followed by E₂ = BLX-05002-3 (1.76 t ha⁻¹) and the lowest was recorded from E₄= LRIL-21-1-1-1-1-6 (1.40 t ha⁻¹). BARI Masur-8 had the highest number of pods per plant (62.00), highest number of seed per pod (1.67) and heaviest seed (25.70 gm per thousand seed). E₄= LRIL-21-1-1-1-1-6 variety had the number of pods per plant (35.67), lowest number of seed per pod (1.47) and lowest seed weight (23.03 g thousand seed⁻¹).

Farmers' opinion: Farmers are satisfied with the yield of lentil var. BARI Masur varieties compared to other lines.

Table 1. Yield and yield contributing character of lentil varieties/lines during 2023-24 at Rajshahi.

Variety/Lines	Days to flowering	Days to maturity	Plant height (cm)	Plant m ⁻²	Pod plant ⁻¹	Seed pod ⁻¹	1000 seed wt. (g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
E ₁ =BLX-09015	63 b	92 c	36.60a	122.73	46 bc	1.46	23.6 b	1.5 cd	1.8 bc
E ₂ = BLX-05002-3	65 bc	95 ab	30.50bc	134.60	56 ab	1.60	23.0 b	1.8 ab	1.9 b
E ₃ = LRIL-21-1-1-1-1	66 a	96 a	29.30c	120.33	46 bc	1.47	23.5 b	1.6 c	2.0 ab
E ₄ = LRIL-21-1-1-1-1-6	64 cd	92 c	28.90c	126.00	36 c	1.60	23.1 b	1.4 d	1.7 c
E ₅ = BLX-05002-6	64 c	93 bc	28.43c	133.00	48 bc	1.53	23.3 b	1.7 b	2.0 ab
E ₆ = BARI Masur-8	65 ab	95 ab	32.25b	134.67	62 a	1.67	25.7 a	1.9 a	2.2 a
CV (%)	1.3	5.2	11.0	14.9	8.7	3.8	3.8	3.9	6.1

Conclusion

BARI developed lentil varieties performed better than the lines. This was first year trial. This trial should be extended in next year for better understanding.

133.YIELD AND ODAP CONTENT VARIATION OF ADVANCED GRASS PEA GENOTYPES IN DROUGHT PRONE AREAS IN BANGLADESH

M.E.A. PRAMANIK, M.S. HOSSAIN AND M.M. RAHMAN

Abstract

An experiment was carried out at FSRD site, Basantapur, Godagari, Rajshahi during Rabi season of 2023-24 to identify drought tolerant grass pea genotypes considering yield and ODAP content variation of among the genotypes in selected areas. Ten treatments viz. E₁= IGYT-110, E₂= IGYT-122, E₃= IGYT-123, E₄=IGYT-124, E₅=IGYT-125, E₆=BGP-1309, E₇=BGP-1310, E₈=116690, E₉=114585, E₁₀=BARI Khessari-3 were used. The experiment was laid out in RCB design with 3 replications at Barind Region. The highest yield (1.93 t ha⁻¹) was obtained from E₅=IGYT-125 and the lowest from E₇=BGP-1310 followed E₉=114585 (1.18 t ha⁻¹).

Introduction

Indeed! Grass pea, scientifically known as *Lathyrus sativus*, is a hardy and adaptable crop that can flourish in extreme environmental conditions like low temperatures, high temperatures, lack of water, and soils impacted by salt. Nevertheless, the cultivation of this plant has declined as a result of the presence of a neurotoxic known as β-N-oxalyl-L-α, β-diaminopropionic acid (β-

ODAP) in the seedlings and seeds. Global efforts have been undertaken to improve grass pea by creating genotypes with reduced β -ODAP levels, while still preserving other favorable characteristics such as grain yield, biomass, early maturity, disease resistance, protein content, and digestibility. Scientists have also examined the association between ODAP levels and seed yield, discovering a notable inverse link. Grass pea (*Lathyrus sativus* L.) is one of the most important pulse crops due to a great source of protein for both human and the domestic animals in Bangladesh. In Rajshahi district, grass pea covered 11135 ha of land and produced 14475 metric tons but yield was lower (1.30 t ha^{-1}) during 2021-22 (DAE, 2022). Grass pea is to be cultivated in high barind land as a relay under Grass pea-T. Aman- Jute cropping pattern but in char land as Grass pea- Maize- Fallow in Barind area. Grass pea production can be increased by improving varietal development, agronomic management and replacing farmer's indigenous production package. Usually, farmers used to broadcast grass pea without fertilizer resulting lower yield. Recently, PRC, BARI has released two new grass pea varieties which need to be tested at farmer's field in Rajshahi. Therefore, the study has been undertaken to identify drought tolerant grass pea genotypes and to identify yield and ODAP content variation among the genotypes in selected areas.

Materials and Methods

The On-Farm field experiment of grass pea was carried out at FSRD site, Basantapur, Godagari, Rajshahi during Rabi season of 2023-24. All fertilizers were applied after harvesting T. Aman. Weeding, irrigation and other intercultural operations were done as per necessary. Data on yield contributing characters were recorded from 20 randomly selected plants from each plot. Grain yield (t ha^{-1}) was recorded from the whole plot. Data were analyzed statistically using R software at 5% level of significance. The details of experimental activities are given in Table 1.

Table 1. Experiment details of grasspea at three locations (FSRD site, Basantapur, Godagari, Rajshahi) during the rabi season of 2023-24

Particulars	OFRD, Barind station, Rajshahi
Locations	FSRD site, Basantapur, Godagari, Rajshahi
Treatments	Ten treatments viz. E1= IGYT-110, E2= IGYT-122, E3= IGYT-123, E4=IGYT-124, E5=IGYT-125, E6=BGP-1309, E7=BGP-1310, E8=116690, E9=114585, E10=BARI Khessari-3
Sowing date	9 November 2023
Sowing method	Broadcasted (relay method)
Design	RCBD
Replications	3
Fertilizer dose	20-20-12-9 kg N-P-K-S kg ha^{-1} in the form of Urea, TSP, MoP and Gypsum
Irrigation	As per required
Weeding	As per required
Harvesting date	15 March 2024

Results and Discussion

The tested genotypes matured by 117-122 days. The highest seed yield was obtained from E5=IGYT-125 (1.93 t ha^{-1}) followed by E2= IGYT-122 (1.48 t ha^{-1}), and the lowest (1.18 t ha^{-1}) from E7=BGP-1310 and E9=114585.

Farmers' opinion

Farmers are satisfied with the yield of lines E5=IGYT-125 and E2= IGYT-122 compared to E7=BGP-1310 and E9=114585 lines.

Conclusion

Lines E5=IGYT-125 and E2= IGYT-122 had the highest yield and farmers are interested to grow these two lines in next year.

Table 2. Yield and yield contributing character of grass pea experiment during 2023-24 at Basantapur, Godagari, Rajshahi

Variety/lines	Days to flowering	Days to maturity	Plant height (cm)	Plants m ⁻²	Pods plant ⁻¹	Seeds pod ⁻¹	1000 grain wt. (g)	Seed yield (t ha ⁻¹)
E1= IGYT-110	84 b	117 d	65 c	70 ab	28 cde	3.9abc	62.4 ab	1.3 abc
E2= IGYT-122	86 a	118 cd	65 c	82 ab	48 a	3.3 a	63.7 a	1.5 ab
E3= IGYT-123	82 c	119 bc	54 d	75 ab	34 bc	3.7 bc	63.1 a	1.4 abc
E4=IGYT-124	79 ef	118 cd	66 c	77 ab	28 bcd	3.6 c	61.1 ab	1.3 abc
E5=IGYT-125	78 f	120 ab	70 bc	69 ab	29 bcd	3.5 c	59.3 b	1.9 a
E6=BGP-1309	79 ef	121 a	65 c	70 ab	37 ab	4.1 ab	63.5 a	1.5 ab
E7=BGP-1310	81 cd	121 a	71 bc	65 b	28 bcd	3.8abc	59.2 b	1.2 c
E8=116690	80 de	121 a	63 cd	68 ab	33 bc	3.8abc	63.1 a	1.4 abc
E9=114585	76 g	121 a	76 ab	83 a	20 de	3.5 c	62.3 ab	1.c
E10=BARI Khessari-3	74 h	118 cd	82 a	74 ab	8.3	3.7 bc	58.3 b	1.3abc
CV (%)	6.20	5.77	7.45	13.33		7.46	3.58	11.62
LS*	**	**	**	**	**	**	**	**

134.ADAPTIVE TRIAL WITH BARI RELEASED GRASSPEA VARIETIES IN GOPALGANJ DISTRICT

M.M. HOWLADER AND D. HALDER

Abstract

The experiment was conducted at four locations Gopalganj Sader and Tungipara under Gopalganj district and Najirpur and Pirojpur under Pirojpur district during rabi season in 2023-`24 to evaluate the performance of tested grass pea varieties. Four selected Grass pea varieties viz. BARI Kheshari-2, BARI Kheshari-3, BARI Kheshari-5 and local were evaluated in the trial. Among the varieties, the highest seed yield was founded by BARI Kheshari-5 (1.71 t ha⁻¹) and the lowest grain yield (1.14t ha⁻¹) recorded by BARI Kheshari-2 and it followed by yield of (1.15 t ha⁻¹) local variety.

Introduction

Grass pea (*Lathyrus sativus*) is one of the hardiest legume crops. It is potential among the grain legumes for its tolerance to saline conditions, its adaptability to unfavorable environments and tolerant to disease or insect problems. Traditionally, the farmers of Gopalganj region grow grass pea by using old variety that reasons they are often deprived from expected yield and quality. In the meantime, BARI has developed some grass pea varieties with higher yield and performance of these varieties needs to be evaluated for cultivation in this area. Keeping this view in mind, the experiment was undertaken to find out a suitable grass pea variety(s) for cultivation in Gopalganj area of Bangladesh.

Materials and Methods

The experiment was conducted at Gopalganj Sader, Tungipara, and Muksedpur under Gopalganj district; Najirpur and Pirojpur Sader under Pirojpur district during rabi season in 2023-`24. Four selected grass pea varieties viz. BARI Kheshari-2, BARI Kheshari-3, BARI Kheshari-5 and local were evaluated in this trial. The experiment was laid out in Randomized Complete Block Design with four dispersed replications. The unit plot size was 10m×8m. Seeds were sown in traditional broadcasting method on 14-23 November 2023. Two weeding were done at 25 days and 45 days after sowing. The crop harvesting date was 12-17 March 2024. Data on yield contributing characters were recorded from 20 randomly selected plants from each plot. Grain yield (ton ha⁻¹) was recorded from the whole plot. Data were analyzed statistically by using R software at 5% level of significance.

Results and Discussion

The tested grass pea varieties differed significantly from one to another in respect of yield and yield contributing characters under farmer's field condition. The data are presented in Table-1. In case of plant per square meter, there was no significant difference found among the varieties. Significantly difference was observed in plant length, the tallest plant was BARI Kheshari-5 (72 cm) followed by BARI Kheshari-2 (68.75 cm) and the shortest plant was local (60 cm). Maximum number of pods plant⁻¹ 47 was produced by BARI Kheshari-5 whereas minimum 29 found from BARI Kheshari-2. The highest seeds pod⁻¹ (4.1) and 1000 seed wt. (55 g) was found from BARI Kheshari-5 and lowest seeds pod⁻¹ (3.5) and 1000 seed wt. (50.4 g) was recorded from local variety. Finally, the highest grain yield (1.7 t ha⁻¹) was recorded by BARI Kheshari-5 which was statistically similar to seed yield (1.6 t ha⁻¹) of BARI Kheshari-3 and lowest grain yield (1.1 t ha⁻¹) was obtained in BARI Kheshari-2. From an economic point of view, the highest BCR can be observed from same variety BARI Kheshari-5 (2.90) and the lowest BCR (1.93) observed from BARI Kheshari-2 (Table 2).

Farmers' Opinion: Farmers were satisfied with the performance of grass pea var. BARI Kheshari-5 with more no. of pod bearing capabilities and higher yield.

Table 1. Performance of grass pea varieties at different MLT sites of Gopalganj during *rabi* season of 2023-24.

Varieties	Plant population m ⁻²	Plant height (cm)	Pods plant ⁻¹	Seeds pod ⁻¹	1000 seed weight (g)	Seed yield (t ha ⁻¹)
BARI Kheshari-2	53.76	68.75	29.35	3.65	50.45	1.14
BARI Kheshari-3	54.50	63.10	36.50	3.89	53.50	1.58
BARI Kheshari-5	56.53	72.00	46.90	4.10	54.98	1.71
Local variety	51.78	59.45	31.35	3.45	50.37	1.15
LSD (0.05)	NS	8.45	5.52	0.48	4.03	0.27
CV (%)	-	8.27	11.04	5.12	5.30	3.61

Table 2. Cost and return analysis of grass pea varieties at different MLT sites of Gopalganj during *rabi* season of 2023-24.

Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)	BCR
BARI Kheshari-2	68400	35430	32970	1.93
BARI Kheshari-3	94800	35430	59370	2.68
BARI Kheshari-5	102600	35430	67170	2.90
Local variety	69000	35430	33570	1.95

Price of grass pea: 60 Tk. kg⁻¹

Conclusion

Grass pea var. BARI Kheshari-6 may be suitable for cultivation at Gopalganj district in respect of yield. For conformation further trial to be needed.

135. REGIONAL YIELD TRIAL OF FIELD PEA IN HIGH BARIND TRACT

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during rabi season 2023-24 to select suitable field pea variety through regional yield trial (RYT) under drought prone area. Three genotypes of field pea viz. BFPX-16003, BFPX-16005, BFPX-16008 and two varieties BARI Motor-1 and BARI Motor-3 as check were tested in the farmer's field. Among the tested genotypes and variety, BFPX-16005 gave the maximum seed yield (1.15 t ha⁻¹) followed by BARI Motor-3 (1.11 t ha⁻¹) and the minimum seed yield was obtained from BARI Motor-1 (0.92 t ha⁻¹).

Introduction

Field pea is a critical economic and nutritive crop and is often called “poor man’s meat” due to its high protein, vitamin and mineral, and prebiotic carbohydrate content yet affordability for poorer consumers (Amarakoon *et al.*, 2012). More specifically, field pea is naturally rich in iron and zinc and thus, could address two of the most common micronutrient deficiencies in the world (Amarakoon *et al.*, 2012). One of the main issues with field pea, and legumes, in general, is that they require much more P input than other crops due to their nodules, which require P for energy transformation (Vance *et al.*, 2003).

Field pea is an important pulse crop in Barind area. Bangladesh has been developing a good number of varieties of fieldpea. BARI has released high yielding and disease resistant/tolerant varieties of field pea. 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. In relation to the above situation the present trial was undertaken with a view to develop suitable variety(s) through farmer’s selection under Barind environments.

Materials and Methods

An experiment on regional yield trial (RYT) of fieldpea was conducted at farmer’s field of FSRD site, Basantopur, Godagari, Rajshahi during Rabi 2023-24. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 8 rows x 4m. Three genotypes of fieldpea viz. BFPX-16003, BFPX-16005, BFPX-16008 and two varieties BARI Motor-1 and BARI Motor-3 as check were tested in the farmer’s field. Line to line distance 50 cm and plant to plant distance 10 cm. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha⁻¹ (BARC, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Fieldpea seeds were sown in 12 December, 2023. Weeding and thinning were done at 30 days after planting of fieldpea seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 45 days after planting of fieldpea seeds. No irrigation was applied during the experimental period as there was no symptom of moisture stress. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Fieldpea was harvested in 17 March, 2024. The seed yield and yield components of fieldpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results and Discussion

The yield and most of the yield contributing characters like days to flowering, days to maturity, plant height (cm), and 1000-grain weight (g) showed significant variation except plant/m² and straw yield. Among the tested genotypes, BFPX-16005 gave the maximum seed yield (1.15 tha⁻¹) followed by BARI Motor-3 (1.11 tha⁻¹) and the minimum seed yield was obtained from BARI Motor-1 (0.92 tha⁻¹).

Table 1. Yield and yield contributing characters of different Fieldpea varieties/lines in HBT during Rabi 2023-24

Entry /varieties	Days to Flowering	Days of maturity	Plant height (cm)	Plants m ⁻²	Pods plant ⁻¹	Seeds pod ⁻¹	1000-seed wt.(g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
E ₁ = BARI Motor-1	55 bc	87 c	79 b	74	24 a	5.5 a	68.4 c	0.9 c	1.3
E ₂ =BFPX-16003	51 c	89 b	108 a	71	18 b	5.3 a	94.5 b	1.0 b	1.1
E ₃ = BFPX-16005	57 ab	90 ab	105 a	73	27 a	5.3 a	125.3 a	1.2 a	1.3
E ₄ = BFPX-16008	57 ab	91 a	111 a	71	24 a	4.5 b	89.4 b	1.0 b	1.3
E ₅ =BARI Motor-3	60 a	90 ab	109 a	71	24 a	4.9 ab	94 b	1.1 a	1.3
CV (%)	3.4	1.0	10.3	6.5	13.1	7.2	4.8	2.5	11.8

Farmer's opinion

Farmers obtained some promising cultivars and variety for Barind condition e.g., BFPX-16005 and BARI Motor-3. Farmers are happy to get higher yield from selected lines/variety. They also observed that pest attack was lowest in selected lines/variety.

Conclusion

The performance of Fieldpea var. BARI Motor-3 along with line BFPX-16005 appeared to be promising at FSRD site, Basantapur, Godagari, Rajshahi. The experiment may be repeated for further evaluation in the next year.

136. REGIONAL YIELD TRIAL OF CHICKPEA IN HIGH BARIND TRACT

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during rabi season 2023-24 to select suitable chickpea through regional yield trial (RYT) under drought prone area. Four genotypes of chickpea viz. BCX-16005-4, BCX-16010-2, BCX-16006-1, BCX-16006-2 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-16006-2 gave the maximum seed yield (1.43 t ha^{-1}) followed by BARI Chola-5 (1.32 t ha^{-1}) and minimum seed yield obtained from BCX-16005-4 (1.21 t ha^{-1}) and BCX-16010-2 and BARI Chola-10 (1.22 t ha^{-1}) which were 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 ($600\text{-}700 \text{ kg ha}^{-1}$) 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 Methods

An experiment on regional yield trial (RYT) of chickpea was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2023-24. The experiment was conducted in randomized complete block design with three replications. The unit plot size was $4\text{m} \times 4\text{m}$. 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, 2018) 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 5 December, 2023.

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 were 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 7 April, 2024. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results and Discussion

Yield and most of the yield contribute 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 Rabi 2023-24 cropping season. All varieties exhibited a flowering period of 76-83 days and a maturity period of 112-120 days with the maximum required for maturity in BCX-16006-1 (120 days) under rainfed conditions in the High Barind Tract. Among the tested genotypes, BCX-16006-2 gave the remarked seed yield ($1.43 t ha^{-1}$). Seed yield of other genotypes ranged from 1.21 to $1.32 t ha^{-1}$.

Farmer's reaction

Farmers obtained some promising cultivars for Barind condition e.g., BCX-16006-2 and BARI chola-5. 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 2023-24.

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	78 b	112 b	39.15c	21.66b	68.13a	1.47ab	12.83d	1.32b	1.84bc
BCX-16005-4	83 a	114 b	46.62a	24.67a	46.00c	1.33b	14.60c	1.21c	1.90b
BCX-16010-2	76 c	118 a	46.74a	21.33ab	41.20c	1.47ab	14.67c	1.22c	2.06ab
BCX-16006-1	76 bc	120 a	43.33b	23.33ab	47.48bc	1.26bc	15.53bc	1.30bc	1.69c
BCX-16006-2	78 b	114 b	47.12a	24.67a	64.03ab	1.60a	18.77a	1.43a	1.96ab
BARI Chola-10	77 bc	112 b	48.11a	23.33ab	42.03c	1.07c	16.27b	1.22c	2.15a
CV (%)	1.22	3.01	9.57	17.71	9.63	3.44	3.91	3.91	6.06

Conclusion

The line BCX-16006-2 showed higher yielded followed by BARI Chola-5 and BCX-16006-1 at FSRD site, Basantapur, Godagari, Rajshahi. The experiment could be repeated next year.

137. PRELIMINARY YIELD TRIAL OF CHICKPEA

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during rabi season 2023-24 to select suitable chickpea variety through regional yield trial (RYT) under drought prone area. Eight genotypes of chickpea viz. BCX-17002-3, BCX-17005-8, BCX-17006-6, BCX-17007-2, BCX-17007-6, BCX-17008-10, BCX-17009-1, BCX-17009-3 and two BARI released varieties BARI Chola-5 and BARI Chola-10 as check were tested in the farmer's field. Among the tested genotypes, BCX-17007-6 gave the maximum seed yield ($1.69 t ha^{-1}$) followed by BCX-17007-2 ($1.51 t ha^{-1}$) and minimum seed yield was obtained from BCX-17008-10 ($1.19 t ha^{-1}$) due to minimum pods per plants.

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. 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 Methods

An experiment on Preliminary yield trial (PYT) of chickpea was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2023-24. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 3-meter x 8lines. Line to line distance 40 cm plant to plant distance 10 cm. Treatment combinations were randomly assigned in each replication. Eight genotypes of chickpea viz. BCX-17002-3, BCX-17005-8, BCX-17006-6, BCX-17007-2, BCX-17007-6, BCX-17008-10, BCX-17009-1, BCX-17009-3 and two BARI released varieties BARI Chola-5 and BARI Chola-10 as check were tested in the farmer's field. 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, 2018) 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 10 November, 2023. 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 were 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 14 March 2024. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results 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 seed weight (g) showed significant variations during 2023-24 crop season. All genotypes exhibited a flowering period of 70-82 days with the earliest in BCX-17009-1 and a maturity period of 118-122 days with the shortest days in BCX-17007-6 under rainfed conditions in the High Barind Tract. Among the tested genotypes, BCX-17007-6 gave the maximum seed yield (1.69 t ha⁻¹) followed by BCX-17007-2 (1.51 t ha⁻¹) and minimum seed yield was obtained from BCX-17008-10 (1.19 t ha⁻¹) due to minimum pods per plants.

Farmer's reaction

The entry BCX-17007-6 showed the highest seed yield of 1.69 t ha⁻¹ with crop duration 118 days and farmers' are satisfied with the performance of entry.

Table 1. Yield and yield attributes of Chickpea genotypes at Basantopur under FSRD site, Godagari, Rajshahi during 2023-24

Entry Names	Days to Flowering	Days to maturity	Plant height (cm)	Plant m ⁻²	Pods plant ⁻¹	Seeds pod ⁻¹	100 seeds wt. (g)	Seeds yield (t ha ⁻¹)
BARI Chola-5	71 fg	121 abc	40.80c	22.67ab	74.00ab	1.40a	12.30e	1.42bc
BCX-17002-3	72 efg	119 bc	43.37bc	20.67b	36.33f	1.20	21.37ab	1.30def
BCX-17005-8	75 cde	121 bcd	56.40a	24.33ab	44.00def	1.20	19.77c	1.34cde
BCX-17006-6	77 bc	122 ab	56.93a	21.67ab	46.67def	1.26	16.77d	1.36cde
BCX-17007-2	70 g	121 abc	54.87a	25.33a	61.67bc	1.40	20.98abc	1.51b
BCX-17007-6	70 g	118 e	53.73a	22.67ab	77.67a	1.33	21.81a	1.69a
BCX-17008-10	80 ab	122 a	54.87a	21.67ab	44.67ef	1.33	19.82bc	1.19f
BCX-17009-1	82 a	120 cde	56.87a	22.00ab	57.33cd	1.40	17.20d	1.43bc
BCX-17009-3	74 def	121 abc	56.40a	22.00ab	52.00cde	1.46	16.83d	1.4cd
BARI Chola-10	76 cd	120 cde	47.63b	23.33ab	42.00ef	1.26	17.60d	1.4bcd
CV (%)	2.50	0.93	6.16	9.93	15.71	12.55	5.03	4.80

Conclusion

The performance of Chickpea genotypes BCX-17007-6 showed the highest yielder but BCX-17007-2 and BARI chola-5 appeared to be promising among the lines. The experiment could be repeated for further evaluation.

138.ON-FARM ADAPTIVE TRIAL OF CHICKPEA VARIETIES IN HIGH BARIND TRACT

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

On-farm field trial was carried out at FSRD site, Basantopur, Godagari, Rajshahi, during 2023-24 to evaluate the performance of BARI developed chickpea varieties. The tested varieties were BARI Chola-5, BARI Chola-9, BARI Chola-10 and BARI Chola-11 evaluated at the farm level. BARI Chola-9 gave the maximum seed yield (1.66 t ha⁻¹) followed by BARI Chola-5 (1.46 t ha⁻¹) and the minimum seed yield was obtained from BARI Chola-10 (1.27 t ha⁻¹) among the tested varieties.

Introduction

Chickpea (*Cicer arietinum* L.) is a popular and profitable pulse crop grown in Bangladesh during the winter season. It is a good source of protein, energy, vitamins, minerals, fiber, and also some potentially health-beneficial phytochemicals (Wood and Grusak, 2007). Chickpea as a common source of carbohydrates and protein so it makes it more economical and affordable for developing countries without compromising on nutritional quality (Malunga et al., 2014). The area under Chickpea cultivation has been decreasing gradually because of the increasing demand for staple grains like rice and wheat (BBS, 2020). Currently, about 4942 t of Chickpea is being produced from an area of 4635 ha of land with an average yield of 1.07 t ha⁻¹ (BBS, 2020). The major constraints responsible for the low yield of Chickpea include low yield potential, sensitivity to high water and fertilizer application, and sensitive to climatic factors as excess soil moisture/humidity and rainfall. Chickpea is found to be a very suitable dry land rabi crop with less soil moisture condition like char land areas. Bangladesh Agricultural Research Institute (BARI) has developed some high yielding and disease resistant/tolerant varieties of chickpeas. Those varieties' yield potential is 2-3 times higher than national average yields under research station/researchers managed trials. It is thought that this yield gap between the research center and the farmer's field is due to multiple reasons such as the knowledge gap, quality seed, tradition cultivation practices and environmental resource constraints of farmers. Traditionally farmers used to cultivate chickpea after harvest of T. Aman rice in residual soil moisture condition. The long duration T. Aman rice affects the proper sowing time of chickpea that causes lower seed yield. Therefore,

development of suitable chickpea variety is necessary for improving chickpea productivity in different region regions of Bangladesh. Already BARI has developed some high yielding chickpea varieties with good quality. Therefore, this study was under taken to evaluate the performance of BARI chickpea varieties and to popularize those varieties among the farmers at different locations of Bangladesh.

Materials and Methods

The on-farm field trial was carried out at FSRD site, Basantopur, Godagari, Rajshahi to evaluate the performance of BARI developed chickpea varieties during 2023-24. The details of experimental activities are given in Table 1. All fertilizers were applied after harvesting of T. Aman. Weeding, irrigation and other intercultural operations were done as per necessary. Data on yield contributing characters were recorded from 10 randomly selected plants from each plot. Grain yield (t ha^{-1}) was recorded from the whole plot. Data were analyzed statistically using R software at 5% level of significance.

Table 1. Experiment details of chickpea at FSRD site, Basantopur, Godagari, Rajshahi during the rabi season of 2023-24

Locations	FSRD site, Basantopur, Godagari, Rajshahi
Treatments	Varieties (4): BARI Chola-5, BARI Chola-9, BARI Chola-10 and BARI Chola-11
Sowing date	7 November 2022
Sowing method	Broadcasted
Design	RCBD
Replications	3
Unit plot size	3 m x 8 lines
Plant spacing	40 cm $\times$ 10 cm
Fertilizer dose	20-20-20-10-1 kg N-P-K-S-Zn-B kg ha^{-1} in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid
Irrigation	As per required
Weeding	Two weeding were done at 25 days and 35 days after sowing
Harvesting date	22 March 2024

Results and Discussion

The yield and most of the yield contributing characters like days to flowering, days to maturity, plant height (cm), and 100-seed weight (g) showed significant variations during 2023-24 crop season. Among the tested variety, BARI Chola-9 gave the highest seed yield (1.66 t ha^{-1}) and the lowest from BARI Chola-10 (1.27 t ha^{-1}). Maximum straw yield found from BARI Chola-11 (2.21 t ha^{-1}) and minimum in BARI Chola-5 (1.61 t ha^{-1}).

Farmers' opinion: Farmers preferred Chickpea var. BARI Chola-5 and BARI Chola-9 due to higher yield and less pest attack.

Table 2. Yield and yield contributing characters of Chickpea at High Barind Tract in Rajshahi during 2023-24.

Treatments	Days to flowering	Days to maturity	Plant height (cm)	Plant m^{-2}	Pod plant^{-1}	Seed pod^{-1}	1000-seed wt. (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
BARI Chola-5	76 a	117 a	48 c	23 ab	77.3a	1.13ab	12.8c	1.46b	1.61c
BARI Chola-9	75 a	117 a	55 b	21 bc	70.6b	1.26a	19.20a	1.66a	1.98b
BARI Chola-10	65 b	112 b	58 b	24 a	47.6d	1.06ab	16.0b	1.27c	1.63c
BARI Chola-11	50 c	109 b	69 a	21 c	65.0c	1.00b	16.1b	1.42b	2.21a
CV (%)	2.6	1.6	4.1	4.7	3.8	9.9	3.2	4.5	4.4

Conclusion

The performance of BARI Chola-5 and Chola-9 appeared to be promising among the varieties. This experiment will be continued for the next year for confirmation.

139. ON FARM TRIAL OF PROMISING CHICKPEA VARIETIES IN HIGH BARIND TRACT

M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during rabi season 2023-24 to select suitable chickpea variety under drought prone area. Three genotypes of chickpea viz. ICCV 181634, BCX-1300z-2, ICCV 181627 and two varieties BARI Chola-5 and BARI Chola-10 as check were tested in the farmer's field. Among the genotypes, ICCV 181627 showed the maximum pods plant⁻¹ (74.66) followed by ICCV 181634 (62.00) while minimum pods plant⁻¹ (34.66) from BARI Chola-10. The ICCV 181627 gave the maximum seed yield (1.57 t ha⁻¹) followed by line ICCV 181634 (1.47 t ha⁻¹) and minimum from BARI Chola-10 (1.26 t ha⁻¹).

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. 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 developed 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. In relation to the above situation the present trial was undertaken with a view to develop suitable variety(s) through farmer's trial under Barind environments.

Materials and Methods

An experiment on chickpea was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2023-24. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 8 rows x 4m. Line to line distance 50 cm and plant to plant distance 10 cm. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha⁻¹ (BARC, 2018) 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 30 November, 2023. Weeding and thinning were done at 30 days after planting of chickpea seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 45 days after planting of chickpea seeds. No irrigation was applied during the experimental period as there was no symptom of moisture stress. Chickpea was harvested in 04 April, 2024. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results 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 hundred grain weight (g) showed significant variation except seeds per pod. Among the genotypes, ICCV 181627 showed the maximum pods plant⁻¹ (74.66) followed by ICCV 181634 (62.00) while minimum pods plant⁻¹ (34.66) from BARI Chola-10. The maximum weight of hundred seeds (20.39 g) was found in ICCV 181634 while BARI Chola-5 gave the lowest (12.63g). ICCV 181627 gave the maximum seed yield (1.57 t ha⁻¹) followed by line ICCV 181634 (1.47 t ha⁻¹) and minimum from BARI Chola-10 (1.26 t ha⁻¹).

Farmer's reaction: Farmers obtained some promising cultivars for Barind condition e.g., ICCV 181627 and ICCV 181634 as well as observed that pest attack was lowest in selected

lines/variety.

Table 1. Yield and yield contributing characters of promising Chickpea varieties/lines in HBT during Rabi 2023-24

Variety/Lines Name	Days to flowering	Days to maturity	Plant height (cm)	Plants m ⁻²	Pod plant ⁻¹	Seed pod ⁻¹	100-seed wt.(g)	Seed yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
E ₁ = BARI Chola-5	78 a	114	37.20d	23.00	44.33b	1.13	12.63b	1.33bc	1.63c
E ₂ = ICCV 181634	77 ab	116	41.83c	23.33	62.00a	1.33	20.39a	1.47ab	1.75c
E ₃ = BCX 1300z-2	78 ab	116	46.487b	22.00	43.00b	1.13	19.27a	1.35bc	1.95b
E ₄ = ICCV 181627	79 a	118	53.00a	26.00	74.66a	1.40	18.50a	1.57a	2.34a
E ₅ = BARI Chola-10	75 b	118	44.667bc	26.00	34.66b	1.20	14.22b	1.26c	1.64c
CV (%)	2.20	1.70	3.61	12.95	13.86	11.96	6.24	6.51	5.25

LS= Level of Significance, NS= non-significant, *= Significant at 5% level, **= Significant at 1% level

Conclusion

The performance of chickpea lines ICCV 181627 and ICCV 181634 appeared to be promising at FSRD site, Basantopur, Godagari, Rajshahi. The experiment may be repeated for further evaluation in the next year.

140. ADAPTIVE TRIAL WITH MUNGBEAN VARIETIES

R. UDDIN AND B. C. KUNDU

Abstract

Mungbean productivity in south central coastal region of Bangladesh is declining due to lack of adoption of improved varieties. Suggestions on location specific performance and economic profitability of mungbean varieties are necessary for rapid adoption. A field trial was conducted at RARS, Rahmatpur, Barishal during Rabi season of 2023-24 to evaluate the performance of existing improved mungbean varieties. Four selected mungbean varieties including BARI and BINA mungbean varieties viz BARI Mung-6, BARI Mung-7, BARI Mung-8 and Binamoog-8 were evaluated in the trial. Results showed that, the highest seed yield (1551.6 kg ha⁻¹) was produced by the variety BARI Mung-6 which was followed by BARI Mung-7 (1448.9 kg ha⁻¹) and Bina moog-8 (1409.7 kg ha⁻¹) and the lowest seed yield (1372.2 kg ha⁻¹) was obtained in BARI Mung-8.

Introduction

Mungbean (*Vigna radiata*) is an important component in the intensive crop production system for its short life cycle and is one of the most leading pulse crops of Bangladesh. The southern agro ecological condition of Bangladesh is favorable for growing this crop. It is a drought tolerant crop and can be grown with a minimum supply of nutrients. Cultivation of mungbean can improve the physical, chemical and biological properties of soil as well as are capable of fixing atmospheric nitrogen by symbiotic process with the help of micro-symbioant (Rhizobium). Mungbean has good digestibility and flavor. Mungbean contains 51% carbohydrate, 26% protein, 10% moisture, 4% minerals and 3% vitamins (Kaul, 1982). Crop production in late rabi season might become comparatively more vulnerable due to larger increase in temperature. High temperature during mungbean crop establishment and intermittent rains during crop growth also affect the crop adversely and cause considerable yield losses by physiological disorder along with appearance and proliferation of aphid pest and white rust, downy mildew and stem rot diseases. Therefore, the experiment was undertaken to evaluate the performance of existing mungbean varieties in southern region of Bangladesh.

Materials and Methods

The trial was conducted at farmers field of Babuganj, Barishal; Rajapur, Jhalokathi and Barguna Sadar, Barguna in the late rabi season, 2023-24 to evaluate the performance of mungbean existing varieties. Seven selected mungbean varieties including BARI and BINA viz. BARI Mung-6, BARI Mung -7, BARI Mung-8 and Bina moog-8 were evaluated in the trial. The experiment was laid out in Randomized Complete Block Design with six dispersed replications. The unit plot was 10 rows and 4m long with spacing 50cm × 5cm. Seeds were sown in the rows on 15th January, 2024. Two weeding operations were done at 25 days and 45 days after sowing. Data on yield contributing characters were recorded from 10 randomly selected plants from each plot. Grain yield (kgha⁻¹) was recorded from the whole plot. Data were analyzed statistically by using R software at 5% level of significance.

Results and Discussion

The tested mungbean varieties differed significantly from one to another in respect of growth and yield contributing performances under field condition. The data were represented in Table 1. Number of plant population did not show significant differences among the varieties. Days to flowering and days to maturity were comparatively higher in BARI Mung-8 and Bina moog-8. The tallest plant can be observed from Bina Moog-8 (about 64 cm). Number of pods/plants did not differ significantly among the varieties. Hundred seed weight also differed significantly among the mungbean varieties. The heaviest hundred seed weight can be observed from BARI Mung-7 (2.8 g). BARI Mung-6 and Bina moog-8 also demonstrated statistically identical hundred seed weight. The highest seed yield (1551.6 kgha⁻¹) was produced by the variety BARI Mung-6 which was followed by BARI Mung -7 (1448.9 kgha⁻¹) and Bina moog-8 (1409.7 kgha⁻¹) and the lowest grain yield (1372.2 kgha⁻¹) was obtained in BARI Mung-8.

Farmers' opinion: Farmers opined that, improved variety BARI Mung-6, BARI Mung-7 and Bina moog-8 gave satisfactory yield in respect of southern belt aspect. But, BARI Mung-8 did not give satisfactory yield and its seed price is comparatively low.

Table 1. Yield and yield contributing characters of seven mungbean varieties during Rabi season of 2023-24

Variety	Plants m ²	Days to flowering	Days to maturity	Plant height (cm)	Pods plant ⁻¹ (no.)	100-seed weight (g)	Seed yield (kg ha ⁻¹)
BARI Mung-6	43	52 ab	66 e	57 b	8	2.5 ab	1552 a
BARI Mung-7	32	49 c	68 d	52 c	8	2.8 a	1449 b
BARI Mung-8	28	44 e	70 bc	58 b	8	1.8 c	1372 b
Bina moog-8	42	47 d	70 b	64 a	10	2.3 b	1410 b
CV (%)	38.8	1.7	0.8	4.3	10.0	9.76	3.53

Conclusion

It can be concluded that the highest seed yield was produced by mungbean var. BARI Mung-6 followed by BARI Mung -7.

141. ON FARAM TRIAL OF BLACKGRAM VARIETIES IN NETROKONA

M. A. ISLAM, M.M. ZAMAN AND N. SULTANA

Abstract

An adaptive trial of blackgram and a local check was conducted in the farmer field of Rajendrapur, Challisha under Netrakona district during Kharif-II season of 2023 to evaluate the performance and adaptability. The highest seed yield was recorded from BARI Mash-4 (1480 kg ha⁻¹) followed by BARI Mash-3 (1399kg ha⁻¹) and the lowest seed yield was obtained from local check (1280 kg ha⁻¹).

Introduction

Pulses are members of the biggest plant family, Leguminoase. Blackgram (*Vigna mungo*) is a leguminous plant species. This pulse crop has long been farmed in the Indian subcontinent and is not known in its natural condition. It is a drought-resistant crop that is planted both as a summer and winter crop, frequently in rotation with rice but sometimes occasionally in mixed agriculture. It has an inherent ability to fixed atmospheric nitrogen. As a result, these crops fulfill a large portion of their own nitrogen requirements. They also leave nitrogen in the soil, which enriches the soil and makes it viable for crop success. Furthermore, because of their root system and varied maturation time, pulses are well suited to contemporary agriculture's intercropping, relay cropping, and multiple cropping systems (Singh *et al.*, 2017). In the vegetarian diet, pulses constitute the primary source of protein. Mashkalai is a highly valued pulse in Bangladesh. It's cooked and eaten whole or broken into dal. The dried seeds contain approximately 9.7% water, 23.4% protein, 1% fat, 57.3% carbohydrate, 3.8% fibre and 4.8% ash. Bangladesh Agricultural Research Institute has developed high yielding Maskalal varieties but their performances in different growing regions have not been well studied. Therefore, an adaptive trial was conducted to evaluate the performance of those varieties at Netrokona district to increase popularities among the farmers and economic return.

Materials and Methods

The experiment was conducted at farmers' field of Rajendrapur, Challisha under Netrokona district (AEZ-9) of Bangladesh during Kharif-II season of 2023. There were three treatments in the experiment viz. two BARI developed Mashkalai varieties and a local check as notated BARI Mash-3, BARI Mash-4 and local cultivar. The experiment was laid out in a randomized complete block design (RCBD) with three disperse replications. The unit plot size was 8m × 4m. The seeds were sown on 18 Sep. 2023 as a broadcast method and seed rate was 35 kg ha⁻¹. Each unit plot was uniformly fertilized at the rate of 20-40-20-10 kg ha⁻¹ of N-P-K-S, respectively. Entire fertilizers were applied as basal during final land preparation. To collect the data on yield and yield component, 10 plants were randomly selected from each plot prior to harvest. The crop was harvested from 29 November 2023. At harvest, the yield data was recorded plot wise and analyzed statistically with the help of a computer package program STAR.

Results and Discussion

The plant height, branch per plant and 1000 grain weight of tested materials were differed significantly (Table 1). The tallest plant was obtained from BARI Mash-4 (40.00 cm) followed by BARI Mash-3 (32.57 cm) whereas the shortest plant was recorded from local cultivar (28.73 cm). Highest number of branches was found from BARI Mash-3 (4.50), while the lowest number of branches was observed in local check (3.50) which was differed significantly. Pod per plant and seed per pod also found non-significant. The 1000 seed weight of three varieties and local check differed significantly. The highest seed weight was obtained from BARI Mash-4 (50.33 g) whereas local check gave the lowest weight (33.00 g). The seed yield of three tested varieties and local check not differed significantly.

Table 1. Yield and yield attributes of black gram variety in the farmer field of Rajendrapur, Challisha, Netrakona during Kharif-II season of 2023

Variety	Plant height (cm)	Branch per (no.)	Pod per plant (no.)	Seed per pod (no.)	1000-seed weight (g)	Seed yield (kg ha ⁻¹)
BARI Mash-3	32.57	4.50	29.4	6.9	41.67	1399
BARI Mash-4	40.00	4.17	24.03	6.17	50.33	1480
Local cultivar	28.73	3.50	18.97	7.53	33.00	1280
LSD (0.05)	5.80	0.19	ns	ns	5.85	ns
CV (%)	7.58	2.17	29.29	8.53	6.2	8.45

Farmers' opinion: Farmers' are happy having the BARI released Maskalai varieties due to higher yield potentiality and ability to tolerance virus infestation. They showed their keen

interest in growing BARI Mash-3 and BARI Mash-4 for its higher yield potentiality, good taste and economic return.

Conclusion

The performance of Blackgram var. BARI Mash-3 and BARI Mash-4 were found better in terms of yield potentiality.

142. ADAPTIVE TRIAL OF DIFFERENT GENOTYPES OF COWPEA IN COASTAL AREA

M.M. ISLAM, H.M.K. BASHAR AND M.S.I. KHAN

Abstract

The experiment was conducted at Kuakata, Kalapara, Patuakhali during rabi season of 2023-24 to evaluate the performance of cowpea genotypes in coastal area. Two Variety Viz. BARI Felon-1 and Local Felon (Bhola) were evaluated as planting materials for this study. Data were collected on days to maturity, plant height, number of branches per plant, number of leaves per plant, number of pods per plant, number of seeds per pod, 1000-seed weight (g) and seed yield per hectares. BARI Felon-1 gave the better performance in respect of all growth and yield parameters. Higher seed yield (1.52 t ha^{-1}) was obtained from BARI Felon-1 variety whereas lower seed yield (1.15 t ha^{-1}) was obtained by variety Local one (Bhola).

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp] belongs to the family Fabaceae which is one of the oldest crops known to man. It was domesticated from a wild plant to a cultivated plant (Ng and Marechal, 1985). Its grain and fresh leaves are important sources of protein, minerals and vitamins, and thus helps to address malnutrition (Nielsen *et al.*, 1997; Santos *et al.*, 2012). Additionally, it fixes atmosphere nitrogen through symbiosis with nodule bacteria (Shiringani and Shimeles, 2011). It is often referred to as the poor man's meat because it is a significant source of protein, minerals and vitamins (Tharanathan and Mahadevamma, 2003) for the rural poor who have limited access to protein from animal sources such as meat and fish. It is also known as 'vegetable meat' (Singh and Mehndiratta, 1970). This crop is a highly resilient crop and can be cultivated under some of the most extreme agricultural conditions in the world (Muoneke *et al.*, 2012). Farmers commonly grow cowpea by one ploughing and scarcely use fertilizer due to its low yield and lack of proper information. Thus, the yield becomes low. With this background the present study was conducted to determine and compare the physical properties of new cowpea genotype against BARI Felon-1. Therefore, this activity was carried out to evaluate the performance of cowpea genotypes and to increase yield in coastal area.

Materials and Methods

On farm trial program with two varieties e.g. BARI Felon-1 and Local variety (Bhola) were conducted at Kuakata, Kalapara, Patuakhali in coastal area during rabi season of 2023-24. The seeds of cowpea @ 50 kg ha^{-1} were used having unit plot size $10 \text{ m} \times 10 \text{ m}$. Seeds were sown on 27 January, 2024 according to plots in line 30 cm apart. The land was fertilized with N_{13} , P_9 , K_{15} and $\text{B}_2 \text{ kg ha}^{-1}$ at the time of final land preparation. Weeding was done at 25 days after sowing followed by thinning to keep plant to plant distance of 10 cm. Other intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml L^{-1} to control insect pests such thrips and pod borers, respectively. The crops of 1 m^2 ($1 \text{ m} \times 1 \text{ m}$) in each plot were harvested by hand picking of pods at different dates as depends on maturity. Crops were harvested 25 April, 2024. Seed yield was recorded at 10-12% moisture content. The yield and other relevant data were recorded and analyzed statistically.

Results and Discussion

The performance of two varieties of cowpea in terms of plant height, number of branches per plant, number of leaves per plant and yield and yield components are presented in Table 1 and 2, respectively. Shorter days to maturity (105 days) were found in Local Felon (Bhola) and the longer (116 days) in BARI Felon-1. Among the two varieties, maximum seed yield was recorded from BARI Felon-1 (1.52 t ha⁻¹) and lower yield 1.15 t ha⁻¹ was found in Local Felon (Bhola). Therefore, out of two varieties, BARI Felon-1 performed better on the basis of yield and yield contributing characters than another variety Local one (Bhola). The seed color of the BARI Felon is somewhat mosaic but the Bhola local are black in color. Salinity level varies 1.98 to 9.05 dS/m from sowing to harvesting period (Fig.1). Salinity level indicates BARI felon-1 capable to produce more yield compare to local varieties.

Table 1. Growth and phenological parameter of cowpea varieties during Rabi 2023-24

Varieties	Days to maturity	Plant height (cm)	Branches/plant
BARI Felon-1	116	58.36	3.52
Local Felon (Bhola)	105	42.15	2.43
P-value	1.68	3.24	0.57

Table 2. Yield and yield components of cowpea varieties during Rabi 2023-24

Varieties	Pods plant ⁻¹	Seeds pod ⁻¹	1000-seed weight (g)	Pod yield (t ha ⁻¹)	
				2023-24	2022-23
BARI Felon-1	11.12	13.08	99	1.52	1.49
Local Felon (Bhola)	9.12	10.65	122	1.15	1.17
P-value	0.98	2.78	6.57	0.47	1.09

Effect on salinity

Cowpea crop can tolerate more salinity than other pea varieties. Salinity level of the experimental plots was 0.63 during seed sowing then it increased with time up to 9.07 dS/m throughout the harvesting stage (Fig. 1). At the stage of pod bearing, the value of soil salinity was found 6.02 dS/m. Among the varieties BARI Felon-1 showed higher saline stress compare to local variety of its higher yield and yield contributing characters.

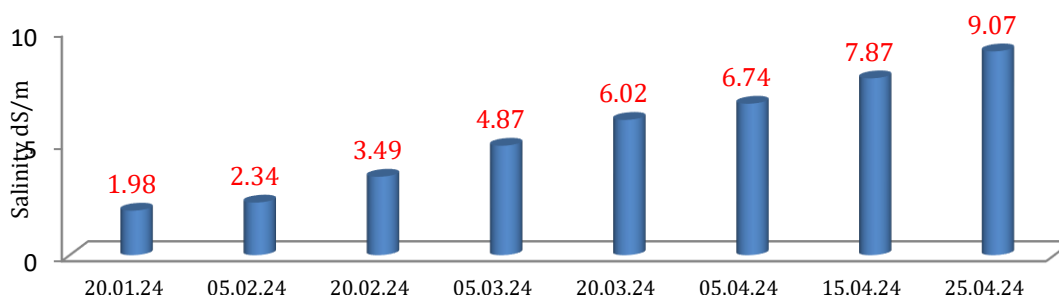


Fig-1: Salinity level of the experimental plots

Farmers' opinion

Farmers opined that they are still very happy with the yield of BARI Felon-1 in coastal region. They also opined that yield performance of Felon relaying with Aman rice is reducing day by day. They committed to continue the cultivation of BARI Felon-1 in coastal region in tillage condition but not relay condition. Because relay cropping needs more seeds and more time to harvesting.

Conclusion

Cowpea var. BARI Felon-1 is very well adopted to the agro-ecological conditions of the coastal area of Bangladesh. Bhola local yield is lower than BARI Felon-1.

143.ON-FARM TRIAL OF WINTER TYPE ONION VARIETIES IN DIFFERENT LOCATION OF BANGLADESH

Abstract

A field trial on onion was carried out at charland of Saghata, Gaibandha during the winter season of 2023-24 to evaluate the performance of onion varieties in winter season and to popularize onion varieties among the farmers in char areas. The varieties were BARI Piaz-1, BARI Piaz-4 and BARI Piaz-6. The bulb highest yield produced by BARI Piaz-4 (15.57 t ha⁻¹), followed by BARI Piaz-6 (11.38 t ha⁻¹) and BARI Piaz-1 (9.58 t ha⁻¹) whereas the lowest yield was produced by local cultivar (8.95 t ha⁻¹). Similarly, the highest gross return and gross margin of Tk. 544950 ha⁻¹ and Tk. 338700 ha⁻¹, respectively, was also found from BARI Piaz-4.

Introduction

Onion (*Allium cepa* L.) is the most important crop among other spice crops. It ranks first among the major spice crops in Bangladesh with a production of 2.52 million ton (Mt) from an area of 0.21 million hectare (Mha) of land, covering 48% of the total area under spices (BBS 2022). The per capita availability of onion for domestic use is now 7.1 kg and it is increasing day by day. In Gaibandha, currently about 1193 hectares of land under onion cultivation and most of it is char land and the area is increasing day by day (BBS, 2022). Char land is very fertile as silt accumulates on the land surface every year and char land are naturally loamy which is suitable for onion cultivation. Therefore, onion cultivation in char areas can be one of the options to increase the total production of onion across the country. The Spices Research Center of BARI has developed some high yielding varieties that can be successfully cultivated in char areas. Hence a trial was conducted to evaluate the performance of onion varieties in the charland of Gaibandha.

Materials and Methods

The experiment was conducted at charland of Saghata, Gaibandha during 2023-24 under the supervision of OFRD, Gaibandha. The experiment was laid out in a RCBD with three (dispersed) replications. Three onion varieties viz. BARI Piaz-1, BARI Piaz-4 and BARI Piaz-6 were evaluated along with local cultivars. The unit plot size was 5 m × 3 m. Seeds were sowing on 25-30 November 2023. The land was fertilized with 120-54-75-20 kg N-P-K-S ha⁻¹ in the form of urea, TSP, MOP, and gypsum, respectively. The entire quantity of TSP, MoP, Gypsum and half of urea were applied as basal during final land preparation. The remaining half of urea were applied in two equal splits at 25 and 50 days after sowing (DAS). Eight to ten irrigations were used. Weeding was done as and when necessary. There were some tips burn and thrips infestation of onion that was well controlled by Luna sensation @ 1 ml L⁻¹ and admire @ 0.5 ml L⁻¹. The crop was harvested on 1-7 April 2024. Ten plants of each variety from each replication were selected randomly to collect data on yield components. Data on yield and yield attributes were taken and analyzed statistically using STAR software at 5% level of significance (p<0.05). Benefit cost analysis was performed considering the prevailing price of onion at the harvesting period in the local market.

Results and Discussion

The highest bulb yield (15.57 t ha⁻¹) was produced by BARI Piaz-4 (Table-1). The highest bulb production by BARI Piaz-4 was due to significant highest individual bulb weight (54.7 g). On the other hand, the lowest bulb yield was produced from the local cultivar with a value of 8.95 t ha⁻¹. The plant height ranged from 47.7 to 51.2 cm and the average leaves plant⁻¹ ranged from 8.1 to 10.2, with no significant difference among the varieties.

The highest gross return (Tk. 544950 ha⁻¹) and gross margin (Tk. 338700 ha⁻¹) was observed from BARI Piaz-4 due the significant highest bulb production despite a lower market price compared to BARI Piaz-1 and BARI Piaz-6. The lowest gross return (Tk. 402750 ha⁻¹) and gross margin (Tk. 217450 ha⁻¹) was also recorded in local cultivar. (Table 2).

Insect and pest incidence:

Table 1. Yield and yield parameters of onion varieties at Saghata, Gaibandha during 2023-24.

Treatment	Plant height (cm)	Leaves plant ⁻¹ (no.)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)
BARI Piaz-1	48.3	9.5	31.2	9.58
BARI Piaz-4	51.2	10.2	54.7	15.57
BARI Piaz-6	49.6	8.4	38.3	11.38
Local cultivars	47.7	8.1	30.5	8.95
LSD (0.05)	ns	ns	7.73	3.81
CV (%)	11.2	9.8	9.3	12.1

Table 2. Cost and return analysis of onion varieties at Saghata, Gaibandha during 2023-24.

Treatment	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
BARI Piaz-1	431100	206250	224850	1.35
BARI Piaz-4	544950	206250	338700	6.79
BARI Piaz-6	512100	206250	305850	5.22
Local cultivars	402750	185300	217450	-

* Onion price BARI Piaz-1 and BARI Piaz-6= 45 Tk kg⁻¹ and BARI Piaz-4= 35 Tk kg⁻¹

Farmer's opinion

Farmers are pleased with the onion varieties developed by BARI and prefer BARI Piaz-1 and BARI Piaz-6 for their high market prices despite lower yields. Additionally, some farmers are interested in cultivating BARI Piaz-4 because of its higher yield potential, shape, size, and appealing color. They have also requested seeds for next year's cultivation in Charland.

Conclusion

Onion var. BARI Piaz-1 appeared to be better in respect to yield and profit in char land of Gaibandha as compared to local variety.

144. ON-FARM TRIAL OF CORIANDER LEAF CULTIVATION IN KISHORGANJ

M.MOHIUDDIN AND M.Y.H. RAYHAN

Abstract

The experiment was conducted at Kuliarchar, Kishoreganj during the rabi season of 2023-2024 to popularize the coriander varieties at farmers' fields. Six varieties were selected for this experiment viz; BARI Dhonia-2, Faizer, Ispahani, Jamal and Vairab seed. The highest leaf yield was obtained from Jamal seed variety (6.89 tha⁻¹) and the lowest from BARI Dhonia-2 (4.20 tha⁻¹). The highest gross return (Tk. 137800 ha⁻¹), gross margin (Tk. 69300 ha⁻¹) and BCR (2.01) were calculated from Jamal seed.

Introduction

Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant with a hollow stem that belongs to the apiaceae family. It is an excellent source of Vitamin A and Vitamin C & packed with fiber, magnesium, protein and many other elements that are making it beneficial for health. It is a crop with high commercial turnover, due to its short cycle (on average 30 to 40 days) and good emergence, generating a fast economic return for producers, which is one of the main reasons for its presence in vegetable farming (PEREIRA *et al.*, 2011). Coriander can be used in all type of curries, pickles. Coriander soups and juices are also popular. The leaves contain 52.10 g/100g carbohydrates, 21.93g/100g proteins and 1246 mg/100g calcium, respectively (Anon., 2013). Kuliarchar of Kishoreganj is very famous for coriander leaf cultivation. Farmers here usually cultivate coriander almost throughout the year. They are not very familiar with the varieties of coriander released by BARI and they used various private companies' hybrid seeds for the

production of coriander. As a result, the cost of production is very high. If we can replace this hybrid variety with BARI released coriander varieties, then the production cost of the farmer will be reduced and at the same time the BARI released coriander varieties could be expanded.

Materials and Methods

The experiment was conducted at Kuliarchar, Kishoregonj during the year 2023-24 to know the performance of BARI released coriander varieties in that area. The design was RCBD with three replication. Six varieties were selected for this experiment viz; BARI Dhonia-2, Faizer, Ispahani, Jamal and Voirab seed. The unit plot sizes were 9 m × 4.5 m². Broadcast method was followed as farmers choice. Coriander seed were sown on 13 November 2023. The recommended fertilize doses were applied as N₈₂ P₂₅ K₆₅ S₂₅ Zn₄B₂kg⁻¹ respectively. Half of urea and MoP and all others fertilizers were used at final land preparation. Harvesting of leaf started from 27th December 2023 and ended at 12th January 2024. Data on yield and yield contributing characters were recorded and analyzed for report writing.

Result and Discussion

Yield and yield contributing characters of coriander leaf cultivation has shown table 1. The highest germination rate was obtained from jamal seed (95%) and lowest from Voirab seed (81%). Ispahani seed took lowest time to start its germination (5 days), on the other hand BARI Dhonia-2 took highest time to start its germination (11 days). Highest leaf yield was obtained from Jamal seed (6.89 tha⁻¹) and the lowest from BARI Dhonia-2 (4.20 tha⁻¹). The highest gross return (Tk. 137800 ha⁻¹), gross margin (Tk. 69300 ha⁻¹) and BCR (2.01) were calculated from Jamal seed and lowest from Voirab (Tk. 96000, 27500 ha⁻¹ and 1.40, respectively).

Farmers' opinion: Farmers didn't accept BARI released coriander variety BARI Dhonia-2 due to low rate of germination and low yield but smell is excellent than other varieties, As a result market demand and price was more than others.

Table 1. Yield and yield contributing characters of coriander leaf during 2023-24

Varieties	Date of sowing	Days to germination started (DAS)	Days to 50% germination (DAS)	Germination (%)	Days to full germination (DAS)
BARI Dhonia-2	13/11/2023	11	18	83	25
Faizer seed	13/11/2023	7	10	88	12
Ispahani seed	13/11/2023	5	8	90	10
Jamal seed	13/11/2023	6	8	95	10
Vairob seed	13/11/2023	10	13	81	16

Table 2. Yield and economic analysis of coriander leaf cultivation in Kishoreganj during 2023-24

Variety	Leaf yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR over TVC
BARI Dhonia-2	4.2	105000	68500	36500	1.53
Faizer seed	5.6	112000	68500	43500	1.64
Ispahani seed	6.68	133600	68500	65100	1.95
Jamal seed	6.89	137800	68500	69300	2.01
Voirab seed	4.8	96000	68500	27500	1.40

*TVC includes land preparation, labour, seed, fertilizers and insecticides, Price (Tk. kg⁻¹): Coriander leaf-20, BARI Dhonia-2=25.

Conclusion

However, most results are obtained during just one growing season, and there is little research on the productive potential and financial return of the coriander leaf cultivation as a function of local weather factors.

145. ON-FARM TRIAL OF CHILLI VARIETIES AT FARMERS FIELD

M.A. ISLAM, M.M. ZAMAN AND N. SULTANA

Abstract

The experiment was conducted at farmers' field of Rajendrapur, Netrakona during rabi season of 2023-2024 to evaluate their performance. The highest chilli yield was obtained from BARI Morich-4 (13.82 t ha⁻¹) followed by BARI Morich-3 (11.43 t ha⁻¹). The highest gross return and gross margin (Tk. 553000 & 434480 ha⁻¹) was observed in BARI Morich-4. The variety BARI Morich-3 also gave an attractive gross return and gross margin (Tk. 457000 and 338480 ha⁻¹).

Introduction

Chilli (*Capsicum annuum* L.) is a major spices crop grown both winter and summer season in Bangladesh. It is available and used in the form of green, dried and powdered. It has become an essential ingredient in Bangladeshi meals. Red chillies contain large amounts of vitamin-C and small amounts of carotene (provitamin-A). Green chillies (unripe fruit) contain a considerably lower amount of both substances. Chilli crop occupy an important place with a wide geographical distribution in various climatic regions viz., tropical, sub-tropical and temperate (Hazra *et al.*, 2011). Lack of suitable high yielding varieties with adaptation to local condition is a factor that affects the yield of Chilli. So there is huge scope to replace low yielder varieties to high yielder one with testing their adaptability. With these views, the present study was undertaken to evaluate the performances the chilli varieties at farmer's field for higher yield and economic return.

Materials and Methods

The experiment was conducted at farmers' field of Rajendrapur, Netrakona during rabi season of 2023-2024. The study was conducted following randomized complete block design with six replications. The trial was consisted of three BARI released chilli varieties i.e. BARI Morich-3, BARI Morich-4 and BARI Morich-5 with a local check. The unit plot size was 5.0m × 4.0 m. Forty five days old seedlings were transplanted with a spacing of 50 cm × 50 cm. Date of transplanting on 14 December, 2023 at Rajendrapur, Netrakona. The crop was fertilized with 130-60-50-15-1.5-1.5 kg ha⁻¹ N-P-K-S-Zn-B ha⁻¹ in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Ten ton cowdung per hectare was also incorporated during final land preparation. Entire TSP, gypsum, zinc sulphate and boric acid; 1/3rd Urea and MoP were applied at the time of final land preparation. Rest of urea and MoP were applied in to three equal installments at 25, 50 and 75 days after transplanting. The field was kept clean by weeding and irrigation was done as and when necessary. Pest and diseases management was also done as and when necessary. There having thrips and mite infestation in some plant and was controlled by spraying with recommended insecticide. The green chilli was harvested from 04 March, 2024 and continued upto 1st week of May, 2024. Ten plants of each variety from each replication were selected randomly to collect the data on yield components. The yield was calculated in ton per hectare considering the whole plot as harvesting area. Collected data were analysed statistically test with STAR software at 5% level of significance. Benefit cost analysis was performed considering the prevailing price of chilli at the harvesting period in the local market.

Results and Discussion

The varietal performance had significant effect on yield and yield contributing characters (Table 1). The tallest plant was found from BARI Morich-4 (84.53 cm) and the shortest plant was found from local cultivar (58.65 cm). The highest number of branches was obtained from BARI Morich-4 (5.92) followed by BARI Morich-3 (4.85) and lowest branch was found from local cultivar (3.12). The range of number of branches per plant was found from 3.12 to 5.92. The maximum number of fruits per plant was obtained from BARI Morich-4 (393.25) and the minimum number of fruits per plant was obtained from local cultivar (105.97). A longer fruit was recorded in BARI Morich-4 (9.47 cm) and local check gave the shortest chilli fruit (5.47 cm). The highest chilli yield

per hectare was recorded in BARI Morich-4 (13.82t ha⁻¹) followed by BARI Morich-3 (11.43 t ha⁻¹), it might be due to number of fruits per plant contributed to higher yield. The lowest yield was obtained from local cultivar (9.59 t ha⁻¹).

The gross and gross were varied among the tested chilli varieties (Table 2). The highest gross return in the context of the study period was observed (Tk. 553000.00 ha⁻¹) in BARI Morich-4 and that by the gross margin (Tk.434480.00ha⁻¹) was also maximum in the same treatment might be due the higher yield potentiality. The lowest gross return (Tk. 383000.00ha⁻¹) and gross margin (Tk. 164480.00 ha⁻¹) was also recorded in lowest yield giving treatment local check.

Farmers' opinion: Farmers showed their keen interest in cultivating BARI Morich-4 and BARI Morich-3as those are high yield potential, hot in taste and green color.

Table 1. Yield and yield contributing characters of different Chilli varieties at Rajendrapur, Netrakona during rabi season of 2023-2024.

Varieties	Plant height (cm)	No. of branch plant ⁻¹	No. of fruits plant ⁻¹	Fruits length (cm)	Green Chili yield (t ha ⁻¹)
BARI Morich-3	73.47	4.85	190.3	8.40	11.43
BARI Morich-4	84.53	5.92	393.25	9.47	13.82
BARI Morich-5	73.38	3.50	108.55	6.25	10.75
Local cultivar	58.65	3.12	105.97	5.47	9.57
LSD (0.05)	12.71	0.93	66.79	0.94	1.49
CV (%)	10.97	13.43	20.93	7.96	8.23

Table 2. Cost and return analysis of Chilli (green) varieties at Rajendrapur, Netrakona during rabi season of 2023-2024

Varieties	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Morich-3	457000	118520	338480
BARI Morich-4	553000	118520	434480
BARI Morich-5	430000	118520	311480
Local cultivar	383000	118520	264480

Price of input and output: Urea: 27.00 Tk. kg⁻¹, TSP: 27.00 Tk. kg⁻¹, MOP: 20.00 Tk. kg⁻¹, Gypsum: 12.00 Tk. kg⁻¹, Zinc sulphate: 280.00 Tk. kg⁻¹, Boric acid: 340.00 Tk. kg⁻¹, Market price of green Chilli40Tk. kg⁻¹

Conclusion

Cultivar BARI Morich-4 followed by BARI Morich-3 for high yield potential and economic performance. This trial may repeat one more year for final recommendation.

146.ON FARM TRIAL OF TURMERIC VARIETIES

M M HOWLADER, D HALDER, MM ALAM, M AHMAD AND MH RAHMAN

Abstract

On farm trial of turmeric varieties were conducted at the farmers' field of Gopalganj and Narsingdi region during rabi season in 2023-24. Four turmeric varieties are evaluated under this experiment viz. BARI Halud-3, BARI Halud-4, BARI Halud-5 and local turmeric to select a suitable variety. The significantly highest yield was found from BARI Halud-4 (34.74 and 28.76 tha⁻¹) and the lowest found from local variety (20.49 and 11.50 tha⁻¹) in Gopalganj and Narsingdi respectively. In case of, financial analysis, BARI Halud-4 gave the highest gross return (Tk. 1042200 and 488920 ha⁻¹), gross margin (Tk. 783700 and 3337304 ha) in Gopalganj and Narsingdi respectively. The lowest gross return (Tk. 614700 and 195500 ha⁻¹), gross margin (Tk. 356200 and 43884 ha⁻¹) found in local variety in Gopalganj and Narsingdi respectively.

Introduction

In Bangladesh total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Turmeric (*Curcuma longa*) is one of the most important spice crops in Bangladesh as well as in south Asia. Local variety covers the greater portion of turmeric growing areas in Gopalganj. Farmers traditionally practice this low yielding local variety for its production and thus get poor yield. If they practice and accept the BARI developed high yielding turmeric variety, they have the possibility to obtain smart yield. Therefore, the study was undertaken to find out the appropriate variety for turmeric.

Material and Methods

The experiment was conducted at the farmers' field of Gopalganj and Narsingdi region during rabi season in 2023-24 to select suitable variety(ies) of turmeric for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI Halud-3, BARI Halud-4; BARI Halud-5 and local variety. The unit plot sizes were 20 m x 10 m. The mother rhizomes were planted on 25 March to 18 June 2023, maintaining 60 cm x 25 cm spacing @ seed rate 1.5 t ha⁻¹. The recommended fertilize doses N-P-K-S-Zn-B @ 140-40-80-15-3-1.5 and 105-30-120-15-3-1.4 were maintained in Gopalganj and Narsingdi respectively. Half of urea and MoP and all other fertilizers were used at final land preparation. The remaining part of urea and MoP fertilizer were 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 were done after 80-90 DAS & 110-120 DAS respectively. This year did not appear any major disease of turmeric. Nevertheless, mancozeb and otostine were applied to control leaf blotch and rhizome rot of turmeric. The crop were harvested at 1-28 March 2024. Data on yield and yield attributes were collected and analyzed statistically.

Results and Discussion

Yield and yield contributing characters have shown table 1. The highest plant height (137.50 cm and 124.00 cm) was found BARI Halud-5 and the lowest (108.25cm and 75.67 cm) was found from local variety for Gopalganj and Narsingdi respectively. The highest number of tillers plant⁻¹ was recorded from BARI Halud-5 (4.20 cm) and BARI Halud-4 (16 cm) and the lowest (2.70 cm and 5.67 cm) was found from local variety, Gopalganj and Narsingdi respectively. Finally, the highest yield (34.74 and 28.76 tha⁻¹) was found from BARI Halud-4 and lowest was found from local variety (20.49 and 11.50 tha⁻¹) for Gopalganj and Narsingdi respectively. In case of economic return, the highest gross return (Tk. 1042200 and 488920 ha⁻¹), gross margin (Tk. 783700 and 337304 ha⁻¹) was found from BARI Halud-4 and the lowest gross return (Tk. 614700 and 195500 ha⁻¹), gross margin (Tk. 356200 and 43884 ha⁻¹) was found from local variety for Gopalganj and Narsingdi respectively.

Table 1. Yield and yield contributing characters of turmeric during the of year 2023-24

Locations	Treatments (Varieties)	Plant height (cm)	No. of tillers plant ⁻¹	Weight of Rhizome plant ⁻¹ (g)	Weight of corm/ finger plant ⁻¹ (g)	Rhizome yield (t ha ⁻¹)
Gopalganj	BARI Halud-3	117.93	3.57	356.50	45.85	29.15
	BARI Halud-4	125.32	4.20	392.70	49.93	34.74
	BARI Halud-5	137.50	3.76	318.80	37.47	26.07
	Local variety	108.25	2.70	205.50	33.96	20.49
	CV (%)	7.33	9.45	4.11	5.98	6.42
	LSD (0.05)	9.22	0.70	20.15	6.85	4.07
Narsingdi	BARI Halud-4	113.67b	16.00a	479.33a	150.00a	28.76a
	BARI Halud-5	124.00a	14.00a	284.00b	112.00b	17.04b
	Local variety	75.67c	5.67b	191.67c	96.00c	11.50c
	CV (%)	2.70	10.11	6.95	4.51	6.95

Table 2. Economic performance of turmeric during the year 2023-24

Locations	Treatments	GR (Tk.ha ⁻¹)	TVC (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
Gopalganj	BARI Halud-3	874500	258500	616000
	BARI Halud-4	1042200	258500	783700
	BARI Halud-5	782100	258500	523600
	Local variety	614700	258500	356200
Narsingdi	BARI Halud-4	488920	151616	337304
	BARI Halud-5	289680	151616	138064
	Local variety	195500	151616	43884

Narsingdi: BARI Halud-4 and BARI Halud-5 Tk. 17/kg and local variety Tk. 20/kg Gopalganj: Halud= 30 tk. kg⁻¹

Conclusion

Turmeric var. BARI Halud-4 performed better regarding yield potentiality and economic return whereas compare to local variety.

147.ON-FARM TRIAL OF BARI DEVELOPED SWEET PEPPER VARIETIES IN HILLY AREAS OF BANDARBAN

M. T. ISLAM, I. HOSSAIN, M. F. HOSSAIN and M. M. ANOWAR

Abstract

On-Farm trial of sweet pepper varieties was conducted at Reicha and Sualok of Bandarban Sadar under two different technologies (Net and Without net) during 2023-24. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatments were: T₁= BARI Mistimorich-1, T₂= BARI Mistimorich-2, T₃= Astha Mistimorich, and T₄= Green Cape. There were significant differences among the treatments. In the case of open field, the highest individual fruit weight (164.92 g) and average fruit yield (21.65 t ha⁻¹) were found from Green Cape and the lowest from BARI Mistimorich-1 (115.90 g, 12.96 t ha⁻¹). At protective condition, the highest individual fruit weight (171.32 g) and average fruit yield (25.84 t ha⁻¹) were also found from Green Cape and the lowest from BARI Mistimorich-1 (120.23 g, 17.18 t ha⁻¹). Maximum pest infestation was found in Astha mistimorich (20.83%) in open fields.

Introduction

Sweet pepper (*Capsicum annuum* L.) belongs to the family Solanaceae is an important nutritious vegetable grown extensively in almost every country especially temperate countries of the world (Greenleaf, 1986). Sweet pepper is popularly known as capsicum and may be eaten as cooked, raw as well as salad. Capsicum is rich in vitamin A, vitamin C, carbohydrates, proteins, fiber, and unsaturated fatty acid and for having capsaicin, capsanthin, carotenoids, and antioxidant properties it has great medicinal value (Aminifard et al. 2012). This crop is well adapted to temperature ranged from 16-25°C. This is very sensitive to environmental factors viz. both biotic and abiotic factors (Bhatt et al., 1992). Fruit setting is largely affected by high temperature at night than day temperature. On the contrary, blossom dropping also occurred at below 16° C night temperature and above 32° C day temperature (Rylski and Spigelman, 1982; Boswell, 1964). In Bandarban, from December to January night temperatures usually don't go below 10° C or less which is detrimental to both the vegetative and fruiting stage of sweet pepper. So, there might be a large potentiality of growing sweet pepper in this area. Again, the prevalence of severe powdery mildew and mite infestation in plants is common when there are longer periods of temperatures between 10 to 15° C and daytime RH between 85 to 95% (Elad et al. 2007). So, these environmental factors need to be considered seriously. On the other hand, the demand of high value crops like sweet pepper is increasing day by day in tourist places like Bandarban. But to meet the local demand, consumers and vegetable sellers have to be dependent on other districts. In the near past, no intervention was taken to evaluate sweet pepper varieties or

production technologies in the Bandarban region. Considering these facts, the present study was undertaken to evaluate BARI-released promising sweet pepper varieties.

Materials and Methods

On-Farm evaluation of sweet pepper was done at Shwarnamondir, Reicha and Sualok of Bandarban Sadar under two different technologies (Net and Without net). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatments were: T₁= BARI Mistimorich-1, T₂= BARI Mistimorich-2, T₃= Astha Mistimorich and T₄= Green Cape. For net-protected structures, the height of the structure was 1.0 meter above the soil surface. White-colored polythene of 0.5mm thickness and 120 mesh white nylon net were used to place over the structure for covering the plants. The seeds were sown in seedbed on 13 October 2023. Thirty days old and healthy seedlings were finally transferred to the experimental field. The unit plot size was 3.2 m × 1.0 m and the plants were spaced 60 cm × 40 cm between plant-to-plant and row-to-row, respectively. Intercultural operations such as watering, weeding, gap filling, earthing up etc. were done as and when necessary. A recommended fertilizer dose with cowdung, urea, TSP, MoP, gypsum and ZnO @5 tha⁻¹, 217 kgha⁻¹, 333 kgha⁻¹, 200 kgha⁻¹, 111 kg/ha and 5 kgha⁻¹, respectively was applied (Saha, 2001). Harvesting of the green fruits was done when they were relatively firm and crispy. Data were collected on growth, yield and yield related parameters and statistically analyzed with the help of STATISTIX-10 software.

Results and Discussion

Open field condition: Yield and yield attributing characteristics of sweet pepper varieties are presented in Table 1. The highest individual fruit weight (164.92 g) and average fruit yield (21.65 t ha⁻¹) were found from Green Cape and the lowest from BARI Mistimorich-1 (115.90 g, 12.96 t ha⁻¹). Maximum pest infestation was found in Astha mistimorich (20.83%) in the open field.

Protective System (Net house): Significant variation was observed among the treatments for all the parameters observed in this experiment (Table 2). Yield and yield attributing characteristics of sweet pepper varieties are presented in Table 2. The highest individual fruit weight (171.32 g) and average fruit yield (25.84 t ha⁻¹) were found from Green Cape and the lowest from BARI Mistimorich-1 (120.23 g, 17.18 t ha⁻¹). Maximum pest infestation was found in BARI Mistimorich-1 (15.28%) in the net house.

Table 1. Yield and yield attributing characteristics of sweet pepper varieties in hill valleys of Bandarban at open field condition

Treatments	Plant height (cm)	Fruits/plant	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Infected plant (%)	Fruit yield (tha ⁻¹)
T ₁	49.69	5.61	7.79	6.57	115.90	19.45	12.96
T ₂	47.98	6.67	8.41	6.86	123.15	13.89	18.19
T ₃	51.97	6.69	8.45	7.1	152.25	20.83	19.80
T ₄	48.44	5.25	9.36	7.61	164.92	19.45	21.65
LSD (0.05)	4.11	0.92	0.65	0.32	8.84	5.72	1.83
CV (%)	4.16	7.57	3.81	2.24	3.18	15.56	5.05

T₁= BARI Mistimorich-1, T₂= BARI Mistimorich-2, T₃= Astha Mistimorich and T₄= Green Cape

Table 2. Yield and yield attributing characteristics of sweet pepper varieties in hill valleys of Bandarban at protective condition

Treatment s	Plant height (cm)	Fruits/p lant	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Infected plant (%)	Fruit yield (tha ⁻¹)
T ₁	53.8	6.17	8.82	6.81	120.23	15.28	17.18
T ₂	52.26	7.04	9.58	6.85	125.83	11.11	20.84
T ₃	56.71	5.75	9.44	8.68	160.68	13.89	24.25
T ₄	58.42	6.02	9.4	7.85	171.32	8.33	25.84
LSD (0.05)	2.3	0.7	0.25	0.46	19.11	6.21	1.53
CV (%)	2.08	5.63	1.34	3.06	6.62	15.67	3.48

148. ADAPTIVE TRIALS WITH BARI BARLEY VARIETIES IN CHAR AREAS AND HIGH BARIND TRACT

M.U.S. KHATUN, G. PAUL, M.A. RAHAMAN, S. ROY, K. ROY, T. TASMIMA, M.J. ALAM, M.S. RANA, A.A. MAHMUD, M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

A set of experiment were conducted to assess the performance and popularize of BARI barley varieties (BARI Barley-7, BARI Barley-8 and BARI Barley-9) in char areas of Tangail and Gaibandha districts, and drought-prone areas Godagari Rajshahi district during 2023-24. Among the tested barley varieties BARI Barley-9 performed better in char areas of Gaibandha and drought prone areas of Rajshahi. The average highest grain yield recorded from BARI Barley-9 (1.96 t ha⁻¹) followed by BARI Barley-7 (1.93 t ha⁻¹) whereas the lowest was from local variety (0.99 t ha⁻¹).

Introduction

Barley (*Hordeum vulgare*) is recognized as the most adaptable cereal crop for diverse environments, including char lands and drought prone areas, compared to other cereals. Nutritionally, barley is superior to wheat, containing about 11.5% protein—almost double that of rice—and soluble fiber that helps lower blood cholesterol and reduce the risk of cardiovascular disease. It is also rich in minerals like niacin (vitamin B3), thiamine (vitamin B1), selenium, iron, manganese, zinc, phosphorus, and copper. Despite its ability to thrive in less fertile soil with minimal inputs, barley remains a minor crop in Bangladesh.

The vast char area of Bangladesh remains fallow where crop intensification is the major challenge. Cultivation of heat-tolerant grain crops like wheat and barley can bring substantial change in the agricultural practice towards increased crop productivity in the country. In Bangladesh, barley is usually cultivated in the less fertile char regions with minimal inputs, and it continues to be a secondary crop. The extensive char lands are often unused, posing considerable challenges for increasing crop production. In the last three years, the area and production of barley have decreased by half, with recent data indicating a production of only 172 tons from 453 acres (BBS, 2022). To achieve greater cropping intensity, barley could be grown profitably in the char areas and the High Barind Tract, where drought and water stress prevent the cultivation of most crops during the dry season. BARI has recently developed some high-yielding barley varieties which have the potential to grow in harsh environments with satisfactory yield. Therefore, the field trial was undertaken to evaluate the performances of the barley varieties in char areas of Tangail and Gaibandha, and high barind of Rajshahi and to get feedback from the farmers on barley cultivation in those areas.

Materials and Methods

The trial was conducted in a char land situation at the MLT site Bhuapur of Tangail, Saghata of Gaibandha and FSRD site, Basantapur, Godagari of Rajshahi during the *Rabi* 2023-24 to evaluate the performance of newly developed BARI barley varieties and to get feedback on barley varieties from the farmers. Three BARI varieties of barley viz., BARI Barley-7, BARI Barley-8 and BARI Barley-9 were tested in these areas. In Tangail local cultivar was used as check. Crop management practices used in different locations is stated in table 1. The unit plot size was 8 m x 5 m in Tangail whereas in Gaibandha and Rajshahi, it was 10 m x 10 m. Seeds were sown on 21 November to 11 December, 2023 as line sowing (row to row distance 25 cm, continuous sowing) method @ 100-120 kg ha⁻¹ seed. All the fertilizers were incorporated with soil during final land preparation. Intercultural operations viz., weeding and thinning were done when necessary. No remarkable disease and pest infestation were observed in the field. Some birds attacked the spike during the pre-mature stage in Tangail which was tried to prevent manually by the farmers themselves. The crop was harvested during 01-23 March 2024.

Table 1. Crop management practices used in different locations during the year 2023-24

Location	Variety	Unit plot size	Sowing time	Fertilizer dose (N-P-K-S kg ha ⁻¹)	Harvesting time with DAS
Bhuapur, Tangail	BARI Barley-7, BARI Barley-9 and Local	8 m x 5 m	21 November, 2023	100-60-40	04 March, 2024
Saghata, Gaibandha	BARI Barley-7, and BARI Barley-9	10 m x 10 m	25-26 November, 2023	100-60-40	1-20 March, 2024
Godagari, Rajshahi	BARI Barley-7, BARI Barley-8 and BARI Barley-9	10 m x 10 m	11 December, 2023	100-60-40-1	23 March, 2024

Results and Discussion

The grain yield (t ha⁻¹) across the locations ranged from 0.99- 2.30 t ha⁻¹, where BARI Barley-9 (2.30 t ha⁻¹) produced the highest grain yield followed by BARI Barley-7 (2.16 t ha⁻¹) in Gaibandha, and BARI Barley-9 (1.98 t ha⁻¹) in Rajshahi and the lowest observed from local variety (0.99 t ha⁻¹) in Tangail. Considering the locations, the average maximum grain yield was produced in Gaibandha (2.23 t ha⁻¹), followed by Rajshahi (1.85 t ha⁻¹) whereas the average minimum grain yield was recorded in Tangail (1.45 t ha⁻¹). Among the varieties, the average maximum grain yield was produced by BARI Barley-9 (1.96 t ha⁻¹), followed by BARI Barley-7 (1.93 t ha⁻¹) whereas the lowest was observed from local variety (0.99 t ha⁻¹).

The cost and return analysis (Table 3) showed that the highest gross return was obtained from BARI Barley-9 (Tk. 127400 ha⁻¹) followed by BARI Barley-7 (Tk. 125450 ha⁻¹). Similar trends were also observed in the gross margin. The average cultivation cost was Tk. 54467 ha⁻¹.

Farmers' opinion: Farmers have expressed a strong interest in BARI Barley-7 and BARI Barley-9 owing to their higher yield potentials, lack of awns, and reduced vulnerability to pests and diseases. They are keen on ensuring a consistent supply of seeds throughout the growing season.

Table 2. Yield (t ha⁻¹) of different barley varieties in different locations during 2023-24

Varieties	Grain yield (t ha ⁻¹)			Mean
	Tangail	Gaibandha	Rajshahi	
BARI Barley-7	1.76	2.16	1.86	1.93
BARI Barley-8	-	-	1.71	1.71
BARI Barley-9	1.61	2.30	1.98	1.96
Local	0.99	-	-	0.99
Mean	1.45	2.23	1.85	-

Table 3. Benefit-cost of barley varieties during the year 2023-24 (average of all locations)

Variety	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Barley-7	125450	56724	68726
BARI Barley-8	111150	56724	54426
BARI Barley-9	127400	56724	70676
Local	64350	47687	16663
Mean	107087	54467	52622

*Barley farm gate price: Tk. 65 kg⁻¹

Conclusion

From the study, it may be concluded that BARI Barely-7 and BARI Barley-9 are more promising varieties of harsh environment of char and barind areas for maximum grain yield.

149. ADAPTIVE TRIAL OF FOXTAIL MILLET IN CHAR AREAS AND HIGH BARIND TRACT

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Abstract

These trials were conducted to observe the performance and popularize foxtail millet varieties (BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4) under the char land situation at Bhuapur, Tangail during Kharif 2023, Melandah Jamalpur and drought-prone areas Godagari Rajshahi district during Rabi 2023-24. Among the tested varieties, BARI Kaon-4 performed better in drought prone areas of Rajshahi and char areas of Tangail than Jamalpur districts. The average highest grain yield recorded from BARI Kaon-4 (1.74 t ha^{-1}) followed by BARI Kaon-2 (1.62 t ha^{-1}) whereas the lowest was from BARI Kaon-3 (1.46 t ha^{-1}).

Introduction

Foxtail millet (*Setaria italica*) is considered as a minor cereal of Bangladesh. It is a less significant grain crop cultivated in arid and infertile soils, requiring less maintenance and inputs. It is an important minor cereal crop in Bangladesh, cultivated on 623 hectare with the production of 617 metric tons and productivity of 990 kg ha^{-1} (BBS, 2019). It is cultivated in 26 countries and ranks second among the millets in terms of global production. Apart from being rich in a variety of amino acids and nutritional minerals taken as food, foxtail millet exhibits high photosynthetic efficiency and drought tolerance (Dai *et al.*, 2011a). It can play partial role in fulfilling the food crisis of our country. It can be cultivated easily with low input in the char areas of Bangladesh. The crop is tolerant to drought. Millets are a significant crop that requires few intercultural activities and can withstand the prevailing drought conditions in the High Barind Tract. The Barind region comprises around 25% of the total area of the Rajshahi division and is characterized by less fertile terrain. Historically, farmers have cultivated T. aman and Boro rice. A significant expanse of land remains uncultivated following the harvest of Boro rice. Therefore, there is a high probability of introducing kaon as a cereal crop. The farmers of char areas usually use their own local varieties. They are not familiar with BARI Kaon varieties. BARI released some high yielding varieties. As kaon can grow well in charlands and drought prone areas. So, the released varieties could be fitted in char areas and farmers would be benefited to introduce this crop in their cropping pattern. Hence the trial was under taken to evaluate the performance of BARI kaon varieties and to popularize them among the farmers.

Materials and Methods

The trial was conducted in a char land situation at the MLT site Bhuapur, Tangail during the *Kharif* 2023, Melandah Jamalpur and FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2023-24 to test the performance of newly developed BARI Kaon varieties and to popularize them among the farmers. Three BARI varieties of kaon viz., BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4 were tested. The trial was laid out in RCB design. Crop management practices used in different locations is stated in table 1. The unit plot size was $8 \text{ m} \times 5 \text{ m}$ in Tangail whereas in Jamalpur, it was $20 \text{ m} \times 3.75 \text{ m}$ and in Rajshahi, it was $4 \text{ m} \times 3 \text{ m}$. Seeds were sown on 30 March 2023 at Tangail in line with seed rate of 10 kg ha^{-1} . The plant spacing was $30 \text{ cm} \times 8 \text{ cm}$. In Jamalpur, seeds were sown on 26 November 2023 maintaining 25 cm row spacing with continuous sowing whereas in Rajshahi, seeds were sown on 30 November, 2023. The plots were fertilized with $45\text{-}30\text{-}20 \text{ kg ha}^{-1} \text{ N P K}$, respectively in Tangail, $45\text{-}30\text{-}20\text{-}1.4\text{-}0\text{-}0 \text{ Kg ha}^{-1}$ of N P K S Zn B , respectively in Jamalpur and $80\text{-}22\text{-}37\text{-}14\text{-}1\text{-}1.5 \text{ Kg ha}^{-1}$ of N P K S Zn B , respectively in Rajshahi. In Tangail, half of N and full amount of other fertilizers were applied at the time of final land preparation in the form of urea, triple super phosphate and muriate of potash respectively. Rest amount of N were applied in two equal splits as top dress at 30 days after sowing (DAS) and 60 DAS whereas in Rajshahi, all the fertilizers were incorporated with soil during final land preparation. Intercultural operations viz., weeding and thinning were done when necessary. No remarkable disease pest and infestation was

observed in the field. Some birds attacked the panicle during pre-mature stage which was tried to prevent manually by the farmers themselves.

Table 1. Crop management practices used in different locations

Location	Variety	Unit plot size	Sowing time	Fertilizer dose (N-P-K-S-Z-B kg ha ⁻¹)	Harvesting time with DAS
Bhuapur, Tangail	BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4	8 m x 5 m	30 March, 2023	45-30-20	30 July, 2023
Melandah, Jamalpur	BARI Kaon-2 and BARI Kaon-4	20 m x 3.75 m	26 November, 2023	45-30-20-1.4-0-0	24 March - 5 April, 2024
Godagari, Rajshahi	BARI Kaon-2 and BARI Kaon-4	4m x 3 m	30 November, 2023	80-22-37-14-1-1.5	18 April, 2024

Results and Discussion

The grain yield (t ha⁻¹) across the locations ranged from 1.40- 1.91 t ha⁻¹, where BARI Kaon-4 (1.91 t ha⁻¹ and 1.81 t ha⁻¹) produced the highest grain yield in Rajshahi and Tangail, respectively followed by BARI Kaon -2 (1.76 t ha⁻¹ and 1.69 t ha⁻¹) in Tangail and Rajshahi, respectively. The lowest grain yield also observed from BARI Kaon -2 (1.40 t ha⁻¹) in Jamalpur. Considering the locations, the average maximum grain yield was produced in Rajshahi (1.8 t ha⁻¹), followed by Tangail (1.68 t ha⁻¹) whereas the average minimum grain yield was recorded in Jamalpur (1.45 t ha⁻¹). Among the varieties, the average maximum grain yield was produced by BARI Kaon-4 (1.74 t ha⁻¹), followed by BARI Kaon-2 (1.62 t ha⁻¹) whereas the lowest was observed from BARI Kaon-3 (1.46 t ha⁻¹).

Farmers' opinion: Farmers have expressed a strong interest in BARI Kaon-2 and BARI Kaon-4 owing to their higher yield potentials and reduced vulnerability to pests and diseases. They are keen on ensuring a consistent supply of seeds throughout the growing season.

Table 2. Yield (t ha⁻¹) of different kaon varieties in different locations during 2023-24

Varieties	Grain yield (t ha ⁻¹)		
	Tangail	Jamalpur	Rajshahi
BARI Kaon-2	1.76	1.40	1.69
BARI Kaon-3	1.46	-	-
BARI Kaon-4	1.81	1.50	1.91
Mean	1.68	1.45	1.8

Conclusion

From the trial, it may be concluded that BARI Kaon-2 and BARI Kaon-4 are more promising varieties and produced the highest yield under drought condition.

150. ADAPTIVE TRIALS WITH FINGER MILLETS IN HIGH BARIND TRACT AND CHAR AREAS

M.U.S. KHATUN, M.E.A. PRAMANIK, M.S. HOSSAIN, M.J. ALAM, M.S. RANA AND A.A. MAHMUD

Abstract

A set of trial were conducted at farmers' field of FSRD site Basantapur, Godagari, Rajshahi to observe the performance of four finger millet lines with one check variety and at the MLT sites in Saghata, Gaibandha to assess the performance of various BARI Raghi-1 in 2023-24. Four finger millet lines viz. IE-2043, IE-2619, IE-3077, IE-3392, and BARI Raghi-1 were tested in Rajshahi. The millet matured during 124-127 days. The maximum grain yield was

harvested from IE-3392 (1.96 t ha⁻¹) and BARI Raghi-1 (1.93 t ha⁻¹). In Gaibandha it matured during 116-120 days and average grain yield of BARI Raghi-1 was 2.03 t ha⁻¹.

Introduction

Millet is a cereal crop belonging to the Gramineae family, characterized by their tiny seeds. Millets, a collection of small-seeded grasses cultivated for food, feed, or forage, include several types such as finger millet (*Eleusine coracana* L. Gaertn.). Among these millets, finger millet is ranked as the fourth most significant, behind sorghum, pearl millet and foxtail millet. Finger millet is very adaptable to various adverse climatic circumstances, making it the most resilient millet in terms of climate tolerance. Therefore, these crops might be referred to as "agriculturally advantageous", offering superior profits compared to other crops in varying weather circumstances. It has wide agro-ecology adaptation (Mwikya *et al.* 2000). Nutritionally, the crop is rich containing high ash, calcium and iron content, which is essential for strengthening bone and teeth and reduce incidence of anemia (Singh and Raghuvanshi, 2012). Finger millet is distinct from other cereals like barley, rye and oats due to its superior nutritional composition and exceptional qualities as a staple food crop. Finger millet contains about 5–8% protein, 1–2% ether extractives, 65–75% carbohydrates, 15–20% dietary fiber and 2.5–3.5% minerals (Chethan and Malleshi 2007a). It has the highest calcium content among all cereals (344 mg/100 g). Millet is a crop that requires minimal resources and can be cultivated in dry conditions, such as charland. BARI possesses several high-yielding and promising its genetic lines. In order to evaluate the performance of finger millets in dry and char conditions, it is necessary to conduct tests on the lines.

Materials and methods

The trial was conducted at farmers' field at FSRD site Basantapur, Godagari, Rajshahi to observe the performance of four finger millet lines with one check variety and at the MLT sites in Saghata, Gaibandha to assess the performance of various BARI Raghi-1 in 2023-24. Four finger millet lines viz. IE-2043, IE-2619, IE-3077, IE-3392, and BARI Raghi-1 were tested. The trial was laid out in RCB design. Crop management practices used in different locations is stated in table 1. The unit plot size was 5m x 5m in Rajshahi whereas in Gaibandha, it was 10 m x 10 m. Seeds were sown on 11 December 2023 with spacing of 40 cm x 20 cm in Rajshahi and in Gaibandha, sowing occurred on 25-26 November 2023. The plots were fertilized with 80-22-37-14-1-1.5 Kg ha⁻¹ of N P K S Zn B, respectively in Rajshahi and 100-60-40 kg ha⁻¹ N P K, respectively in Gaibandha. The crop was harvested on 18 April 2024 in Rajshahi whereas in Gaibandha harvesting of the crop was done between March 1 and March 20, 2024. Standard crop management practices with irrigation, weeding was done properly.

Table 1. Crop management practices used in in Rajshah and Gaibandha during the year 2023-24

Location	Variety	Sowing time	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	Harvesting time with DAS
Godagari, Rajshahi	IE-2043, IE-2619, IE-3077, IE-3392, and BARI Raghi-1	11 December, 2023	80-22-37-14-1-1.5	18 April, 2024
Saghata, Gaibandha	BARI Raghi-1	25-26 November, 2023	100-60- 40	1-20 March, 2024

Results and Discussion

Rajshahi: Grain yield (t ha⁻¹) of finger millets varied significantly among the tested genotypes. Days to maturity ranged from 124 to 126 among the genotypes tested in the farmers' field. The maximum grain yield was harvested from IE-3392 (1.23 t ha⁻¹) followed by IE-3077 (1.0 t ha⁻¹) and BARI Raghi-1 (0.92 t ha⁻¹) (Table 2).

Gaibandha: Results of yield of BARI Raghi-1 presented on table 3. Result revealed that duration of the crop was 118 days. BARI Raghi-1 produced 1.85-2.20 t ha⁻¹ grain with an average of 2.03 t ha⁻¹.

The results indicated that, BARI Raghi-1 performed better in Gaibandha than Rajshahi. In Rajshahi, grain yield was very low.

Farmer's opinion: BARI Raghi-1 is a new crop to the farmers, and they don't know the use of it and there is no established market where the farmers sell their product. That's why they showed less interest in it.

Table 2. Yield and yield contributing characters of raghi genotypes at FSRD site Basantapur, Godagari, Rajshahi during 2023-24

Name of Variety/lines	Days to maturity	Grain yield (t ha ⁻¹)
BARI Raghi-1	126.33	0.92
IE-2043	124.33	0.75
IE-2619	126.00	0.66
IE-3077	125.67	1.0
IE-3392	125.67	1.23

Table 3. Yield and yield contributing characters of raghi variety at Charland in Gaibandha during 2023-24

Variety	Days to maturity	Yield (t ha ⁻¹)
BARI Raghi-1	118	2.03

Table 4. Grain yield performance of raghi genotypes at a glance in Rajshahi and Gaibandha

Location	BARI Raghi-1	IE-2043	IE-2619	IE-3077	IE-3392
Rajshahi	0.92	0.75	0.66	1.0	1.23
Gaibandha	2.03	-	-	-	-

Conclusion

Raghi represents a promising new grain crop within the char ecosystem and drought prone areas.

151.ADAPTIVE TRIALS WITH BARI CHIA VARIETY IN CHAR AREAS AND PLANE LAND

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Abstract

A set of experiment were conducted to assess the performance and popularize of BARI Chia-1 in char lands of Saghata, Gaibandha; Bhuapur, Tangail and plane lands of Shibaloya, Manikganj in 2023-24. BARI Chia-1 achieved the grain yield with an average of 0.96 t ha⁻¹, ranging from 0.86 to 1.02 t ha⁻¹. The highest grain yield (1.02 t ha⁻¹) was obtained from Saghata, Gaibandha followed by Bhuapur, Tangail (0.99 t ha⁻¹) and Shibaloya, Manikganj (0.86 t ha⁻¹).

Introduction

Chia (*Salvia hispanica*) is very nutritious food now a days. It contains protein (15%–25%), fats (30%–33%), carbohydrates (26%–41%), high dietary fiber (18%–30%), ash (4%–5%), minerals, vitamins, calories(138 g), dry matter (90%–93%) and also contains a high amount of antioxidants (Ixtaina *et al.*, 2008). Another key characteristic of chia seed it does not contain gluten (Bueno *et al.*, 2010). In Bangladesh, chia is a new crop, but the economic value of chia in international market and even in Bangladesh market is very high. Chia seeds are an excellent source of antioxidants. Recently, chia seed has become important for human health and nutrition because its high content of ω -3 fatty acid that promotes beneficial health effects (Vuksan *et al.*, 2010). Chia seeds may help lower blood pressure, support healthy digestion, improve blood sugar control etc.

chia seeds can help reduce inflammation and decrease the chance of developing deep vein and arterial thrombosis or arrhythmia (irregular heartbeat). Chia seeds can also help raise HDL, the healthy cholesterol, which will help reduce plaque in the arteries and improve brain and cognitive function. The carbohydrates in chia seeds have a slow conversion time, which makes nutrients available for a longer period. Just a spoonful of the seeds mixed with water and a splash of lemon can help sustain hydration and energy during exertion. A one-ounce serving of chia seeds contains approximately five grams of protein- about ten percent of the average daily requirement of this nutrient. BARI has developed one chia variety namely BARI Chia-1 which is high yielding and less susceptible to pest and diseases. Therefore, the trial was undertaken to evaluate the performances of BARI Chia variety in char areas and plane land of farmer's field for dissemination and popularizing among the farmers.

Materials and Methods

The trial took place on char lands at the MLT site in Saghata, Gaibandha; Bhuapur, Tangail and plane lands in Shibaloya, Manikganj to observe the performance and popularize of BARI Chia-1 among the farmers during the 2023-24 period. The trial was laid out in RCB design. Crop management practices including design, plot size used in different locations is stated in table 1. The unit plot size was 10 m x 10 m in Gaibandha and Manikganj whereas in Tangail it was 20 m x 20 m. Seeds were sown on 08 November to 20 December, 2023. The plots were fertilized with 100-60-40 kg ha⁻¹ N P K, respectively in Gaibandha, 60-40-50-60-8 kg ha⁻¹ of NPKS, respectively in Tangail and 82.95-25-60-9.6-1.8-0.26 kg ha⁻¹ of N-P-K-S-Zn-B, respectively in Manikganj. Half of N and all other fertilizer were applied during final land preparation. Rest half of N was applied at 25-30 DAS. Intercultural operations such as weeding and thinning were carried out as needed. The crop was harvested during 01-31 March 2024.

Table 1. Crop management practices used in different locations during the year 2023-24

Location	Variety	Unit plot size	Sowing time	Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	Harvesting time with DAS
Saghata, Gaibandha	BARI Chia-1	10 m x 10 m	25-26 November, 2023	100-60-40	1-20 March, 2024
Bhuapur, Tangail	BARI Chia-1	20 m x 20 m	20 December, 2023	60-40-50-60-8	31 March, 2024
Shibaloya, Manikganj	BARI Chia-1	10 m x 10 m	08 November, 2023	82.95-25-60-9.6-1.8-0.26	08 March, 2024

Results and Discussion

BARI Chia-1 achieved the grain yield with an average of 0.96 t ha⁻¹, ranging from 0.86 to 1.02 t ha⁻¹. The highest grain yield (1.02 t ha⁻¹) was obtained from Saghata, Gaibandha followed by Bhuapur, Tangail (0.99 t ha⁻¹) and Shibaloya, Manikganj (0.86 t ha⁻¹).

The cost and return analysis (Table 3) showed that the highest gross return (Tk. 510000 ha⁻¹) was obtained from Gaibandha followed by Tangail (Tk. 494500 ha⁻¹). Similar trends were also observed in the gross margin. The average cultivation cost was Tk. 77729 ha⁻¹.

Farmers' opinion:

The farmers opined that BARI Chia-1 is a new crop in the area. They have expressed a strong interest in BARI Chia-1 owing to their higher yield potentials, required less care than other field crops and reduced vulnerability to pests and diseases. They are intense on ensuring a marketing facility of chia seeds in the local market.

Table 2. Yield (t ha⁻¹) of BARI Chia-1 variety in different locations during 2023-24

Variety	Gaibandha	Tangail	Manikganj	Mean
BARI Chia-1	1.02	0.99	0.86	0.96

Table 3. Benefit-cost of chia variety in different locations during 2023-24

Locations	BARI Chia-1		
	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
Gaibandha	510000	77729	432271
Tangail	494500	82498	412002
Manikganj	345600	72960	272640
Mean	450033	77729	372304

*Chia farm gate price: Tk 500 Kg⁻¹ (Gaibandha and Tangail) and Tk. 400 kg⁻¹ (Manikganj)

Conclusion

Considering the yield performance of BARI Chia-1 could be suitable for large-scale cultivation in the char areas and plane land of Bangladesh.

152. ADAPTIVE TRIALS WITH BARI OAT VARIETY IN CHAR AREAS

M.U.S. KHATUN, M.J. ALAM, M.S. RANA AND A.A. MAHMUD

Abstract

An experiment was conducted on the char lands at the MLT sites in Saghata, Gaibandha to assess the performance and popularize of BARI Oat-1 in char areas during 2023-24. BARI Oat-1 achieved the grain yield with an average of 0.92 t ha⁻¹, ranging from 0.90 to 0.94 t ha⁻¹.

Introduction

Oats (*Avena sativa* L.) is another important minor cereal crop grown both in irrigated and rain-fed areas. Its adaptation to the changing environment and soil type makes it a better choice than other food crops (Ahmad *et al.*, 2014). It contains more protein than other cereals. Oat contains 17.1% protein, 6.4% fat, 11.3% crude fiber, 3.2% ash, 52.8% starch, 12.5% total dietary fiber and 1.2 mg 100 g⁻¹ total phenol (Saldivar, 2003). Oats are one of the healthiest crops in the world. They are a gluten-free whole grain and a great source of important vitamins, minerals, fiber and antioxidants. Studies show that oats and oatmeal have many health benefits such as weight loss, lowering blood sugar levels and reducing the risk of heart disease. BARI has developed high yielding oat variety BARI Oat-1 that has the potential to grow in harsh environments with satisfactory yields. Therefore, the trial was undertaken to evaluate the performances of BARI Oat-1 in char areas of Gaibandha for dissemination and popularizing among the farmers.

Materials and Methods

The trial took place on char lands at the MLT site in Saghata, Gaibandha to assess the performance and popularize of BARI Oat-1 during the 2023-24 period. The trial followed a Randomized Complete Block (RCB) design with two separate replications. Each plot measured 10 m x 10 m. Sowing occurred on November 25-26, 2023. Nitrogen, Phosphorus, and Potassium were applied at rates of 100 kg, 60 kg, and 40 kg respectively, using urea, Triple Super Phosphate (TSP), and Muriate of Potash (MoP). These fertilizers were mixed into the soil during the final land preparation. Intercultural operations such as weeding and thinning were carried out as needed. Harvesting of the crop was done between March 1 and March 20, 2024.

Results and Discussion

BARI Oat-1 produced 0.90-0.94 t ha⁻¹ grain with an average of 0.92 t ha⁻¹ in char areas of Gaibandha (Table 1). The average infield crop duration of BARI Oat-1 was 125 days.

Farmers' opinion: Farmers showed keen interest in BARI Oat-1 due to its high yield potential as well as low incidence of diseases and insects.

Table 1. Yield and yield contributing characters of BARI Oat variety at Charland in Gaibandha during 2023-24

Variety	Days to maturity	Plant height (cm)	Yield (t ha ⁻¹)
BARI Oat-1	125	105.2	0.92

Conclusion

The yield performance of BARI Oat-1 could be suitable for large-scale cultivation in the char regions of Gaibandha.

153. UP SCALING OF PROSO MILLET VARIETY IN CHAR AREAS

M.U.S. KHATUN, M.M. RAHMAN, A.K.M.Z.U. NOOR AND N. SULTANA

Abstract

The experiment was conducted to up-scale BARI released proso millet variety BARI Cheena - 1 at char lands of Shahjatur, Melandah Jamalpur, during rabi season 2023-24. Results obtained from the study indicated that BARI Cheena -1 produced the yield 1.2 t ha⁻¹. The Gross return and Gross margin of BARI Cheena -1 was Tk. 844000 ha⁻¹ and Tk. 3910 ha⁻¹, respectively.

Introduction

Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture (Singh *et al.*, 2015), making them the preferred cereal crop for drought prone areas. Millets are also annual cereals grown for food, feed, forage and fuel (Kothari *et al.*, 2005). Proso millet (*Panicum miliaceum* L.) is rich in protein, minerals, vitamins and micronutrients such as iron, zinc, copper and manganese and its nutritive parameters are comparable or better than common cereals (Kalinova and Moudry, 2006). Under drought and poor soil conditions, proso millet gives a yield which surpasses the yield of all other crops and has the potential to produce food where other grain crops would fail (Magness *et al.*, 1971; Jiaju, 1986). Millet crops are grown on marginal lands and under low-input agricultural conditions situations in which major cereal crops often produce low yields (Amadou *et al.*, 2013). The upscaling trial with BARI released proso millet variety was undertaken to evaluate the performance at this location and to increase production and farmer's income.

Materials and Methods

The experiment was conducted to up-scale the proso millet variety BARI Cheena -1 at char lands of Shahjatur, Melandah, Jamalpur during rabi season 2023-24. Seeds were sown in 20 m x 3.75 m plot maintaining 25 cm row spacing with continuous sowing. Seeds were sown on 26 November 2023. Crop were harvested on 24 march, 1 April and 5 April, 2024 respectively. Fertilizers were applied at the rate of 45-30-20-1.4-0 Kg ha⁻¹ of N, P, K, S, Zn and B respectively. Standard agronomic practices were followed and plant protection measures were taken as and when necessary.

Results and Discussion

Results of yield and yield attributes are presented on table 1. Result revealed that duration of the crop was 120 days. BARI Cheena -1 is the shortest statured (50.4 cm). Panicle length was 11.9 cm. BARI Cheena-1 produced 1.20 t ha⁻¹ yield.

Gross return (Tk. 84000 ha⁻¹) and Gross margin (Tk. 33910 ha⁻¹) resulted from BARI Cheena -1.

Table 1. Yield and yield attributes of cheena variety at Shahjatpur, Melandah, Jamalpur, during 2023-24

Variety	Duration (days)	Plant height (cm)	Panicle length (cm)	Grain yield (t ha ⁻¹)	Thousand grains weight (g)
BARI Cheena-1	120	50.4	11.9	1.20	4.0

Table 2. Cost and return analysis of cheena variety at Shahjatpur, Melandah Jamalpur, during 2023-24

Variety	Gross return (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Cheena-1	84000	50090	33910

Price of Cheena grain Tk. 70 kg⁻¹

Conclusion

The proso millet variety BARI Cheena-1 might be cultivated in char land because of low price, availability of its seeds, less risk and water requirement, easily grown without modern technology.

Integrated Farming

154. INTEGRATED FARMING FOR IMPROVING LIVELIHOOD OF RESOURCE POOR FARM HOUSEHOLDS IN A PARTICIPATORY APPROACH

M.S.H. MOLLA, M.A.H. TALUKDER, Z. FERDOUS, S. AHMED, S. SULTANA AND M.A. RAHMAN

Abstract

Enhancing one's livelihood is a complicated process that requires one to obtain the basics necessary to meet one's basic demands. To increase family income and livelihood, integrate component technologies with effective use of farm resources, develop integrated farming technologies, and fine-tune innovations generated by NARS institutes, the program was conducted in a participatory way in 2023–2024 and continued from the previous year. It was conducted at 5 Farming Systems Research and Development (FSRD) Sites viz., Gangarampur (Pabna), Ajodhpur (Rangpur), Tarakandi (Sherpur), Sholakundu (Faridpur) and Atia, Delduar (Tangail). The homestead vegetables and fruits, field crops, livestock, fisheries, and off-farm components of farming systems were all or partially taken into consideration by the marginal, small, and medium-sized farmers who participated in the group. The used components were brought under improved technological intervention. At the FSRD sites in Rangpur, Pabna, Sherpur, Faridpur, and Tangail, the average homestead size was 0.14, 0.05, 0.07, 0.09, and 0.13 ha, respectively. Over the location, the average vegetables produced per homestead 821 kg after intervention (AI), which was only 237 kg before intervention (BI). The average vegetables consumption during AI was 294 g head⁻¹day⁻¹, which was 303% higher than BI. The average fruits produced per homestead 503 kg, which was only 301 kg during BI. The average consumption of fruits was also increased (Avg. 92%) during AI. The daily nutritional requirements of a family members were supplemented considerably especially carotene and Vit-C through more consumption of vegetables and fruits from the homestead gardening. Animal products from fish, chicken, duck and cattle also could help to minimize the protein deficiency. Fruit tree management created a good impact on farm households and a total of 728 fruit trees were brought under pest management and a total of 1454 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. The average crop land size was 0.43, 0.84, 0.54, 0.64 and 0.61 ha⁻¹ in Rangpur, Pabna, Sherpur, Faridpur and Tangail area, respectively. The improved cropping patterns at field levels were practiced with including improved crops/varieties. Among them T. Aman rice-Pea-Boro rice and T. Aman-Lentil-Sesame produced higher REY 32.83 and 15.58 t ha⁻¹, respectively. In livestock component, after deworming and vaccination, the frequency of major diseases of cattle were reduced to below 5%. Cattle fattening programs were created interest among the farmer. Goat rearing was found promising as low cost required for rearing. In poultry system, Sonali breed, Naked-neck (Garchila) chicken and Khaki Campbell duck rearing were continued in some homestead and area created a good impact among the farm families as a good source of income and child nutrition. Mortality of poultry reduced and was ranged 3-5% after vaccination. Moreover, production of farmyard manure (3550 kg homestead⁻¹) and vermicompost (320 kg homestead⁻¹) and their utilization, and also green fodder production (68 t ha⁻¹) in some homestead area were created a good impact among the farm families. The average pond size was 0.04-0.06 ha over the locations. Seasonal fish culture with carp polyculture in seasonal pond was found promising and some farmers were continued with their own initiatives. Carp polyculture gave a satisfactory fish yield (avg. 3435 kg per ha). From different types of off-farm activities, farmers also earned some extra money (avg. gross margin Tk. 5500 household⁻¹). Among the different production components, field crop sector gave maximum gross margin but gross margin increased maximum at homestead vegetable production sector, where total gross margin increased 101-772% per farm. The activities (seed and seedling collection, production and distribution/sell, vaccination, spraying and other activities) of Local Service Provider (LSP) was found promising for home gardening, at FSRD site, Gangarampur, Pabna. It was found that partially integrating farm components was a cost-saving strategy.

Introduction

The combination of different agricultural activities and a whole farm management system is integrated farming, which aims to deliver more sustainable agriculture. This dynamic strategy can be implemented in any farming system globally. Bangladesh's subsistence farms are immensely diverse, with complicated linkages between the many subsystems and the farms inside each one. While there are several production methods, farmers have limited resources. These resources can be used in ways that enhance farm output, farmer benefit, and resource efficiency while remaining ecologically responsible and sustainable. A holistic management approach that views the farm as a single, interconnected entity is prioritized, as is understanding the basic role and function of agro-ecosystems, maintaining balanced and crop-demand-appropriate nutrient cycles, and ensuring the health and welfare of all farm animals. Essential fundamentals include preserving and boosting soil fertility, preserving and increasing a diversified environment, and adhering to moral and social standards (Boller et al., 2004). EISA (European Initiative for Sustainable Development in Agriculture) states that the following are included in the Integrated Farming Framework: Soil management, Crop Nutrition, Crop Health and Protection, Animal Husbandry, Health and Welfare, Landscape and Nature Conservation, Energy Efficiency, Water Use and Protection, Climate Change and Air Quality, 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. The farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirements to farm household while presenting resources base and maintaining a high-level environmental quality (Lal and Millar, 1990). In other words, a 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 (Fresco and Westphal, 1988). In particular, the system refers to a collection of enterprises where the outputs or byproducts of one of them are used as inputs for the creation of another enterprise. Farmers' decisions to pursue different business ventures are, nevertheless, influenced by environmental conditions, land topography, soil composition, and the availability of various inputs (Uddin and Takeya, 2005). This needs to be accomplished by optimizing the complementary interactions between several farming enterprises/production systems, the biophysical and socioeconomic environment, and technology generation and packaging through a holistic approach.

The Bangladesh Agricultural Research Institute (BARI) conducts research in multiple disciplines through various divisions and programs. 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. Furthermore, it is necessary to get relevant farmer feedback to modify existing technology or develop new technology through on-farm trials. BARI has given this noble responsibility to OFRD to test those developed on-station technologies directly to the farmer's field. Higher production and income generation can be ensured by proper utilization of farmers resources with improved technologies. Several technologies developed at BARI that farmers might employ to increase their income and production. BARI and BRRI have already developed several improved cropping patterns with management practices involving 3 or 4 crops. Besides, BLRI and BFRI also developed improved technologies on calf, goat and poultry rearing, cattle fattening, and high value fish culture.

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. The development of Local Service Providers (LSPs) at the site level was encouraged to increase the sustainability of farming systems operations. This program included the verification of new technologies, the integration of various farming components to improve livelihoods, and the dissemination of proven technologies developed by NARS institutes on crops, cropping patterns,

climate resilient options, resource conservation technologies, planting of saplings, homestead production systems, fish, livestock, and poultry production, as well as other means of generating income. The initiative, thus, focused on improving rural households' livelihood through the development and implementation of farming system technologies and was carried out in a farmer-participatory manner within the plainland ecosystem.

Objectives

- i) Optimization of homestead land use for the availability of vegetables round the year.
- ii) Utilization of family labor and inclusion of new and profitable technologies as Income Generating Activities (IGA).
- iii) Improvement of human nutrition by supplying required vitamin A, B, C, protein and iron.
- iv) Incorporation of leguminous crops in the existing cropping pattern.
- v) Strengthen linkage among researchers, extension agents and farmers to expedite the technology transfer process.

Methodology

The integrated farming program for improving livelihood of resource poor farm households was implemented in a farmer's participatory approach at five farming systems research and development (FSRD) sites as follows-

FSRD site Gangarampur, Pabna: In Pabna, Gangarampur has a distance of eighteen km from the upazila head quarter and is located at the east side (24°03' N latitude and 89°38' E longitude). The area is under the High Ganges River Floodplain (AEZ-11).

FSRD site Ajoddhapur, Rangpur: The village Ajoddhapur under Rangpur sadar has a distance of sixteen km from the upazila head quarter and is located at the west side (25°40' N latitude and 89°10' E longitude; AEZ-3).

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.

FSRD site Sholakundu, Faridpur: The FSRD site Sholakundu, Faridpur is located at 23°43' north latitude and 89°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 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. The site 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. Dholesori river flows at the west side of this Upazila.

Specific Methodology

The integrated farming research and development activities were continued at five FSRD sites under Plainland ecosystem (FSRD site Gangarampur, Pabna; Ajoddhapur, Rangpur; Sholakundu, Faridpur; Atia, Tangail and Tarakandi, Sherpur) in 2023-24 to optimize the uses of farmers homestead land and other resources for improving their livelihood. The program was executed in a participatory approach, where limited critical inputs and technological suggestions were provided by BARI personnel and other commodities were used from farmer's own sources. Due to inadequate BARI funding in the absence of project support, some FSRD sites were unable to continue with all component activities this year.

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 selected earlier and continued it in six farm households 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)
Gangarampur, Pabna	Marginal	2	5.0	0.435	0.084	0.03
	Small	2	5.75	0.891	0.126	0.04
	Medium	2	5.5	1.188	0.195	0.04
Ajoddhapur, Rangpur	Marginal	2	4.5	0.18	0.057	0.032
	Small	2	4.25	0.44	0.058	0.034
	Medium	2	5.25	0.97	0.048	0.054
Tarakandi, Sherpur	Marginal	1	4.00	0.06	0.06	-
	Small	3	4.38	0.45	0.064	0.048
	Medium	2	5.33	1.12	0.08	0.08
Sholakundu, Faridpur	Marginal	2	4.50	0.17	0.047	0.028
	Small	2	5.00	0.64	0.103	0.037
	Medium	1	4.25	1.12	0.11	0.06
Atia, Delduar Tangail	Marginal	2	6.5	0.19	0.11	-
	Small	2	4.66	0.58	0.13	0.05
	Medium	2	5.0	1.05	0.16	0.05

An individual household survey (Benchmark survey) was carried out earlier during the project period. The detail information regarding livelihoods pattern were documented that time, which is used here as pre-intervention status of a farmer. 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. Vegetable production throughout the year, accompanied by a location-specific model for each homestead, fruit tree management and new plantations, improved cropping patterns and promising variety testing, vaccination of livestock and poultry, poultry rearing, production of green fodder, fish culture, and certain off-farm activities were determined to be their main areas of potential.

Meetings of site working group, informal training, LSP development in some locations, and field visit were held during the implementation period of the program. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. Data on output by season, farm-level utilization and disposal patterns, potential component integration, economic return that focuses on income and expenses, and other socioeconomic data were gathered and tabulated in the study.

A. HOMESTEAD PRODUCTION SYSTEM

Six different categories farmers were involved in homestead production system and averaged shown here. The baseline of the cooperator farmers regarding agricultural practices were documented earlier and used here as pre-intervention. Each farm families consist of average 5 members. The selected farmers were provided informal training and suggestion by the FSRD team on year-round vegetables and quick growing fruits production following respective site wise production model. Thereafter, the farm families produced vegetables and fruits in their homestead area following respective site-wise homestead production model.

a) Vegetables

The vegetables production models of different locations were determined depending on farmers' choice and agro-ecological suitability.

Table 2. Different models for vegetables production in homestead area in different farming system research and development (FSRD) sites under plainland ecosystem.

Table 2a. Goyeshpur model (Gangarampur, 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
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 2b. 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 tarro (Kalakachu), Aroid (Latiraj)		
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		Creeper vegetables, Papaya, Lemon, Napier grass etc.		

Table 2c. Narekeli model (Tarakandi, Sherpur)

Space		Year round vegetable production pattern in homestead		
		Rabi	Kharif I	Kharif II
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	

Space	Year round vegetable production pattern in homestead		
	Rabi	Kharif I	Kharif II
Roof top	Country bean	White gourd	-
Trellis	Country bean, bottle gourd	Yard long bean	-
Fence	Bitter gourd	-	-
Marshy land	-	Latiraj kachu	-
Shady place	Turmeric, Ginger	-	-
Boundary	Papaya, Drumstick	-	-
Unused tree	-	Potato yam	-
Backyard	Sweet gourd	-	

Table 2d. Ishan Gopalpur model (Sholakundu, Faridpur)

Sl.no	Spaces		Crops and Cropping Pattern
1	Open space	Bed 1	Radish-Red Amaranth-Indian spinach
		Bed 2	Spinach-Tomato-Stem Amaranth
		Bed 3	Cabbage-Okra-Okra
		Bed 4	Cauliflower -Gimakolmi- Gimakolmi
		Bed 5	Broccoli-Red Amaranth- Stem Amaranth
		Bed 6	Potato-Indian Spinach-Indian Spinach
2	Roof top	a	Bottle gourd-Ash gourd
3	Trelli	a	Bottle gourd-Sponge gourd
		b	Bottle gourd- Sweet gourd
4	Tree support	a	Potato yam
5	Partial shady area	a	Moulavi kachu
6	Marshy Land	a	Tarro
7	Fence	a	Country bean-Ribbed gourd
		b	Country bean- Bitter gourd
8	Homestead boundary	a	Papaya
		b	Guava
		c	Lemon
9	Back Yard/ Waste land	a	Banana
10	Pond bank	a	Sweet gourd-Ash gourd
		b	Country bean- Ribbed gourd

Table 2e. Palima model (Atia, Tangail)

1. Open sunny space	Rabi	Kharif-1	Kharif-2
	Plot 1 : Tomato/Radish	Okra	Indian spinach
	Plot 2 : Brinjal + Lalshak	Indian spinach	Okra + Lalshak
	Plot 3 : Spinach	Gimakalmi	Gimakalmi
	Plot 4 : Bush bean	Amaranthus	Indian spinach
2. House roof	Roof 1 : BARI Lau/local	Ash gourd	Ash gourd
	Roof 2 : Sweet gourd	Ash gourd	Ash gourd
3. Trellis	T-1 : BARI Lau-1/local	Ash gourd	Sponge gourd
	T-2 : BARI Lau-2/local	Bitter gourd	Snake gourd
	T-3 : Lau	Sweet gourd	Ash gourd
4. Land below trellis	CP-1 Ginger	Ginger	Ginger
	CP-2 Turmeric	Turmeric	Turmeric
5. Pond bank	CPI : Napier	Napier	Napier
	CP2 : Lau	Blakgram	Blackgram
	CP3 : Arum	Arum	Arum
6. Slightly marshy land	CP1 : Latiraj	Latiraj	Latiraj
7. On trees	Creeper 1 : Mete Alu	Mete Alu	Mete Alu
	Creeper 2 : Mete Alu	Mete Alu	Mete Alu
	Creeper 3 : -	Sponge gourd	Sponge gourd

b) Fruits

Fruit saplings were provided, and plantations were made in the homestead area and surrounding homestead areas based on the preferences of the farmers, the agro-ecological compatibility, and the need for human nutrition. This approach included managing fruit trees, both new and old, through irrigation, fertilization, insect control, and other measures.

B. CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

Among the existing cropping patterns of different locations, more prominent cropping pattern were considered for the improvement or replace by alternate profitable cropping pattern. To increase crop productivity, one to two cropping patterns were considered for development at three 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
Gangarampur, Pabna	Boro (Toba)	22-28.2.23	20-26.6.	Boro (BRRI dhan28)	7-12.3.23	27-30.6.23
	T. Aman (BRRI dhan39)	27-31.7.23	17-25.11.23	T. Aman (Binadhan-17)	22-27.7.23	12-17.11.23
	Mustard (Tori-7)	25-30.11.23	10-16.02.24	Mustard (BARI Sarisha-17)	20-25.11.23	20-25.2.24
	Sesame (Local)	15-25.3.23	17-23.6.23	(Sesame (BARI Til-4)	10-15.3.23	20-25.6.23
Ajoddhapur, Rangpur	T. Aman (BRRI dhan39)	25-29.7.	16-22.11.23	T. Aman (Binadhan-17)	20-25.7.23	10-17.11.23
	Lentil (BARI Masur-6)	27.11-3.12.23	10-15.3.24	Lentil (BARI Masur-8)	22-27.11.23	10-15.3.24
	T. Aman (Swarna)	23-28 July	27-30 Nov	T. Aman (Binadhan-17)	5-18 Aug	11-19 Nov
	Fallow	-	-	Mustard (BARI Sarisha-14)	27 Nov-7 Dec	22-27Feb
Tarakandi, Sherpur	Boro (BRRI dhan28)	24-28 Feb	20-23 Jun	Boro (BRRI dhan84)	25 Feb-7 Mar	28Jun-11 Jul
	T. Aman (Dhani gold (Hybrid)	15.07.23	02.11.24	T. Aman (Dhani gold (Hybrid)	25.07.23	02.11.23
	Fallow	-	-	Pea (BARI Motorsuti-3)	15.11.23	06.02.24
	Boro (Hybrid (Sachchal)	25.01.24	09.05.24	Boro (Hybrid (Sachchal)	09.02.24	15.05.24

b) On-farm verification/production program

Many modern crop varieties that are short in duration and have excellent yields have been developed by the Bangladesh Agricultural Research Institute and other NARS Institutes. The pre-identified suitable varieties of mustard, lentil, chiya, potato and tomato were brought under production program at two locations in 2023-24. The details of crop management are given in the result part.

Table 4. Different operations conducted for production program at different FSRD sites under plainland ecosystem during 2023-24.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Gangarampur, Pabna	Mustard	BARI Sarisha-14	3	0.5	25-30.11.23	3-5.3.24
		BARI Sarisha-17	7	0.6	21-30.11.23	21-29.2.24
		BARI Sarisha-20	4	0.4	25-30.11.23	28.02-1.3.24
	Lentil	BARI Masur-8	7	0.9	25-30.11.23	15-21.03.24
	Chiya	BARI Chiya-1	5	0.02	19-26.12.23	3-9.3.24
	Mustard	BARI Sarisha-14	4	1	22-27 Nov.	25-27 Feb.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/transplanting	Date of harvesting
Gangarampur, Pabna	Mustard	BARI Sarisha-14	3	0.5	25-30.11.23	3-5.3.24
		BARI Sarisha-17	7	0.6	21-30.11.23	21-29.2.24
		BARI Sarisha-20	4	0.4	25-30.11.23	28.02-1.3.24
	Lentil	BARI Masur-8	7	0.9	25-30.11.23	15-21.03.24
	Chiya	BARI Chiya-1	5	0.02	19-26.12.23	3-9.3.24
Ajoddhampur, Rangpur		BARI Sarisha-18	2	0.5	19-29 Nov.	6-8 March
	Tomato	BARI Tomato-15	1	0.25	15-18 Nov.	13 Feb-07 March
	Potato	BARI Alu-25	2	0.5	27-29 Nov.	25 Feb.-04 March
		BARI Alu-53	2	0.12	30 Nov-10 Dec	05-11 March

C. LIVESTOCK COMPONENT

Maintaining the health of livestock is a crucial component of integrated farming, since it is the basis for increased production and profitability in livestock farming. Deworming cattle can improve their health, which could help the farmer economically. The 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 programs were also continued at some areas. In addition to cattle products, cowdung is a valuable by-product of integrated farming. Rather than burning the cowdung for fuel, farmers were encouraged to utilize it to prepare farm yard manure (FYM), which includes other homestead waste products. Napier grass was found as an appropriate and profitable green fodder to cultivate on the farmhouse and its adjacent areas, particularly along the pond bank. Farmers were urged to use FYM after each cut of grass. It was introduced to farmers as part of the initiative to help them produce for their livestock. In addition to feeding their cattle, farmers sold their produced Napier grass in the market.

Poultry farming is widely practiced in rural Bangladesh. chickens disease is the most serious concern that farmers encounter when producing chickens. Only effective immunization can minimize the mortality rate in poultry. This initiative was carried out on the farmer's field to minimize mortality rates and investigate the impact of chicken vaccines at the farmer level. A large number of poultry birds were vaccinated during the project's duration. The vaccinated group received BCRDV, RDV, fowl pox, fowl cholera, and duck plague vaccines according to the prescribed schedule. The facilitator team maintained regular touch with the participants in order to provide required suggestions to resolve their individual issues.

D. FISHERIES COMPONENT

Improper management is a key impediment to success in fish culture in ponds located in homestead areas. The carp poly culture program 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, Katla, Rui, Mrigal, Common and Mirror carp may vary from 20–30%, 10–15%, 15–20%, 10–15% and 15–20% respectively maintaining 20-30 fingerlings decimal⁻¹. Fingerlings, lime, and fish feed were partially collected and supplied by cooperative farmers. The office

personnel at the different FSRD sites were checked on a regular basis and given suggestions for fish cultivation.

E. OFF-FARM ACTIVITIES

The percentage of farm household income that is earned outside of the farm, such as nonfarm wages and salaries, pensions, and interest income received by farm families, is referred to as off-farm (non-farm) income. According to Barrett et al. (2001), during the past thirty years or so, there has been an increasing number of evidence demonstrating that small-holder farm households in developing nations seldom rely solely on agriculture but rather maintain a portfolio of income-generating ventures, of which off-farm activities are a significant part.

A number of farming families, particularly those headed by women, were involved in non-farm pursuits. Some farmers also practiced machine stitching cloth and weaving Katha, and they operated little grocery shops that they opened in their spare time. In few instances, men engage in commercial cooking as well. During their free time, women made Kumra bora, Pilo covers, and handicrafts out of rope, plastic balls, etc., while men made baskets and pulled vans and rickshaws.

F. LOCAL SERVICE PROVIDER (LSP)

One male and one female Local Service Provider (LSP) was chosen from the co-operator farmers at Pabna in order to improve the farming operations and make them more sustainable. The LSP was chosen based on a variety of factors, including their degree of expertise, zeal, capacity to comprehend and disseminate technology, and acceptance in the community and among peers.

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Integrated farming includes a number of interconnected enterprises, such as home fruit and vegetable gardening, crops and cropping systems, dairying, poultry, fisheries, and so forth. One firm's waste and completed products may be used as raw materials for another. Furthermore, using farm resources wisely can lower manufacturing costs and contribute to environmental cleanliness. For sustainable farming, the impact of one component on other component(s) is crucial to take into account.

Results and Discussion

A. HOMESTEAD PRODUCTION SYSTEM

Activity 1. Year-round vegetables and fruits production in homestead area

FSRD Site, Gangarampur, Pabna

Vegetables production: The Goyeshpur model was used to cultivate the recommended vegetables in the homestead areas' available and useable production niches. 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 444 kg homestead⁻¹ in *Rabi* season followed by *Kharif-1* (351 kg homestead⁻¹) and *Kharif-2* (345 kg homestead⁻¹) season (Table 5a).

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 187% compared to before intervention of the program (Table 5b). The remarkable increment of vegetables production in homestead areas 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 5c). The average vegetables consumption per year per farm family was 510 kg after program intervention which was 143% 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. After program intervention, the average distribution of vegetables per farm per year was recorded 105 kg and sell of vegetables per year was 525 kg. 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 sale.

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 after interventional than before intervention (Table 5a). 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 60% compared to before intervention of the program (Table 5b). 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 consumption per year per farm family was 650 kg after program intervention which was 120% higher as compared to before intervention (295 Kg per family per year) mainly due to incremental production (Table 5c). After program intervention, the distribution of fruits per year per family was recorded 222 kg and selling of fruits per year per family was 465 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. 17100 and Tk. 13110 per year per farm from year-round vegetables whereas gross return and gross margin was Tk. 5955 and Tk. 4565 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. 20055 and Tk. 12701 per farm whereas gross return and gross margin was Tk. 12525 and Tk. 7933 per year per farm was noted before intervention (Table 5c).

Table 5a. Round the year vegetable and fruits production from different niches of homestead during 2023-24 at FSRD site, Gangarampur, Pabna.

Space		Rabi		Kharif-1		Kharif-2		Total (kg)	
		October-March		April-June		July-September			
Open Sunny space		Before	After	Before	After	Before	After	Before	After
	Bed-1	-	56.5	-	32	-	30.5	-	119
	Bed-2	-	62.5	-	29.5	-	19.5	-	111.5
	Bed-3	-	48.5	-	25.5	-	18	-	92
	Bed-4	-	22	-	30	-	19	-	71.5
Roof top		25	42	-	25	-	27	25	94
Trellis		48	65.5	15	30	20	28	83	123.5
Shady space		15	33.5	20	26	18	32	53	91.5
Marshy land		-	-	12	24	22	31	34	55

Space	Rabi		Kharif-1		Kharif-2		Total (kg)	
	October-March		April-June		July-September			
Unproductive tree	8	14	-	15	-	15	8	44
Fence	-	18	-	15	-	10	-	43
Backyard	20	33	25	47	34	40	79	120
House boundary	40	48	37	52	38	75	115	175
Total vegetables	156	444	109	351	132	345	397	1140
Total fruits	170	340	290	445	375	552	835	1337
Total (vegetables + fruits)	326	784	399	796	507	897	1232	2477

Table 5b. Income from round the year vegetables and fruits production from different niches of homestead during 2023-24 at FSRD site, Gangarampur, Pabna..

Niches	Before intervention		After intervention		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%)	Income (%)
Open sunny place	-	-	394	5910	-	-
Roof top	25	375	94	1410	276	276
Trellis	83	1245	123.5	1852.5	49	49
Shady place	53	795	91.5	1372.5	73	73
Marshy place	34	510	55	825	62	62
Unproductive tree	8	120	44	660	450	450
Fence	-	-	43	645	-	-
Backyard	79	1185	120	1800	52	52
House boundary	115	1725	175	2625	52	52
Total	397	5955	1140	17100	187	187
Fruit (Other places)	835	12525	1337	20055	60	60
Total (veg. + fruit)	1232	18480	2477	37155	101	101

Table 5c. Round the year vegetables and fruits production and utilization pattern before and after intervention during the years of 2023-24 at FSRD site, Gangarampur, Pabna.

Description	Before intervention		After intervention	
	Vegetables (kg)	Fruits (kg)	Vegetables (kg)	Fruits (kg)
Consumption	210	295	510	650
Distribution	37	118	105	222
Selling	150	422	525	465
Total production	397	835	1140	1337
Gross return (Tk.)	5955	12525	17100	20055
Total variable cost (Tk.)	1390	4592	3990	7354
Gross margin (Tk.)	4565	7933	13110	12701

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 2b) during 2023-24. From the results it was found that Open sunny place contributed more for vegetables production followed by Backyard and trellis. The total vegetables production was found 135.58 kg/ homestead/ round the year (Table 6a). It was partially contributed by the total number of available production niches. After intervention of the improved technologies, the average vegetable production was increased.

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 average results indicated that disposal pattern of vegetables varied (Table 6a). The average vegetable intake per year per family was increased. The average vegetables intake by each family was increased. 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 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. After implementation of the program, the average fruits production was increased. 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. The average fruits intake per year per farm family was increased remarkably. 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. 2998/ homestead. (Table 6a).

Table 6a. Round the year vegetables and fruits production per homestead from different niches of homestead during 2023-24 at FSRD site, Ajoddhapur Rangpur

Space		Total production (kg)	Mean production (kg)	Mean of disposal (kg)			Total income (Tk)	Mean income (Tk)
				Self-intake (kg)	Distributed (kg)	Sale (kg)		
Open sunny space	Bed-1	35.9	3.59	24.70	6.30	4.92	359	36
	Bed-2	141.3	14.13	88.45	14.25	38.61	2120	212
	Bed-3	175.2	17.52	92.70	26.65	55.80	4379	438
	Bed-4	109.4	10.94	70.45	8.93	30.0	2188	21
	Bed-5	29.1	2.91	26.12	3.0	-	728	73
Roof		74.98	7.50	41.78	12.70	20.50	1128.70	112
Trellis		128.22	12.82	49.37	23.85	55.0	2564.40	256
Fence		11.36	1.14	7.99	1.12	2.25	568.0	56
Tree support		43.68	4.37	41.68	2.0	-	3057.60	305
Marshy land		6.85	0.69	6.85	-	-	548.0	54
Backyard		139.87	13.99	70.12	17.20	52.55	2797.40	279
Partially shady place		124.16	12.42	62.56	14.10	47.50	3104.0	310
House boundary		93.19	9.32	49.40	17.25	26.54	1863.80	186
Pond bank		75.86	7.59	36.46	7.50	31.90	1896.50	189
Total (vegetable)		1189	119	668	155	366	731.20	73
Fruits		130.15	13.02	41.45	18.20	70.50	1952.25	195
Total (vegetables +fruit)		1355.76	135.58	-	-	-	29981.05	2998

FSRD Site, Tarakandi, Sherpur

Vegetables production: The performance of vegetable crops grown in different niches of homestead area of the average of ten farmers is presented in Table 1. Nine production unit of the homestead were brought under production with the suggested vegetables of the Narekeli model

at FSRD site, Tarakandi, Sherpur during April 2023 to March 2024. It was observed that the production of vegetables was higher at sunny spaces followed by trellis and roof top. Average total production of vegetables per farm was 408.68 kg with total cash income Tk. 7710.0 (Table 7a and Table 7b). Before intervention total vegetable production was only 62 kg which increased 346.68. Kg/farm after intervention.

Utilization of vegetables: Disposal of different vegetables produced under homestead was recorded regularly. The result indicated that disposal pattern of vegetables varied with production (Table 7c). From the Table, it was indicated that the higher vegetable production was in February and March and lowest was in July. The intake of vegetables was higher in January and February due to higher production and lower in October due to lower production. The distribution was higher in August and sell of vegetables was higher in the month of March. Besides, intake and distribution they would earn some cash money during this period. However, cash income of the farmers was higher in the month of February.

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 7a). 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 7b). 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 7c). 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. 6531 with the average gross margin of Tk. 5576 which was only Tk. 560 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 7b).

Table 7a. Round the year vegetables and fruits production from different niches of homestead during 2023-24 at FSRD site, Tarakandi, Sherpur.

Space		Rabi October- March	Kharif-1 April-June	Kharif-2 July-September	Total (kg)
Open sunny space	Bed-1	60.4	12.15	6.60	79.15
	Bed-2	76.7	19.40	6.50	102.6
	Bed-3	13.0	16.55	5.40	34.95
	Bed-4	14.40	5.5	6.10	26.00
	Bed-5	22.53	10.50	6.95	43.98
Roof top		60	-	-	60
Trellis		25	-	-	25
Shady Place		12	-	-	12
Unproductive Tree		2.5	-	-	2.5
Fence		6.5	-	-	6.5

Space	Rabi	Kharif-1	Kharif-2	Total (kg)
	October- March	April-June	July-September	
Marshy land	-	-	-	-
Backyard	5.0	-	-	5.0
House Boundary	12	-	-	12
Total (vegetables)	310.03	64.10	34.55	408.68
Fruits	22	45	30	97
Total	332.03	109.10	67.55	505.68

Table 7b. Round the year vegetables and fruits production and income from different niches of homestead during 2023-24 at FSRD site, Tarakandi, Sherpur.

Niche	Before intervention		After intervention	
	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)
Open sunny place	22	215.00	286.68	5300.00
Roof top	15	150.00	60	900.00
Trellis	25	250.00	25	400.00
Shady place	0	0	12	360.00
Marshy place	0	0	2.5	100.00
Unproductive tree	0	0	6.5	125.00
Fence	0	0	0	225.00
Backyard	0	0	5.0	100.00
House boundary	0	0	12	300.00
Total	62	615.00	408.68	7810
Fruit (other places)	10	150.00	97.0	1900.00

Table 7c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during 2023-24 at FSRD site, Tarakandi, Sherpur.

Description	Before Intervention (2017-18)		After Intervention (2023-24)	
	Vegetable (kg)	Fruits (kg)	Vegetable (kg)	Fruits (kg)
Consumption	18	6	130	42
Distribution	6	0	50	15
Selling	38	4	228.0	40
Total	62	10	408.68	97

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 Ishangopalpur 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 during 2023-24 (Table 8a). 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 8a). The total vegetable production was 917 kg per homestead after the intervention, whereas the vegetable production was 174 kg per homestead before intervention (Table 3). Average increment of vegetables production and income over before intervention was 743 kg and 656%, respectively (Table 8c). 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 387 kg per homestead after the intervention, whereas the fruit production was 124 kg per homestead before intervention

(Table 8b). Average increment of fruit production and income over before intervention was 263 kg and 239%, respectively (Table 8b). 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, malta etc. In every homestead, a total of 1304 kg of fruit and vegetables were produced and income was 31212 Tk. showing 398% income increment over before intervention (Table 8c).

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 8c). Before intervention, vegetable consumption, distribution and selling was 101 kg, 14 kg and 59 kg, respectively whereas after intervention, utilization pattern was increased remarkably, i.e. vegetable consumption, distribution and selling was 610 kg, 107 kg and 200 kg, respectively. 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, distribution and selling per year per farm family was 205 kg, 82 kg and 100 kg, respectively whereas after intervention, utilization pattern was increased remarkably, i.e. fruit consumption, distribution and selling was 150 kg, 45 kg and 175 kg, respectively. Thus, it is concluded that, consumption ratio was increasing. Average gross margin of after intervention for vegetables and fruits were Tk. 12206 and Tk. 12046, respectively. Total return was increased by 398% after intervention compared to before intervention.

Table 8a. Round the year vegetables and fruits production from different niches of homestead during 2023-24 at the FSRD site, Sholakundu, Faridpur.

during 2023-24 at the FSRD site, Sholokunda, Palurapur.

Space		Rabi		Kharif-1		Kharif-2		Total (kg)	
		October- March		April-June		July-September			
		Before	After	Before	After	Before	After	Before	After
Open sunny space	Bed-1	0	30	0	32	0	25	0	87
	Bed-2	0	20	0	25	0	20	0	65
	Bed-3	0	28	0	20	0	25	0	73
	Bed-4	0	12	0	15	0	15	0	42
	Bed-5	0	30	0	25	0	10	0	65
Roof top		12	30	0	33	0	15	12	78
Trellis		61	25	0	32	0	20	61	77
Fence		0	35	0	22	0	23	0	80
Shady Place		11	20	0	15	0	15	11	50
Marshy Land		10	25	0	22	0	23	10	70
Backyard		18	28	0	32	0	33	18	93
Homestead Boundary		47	25	0	30	0	35	47	90
Pond bank		15	15	0	10	0	22	15	47
Total (vegetable)		174	323	0	313	0	281	174	917
Total (Fruits)		124	130	0	132	0	125	124	387
Total		268	453	0	445	0	406	268	1304

Table 8b. Round the year vegetables and fruits production from different niches of homestead during 2023-24 at FSRD site, Sholakundu, Faridpur.

Niches	Before intervention		After intervention		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (%)
Open sunny place	0	0	332	5976	-	-
Trellis	61	732	77	1386	16	89.34
Roof top	12	144	78	1404	66	875.0
Shady Place	11	110	50	900	39	718.1
Tree support (Fence)	0	0	80	1440	-	-
Pond bank	15	168	47	846	32	403.5
Homestead Boundary	47	494	90	1620	43	227.9
Backyard	18	180	93	1674	75	830.0
Marshy Land	10	100	70	1260	60	1160
Total (vegetable)	174	1928	917	16506	743	756.1
Total (Fruits)	124	4340	387	14706	263	238.8
Grand Total	298	6268	1304	31212	1006	397.9

Table 8c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during 2023-24 at FSRD site, Sholakundu, Faridpur.

Description	Before Intervention		After Intervention	
	Vegetables (kg)	Fruits (kg)	Vegetables (kg)	Fruits (kg)
Consumption	101	65	610	205
Distribution	14	25	107	82
Selling	59	34	200	100
Total production	174	124	917	387
Gross return (Tk.)	1928	4340	16506	14706
Total Variable cost (Tk.)	276	280	4300	2660
Net return (Tk.)	1652	4060	12206	12046
Total return (Tk.)	5712		24252	

FSRD Site, Atia, Tangail

Vegetables production and income: Homestead gardening was introduced among the 6 Resource Poor Farmers (RPF). “Palima Model” was followed in homestead yard area for year-round vegetable. Seven production unit/niches have been considered for vegetable cultivation according to “Palima Model” (Table 2e.). From each homestead farmers harvested on an average of 451 kg vegetable and 209 kg fruits of which 230, 60 and 118 kg veg. and 140, 19 and 48 kg fruits were consumed, distributed and sold respectively (Table. 9c & 9f) and the percentage of consumption, distribution and sell was 51, 13, 26 and 67, 09, 23 for veg. and fruits respectively. After intervention the average consumption of vegetables per head per day was 125 g/head/day whereas before intervention it was only 27 g/head/day. The area of homestead is very small but from nutritional point of view, its importance is higher. However, the amount is small but it helped very positively in mitigating daily need of nutrient. They had to purchase the daily requirements of vegetables from the market. But, now with the increased production of vegetables in homestead, they almost don’t have to go to market for purchasing vegetables. Each farm family sold a portion of their produce to the local market to meet up their daily necessities. However, economic return was also calculated on the basis of total production. Among the farmers after intervention the average gross return was 13025 Tk. and the net return was 8218 Tk. besides this before intervention their gross return was 2913 and net return was only 2007 Tk. (Table 9d). It was found that the total net return was increased by 309% from the homestead component.

Table 9a. Yearround vegetables and fruits production (kg) from different niches of homestead at FSRD site, Atia, Tangail during 2023-24

Space		Rabi	Kharif-1	Kharif-2	Total (kg)
		October- March	April-June	July-September	
Open sunny space	Bed-1	37	18	13	68
	Bed-2	29	10	11	50
	Bed-3	35	17	14	66
	Bed-4	33	13	11	57
House Roof		26	12	13	51
Trellis		23	14	14	51
Land below trellis		34	0	0	34
House /Pond boundary		15	16	11	42
Slightly Marshy Land		0	9	9	18
On Tree (Unproductive)		0	14	0	14
Total (vegetable		232	123	96	451
Fruits		33	95	81	209
Total		265	218	177	660

Table 9b. Year round vegetable production in kg per homestead at FSRD site Atia, Tangail during 2023-24 (before and after intervention).

Space		Rabi		Kharif-1		Kharif-2	
		October-March		April-June		July-September	
		Before	After	Before	After	Before	After
Open Sunny space	Bed-1	20	37	11	18	10	13
	Bed-2		29		10		11
	Bed-3		35		17		14
	Bed-4		33		13		11
Roof top		7	26	5	10	0	13
Trellis		6	23	4	17	0	14
Land below trellis		0	34	0	0	0	0
House /Pond boundary		4	15	0	12	0	11
Slightly Marshy Land		0	0	0	10	0	9
On Tree (Unproductive)		0	0	0	11	0	0
Total (vegetable)		37	232	20	116	10	96

Table 9c. Homestead vegetable production and utilization pattern at FSRD site, Atia, Tangail during 2023-24 (before and after intervention)

Total production (kg)		Disposal pattern of vegetable per year								Intake increased (%)
		Intake (kg)		Intake (g head ⁻¹ day ⁻¹)		Distributed (kg)		Sold (kg)		
Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	
67	451	50	230	27	125	6	60	11	118	360

Table 9d: Cost and return analysis of vegetable production in a homestead per year at FSRD site, Atia, Tangail during 2023-24(before and after intervention)

Before intervention (Tk)			After intervention (Tk.)			GM increased (%)
GR	TVC	GM	GR	TVC	GM	
1320	526	794	7800	3567	4233	433

Note: GR = gross return; TVC = total variable cost; GM = gross margin

Table 9e. Round the year fruits production in kg per homestead at FSRD site, Atia, Tangail during 2023-24

FSRD site	Rabi	Kharif-1	Kharif-2	Total (kg)
	October- March	April-June	July-September	
Atia, Tangail	33	95	81	209

Table 9f. Homestead fruits production and utilization pattern at FSRD site, Atia, Tangail during 2023-24 (before and after intervention)

Total production (kg)		Disposal pattern of fruits per year								Intake increased (%)
		Intake (kg)		Intake (g head ⁻¹ day ⁻¹)		Distributed (kg)		Sold (kg)		
B	A	B	A	B	A	B	A	B	A	
52	209	38	140	21	77	14	19	0	48	268

A= After Intervention, B= Before intervention

Table 9g: Cost and return analysis of fruits production in a homestead per year at FSRD site, Atia, Tangail during 2023-24 (before and after intervention)

Before intervention (Tk)			After intervention (Tk)			GM increased (%)
GR	TVC	GM	GR	TVC	GM	
1593	380	1213	5225	1240	3985	229

Note: GR = gross return; TVC = total variable cost; GM = gross margin

Activity-2: Family labor utilization pattern in homestead production system at different FSRD sites during 2023-24

One area where family members might collaborate is homestead gardening. Women were able to work and gain empowerment through the homestead production system. Table 10 showed that women were well-represented in the preparation and planting of seeds and seedlings, intercultural operations, harvesting, and sale of fruits and vegetables. It's evident that more women are stepping up to participate in the system of revenue generating. Men laborers put in a lot of hard effort when it came to preparing the property. In the industrial processes, children assisted both adult male and female workers, particularly in non-hardworking areas. Thus, it was found that homestead gardening has made it possible for resource-poor farm families to profitably employ the underutilized labor of women and children in order to increase crop productivity and income.

Table 10. Family labor utilization pattern for homestead vegetables and fruits production at different FSRD sites.

Working area	Men (%)					Women (%)					Children (%)				
	Pab	Ran	Sher	Far	Tan	Pab	Ran	Sher	Far	Tan	Pab	Ran	Sher	Far	Tan
Land preparation	30	70	65	70	55	65	25	25	30	55	5	5	10	0	-
Seed/seedling production	30	55	30	50	60	70	40	50	40	50	0	5	20	10	5
Sowing/planting	25	35	25	40	55	75	65	55	40	50	0	0	20	20	5
Intercultural operation	10	25	45	30	50	70	65	45	50	45	20	10	10	20	5
Harvesting	10	25	20	30	45	80	60	55	60	55	10	15	25	10	10
Marketing	20	45	75	20	95	70	55	20	80	-	10	0	5	0	
Cooking	0	0	0	00	-	100	90	85	100	100	0	10	15	00	-

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 2023-24.

FSRD Site, Gangarampur, Pabna

To increase nutrient intake from the fruit sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, several different quality fruits saplings of BARI developed varieties, and locally popular varieties were supplied to homestead e.g., Mango and

Papaya. The total number of supplied saplings of different fruit plants was 280. The saplings are in good condition and survival rate ranges from 95-100% (Table 11). The FSRD team also provides technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 11. Distribution of fruit saplings at FSRD site, Gangarampur, Pabna during 2023-24.

Sl. No	Types of fruits sapling	Variety	Number of saplings	Mortality (%)
01	Mango	BARI Aam-4	60	0
02	Papaya	Local improved	220	5
Total			280	-

FSRD site, Ajoddhapur, Rangpur

Sapling/seedling distribution: Several different quality fruits trees were sprayed for hopper and other pest control (Table 12)

Table 12. Number of fruit trees sprayed for hopper and other pest control at FSRD site during the year of 2023-24

FSRD site	Mango	Guava	Jackfruit	Litchi	Malta	Coconut	Others*
Ajoddhapur, Rangpur	92	20	40	35	50	12	28

FSRD Site, Tarakandi, Sherpur

All the twelve homestead farmers were supplied with mango, litchi, guava and malta saplings. Each farmer received two mango, one litchi, one guava and one malta saplings. Different fruit trees distribution among the farmers at FSRD site. Most of the fruit trees are survived and growing well.

Table 13. Distributed fruit saplings at FSRD site, Tarakandi, Sherpur during 2023-24.

Sl. No.	Types of the fruit saplings	Variety	Number	Mortality (%)
1	Mango	BARI Am-3	100	-
		BARI Am-4	100	-
		BARI Am-11	25	-
2	Lemon	BARI Lebu-4	250	5
3	Malta	BARI Malta-1	100	-
4	Litchi	BARI Litchu-3	50	5
5	Banana	BARI Kola-1	12	-
6	Coconut	Dwarf variety (Vietnam)	8	-
Total			595	10

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. Mango, hog plum, lemon, dragon fruit, jackfruit and coconut. Total number of supplied saplings of different fruit plants were 302. The saplings are in good condition. 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 the FSRD site during 2023-24

Sl.no.	Types of fruits sapling	Variety	Total
1	Mango	BARI Aam-3	30
		BARI Aam-4	60
		BARI Aam-8	30
		BARI Aam-11	30
2	Hog plum	BARI Amra-2	30
3	Lemon	BARI Lebu-3	30
4	Dragon fruit	BARI Dragon fruit-1	30
5	Jackfruit	BARI Kathal-1	30
6	Coconut	BARI Narikel-2	32

Activity-4: Pest management activities for increasing fruits production in homestead area during 2023-24.

Pest management of fruit tree: Fruit trees are a good source of nutrition for humans in the homestead region. While most of the time pests are the main obstacle to producing enough edible fruits, this can occasionally discourage farmers from planting fruit trees in their homestead areas. However, relatively basic technology- two sprays of fungicide and insecticide, one right before flower blooming and one at the pea-sized fruit stage- can support fruit production in homestead areas. These perspectives led to the safe application of pesticides at every FSRD site (Table 15). Insecticide and fungicide were applied on 728 fruit plants in total, with the majority being mango trees (330).

Table 15. Number of fruit trees sprayed for hopper and other pest control at different FSRD sites during 2023-24

FSRD site	Mango	Guava	Jackfruit	Litchi	Multa	Coconut	Others*
Gangarampur, Pabna	152	-	63	24	6	-	20
Ajoddhapur, Rangpur	45	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>	330	43	114	71	54	31	85

c) Apparent nutrient intake and supplementation: The most important sources of nutrition for humans are the fruits and vegetables grown on homesteads. 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 16a). 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 16b). 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 and fish sources. Iron supplementation was more in Gangarampur, Pabna (79.99%), which is very crucial nutrient for women. Apart from Tarakandi, Sherpur from homestead vegetable and fruit sources, nutrient intake and supplementation increased significantly following program intervention. This may have been caused by increased production and, in comparison, increased intake through motivational activities. Carotene and vitamin C in particular, were more or less adequately supplemented.

Table 16a. Apparent nutrient Consumption in a year by a family from homestead vegetables and fruits (before and after intervention) during 2024-25.

FSRD site	Intervention	Protein (g)	Iron (mg)	Carotene (µg)	Vit-B (mg)	Vit-C (mg)
Gangarampur, Pabna	Before	9108	18687	15227000	611	160516
	After	20921	40879	34976875	1402	368712
Ajoddhapur, Rangpur	Before	6583	13506	11005654	442	116016
	After	12807	25023	21410672	858	225702
Sholakundu, Faridpur	Before	2994	6143	5005311	201	52764
	After	14699	28721	24574270	985	259052
Atia, Tangail	Before	1533	3145	2562960	103	27018
	After	6673	13039	11156417	447	117606
Tarakandi, Sherpur	Before	649	1332	1085489	44	11443
	After	3102	6061	5186226	208	54671

Table 16b. 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 2023-24.

FSRD site	Category	Year	Protein (%)	Iron (%)	Vit-A (%)	Vit-B (%)	Vit-C (%)
Gangarampur, Pabna	Male	Before	9.07	36.56	139.06	27.90	219.88
		After	20.84	79.99	318.84	64.04	505.09
	Female	Before	9.99	36.56	139.06	33.46	219.88
		After	22.93	79.99	318.84	76.85	505.09
Ajoddhapur, Rangpur	Male	Before	6.55	26.42	100.51	20.16	158.92
		After	12.76	48.97	195.17	39.20	309.18
	Female	Before	7.22	26.42	100.51	24.19	158.92
		After	14.03	48.97	195.17	47.04	309.18
Sholakundu, Faridpur	Male	Before	2.98	12.02	45.71	9.17	72.28
		After	14.64	56.20	224.01	44.99	354.87
	Female	Before	3.28	12.02	45.71	11.00	72.28
		After	16.11	56.20	224.01	53.99	354.87
Atia, Tangail	Male	Before	1.53	6.15	23.41	4.70	37.01
		After	6.65	25.52	101.70	20.43	161.11
	Female	Before	1.68	6.15	23.41	5.63	37.01
		After	7.31	25.52	101.70	24.51	161.11
Tarakandi, Sherpur	Male	Before	0.65	2.61	9.91	1.99	15.67
		After	3.09	11.86	47.28	9.50	74.89
	Female	Before	0.71	2.61	9.91	2.39	15.67
		After	3.40	11.86	47.28	11.39	74.89

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

Activity-5: Improvement of cropping pattern (CP)

FSRD Site, Gangarampur, Pabna

I. Improvement of existing Mustard-Boro-T. Aman rice cropping pattern at FSRD site, Gangarampur, Pabna 2023-24.

Existing cropping pattern: Mustard (Tori-7)-Boro (Local Toba)- T. Aman rice (BRRI dhan39)

Improved cropping pattern: Mustard (BARI Sarisha-17)- Boro (BRRI dhan28)- T. Aman rice (Binadhan-17)

Different crop management practices are presented in Table 17a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in

Table 17b. In the improved pattern though Tori-7 required at least 9 days less than BARI Sarisha-17 but BARI Sarisha-17 gave higher seed yield (1.72 t ha^{-1}) over Tori-7 (1.12 t ha^{-1}) at the FSRD site, Gangarampur, Pabna. The T. Aman variety BRRI dhan39 gave lower yield (4.25 t ha^{-1}) than the Binadhan-17 (5.40 t ha^{-1}). Yield of Boro rice in improved pattern is also higher (5.56 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 54 %, Boro rice yield increased by 20 % and T. Aman rice yield increased by 27 %, 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 $17.24 \text{ t ha}^{-1} \text{ yr}^{-1}$ which was about 30 % higher against existing cropping pattern ($13.30 \text{ t ha}^{-1} \text{ yr}^{-1}$). 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. 261500 ha^{-1} which was 70 % higher than existing cropping pattern. The marginal benefit cost ratio (MBCR) was obtained 11.49 which further indicated the superiority to improved cropping pattern over existing pattern (Table 17b).

Table 17a. Crop managements of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Variety	Binadhan-17	BARI Sarisha-17	BRRI dhan28	BRRI dhan39	Tori-7	Local Toba
Date of sowing/Transplanting	22-27.7.23	20-25.11.23	7-12.3.23	27-31.7.23	25-30.11.23	22-28.2.23
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)	12-17.11.23	20-25.2.24	27-30.6.23	17-25.11.23	10-16.02.24	20-26.6.23
Field duration(days)	100-105	90-91	110-112	104-109	76-79	115-120
Turned around time (days)	11-13	17-20	27-30	9-10	12-15	35-37

Table 17b. Yield and economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during 2023-24

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Mustard	Boro	T. Aman	Mustard	Boro	T. Aman
	Tori-7	Toba	BRRI dhan39	BARI Sarisha-17	BRRI dhan28	Binadhan-17
Seed /grain yield (t ha ⁻¹)	1.12	4.65	4.25	1.72	5.56	5.40
Straw yield (t ha ⁻¹)	1.71	5.795	4.5	2.5	7.418	5.15
Rice equivalent yield (t ha ⁻¹)	2.91	5.38	5.00	4.47	6.52	6.26
Whole pattern Rice equivalent yield (t ha ⁻¹)	13.30			17.24		
Gross return (Tk. ha ⁻¹)	87420	161500	150000	134000	195550	187750
Total variable cost (Tk. ha ⁻¹)	65500	95500	84500	68500	99800	87500
Gross margin (Tk. ha ⁻¹)	21920	66000	65500	65500	95750	100250
Whole pattern gross margin (Tk. ha ⁻¹)	153420			261500		
MBCR	11.49					

Unit price (Tk. kg^{-1}): Boro rice=28.5, T. Aman rice =30.0, Rice straw = 5.0, mustard seed =75.0 and stover=2.00, lentil= 90, chiya= 500

II. Improvement of existing T. Aman-Lentil-Sesame cropping pattern at FSRD site, Gangarampur, Pabna during 2023-24.

Existing cropping pattern: Lentil (BARI Masur-6)- Sesame (Local)-T. Aman rice (BRRI dhan39)

Improved cropping pattern: Lentil (BARI Masur-8)- Sesame (BARI Til-4)-T. Aman rice (Binadhan-17)

Different crop management practices are presented in Table 18a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 18b. In the improved pattern BARI Masur-8 gave higher seed yield (1.87 t ha^{-1}) over BARI Masur-6 (1.75 t ha^{-1}) at the FSRD site, Gangarampur, Pabna. The T. Aman variety BRRI dhan39 gave lower yield (4.57 t ha^{-1}) than the Binadhan-17 (5.45 t ha^{-1}). The yield of BARI Til-4 in improved pattern is also higher (1.50 t ha^{-1}) than the existing local (1.35 t ha^{-1}). In improved cropping pattern, lentil yield was increased by about 7 %, sesame yield was increased by 11 % and T. Aman rice yield was increased by 19 % 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 $17.49 \text{ t ha}^{-1} \text{ yr}^{-1}$ which was about 12 % higher against existing cropping pattern ($15.58 \text{ t ha}^{-1} \text{ yr}^{-1}$). 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. 317300 ha^{-1} which was about 19 % higher than existing cropping pattern (267200 Tk. ha^{-1}). The marginal benefit cost ratio (MBCR) was obtained 7.91 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 18a. Crop management of improved and existing cropping pattern at angarampur, 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	20-25.7.23	22-27.11.23	15-20.3.23	25-29.7.23	27.11-3.12.23	15-25.3.23
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)	10-17.11.23	10-15.3.24	20-25.6.23	16-22.11.23	10-15.3.24	17-23.6.23
Field duration (day)	105-107	112-117	95-98	106-111	107-115	91-95
Turned around time (day)	7-10	6-9	30-34	10-11	7-10	25-28

Table 18b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during 2023-24.

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
	BARI Masur-6	Local	BRRI dhan39	BARI Masur-8	BARI Til-4	Binadhan-17
Seed /grain Yield (t ha ⁻¹)	1.75	1.35	4.57	1.87	1.50	5.45
Straw yield (t ha ⁻¹)	3.38	6.88	4.82	3.50	7.55	5.68
Rice equivalent yield (t ha ⁻¹)	5.48	4.73	5.37	5.84	5.25	6.40
Whole pattern Rice equivalent yield (t ha ⁻¹)	15.58			17.49		
Gross return (Tk. ha ⁻¹)	164250	142000	161200	175300	157600	191900
Total variable cost (Tk. ha ⁻¹)	54000	60750	85500	55500	63500	88500
Gross margin (Tk. ha ⁻¹)	110250	81250	75700	119800	94100	103400
Whole pattern gross margin (Tk. ha ⁻¹)	267200			317300		
MBCR	7.91					

Unit price (Tk. kg^{-1}): Boro rice=28.5, T. Aman rice =30.0, Rice straw = 5.0, mustard seed =75.0 and stover=2.00, lentil= 90, chiya= 500, Sesame seed=95.0 and stover=2.00

FSRD site, Ajoddhapur, Rangpur

III. Improvement of existing T. Aman-Fallow-Boro cropping pattern at FSRD site, Ajoddhapur, Rangpur during 2023-24.

Existing cropping pattern: T. Aman (Swarna)-Fallow-Boro (BRRI dhan28)

Improved cropping pattern: T. Aman (Binadhan-17)-Mustard (BARI Sarisha-14)-Boro (BRRI dhan84)

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. 2023 to January 2024 is presented in Table 19b. Rice equivalent yield (REY) was 10.81 t ha⁻¹ with the whole pattern gross margin Tk. 24460. The MBCR in improved cropping pattern was attained 3.14 and 4.23 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 19a. Crop managements of improved and existing cropping pattern at FSRD site, Ajoddhapur Rangpur

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	03-11 Aug.	23 Nov.-02 Dec.	22 Feb.-04 Mar.	20-24 Jul.	-	23-27 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)	10-16 Nov.	20-24 Feb.	27 Jun.-10 Jul.	25-30 Nov.	-	21-25 Jun.
Field duration (days)	90-95	80-85	118-124	113-116	-	119-125
Turned around time (days)	18-24	7-10	26-34	70-85	-	28-31

Table 19b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed/grain Yield (t ha ⁻¹)	4.41	1.450	4.	3.31	-	-
Straw yield (t ha ⁻¹)	4.81	-	-	3.7	-	-
Rice equivalent yield (t ha ⁻¹)	5.73	-	-	9.56	-	-
Whole pattern Rice equivalent yield (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 gross margin (Tk. ha ⁻¹)	24460			8250		
MBCR	-			-		

Unit price (Tk. kg⁻¹): Aman rice=25, Boro rice=20, Rice straw =6, Mustard=60, Mustard stover=1.

FSRD Site, Tarakandi, Sherpur

IV: Development of alternative cropping pattern at FSRD site, Tarakandi, Sherpur during 2023-24.

Existing cropping pattern: T. Aman (Dhani gold (Hybrid))-Fallow-Boro (Hybrid (Sachchal))

Alternate cropping pattern: T. Aman (Dhani gold (Hybrid))-Pea (BARI Motorsuti-3)-Boro (Hybrid (Sachchal))

Crop management, yield and economics of alternate cropping pattern during 2023-24 have been shown in Table 20a & 20b. Grain yield (5.28t/ha) of T.Aman rice was obtained from existing pattern and alternate cropping pattern. The grain yield (6.85/ha) was obtained from improved cropping pattern and existing cropping pattern. Pea seed yield (8.6 t/ha) was obtained from alternate cropping pattern.

From the Table 20b, it was observed that the highest gross return (Tk. 755132/ha), gross margin (Tk. 456417/ha) and BCR (1.52) was obtained from improved cropping pattern.

Table 20a. Crop management of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T.Aman	Pea	Boro	T. Aman	Fallow	Boro
Variety	Dhani gold (Hybrid)	BARI Motorsuti-3	Hybrid (Sachchal)	Dhani gold (Hybrid)	-	Hybrid (Sachchal)
Sowing/Planting	25 July, 2023	15 Nov., 2023	09 Feb - 2024	25 July, 2023	-	25 Jan, 2024
Seed rate (kg ha ⁻¹)	40	7	20	50	-	40
Spacing	20cm ×15cm	25cm ×10cm	20cm ×15cm	20 cm ×15cm	-	20 cm ×15cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	82-24-35-11-4-0	46-30-50-0-0-0	100-14-40-10-3.6-0	90-20-25-0-0-0	-	130-30-81-15-0-0
Date of harvesting	2 Nov., 2023	06 Feb, 2024	15 May, 2024	2 Nov., 2023	-	09 May, 2024

Table 20b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Motorsuti	Boro	T.Aman	Fallow	Boro
Grain yield (t ha ⁻¹)	5.28	8.6	6.85	5.28	-	6.85
Straw yield (t ha ⁻¹)	5.61	-	7.15	5.61	-	7.15
Gross return (Tk ha ⁻¹)	156696	420000	178436	156696	-	178436
Production cost (Tk ha ⁻¹)	92220	108500	97995	92220	-	97995
Gross margin (Tk ha ⁻¹)	64476	311500	80441	64476	-	80441
REY (t ha ⁻¹)	32.83			14.57		
Gross return (Tk ha ⁻¹)	755132			335132		
Production cost (Tk ha ⁻¹)	298715			190215		
Gross margin (Tk ha ⁻¹)	456417			144917		
BCR	1.52			0.76		

Price of output: T. Aman (Dhani gold): Tk 23/kg, Boro rice: Tk. 22 /kg and straw 1.0/kg, Motorsuti: Tk 50.00/kg.

Activity-6: On-farm verification/Production program

Production program

I. Production with modern varieties of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during 2023-24.

FSRD site, Gangarampur, Pabna

The production programs on Mustard, Lentil and Chiya were conducted at FSRD site, Gangarampur, Pabna during 2023-24. The number of cooperator farmers, area coverage, date of sowing/planting and date of harvesting is presented in Table 21. The variety BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-20, BARI Masur-8 and BARI Chiya-1 were used in the production program. The average seed yield of BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-20 were 1.65, 1.89 and 2.20 t ha⁻¹ (Table 21). The average seed yield of Lentil (BARI Mashur-8) and Chiya (BARI Chiya-1) were 1.50 and 0.75 t ha⁻¹, respectively (Table 21).

Table 21: Different operations conducted for production program at FSRD site, Gangarampur, Pabna during 2023-24.

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (ha)	Yield (t ha ⁻¹)
Mustard	BARI Sarisha-14	25-30 Nov.	27-28 Feb.	3	0.5	1.65
	BARI Sarisha-17	21-30 Nov.	27-28 Feb.	7	0.6	1.86
	BARI Sarisha-20	25-30 Nov.	27-28 Feb.	4	0.4	2.20
Lentil	BARI Masur-8	25-30 Nov.	15-21 March	7	0.9	1.50
Chiya	BARI Chiya-1	19-26 Dec.	03-09 March	5	0.02	0.75

FSRD Site, Tarakandi, Sherpur

Potato: The tuber yield, gross return, variable cost and gross margin of Potato varieties are presented in Table 22. The tuber yield ranged from 37.23 to 44.26 t ha⁻¹. Significantly, the highest tuber yield (44.26 t/ha) was produced by BARI Alu-37. On the other hand, BARI Alu-41 produced lowest tuber yield (37.23 t/ha). The highest gross return (Tk. 531120 ha⁻¹) and gross margin (Tk. 355930 ha⁻¹) was recorded from BARI Alu-37 and BARI Alu-41 gave the lowest gross return (Tk. 446760 ha⁻¹) and gross margin (Tk. 271570 ha⁻¹) which was only due to yield differences.

Table 22. Grain yield and economics of Potato at FSRD site, Tarakandi, Sherpur during 2023-24

Varieties	Tuber yield (t ha ⁻¹)	Gross return (Tk.ha ⁻¹)	TVC (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)
BARI Alu-35	40.06	480720/-	175190/-	305530/-
BARI Alu-36	41.35	496200/-	175190/-	321010/-
BARI Alu-37	44.26	531120/-	175190/-	355930/-
BARI Alu-40	40.22	482640/-	175190/-	307450/-
BARI Alu-41	37.23	446760/-	175190/-	271570/-
Average	40.62	487488/-	175190/-	312298/-

Price of potato - Tk. 12.00/kg

C. LIVESTOCK SYSTEM

I. Vaccination program on Cattle

Activity-7: Effect of vaccination and deworming on cattle at different FSRD sites during 2023-24.

FSRD site, Gangarampur, 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 23 shows the information on number of cattle under vaccination program, and name of the vaccine applied to the selected cattle. Total number of livestock brought under vaccination and deworming program was

94 at FSRD site, Gangarampur, Pabna during the years of 2023-24. Percentage of disease infestation before and after vaccination was recorded among the cooperator farmers. It was found that before vaccination and deworming infestation rate of cattle was higher (15-25%). After vaccination of cattle, all of the diseases frequency reduced drastically, and infestation rate was around 2-4%.

Table 23. Mortality (%) of livestock before and after vaccination against major disease at FSRD site, Gangarampur, Pabna during 2023-24.

Activities	No. of livestock vaccinated			Percentage of disease infestation (%)	
	Cattle	Goat	Sheep	Before intervention	After intervention
Anthrax	49	-	-	25	3
FMD	45	-	-	20	2
De-worming	94	-	-	15	4

Table 24. Increase of net return in livestock component in the study area before and after vaccination

Site	Before intervention			After intervention			Net return increased (%)
	Gross return (Tk.)	Total cost (Tk.)	Net return (Tk.)	Gross return (Tk.)	Total cost (Tk.)	Net return (Tk.)	
Gangarampur	118050	60500	57550	197500	90850	106650	85.32

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 25. In an about 194 numbers of cattle including cow, ox, calf and goat were vaccinated.

Table 25: Number of vaccinated livestock against major diseases at FSRD site, Ajoddhapur, Rangpur during 2023-24.

Name of diseases/vaccine	No. of livestock vaccinated and dewormed					Total
	Cattle	Goat	Chicken	Duck	Pigeon	
Torka	116					116
PPR		78				78
RDV, BCRDV			215			215
Duck plague				58		58
Pigeon Pox					23	23
Dewarming (Helmex)	92	69				161

FSRD Site, Tarakandi, Sherpur: 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 26 shows the information on number of cattle under vaccination programme, name of the vaccine applied to the selected cattle and dates of vaccination. The numbers of different types of vaccinated livestock were 155 and 73 in case of Torka and PPR, respectively. Frequency of livestock diseases was listed among the cooperative farmers. It is found that before vaccination frequency of different diseases was higher. After vaccination of cattle, all of the diseases frequency reduced drastically, and mortality rate is almost nil now (Table 26).

Table 26. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Tarakandi, Sherpur during 2023-24.

Date of vaccination	Name of the vaccine	Number of cattle Vaccinated	Percentage of mortality (%)	
			Before intervention	After intervention
05.08.23	Torka	155	10	0
	PPR	73	5	0

II. Vaccination program on poultry birds

Activity-8: Effect of vaccination on poultry production at different FSRD sites, 2023-24

FSRD Site, Gangarampur, Pabna

Vaccination program of chicken was conducted at FSRD site, Gangarampur, Pabna during 2023-24. Table 27 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 205, 145, 100 and 105 in case of BCRDV, RDV, FOWL POX and FOWL COLERA, respectively. 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 (20-30%). After vaccination of poultry, all of the diseases reduced drastically, and mortality rate was recorded about 3-5% (Table 27).

Table 27. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Gangarampur, Pabna during the years of February 2023-24.

Name of vaccine	No. of poultry birds vaccinated				Percentage of mortality	
	Chicken	Duck	Pigeon	Turkey	Before	After
BCRDV	205	-	-	-	30	5
RDV	145				20	5
Fowl pox	100				20	3
Fowl cholera	90	15			20	5

FSRD site, Ajoddhapur, Rangpur

Poultry vaccination program was performed at FSRD site, Ajoddhapur, Rangpur during 2023-24. Four different types of vaccines (BCRDV, RDV, Duck plague and Pigeon Pox) were provided to 296 birds (Table 28).

Table 28: Number of vaccinated livestock against major diseases at FSRD site, Ajoddhapur, Rangpur during 2023-24.

Name of diseases/vaccine	No. of livestock vaccinated and dewarmed					Total
	Cattle	Goat	Chicken	Duck	Pigeon	
Torka	116					116
PPR		78				78
RDV, BCRDV			215			215
Duck plague				58		58
Pigeon Pox					23	23
Dewarming (Helmex)	92	69				161

FSRD Site, Tarakandi, Sherpur

The cooperator farmers were interested to adopt vaccination technology as per routine work because it reduces mortality of poultry due to different diseases. Table 29 shows the information on number of poultry under vaccination program. The numbers of different types of vaccinated poultry were 238 and 188 in case of BCRDV and RDV, respectively. Frequency of poultry diseases was listed among the cooperative farmers. It is found that before vaccination frequency of different diseases was higher. After vaccination of poultry, all of the diseases frequency reduced drastically, and mortality rate is 4-5% (Table 29).

Table 29. Mortality (%) of poultry **birds** before and after vaccination against major diseases at FSRD site Tarakandi, Sherpur during 2023-24.

Duration of Vaccination	Name of the vaccine	Number of bird vaccinated	Mortality rate (%)	
			Before vaccination	After vaccination
05.08.23	BCRDV	238	25	5
	RDV	188	15	4

III. Cattle fattening

Activity-9: Cattle fattening program at different FSRD sites during 2023-24.

FSRD Site, Gangarampur, Pabna

Beef fattening program was conducted during 2023-24. Three cooperator farmers were involved with beef fattening program. 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 30). Market value was estimated and found that it was increased around 77-125% as compared to initial value of the cattle.

Table 30. Body weight and market value for beef fattening at FSRD site Pabna during 2023-24

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 (%)
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

IV. Goat rearing

Activity-10: Goat rearing in the farmer's household for increase income of farmers

Two farmers were involved with goat rearing program at FSRD site, Gangarampur, Pabna. Each farmer reared at least one female goat. The average initial body weight of the supplied goat was 5 kg. The survival rate of the supplied goat was 100%. After 6 months of goat rearing each farm family gets on an average gross margin Tk. 7033 (Table 31).

Table 31. Performance of goat at farmers level at FSRD site Pabna during 2023-24

Description of Items	February 19-January 20
Number of farmers	2
Number of goats	5
Initial body wt. goat ⁻¹ (kg)	5 Kg
No of goat survive	100%
Wt. gained/goat after 6 months	4 kg
Total number of kids born per farm family	2
Total return (Tk.) per farm family	15033/-
Total variable cost (Tk.) per farm family	8000/-
Gross margin (Tk.) per farm family	7033/-

V. Sonali chicken rearing in the farmer's household

Activity 11: Performance of Sonali chicken at different FSRD sites during 2023-24.

FSRD Site, Gangarampur, Pabna

The cooperator farmers of FSRD site Gangarampur, Pabna were interested in rearing poultry for meat and egg purpose. Three farmers were reared poultry, and each farmer was reared 10 number of Sonali chicks (ratio between male and female is 1:9). BCRDV and booster dose of BCRDV vaccine was provided in schedule time and other vaccines were provided at due time. The initial weight of Sonali breed was about 0.6 kg and the average final body obtained from those chickens was about 1.04 kg. It was found that gross margin per farm was Tk.3480 (Table 32). Farmers showed their interest in rearing Sonali chick because of better production of egg and meat.

Table 32. Performance of Sonali chicken at farmers level for egg and meat purpose at FSRD site Pabna during 2023-24

Description of Item	2023-24
Number of farmers	12
No. of bird per farm family	10
Initial body weight (kg)	0.6
No. of chicken survived	9
Total number of eggs	240
Weight gained bird ⁻¹ (kg)	1.04
Total number	9
Total income from bird (Egg & Meat) (Tk.)	5100
Total variable cost (Tk.)	1620
Gross margin	3480

FSRD Site, Tarakandi, Sherpur

Activity-12: Performance of Naked neck (Garchila) chicken at different FSRD site Tarakandi, Sherpur during 2023-24.

From the experiment it has been found that average initial body weight were 802 g, 726 g, 862 g, 736 g, 536 g, 796 g, 624 g, 554 g, 732 g, 562 g 734 g and 596 g which after 4 month raised to 914g, 880g, 925g, 966g, 878g, 852g, 736g, 848g, 836g, 856g, 884g and 844g respectively in different farmers (Table 33). Some of the egg was hatched by farmers' management and they were reared under close observation. Regular vaccination was given to the chick. Relative and neighbors were also hatched the egg by taking the egg from the selected farmers. From the table 33, it was revealed that on an average, farmer sold their egg by Tk. 312.50 up to 4 month.

Table 33. Average performances of Garchila breed at farmers' level up to 4 months of rearing at FSRD site, Tarakandi, Sherpur.

Number of farmers	12
No of birds supplied	60
Date of supplied period	01-10-2019 to 15-10-2019
Initial wt/bird (kg)	0.688
Initial value/bird (Tk.)	220
Starting of delivery egg	04-11-2019
Feed Supplements/ bird (g)/Day	50
Feed Supplements cost/ bird (Tk)	2.20
No. of egg/farm	25
Total value of egg/farm (Tk.)	312.50
Present wt/bird (kg)	0.868
Weight gained/bird (Kg)	0.180
Cost /farmer in Tk. (Feed cost/farm/day)	11
Total variable cost (Tk) (Initial cost of chick & feed)	2420
Total return/farmer in Tk. (Market value of Egg)	312.50 (Only from egg)
Gross margin (Tk)	-

VI. Duck rearing in the farmer's household

Activity 13. Performance of Khaki Campbell duck at different FSRD sites

FSRD Site, Tarakandi, Sherpur

From the experiment it has been found that egg production per farm 392.25 (Table 34). From the table, average consumption, distribution and selling were 106, 30.25 and 256 per farm. The monthly income was found Tk.653.5 per farm.

They were reared under close observation. Regular vaccination was given to the duck. Our project objectives are livelihood development of the rural people. In that view of point it is observed that the cooperative farmers sold some eggs and earned some cash from rearing of duck.

Table 34. Performance of improved breed's up to 6 months.

Name of farmers	No. of ducks supplied	Total egg production	Egg production			Monthly income (Tk.)
			Consumption	Distribution	Selling	
Md. Nurul Islam	10	315	97	27	191	525
Md. Nur Islam	10	335	96	26	213	558
Md. Tuta Mia	10	452	104	28	320	753
Md. Nazmul Islam	10	467	127	40	300	778
Average	10	392.25	106	30.25	256	653.5

VII. Green fodder production

Activity-14: Performance of green fodder production at household level

FSRD site, Ajoddhapur, Rangpur

The production of Napier grass was 68 t ha⁻¹ and the average gross margin was calculated Tk. 28000 ha⁻¹ (Table 35).

Table 35. 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)
2023-24	14	68	68000	40000	28000

VIII. Compost production

Activity 15. Performance of Farm Yard Manure production at different FSRD sites during 2023-24.

FSRD site, Gangarampur, Pabna

Farm Yard Manure (FYM): Farm yard manure was produced by using cattle dung and homestead wastage at the homestead area during 2023-24. The average production of FYM per homestead was 3550 kg and the gross margin was equivalent to Tk.6000 homestead⁻¹ (Table 36).

Table 36. Average performances of compost production and utilization.

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)
Before	2500	2500	0	0	5000	500	4500
After	3550	3000	0	550	7100	1100	6000

Vermicompost

Activity-16: Performance of vermicompost production at different FSRD sites during 2023-24.

Vermicompost was produced in six farmers homestead area using cement ring. The total vermicompost production was 320 kg homestead⁻¹. Gross margin was calculated Tk. 5400 homestead⁻¹ after first time production (Table 37).

Table 37. Average performances of compost production and utilization during 2023-24

Intervention	Average compost produced (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)
Vermicompost	320	282	0	225	6100	700	5400

D. FISHERIES SYSTEM

I. Production program of carp polyculture in seasonal pond

Activity-17: Maximization of farmers' income through carp polyculture technique at different FSRD sites during 2023-24.

FSRD Site, Gangarampur, Pabna: Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 38a. Five farmers ponds were selected for polyculture of carp fishes during 2023-24. 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 72%.

Yield and economic analysis are shown in Table 38b. The average yield of fish was obtained 228 kg per pond with the gross margin of Tk. 13700 per pond.

Table 38 (a). Performance of carp polyculture fish farming at FSRD site during 2023-24.

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 (%)
10 dec. and 2m	55 kg #360	151	875	228 kg #260	72.23

Table 38 (b). Yield and economics of carp polyculture farming.

Average total wt. (kg/pond)	Total cost (tk/pond)	Gross return (tk/pond)	Grass margin (tk/pond)
228	20500	34200	13700

FSRD Site, Tarakandi, Sherpur: In the program, four seasonal ponds were brought under culture technique with suggested fish. Initial size and weight, final weight and length of fish, total production of fish, survival rate are shown in Table 39a and Table 39b. The yield and utilization pattern of harvested fish are shown in Table 39c. Utilization patterns of fishes before and after intervention of the program are shown in Table 39c. It is observed that weight and length of silver carp were higher in respect to other fishes. From table 39b, it was revealed that production was more after intervention than before intervention because timely management and done other activity.

Table 39a. Performance of carp polyculture fish farming at FSRD site, Tarakandi, Sherpur.

Breed	Initial size (cm)	Initial wt (g)	Size after 90 days (cm)	Weight after 90 days (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial	Survival rate (%)
Ruhi	25	210	28	310	30.2	380	80.9	95.5
Kalbaus	24.7	193.3	26.33	246.57	27.8	346.7	79.35	96.3
Grass carp	42.06	783.34	48.33	1106	55	1733	121.23	98
Katla	27.25	320	30.3	450	34.5	656.6	105.2	97
Mrigel	31.25	300	35.67	490	38	650	116.7	96
Silver carp	20	106.6	31.34	350	35.67	560	425.3	97

Table 39b. Production and economics before and after intervention for fish culture of the farmer.

Before intervention					After intervention				
Production (kg/ha ⁻¹)	Total income (Tk. ha ⁻¹)	Cost (Tk. ha ⁻¹)	Benefit (Tk. ha ⁻¹)	BCR	Production (kg/ha ⁻¹)	Total income (Tk. ha ⁻¹)	Cost (Tk. ha ⁻¹)	Benefit (Tk. ha ⁻¹)	BCR
3435	412200	250000	162200	1.65	5407	1027330	450000/-	577330	2.28

Table 39c. Utilization pattern of harvested fish.

Total Yield (kg/Pond)	Consumption (Kg)	Distribution (Kg)	Sold (Kg)
216.3	60	21	135

Average pond size = 16 .75 Decimal. Price of fish=130 Tk. kg⁻¹

E. OFF-FARM ACTIVITIES

Activity-18: Maximization of farmers' income through Off-farm activities at different FSRD sites during 2023-24.

FSRD Site, Gangarampur, Pabna: Other than agricultural activities, which are called off-farm activities is also a good opportunity for increasing farm total income. Three households were practicing 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 to the livelihood of the resource poor farmers to some extent. After intervention net benefit from off- farm activities were recorded Tk. 30975 farm⁻¹ (Table 40). So, if all households could introduce some off-farm activities, it would be helpful to increase their total farm income which eventually contributes to the improvement of the rural household.

Table 40. Cost and return of off-farm activities at FSRD site, Gangarampur, Pabna during 2023-24.

Types of activities	Before intervention			After intervention (Tk)		
	Total income	Cost	Net income	Total income	Cost	Net income
Sewing katha	666	320	346	15550	8850	6700
Puffed rice (Muri vaja)/ Kumra bora	483	230	253	3050	1450	1600
Seedling nursery	200	50	150	4350	1875	2475
Jam jelly	20	15	5	1750	750	100
Tailoring	46	20	26	6250	1550	4700
Modi shop	100	50	50	32750	18250	14500
Total	1515	685	830	63700	32725	30975

FSRD Site, Tarakandi, Shepur: Some farmers and their wife are involved with off-farm activities such as Katha sewing, made of cocunut stick etc. in the working area.

Table 41. Cost and return of off-farm activities.

FSRD site	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Tarakandi, Shepur	7000	5000	2000	13000	9000	4000	100

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 production. A total 2000 kg of vermicompost were distributed. So, if all households could introduce some off-farm activities which would be helpful to increase total farm income.

Table 42. Cost and return of off-farm activities.

Activities	Before intervention	After intervention	Production cost (tk.)	Sale value (tk.)	Return (tk.)
Vermi-compost production	0 kg	20000 kg	23000	30000	7000

Income enhancement

FSRD Site, Gangarampur, 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 a remarkable increment could obtained from homestead gardening, fisheries and livestock sector after program intervention. Regarding the increasing of different components over previous status, off-farm activities demonstrated maximum increase (3631%) in return over previous status followed by fisheries sector (640%) (Table 43).

Table 43. Technologies used and returned from different sub-systems of integrated farming during 2023-24.

Component	Before intervention			After intervention			Gross margin increased (%)
	Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead	24480	6000	18480	48505	11350	37155	101.06
Field crop	265947	163667	102280	344867	170533	174333	70.45
Livestock	118050	60500	57550	197500	90850	106650	85.32
Poultry	2400	1000	1400	5100	1620	3480	148.57
Fisheries	4350	2500	1850	34200	20500	13700	640.54
Off-farm	1515	685	830	63700	32725	30975	3631.93
Total:	416741.7	234351.7	182390	693871.7	327578.3	366293.3	100.83

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, labour, 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 551% and 772% increased after intervention of technologies. Before intervention of the project, the average per farm gross margin was Tk. 267204 whereas it was Tk. 1219884 2023-24 after intervention of the project activities. The average increment of gross margin after intervention was 357% compared to before intervention (Table 44).

Table 44. Technologies used and returned from different sub-systems of integrated farming systems at FSRD site Tarakandi, Sherpur during 2023-24.

Components	Before Intervention (Tk.)			After Intervention (Tk.)			% Increased
	Gross return	TVC	Gross margin	Gross return	TVC	Gross margin	
Homestead	765	271	494	9710	5400	4310	772.4
Field crop	334055	237825	96230	1570553	944143	626410	551
Livestock	11,080	4,800	6,280	13093.50	5260	7833.50	25
Fisheries	412200	250000	162200	1027330	450000	577330	255
Off-farm	7000	5000	2000	13000	9000	4000	100
Total	765100	497896	267204	2633687	1413803	1219884	357

FSRD Site, Sholakundu, Faridpur

By integration of year-round vegetables production and production technologies, 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 a remarkable return recorded from the homestead area which was 325% increased after intervention of technologies. The off-farm activities contributed a good amount to the increase in farm income (Table 45).

Table 45. Technologies used and returned from different sub-systems of integrated farming systems at FSRD site Sholakundu, Faridpur during 2023-24.

Component	Before intervention (TK.)			After intervention (Tk.)			% increase of GM with before intervention
	GR	VC	GM	GR	VC	GM	
Homestead	1652	4060	5712	31212	6960	24252	325%
Off-farm	0	0	0	30000	23000	7000	-
Total	1652	4060	5712	61212	29960	31252	447%

FSRD Site, Atia, Tangail

It was observed that a remarkable return recorded from the homestead area which was 433% increased in vegetables production sector after intervention of technologies. The gross margin from fruits production was increased and that was 229% (Table 46).

Table 46. Gross return, cost and gross margin for before and after intervention of suitable fruits and vegetables at FSRD site, Atia, Tangail during 2023-24

Components	Before Intervention (Tk)			After Intervention (Tk.)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Vegetables	1320	526	794	7800	3567	4233	433
Fruits	1593	380	1213	5225	1240	3985	229
Total	2913	906	2007	13025	4807	8218	309

F. DEVELOPMENT OF LOCAL SERVICE PROVIDER (LSP)

Activity-19: Development of Local Service Provider at different FSRD sites during 2023-24.

FSRD site, Gangarampur, Pabna

One female and one male co-operative farmer was acted as LSP at the project area. The female LSP produced different types of vegetables seedling in his own nursery and also collected seeds and seedlings from other sources and supplied to the project farmers and remaining part sold to the neighbour other farmers. The beneficiary farmers were return back partially in cash and mostly some parts of their produce (vegetables/fruits/seeds) to the LSP. The female LSP also provided vaccine to the poultry (chicken and duck) of the neighbour farmers and earn some extra money. Besides of seedling production, existing fruits trees in the project area were sprayed with pesticides by the male LSP and earned some extra money. A regular fortnight discussion meeting on home garden management, human nutrition and sanitation also organized by the LSP at the project area. These activities were found a suitable practice for the sustainable farming activities. Table 47 shows the activities of female and male LSP.

Table 47. Activities of Local Service Provider (LSP) at FSRD site Ajoddhapur, Rangpur during 2023-24.

LSP	Activities	Crop	Number	Supply to homestead member (no.)	Sell to other farmer (no.)	Gross return (Tk)	TVC (Tk)	Gross margin (Tk.)	Product sharing
Female	Seedling production	Bottle gourd	200	72	128	600	800	1925	Bottle gourd, Sweet gourd
		Sweet gourd	80	48	32	240			
		Sponge gourd	65	48	17	195			
		Bitter gourd	60	60	-	180			
		Ridge gourd	96	72	24	480			
		Snake gourd	46	46	-	230			
		Ash gourd	160	72	88	800			
	Vaccination	Hen	165	-	-	825	240	665	Egg
		Duck	16	-	-	80			

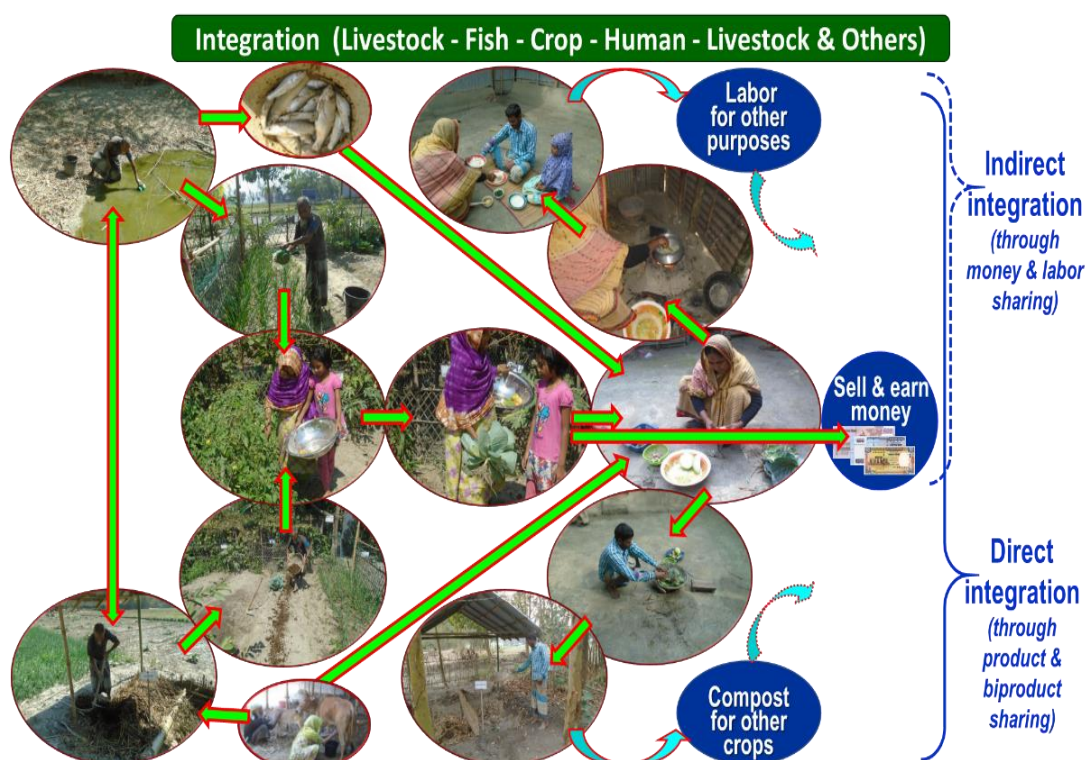
Male	Seedling production	Brinjal	420	360	60	2100	700	2160	Veg. will be shared
		Chilli	380	360	20	760			
	Spray on fruit trees	Mango	278	-	-	5560	5500	220	Fruits will be shared
		Jackfruit	5	-	-	100			
		Litchi	3	-	-	60			
	Total					12210	8740	4970	

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Activity-20: Feasibility study on integration among different household components at different FSRD sites during 2023-24.

FSRD site, Gangarampur, Pabna

A farmer's enterprises, such as home gardening with vegetables and fruits, crops and cropping systems, dairying, poultry, and fisheries, are all interconnected. The end product and waste from one firm were used as inputs in another. Furthermore, careful use of farm resources can cut production costs while also helping to keep the environment clean. The impact of one component on another is a key factor in integrated farming for sustainability. There were two types of integration among the many components of a farm: direct integration and indirect integration. Direct integration was accomplished by sharing a product or a product directly with one another, whereas indirect integration occurred through the sharing of money, nutrition, or labor.



Direct and indirect integration among the farm components

Livelihood improvement (sustainability)

Improving one's livelihood is a complicated process that requires one to be able to obtain the requirements of life in order to meet one's basic demands. The enhancement of livelihood may encompass raising one's capacity for earning enough money, securing wholesome and safe food,

access to healthcare, education, and possessions, as well as leading an acceptable life and rising in the social hierarchy. Nonetheless, the following lists the criteria that were taken into account for the durability of livelihood improvement across various FSRD sites.

Impact of integrated farming system on livelihood

- Increase production of vegetables in homestead, decrease purchasing vegetables from market
- Proper utilization of unused fallow land
- Change dietary habit, grow tendency to take vegetables and also increase vegetables consumption by the family members
- Improve family nutrition
- Improve social status, create very positive impact on family member, neighbors and visitors
- Ensure employment opportunity
- Increase income of the family and also increase economic return

Lessons Learned

- i. There is plenty of scope to utilize the rural farm household all over the country to produce vegetable and fruits and increase farm income.
- ii. Home gardening with vegetables and fruits will lessen the pressure on the mainland.
- iii. Inclusion of proper variety, quality seed and improved crop management can enhance cropping intensity and productivity compared to existing cropping practice.
- iv. Proper utilization of farm resources could help income enhancement compared to existing conditions.
- v. Changed in consumption habit with vegetables and fruits due to availability of diversified vegetables and fruits round the year and it also influence the nutritional status of the rural people.
- vi. Regular vaccine should be applied at early in the morning to poultry and livestock for more success.
- vii. Proper management of compost pit and its utilization can help to produce safe and nutritious vegetables.
- viii. Water needs to be supplemented in seasonal ponds during dry season for optimum growth of fish.

Challenges

- Uneven rainfall/heavy rainfall/flood.
- Short term and irregular funding hamper the smoothness of the program.
- Shortage of manpower. Lack of strong multidisciplinary scientific team like fisheries and livestock to implement the program.
- Lack of proper agricultural knowledge of farmer.
- Lack of proper machineries and spare parts for mechanization.
- Lack of climate change resilient technology
- Lack of small-scale irrigation facilities.
- Lack of seed production and storage facilities of huge number of vegetables.
- Homestead activities hampered sometimes due to dense vegetation.

Conclusion

A growing tendency in the program indicates that the key to improving livelihoods is to increase income relative to existing conditions. So, the proper utilization of farmers' resources could help them in this area. Generally, most of the homestead area of the farmers was unproductive and unused, female labor was less or unused and vegetables & 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, the 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 the FSRD 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 production of FYM, an input in agricultural systems, uses dairy waste such as dung, urine, trash, and so on. Cattle are fed straw that is harvested from the crops. Nonetheless, the development of a local service provider (LSP) is necessary for integrated farming operations to be profitable and sustainable.

155. INTEGRATED FARMING FOR IMPROVING LIVELIHOOD OF RESOURCE POOR FARM HOUSEHOLDS IN A PARTICIPATORY APPROACH

M.S. HOSSAIN, M. I. NAZRUL AND M.E.A. PRAMANIK

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. Furthermore, resource poor farm households are more concern with the decreasing of agricultural land. It needs to manage properly all the resources of a farm household in integrated approach. The integrated farming activities were carried out at FSRD site, Basantapur, Godagari, Rajshahi and Kamalbazar, Sylhet during 2023-24 to utilize available farm resources and to improve livelihood of the resource poor farm households. The research areas were i) Homestead production system ii) Crops and cropping system. Main components of integrated farming such as vegetables, fruits, cereal crops, were brought under improved technological intervention and accordingly income was increased from these components. **In Barind areas**, the overall results of those experiments showed that farmers obtained higher yield and economic return from their improved cropping pattern with improve variety (s). Two improved cropping patterns were conducted of which Tomato-Boro-T. Aus gave the highest productivity and economic return. Newly released high yielding crop varieties were also introduced through on farm validation program where farmers obtained higher crop yields and gross margin. Results of homestead production program revealed that intake of vegetable were markedly increased (avg. 250%) by all families included in this system. Average intake of fruits per year was also increased (Avg. 156.25%) after intervention of the technology. Moreover, farm yard manure (FYM) production and utilization were created a good impact among the farm family. Finally, it can be concluded that interventions made in different components exerted a visible positive impact in improving farmers' socio-economic condition and livelihood as well. The results of FSRD activates imply that by implementing the coordinated approach of farming systems at FSRD sites has brought a good impact on the resource-poor farmers for the betterment of livelihood. **In Kamalbazar, Sylhet region**, six farm households from each category of marginal, small and medium farms were intervened under integrated farming study. Results found that farmers introduced several alternatives practices and new enterprises in almost all farming subsystems after intervention. Results revealed that after intervention of the proven and improved technologies in the homestead following the Golapgonj model, vegetable production has been increased 5.45 compared to before intervention of the program. The vegetables and fruit productions per homestead were 619 and 521 kg, respectively. The gross margin of produced vegetables and fruits were Tk. 7830 and 12160, respectively based on the present market price in the locality. Inclusion and production of high yielding crop varieties eg. Potato (BARI Alu-41), BRRI dhan48 and Binadhan-7 in T. aus and T. aman rice season, respectively in the improved cropping pattern was enhanced higher economic return over farmers existing pattern. BARI Sarisha-14 would also be well-fitted into farmers existing cropping system. Involvement of women and children in homestead gardening were more compared to men. However, all these led to full utilization of both physical & other farm resource available in the disposal of the farm and helped to mobilize resources for food security, income generation and improvement of livelihoods.

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 & development program was initiated in Bangladesh through nine FSRD sites. 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 subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a sub-system. While there are different production alternatives, farmers have a limited set of resources. 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. These research & development technologies have created good impression on farmer's income and nutrition. Farming system is an inter-linked product & consumption system of a farmer based on all components viz. crop, livestock, fisheries, Agro-forestry etc. The Farming System Research & Development (FSRD) program is aimed to enhance the efficiency of farm productivity by developing & applying technologies on the household product system. It involves management & manipulation of the farm resources. Farming system Research in the High Barind Tract was initiated in 1985 at FSRD site, Saroil, Rajshahi and drought prone areas in Kamalbazar, Sylhet. Many technologies were developed through research to solve identified problem & many of those technologies were expended in the extrapolation area. Besides of this, natural calamity like drought, low rainfall, undulating land, tenure system etc. was constraining for smoothly run of the program. Now a day, a large number of farmers have been motivated & adopted promising technologies sincerely. Therefore, the project has been undertaken to utilize the present 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.

Overall Objectives

- 1) Optimization of homestead land use, availability of vegetable round the year.
- 2) Utilization of women and child labour, adequate supply of vitamin A and C and also supply of good quantity of iron, calcium and thiamin.
- 3) Farmer's social status improved through intervention of new and profitable technologies as Income Generating Activities (IGA).
- 4) Minimize degradation of soil fertility and improve human nutrition by incorporating leguminous crops in the existing cropping pattern.
- 5) Strengthen linkage among researches, extension agents and farmers to expedite technology transfer process.

Methodology

The integrated farming system was carried out at farmers' field of farming system research and development (FSRD) site, **Kamalbazar, Sylhet** during the year 2023-24. There were twenty (20) vegetables grown in different production units of homestead as per Golapgonj model with a view to maximize the utilization of all available farm resources, farm productivity and income. On the other hand, to integrate farmers' resources with the view of improving production, nutrition, income and livelihood, the activities were carried out at FSRD site, **Basantapur, Godagari, Rajshahi** during 2023-24. 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 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 sizeable homestead under single ownership were targeted and six farm households were selected. Before going to implement the project activities,

a case study of individual households was carried out. 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 & 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 Barind model in each homestead, fruit tree management, improving crops and cropping pattern 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 in Barind

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 models are given below.

Results and discussion for Barind region

Farming system consists of several enterprises like home gardening, cropping system, poultry, fishery, etc. These enterprises are interrelated. The end product and wastes of one enterprise are used as inputs in others. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems (Table 19). The straw obtained from the crops is used as fodder for cattle are highly interrelated. However, different location and component-wise findings are discussed in underneath (Tables 1, 3, 4).

Table 1. High Barind model for vegetable production

SI. No.	Spaces	Cropping patterns		
		Rabi	Kharif-1	Kharif-11
1.	Open sunny land			
	Bed 1	Brinjal	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/ Green 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	Country bean	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 2. Vegetables production with Golapgonj Model in Sylhet

Sl. No.	Spaces	Pattern No./Bed	Cropping patterns		
			Rabi	Kharif-I	Kharif-II
1.	Open sunny land	Bed-1	Radish/Indian Spinach	Indian Spinach/Pudina	Kang Kong
		Bed-2	Radish/Tomato	Red amaranth/Okra	Indian Spinach
		Bed-3	Bushbean/ Stem am.	Kang Kong	Brinjal
		Bed-4	Dhonia/ Lettuce/mint	Dhonia/ Pudina	Amaranth
2.	Cottage roof/top	a.	Country bean/Bottle gourd	Ash gourd	-
3.	Trellis	a.	Country Bean/Bottle gourd	Snake gourd	Ridge gourd
4.	Fences/Boundary wall	a.	Bitter gourd	Bitter gourd	-
5.	Non-fruit trees	a.	Yam	Yam	Yam
6.	Partially shady land	a.	Bilati Dhonia	Turmeric/Ginger	Turmeric/Ginger
7.	Homestead areas	a.	Papaya	Papaya	Papaya
8.	West and Marshy land	a.	Aroids (Panikachu)	Aroids	Aroids

In Sylhet region, based on the pre-intervention status, the system performance was analyzed in the context of existing biophysical and socio-economic environment of the farm and constraints and potentials were identified. To ensure maximum utilization of existing farm resources, alternate/new packages of technologies for different enterprises of all components of the farm were identified and finally selected on the basis of farmers' option. The farmers were motivated through all possible ways to utilize their own resources to adopt the interventions. Throughout the entire period of implementation, regular technical supports were provided on as and when necessary basis and the performance of different interventions were monitored regularly. Data on date all operations, intercultural operations, production of vegetables, prices, disposal pattern, family labour utilization, economic return etc. were recorded in time using standard methods and subjected to tabulate and analyzed by using MS-Excel software accordingly (Tables 2,5,6).

B. Improvement of Cropping Systems in Barind areas

Table 3. Improvement of cropping pattern Boro-T. Aman rice to Mustard-Boro-T. Aman at Basantapur, Godagari, Rajshahi during 2023-24

Observation	Improved cropping pattern			Existing cropping pattern		
	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisa-17	BRRRI dhan-88	BRRRI dhan49	BRRRI dhan-28	-	BRRRI dhan51
Date of sowing/ Transplanting	5-7 Nov. 2023	10-12 Feb 2024	18-20 July 2023	6-7 Feb 2024	-	25-28 July 2023
Seed rate (kg ha ⁻¹)	7.5	50	40	50	-	40
Spacing	Broadcasting.	20 cm x 15 cm	20 cm x15cm	20 cm x 15 cm	-	20 x15 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	86-22-45-27-2-1.5	100-15-37-12	86-13-15-10-5-10	120-20-35-13	-	80-12-25-10-0-0
Date of harvesting (range)	4-5 Feb 2024	08-10 May 2024	29-31 Oct. 2023	5- 7 May 2024	-	2-6 Dec 2023

Table 4. Improvement of cropping pattern Fallow-Boro-T. Aus to Tomato-Boro-T. Aus rice at Basantapur, Godagari, Rajshahi during 2023-24

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Tomato	Boro	T. Aus	Fallow	Boro	T. Aus
Variety	VL-642	BRRI dhan81	BRRI dhan82	-	BRRI dhan28	BRRI dhan51
Date of sowing/ Transplanting	15-20 Sep. 2023	2-4 Feb. 2024	6-12 June 2023	-	26-28 Jan. 2024	25-28 July 2023
Seed rate(kg ha ⁻¹)	120g/ha	50	40	-	50	40
Spacing	40 cm X 60cm	20 cm x 15 cm	20 cm x15cm	-	20 cm x 15 cm	20 x15 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha ⁻¹)	130-40-65-20	100-15-37-12	86-13-15-10- 5-10		120-20-35-13	80-12-25-10- 0-0
Date of harvesting (range)	25 Nov. 2021 to -25 Jan. 2023	4-6 May 2024	8-12 Sep. 2023	-	7-12 May 2024	2-6 Dec 2023

Improvement of cropping system in Sylhet region

Table 5. Activities under improvement of cropping systems at FSRD, Kamalbazar in Sylhet

Existing cropping pattern	Date of sowing/ transplanting	Date of harvesting	Alternative/ improvement cropping pattern	Date of sowing/ transplanting	Date of harvesting
Fallow-T. aus (BR-26)-T. aman (Pajam)	17-22 May 19-26 Aug	- 19-22 Aug 5-10 Dec	Potato (BARI Alu-41)- T. aus (BRRI dhan48)- T. aman (Binadhan-7)	18-22 Nov 12-16 April 20-24 July	10-15 Feb 14-18 July 01-04 Nov

On-farm verification

Table 6. Activities under **on-farm verification** at FSRD, Kamalbazar in Sylhet

Crop (variety)	No. of farmers	Area (Av.)	Date of sowing	Date of harvesting
Mustard (BARI Sarisha-14)	2	100	19-23 Nov	05-12 Feb, 2024
Mustard (BARI Sarisha-18)	3	120	19-23 Nov	24-28 Feb, 2024

A. Homestead production system

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following the Barind model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. 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. It was observed that average total vegetables production was 669 kg homestead⁻¹. The maximum vegetable was produced in Rabi season (304 kg homestead⁻¹) followed by Kharif-1 (207 kg homestead⁻¹) and Kharif-2 (158 kg homestead⁻¹) (Table 7). After intervention of the improved technologies, vegetables production was increased by 280%. The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and judicious time management (Table 19).

Table 7. Vegetable production per homestead at different niches at Basantapur, Godagari, Rajshahi during 2023-24

Space		Rabi		Kharif-I		Kharif-II		Total (kg)	
		October-March		April- June		July-September			
		Before	After	Before	After	Before	After	Before	After
Open Sunny space	Bed-1	32	45	08	22	15	28	55	95
	Bed-2		45		30		13		88
	Bed-3		23		18		22		63
	Bed-4		36		19		22		77
	Bed-5		55		11		10		76
Cottage Roof/top		10	40	05	11	-	10	15	61
Trellis		25	12	07	30	-	17	32	59
Shady space		-	-	-	7	-	-	-	7
Non-fruit trees		05	10	12	17	-	9	17	36
Fence/Boundary wall		10	11	10	21	05	17	25	49
Pond/ditch banks and slope		15	11	-	08	-	-	15	19
Homestead area		10	16	-	6	07	10	17	32
Marshy land		-	-	-	9	-	-	-	9
Total vegetable (kg)		107	304	42	207	27	158	176	669

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 (Table 8). The average vegetables intake per year per farm family was 421 kg after program intervention and the increment was 250% whereas intake was 120 kg per farm family before program intervention. After program intervention, the distribution of vegetables per year was recorded as 75 kg and sell of vegetables per year was 173 kg. 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 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.

Table 8. Homestead vegetables production and utilization pattern at FSRD, Basantapur, Rajshahi in 2023-24

Total production (kg)		Disposal pattern of vegetable per year								Intake Increased (%)
		Intake (kg)		Intake (g head ⁻¹ day ⁻¹)		Distributed (kg)		Sold (kg)		
Before	After	Before	After	Before	After	Before	After	Before	After	
176	669	120	421	65.75	230.68	16	75	40	173	250

Income: After program intervention, from the vegetables production gross return per farm was recorded as Tk. 16725 which was only Tk. 2640 before intervention. The gross margin attained from vegetables sector after program intervention as Tk. 12175 with the increment of 536% (Table 9).

Table 9. Cost and return analysis of vegetables production in a homestead per year

FSRD site	Before intervention (Tk)			After intervention (Tk)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Kadamshahar, Rajshahi	2640	725	1915	16725	4550	12175	536%

Family labor utilization pattern: Homestead production system gave an opportunity for women employment. From the Table 10, it was revealed that women had a good involvement in intercultural operation and harvesting. During the latter period of the program, it was found that

women played a vital role for marketing of vegetables and fruits, which in turn stated that women are coming forward and participating more in income generation system. Hard working 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 labor of women and children properly.

Table 10. Family labour utilization pattern for homestead vegetables at Basantapur, Godagari, Rajshahi during 2023-24

Work area	Men (%)	Women (%)	Children (%)
Land preparation	90	10	0
Seed/seedling	50	40	10
Sowing/planting	50	40	10
Intercultural operations	40	50	10
Harvesting	20	70	10
Marketing	70	25	05
Cooking	-	100	-

Fruits Production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, 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. Higher quantity of average fruits production was found in Kharif-1 (266 kg homestead⁻¹) season followed by Kharif-2 (113 kg homestead⁻¹) and Rabi (49 Kg homestead⁻¹) season (Table 11). Relatively lower 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 and it was 300% compared to before intervention of the program (Table 11). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Table 11. Season-wise fruits production per homestead at FSRD sites, Basantapur, Rajshahi during 2023-24

FSRD site	Rabi	Kharif-1	Kharif-2	Total (kg)
	October-March	April-June	July-September	
After	49	266	113	428
Before	15	65	25	105

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average of fruits intake per year per farm family was 238 kg after program intervention, whereas it was only 80 kg before intervention and the 197 % increment was mainly due to increment of total production (Table 12). After program intervention, the distribution of fruits per year was recorded as 40 kg and sell of fruits per year was 150 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.

Table 12. Homestead fruit utilization pattern at FSRD sites, Basantapur, Rajshahi during 2023-24

Total production (kg)		disposal pattern of fruits per year								Intake increased (%)
		Intake (kg)		Intake (g head ⁻¹ day ⁻¹)		Distributed (kg)		Sold (kg)		
Before	After	Before	After	Before	After	Before	After	Before	After	
105	428	80	238	43.83	130	05	40	20	150	160.45%

Income: Form the fruits sector, after program intervention, gross return per farm was recorded as Tk. 19710 which was only Tk. 3150 before intervention. The gross margin attained from fruits sector after program intervention as Tk. 12625 and the average increment of 380.03% (Table 13).

Table 13. Cost and return analysis of fruits production in a homestead per year (before and after intervention).

FSRD site	Before intervention (Tk)			After intervention (Tk)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Basantapur, Rajshahi	3150	520	2630	19710	7085	12625	380.03

Note: GR= gross return; TVC= total variable cost; GM= gross margin

Apparent nutrient intake and supplementation: 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 14). The apparent nutrient supplementation was also calculated on the basis of apparent nutrient intake from vegetables and fruits sources (Table 15). Intake of nutrient was positively correlated with vegetable and fruits consumption and also with production. Among the nutrients protein intake was increased more than other nutrients but it still needs to supplement from animal source. Iron intake was increased which is very crucial nutrient for women. Other nutrients intake also increased remarkably especially carotene and vitamin B, which was more or less sufficiently supplemented from homestead vegetables and fruits source (Table 15).

Table 14. Apparent nutrient intake in a year by a family from homestead vegetable and fruits at FSRD sites, Basantapur, Godagari, Rajshahi (before and after intervention)

FSRD site	Intervention	protein (g)	Iron (mg)	Carotene (ug)	Vit-B (mg)	Vit-C (mg)
Basantapur, Rajshahi	Before	4325	6725	6515379	256	76546
	After	10526	15335	15333182	574	145354

Table 15. 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).

FSRD site	Category	year	Protein (%)	Iron (%)	Vit-A (%)	Vit-B (%)	Vit-C (%)
Basantapur, Rajshahi	Male	Before	4.30	13.85	66.35	14.78	123.50
	Female	After	12.30	33.83	197.35	36.58	340.63

Sapling/seedling distribution: A numbers of different fruits sapling were supplied to the co-operator farmers of FSRD site in the view of increasing nutrient intake from fruits sector by the mango, guava and papaya etc. were supplied. The supplied total number of saplings of different fruits plants are shown in Table 16.

Table 16. Number of distributed fruits saplings to the homestead farmers at FSRD site, Godagari, Rajshahi during 2023-24

FSRD site	Mango (BARI Aam-4)	Guava (BARI Paraya-3)	Malta (BARI Malta-1)	Papaya
Basantapur, Rajshahi	100	12	12	100

B. Improvement of cropping system in Barind region

1) Existing cropping pattern: Boro-Fallow- T. Aman (Swarna)

Improved CP: Mustard -Boro – T. Aman

The improved cropping pattern with Mustard-Boro-T. Aman rice against the existing pattern Boro-Fallow-T. Aman rice was initiated under medium high land situation at the FSRD site, Basantapur, Godagari, Rajshahi during 2023-24 to get higher yield and economic return. In the improve pattern, BARI Sarish-17 gave seed yield 1.85 t ha⁻¹. BRRI dhan88 gave grain yield (5.80 t ha⁻¹). BRRI dhan49 gave higher yield (4.75 t ha⁻¹) compared to Swarna (4.72 t ha⁻¹). It was observed that the higher total gross margin Tk. 306800 ha⁻¹ was obtained from improve cropping pattern Mustard-Boro-T.aman against existing cropping pattern Boro- fallow-T.aman where

gross margin was TK. 186100 ha⁻¹ at the FSRD site, Basantapur, Godagari, Rajshahi. The improve pattern gave higher MBCR (3.98) existing one. Higher yield and economic return in improve pattern mainly due to application of balance fertilizer, appropriate seedling age and better management practice and also due to inclusion of modern variety of mustard and T.Aman rice (Table 17).

Table 17. Performance of existing and improved cropping pattern at FSRD site, Basantapur, Godagari, Rajshahi in 2023-24

Parameters	Existing cropping pattern			Improved cropping pattern		
Crops (t ha ⁻¹)	Boro	Fallow	T. Aman	Mustard	Boro	T. Aman
Variety	BRRI dhan28	-	BRRI dhan51	BARI sarisa17	BRRI dhan88	BRRI dhan49
Yield (t ha ⁻¹)	4.85	-	4.72	1.85	5.80	4.75
Yield (increased over existing crops (%))	-	-	-	-	-	-
Gross return (Tk. ha ⁻¹)	145500	-	141600	129500	174000	142500
TVC (Tk ha ⁻¹)	56000	-	45000	35750	57250	46200
Gross margin (Tk ha ⁻¹)	89500	-	96000	93750	116750	96300
Whole pattern GM (Tk ha ⁻¹)	186100			306800		
MBCR	-			3.98		

Unit price (Tk.kg⁻¹): Mustard=70, Paddy=30

2) Existing cropping pattern: Boro- Fallow -T. Aman (Hotra)

Improved cropping pattern: Tomato (VL-642)-Boro (BRRI dhan81)-T. Aus (BRRI dhan82)

The improved cropping pattern with Tomato-Boro-T. Aus against the existing pattern Boro-fallow-T. Aman (Swarna) was initiated under medium high land situation at the FSRD stie, Basantapur, Godagari, Rajshahi during 2021-22 to improve the existing cropping pattern for higher yield and economic return. In the improve pattern, Tomato (VL 642) gave fruit yield 46.78 t ha⁻¹ at the FSRD site, Basantapur, Godagari, Rajshahi while in the existing cropping pattern the land was remained fallow. The Boro was the common crop in both the improve and existing cropping pattern. The grain yield of Boro in existing pattern (4.85 t ha⁻¹) was lower compared to improve one (5.32 t ha⁻¹). In improve pattern, BRRI dhan82 gave grain yield (4.87 t ha⁻¹). BRRI dhan51 in existing pattern (4.47 t ha⁻¹). From the results, it was observed that the higher total gross margin Tk 583030.ha⁻¹ was obtained from improve cropping pattern Tomato-Boro-T. Aus against existing cropping pattern Boro-Fallow-T. Aus where gross margin was Tk.182048 ha⁻¹ at the FSRD site, Basantapur, Godagari, Rajshahi. The improve pattern also gave higher MBCR (3.63) over existing one. Introduction of tomato, application of balance fertilizer, appropriate seedling rate and age and better management practice resulted higher productivity, gross margin and BCR (Table 18).

Table 18. Performance of existing and improved cropping pattern at FSRD site, Basantapur, Godagari, Rajshahi in 2023-24

Parameters	Existing cropping pattern			Improved cropping pattern		
	Boro	Fallow	T.Aman	Tomato	Boro	T. aus
Variety	BRRI dhan28	-	BRRI dhan51	VL 642	BRRI dhan81	BRRI dhan82
Yield (t ha ⁻¹)	4.85	-	4.52	46.78	5.32	4.87
Gross return (Tk ha ⁻¹)	145500	-	135600	514580	159600	146100
TVC (Tk ha ⁻¹)	56000	-	43052	132000	57250	48000
Gross margin (Tk ha ⁻¹)	89500	-	92548	382580	102350	98100
Whole pattern GM (Tk ha ⁻¹)	182048			583030		
BCR (Whole pattern)	-			3.63		

Unit price (Tk.kg⁻¹): Tomato-11, Paddy-30

Before intervention each household produced average 320 kg year⁻¹ FYM and after intervention it raised to 1200 kg year⁻¹(Table 19).

Table 19. Comparative performance of production of FYM at FSRD site Basantapur, Godagari, Rajshahi during 2023-24

Before intervention (kg household ⁻¹)	After intervention (kg household ⁻¹)	Production increase (%)
320	1200	228

Results and Discussions for Sylhet region

The results of intervention with improved technologies/practices as compared to the pre-intervention period and details on homestead land use, availability of vegetable round the year and to utilization of women and child labor are described below:

A. CROP COMPONENT

Homestead Production System: The space wise vegetables productions of the homestead areas both before and after intervention were brought under cultivation with the suggested vegetables following the Golapgonj model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space, where nine niches were utilized. The total vegetable production of homestead in Kamalbazar is presented in Table 20. Results revealed that after intervention of the proven and improved technologies in the homestead, vegetable production has increased significantly. However, before intervention the mean vegetables production per homestead was 75 kg. It was observed that the vegetable production was maximum (303 kg/homestead) in *Rabi* season followed by *Kharif- I* (175 kg/homestead) and *Kharif-2* (123 kg/homestead) season (Table 20). However, round the year total vegetable produced 619 kg/homestead and it might be partially contributed by the total number of available production niches. After intervention of the improved technologies, vegetable production was increased 5.45% compared to before intervention of the program (Table 21). The remarkable increment of vegetable production in homestead area might be enhanced by using improved technologies and judicious time management.

Utilization of vegetables: 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 after intervention (Table 21). The average vegetable intake per year per farm family was 420 kg after program intervention and the increment was 3.70%, whereas intake was only 405 kg per farm family per year before program intervention.

Income: After program intervention, from the vegetable production gross return per farm was recorded as Tk. 12380 with the gross margin of Tk. 7830, which was only Tk. 790 before intervention (Table 22). The increment of gross margin was 891%.

Family labor utilization pattern: Homestead production system gave an opportunity for women employment and empowerment. Results found that involvement of women and children in homestead gardening were more compared to men. From the Table 23, it was revealed that women had a good involvement in intercultural operation, harvesting and marketing of vegetable and fruits. During the latter period of the program, it was found that the marketing by women was increased, which in turn stated that women are coming forward and participating more in income generation system. Hard working 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 labor of women and children properly.

Fruits production: Quick growing fruit trees (Guava, Papaya, Seedless lemon, Multa 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 in the homestead, fruits production has increased significantly. Higher quantity of fruits production was found in *Kharif-I* (204 kg/homestead) season followed by *Kharif-II* (185 kg/homestead) which was more or less the reverse scenario of vegetable production (Table 24). Minimum fruits were produced during *Rabi* season (132 kg/homestead) 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 385% (Table 25). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: Alike vegetables farm family was also utilized their fruits as their own consumption, some of them distributed to others and the rest were sold. The disposal pattern of different fruits produced under homestead area was recorded timely. The fruits intake per year per farm family was 315 kg after program intervention, whereas it was only 85 kg before intervention and the 274% increment was mainly due to increment of total production (Table 25, 27). After program intervention, the distribution of fruits per year was recorded as 72 kg and sell of fruits per year was 134 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: From the fruits sector, after program intervention, gross return per farm was recorded as Tk. 18235 with the gross margin of Tk. 12160, which was only Tk. 3450 before intervention. The increment of gross margin was 252% (Table 26).

Improvement of Cropping Systems

Existing cropping pattern: Fallow-T. aus (BR-26)-T. Aman rice (Pajam)

Improved cropping pattern: Potato (BARI Alu-41)-T. Aus (BRRI dhan48)-T. Aman (Binadhan-7)

Agronomic and economic performance of the tested pattern against existing pattern is presented in Table 6. In the improved pattern potato variety Diamant was cultivated during the fallow period and the yield was provided 30.00 t ha⁻¹. During T. aus rice cultivation, the variety BR-26 gave lower yield (3.65 t ha⁻¹) in farmer existing cropping pattern than the BRRI dhan48 (4.10 t ha⁻¹) in improved cropping pattern. While in T. aman season, the rice variety Binadhan-7 gave higher yield (4.15 t ha⁻¹) as compared to existing Pajam variety (3.80 t ha⁻¹). Potato yield in improved cropping pattern was increased by 100% and T. aus and T. aman rice yields increased by 13.25 and 11.17%, respectively due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. It was observed that the higher total gross margin Tk. 339050 ha⁻¹ was obtained from improve cropping pattern potato (BARI Alu-41)-T. aus (BRRI dhan48)-T. aman rice (Binadhan-7) against existing cropping pattern Fallow-T. aus (BR-26)-T. aman rice (Pajam) with Tk.96800 ha⁻¹ (Tables 28,29,30)

Table 20. Year round vegetable production in kg per homestead at FSRD, Kamalbazar (before and after intervention)

Space		Rabi		Kharif-1		Kharif-2		Total (kg)	
		October-March		April-June		July-September			
		Before	After	Before	After	Before	After	Before	After
Open sunny space	Bed-1	20	50	3	12	1	11	24	73
	Bed-2	8	53	5	16	2	14	15	83
	Bed-3	18	38	0	28	0	25	18	91
	Bed-4	2	9	0	9	2	14	4	32
Cottage roof/top		11	53	10	28	0	4	21	85
Trellis		10	25	9	26	4	16	23	67
Fences/Boundary wall		0	20	0	19	0	5	0	44
Non-fruit trees		0	14	2	12	0	7	2	33
Partially shady land		0	23	2	2	0	2	2	27

Homestead areas	6	22	4	13	2	13	12	48
Wet and Marshy land	0	14	0	10	1	12	1	36
Total (vegetables)	75	321	35	175	12	123	122	619

Table 21. Homestead vegetable production and utilization pattern at FSRD, Kamalbazar (before and after intervention)

Total production (kg)		Disposal pattern of vegetable per year						Production increased (%)	Intake increased (%)
		Intake (kg)		Distributed (kg)		Sold (kg)			
Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention		
587	619	405	420	0	104	84	95	5.45	3.70

Table 22. Cost and return analysis of vegetable production in a homestead per year (before and after intervention) at FSRD, Kamalbazar.

Before intervention (Tk)			After intervention (Tk)			GM increased (%)
GR	TVC	GM	GR	TVC	GM	
2440	1650	790	12380	4550	7830	891

Note: GR = gross return; TVC = total variable cost; GM = gross margin

Table 23. Family labor utilization pattern for homestead vegetable production at FSRD, Kamalbazar.

Working	Men (%)		Women (%)		Children (%)	
	Before	After	Before	After	Before	After
Land preparation	95	76	5	15	-	9
Seed/seedling	80	58	15	42	5	0
Sowing/planting	80	51	20	43	-	5
Fencing	90	53	10	47	-	-
Intercultural operations	70	30	30	64	-	6
Harvesting	45	15	55	80	-	5
Marketing	90	35	10	65	-	-
Cooking	-	-	100	100	-	-

Table 24. Round the year fruits production in kg per homestead at FSRD, Kamalbazar (before and after intervention)

Rabi		Kharif-1		Kharif-2		Total (kg)	
October- March		April-June		July-September			
Before	After	Before	After	Before	After	Before	After
46	132	60	204	30	185	136	521

Table 25. Homestead fruits production and utilization pattern at FSRD, Kamalbazar (before and after intervention)

Total production (kg)		Disposal pattern of fruits per year						Intake increased (%)
		Intake (kg)		Distributed (kg)		Sold (kg)		
Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	
136	521	85	315	20	72	30	134	270.58

Table 26. Cost and return analysis of fruits production in a homestead per year at FSRD, Kamalbazar (before and after intervention)

Before intervention (Tk)			After intervention (Tk)			GM increased (%)
GR	TVC	GM	GR	TVC	GM	
4760	1350	3450	18235	6075	12160	252.46

Note: GR = gross return; TVC = total variable cost; GM = gross margin

Table 27. Number of distributed fruits saplings to the homestead farmers at FSRD site Kamalbazar, Sylhet during July, 2023 to March, 2024.

Guava	Seedless lemon	Papaya	Multa
50	25	50	25

Table 28. Performance of existing and improved cropping pattern at FSRD, Kamalbazar (2023-24)

Parameters	Existing cropping pattern			Improved cropping pattern		
	Fallow	T. aus	T. aman	Potato	T. aus	T. aman
Variety	-	BR 26	Pajam	BARI Alu-41	BRRi dhan48	Binadhan-7
Yield (t ha ⁻¹)	-	3.65	3.80	32.00	4.10	4.15
Yield increased over (%) existing crops	-	-	-	100	12.50	9.33
Gross return (Tk. ha ⁻¹)	-	91250	102600	448000	102500	107900
TVC (Tk. ha ⁻¹)	-	47200	49850	218000	218000	51100
Gross margin (Tk. ha ⁻¹)	-	44050	52750	230000	230000	56800
Whole pattern gross margin (Tk. ha ⁻¹)	-	-	96800	-	-	339050

Unit price (Tk. kg⁻¹): Potato- 14.00, T. aus rice- 35.00, T. aman rice- 26.00

Table 29. Grain/seed yield and cost & benefit of different crops at FSRD, Kamalbazar during 2023-24.

Crops (variety)	Grain/seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Cost of production (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Mustard (BARI Sarisha-14)	1.40	119000	56500	62400
Mustard (BARI Sarisha-18)	1.65	140250	58300	81950

Unit price (Tk. kg⁻¹): Wheat: 30.00, Mustard: 85.00

Income enhancement

Table 30. Gross return, cost and gross margin for before and after intervention of suitable homestead vegetable and fruits with management at FSRD, Kamalbazar.

Components	Before Intervention (Tk.)			After Intervention (Tk.)			GM increased (%)
	GR	TVC	GM	GR	TVC	GM	
Homestead(Veg.)	2440	1650	790	12380	4550	7830	891
Homestead(Fruits)	4760	1350	3450	18235	6075	12160	252
Field Crop	193850	97050	96800	658400	319350	339050	250
Livestock	-	-	-	-	-	-	-
Fisheries	-	-	-	-	-	-	-
Off-Farm	-	-	-	-	-	-	-
Total	201050	100050	101040	689015	329975	359040	2.55

Barind Region	Sylhet Region
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	Farmers' opinion The resource poor farmers showed their interest to integrate farming systems for increasing productivity and harvest fresh vegetables to meet up their daily demand. They are interested to adopt those technologies which can provide additional production and quick return in terms of cash income. The increased productivity, gross margin and nutrition supplementation from the homestead vegetables and fruits production

made them confident for livelihood improvement.	source made them confident for livelihood improvement.
Impact • Farmers gather 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, taking care of fruit trees, and composting because they were trained 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.	Impact of year-round homestead vegetables production • Homestead vegetable production has been increased due to use of modern varieties of different vegetables. • Farmers are being familiar with the BARI released improved vegetable varieties. • Use of farmers' homestead resources like cowdung, poultry litter, compost, pond water, different fallow land, non-fruit tree and family labor have increased at homestead area. • Women employment has been increased which ensure women participation in agricultural activities as well as made positive effect on equity within the family and in community. • Consumption of fresh vegetables by the family has been increased and also has changed the consumption habit towards vegetables. • Farmers' dependency on local vegetable market has been decreased due to own homestead vegetable production.
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	Limitations of the study • Lack of skills of farmers in production techniques of different components with season. • Lack of scientist and scientific staff for monitoring and implementing the program smoothly. • Initially higher investment is required which is a major problem. • Marginal farmers in farming system research activities are not always effective as they may not have all components viz. pond, animal etc.

Conclusion

For Barind

- 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 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.

For Sylhet

- Results revealed that after intervention of the proven and improved technologies in the homestead following the Golapgonj model, vegetable production has increased significantly 5.45% compared to before intervention of the program.
- Utilization of all production niches of homestead garden following Golapgonj model would develop a clean homestead, which in turns will be helpful for good sanitation and healthy family.
- Inclusion and production of high yielding crop varieties eg. BARI Alu-41, BRRI dhan48 and Binadhan-7 in T. aus and T. aman rice season, respectively in the improved cropping pattern was enhanced higher economic return over farmers existing pattern.
- Production of high yielding mustard variety BARI Sarisha-14 would also be well-fitted into farmers existing cropping system.
- Results found that involvement of women and children in homestead gardening were more compared to men. Homestead gardening had created a good opportunity to utilize labor of women and children properly.
- However, acquired knowledge from the different production and training program will help the farmers to act as a local service provider regarding technologies, seed, seedlings and saplings, which in turns will be helpful for sustainable production.

156. CLIMATE RESILIENT FARMING SYSTEMS RESEARCH AND DEVELOPMENT FOR THE COASTAL ECOSYSTEM

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Abstract

Among various hydrometrological calamities, coastal regions of Bangladesh are severe prone to cyclones, tidal surges, floods, droughts, salinity in the soil, saline water intrusion and water logging, among other hydrometeorological calamities. This directly affects the livelihoods of the inhabitants because, in Bangladesh, agriculture employs more than 60% of the workforce and is a major source of income for the 40 million people who live along the shore. The environment has a major influence on the agricultural systems. Instead of using a seasonal or crop-specific method in coastal areas, it is now urgently necessary to exhibit current agricultural technologies through "Integrated farming or Mixed Crop-Livestock System Approach". Farmers have a limited number of resources, despite the fact that there are various production options. In order to maximize the complementary interactions among various farming enterprises/production systems and the biophysical and socioeconomic environment, a holistic approach to technology generation and packaging is necessary to achieve this goal. The activities under integrated farming were carried out at two new project area located at Umidpur and Diaramkhola of Kalapara, Patuakhali and North Wapda, Sadar, Noakhali during 2023-2024 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 and v) Off-farm activities. All components of integrated farming such as vegetables, fruits, cereal crops, livestock and off-farm activities were brought under improved technological intervention and accordingly income were increased from these components. On the basis of PRA and base line survey report, farmers need based technologies were intervened among small, marginal and resource-poor farmers. Year round homestead vegetables and quick growing fruits production, intervention of new modern varieties such as sunflower, mungbean, cowpea, grasspea, T.Aus and T.Aman rice, Fodder production, De-worming and vaccination program have been brought under the program in Patuakhali. On the other hand, In Noakhali, intervention many modern field crops such as mustard, soybean, mungbean, sunflower, groundnut, grasspea, T. Aus rice and T. Aman rice. It is revealed that vegetables production as well as income increased by 169%, 380%, 104% of marginal, small and medium farmers, respectively in Patuakhali after project intervention, where intake of vegetables was markedly increased (**48-113%**) as compared to before intervention. Contrary, in Noakhali, it was increased about 90%, 65% and 90% of marginal, small and medium farmers, respectively and intake of vegetables was increased 30-75%. Average intake of fruits per year will be increased next years as the existing fruit trees are managed properly. A total of 168 saplings were distributed to enrich agroforestry system with 4 types of fruit trees in Noakhali, whereas 4 types of fruit trees a total of 192 saplings were distributed at Patuakhali site. In case of field crops, many modern new varieties were intervened and increased income as compared to existing one. Mortality of existing poultry reduced to 4 to 8% after vaccination in Patuakhali. Off-farm activities were very poor or absent in the sites. Women participation in agricultural activities especially in homestead vegetable production and poultry rearing was observed remarkable that may help to create positive effect on gender equity within the family. The results of FSRD activities imply that by implementing the program of integrated farming at project sites has created an opportunity to improve livelihood of the resource-poor farmers.

Introduction

Bangladesh is the third most vulnerable country in terms of population exposed to sea level rise. Coastal areas of Bangladesh are also a hub of hydro meteorological disasters including cyclones, tidal surges, floods, drought, soil salinity, saline water intrusion, water logging, 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 such as the timing, intensity and distribution of the monsoon, soil salinity and the availability of freshwater for irrigation. Anticipated climate change effects suggest that total rainfall in the coastal area is unlikely to decrease. Moreover, higher temperatures, changes in monsoon timing and predictability, sea-level rise and land subsidence driven by natural and human activities will make farming less secure as a livelihood unless there is improved farm management. 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 to that particular soil and micro-climatic conditions especially 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. So the project was designed to develop integrated farming technologies to maximize farm productivity and efficient use of resources, to modify/fine tune on-station technologies generated by NARS institutes at different FSRD sites of coastal ecosystems and to integrate component technologies (crops, livestock, fisheries, agro-forestry and homestead gardening, etc.) for improving farm practices, establish linkage with different stakeholders.

Approaches and Methodologies

Patuakhali: The project activities were conducted at new project area located at Umidpur and Diaramkhola, Kalapara, Patuakhali during 2023-24. Umidpur is situated at 06 Km south from Kalaparaupazila head quarter and Diaramkhola is at Kuakata adjacent to the Bay of Bengal. Both two villages bear coastal ecology having soil salinity and fresh irrigation water scarcity. According to the aim of the project, resource poor farmers viz. marginal, small and medium having major components of farming and considerable homestead under single ownership were targeted and twelve farm households from each site covering four farmers from each category were selected. Prior to implement the project activities, a baseline survey of individual households was carried out. The detail information regarding livelihoods pattern of each household especially total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year were documented. Based on the potentials, suitable technological options were addressed and accordingly farmers' selected suitable technologies were adjusted with their need for livelihood improvement.

The activity was conducted at new project area at Umidpur, Kalapara, Patuakhali during 2023-24. BARI developed 'Lebukhali model' (Table 1) has been modified on the basis of farmers choice and ecology of the region to use year-round vegetable production. In modified Ledukhali model (Table 2) only six nieces were used instead of previous seven. Marshy Land nieces were removed as they were not available in the homestead. Nearby fallow space incorporated in the model that was used as sorjan and raised bed system of vegetable production. Cropping pattern in open sunny place was also modified presented in Table 2. Seeds of different vegetables were distributed among twelve farmers of 3 categories i.e. medium, small and marginal. For implementing Modified Lebukhali model, five beds were prepared by each farmer. Intercultural operation and management practices were done by the farmers following recommended practices.

Table 1. Lebukhali model includes seven production units as follows:

Niche/space		Year round homestead vegetable pattern		
		<i>Rabi</i>	<i>Kharif I</i>	<i>Kharif II</i>
Open sunny space	Bed-1	Red amaranth + Radish	Brinjal	Brinjal
	Bed-2	Red amaranth + Nolkhol	Okra	Indian spinach
	Bed-3	Coriander leaf + cabbage	Stem amaranth	Kangkong
	Bed-4	Red amaranth + Brinjal	Kangkong	Kangkong
	Bed-5	Red amaranth + Tomato	Indian spinach	Indian spinach
Fence		Bitter gourd	Yard long bean	-
Trellis		Cucumber, Bitter gourd	Ribbed gourd	-
Non-fruit trees		-	Sponge gourd/Yam	Sponge gourd/Yam
Pond/ditch slope		Bottle gourd	Bitter gourd	-
Shady place		Turmeric	Turmeric/MukhiKachu	Turmeric/MukhiKachu
Marshy land		Taro	Aroid (Latiraj)	Aroid (Latiraj)

Table 2. "Modified Lebukhali Model" includes six production units as follows:

Niche/space		Year round homestead vegetable pattern		
		Rabi	Kharif I	Kharif II
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
Shady place		Turmeric	Turmeric/MukhiKachu	Turmeric/MukhiKachu
Pond/ditch slope		Bottle gourd/Sweet gourd	Bitter gourd	
Nearby homestead		Tomato+ Red Amaranth	Bottle gourd	

Noakhali: The program was conducted at Farming System Research and Development (FSRD) site located at North Wapda, Sadar, Noakhali during 2023-24. According to the objective resource poor farmers: marginal, small and medium having major components of farming and sizable homestead under single ownership were targeted. Twelve farm households covering four farmers from each category were selected. The detail information regarding livelihoods pattern of each household especially total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year were documented. Based on the potentials, suitable technological options were addressed and accordingly farmers' selected suitable technologies were adjusted with their need for livelihood improvement. In this report only crop component was included.

The activity was conducted at the FSRD site North Wapda, Sadar, Noakhali during 2023-24. OFRD, BARI, Noakhali developed modified Kalikapur model named as 'Atkopalia model' (Table 3) was used at North Wapda, FSRD site for homestead year-round vegetable production. In Atkopalia model only four niches: open sunny space, trellis, non-fruit trees and pond/ditch slope were used instead of previous seven. Fence, shady place and marshy land niches were removed as they were not available in the homestead. Seeds of different vegetables were distributed among twelve farmers of three categories i.e. medium, small and marginal. For implementing the Atkopalia model, five beds were prepared by each farmer. Other three niches mentioned above were also utilized for vegetable production. Intercultural operation and management practices were done by the farmers following standard recommended practices.

Table 3. Atkopalia model includes four production niches

Niche/space	Year round homestead vegetable pattern		
	<i>Rabi</i>	<i>Kharif I</i>	<i>Kharif II</i>
Bed-1	Red amaranth + Radish	Stem amaranth	Indian spinach
Bed-2	Batishak + Tomato	Okra	Stem amaranth
Bed-3	Cauliflower + spinach	Kangkong	Kangkong
Bed-4	Cabbage + spinach	Okra	Red amaranth
Bed-5	Radish + Batishak	Indian spinach	Stem amaranth
Trellis	Cucumber, Bottle gourd	Ribbed gourd	Bitter gourd
Non-fruit trees	-	Sponge gourd/Yam	Sponge gourd/Yam
Pond/ditch slope	Bottle gourd	Bitter gourd	Sweet gourd

Results and Discussions

FSRD site, Patuakhali

A. Crop component

Year-round vegetables production in homestead: Income increased over vegetable and fruit production 124% for Marginal, 308% for small and 102% for medium farmers after intervention of modified Lebukhali model at new project site at Umidpur and Diaramkhola, Kalapara, Patuakhali (Table 4& 5). Homestead vegetable production as well as consumption, distribution and selling increased after intervention. Consumption, distribution and selling of vegetables increased about 48%, 0%, 234% for marginal farmer, 113%, 150%, 577% for small farmer and 100%, 67%, 119% for medium farmer respectively and fruits increment increased about 67%, 0%, 17% for marginal farmers, 114%, 0%, 180% increased for small farmers and 33%, 0%, 0% increased for medium farmers after intervention (Table-6).

Table 4. Round the year vegetables and fruits production from different niches under Farming System Research homestead during July, 2023 to June, 2024.

Farm Categories	Spaces	Before intervention		After intervention		Income (%)
		Prod ⁿ (kg)	Income (Tk.)	Prod ⁿ (kg)	Income (Tk.)	
Marginal	Open sunny place	10	200	112	2240	1020
	Trellis	15	300	22	440	47
	Non-fruit trees	0	0	18	360	-
	Pond/ditch slope	35	700	52	1040	49
	Total (Veg)	72	1440	194	3880	169
	Fruit	18	720	24	960	33
	Total (Veg+Fruit)	90	2160	218	4840	124
Small	Open sunny place	20	400	299	5980	1395
	Trellis	12	240	26	520	117
	Non-fruit trees	0	0	16	260	-
	Pond/ditch slope	42	840	176	3520	319
	Place nearby homestead	28	560	134	2680	379
	Total (Veg)	132	2640	634	12680	380
	Fruit	22	880	42	1680	91
Medium	Total (Veg+Fruit)	154	3520	676	14360	308
	Open sunny place	16	320	102	2040	538
	Trellis	22	440	29	580	32
	Non-fruit trees	0	0	16	320	0
	Pond/ditch slope	45	900	112	2240	149
	Place nearby homestead	65	1300	72	1440	11
	Total (Veg)	162	3240	331	6620	104
	Fruit	20	800	39	1560	95
	Total (Veg+Fruit)	182	4040	370	8180	102

Table 5. Round the year vegetables and fruits production and utilization pattern before and after Intervention during 2023-2024.

Farmers category	Description	Before Intervention		After Intervention	
		Veg. (kg)	Fruits (kg)	Vegetables (kg)	Fruits (kg)
Marginal	Consumption	25	6	37	10
	Distribution	0	0	0	0
	Selling	47	12	157	14
	Total prod ⁿ	72	18	194	24
	GR (Tk.)	1440	720	3880	960
	VC (Tk.)	375	0	561	225
	NR (Tk.)	1065	720	3319	735
Small	Consumption	45	7	96	15
	Distribution	12	0	30	0
	Selling	75	15	508	27
	Total prod ⁿ	132	22	634	42
	GR (Tk.)	2640	880	12680	1680
	VC (Tk.)	500	200	1000	450
	NR(Tk.)	2140	680	11680	1230
Medium	Consumption	62	15	124	20
	Distribution	15	5	25	5
	Selling	83	0	182	14
	Total prod ⁿ	162	20	331	39
	GR (Tk.)	3240	800	6620	1560
	VC (Tk.)	500	250	800	500
	NR(Tk.)	2740	550	5820	1060

Vegetables avg. price=20 Tk/kg, Fruits avg. price=40 Tk/kg.

Table 6. Increment of consumption, distribution and selling of different categories of farmer during 2023-24 at Kalapara, Patuakhali.

Farmers category	Disposal event	Vegetable			Fruit		
		Before Intervention	After intervention	Avr. Increment (%)	Before Intervention	After intervention	Avr. increment (%)
Marginal	Consumption	25	37	48	06	10	67
	Distribution	0	0	0	0	0	0
	Selling	47	157	234	12	14	17
	Total prod ⁿ	72	194	169	18	24	33
Small	Consumption	45	96	113	07	15	114
	Distribution	12	30	150	0	27	0
	Selling	75	508	577	15	42	180
	Total prod ⁿ	132	634	380	22	55	150
Medium	Consumption	62	124	100	15	20	33
	Distribution	15	25	67	05	05	0
	Selling	83	182	119	0	14	0
	Total prod ⁿ	160	331	106	20	39	95

FSRD site, Noakhali

Year-round vegetables production in homestead

Both vegetable and fruit production increased after intervention following the Atkapalia model as compared to the pre-intervention. Vegetable production increased 90, 65 and 78% for marginal, small and medium farmers' homesteads, respectively after intervention (Table 7). Similarly fruit production also increased after intervention. Fruit production increased 60, 43 and 72% at marginal, small and medium farmers' homesteads, respectively. Homestead vegetable production as well as consumption, distribution and selling increased after intervention. Gross margin from vegetable cultivation obtained were Tk. 2980, 3950 and 4080 from marginal, small and medium farmers' homesteads, respectively, whereas from fruit cultivation the amount were Tk. 1035, 1240 and 1355, respectively (Table 8). After intervention 88, 60 and 86% gross margin increment was noticed from vegetables production at marginal, small and medium farmers' homesteads, respectively, whereas the increment from fruit production were 28, 16 and 64%, respectively. Consumption, distribution and selling of vegetables increased about 75, 50 and 100% for marginal farmers, 30, 40 and 90% for small farmers and 30, 50 and 122% for medium farmers, respectively over before intervention (Table 9). Marginal farm family increased their vegetable consumption with the increase of production as compared to small and medium farm families. Distribution of vegetables to relatives and neighbors of marginal farmers also increased with the increased of production as compared to other two categories. Selling vegetables followed different trend. Marginal and medium farm families sold more vegetables than small farm family. It might be due to different reasons for these two categories. Marginal farm family sold more vegetables for income generation. On the other hand medium farmers sold extra vegetables after fulfill their family need. Among the fruits mango, guava, velvet apple, jackfruit, coconut and banana were prominent.

Table 7. Round the year homestead vegetables and fruits production from different niches under Farming System Research before intervention (July 2022–June 2023) and after intervention (July 2023- June 2024).

Farm Categories	Nieces	Before intervention (2022-23)		After intervention (2023-24)		Average income Increment (%)
		Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	
	Open sunny place	10	300	42	1260	320
	Trellis	12	360	22	660	83
	Non-fruit trees	16	480	20	600	25

Farm Categories	Nieces	Before intervention (2022-23)		After intervention (2023-24)		Average income Increment (%)
		Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	
Marginal	Pond/ditch slope	30	900	45	1350	50
	Total (Veg)	68	2040	129	3870	90
	Fruit	18	810	26	1300	60
	Total (Veg+Fruit)	86	2850	155	5170	81
Small	Open sunny place	18	540	67	2010	272
	Trellis	24	720	31	930	29
	Non-fruit trees	20	600	22	660	10
	Pond/ditch slope	39	1170	47	1410	21
	Total (Veg)	101	3030	167	5010	65
	Fruit	28	1260	40	1800	43
	Total (Veg+Fruit)	129	4290	207	6210	45
Medium	Open sunny place	24	720	67	2010	179
	Trellis	20	600	33	990	65
	Non-fruit trees	15	450	20	600	33
	Pond/ditch slope	40	1200	56	1680	40
	Total (Veg)	99	2970	176	5280	78
	Fruit	25	1125	43	1935	72
	Total (Veg+Fruit)	124	4095	219	7215	76

Vegetables avg. price=30 Tk/kg, Fruits avg. price=45Tk/kg.

Table 8. Round the year vegetables and fruits production and utilization pattern before intervention (July 2022 – June 2023) and after intervention (July 2023- June 2024).

Farmers category	Description	Before Intervention		After Intervention	
		Vegetable (kg)	Fruits (kg)	Vegetable (kg)	Fruits (kg)
Marginal	Consumption	20	9	35	15
	Distribution	4	1	6	3
	Selling	44	8	88	8
	Total production	68	18	129	26
	GR (Tk.)	2040	810	3870	1300
	VC (Tk.)	456	0	890	265
	GM(Tk.)	1584	810	2980	1035
Small	Consumption	37	14	48	25
	Distribution	5	2	7	5
	Selling	59	12	112	10
	Total production	101	28	167	40
	GR (Tk.)	3030	1260	5010	1800
	VC (Tk.)	560	190	1060	560
	GM(Tk.)	2470	1070	3950	1240
Medium	Consumption	40	20	52	37
	Distribution	10	5	15	6
	Selling	49	0	109	0
	Total production	99	25	176	43
	GR (Tk.)	2970	1125	5280	1935
	VC (Tk.)	780	300	1200	580
	GM (Tk.)	2190	825	4080	1355

Vegetables avg. price=30 Tk/kg, Fruits avg. price=45Tk/kg. GR= gross margin, VC= variable cost, GM= gross margin

Table 9. Increment of consumption, distribution and selling of different categories of farmer before intervention (July 2022 – June 2023) and after intervention (July 2023- June 2024).

Farmers category	Disposal event	Vegetables			Fruit		
		Before intervention	After intervention	Average increment (%)	Before intervention	After intervention	Average increment (%)
Marginal	Consumption	20	35	75	9	15	67
	Distribution	4	6	50	1	3	200
	Selling	44	88	100	8	8	0
	Total production	68	129	90	18	26	44
Small	Consumption	37	48	30	14	25	79
	Distribution	5	7	40	2	5	150
	Selling	59	112	90	12	10	-17
	Total prouction	101	167	65	28	40	43
Medium	Consumption	40	52	30	20	37	85
	Distribution	10	15	50	5	6	20
	Selling	49	109	122	0	0	0
	Total production	99	176	78	25	43	72

Intervention of modern varieties of field crops

FSRD site, Patuakhali

Participatory variety selection trials on Aus Rice: Generally, co-operative farmers do not cultivated Aus rice in Kharif- I season. But we were trying to introduce Aus rice in Kharif- I season. So, to select T. Aus modern varieties a Participatory variety selection trial on Aus Rice was conducted with the co-operative farmers. According to the yield and for fit in to the cropping pattern one modern rice varieties i.e. BRRI dhan48 were supplied during Kharif-I of 2023. The average yield (3.56 t ha⁻¹) was found from BRRI dhan48 (Table 10).

Table 10. Average Yield of different T. Aus rice varieties at selected farmers of Umidpur, Kalapara, Patuakhali during Kharif II season of 2023-24.

Varieties	Date of Trans.	Date of harvest	Mean yield (t ha ⁻¹)	Avr. local rice yield (t ha ⁻¹)
BRRI dhan48	02-07 June 2023	03-10 Sep. 2023	3.56	No Aus

Participatory variety selection trials on Aman Rice:

Generally, co-operative farmers cultivated local T. Aman in Kharif II season. They prefer local rice varieties having tall seedling and bolder grain. So, to select T. Aman modern varieties like local a Participatory variety selection trial on Aman Rice was conducted with the co-operative farmers. According to their choice two modern rice varieties i.e. BRRI dhan49 and BRRI dhan87 were supplied during Kharif-2 of 2023. The highest yield (3.85 t ha⁻¹) was found from BRRI dhan49 (Table 11).

Table 11. Average Yield of different T. Aman rice varieties at selected farmers of Umidpur, Kalapara, Patuakhali during Kharif II season of 2023-24.

Varieties	Date of transplanting	Date of harvesting	Mean yield (t ha ⁻¹)	Avr. local rice yield (t ha ⁻¹)
BRRI dhan49	15 September 2023	01-05 Dec 2023	3.85	2.91
BRRI dhan87	16 September 2023	10 Dec 2023	3.36	

Intervention of Rabi crop varieties: Scope of Rabi field crop cultivation is very limited due to late harvest of Aman rice. Moreover remaining excessive moisture in field delay land preparation for Rabi crops by this time sowing period of maximum Rabi crops passed away. So a very few crops could be cultivated in Rabi in project site. The crops that could be sown first to mid-January

should be selected to cultivate. Mungbean, Sunflower is such crops and their yield performance also satisfactory. Relaying of Grasspea and Cowpea is common in the region but most of years these two crops damaged by unusual rainfall during Rabi season. Moreover their yield performance is also poor (Table 12).

Table 12. Average yield and economic analysis of different *Rabi* crops in production program trials during 2023-24

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			
Sunflower	BARI Surjamukhi-2	1.76	1.72 (Hysun)	123200	70600	52600
Mungbean	BARI Mung-6	1.78	1.25	142400	45600	96800
Cowpea	BARI Felon-1	1.82	1.10	127400	45055	82345
Grasspea	BARI Khesari-2	1.58	0.97 (Local)	94800	30430	64370

Price (Tk./Kg): Mungbean =80, Sunflower =70, Cowpea=70, Khesari= 60

FSRD site, Noakhali

Intervention of modern varieties of field crops: Scope of Rabi field crop cultivation is very limited due to late harvest of T. Aman rice. Moreover remaining excessive moisture in the soil delayed land preparation for Rabi crops, by this time sowing period of maximum Rabi crops passed away. So a very few crops could be cultivated in Rabi season. The crops that have late sowing potentiality should be chosen. BARI developed mustard varieties like, BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18, BARI Soybean-5, BARI mung-6, BARI sunflower-2, BARI sunflower-3, BARI Chinabadam-8 etc. were promising. They can produce satisfactory yield even in late sowing condition. Relaying of Grass pea with T. Aman rice is a common practice in the region but some years the crop damaged by unusual rainfall just after sowing. Different field crops intervened with the co-operator farm families with their agronomic and economic performance were presented in Table 5. Among the rabi crops BARI Chinabadam-8 produced the highest gross margin (Tk. 104000 ha⁻¹) next to BARI Sarisha-18 (Tk. 101450 ha⁻¹). BARI Mung-6 produced the lowest gross margin (Tk. 28700 ha⁻¹). Production cost of grass pea was also the lowest due to relay cropping. Gross margin of T. Aman rice (Tk. 64350 ha⁻¹) was higher than T. Aus rice due to higher yield.

Table 13. Average yield and economic analysis of different field crops in production program trials during 2023-24.

Crops	Varieties	Mean Yield (t ha ⁻¹)		GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
		Trial field	Farmer's field			
Mustard	BARI Sarisha-14	1.62	1.32	129600	45750	83850
	BARI Sarisha-17	1.58	1.26	126400	45750	80650
	BARI Sarisha-18	1.84	-	147200	45750	101450
Soybean	BARI Soybean-5	1.76	1.34	105600	48560	57040
Mungbean	BARI Mung-6	1.25	1.16	75000	46300	28700
Sunflower	BARI Surjamukhi-2	1.84	1.77 (Hysun)	156400	60500	95900
	BARI Surjamukhi-3	1.58		134300	60500	73800
Groundnut	BARI Chinabadam-8	2.17	1.82 (Dhaka-1)	173600	69600	104000
Grass pea	BARI Khesari-2	1.14	0.91	68400	26750	41650
T. Aus rice	BRRI dhan48	4.21	-	105250	61450	43800
T. Aman rice	BRRI dhan52	4.75	4.22	118750	54400	64350

Price (Tk. Kg⁻¹): Mustard = 80, Soybean = 60, Mungbean = 60, Sunflower =85, Groundnut = 80, Grass pea = 60, T. Aus rice =25 and Aman rice 25, GR= gross return, TVC= total variable cost, GM= gross margin

FSRD site, Patuakhali

Saplings distribution: Each farmer received three types of fruit saplings and the average number of samplings per farmer was 12. The survival rate of dragon and malta was 85% whereas the survival rate of mango and guava was 90%.

Table 14. Name of the varieties of supplied saplings among the co-operative farmers at project sites, Patuakhali.

Varieties of the saplings		No. of Saplings/farmer	Survival rate (%)
Mango	BARI Aam-3	12	85
	BARI Aam-4		90
Guava	BARI Peyara-2		90
Malta	BARI Malta-1		85

Fruit trees of homestead were fertilized twice in a year. Pesticide and fungicides were sprayed in mango trees in 12 co-operative farmers for controlling mango fruit fly.

FSRD site, Noakhali

Each farmer received four types of fruit saplings: mango, dragon fruit, guava and lemon (Table 15). Average number of samplings per farmer was 22. The survival rate of dragon and lemon was 84% whereas the survival rate of mango and guava was 90%.

Table 15. Fruit saplings supplied among the co-operator farmers at FSRD sites, Noakhali in 2023-24

Crop	Variety	No. of Saplings distributed farmer ⁻¹	Survival rate (%)
Mango	BARI Aam-4	05	90
	BARI Aam-11	01	90
Dragon fruit	BARI Dragon-1	10	84
Guava	BARI Peyara-2	03	90
Lemon	Local	03	84

Management of existing fruit trees: Existing fruit trees of homestead and previously distributed high yielding BARI fruit varieties saplings were fertilized twice in a year. Pesticide and fungicides were sprayed in mango trees in the co-operator farmers' homestead. The fruit trees were irrigated in drip system throughout the dry period. Fruit production was highest in case of medium category of farm due to abundance of different fruit species along with space for fruit trees in the homestead. On the other hand fruit production, consumption and distribution was found lowest in marginal category of farm due to less diversity of fruit trees. Moreover, selling of fruit is comparatively higher in all cases due to good market price and demand of fruit throughout the year.

FSRD site, Patuakhali

B. Livestock Component

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. Proper vaccination against major diseases reduces the mortality rate of cattle. In the vaccinated group Anthrax Vaccine and FMD vaccine were injected as per recommended schedule. Poultry rearing are common practices in the site. 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 this program was conducted at the site. The BCRDV, RDV and Fowl pox vaccine for Chick and the Duck plague vaccine for ducks were used as per recommended schedule.

Improvement of cattle health by de-worming and vaccination: De-worming and vaccination program was carried out at the project site of Umidpur, Kalapara, Patuakhali. Twenty cattle including 03 milking cows owned by the cooperative farmers were selected for de-worming and vaccination (Table 16). Second dose of de-worming was given 10 days interval as per body weight of the cattle recommended by concerned personnel of ULO, Kalapara, Patuakhali. After de-worming the cattle their milking rate per day and body weight gaining were observed promisingly. However, the information regarding de-worming cattle and performance are presented in Table 10. It was observed that de-worming is an easy process to adopt with

minimum cost. The gaining body weight of dewormed milk cow was observed as 40 g/day/cow whose average lactation yield was increased up to 0.75 L/day over the controlled (Table 17). It was also observed that among the vaccinated cattale no anthrax disease was found and incidence of foot and mouth disease was only 01% that is 88% lower than before of vaccination (Table-18).

Table 16. Livestock covered by de-worming and vaccination program at Umidpur, Kalapara, Patuakhali

Livestock Type	De-worming	Vaccination
Cattle	20	Anthrax (20), Foot and Mouth (20)

Table 17. Av Body wt and Av Lactation yield increased by de-worming

Treatment	Animal (no)	Av Body wt gain/day/animal (g)	Av Lactation yield (litre/day)	Av Lactation period (day)
Controlled Cattle	03	70	1.5	180
De-wormed Cattle	03	110	2.25	205

Table 18. Effect of cattle vaccination at Umidpur, Kalapara, Patuakhali

Diseases	Before vaccination (%)	After vaccination (%)
Anthrax	05	0
Foot and Mouth	09	01

Vaccination program on poultry production

This program was conducted at Umidpur, Kalapara, Patuakhali during 2023-24. The vaccination of poultry program has created a great awareness to the co-operative farmers and neighborhood farm families in the site. Four types of vaccines as BCRDV, RDV, Fowl Pox and Duck plague were vaccinated in the program (Table 19). It's revealed that, mortality rate can be minimized significantly through vaccination and it goes down below 5% most of the cases in the sites which can be considered as negligible comparing to the condition before the vaccination program. 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 came below 8% (Table 19) and this type of program is mostly impacted on concern farmer and so far they would follow to vaccinate the poultry in routinely.

Table 19. Number of birds vaccinated and mortality rate before and after vaccination at Umidpur, Kalapara, Patuakhali

Name of poultry	Name of vaccine	No. of bird vaccinated	Mortality before Vaccination (%)*	Mortality after Vaccination (%)*	Mortality reduce (%)
Chicken	BCRDV	85	60	4	93
	RDV	100	80	7	91
	FOWL POX	150	45	6	87
Duck	Duck plague	180	80	8	90

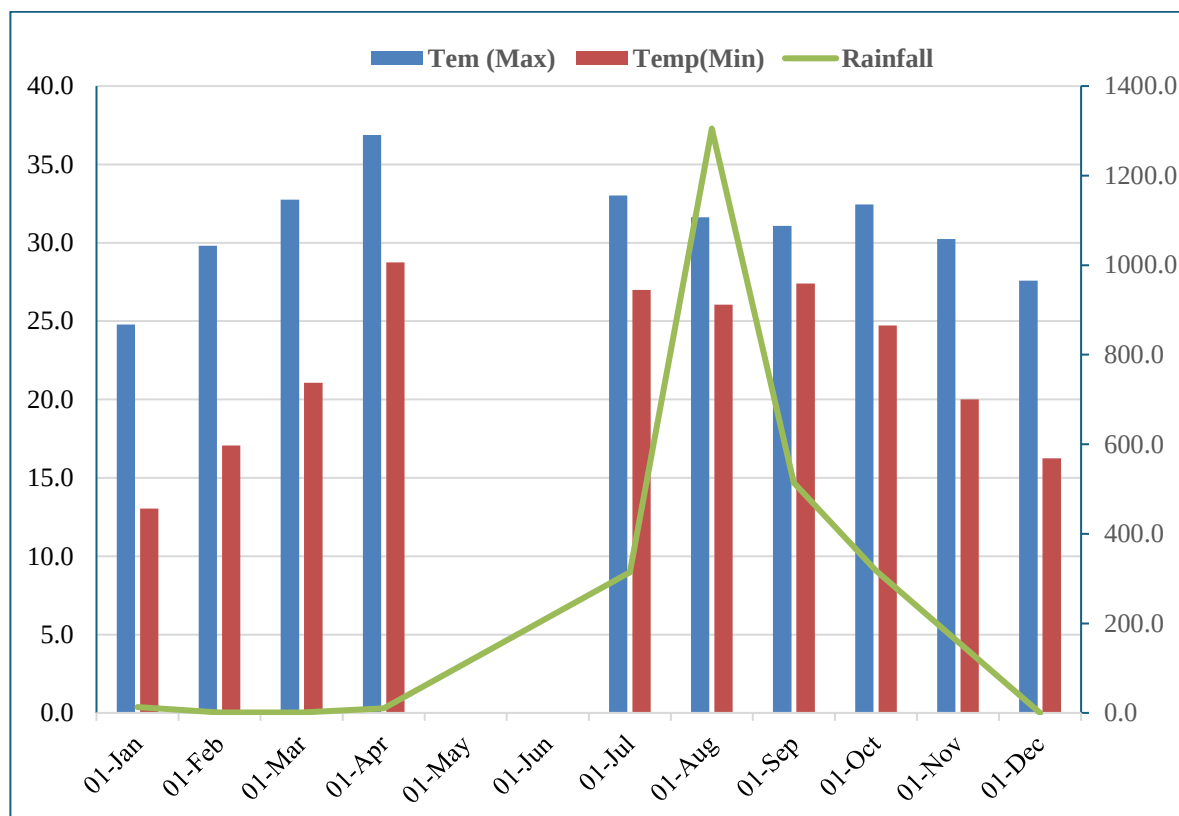
Challenges found

Farmers faced the following challenges to crop production in coastal saline areas are given below

Table 20: Problems faced by the farmers

Season	Problems
Rabi	Short duration Rabi period
	Unavailability of improved varieties of different crops
	Irrigated water cannot be hold due to high rate of percolation.
	Early inundation in late rabi season
	Free cattle rearing

Kharif	Fortnightly tidal submergence
	Sometimes Sesame and Melon damaged by tidal water
	Higher weed infestation
	T. Aus damaged by heavy tidal water flow
	Severe birds attack in case of early transplanted T. Aman
Common	Low price at harvesting period
	Problem of transportation



Weather report during July/23 to June/24 at Patuakhali

Socioeconomic Studies

157. STUDY ON THE IMPACT OF FARMING SYSTEM RESEARCH ACTIVITIES OF BARI

M. S. RAHMAN, NASIMA AKTER, MAZHARUL ANWAR

Abstract

The study was conducted in Shyampur and Barind of Rajshahi, Kushtia and Pabna FSRD sites of OFRD, BARI in Bangladesh to see the impact of FSRD project activities of BARI during 2022-2024. Tabular analysis was followed. The production and consumption of vegetables and fruits were increased of the selected sampled farmers after intervention of the FSRD project. It is found positive impact. Moreover, the production and consumption of vegetables and fruits in survey period were decreased compared to end of project while it was higher than that of base period or before project. Farmers opined some problems which were lack of good quality/ HYV seeds and seedlings/ saplings, insufficient training, shortage of manpower, drought and lack of modern agril. inputs. So, they suggested to supply good quality/ HYV seeds and seedlings/ saplings, providing training, supply modern agril. inputs, taking initiative for developing awareness and supply deep tube well /tube well to the community.

Introduction

Farming system is a resource management strategy to achieve economic gains and sustained production to meet diverse requirement to farm household while presenting resources base and maintaining a high level environment quality (Lal and Miller, 1990). Farming system consists of several enterprises like cropping system, dairying, poultry, fishery etc. These enterprises are interrelated with each other. A part of end product and wastes of one enterprise are used as inputs in others. The waste of dairying like dung, urine, etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the different crops is used as fodder for cattle. Thus, different enterprises of farming systems are highly interrelated. The goal of farming research system is to develop sustainable land use systems which will optimize the farm resource use, minimize degradation with consideration to regenerative capacity and increase income and employment for farm families and promote quality of life and environment. Several production studies conducted on farming systems showed that farming system approach is better than conventional farming. The outcome of the present investigation is of immense importance to evolve, develop and implement the location specific farming systems in study area as well as the area with similar situations elsewhere.

BARI has developed a good number of farming system model which is very popular and profitable to the farmers. BARI has also conducted a several research project with the title of Farming System Research and Development (FSRD) in a long time in collaboration of different GOs. But the impact of this research project is unknown to the other researchers and policymakers. Because, no study was done in this line. Now a days a question is arisen to the policymakers that what is the impact of FSRD project activities of BARI. Therefore, the answer of the question is expected to provide valuable information and may be useful to the researchers of BARI as well as the policy makers of both GO and NGO for formulating appropriate policy for widespread extension of FRSD activities in Bangladesh. With this view in mind, the study was undertaken to the following objectives;

Objectives

- i. To know the socio-economic profile of the project farmers, adopter and non-adopter respondents;
- ii. To assess the activities of farming system research in respect to different component;
- iii. To assess the socio-economic impact of adopting different components; and
- iv. To identify the constraints to adopt FSRD activities and to make some policy recommendations.

Materials and Methods

Sampling design: A purposive sampling procedure was followed to select study areas and sample

households. The study was conducted in four FSRD sites where OFRD, BARI had been conducted different activities under farming system research project. The name of FSRD site were Shyampur, Rajshahi, Barind, Rajshahi, Pabna and Kushtia. Purposive sampling technique was followed to collect farm level data. Data were collected from project farmers, adopter and non-adopter. This is two years project (July 2022 to June 2024). A total of 99 farmers taking 48 project farmers, 3 adopters and 48 non-adopters from four sites were selected for interview.

Data collection procedure: Data for the present study were collected by interviewing samples using a pre-tested interview schedule during the period from March to May, 2023. Secondary data were also collected from On-Farm Research Division (OFRD), BARI and Directorate of Agricultural Extension (DAE) to supplement the study and different issues of BBS.

Analytical techniques: The collected data were analyzed by tabular and statistical methods. The collected data were coded, edited, summarized, tabulated and analyzed to fulfill the objectives of the study. The impact was measured in comparison between before the project and after the project activities. The profitability was estimated using gross margin, net return and benefit cost ratio analysis.

FSRD model used: Modified Barind model (followed by Barind and Chanduria, Rajshahi) and Goeshpur model (Pabna and Kushtia) were followed for the study.

Table 1a. Modified Barind model (followed by Barind and Chanduria, Rajshahi)

Niches/spaces		Cropping pattern for year round homestead veg. production		
		Rabi	Kharif-1	Kharif-11
1. Open sunny land	Bed 1	Brinjal	Kangkong	Kangkong
	Bed 2	Spinach-Spinach	Indian spinach	Red amaranth
	Bed 3	Radish-Red amaranth	Stem amaranth	Green Shak
	Bed 4	Cabbage	Onion	Red amaranth/Jute shak
	Bed 5	Cauliflower-Red amaranth	Okra	Red amaranth/Jute shak
2. Fence		Country bean	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	Fodder, chewing sugarcane

Table 1b. Goyeshpur model (followed by Kushtia and Pabna)

Niches/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

Niches/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	

Results and Discussions

Shyampur, Rajshahi: The farming system research project activities was conducted at Ratul and Deutola villages under Tanore upazila in Rajshahi district. The project was started October 2019 and ended June 2022. Some basic information like average age of sample farmers, educational status, average family size, average crop land size, average homestead areas and pond area is given Table 2. The average homestead area of project, adopter and non-adopter samples was 0.09, 0.06 and 0.04 ha, respectively (Table 2).

Barind, Rajshahi: The average homestead area of project and non-adopter samples was 0.06 and 0.05 ha, respectively (Table 2).

Kushtia: The average homestead area of project and non-adopter samples was 0.09 and 0.08 ha, respectively (Table 2).

Pabna: The average homestead area of project and non-adopter samples was 0.10 and 0.09 ha, respectively (Table 2).

Table 2. Category-wise socio-economic information of selected samples under different FSRD sites

Categories of farm	No. of Farmer	Age (yr)	Educational level	Family size (no.)	Farm size (ha)	Homestead area (ha)	Pond area (ha)
Shyampur:							
Project samples	12	53	Sign - HSC	4.42	0.73	0.09	0.04
Adopter	3	57	Sign	4.67	0.38	0.06	0
Non-adopter	12	51	Sign - BA	3.75	0.81	0.04	0.09
Barind:							
Project samples	12	45	One -HSC	5.25	0.83	0.06	0.04
Non-adopter	12	51	Sign - HSC	5.33	0.89	0.05	0.04
Kushtia:							
Project samples	12	48	Five- HSC	6.17	0.71	0.09	0.13
Non-adopter	12	53	Sign- HSC	6.08	0.58	0.08	0.04
Pabna:							
Project samples	12	44	Illiterate – SSC	4.92	0.68	0.10	0.02
Non-adopter	12	44	Two - BA	5.58	0.66	0.09	0.01

Income, Expenditure and Net income /Profit

Shyampur, Rajshahi: The average income of project, adopter and non-adopter samples was found to be Tk. 448567, Tk. 309643 and Tk. 388597 per year, respectively, while, it was Tk. 264825, Tk. 205000 and Tk. 241364 yearly expenditure, respectively (Table 3). The yearly profit was calculated at Tk. 183741, Tk. 104643 and Tk. 147233 for project, adopter and non-adopter samples, respectively.

Barind, Rajshahi: The average income of project and non-adopter samples was found to be Tk.

460568 and Tk. 401700 per year, respectively, while, it was Tk. 431456 and Tk. 341298 yearly expenditure, respectively (Table 3). The yearly profit was calculated at Tk. 29112 and Tk. 60402 for project and non-adopter samples, respectively.

Kushtia: The average income of project and non-adopter samples was found to be Tk. 699366 and Tk. 395308 per year, respectively, while, it was Tk. 364467 and Tk. 245950 yearly expenditure, respectively (Table 3). The yearly profit was calculated at Tk. 304058 and Tk. 118517 for project and non-adopter samples, respectively.

Pabna: The average income of project and non-adopter samples was found to be Tk. 656395 and Tk. 468273 per year, respectively, while, it was Tk. 509917 and Tk. 459149 yearly expenditure, respectively (Table 3). The yearly profit was calculated at Tk. 146478 and Tk. 9125 for project and non-adopter samples, respectively.

Table 3. Yearly Income, Expenditure and Net income/Profit

Categories of samples	Income (Tk./yr)	Expenditure (Tk./yr)	Profit (Tk./yr)
Shyampur:			
Project samples	448567	264825	183741
Adopter	309643	205000	104643
Non-adopter	388597	241364	147233
Barind:			
Project samples	460568	431456	29112
Non-adopter	401700	341298	60402
Kushtia:			
Project samples	699366	395308	304058
Non-adopter	364467	245950	118517
Pabna:			
Project samples	656395	509917	146478
Non-adopter	468273	459149	9125

Year-round vegetables and fruits production in homestead area of project samples

Shyampur: Barind model was followed in the homestead production system. The average total vegetables production of project samples under before project, end of project and survey period were calculated at 108, 653 and 345 kg/hh/year, respectively, while fruits production were 181, 435 and 245 kg/hh/year, respectively (Table 4). Total vegetables and fruits production at the time of end of project were increased 276% from base period, while 104% increased from base to survey period, but 46% decreased from end of project to survey period. It is found positive impact of FRSD project.

Barind: Barind model was also followed in the homestead production system. The average total vegetables production of project samples under before project, end of project and survey period were calculated at 99, 833 and 553 kg/hh/year, respectively, while fruits production were 135, 455 and 120 kg/hh/year, respectively (Table 4). Total vegetables and fruits production at the time of end of project were increased 450% from base period, while 185% increased from base to survey period, but 48% decreased from end of project to survey period. It is found positive impact of FRSD project.

Kushtia: Goyeshpur model was followed in the homestead production system. The average total vegetables production of project samples under before project, end of project and survey period were calculated at 112, 754 and 526 kg/hh/year, respectively, while fruits production were 15, 191 and 100 kg/hh/year, respectively (Table 4). Total vegetables and fruits production at the time of end of project were increased 644% from base period, while 393% increased from base to survey period, but 34% decreased from end of project to survey period. It is found positive impact of FRSD project.

Pabna: Goyeshpur model was followed in the homestead production system. The average total vegetables production of project samples under before project, end of project and survey period

were calculated at 397, 930 and 511 kg/hh/year, respectively, while fruits production were 835, 1230 and 950 kg/hh/year, respectively (Table 4). Total vegetables and fruits production at the time of end of project were increased 75% from base period, while 19% increased from base to survey period, but 32% decreased from end of project to survey period. It is found positive impact of FRSD project.

Table 4. Year-round vegetables and fruits production of project farmers in different periods and locations.

Areas/ products	Rabi (kg/hh)			Kharif-I (kg/hh)			Kharif-II (kg/hh)			Total (kg/hh/yr)		
	Before project	End of Project	Survey period	Before project	End of Project	Survey period	Before project	End of Project	Survey period	Before project	End of Project	Survey period
Shyampur:												
Vegetables	48	261	142	23	196	123	37	196	80	108	653	345
Fruits	26	49	32	133	267	145	22	119	68	181	435	245
Total (veg. + fruits)	74	310	174	156	463	268	59	315	148	289	1088	590
Barind:												
Vegetables	50	374	288	34	238	182	15	221	83	99	833	553
Fruits	12	46	20	68	296	80	55	113	60	135	455	160
Total (veg. + fruits)	62	420	308	102	534	262	70	334	143	234	1288	713
Kushtia:												
Vegetables	57	204	170	25	297	209	30	253	147	112	754	526
Fruits	03	53	25	10	65	35	02	73	40	15	191	100
Total (veg. + fruits)	60	257	195	35	362	244	32	326	187	127	945	626
Pabna:												
Vegetables	175	381	255	140	278	164	82	271	92	397	930	511
Fruits	235	284	250	305	410	350	295	536	350	835	1230	950
Total (veg. + fruits)	410	665	505	445	688	514	377	807	442	1232	2160	1461

Year-round vegetables and fruits production at homestead area of project samples, adopter and non-adopter

Shyampur: Barind model was followed in the homestead production system. The average total vegetables and fruits production of project samples, adopter and non-adopter under survey period were calculated at 590, 199 and 74 kg/hh/year, respectively (Table 5). Total vegetables production of project samples, adopter and non-adopter under survey period were calculated at 345, 184 and 62 kg/hh/year, respectively, while fruits production at the time of project samples, adopter and non-adopter were 245, 15 and 12 kg/hh/year, respectively (Table 5). The vegetables and fruits production of project samples were higher 196% and 697% from adopter and non-adopter, respectively while adopter was 169% higher than non-adopter. It is found positive impact of FRSD project.

Barind: Barind model was also followed in the homestead production system. The average total vegetables and fruits production of project samples and non-adopter under survey period were calculated at 673 and 187 kg/hh/year, respectively (Table 5). Total vegetables production of project samples and non-adopter under survey period were calculated at 553 and 144 kg/hh/year, respectively, while fruits production at the time of project samples and non-adopter were 120 and 43 kg/hh/year, respectively (Table 5). The vegetables and fruits production of project samples were higher 260% than non-adopter. It is found positive impact of FRSD project.

Kushtia: Gayeshpur model was followed in the homestead production system. The average total vegetables and fruits production of project samples and non-adopter under survey period were calculated at 626 and 308 kg/hh/year, respectively (Table 5). Total vegetables production of project samples and non-adopter under survey period were calculated at 526 and 219 kg/hh/year, respectively, while fruits production at the time of project samples and non-adopter

were 100 and 89 kg/hh/year, respectively (Table 5). The vegetables and fruits production of project samples were higher 103% than non-adopter. It is found positive impact of FRSD project.

Pabna: Gayeshpur model was also followed in the homestead production system. The average total vegetables and fruits production of project samples and non-adopter under survey period were calculated at 1461 and 649 kg/hh/year, respectively (Table 5). Total vegetables production of project samples and non-adopter under survey period were calculated at 511 and 446 kg/hh/year, respectively, while fruits production at the time of project samples and non-adopter were 950 and 203 kg/hh/year, respectively (Table 5). The vegetables and fruits production of project samples were higher 125% than non-adopter. It is found positive impact of FRSD project.

Table 5. Year-round vegetables and fruits production of project farmers, adopter and non-adopter at different locations in survey period

Areas/ products	Rabi (kg/hh/yr)		Kharif-1 (kg/hh/yr)		Kharif-2 (kg/hh/yr)		Total (kg/hh/yr)		
	Vegetables	Fruits	Vegetables	Fruits	Vegetables	Fruits	Vegetables	Fruits	Veg.+Fruit
Shyampur:									
Project samples	142	32	123	145	80	68	345	245	590
Adopter	80	0	66	15	38	0	184	15	199
Non-adopter	30	0	25	12	15	0	62	12	74
Barind:									
Project samples	288	20	182	80	83	60	553	160	713
Non-adopter	69	15	44	5	31	23	144	43	187
Kushtia:									
Project samples	170	25	209	35	147	40	526	100	626
Non-adopter	110	20	45	25	64	34	219	89	308
Pabna:									
Project samples	255	250	164	350	92	350	511	950	1461
Non-adopter	207	50	153	43	86	110	446	203	649

Disposal Pattern of produced vegetables and fruits in project samples, adopter and non-adopter in different locations

Shyampur: The lion share of production was consumed by the all categories of samples (Table 6). The vegetables consumption was calculated at 72, 392, 199, 158, and 56 kg/hh/yr for before project, end of project, survey period of project samples, adopter and non-adopter, respectively. The fruits consumption of project samples under before project, end of project, survey period, adopter and non-adopter was found to be 92, 165, 115, 15, and 12 kg/hh/yr, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn. But some adopter was received the model partially in the study area of OFRD Shyampur, Rajshahi.

Table 6. Disposal pattern of vegetables and fruits production under Shyampur, Rajshahi

Items	Project samples (kg/hh/yr)			Adopter (kg/hh/yr)	Non-adopter (kg/hh/yr)
	Before project	End of Project	Survey period	Survey period	Survey period
Vegetables:					
Consumption	72	392	199	158	56
Sell	22	195	88	0	0
Gift	14	66	58	26	6
Total Vegetables Production	108	653	345	184	62
Fruits:					
Consumption	92	165	115	15	12
Sell	54	217	84	0	0
Gift	35	53	46	0	0
Total Fruits Production	181	435	245	15	12
Total (veg. + fruits)	289	1088	590	196	74

Barind: The lion share of production was consumed by the all categories of samples (Table 7). The vegetables consumption was calculated at 85, 517, 402, and 100 kg/hh/yr for before project, end of project, survey period of project samples, and non-adopter, respectively. The fruits consumption of project samples under before project, end of project, survey period, and non-adopter was found to be 95, 274, 108, and 40 kg/hh/yr, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 7. Disposal pattern of vegetables and fruits production under Barind, Rajshahi

Items	Project farmers (kg/yr/hh)			Non-adopter (kg/yr/hh)
	<i>Before project</i>	End of Project	Survey period	Survey period
Vegetables:				
Consumption	85	517	402	100
Sell	0	218	102	24
Gift	14	98	49	20
Total veg. production	99	833	553	144
Fruits:				
Consumption	95	274	108	40
Sell	0	129	38	0
Gift	40	51	14	3
Total Fruits Production	135	455	160	43
Total (veg. + fruits)	234	1288	713	187

Kushtia: The lion share of production was consumed by the all categories of samples (Table 8). The vegetables consumption was calculated at 100, 522, 347 and 145 kg/hh/yr for before project, end of project, survey period of project samples, and non-adopter, respectively. The fruits consumption of project samples under before project, end of project, survey period, and non-adopter was found to be 15, 40, 80, and 70 kg/hh/yr, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 8. Disposal pattern of vegetables and fruits production under Kushtia

Niche/ space	Project farmers (kg/yr/hh)			Non-adopter (kg/yr/hh)
	<i>Before project</i>	End of Project	Survey period	Survey period
Vegetables:				
Consumption	100	522	347	145
Sell	0	203	124	55
Gift	12	83	55	19
Total veg. production	112	808	526	219
Fruits:				
Consumption	15	40	80	70
Sell	0	138	5	7
Gift	0	13	15	12
Total Fruits Production	15	192	100	89
Total (veg. + fruits)	127	1000	626	308

Pabna: The lion share of production was consumed by the all categories of samples (Table 9). The vegetables consumption was calculated at 210, 466, 180 and 183 kg/hh/yr for before project, end of project, survey period of project samples, and non-adopter, respectively. The fruits consumption of project samples under before project, end of project, survey period, and non-adopter was found to be 295, 599, 335, and 82 kg/hh/yr, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 9. Disposal pattern of vegetables and fruits production under Pabna

Niche/ space	Project farmers (kg/yr/hh)			Non-adopter (kg/yr/hh)
	Before project	End of Project	Survey period	Survey period
Vegetables:				
Consumption	210	466	180	183
Sell	150	392	282	238
Gift	37	72	49	25
Total veg. production	397	930	511	446
Fruits:				
Consumption	295	599	335	82
Sell	422	456	524	109
Gift	118	175	91	12
Total Fruits Production	835	1230	950	203
Total (veg. + fruits)	1232	2160	1461	649

Consumption pattern per head per day

Shyampur: The vegetables consumption was calculated at 37, 203, 104, 93, and 41 g/h/d for before project, end of project, survey period of project samples, adopter and non-adopter, respectively (Table 10). The fruits consumption of project samples under before project, end of project, surveyed period, adopter and non-adopter was found to be 48, 86, 60, 9, and 9 g/h/d, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn. But some adopter was received the model partially in the study area of OFRD Shyampur, Rajshahi.

Table 10. Vegetables and Fruits production and consumption pattern under Shyampur, Rajshahi

Observations	Vegetables (kg/yr/hh)		Fruits (kg/yr/hh)	
	Production	Consumption	Production	Consumption
Project farmers				
Before Project	108	72 (37 g/h/d)	181	92 (48 g/h/d)
End of Project	653	391 (203 g/h/d)	435	165 (86 g/h/d)
Survey period	345	199 (104 g/h/d)	245	115 (60 g/h/d)
Adopter				
Survey period	184	158 (93 g/h/d)	15	15 (9 g/h/d)
Non-adopter				
Survey period	74	56 (41 g/h/d)	12	12 (9 g/h/d)

Barind: The vegetables consumption was calculated at 44, 270, 210 and 51 g/h/d for before project, end of project, survey period of project samples, and non-adopter, respectively (Table 11). The fruits consumption of project samples under before project, end of project, surveyed period, and non-adopter was found to be 50, 143, 51, and 21 g/h/d, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 11. Vegetables and Fruits production and consumption pattern under Barind, Rajshahi

Observations	Vegetables (kg/yr/hh)		Fruits (kg/yr/hh)	
	Production	Consumption	Production	Consumption
Project farmers				
Before Project	99	85 (44 g/h/d)	135	95 (50 g/h/d)
End of Project	833	517 (270 g/h/d)	455	274 (143 g/h/d)
Survey period	553	402 (210 g/h/d)	160	108 (56 g/h/d)
Non-adopter				
Survey period	144	100 (51 g/h/d)	43	40 (21 g/h/d)

Kushtia: The vegetables consumption was calculated at 44, 265, 176 and 65 g/h/d for before project, end of project, survey period of project samples, and non-adopter, respectively (Table 12). The fruits consumption of project samples under before project, end of project, surveyed period, and non-adopter was found to be 8, 20, 41, and 32 g/h/d, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 12. Vegetables and Fruits production and consumption pattern under Kushtia

Observations	Vegetables (kg/yr/hh)		Fruits (kg/yr/hh)	
	Production	Consumption	Production	Consumption
Project farmers				
Before Project	112	100 (44 g/h/d)	15	15 (8 g/h/d)
End of Project	808	522 (265 g/h/d)	192	40 (20 g/h/d)
Survey period	526	347 (176 g/h/d)	100	80 (41 g/h/d)
Non-adopter				
Survey period	219	145 (65 g/h/d)	89	70 (32 g/h/d)

Pabna: The vegetables consumption was calculated at 117, 260, 100 and 90 g/h/d for before project, end of project, survey period of project samples, and non-adopter, respectively (Table 13). The fruits consumption of project samples under before project, end of project, surveyed period, and non-adopter was found to be 164, 334, 187, and 46 g/h/d, respectively. After intervention of project, consumption was increased. It is observed that production and consumption was decreased when project support was withdrawn.

Table 13. Vegetables and Fruits production and consumption pattern under Pabna

Observations	Vegetables (kg/yr/hh)		Fruits (kg/yr/hh)	
	Production	Consumption	Production	Consumption
Project farmers				
Before Project	397	210 (117 g/h/d)	835	295 (164 g/h/d)
End of Project	930	466 (260 g/h/d)	1230	599 (334 g/h/d)
Survey period	511	180 (100 g/h/d)	950	335 (187 g/h/d)
Non-adopter				
Survey period	446	183 (90 g/h/d)	203	82 (46 g/h/d)

Problems faced by project farmers regarding homestead gardening:

Sample farmers in the study areas faced several problems (Table 14). Cent percent farmers opined that lack of good quality/ HYV seeds and seedlings/ saplings were the major problem. The second highest problem was insufficient training (81%). Seventy three percent farmers reported shortage of manpower, drought and lack of modern agril. inputs. The last problems were scarcity of water (71%).

Table 14. Problems faced by project farmers regarding homestead gardening

Problems	Percent of farmers				
	Shyampur	Barind	Kushtia	Pabna	All areas
1. Lack of good quality/HYV seeds and seedlings/saplings	100	100	100	100	100
2. Shortage of manpower	83	75	83	50	73
3. Scarcity of water	100	100	42	42	71
4. Drought	100	100	50	42	73
5. Lack of modern agril. Inputs	75	75	58	83	73
6. Insufficient training	83	83	75	83	81

Suggestions given by project farmers regarding homestead gardening:

Sample farmers in the study areas suggested to overcome the above cited problems (Table 15). Cent percent farmers opined for supplying good quality/ HYV seeds and seedlings/ saplings,

81 percent farmers responded providing training (81%), 75 percent farmers suggested for supplying modern agril. inputs, 73 percent farmers opined taking initiative for developing awareness and 71 percent farmers told for supplying deep tube well /tube well to the community.

Table 15. Suggestions to overcome the cited problems faced by project farmers regarding homestead gardening

Suggestions	Percent of farmers				
	Shyampur	Barind	Kushtia	Pabna	All areas
1. Supply good quality/ HYV seeds and seedlings/ saplings	100	100	100	100	100
2. Taking initiative for developing awareness	83	75	83	50	73
3. Supply deep tube well /tube well	100	100	42	42	71
4. Supply modern agril. inputs	75	75	67	83	75
5. Providing training	83	83	75	83	81

Conclusion and Recommendations

Based on the above findings, it is revealed that production and consumption of vegetables and fruits were increased of the selected samples after intervention of the FSRD project and it is continued upto survey period. It is found positive impact. Farmers opined that lack of good quality/ HYV seeds and seedlings/ saplings were the major problem. The other problems were insufficient training, shortage of manpower, drought and lack of modern agril. inputs. Sample farmers in the study areas suggested to supply good quality/ HYV seeds and seedlings/ saplings, providing training, supply modern agril. inputs, taking initiative for developing awareness and supply deep tube well /tube well to the community.

158.ADOPTION AND COST EFFECTIVENESS OF VEGETABLES PRODUCTION UNDER RAISED BED SYSTEMS IN PATUAKHALI

M. AKHTAR HOSSAIN, H. M. K. BASHAR, M. M. ISLAM AND M.M ANWAR,M.M.UDDIN, M. S. RAHMAN

Abstract

The study was executed in Kumirmara under Kolapara upazila of Patuakhali districts. Data were collected from randomly selected of 40 sample farmers by purposive sampling during April to May 2024 to estimate cost and return of vegetables and to identify constrains of vegetables production in raised bed. The adoption rate of the raised bed vegetable production system was found 23% and the levels of adoption of most management technologies were found to be low compared to recommendation. The total number of human labor was used 311 man-days ha⁻¹. Farmers used bitter gourd seeds at the rate of 2 kg ha⁻¹. The application of manure, urea, TSP, MoP, gypsum and Borax for bitter gourd were 1230 kg ha⁻¹, 58 kg ha⁻¹, 136 kg ha⁻¹, 48 kg ha⁻¹, 71 kg ha⁻¹ and 3 kg ha⁻¹, respectively. The total cost of production was Tk. 439071 ha⁻¹. Human labor costs were the lion share (49.58 %) in cost of Production. The average yields were 29.81 t ha⁻¹ Gross return was calculated Tk.400243 ha⁻¹. Benefit cost ratio over total cost was 1.70. Farmers reported that pest and disease infestation especially fruit borer were the main constrains (93%) for bitter gourd cultivation in raised bed in the study area.

Introduction

Regular tidal water erosion, heavy rains, varying degrees of soil and water salinity in coastal areas, lack of water in the dry season, heavy silty clay soil, etc are the scenario of coastal area. Except rice, vegetables production are very limited in this areas. The limited number of vegetables produced in this area does not meet the minimum portion of the demand. The small

and marginal farmers do in hardship work with the crops produced in these conditions. High value vegetables and high yielding fruits are grown in monsoon season. Vegetables and fruit trees are irrigated from the canal water during the dry season. However, the raised bed vegetables system is getting popularity in the Southern region day by day. In the raised bed system, after cultivating vegetables, the farmer can break the beds again and cultivate seedlings of paddy. If the farmer cultivates vegetables in the high fence system, the roots of the plants can spread easily in the soil. Plants take nutrients from the soil, light and air can easily penetrate and soil water retention increases. In raised bed system, bed size depends on the variety of vegetable crops. Farmers in the south are growing bitter gourd, snake gourd, sponge gourd, ridge gourd, sweet gourd etc. in raised bed by getting more profit in a short time. Farmers do not keep records of their production. No effort has been given yet before to consolidate the relevant information on cost and return of raised bed vegetable production in the study area. Therefore, the present study is undertaken to meet the following objectives.

- To know the adoption status of vegetables production in raised bed systems.
- To estimate the cost and return of vegetables production in raised bed and
- To identify constraints of vegetables production in raised bed at farm level

Methodology

The study was executed in Kumirmara under Kolapara upazila of Patuakhali districts. Data were collected during April to May 2024. The study area was selected based on the intensive cultivation of the raised bed vegetables in consultation with the department of agricultural extension and OFRD of BARI. At first, a list of all raised bed vegetables growers was collected from the study area and then a total of 40 growers were selected randomly from the lists by purposive sampling technique. Data were collected by the researchers and scientific assistants using pretested interview schedule. The collected data were summarized and analyzed by tabular methods using average, percentage, ratios, etc.

Analytical Technique

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 bitter gourd cultivation in raised bed. Land use cost was calculated on the basis of half 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 bitter gourd in raised bed.

Π = Gross return – (Variable cost + Fixed cost)

Here,

Π = Profit per hectare

Gross return = Total production $\times$ per unit price

Variable costs includes cost of human labor, cost of land preparation, cost of insecticide, cost of irrigation, cost of seed, cost of urea, cost of TSP, cost of MP, cost of borax, cost of Gypsum and interest on operating capital. On the other hand, fixed cost was the family labor and land use cost for bitter gourd in raised bed.

Benefit cost ratio: 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:

$$\text{Benefit cost ratio} = \frac{\text{Gross benefit}}{\text{Gross cost}}$$

Results and Discussion

Adoption status and agronomic performance of bitter gourd in raised bed followed by the farmers: Appropriate inputs use and time of operations are essential for achieving higher yield and economic benefit. Therefore, it is important to know the existing level of technology in terms of agronomic practices, time of operation and input use. The existing level of technology employed in the production bitter gourd in raised bed were presented in Table 1, which indicated that the levels of adoption of most management technologies were found to be low compared to recommendation. Land preparation needed to make the soil suitable for bitter gourd cultivation in raised bed. The bitter gourd farmers dig the soil of their land for making the raised bed in the study area. They do not plough their lands by power tiller. They used mainly Tia variety for bitter gourd from Lalteer Seed Company. They sow twice seeds in a pit during 2nd week of April and harvested on 1st week of June. Inter cultural operation as weeding, irrigation, spray has been done when necessary. About 23 percent farmers were practicing the raised bed vegetables production technology in the study area and getting profit by growing different vegetables

Table 1. Agronomic performance of bitter gourd in raised bed followed by the sample farmers

Technology	Information
Crops	Bitter gourd
Varieties	Tia (Lalteer)
Transplanting/ Sowing date	2 nd week of April
No. of Weeding	2-3
No. of Irrigation	3-5
No. of spray for insect, disease and pest	1 spry/week
Harvesting time	1 st week of June

Source: Field survey, 2024

Input use pattern of bitter gourd cultivation in raised bed by the sample farmers: Human labor was measured in terms of man-day, which usually consisted of 8 hours. It was employed for bed preparation, fertilizing, weeding, soil earthing up, pesticing, harvesting, transporting etc. The total number of human labor used for producing bitter gourd in raised bed was 311 man-days ha⁻¹. It was revealed from the Table 2 that farmers used bitter gourd seeds at the rate of 2 kg

ha⁻¹. The application of manure, urea, TSP, MoP, gypsum and Borax for bitter gourd were 1230 kg ha⁻¹, 58 kg ha⁻¹, 136 kg ha⁻¹, 48 kg ha⁻¹, 71 kg ha⁻¹ and 3 kg ha⁻¹, respectively.

Table 2. Per hectare input use for bitter gourd cultivation in raised bed by the sample farmers

Items	Quantity
Human Labor (Man-days):	
Hired	214
Family	97
Ploughing by power tiller (No.)	-
Seed rate (kg)	2
Cowdung (kg)	1230
Fertilizer dose (kg):	
Urea	58
TSP	136
MOP	48
Gypsum	71
Borax	3

Source: Field survey, 2024

Cost of production of bitter gourd in raised bed

The cost of production for bitter gourd was calculated on the basis of total variable cost and total cost. The average cost of production of bitter gourd in raised bed cultivation was Tk. 345057 and Tk. 439071 ha⁻¹ on the basis of total variable cost and total cost (Table 3). The cost of production of bitter gourd was higher due to higher of all input costs. Human labor costs were the lion share (49.58 %) in cost of production of bitter gourd and it followed by trellis making costs, seeds, land use, irrigation costs, pesticides and fertilizers.

Table 3. Per hectare production cost of bitter gourd in raised bed cultivation

Items	Quantity	Unit price (Tk.)	Total (Tk.)	%
Human Labor (Man-days):				49.58
Hired	214	700	149800	34.12
Family	97	700	67900	15.46
Ploughing by power tiller (No.)	-			
Seed rate (kg)	2	17000	34000	7.74
Cowdung (kg)	1230	2	2460	0.56
Fertilizer dose (kg):				2.37
Urea	58	30	1740	0.40
TSP	136	30	4080	0.93
MOP	48	25	1200	0.27
Gypsum	71	33	2343	0.53
Borax	3	350	1050	0.24
Irrigation cost (Tk.)	3-5	-	16500	3.76
Pesticides cost (Tk.)	1 spray/week		11300	2.57
Trellis making cost (Tk.)			112518	25.63
Land use cost (Tk.)			26114	5.95
Int. on OC. (Tk.)	6 months @ 6%		8066	1.84
Total variable cost (Tk.)			345057	78.59
Total fixed cost			94014	21.41
Total production cost (Tk.)			439071	100.00

Source: Field survey, 2024

Yield, return and profitability of bitter gourd in raised bed: The average yields of bitter gourd were 29.81 t ha⁻¹ in raised bed cultivation (Table 4). On an average, gross return of bitter gourd was found to be Tk.400243 ha⁻¹ in the study area. The average gross margin of bitter gourd was found to be Tk. 400243 ha⁻¹. On an average, net return of bitter gourd was found to be Tk. 306229 ha⁻¹. The benefit cost ratio over total cost of bitter gourd was found to be 1.70 and 2.16 was over variable cost. Per kg production cost of bitter gourd was calculated Tk. 14.73 in the study area.

Table 4. Per hectare profitability of bitter gourd in raised bed cultivation

Items	Quantity	Unit price	Total
Yield (t ha ⁻¹)	29.81		29.81
Total variable cost (Tk.)			345057
Total production cost (Tk.)			439071
Gross return (Tk.)	29812	25	745300
Net return (Tk.)			306229
Gross margin (Tk.)			400243
BCR (over TC)			1.70
BCR (over VC)			2.16
Per kg production cost (Tk.)			14.73

Source: Field survey, 2024

Constraints to produce bitter gourd in raised bed cultivation by the farmers: Farmers in the study area encountered some socio-economic and bio-physical related 10 major constraints which were shown in Table 5. The constraints were identified according to farmer's opinions. They reported that pest and disease infestation especially fruit borer were the main constraints (93%) for bitter gourd cultivation in raised bed in the study area followed by unavailability of BARI bitter gourd varieties seed (91%), lack of getting Sluice gate facility (90%), natural calamity (88%) like, heavy rainfall, flash water, high temperature etc. They did not get reasonable price in local market in harvesting period (85%). They faced labor crisis and high wage rate (81%) during production period. Quality seed was another problems (78%) to them. About 70% farmers did not aware of market information for their produces. Lack of credit facilities were also constraints to 65 % farmers. Lack of technical knowledge on modern technology was also a constraints to them (62%) in the study area.

Table 5. Constraints to produce bitter gourd in raised bed cultivation by the farmers in the study area

Sl.No.	Constraints	% farmers responded	Rank
1.	Insects, pest and disease infestation especially fruit borer	93	1
2.	Unavailability of BARI bitter gourd varieties seed	91	2
3.	Lack of getting Sluice gate facility	90	3
4.	Natural calamity	88	4
5.	Low product price in harvesting period	85	5
6.	Labor crisis and high wage rate	81	6
7.	Lack of quality seed	78	7
8.	Lack of market information	70	8
9.	Lack of credit facilities	65	9
10.	Lack of technical knowledge	62	10

Source: Field survey, 2024

Conclusion

Vegetables productions are very limited in Southern areas of Bangladesh due to water salinity in coastal areas and lack of water in the dry season. The limited number of vegetables produced in this area does not meet the minimum portion of the demand. For the boost of vegetable production, the raised bed vegetables system is getting popularity in the Southern region day by day. Farmers are getting profit from raised bed systems by producing different vegetables. They had to face some constraints like insects, pest and disease infestation, natural calamity, lack of market information, lack of quality seed etc. So, Government and private organization should take initiative to minimize the constraints for better livelihood of the farmers in the study area.

159.PRODUCTIVITY AND PROFITABILITY OF SUMMER CHILLI CULTIVATION IN SOME SELECTED AREAS OF KISHOREGANJ DISTRICT

M. MOHIUDDIN

Abstract

A survey was carried out in two upazillas of Kishoreganj district to assess the existing agronomic practices of summer chilli production, to estimate productivity and profitability as well as to identify the problems of production of summer chilli in the farmers field during 2023-24 cropping season. Tabular method was followed. The majority of the farmers sowed their seeds during the second to third week of February. Farmers used fertilizers in irrational dose. The average yield of summer chilli was found to be 4.68 ton per hectare. The average gross margin was estimated at Tk. 259882 on variable cost basis. The production cost of chilli per kg was Tk. 55.34 and return was Tk. 105.51. Lack of quality seed, high insect pest infestation, lack of scientific production technology, low germination of seed, scarcity of labour and low output price were the major problems in the study areas. Farmers cultivate summer chilli for getting higher profit and easy growing.

Introduction

Chilli (botanically known as *Capsicum annum* L.; *Capsicum frutescens* L.), commonly referred to as the 'wonder spice,' is one of the most important commercial spice crops used extensively worldwide. There are more than 3,000 different varieties of chillies all over the world. One of the main uses for chilli is in culinary applications, as a spice, seasoning, or to add colour. However, chillies have a diverse range of uses, which includes pharmaceuticals, cosmetics, farm protection, paint manufacturing and even in self defense weapons. It also has its place in Ayurveda, the traditional Indian medical system, revealing its numerous medicinal properties such as stimulating good digestion and endorphins and as a natural pain reliever. In terms of nutritional value, chilli is a good source of vitamins and minerals. It is rich in vitamin C, which is essential for a strong immune system and collagen production. It also contains significant amounts of vitamin A, which is important for vision, skin health, and immune function. Chilli also provides dietary fibre, which aids in digestion and helps prevent constipation. It is low in calories and fat, making them a healthy addition to a balanced diet. Moreover, it is a good source of potassium, which contributes to proper muscle and nerve function, as well as blood pressure regulation.

Chilli (Rabi) was cultivated in an area of 78020 hectare during 2021-22, with a total production of 4.96 lakh mt and 20361 ha of land cultivating Chilli (Kharif) produced 1.29 lakh mt (BBS, 2022). Chilli is usually cultivated in winter in Bangladesh and the price is 52 Tk/kg (BBS, 2022) during harvesting in winter. As the production of summer chilli is relatively low, the price of chilli increased during this time, which was up to 500-1000 Tk/kg this year (The Daily Star, 2023). Its demand is very high in summer season but the production is very low due to lack of good varieties. So far I know, Spices research Centre, BARI has developed one variety BARI Morich-2 for cultivation Kharif season. Therefore, increasing the production of summer chilli is very important in the socio-economic context of the country. Chilli is a very labour-intensive crop, which generates employment in rural areas. Earlier some socio-economic studies have been done on different aspect in different locations for winter chilli cultivation (Sanap *et al.* 2023; Chowdhury *et al.* 2012 and Islam *et al.* 2011) but no study was done on summer chilli till now. Hence this study was conducted on productivity and profitability of summer chilli in some selected areas of Kishoreganj district which provide valuable information through fulfillment the objectives set for the study.

Objectives

1. To know the socio economic characteristics of the summer chilli growers in study area;
2. To find out the agronomic practices and productivity of summer chilli cultivation;

3. To estimate cost and return of summer chilli cultivation at farm level; and
4. To identify the problems faced by the farmers in cultivating summer chilli.

Methodology

The present study was conducted in purposively selected two upazilas namely Pakundia and Hossainpur under Kishoreganj district. Purposive random sampling techniques were followed to select the sample size. Firstly, in each upazila Two union were selected (Sidhla and Jamail union from Hossainpur and Jangalia and Sukhia from Pakundia) and from each union, one village was selected based on intensive producing areas in consultation with Upazila Agricultural Officer and SAAO from DAE to collect primary data and information. Secondly, a list of all summer chilli growing farmers in each selected village was prepared and thirdly, a total of 60 farmers taking 15 from each village were randomly selected. A sample size of 60 is generally regarded as the minimum requirement for larger population that will yield a sufficient level of certainty for decision-making (Poate and Daplyn, 1993). The collected data were coded, edited, summarized, tabulated and analyzed to fulfill the objectives of the study.

Analytical technique

Financial Profitability Analysis:

Measurement of cost and return from crop cultivation

Equation for cost analysis as follows:

$$\text{Variable Cost} = VC_{ij} = \sum_{i=1}^n (X_{ij} P_{ij})$$

$$TVC_{ij} = VC_{ij} + IOC_{ij}$$

$$TC_{ij} = TVC_{ij} + TFC_{ij}$$

Where,

TC_{ij} = Total cost (Tk./ha)

TVC_{ij} = Total variable cost (Tk./ha)

TFC_{ij} = Total fixed cost (Tk./ha)

VC_{ij} = Variable cost (Tk./ha)

IOC_{ij} = Interest of operating capital (Tk./ha)

X_{ij} = Quantity of inputs (kg/ha)

P_{ij} = Price of inputs (Tk./kg)

j = Number of crops

i = Number of farmers (1.2.3.....n)

The following equations were used for profitability analysis.

$$\text{Gross Return } GR_{ij} = Y_{ij} P_{ij}$$

$$\text{Net return} = GR_{ij} - TC_{ij}$$

$$\text{Gross margin} = GR_{ij} - VC_{ij}$$

Where,

GR_{ij} = Gross return (Tk/ha)

P_{ij} = Price (Tk./kg) of j th crops received by i th farmer

Y_{ij} = Quantity (kg/ha) produced from crops

Results and Discussion

Socio-economic profile of the respondent farmers

Age: Age of farmers plays an important role in the decision of crop production, better management of the farming activities and adoption of innovated improved technologies. The age of the selected summer chilli growers was examined by classifying the four groups: 20-29, 30-39, 40-49, 50-59 and 60 years and above (BBS, 2023) (Table 1). On an average, most of the farmers belonged to the age group of 30-39 years (30%) followed by the age group of 40-49 years (25%). This information implied that majority of the farmers were relatively younger and middle aged and were in a position to put more physical effort for summer chilli cultivation. Farmers belonging to this age group were supposed to have enormous vigor and risk bearing ability. It is observed from the analysis that at the farm level, the highest, 10% of the total population belongs to the age of 60 years and above which was found similar to the national average of 9.26%.

Table 1. Percent distribution of average age of the respondent farmers

Age group (year)	Percent of the respondent
20-29	15
30-39	30
40-49	25
50-59	20
60 and above	10
Total	100

Education: Literacy may be defined as the ability of an individual to read and write or formal education received up to certain standard. Education helps individuals to become conscious of their environment and develop rational insight into many matters of life. Farmer's education is expected to play an important role in increasing the farming output. Moreover, education is likely to influence the farmers to adopt modern technology and it makes them more capable to manage scarce resources efficiently so that they can earn higher profit. The sample farmers were classified into five groups based on their education level. Information on the educational levels of the respondents is presented in Table 2. It was observed that on an average 17% of the respondents were illiterate that means 83% of the farmers were literate in the study areas which were higher than the national average of 74.08 (BBS, 2023). Among the educated farmers most of them (42%) had primary level of education followed by secondary level (23%) and can sign only (10%) respectively.

Table 2. Percent distribution of farmers according to their educational qualification

Education level	Percent of the respondent
Illiterate	17
Can sign	10
Primary	42
Secondary	23
Above secondary	08
All	100

Household size: Household size included the number of adult male, adult female and children of the respondent households. Household size was categorized by three categories such as number of members' 1-3 persons, 4-6 persons, 7 and above persons (Table 3). Among all surveyed farmers most of the farmers (50%) had household size within the number of 4-6 persons followed by 1-3 persons (35%). A small percentage of farmers (15%) had large household size with member of above 7 persons (Table 3).

Table 3. Percent distribution of farmers according to family members

Family member	Percent of the respondent
1-3	35
4-6	50
7 and above	15
Total	100

Occupation: The sample farmers had both main and subsidiary occupation. The farmers of the study areas involved in various occupations such as agriculture, business, rickshaw/van puller and service etc. for their livelihood. On an average, about 78% farmers were engaged in agriculture as their main occupation which was higher than the national average. On the other hand, the subsidiary occupation was reported to be business in the study area (Table 4). Overall, data showed that only 15% of the sample farmers were engaged in business as their subsidiary occupation (Table 4) in the study areas.

Table 4. Percent distribution of farmers according to their occupational status

Occupation	Percent of the respondent
Main Occupation	
Agriculture	78
Business	15
Others	7
Subsidiary Occupation	
Agriculture	20
Business	15
Others	4

Experience in summer chilli cultivation: Farming experience is an important factor to ensure farm productivity. Farmers who have more experience in farm operations generally attain higher levels of technical efficiency. Technical inefficiency of the production is significantly related to farming experience of the farmers. It was found that about 43% of sample farmers belonged to more than 10 years of farming experience to cultivate summer chilli followed by 3-5 years of farming experience (30%) in the study areas (Table 5). A good number of farmers (27%) had 6-10 years of experience in summer chilli cultivation.

Table 5. Percent distribution of farmers according to experience of summer chilli cultivation

Years	Percent of the respondent
3-5	30
6-10	27
Above 10	43
Total	100

Sowing of seeds: Farmers followed transplanting method for chilli production in the study area. Maximum farmers (69%) sowed the seeds in their seed bed during second to third week of February (Table 6). The time of seedling transplanting depended on wheat and potato harvest completed. Generally farmers transplant 35-40 days old seedlings from seed bed to main field.

Table 6. Distribution of farmers according to different dates of sowing

Date of sowing		Percent of the farmer
Month	Week	
February	1	15
February	2	26
February	3	43
February	4	16
Total		100

Source of seed: All of the farmers used local variety seed named Paboyia variety. Among the sources, the maximum (62%) farmers purchased seeds from their neighbor followed by own seed saved from the previous harvest (22%) while the rest (17%) purchased from the market. The average seed rate per hectare of summer chilli cultivation was found to be 4.94 kg. The seed rate used by the farmers was three times higher than the recommended seed rate of BARI Morich 2: 500-800g.

Table 7. Source of seed used by the farmers

Source	Percent of the farmer
Own saved seed	22
Purchased from local market	17
Purchased from neighbor	62
Total	100.00
Used seed rate (kg/ha)	4.94
Rec. seed rate (gm/ha)	500-800

Input use

Human labour was required for land preparation, transplanting, application of manure and fertilizers, spraying, weeding, irrigation and harvesting etc. On an average, about 289 man-days/ha was required for summer chilli cultivation in which 84% was hired labour (Table 8). The numbers of human labour varied from one year to another year due to change in number of weeding, spraying of pesticides, irrigation and multiple harvesting.

Use of chemical fertilizer: It is noted that all the farmer found in the study areas used cowdung in their summer chilli field. The average dose of urea, TSP, MoP, Gypsum, Boron, Zinc oxide and Cowdung application were found to be 100, 335, 216, 82, 8, 4.94 and 5632 kg per hectare, respectively. The recommended dose of urea, TSP, MoP, Gypsum for BARI Morich-2 were 210, 330, 200 and 110 kg/ha, respectively (Krishi Projukti Hatboi, 2020). Among the different kinds of fertilizer used, the rate of application of TSP and MoP were found slightly higher than recommended dose, while Urea was found very lower use and Gypsum was found slightly lower than that of recommendation.

Table 8. Per hectare input use pattern of Summer Chilli cultivation

Inputs	All
Human labour (Man days)	289
Family labour	46
Hired labour	243
Wage rate	500
Seed (Kg/ha) (need seedling no./ha)	4.94
Fertilizer (Kg/ha)	
Urea	100
TSP	335
MoP	216
Gypsum	82
Boron	8
Zinc	4.94
Cowdung	5632

Economic profitability of Summer Chilli cultivation

Profitability is one of the major criteria for determination of acceptance of a crop. The production cost, gross return, gross margin, benefit cost ratio, etc. for summer Chilli cultivation in Kishoreganj are discussed below:

Cost of production: For calculation of cost of production, only the cost of variable inputs like seed, fertilizers, human labour, power tiller, pesticide, irrigation etc. were considered.

The cost included both cash cost and imputed value of farmers own resources used. A perusal of Table 9 revealed that on an average, total cost of summer chilli cultivation was estimated at Tk. 258980 per hectare of which about 56, 12, 5, 4 and 11 percent were for human labour, fertilizer, seed, land preparation and pesticides, respectively. No farmer used biopesticides. All of the farmers in the study area used fungicides like furadan 5g. About 8 percent of the total cost was incurred for the purpose of land use. Fixed costs included the opportunity cost of land and interest on operating capital, which jointly accounted for 10% of the total production costs. Among the cost, total variable cost and fixed cost were calculated at 90 and 10 percent, respectively.

Table 8. Per hectare production cost of cultivation

Cost items	All
Cost of land preparation	11362 (4)
Cost of human labour	144320 (56)
Family labour	23000 (8.88)
Hired labour	121320 (46.85)
Cost of seeds	14114 (5)
Cost of fertilizers	30874 (12)
Cost of pesticide	33240 (13)
Land use cost	21171 (8)
Interest on op. capital	3899 (2)
Total Variable Cost	233910 (90)
Total Fixed Cost	25070 (10)
Total Cost	258980 (100)

Return from summer chilli cultivation: Return per hectare of summer chilli cultivation in the study area is shown in Table 10. It is conspicuous from the table that the average yield of summer chilli per hectare was 6.73 metric ton. Gross return was calculated at 493792 Tk./ha. The average gross margin was calculated to be Tk. 259882 on total variable cost basis. On an average, benefit cost ratio on total cost basis was found to be Tk.1.91. It indicated that for every one taka investment, the farmer will get Tk.1.91. The cost per kilogram of chilli cultivation was Tk. 55.34 and return from one kilogram of chilli production was calculated as Tk. 105.51.

Table 9. Return per hectare of summer Chilli cultivation in the survey areas

Items	All
Yield (Kg/ha)	4680
Gross return (Tk./ha)	493792
Gross margin (Tk./ha)	259882
Net return (Tk./ha)	234812
Cost per kg	55.34
Return per kg	105.51
Benefit Cost Ratio on total cost basis	1.91
Benefit Cost Ratio on cash cost basis	2.11

Price range

At the beginning of the season, price was low. Price was increases at the end of the June and it was high till August due to adverse weather like heavy rainfall. Price was varied from 70-170 taka per kilogram of summer chilli at farmers level.

Problems of Summer Chilli cultivation

Although summer chilli is profitable crop in the study areas, there are some problems to its higher production. Lack of quality seed was one of the most important limitations of producing summer

chilli in the study area. Study revealed that a major reason was adverse weather for lower production as green chili grows under specific conditions or controlled temperatures. They also mentioned that due to severe infestation of insect and diseases (86%), chilli yield drastically reduced and it led to heavy loss to the growers. Crop pests and diseases are a key factor affecting global food security (Strange and Scott, 2005; Savary et al., 2012). About 73% of the farmers reported that lack of scientifically innovated modern production technology was one of the main problem. Other problems were low rate of seed germination (71%) might be due to moisture absorption in seed storage periods, low output price (68%) and crisis of labour at harvesting time (63%). They also opined lack of storage facility and high wage rate were also the problems (Table 10). Public and private initiatives should be taken to reduce or eliminate these problems for the sake of better production of chilli.

Table 10. Problems of summer Chilli cultivation in the study areas

Types of problems	% of farmers responded
Lack of quality seed	96
Heavy rainfall at harvesting	93
High infestation of pests	86
Lack of knowledge about improved production technology	73
Low rate of seed germination	71
Low output price in early harvesting stage	68
Labour crisis at harvesting period	63
Lack of storage facility	61
High wage rate	55

Conclusions

From the above discussion summer chilli production is profitable crop. The cost and returns structure per hectare of agricultural production, helps the farmer in mapping adjustment in the organization and thereby secure the optimum level of production and income. The Table 9 indicates that at overall average gross return workout to Tk. 493792. The highest input output ratio at 'Cash cost basis' was recorded 2.11 and the lowest input output ratio at 'total cost basis' was recorded 1.91. Chilli provided high return to investment. This crop is gaining popularity in the country very quickly due to its high yield potential with low cost.

Recommendations

Traditional cultural practices are being followed by the farmers so, it is necessary to provide information regarding proper time of sowing, seed rate, fertilizer dose, etc. to the farmers. Appropriate level of input use and time of operation is important for achieving higher yield and profits. Altogether, scientifically innovated improved or modern production technology with its high yielding new seed varieties/ cultivars to counter the climatic changes and pest incidences is very needed at this time. Pathologist should conduct research on summer chilli for controlling insect pest infestation. The department of agricultural marketing should give more importance on market monitoring to ensure fair market price. The findings of the present study provides the empirical feedback to NARS institute (such as BARI, BINA), Agricultural universities who work to develop high yielding varieties, DAE, and allied departments to strengthen the research-extension farmers linkage by providing credible and timely information to the farming community.

Transfer of Technologies

160.PRODUCTION PROGRAM OF BARI RELEASED BT BRINJAL VARIETIES IN BANGLADESH

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Abstract

The field trial was conducted at 30 farmers field of 05 districts in Bangladesh such as Bogura, Cox's Bazar, Cumilla, Dinajpur and Khulna during 2023-24 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. The yield of BARI Bt Begun-4 range from 25.20-42.86 ton per hectare. BSFB infestation in shoot 0.00-3.90 percent and in the fruit (by no.) 0.00-0.73 percent as well as infestation (by wt.) 0.00-0.85 percent in BARI Bt Begun-4. The non-Bt counterpart of the variety BARI Begun-6 and BARI Begun-12 was infected by BSFB both in shoot and fruit and infestation observed 13.88-26.24 percent shoot and 14.99-59.25 percent fruit (by no.) along with 11.16-57.30 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 18.65-31.35 ton per hectare. Among the five districts, field trial under two 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 (*Cry1Ac*) 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 30 farmers' field of 05 districts such as Bogura, Cox's Bazar, Cumilla, Dinajpur and Khulna during 2023-24 to observe the performance of BARI Bt begun-4. Unit plot area was 16.50-33 decimal with the spacing of 100 cm × 80 cm. The crop was sowing at 27 October 2023 -22, December, 2023 and its harvested date was 10 January -15, May 2024. Two rows of non Bt counterpart (BARI Bagun-6, BARI Bagun-12) of 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. Imitaf Admire 5 EC), Ektara, Vertimates, Pegasus-50 SC and Karata-2.5 EC, Bioferti, Success etc. were sprayed to control sucking pests as and when necessary. Similarly, Autostin @ 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 2023-24

Location	No. of trial	Varieties	Sowing time	Harvesting time
Bogura, Joypurhat and Gabtoli	06	BARI Bt begun-4 with non Bt counterparts (BARI Bagun-6)	27 October to 12 November 2023	12 February onwards in a regular interval up to 30 April 2024
Cox's Bazar	05	BARI Bt begun-4 with non Bt counterparts	November 10, 2023	15 March to May 2024
Cumilla, Kashimpur, Madhaiya	06	BARI Bt begun-4 with non Bt counterparts (BARI Bagun-6)	22 December, 2023	8 February to 28 April 2024
Dinajpur, Khamar kantobag, Sadar	01	BARI Bt begun-4 with non Bt counterparts (BARI Bagun-6)	27 Oct- 17 Nov 2023	20 Feb-30 April 2024
Khulna, Koyra	12	BARI Bt begun-4 with non Bt counterparts (BARI Bagun-12)	15 November to 28 November, 2023	10 January to 15 May, 2024
Total	30	BARI Bt begun-4 with non Bt counterparts (BARI Bagun-6, BARI Bagun-12)	27 October 2023 - 22, December, 2023	10 January -15, May 2024

*Non Bt counterparts of the varieties were also planted as border crops

Results and Discussion

Performance of BARI Bt begun-4: BARI Bt begun-4 was cultivated in Bogura, Cox's Bazar, Cumilla, Dinajpur and Khulna districts. The yield of BARI Bt begun-4 range from 25.20-42.86 ton per hectare. BSFB infestation in shoot 0.00-3.90 percent and in the fruit (by no.) 0.00-0.73 percent as well as infestation (by wt.) 0.00-0.85 percent in BARI Bt begun-4. The non-Bt counterpart of the variety BARI Begun-6 and BARI Begun-12 was infected by BSFB both in shoot and fruit and infestation observed 13.88-26.24 percent shoot and 14.99-59.25 percent fruit (by no.) along with 11.16-57.30 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 18.65-31.35 ton per hectare (Table 2).

Table 2. Performance of BARI Bt begun-4 over location during 2023-24

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
Bogura	0.00	23.50	0.00	59.25	0.00	57.30	34.75	21.60
Cox'sbazar	0.00	22.00	0.00	26.50	0.00	11.16	38.78	18.65
Cumilla	0-0.41	26.24	0-0.58	33.71	0-0.75	22.27	25.20	22.35
Dinajpur	0-0.48	20.50	0.73	51.25	0.85	42.30	35.84	31.35
Khulna	0-3.90	13.88-24.22	0-0.54	14.99-30.62	0-0.69	14.30-28.47	42.86	29.13
Range	0.00-3.90	13.88-26.24	0.00-0.73	14.99-59.25	0.00-0.85	11.16-57.30	25.20-42.86	18.65-31.35

Non target Pest incidence: Different sucking pests (Jassid, Whitefly, Thrips, Aphid, Flea beetle, Red mite, *Epilachna* beetle etc.) and diseases (*Fusarium* wilt, *Phomopsis* blight, Bacterial wilt, Little

leaf etc.) were observed in some locations (Table 3). These pests and diseases were controlled by appropriate management approaches.

Table 3. Major disease and insect infestation observed in Bt Brinjal field during 2023-24.

Treatment	Major diseases	Insect infestation	Insecticide sprayed	Fungicide sprayed	No of spray	
BARI Bt begun-4	Wilt, Little leaf (18-24%), Phomopsis blight	Flee beetle, white fly, thrips, red mite	Imitaf, Admire 5 EC), Ektara, Vertimates, Pegasus-50 SC and Karata-2.5 EC, Bioferti, Success.	Provex, Autostin, Tilt-250EC	Insecticide	Fungicide
BARI Begun-6 and BARI Begun-12 (Non Bt)					7	5

Economic analysis

The gross economic return was calculated on the basis of prevailing market price of the commodities (Table 4). In Bogura, the fruit yield of BARI Bt begun-4 was (34.75 t ha⁻¹) where gross return was (581700 Tk ha⁻¹), gross margin was (456400 Tk ha⁻¹) and benefit cost ratio was (4.64). The fruit yield Non Bt begun (BARI Begun-6) was (21.60 t ha⁻¹) where gross return was (208800 Tk ha⁻¹), gross margin was (99300 Tk ha⁻¹) and benefit cost ratio was (1.91) (Table-3). In Cox's Bazar, the fruit yield of BARI Bt begun-4 was (38.78 t ha⁻¹) where gross return was (504000 Tk ha⁻¹), gross margin was (328944 Tk ha⁻¹) and benefit cost ratio was (2.88). The fruit yield Non Bt begun (BARI Begun-6) was (18.65 t ha⁻¹)y where gross return was (208800 Tk ha⁻¹), gross margin was (99300 Tk ha⁻¹) and benefit cost ratio was (1.91). In Cumilla, the fruit yield of BARI Bt begun-4 was (25.20 t ha⁻¹) where gross return was (590750 Tk ha⁻¹), gross margin was (502625 Tk ha⁻¹) and benefit cost ratio was (6.70). The fruit yield Non Bt begun (BARI Begun-6) was (22.35 t ha⁻¹)y where gross return was (208800 Tk ha⁻¹), gross margin was (99300 Tk ha⁻¹) and benefit cost ratio was (1.91). In Dinajpur, the fruit yield of BARI Bt begun-4 was (35.84 t ha⁻¹) where gross return was (510750 Tk ha⁻¹), gross margin was (333250 Tk ha⁻¹) and benefit cost ratio was (2.88). The fruit yield Non Bt begun (BARI Begun-6) was (31.35 t ha⁻¹)y where gross return was (271650 Tk ha⁻¹), gross margin was (78650 Tk ha⁻¹) and benefit cost ratio was (1.41). In Khulna, the fruit yield of BARI Bt begun-4 was (42.86 t ha⁻¹) where gross return was (642900 Tk ha⁻¹), gross margin was (497150 Tk ha⁻¹) and benefit cost ratio was (4.41). The fruit yield Non Bt begun (BARI Begun-12) was (29.13 t ha⁻¹) where gross return was (305865 Tk ha⁻¹), gross margin was (160115 Tk ha⁻¹) and benefit cost ratio was (2.10).

Table 4. Cost and return analysis of BARI Bt Begun-4 and non-Bt variety at different districts during 023-2024

Location	Variety	Fruit yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Bogura	BARI Bt begun-4	34.75	581700	125300	456400
	BARI Begun-6	21.60	208800	109500	99300
Cox's bazar	BARI Bt begun-4	38.78	504000	175056	328944
	BARI Begun-6	18.65	208800	109500	99300
Cumilla	BARI Bt begun-4	25.20	590750	88125	502625
	BARI Begun-6	22.35	208800	109500	99300
Dinajpur	BARI Bt begun-4	35.84	510750	177500	333250
	BARI Begun-6	31.35	271650	193000	78650
Khulna	BARI Bt begun-4	42.86	642900	145750	497150
	BARI Begun-12	29.13	305865	145750	160115

Market price of Brinjal: Cox's bazar: Fresh @ 15 and infested @ 9.67 Tk. kg⁻¹; Cumilla: Fresh @ 20 and infested @ 9.67 Tk. kg⁻¹; Bogura: Fresh @ 17 and infested @ 9.67 Tk. kg⁻¹; Dinajpur: Farm gate price of Brinjal = Tk. 14.25 and infested @ 8.67 Tk. kg⁻¹; Khulna, Koyra: BARI Bt begun-4 @ 15 Tk. kg⁻¹ and infested @ 10.50 Tk. kg⁻¹

Farmers' Opinion

- As the fruits of Bt-brinjal varieties are almost free from BSFB infestation, no sorting is required.
- Timely planting is required for earning high price and more benefits.
- 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.

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 05 districts, field trial under 02 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.

161.PILOT PRODUCTION PROGRAMME OF POTATO VARIETIES AT DIFFERENT LOCATIONS IN BANGLADESH

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The production program was conducted at various locations in Bangladesh, including Tangail, Dinajpur, Cox'sbazar, Kishoreganj, Chuadanga, Gopalganj, and Kushtia. The BARI potato varieties BARI Alu-25, BARI Alu-35, BARI Alu-47, BARI Alu-49, BARI Alu-62, BARI Alu-72, BARI Alu-73, and BARI Alu-78 were evaluated during the growing season of 2023-24. The study involved 51 farmers, cultivating a total area of 6.31 hectares. Each variety was transplanted and harvested at different dates specific to each location.

The average yield of BARI Alu-25 across the four locations (Tangail, Dinajpur, Cox'sbazar, and Kishoreganj) was 26.44 t ha⁻¹. The highest yield for BARI Alu-25 was recorded in Kishoreganj at 29.37 t ha⁻¹, while the lowest yield was in Cox'sbazar at 22.7 t ha⁻¹. This variation in yield could be attributed to the differences in agro-climatic conditions, soil fertility, and local agronomic practices. In Tangail, BARI Alu-25 yielded 26.26 t ha⁻¹, which was slightly below the average yield. The yield in Dinajpur was higher at 27.42 t ha⁻¹. The higher yield in Dinajpur could be due to better soil conditions and favorable climatic factors during the growing season. The yield in Cox'sbazar was the lowest at 22.7 t ha⁻¹, which may be due to the less favorable coastal climatic conditions and potential salinity issues in the soil.

Comparing the performance of different BARI potato varieties across locations, BARI Alu-35 showed a significantly higher average yield (29.25 t ha⁻¹) compared to BARI Alu-25. The gross return and gross margin for BARI Alu-35 were also higher, with an average gross return of Tk. 789750 ha⁻¹ and a gross margin of Tk. 588500 ha⁻¹. This suggests that BARI Alu-35 is more economically viable and productive compared to BARI Alu-25. BARI Alu-49 exhibited excellent performance in Kushtia with the highest yield (30.88 t ha⁻¹) and gross return (Tk. 1080800 ha⁻¹) among all varieties tested. The high market price of Tk. 35 kg⁻¹ in Kushtia significantly contributed

to its high economic return. In contrast, BARI Alu-25 had lower economic returns in Cox'sbazar due to the lower market price of Tk. 20 kg⁻¹ (Table 1).

Farmers provided positive feedback on the performance of the BARI potato varieties, particularly highlighting their high yield potential and disease resistance. However, some farmers expressed concerns about the varying market prices and the cost of inputs.

Table 1. Performance and cost and return of BARI released potato varieties grown at different locations of Bangladesh during 2023-24.

Locations	Variety	Farmer (no.)	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Tangail	BARI Alu-25	08	1.28	11-22 December 2023	05-13 March 2024	26.26	787740	622272.4
Dinajpur	BARI Alu-25	04	1.0	26 November to 10 December 2023	20 January to 5 March 2024	27.42	688000	467500
Cox'sbazar	BARI Alu-25	02	0.20	2 December 2023	26 February 2024	22.7	454000	182000
Kishoreganj	BARI Alu-25	03	1.21	02-05 December 2023	01-03 March 2024	29.37	513975	209395
Total		17	0.92	Average		26.44	610929	370292
Chuadanga	BARI Alu-35	02	0.20	16 December 2023	20 March 2024	22.50	787500	605000
Gopalganj	BARI Alu-35	01	0.10	2 December 2023	17 March 2024	36.0	792000	572000
Total		03	0.3	Average		29.25	789750	588500
Kishoreganj	BARI Alu-47	01	0.24	02-05 December 2023	01-03 March 2024	28.13	478210	173630
Kushtia	BARI Alu-49	03	0.20	08-10 December 2023	07-12 March 2024	30.88	1080800	898300
Kishoreganj	BARI Alu-49	01	0.24	02-05 December 2023	01-03 March 2024	27.68	470560	165980
Gopalganj	BARI Alu-49	01	0.12	23 December 2023	29 March 2024	39.30	864600	644600
Gopalganj	BARI Alu-62	01	0.20	23 December 2023	30 March 2024	37.82	832040	612040
Cox'sbazar	BARI Alu-72	03	0.17	2 December 2023	26 February 2024	29.40	588000	316000
Sylhet	BARI Alu-72	08	0.40	2-5 December 2023	11-14 March 2024	20.15	302250	140250
Total		11	0.57	Average		24.77	445125	228125
Cox'sbazar	BARI Alu-73	02	0.15	2 December 2023	26 February 2024	22.1	442000	170000
Sylhet	BARI Alu-73	08	0.40	2-5 December 2023	11-14 March 2024	19.31	289650	127650
Total		10	0.55	Average		20.71	365825	148825
Cox'sbazar	BARI Alu-78	03	0.20	2 December 2023	26 February 2024	33.6	672000	400000
Grand total		51	6.31	-		-	-	-

Price: At Tangail: BARI Alu-25= Tk. 30 kg⁻¹; at Dinajpur= Tk. 25 kg⁻¹, at Kushtia & Chuadanga= Tk. 35 kg⁻¹; at Cox'sbazar = Tk. 20 kg⁻¹; at Kishoreganj: BARI Alu-25= Tk. 17.50 kg⁻¹, BARI Alu-47 & 49 = Tk. 17 kg⁻¹ and at Gopalganj= Tk. 22 kg⁻¹

162. PRODUCTION PROGRAM OF PANI KACHU VARIETY

M. M. RAHMAN, A.K.M.Z.U. NOOR AND N.SULTANA

A production program of panikachu (var. BARI Panikachu-1) was conducted during 2022-23 at Khunua, Sherpur Sadar under Sherpur district. The seedlings were transplanted on 15 November 2022. The unit plot size was 1.0 bigha maintaining line to line distance 60 cm and plant to plant distance 45 cm. The crop was fertilized with a dose of 275-125-225 kg/ha of Urea-TSP-MOP, respectively and 20 t ha⁻¹ of cowdung. The crop was harvested on 28 July 2023.

The plant height was 1.32 m, number of stolon per plant 21, stolon length 86.6 cm, stolon yield per plant 670gm, the rhizome length 45.0 cm, rhizome diameter 26 cm. From table 2. it was found that Stolon yield per hectare 23.4 ton, rhizome yield per hectare 25.0 ton. Gross return and gross margin per hectare resulted in Tk8,27,000 and Tk. 6,13,280 respectively. The yield performance of BARI Panikachu-1 appeared to be promising in the tested location. Therefore, it might be disseminated in the Sherpur region (Tabl1 1 & 2).

Farmers are interested in cultivating BARI Panikachu-1 due to higher stolon yield and economic return. They are interested in cultivating variety for the next year.

Table 1. Yield and yield attributes of BARI Panikachu-1 variety at Sherpur during 2022-23

Area (ha)	Crop duration (days)	Plant height (cm)	No. of stolon plant ⁻¹	stolon length x breadth (cm)	Stolon weight plant ⁻¹ (g)	Rhizome length x breadth (cm)
0.12	256	132	21	86.6 cm x 4.8 cm	670	45 cm x 26 cm

Table 2. Stolon Yield and rhizome yield, gross return, variable cost and gross margin of BARI Panikachu-1 variety at Sherpur during 2022-23

Stolon yield (t/ha)	Rhizome yield (t ha ⁻¹)	GR (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)
23.4	25.0	827000	213720	613280

Price of stolon =Tk 30.0 kg⁻¹; Rhizome Tk 5.0 kg⁻¹

163. PILOT PRODUCTION OF BARI Panikachu-2

M.A. ISLAM, M.M. ZAMAN AND N. SULTANA

The production program was carried out at Rampur and Bagan, Trishal under Mymensingh district during Kharif season of 2023. The BARI Panikachu-2 was practiced in tested locations. The seedlings were planted on 02-18 February, 2023 with maintaining line to line distance 60 cm and plant distance 45 cm. The crop was fertilized with a dose of 350-175-300-125-13-10 kg ha⁻¹ of Urea-TSP-MOP- Gypsum- Zinc sulphate- Boric acid, respectively and 15 t ha⁻¹ of cowdung. A devastating infestation of *prodonia* caterpillar was prevented by routinely spraying Nitro and Acimix @ 2 ml L⁻¹ at 6-8 times an interval of 7 days attaining at 30 to 40 days old. There was no other remarkable pest and diseases infestation observed during BARI Panikachu-2 in the field. The stolon was harvested from 26 April 2023 to 20 August, 2023 and rhizome was harvested from 01 September to 10 September 2023 (Table 1). The stolon and rhizome yield of BARI Panikachu-2 was 19.12 t ha⁻¹ and 19.05 t ha⁻¹, respectively. Stolon harvesting was started from 26 April, 2023 and ended 20 August, 2023. Harvesting duration of stolon was 117 days. The total gross return and gross margin from stolon and rhizome was prevailing as Tk. 897800.00 ha⁻¹ and 576480.00 ha⁻¹ where the farmer expends only Tk. 321320.00 ha⁻¹ (Table 2).

Farmers are interested to large-scale production of BARI Panikachu-2 in the next year for higher income and to fill up the demand of stolon and rhizome in Bangladesh.

Table 1. Average yield and yield attributes of BARI Panikachu-2 at Trishal, Mymensingh, 2023-24

Farmers involved (no)	Area covered (dec)	Duration of stolon collection (days)	Stolon yield (t ha ⁻¹)	Rhizome yield (t ha ⁻¹)
03	95	117 (26.4.2023 to 20.8.2023)	19.12	19.05

Table 2. Cost and return analysis of BARI Panikachu-2 at Trishal, Mymensingh during Kharif- 2023

Gross return (Tk. ha ⁻¹)			Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Stolon	Rhizome	Total		
669200.00	228600.00	897800.00	321320.00	576480.00

Price of input and output: Urea: 27.00 Tk. kg⁻¹, TSP: 27.00 Tk. kg⁻¹, MoP: 20.00 Tk. kg⁻¹, Gypsum: 12.00 Tk. kg⁻¹, Zinc sulphate: 200.00 Tk. kg⁻¹, Boric acid: 660.00 Tk. kg⁻¹, Insecticide, fungicide and miticide: 10000.00 Tk. per ha, Seedling of Panikachu: 1.00 Tk. per piece, Market price of stolon 35.00 per kg and Rhizome 12.00 per kg.

164. PRODUCTION PROGRAM OF MUKHIKACHU

S. SULTANA, M.M. ZAMAN AND N. SULTANA

A production program was conducted with Mukhikachu variety in Mymensingh and Cumilla during the 2023-24 growing season. Three farmers participated, cultivating a total area of 0.16 hectares. The transplanting dates were 05 April 2023 for Mymensingh and 24 March 2023 for Cumilla. Harvesting occurred on 22 September 2023 in Mymensingh and 30 September 2023 in Cumilla. The price of corm was Tk. 70 per kg in Mymensingh and Tk. 42.50 per kg in Cumilla. The yield of BARI Mukhikachu-1 in Mymensingh was 20.1 t ha⁻¹, with a gross return of Tk. 1407000 and a gross margin of Tk. 1299400. In comparison, BARI Mukhikachu-2 yielded 24.2 t ha⁻¹ in Mymensingh and 30 t ha⁻¹ in Cumilla, with gross returns of Tk. 1694000 ha⁻¹ and Tk. 1275000 ha⁻¹, respectively. The higher yield of BARI Mukhikachu-2 translated into greater economic benefits, with gross margins of Tk. 1416400 ha⁻¹ in Mymensingh and Tk. 939750 ha⁻¹ in Cumilla.

Farmers expressed a preference for BARI Mukhikachu-2 due to its higher yield and profitability. They noted that the variety's robust growth and disease resistance contributed to its superior performance. The economic benefits of cultivating BARI Mukhikachu-2 were particularly appreciated, with farmers highlighting the increased income potential.

Table 1. Performance and economic benefits of BARI Mukhikachu-1& BARI Mukhikachu-2 at Mymensingh and Cumilla during the year 2023-24

Locations	Variety	Number of farmers involved	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Mymensingh	BARI Mukhikachu-1	01	0.06	05 April 2023	22 September 2023	20.1	1407000	1299400
Total		01	0.06	Average		20.1	1407000	1299400
Mymensingh	BARI Mukhikachu-2	01	0.06	05 April 2023	22 September 2023	24.2	1694000	1416400
Cumilla	BARI Mukhikachu-2	01	0.04	24 March 2023	30 September 2023	30	1275000	939750
Total		3	0.10	Average		27.1	1316875	1345700

Price of corm at Cumilla=Tk. 42.50 Kg⁻¹ and at Mymensingh Tk. 70 kg⁻¹

165. PRODUCTION PROGRAM OF SWEET POTATO VARIETIES AT DIFFERENT LOCATIONS IN BANGLADESH

N. SULTANA, M. J. MAHMUD AND M. MOHIUDDIN

The production program was conducted in three distinct locations: Kristopur (Netrakona), Kalukhali (Rajbari), and Nikli (Kishoreganj). The number of farmers involved and the area covered varied across locations (Table 1). Planting dates ranged from November 6 to November 15, 2023, with harvesting dates between February 24 and March 28, 2024. The duration from planting to harvest varied between 108 to 134 days.

At Kristopur, Netrakona the variety BARI Mistialu-17 yielded 26.50 t ha⁻¹ over 134 days; at Kalukhali, Rajbari BARI Mistialu-8 yielded 15.0 t ha⁻¹ over 128 days and at Nikli, Kishoreganj BARI Mistialu-12 and BARI Mistialu-17 yielded 35.61 t ha⁻¹ and 31.20 t ha⁻¹ respectively, each over a duration of 108 days. At Kristopur, Netrakona, BARI Mistialu-17 had a gross return of Tk. 530,000 with a total variable cost of Tk. 107,400, resulting in a gross margin of Tk. 395,960; at Kalukhali, Rajbari, BARI Mistialu-8 had a gross return of Tk. 375,000, total variable cost of Tk. 1,185,640, and a gross margin of Tk. 189,360 and at Nikli, Kishoreganj, BARI Mistialu-12 and BARI Mistialu-17 had gross returns of Tk. 356,100 and Tk. 312,000, with total variable costs of Tk. 141,550 and Tk. 130,400, resulting in gross margins of Tk. 214,550 and Tk. 181,600 respectively. The variety BARI Mistialu-12 in Nikli, Kishoreganj demonstrated the highest yield at 35.61 t ha⁻¹, indicating its suitability for this region. However, the highest gross margin was observed for BARI Mistialu-17 in Kristopur, Netrakona, suggesting a balance between yield and cost efficiency. the production program of BARI released sweet potato varieties in those areas for the improvement of the farmer's livelihood (Table 2).

Farmers were happy with the higher yield and market price of BARI Mistialu-8, BARI Mistialu-12 and BARI Mistialu-17 due to its high yield, attractive color, market demand, and taste.

Table 1. Performances of BARI sweet potato varieties at different locations of Bangladesh during 2023-24

Location	Farmers involved (no)	Area covered (decimal)	Planting date	Harvesting date (DAT)	Duration (Days)
Kristopur, Netrakona	01	100	15 Nov., 2023	28 March 2024	134
Kalukhali, Rajbari	01	05	6 November, 2023	12 March 2024	128
Nikli, Kishoreganj	-	-	06 November 2023	24 February 2024	108

Table 2. Yield, cost and return analysis of BARI released sweet potato varieties at different locations of Bangladesh during 2023-2024

Location	Variety	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Kristopur, Netrakona	BARI Mistialu-17	26.50	530000	10740	395960
Kalukhali, Rajbari	BARI Mistialu-8	15.0	375000	1185640	189360
Nikli, Kishoreganj	BARI Mistialu-12	35.61	356100	141550	214550
Nikli, Kishoreganj	BARI Mistialu-17	31.20	312000	130400	181600

Market price of sweet potato =Tk.20, 25 and 25 kg⁻¹ respectively at Kishoreganj, Netrakona and Rajbari

166. PRODUCTION PROGRAM OF BARI DEVELOPED BOTTLE GOURD VARIETY

M. S. HUDA AND M. H. HOWLADER

A production program was conducted in two distinct locations in Bangladesh: Dinajpur and Gopalganj, during the 2023-2024 growing season. Dinajpur is located in the northwestern part of Bangladesh, characterized by a cooler climate and fertile soils, while Gopalganj is situated in the central region, known for its warm and humid climate. The experiment involved a total of four farmers: one from Dinajpur and three from Gopalganj, each cultivating BARI Lau-4 over varying plot sizes. In Dinajpur, the area under cultivation was 0.20 hectares, while in Gopalganj, the total area was 0.30 hectares. The yield of BARI Lau-4 was significantly higher in Gopalganj (50.43 t ha⁻¹) compared to Dinajpur (30.3 t ha⁻¹). Consequently, the gross return in Gopalganj was also higher (Tk. 756,450 ha⁻¹) than in Dinajpur (Tk. 353,750 ha⁻¹). The total variable costs were higher in Gopalganj (Tk. 192,000 ha⁻¹) than in Dinajpur (Tk. 123,500 ha⁻¹), reflecting the different input requirements and cost structures in the two locations. BARI Lau-4 is a high-yielding and economically viable crop variety in Bangladesh, with significant potential to enhance farmers' income. Further research is needed to explore the long-term sustainability and scalability of BARI Lau-4 cultivation across different agroecological zones in Bangladesh (Table 1).

Farmers expressed strong interest in cultivating the BARI Lau-4 variety due to its higher yield and the ability to grow it in both seasons. Farmers and their neighbors in Muksedpur and Tungipara were particularly enthusiastic about its yield and profitability.

Table 1Yield and economics of BARI Lau-4 at different locations of Bangladesh during 2023-`24

Locations	Variety	No. of farmers	Area (ha.)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Dinajpur	BARI Lau-4	1	0.20	30.3	353750	123500	230250
Gopalganj	BARI Lau-4	3	0.30	50.43	756450	192000	564450

Price: BARI Lau-4=15 Tk. kg⁻¹ at Gopalganj and at Dinajpur, price of bottle gourd @ Tk. 8 kg⁻¹

167.PILOT PRODUCTION PROGRAM OF BARI Begun-12 AT DIFFERENT LOCATIONS OF BANGLADESH

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M. M. HOWLADER AND M. J. UDDIN

Eggplant (*Solanum melongena* L.) is a crucial vegetable crop in Bangladesh, significantly impacting the national economy and dietary needs. This study evaluates the performance of BARI Begun-12, an improved variety developed by the Bangladesh Agricultural Research Institute (BARI), known for its high yield potential, pest and disease resistance, and adaptability. Conducted across nine districts-Tangail, Dinajpur, Kushtia, Faridpur, Bandarban, Netrakona, Kishoreganj, Gopalganj, and Cumilla-the study involved 16 farmers covering 4.63 hectares. The multi-location trial assessed regional variations in yield, pest and disease resistance, and economic benefits. Transplanting dates varied across locations, ranging from late September to early December 2023. Harvesting commenced in late December 2023 and continued until mid-May 2024. Results indicated an average yield of 43.52 t ha⁻¹, with the highest in Kushtia (63.45 t ha⁻¹) and the lowest in Kishoreganj (31.67 t ha⁻¹). The average gross return was Tk. 885368 ha⁻¹, peaking in Gopalganj (Tk. 1375000 ha⁻¹) and lowest in Kishoreganj (Tk. 316700 ha⁻¹). These variations were attributed to differences in soil fertility, climate, and farming practices. Farmer feedback highlighted BARI Begun-12's high yield, disease resistance, and market demand. The study concludes that while BARI Begun-12 is promising, its success depends on regional growing conditions, necessitating improvements in soil fertility and farming practices to enhance productivity and economic returns. The variety's adaptability to diverse agro-climatic conditions makes it a promising option for widespread cultivation. Future research should focus on optimizing pest management and exploring sustainable farming practices to maximize the benefits of BARI Begun-1 (Table 1).

Farmers expressed positive feedback regarding BARI Begun-12, citing its high yield, disease resistance, and market demand as significant advantages. Some farmers suggested improvements in pest management practices to further enhance productivity.

Table 1. Performance and economic benefits of BARI Begun-12 at different locations of Bangladesh during the year 2023-24.

Locations	Variety	Farmer (no.)	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Tangail	BARI Begun-12	01	0.40	30 Oct. 2023	01 March to 17 May, 2024	26.46	787740	622272
Dinajpur	BARI Begun-12	02	0.40	15 October to 20 November	2 January to 15 May, 2024	39.4	864000	604000
Kushtia	BARI Begun-12	02	0.15	26 November, 2023	15 March to 10 May, 2024	63.45	126900	1703000

Locations	Variety	Farmer (no.)	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Faridpur	BARI Begun-12	02	0.20	30 September 2023	25 February 2024 12 times	33.25	997500	748750
Bandarban	BARI Begun-12	01	0.02	October 2023	25 February-5 April 2023	58.79	587900	442400
Netrakona	BARI Begun-12	01	0.12	30 October 2023	31 December 2023 to 04 April, 2024	50.53	1263250	1151250
Kishoreganj	BARI Begun-12	01	0.40	6 December, 2023	Up to 25 April, 2024	31.67	316700	140350
Gopalganj	BARI Begun-12	03	1.0	18 October- 8 November 2023	02 January-07 April 2024	55	1375000	1039420
Cumilla	BARI Begun-12	03	0.14	30 September- 01 November 2023	14 January to 15 April 2024	33.13	507226	288594
Average		16	4.63	-	-	43.52	885368	678393

Average farm gate prices of BARI Begun-12 are Tk. 30, 20, 20, 30, 10, 25, 10, 25 and 20 kg⁻¹ respectively at Tangail, Dinajpur, Kushtia, Faridpur, Bandarban, Netrakona, Kishoreganj, Gopalganj and Cumilla

168.PILOT PRODUCTION PROGRAMME OF SUMMER TOMATO VARIETIES AT DIFFERENT LOCATIONS OF BANGLADESH

M.S. HUDA, M. A. RAHAMAN AND N. SULTANA

The production program was conducted in Dinajpur, Tangail, Sherpur and Netrakona during 2023-24. Three hybrid tomato varieties (BARI Hybrid Tomato-11, BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8) were evaluated. BARI Hybrid Tomato-11 gave an average yield of 37.62 t ha⁻¹, with the highest gross return and gross margin observed in Sherpur. BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 in Netrakona exhibited yields of 52.25 t ha⁻¹ and 68.61 t ha⁻¹, respectively (Table 1 & 2).

Farmers reported positive experiences with the hybrid tomato varieties, noting improved yield, quality, and marketability compared to local varieties. The higher gross margins and returns provided a strong incentive for adopting these varieties. Challenges included the need for timely input supply and training on best practices for hybrid tomato cultivation.

Table 1. Performance of BARI Hybrid Tomato-11 at different locations during 2023-24.

Locations	Variety	Farmer (no.)	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Dinajpur	BARI Hybrid Tomato-11	01	0.20	03 February 2024	Up to 31 May, 2024	34.57	864250	640750
Tangail	BARI Hybrid Tomato-11	03	0.28	26-30 Aug. 2023	10 Nov. to 12 Dec. 2023	29.4	1470000	895830
Sherpur	BARI Hybrid Tomato-11	04	0.16	27 June- 9 August 2023	16 January 2023 to 5 January 2024	48.90	3912040	1803940
Total		08	0.64	Average		37.62	2082097	1113507

Average farm gate prices of BARI Hybrid Tomato-11 are Tk. 25, 50, and 80 kg⁻¹ respectively at, Dinajpur, Tangail, and Sherpur.

Table 2. Performance and economic benefits of BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 at Netrakona, Bangladesh during the year 2023-24

Locations	Variety	Farmer (no.)	Area (ha.)	Transplanting Date	Harvesting Date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Netrakona	BARI Hybrid Tomato-4	20	2.94	03 May to 07 September 2023	07 August 2023 to 26 January 2024	52.25	3918750	2199113
Total		20	2.94	Average		52.25	3918750	2199113
Netrakona	BARI Hybrid Tomato-8	20	2.02	03 May to 07 September 2023	7 August 2023 to 26 January 2024	68.61	5145750	3426113
Cumilla	BARI Hybrid Tomato-8	05	4.40	10 July to 21 August 2023	16 Sept. to 12 Nov. 2023	28.59	1715400	1002450
Total		25	6.42	Average		48.60	3430575	2214281.5

Average farm gate prices of BARI Hybrid Tomato-8 and 4 = Tk.75 kg⁻¹ at Netrakona, at Cumilla =Tk. 60 kg⁻¹

169. PRODUCTION PROGRAM OF STEM AMARANTH VARIETIES

S. AKHTAR, S. SULTANA, M.M. ZAMAN, N. SULTANA AND M. J. UDDIN

The production program was conducted in Cumilla and Mymensingh, Bangladesh, during the year 2023-24 to evaluate the performance and economic benefits of BARI stem amaranth varieties (BARI Danta-1 and BARI Danta-3). The experiment involved a total of seven farmers across these locations, with a total cultivated area of 0.182 hectares. The sowing dates ranged from October to December 2023, and harvesting occurred from February to April 2024. The results indicate that BARI Danta-3 outperformed BARI Danta-1 in both yield and economic returns. In Mymensingh, BARI Danta-3 yielded 65 t ha⁻¹, with a gross return of Tk. 650,000 ha⁻¹ and a gross margin of Tk. 567,500 ha⁻¹. In Cumilla, BARI Danta-3 produced a yield of 73.30 t ha⁻¹, with a gross return of Tk. 366,500 ha⁻¹ and a gross margin of Tk. 237,250 ha⁻¹. The BARI Danta-1 variety, grown in Cumilla, showed a yield of 59.05 t ha⁻¹, with a gross return of Tk. 413,350 ha⁻¹ and a gross margin of Tk. 286,165 ha⁻¹ (Table 1).

Farmers involved in the study expressed positive feedback regarding the BARI-released varieties. They reported better crop performance, higher yields, and increased profitability. The ease of cultivation and resistance to common pests and diseases were also noted as advantages of these varieties. Farmers in Mymensingh particularly appreciated the higher market prices for the BARI Danta-3 variety, which contributed to increased gross margins.

Table 1. Performance and economic benefits of BARI released stem amaranth varieties at different locations of Bangladesh during the year 2023-24.

Locations	Variety	Farmer (no.)	Area (ha.)	Sowing date	Harvesting date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Cumilla	BARI Danat-1	02	0.081	14-23 October 2023	30 Nov. - 07 Dec. 2023	59.05	413350	286165
Total		02	0.081	Average		59.05	413350	286165
Mymensingh	BARI Danta-3	03	0.081	13-21 Dec. 2023	05 February -30 March 2024	65	650000	567500
Cumilla	BARI Danta-3	02	0.02	26-30 Dec. 2023	10 February -03 April 2024	73.30	366500	237250
Total		05	0.101	Average			508250	402375

Price of danta: At Mymensingh Tk. 10 kg⁻¹ and at Cumilla Tk. 5-7 kg⁻¹

170. PILOT PRODUCTION PROGRAM OF GARLIC AT DINAJPUR

M. S. HUDA AND M. J. UDDIN

This study evaluates the garlic production program in Dinajpur and Tangail region during the 2023-24 growing season, focusing on the performance of the BARI Rosun-1 variety. The program involved one farmer in Dinajpur cultivating 0.2 hectares and two farmers in Tangail cultivating 0.26 hectares. Sowing occurred in November 2023, with harvesting completed by March 2024 in Dinajpur and April 2024 in Tangail. The average yields were 6.46 t ha⁻¹ in Dinajpur and 5.7 t ha⁻¹ in Tangail, resulting in gross returns of Tk. 646,000 and Tk. 627,000 per hectare, respectively. The gross margin was slightly higher in Dinajpur (Tk. 449,250 ha⁻¹) than in Tangail (Tk. 447,855 ha⁻¹). These results indicate the profitability of garlic production, particularly with the BARI Rosun-1 variety, under the prevailing agronomic practices (Table 1).

Farmers in both Dinajpur and Tangail expressed optimism about the profitability of cultivating BARI Rosun-1. They were pleased with the good yields and substantial gross margins, particularly noting the favorable market prices. Given the promising results, they are encouraged to continue growing this variety in the future, seeing it as a lucrative option for their farming practices.

Table 1. Production program of garlic at Dinajpur and Tangail during 2023-24

Location	Variety	Farmers no.	Area (ha)	Sowing date	Harvesting date	Yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Dinajpur	BARI Rosun-1	01	0.2	16 Nov. 2023	30 March 2024	6.46	646000	449250
Tangail	BARI Rosun-1	02	0.26	22-26 Nov. 2023	10-17 April 2024	5.7	627000	447855

Market price: BARI Rosun-1= Tk. 100 kg⁻¹ at Dinajpur & BARI Rosun-3= Tk. 110 kg⁻¹ at Tangail

171. PILOT PRODUCTION OF ONION VARIETY

M. S. Huda, M. M. RAHMAN, A. K. M. Z. U. NOOR, N. SULTANA, J. A. MAHMUD, M. M. MORSHED AND M. M. HOSSAIN

The demand for onions is continually rising, driven by both domestic consumption and export opportunities. However, onion production in Bangladesh faces challenges such as low yield, pest infestations, and inadequate access to high-yielding varieties. BARI Piaz-4 is a recently introduced variety developed by the Bangladesh Agricultural Research Institute (BARI) with the potential to increase onion yield and profitability. This study aimed to assess the yield and economic returns of BARI Piaz-4 onion variety during the Rabi season of 2023-24 across three distinct locations in Bangladesh: Dinajpur, Sherpur, and Kushtia. Six farmers participated, covering a total area of 0.89 hectares. The transplanting dates varied across locations, ranging from 10 November 2023 in Sherpur to 1 January 2024 in Kushtia. Yield data were collected from 7 March 2024 to 7 April 2024. The yield of BARI Piaz-4 onion varied significantly across the three locations. Kushtia recorded the highest yield of 27.8 t ha⁻¹, which can be attributed to favorable agro-climatic conditions and effective management practices. Dinajpur and Sherpur recorded slightly lower yields of 22.4 t ha⁻¹ and 22.0 t ha⁻¹, respectively. The gross margin was highest in Sherpur (Tk 809,240 ha⁻¹), primarily due to the higher market price of onions (Tk 45 kg⁻¹). In contrast, Kushtia, despite having the highest yield, recorded a lower gross margin (Tk 667,725 ha⁻¹) due to the lower market price of Tk 33 kg⁻¹. Dinajpur, with a yield of 22.4 t ha⁻¹, achieved a gross margin of Tk 404,700 ha⁻¹ (Table 1).

The farmers involved in this study expressed satisfaction with the performance of BARI Piaz-4, particularly in terms of yield and disease resistance. However, they highlighted the need for better access to market information and storage facilities to maximize their profits. Farmers from Sherpur were particularly pleased with the economic returns due to the high local market price. They are interested in cultivating it again next year for better returns.

Table 1. Performance and economic benefits of BARI Piaj-4 at different locations during 2023-24.

Locations	Farmer (no.)	Area (ha.)	Sowing date	Harvesting date	Yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Dinajpur	6	0.69	10 Feb. to 1 Jan. 2024	7 March to 7 April 2024	22.4	404700
Sherpur					22.0	809240
Kushtia					27.8	667725

172. PRODUCTION PROGRAM OF BARI Piaj-5

M. M. HOWLADER AND D. HALDER

Onion (*Allium cepa*), one of the most important spice crops in Bangladesh, is primarily cultivated during the rabi season. A production program for BARI Piaj-5 was conducted during the 2023-24 rabi season under farmer field conditions at the MLT sites of Tungipara and Muksudpur in the Gopalganj district. Seedlings were transplanted on November 8 and 14, 2023, and the crop was fertilized using a specific nutrient management regime. Pesticides such as Roval, Ridomil, Amistar Top, Confidor, and Karate were applied to manage pests and diseases. Results indicated a mean yield of 23.62 t ha⁻¹, a gross return of 944,800 Tk. ha⁻¹, and a gross margin of 664,300 Tk. ha⁻¹ with a benefit-cost ratio (BCR) of 2.36 (Table 1).

Farmers and their neighbors at the MLT sites in Muksudpur and Tungipara expressed great interest in cultivating BARI Piaj-5 due to its superior yield and profitability. Their positive feedback suggests that BARI Piaj-5 has the potential for wider adoption across the region, improving the livelihoods of onion growers.

Table 1. Yield and economic benefits of BARI Piaj-5 at Gopalganj during rabi season of 2023-24.

Sowing date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
8-14 November 2023	23.62	944800	664800

173. PILOT PRODUCTION PROGRAM OF BARI DEVELOPED TURMERIC VARIETIES AT DIFFERENT LOCATIONS OF BANGLADESH

M. MOHIUDDIN, M. Y. H. RAYHAN AND M. J. UDDIN

Turmeric (*Curcuma longa*) is a crucial spice crop in Bangladesh, with significant cultural, medicinal, and economic importance. Despite its importance, domestic production falls short of meeting national demand, with 4.5 lakh tons produced annually and an additional 11.5 lakh tons imported to bridge the gap (BBS, 2023). The production program was carried out during the 2023-24 growing season in Karimganj Upazila of Kishoreganj and in Cumilla. The variety BARI Halud-4 and BARI Halud-3 were tested. Sowing occurred on April 7, 2023, in Kishoreganj and April 16, 2023, in Cumilla, with harvests on January 10, 2024, and February 25, 2024, respectively. Fertilizers were applied according to BARI recommendations, and standard agronomic practices were followed. BARI Halud-4 significantly outperformed BARI Halud-3 in terms of yield and economic returns. In Kishoreganj, BARI Halud-4 yielded 18.75 t/ha, resulting in a gross return of Tk. 375,000/ha and a gross margin of Tk. 229,640/ha. In Cumilla, BARI Halud-4 yielded 24.15 t/ha with a gross return of Tk. 374,325/ha and a gross margin of Tk. 228,962/ha. In comparison, BARI Halud-3 in Cumilla yielded 21.57 t/ha, with a gross return of Tk. 334,335/ha and a gross margin of Tk. 189,172/ha. The superior performance of BARI Halud-4 can be attributed to its genetic potential and the effectiveness of the agronomic practices applied (Table 1).

Farmers expressed a strong preference for BARI Halud-4 due to its high yield and superior color quality. However, they raised concerns about the availability of rhizomes, which could limit the adoption of this variety. Ensuring a reliable supply of planting materials will be crucial for the successful scaling of BARI Halud-4.

Table 2. Performance and economic benefits of BARI Halud-3 and BARI Halud-4 at different locations of Bangladesh during the year 2023-24

Locations	Variety	Farmer (no.)	Area (ha.)	Sowing date	Harvesting date	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Kishoreganj	BARI Halud-4	01	0.25	07 April 2023	10 January 2024	18.75	375000	229640
Cumilla	BARI Halud-4	01	0.02	16/4/23	25/2/24	24.15	374325	228962
Total		02		Average			374662	229301
Cumilla	BARI Halud-3	01	0.02	16/4/23	25/2/24	21.57	334335	189172
Total		01		Average				

Price: BARI Halud-4 was Tk.15 kg⁻¹ at Kishoreganj, BARI Halud-3= Tk.15.50 kg⁻¹ & BARI Halud-4= Tk.15.50 kg⁻¹ at Cumilla

174. PRODUCTION PROGRAM OF BARI MUSTARD VARIETIES

M.R.AMIN, M.MOHIUDDIN, N.SULTANA, M.S.ISLAM, H.M.K.BASAR, M.S.HOSSAIN, M.A.H.TALUKDER, J.A.MAHMUD, M.J.UDDIN, G.N.HASAN, S.MANDOL, M.T.ISLAM, M.AHMAD, M.I.NAZRUL, S.AHMAD, M.S.H.MOLLA

A production program was conducted in the Kishoreganj, Manikganj, Mymensingh, Noakhali, Patuakhali, Rajshahi, Rangpur, Kushtia, Cumilla, Bhola, Satkhira, Jhenaidha, Bandarban, Cox'sbazar, Sylhet, Faridpur, Pabna and Gopalganj district during the rabi season of 2023-24 to assess the performance of BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-18, BARI Sarisha-19 and BARI Sarisha-20 at the farmers field. All the varieties of Mustard in different locations gave better seed yield than that of the national average (1154 kg ha⁻¹). However, among the short-duration tested mustard varieties (BARI Sarisha-14 and 17) the highest seed yield (1.77 t/ha) was found in BARI Sarisha-17 at Kushtia district. BARI Sarisha-18 gave the highest seed yield in Sherpur (2.35tha⁻¹) through the variety took more duration for its maturity. The highest gross return (204250Tk/ha), gross margin (140750 Tk/ha) from Sylhet were calculated from BARI Sarisha-18 at Rajdhani and the lowest gross return (88400Tk/ha) at Tangail, gross margin (29720 Tk/ha) from BARI Sarisha-14 at Narsindi (Table 1).

Farmers are interested in cultivating BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-19, the reason being impressed to have the higher yield of BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-19 within a short period (75-85 days) and these varieties can be easily developed three or four crop based cropping pattern without hampering Boro cultivation. Coastal farmers choose BARI Sarisha-19 because of its high yield capability and fit for the Mustard- Sesame- T. Aman cropping pattern. BARI Sarisha-18 took more days to attain maturity which can be fitted Mustard-Jute-T. Aman cropping pattern.

Table 1. Yield performance of BARI Sarisha during 2023-24

Location	Variety	No. of farmer	Area (Bigha)	Duration (day)	Seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Manikganj	BARI Sarisha-14	24	59	87-94	1.58	128475	78555	49920	1.64
	BARI Sarisha-17	04	15	90-95	1.61	130645	78555	52090	1.66
	BARI Sarisha-18	02	02	98-105	1.71	130558	75655	54903	1.73
Tangail	BARI Sarisha-14	81	29.05	78-85	1.38	88400	54888	33512	1.61
	BARI Sarisha-17	14	4.49	80-85	1.47	89960	55591	34369	1.62
	BARI Sarisha-18	12	3.35	98-105	1.88	116247	57114	59133	2.04
	BARI Sarisha-20	1	0.24	86	1.81	108600	52085	56515	2.09

Location	Variety	No. of farmer	Area (Bigha)	Duration (day)	Seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Sherpur	BARI Sarisha-14	10	10	83	1.65	131300	78,925	52,375	1.66
	BARI Sarisha-18	15	12	108	2.35	188000	78,925	109075	2.41
Narsindi	BARI Sarisha-14	30	37	78-82	1.18	95480	65760	29720	1.45
	BARI Sarisha-18	05	10	95-98	1.83	148320	70380	77940	2.11
	BARI Sarisha-17	05	12	95-100	1.66	141645	68360	73285	2.07
Pabna	BARI Sarisha-17	37	100	86-90	1.89	141750	75760	65990	1.88
	BARI Sarisha-18	10	50	98-103	1.97	147750	75760	71990	1.95
Kushtia	BARI Sarisha-14	05	08	83-86	1.56	109200	57500	51700	1.90
	BARI Sarisha-17	10	15	85-90	1.77	123900	57500	66400	2.15
	BARI Sarisha-18	12	17	99-105	2.05	143500	57500	86000	2.50
Faridpur	BARI Sarisha-19	100	125	106	1.67	125250	68078	57172	1.84
	BARI Sarisha-14	40	50	90	1.32	99000	62340	36660	1.59
Bandarban	BARI Sarisha-18	05	08	92-98	1.56	109200	52500	56700	2.08
Cox'sbazar	BARI Sarisha-14	05	08	75-78	1.41	107540	52400	55140	2.05
Noakhali	BARI Sarisha-14	12	25	78-82	1.36	108800	54560	54240	1.99
	BARI Sarisha-17	07	18	80-84	1.57	124800	54560	70240	2.29
	BARI Sarisha-18	05	13	100-103	1.76	140800	54560	86240	2.58
Sylhet	BARI Sarisha-14	10	10	75-80	1.53	145350	63500	81850	2.29
	BARI Sarisha-17	15	20	80-85	1.25	118750	63500	55250	1.87
	BARI Sarisha-18	30	50	92-98	2.15	204250	63500	140750	3.22
Mymensingh	BARI Sarisha-14	135	295	75-88	1.44	100800	54195	46605	1.86
Barind, Rajshahi	BARI Sarisha-14	33	190	75-78	1.67	116900	37340	79560	3.13
	BARI Sarisha-17	34	146	80-85	1.74	121800	37340	84460	3.26
	BARI Sarisha-18	64	290	95-100	1.75	122500	37340	85160	3.28
Cumilla	BARI Sarisha-14	25	26	85	1.24	86800	52500	34300	1.65
	BARI Sarisha-17	07	12	85-88	1.41	98700	52500	46200	1.88
	BARI Sarisha-18	14	20	95-100	1.67	116900	52500	64400	2.23
Kishoreganj	BARI Sarisha-14	30	144	80-82	1.63	105950	42560	63390	2.49
	BARI Sarisha-14	03	02	78-82	1.57	102050	42560	59490	2.40
Gopalganj	BARI Sarisha-18	21	40	93-98	1.85	148000	67500	80500	2.19
Patuakhali	BARI Sarisha-14	11	07	77-82	1.46	124100	63500	60600	1.95
	BARI Sarisha-18	08	08	92-95	1.72	146200	63500	87200	2.30
	BARI Sarisha-19	07	10	85-90	1.70	144500	63500	81000	2.28
Total		898	1860		1.66 (avg.)				

*TVC includes labour, Land preparation, Seed, fertilizers and Insecticides, Price of mustard at Manikganj @ Tk. 75.00 kg⁻¹ and straw @ Tk. 1.00 kg⁻¹. Tangail @ Tk. 62 kg⁻¹, Sherpur@ BARI Sarisha -14 and 18 seed Tk. 80.0 kg⁻¹; Stover Tk. 2.0 kg⁻¹, Narsindi @ Tk. 80.00 kg⁻¹ and straw @ Tk.1.00 kg⁻¹. Pabna@ Tk. 75.00 kg⁻¹. Kushtia@ Tk. 70.00 kg⁻¹. Kushtia@ Tk. 80.00 kg⁻¹. Bandarban@ Tk. 70.00 kg⁻¹. Cox'sbazar @ Tk. 76.00 kg⁻¹. Noakhali @ Tk. 80.00 kg⁻¹. Sylhet @ Tk. 95.00 kg⁻¹. Mymensingh @ Tk. 70.00 kg⁻¹. Barind, Rajshahi @ Tk. 70.00 kg⁻¹. Cumilla @ Tk. 70.00 kg⁻¹. Kishoreganj @ Tk. 65.00 kg⁻¹. Gopalganj @ Tk. 80.00 kg⁻¹. Gopalganj @ Tk. 85.00 kg⁻¹. Patuakhali @ Tk. 85.00 kg⁻¹.

175. SEED PRODUCTION PROGRAM OF MUSTARD THROUGH BLOCK APPROACH

M. MANIRUZZAMAN, M. S. H. MOLLA, M. A. ISALM, M. Z. HASAN AND M. A. SUBORNA

The seed production program was conducted at MLT site, Sirajganj of Sirajganj district during the rabi season of 2023-24 to produce quality seed as well as to disseminate the BARI Sarisha-18 at the farmers' level. The crop was fertilized with 120-34-45-29-2-2 kg N-P-K-S-Zn-B respectively. Sowing date of the crop was 10-12 Nov. 2023. Fungicide Rovral 50 WP was applied two times at the mid and later stages of seed filling depending on disease incidence. Other intercultural operations were done when required. BARI Sarisha-18 was harvested on 20-25 February 2024. The average seed yield (2.15 t ha⁻¹) of BARI Sarisha-18 was recorded with gross margin (Tk. 132070 ha⁻¹) (Table 1).

Farmers opined that though the duration of BARI Sarisha-18 is quite long, they also prefer this variety due to its higher seed yield and stover yield and suitable for Mustard-Sesame-T. Aman or Mustard-Jute-T. Aman cropping pattern. They preserved seeds with a view to grow this variety in the next season.

Table 1. Seed yield, cost and return Performance BARI Sarisha-18 under block approach at MLT site Char Mechra, Kazipur, Sirajganj of OFRD, Pabna during 2023-24.

Land area (ha.)	Av. Seed yield (t ha ⁻¹)	Av. Stover yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk ha ⁻¹)
1.0	2.15	3.74	200980	68910	132070

Seed: 90.00 Tk. kg⁻¹ and Stover: 2.00 Tk. kg⁻¹

176. PRODUCTION PROGRAM OF BARI GROUNDNUT VARIETIES

M. M. RAHMAN, M. AHMAD, M. S. ISLAM, G. N. HASAN, M. MOHIUDDIN AND M. M. HOWLADER

The Production program of BARI Chinabadam-8 and BARI Chinabadam-9 was carried out at different Agro Ecological Zones of Bangladesh during Rabi season of 2023-2024 to popularize and increase oil seed productivity as well farmers' income. BARI high yielding groundnut variety such as BARI Chinabadam-8 and BARI Chinabadam-9 was distributed among the 60 farmers at different districts where the total land area was 15.25 hectare. The crop was fertilized with 12-32-43-54-2 kg NPKSB ha⁻¹, respectively. The seeds of BARI Chinabadam-8 and BARI Chinabadam-9 were sown on 6 to 9 November 2023 with a seed rate of 100 kg ha⁻¹. The crop was harvested from 2 to 4 May 2024. The seed yield of BARI released groundnut varieties were ranged from 1.88-2.54 t ha⁻¹ where the highest seed yield was obtained from BARI Chinabadam-09 (2.54 t ha⁻¹) in Gopalganj. The lowest seed yield from BARI Chinabadan-8 (1.88) in Noakhali. The highest gross return (304800) from Gopalganj (Table.1).

Farmers across various regions have positively received BARI Chinabadam-8 and BARI Chinabadam-9 due to their higher yields, larger seed sizes, and pest tolerance. In Tangail, many are stored seeds for future planting. In Cox's Bazar, the larger seeds of BARI Chinabadam-8 were seen as an improvement over the local Dhaka-1 variety. Noakhali farmers found BARI Chinabadam-8 effective for utilizing marginal land after the T. Aman rice harvest. In Bhola, BARI Chinabadam-9 is favored for its high yield and strong seed demand. Although farmers in Kishoreganj faced irrigation and seed scarcity challenges, they appreciated the profitability of BARI Chinabadam-8. In Gopalganj, BARI Chinabadam-9's promising yield and profitability sparked significant interest among farmers.

Table 1. Yield performance of BARI Chinabadam during 2023-24

Location	Variety	No. of farmer	Area (ha)	Seed yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Tangail	BARI Chinabadam-8	24	03	2.29	206100	94300	111800	2.19
	BARI Chinabadam-9	04	04	2.30	207000	94300	112700	2.20
Cox'sbazar	BARI Chinabadam-8	04	02	2.20	198000	95000	103000	2.09
Noakhali	BARI Chinabadam-8	03	1.25	1.88	159800	58500	101300	2.74
Bhola	BARI Chinabadam-9	05	02	2.21	198900	75000	123900	2.64
Kishoreganj	BARI Chinabadam-8	10	02	2.23	230000	118620	111380	1.95
Gopalganj	BARI Chinabadam-9	10	01	2.54	304800	142000	162800	2.14
		60	15.25	2.20 (avg)				

*TVC includes labour, Land preparation, Seed, fertilizers and Insecticides, Price of groundnut at Tangail @ Tk. 90.00 kg⁻¹. groundnut at Cox'sbazar @ Tk. 90.00 kg⁻¹. groundnut at noakhali @ Tk. 85.00 kg⁻¹. groundnut at bhola @ Tk. 90.00 kg⁻¹. groundnut at kishoregang @ Tk. 100.00 kg⁻¹. groundnut at gopalgong @ Tk. 120.00 kg⁻¹.

177. PRODUCTION PROGRAM OF GARDEN PEA VARIETY

M. M. RAHMAN, A.K.M.Z.U. NOOR, N. SULTANA, M. M. ZAMAN, N. SULTANA AND MST ESMAT ARA BEGUM

The production program was conducted at FSRD Site, Tarakandi, Sherpur and Char Kharicha, Mymensingh during rabi season of 2023-24. The variety BARI Motorsuti-3 was used. The seeds were sown on 11 November 2023 at Tarakandi and 4 December 2023 at Char Kharicha. Fertilizers were applied in the field as per BARI recommended dose. Furadan was applied during final land preparation for controlling soil insect's and companion was sprayed to control foot rot. The crop was harvested from 19 January 2024 at Tarakandi and 12 February, 2024 at Char Kharicha. An average green pod yield (8.40 t ha⁻¹, 5.98 t ha⁻¹) obtained from BARI Motorsuti-3. The crop duration was 69 days. The yield performance of Garden pea variety BARI Motorsuti-3 appeared to be promising in the tested location. Higher gross return was found Tk. 418600 ha⁻¹ in Mymensingh and gross margin (Tk. 229700 ha⁻¹) from Tarakandi, Sherpur (Table 1).

Farmers' are interested to cultivate BARI Motorsuti-3 due to market price is high and it can be easily fitted in Motorshuti-Boro-T. Aman cropping pattern without impede Boro cultivation.

Table-1. Area, days to maturity, sowing, harvesting, seed yield and gross margin of Garden Pea variety during 2023-2024

Location	Area (decimal)	Sowing date	Harvesting date	Duration (Days)	Pod yield (t ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Tarakandi Sherpur	30	11.11.23	19.01.24	69	8.40	347700	229700
Char kharicha, Mymensingh	30	04.12.23	12.02.24	68	5.98	418600	189800

Price of BARI Motorsuti-3 green pod Tk 40.0 kg⁻¹ at Tarakandi Sherpur and Tk 70.0 kg⁻¹ at Mymensingh

178. UP-SCALING OF BARI FOXTAIL MILLET AND PROSO MILLET VARIETIES IN CHAR AREAS

MD. JAHANGIR ALAM, MD. SHOHEL RANA AND ABDULLAH AL MAHMUD

The trial was conducted at the farmer's field of Kanaipara Char, Saghata, Gaibandha during *rabi*, 2023-24. The tested varieties were BARI Kaon-2, BARI Kaon-4 and BARI Cheena-1. Four farmers were selected for the study. Seeds were sown on 10-22 December 2023. Nitrogen, phosphorus and potassium were applied 45, 30 and 20 kg ha⁻¹, respectively. The crop was harvested on 13 March-12 April 2023. The days to maturity in BARI Kaon-2 ranged from 118-124 d with an average of 122 d, plant height ranged from 118.50-121.24 cm with an average of 119.75 cm. In BARI Kaon-4, days to maturity ranged from 106-109 d with an average of 108 d and plant height ranged from 97.45-106.11 cm with an average of 101.81 cm. The average in-field duration of BARI Kaon-4 was about 2 weeks earlier compared to BARI Kaon-2. However, the average highest grain yield (3.06 t ha⁻¹) was recorded from BARI Kaon-4 that was 11% higher compared to BARI Kaon-2 (2.76 t ha⁻¹). In case of proso millet, the days to maturity in BARI Cheena-1 ranged from 89-93 d with an average of 91 d, plant height ranged from 59.75-65.65 cm with an average of 62.94 cm. Grain yield ranged from 2.65 to 2.80 t ha⁻¹ with an average of 2.73 t ha⁻¹. No lodging, disease and insect incidence occurred in the BARI Kaon-2, BARI Kaon-4, BARI Cheena-1.

Farmers preferred BARI Kaon-2, BARI Kaon-4 and BARI Cheena varieties due to higher yield. Farmer's demanded a timely supply of more quality seed to spread in char areas.

Table 1. Yield and other parameters of BARI developed Foxtail millet and proso millet varieties in farmer's field of char areas, Gaibandha during 2023-24.

Variety	Farmers (no)	Days to maturity	Plant height (cm)	Yield (t/ha)	Lodging (%)	Disease (%)	Insect
BARI Kaon-2	(E1)	123	118.50	2.65	x	x	x
	(E2)	118	119.12	2.73	x	x	x
	(E3)	121	120.15	2.91	x	x	x
	(E4)	124	121.24	2.75	x	x	x
	Mean	122	119.75	2.76	x	x	x
BARI Kaon-4	(E1)	108	101.23	2.91	x	x	x
	(E2)	106	97.45	2.86	x	x	x
	(E3)	107	102.44	3.15	x	x	x
	(E4)	109	106.11	3.32	x	x	x
	Mean	108	101.81	3.06	x	x	X
BARI Cheena-1	(E1)	92	62.15	2.80	x	x	x
	(E2)	89	64.21	2.65	x	x	x
	(E3)	93	65.65	2.72	x	x	x
	(E4)	91	59.75	2.76	x	x	x
	Mean	91	62.94	2.73	x	x	x

179.PRODUCTION PROGRAM OF BARI LENTIL VARIETY (BARI MASUR-8) IN KUSHTIA

J. A. MAHMUD, M. M. MORSHED, M. M. HOSSAIN

The Production program of BARI Masur-8 was conducted at Kushtia Sadar, MLT site: Bheramara, Chuadanga Gangni, and Mujibnagar, Meherpur during Rabi season 2023-2024 to popularize BARI Masur-8 in block approach. Total land area was 2.50 ha under the production program. Seed rate was 37.5 kg ha⁻¹. Seeds were sown on 13-26 November 2023 in different location. Fertilizers were applied @ 20-17-17.5-9-1 kg ha⁻¹ NPKS and B, respectively. The crop was sprayed by Provex-200 and Rovral 50WP for controlling foot rot and Stemphylium blight diseases. The crop was sprayed by Taigor @ 2ml L⁻¹ to control aphid at 65-75 DAS. The crop was harvested on 05-20 March, 2024.

Twelve famers were involved in the production program. The average seed yield of BARI Masur-8 in Kushtia Sadar, MLT site: Bheramara, Chuadanga, Gangni and Mujibnagar were 2.45 t ha⁻¹, 2.00 t ha⁻¹, 2.15 t ha⁻¹, 2.05 t ha⁻¹, and 2.11 t ha⁻¹ respectively. Average gross margin of BARI Masur-8 in Kushtia was Tk. 132920 ha⁻¹.

Farmers were pleased to see the higher yield of BARI Masur-8. Farmers expressed their satisfaction with higher market price. A good amount of seed has been stored by the farmers for next year sowing.

Table 1. Performance of BARI Masur-8 during rabi 2023-24 in different location under OFRD, Kushtia

Location	No. of farmers involved	Total Area (ha)	Seed yield (t ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Kushtia Sadar	03	1.20	2.45	158250
MLT site, Bheramara	02	0.20	2.00	120000
MLT site, Chuadanga	02	0.20	2.15	132750
MLT site, Gangni	02	0.40	2.05	124250
MLT site, Mujibnagar	03	0.50	2.11	129350
Average			2.15	132920

Market price of lentil @ 85 TK kg⁻¹

180. PRODUCTION PROGRAM OF BARI Til-5 IN KUSHTIA

J. A. MAHMUD, M. M. MORSHED, M. M. HOSSAIN

The production program of BARI Til-5 was conducted at Kushtia Sadar and MLT Site, Bheramara during the season of 2023-2024 to observe the yield performance of BARI Til-5 in block approach. Five farmers were involved in the production program covering land area of 1.00 ha. The seed rate was 7 kg ha⁻¹. The crop was fertilized with recommended dose of fertilizer at the rate of 55-28-22.5-19-1.80-1.80 kg ha⁻¹ NPKSZn and B, respectively. The seeds were sown on 07-10 March, 2024. Pre-sowing irrigation will be needed. The crop was harvested during 02-10 June, 2024.

The performance of BARI Til-5 was presented in Table1. Average seed yield of BARI Til-5 at Kushtia Sadar and MLT Site, Bheramara were 1.63 t ha⁻¹ and 1.51 t ha⁻¹ respectively. Gross margin at Kushtia Sadar and MLT Site, Bheramara were Tk (73030) ha⁻¹ and Tk (62830) ha⁻¹ respectively. Satisfactory grain yield and gross margin was achieved might be due to sowing at optimum time and timely proper management practices like weeding, thinning and pest management. The variety also produced a good amount of straw which is used for fuel purposes. BARI Til-5 was profitable to the farmers. More production program should be done to make the availability of BARI Til-5 to the rural farmers.

Farmers were happy to get higher yield. They preserved their seeds and will go for cultivation in the next year. They sold seeds of BARI Til-5 among the neighboring farmers and they were also happy and interested to cultivate in the next year.

Table 1. Seed yield and yield contributing characters of BARI Til-5 at different location, 2023-24

Location	Days to maturity	Ave. seed yield (t ha ⁻¹)	Ave. Straw yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Kushtia Sadar	88	1.63	3.75	138550	65520	73030
MLT Site, Bheramara	92	1.51	3.65	128350	65520	62830

Market price of mustard @ 85 Tk.kg⁻¹

181. PRODUCTION PROGRAM OF BARI OAT-1 IN FARIDPUR

SELIM AHMED

A production program of BARI Oat-1 was conducted at the FSRD site of Faridpur during the *rabi* 2023-24 to observe the performance and to popularize BARI Oat-1 among the local farmers. Seeds were sown at 70 kgha⁻¹ with 25 cm line to line spacing by continuous sowing on 17 December 2023. The crop was fertilized with 80-30-30-10-3-1 kg of N-P-K-S-Zn-B ha⁻¹. The crop was harvested on 9 April, 2024 (114 DAS).

They were enthusiastic and hopeful for new crop because it needs less care, but the conventional market system does not include oat. So, farmers are worried about large scale production. Besides, oat is not our regular food item which has left farmers into confusion what to do with this crop. DAE should take it into consideration to ensure the farmers about proper selling channel and by doing so, DAE will patronize large scale production so that oat becomes a representative crop of Faridpur like jute.

Table 1. Crop management practices considered in BARI Oat-1 in Faridpur during 2023-24.

Variety	No. of cooperator farmer	Area (dec.)	Date of sowing	Fertilizer dose(kg ha ⁻¹) N-P-K-S-Zn-B)	Irrigation	Date of harvest
BARI Oat-1	01	33	17 Dec. 2023	80-30-30-10-3-1	2 times (Immediate, 28 DAS)	9 April. 2024 (114 DAS)

Table 2. Yield and Cost-Return analysis of BARI Oat-1 in Faridpur during 2023-24.

Variety	Grain yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
BARI Oat-1	1.51	151000	74897	76103

Input price (Tk/kg): Urea- 27, DAP- 21.00, MoP-22, Gypsum- 12.00, Zinc- 250.00, Boron-350 Output price (Tk/kg): BARI Oat-1: 100

182. PRODUCTION PROGRAM OF BARI SOYBEAN-5 IN NOAKHALI REGION

M.S. ISLAM and M.M. BASHIR

The production program was conducted in 730 decimal (2.96 ha) area of three farmers' field at Sadar and Subarnachar upazila under Noakhali district during Rabi season of 2023-24 to increase crop productivity through replacing Shohag by BARI Soybean-5. Field's soil was silty clay loam under the saline area of AEZ-18 with low organic matter content. The field was fertilized at the rate of 28-35- 60-21-1 kg ha⁻¹ of N-P-K-S-B. Soybean seeds were sown on well cultivated land in line maintaining 30cm×continuous @ 50 kg ha⁻¹ during 25 December 2023 to 12 January 2024. Weeding was done twice at 20-25 and 40-45 DAS for maintaining hygienic condition. Soil salinity was measured at an interval of 15 days after sowing. Soil salinity at pod formation stage ranged from 4.52-6.36 dS m⁻¹. For controlling pest and diseases, Karate, Autostin, Nitro and Virtako were sprayed for controlling cut worm, leaf roller, hairy caterpillar and root rot diseases. The crop was harvested on 12-22 April 2024.

On average, the crop duration of BARI Soybean-5 was 100 days with an average seed yield of 1.73 t ha⁻¹. Total variable cost (TVC) for soybean cultivation in the late Rabi season was Tk. 48560 ha⁻¹. Average gross return (GR) and gross margin (GM) were Tk. 103920 and Tk. 55360 ha⁻¹, respectively. Farm gate price of fresh soybean seed produced in rabi season was Tk. 60.0 kg⁻¹.

Farmers expressed their satisfaction to BARI Soybean-5 because of getting higher yield than Shohag.

Table 1. Yield and economic performance of soybean production program in Noakhali, 2023-24.

Crop/variety	Farmer	Area (Dec.)	Seed yield (t ha ⁻¹)	GR (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	GM (Tk. ha ⁻¹)
BARI Soybean-5	F ₁	130	1.72	103200	48560	54640
	F ₂	200	1.68	100800	48560	52240
	F ₃	80	1.74	104400	48560	55840
	F ₄	150	1.85	111000	48560	62440
	F ₅	170	1.67	100200	48560	51640
Average of 5 farmers		146	1.73	103320	48520	55360

Output price Tk. 60 kg⁻¹, GR= gross margin, TVC= total variable cost, GM= gross margin

183. PRODUCTION PROGRAM OF SUNFLOWER

S. SULTANA, M.M. ZAMAN AND N. SULTANA, M.MOHIUDDIN AND M.Y.H. RAYHAN, J. A. MAHMUD, M. M. MORSHED, M. M. HOSSAIN

The production program was conducted at farmer's field of Muktagacha, Mymensingh, Kishoreganj Sadar and Chuadanga, Kushtia during rabi season of 2023-24. Land preparations were done on December 18, 2023. Seeds of BARI Surjomukhi-3 were sown 09 November to December 19, 2023, after germination test of seeds and harvesting was done on 23 February to March 30, 2024. Total area was 400 decimal maintaining a line to line spacing of 50 cm and plant to plant spacing of 25 cm. The crop was fertilized with a dose of 115-30-110 kg ha⁻¹ NPK. Only a few plants of BARI Surjomukhi-3 were infested by caterpillar at later growth stage. To control

this infestation Nitro 505 EC was sprayed @ 2 ml L⁻¹, 2 times at 10 days interval. The average height of BARI surjomukhi-3 was 163 cm. The days required to be mature the crop was 92-95 days. The average seed yield of BARI Surjomukhi-3 was 1436 kg ha⁻¹. Higher seed yield (1900 kg ha⁻¹) was obtained from Kushtia and lower (1170 kg ha⁻¹) at Mymensingh. The gross return (Tk. 42500 ha⁻¹) and gross margin (Tk. 62100 ha⁻¹) were higher at Kushtia.

Farmers of Mymensingh are happy in growing BARI Surjomukhi-3 due to its higher yield and an extra income generation. They also opined that it has an aesthetic value while flowers blooming. They are interested in cultivating for the next year if the seeds are available. In Kishoreganj, since sunflower cultivation was totally new in the haor area, farmers are highly appreciated to get a new variety and they pleased to observe the dwarf type and yield performance of BARI Surjomukhi-3. Farmers are facing problem to sell their produce. Besides sunflower opened new horizons of tourism in haor area but tourists break the flowers and hence sunflower farming in haor has come to a standstill. In Kushtia, farmers were very much impressed of BARI Surjamukhi-3 due to its short height, uniform big head and higher seed yield. They preserved their seeds and will go for cultivation in the next year. They sold BARI Surjamukhi-3 seeds among the neighboring farmers and they were also happy and interested to cultivate in the next year.

Table 1. yield attributes, Cost and return of BARI Surjomukhi-3 at Mymensingh, Kishoreganj and Kushtia during 2023-2024

Locations	Area covered (decimal)	Sowing date	Harvesting date	Seed yield (kg ha ⁻¹)	Gross return (Tk ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)
Mymensingh	20	19 Dec. 2023	22 March 2024	1170	117000	64700	52300
Kishoreganj	300	19 Dec. 2023	30 March 2024	1240	78120	42680	35440
Kushtia	80	09 November	23 February 2024	1900	142500	80400	62100
Avg.				1436			

Price of input and output: Selling price at Mymensingh: 100 Tk kg⁻¹, Kishoreganj: 63 Tk kg⁻¹, Kushtia: 75 Tk kg⁻¹

Crop Management and Climate Change

184. YIELD PREDICTION OF LENTIL BY LINKING CROP CUTS WITH PHENOLOGY ANALYSIS OF SENTINEL-2 TIME SERIES

TASLIMA ZAHAN, ISTIAK AHMED, MD. SHAKHAWAT HOSSAIN AND APURBO K. CHAKI

Abstract

A study was conducted for two consecutive years (2021-22 and 2022-23) to predict the yield of lentil at Godagari Upazila of Barind, Rajshahi. The sample data was collected from 117 farmer fields in 2021-22 and 203 farmer fields in 2022-23 by the survey using the Kobo Toolbox to get information on cultivated lentil variety, planting and harvest time, and yield. Optical satellite data of Sentinel-2 were collected from October to April during 2021-2022 and 2022-2023. These satellite data were processed and analyzed, and different vegetation indices viz. NDVI, EVI, and NDWI were calculated. The study revealed that BARI masur-8 was mostly grown by farmers. Using satellite-derived maximum NDVI and EVI were used to develop a model for yield prediction of lentils. However, a limited number of data was collected and analyzed, a best-performing model was tried to identify to predict the yield. The study noticed that the linear regression model predicted yield by 17-24% whereas the support vector model performed well during 2021-22 and the ensemble model performed well in 2022-23. This study will continue to improve the model through following other advanced techniques.

Introduction

Lentil (*Lens culinaris* L.) is an annual legume of the family Fabaceae. This pulse crop is a good source of protein; therefore, it is an important crop considering its food value and economic value. The production of lentils or any other crop is highly related to its vegetative growth. Nowadays, the phenology and growth of crops can be monitored from satellite imagery. The satellite-derived Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) are good indicators of vegetation greenness and activity (Peng et al, 2010; Cunha and Silva, 2020). It would be a good opportunity to use NDVI and EVI to understand lentils' phenology from satellite and monitor their growth. Besides this, lentil yield can also be predicted using satellite imagery early before harvest. The use of satellite remote sensing has become an effective way of making yield predictions due to its advantages of simple data acquisition, low cost, efficiency, wide spatial coverage, and short operating cycles (Peng et al. 2014; Zhang et al. 2019; Wang et al. 2020). The traditional agricultural yield forecasting methods mainly include agronomic forecasting methods (Feng and Wu, 2006), crop-growth models (Thorp et al, 2008), and meteorological statistics methods (Betbeder et al, 2016), and these are used to establish crop yield models based on different perspectives. These methods not only consume a lot of manpower and material resources; however, there are also spatial and temporal gaps in the results. Vegetation indices like NDVI and EVI have been widely used to predict crop yields over the past few decades (Jin et al, 2017; Kamir et al, 2020). However, these vegetation indices mainly reflect the greenness of vegetation and cannot fully capture environmental stresses on crops (Zhang et al, 2021). This means that the role of other vegetation indices such as the Normalized Difference Water Index (NDWI) (Gao, 1996), which reflects the crop water content, and the Red Edge Position Index (REP), which is sensitive to changes in chlorophyll concentration, should also be considered when making yield estimates.

The traditional method of estimating yields is the construction of linear regression models linking vegetation indices or climatic variables that track the evolution of crop canopy spectral reflectance patterns over the growing season and yields (He and He, 2013). However, although the calculations may be simple, the relationships involved are not simply linear, and these methods do not capture yield variations well. In the last few years, with the advent of the big data era, conditions have been created for machine-learning methods (Zhang et al, 2021), and more and more computer-dependent machine-learning models have been applied to crop yield estimation, usually outperforming traditional linear regression. Deep learning is an advanced

Machine Learning method that uses multiple, stacked nonlinear layers, at each of which the original input data can be transformed into a higher and more abstract representation (Cai et al, 2019), such as Long Short-Term Memory (LSTM), deep Neural Network (DNN), Convolutional Neural Network (CNN), and Recurrent Neural Network (RNN), have produced higher accuracies across various regression and classification tasks (LeCun et al, 2015). Therefore, a study was designed with two research questions: (1) is it possible to identify and monitor the phenology of lentils from Sentinel-2 imagery using machine learning algorithms and TIMESAT software, and (2) whether a model could be developed using machine learning techniques to predict the yield of lentil early before harvest.

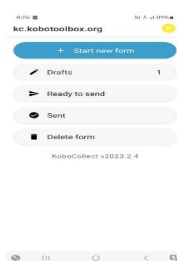
Materials and Methods

Study area: The study was conducted consecutive two years (2021-22 and 2022-23) at Godagari upazila of Rajshahi district covering the area under 24° 3954' to 24° 6155' N latitude and 88° 40052' to 88° 48854' E longitude during 2021-22 and 24° 38727' to 24° 43508' N latitude and 88° 39751' to 88° 47789' E longitude during 2022-23.

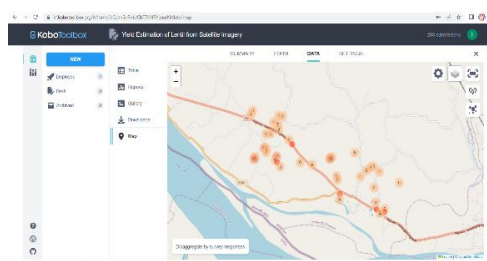
Data collection: This study obtained lentil data from plot-based manual surveys (Sun et al, 2020). The data on variety, soil type, planting, maturity and harvest dates, and yield of lentils were collected from the fields of 117 farmers in 2021-22 and 203 farmers in 202-23 with GPS coordinates using the Kobo Toolbox.



Sample data collection from lentil fields by Kobo Toolbox installed in the mobile



Interface of Kobo Toolbox



View of the positions of the collected sample data in Kobo Toolbox

The sample data were collected by the Scientific assistants of OFRD, Barind, Rajshahi. The App of Kobo Toolbox was installed in their mobiles and their access was permitted to the lentil project having the pre-set questionnaire form. One lentil field is considered as one sample data point. After filling up information in the questionnaire form, all forms were submitted and the forms with the information were automatically saved in the server of Kobo Toolbox. From the server, the data were downloaded in an Excel file.

Data checking and pre-processing: After getting data into an Excel file, the data quality was checked at first following some techniques like visually checking data distribution or plotting the dataset in Box-plots. Then the abnormal or outlier data points were cleaned and again checked in QGIS. The data positions were corrected after checking in QGIS to minimize the error in getting EVI values. Then, the final corrected data was saved for final processing.

Data processing: The collected sample data were processed to get the phenology of lentils from satellite-derived EVI using Sentinel-2 time-series data and to develop a model for yield prediction. The multispectral data of Sentinel-2 imageries were extracted from the COPERNICUS/S2 hub. The Level-2 (atmospherically corrected) multispectral broadband and narrowband data were acquired for each collected sample data point at 5-day intervals and at 10 m resolution using Python codes in Google Earth Engine (GEE). The codes were run for two years separately in the GEE. For 2021-22, the number of collected Sentinel-2 images was 53 considering the period from 15 October 2021 to 31 March 2022. The image number was 59 from 15 October 2022 to 31 March 2023. The reflectance values of NIR, RED, and BLUE bands were considered to calculate the

normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) at each sample point separately for the two years using the following equations.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$EVI = 2.5 \times \frac{NIR - RED}{1 + NIR + 6 \times RED - 7.5 \times BLUE}$$

Train and test models using Machine learning: Based on the relation of maximum NDVI ($NDVI_{max}$) and EVI (EVI_{max}) with yield, six machine learning models named Linear model (LM), RandomForest (RF) model, Support vector model (SVM), Gradient boost model, Artificial Neural Network, and the ensemble of RF, SVM, and Gradient boost models were run. Those models were trained and tested with $NDVI_{max}$, EVI_{max} , and yield data at 80% and 20% ratios. The performance of the machine learning models was tested based on root mean square error (RMSE). Data were checked and cleaned again to improve the model. Lastly, we considered 105 cleaned data from 2021-22 and 159 data from 2022-23 for developing a good model for yield prediction.

Results and discussion

Variety: The study found that the farmers of Godagari, Rajshahi grew mostly BARI lentil varieties (78% in 2021-22 and 92% in 2022-23). Among BARI lentil varieties, BARI masur-8 was cultivated by most of the farmers (Table 1).

Table 1: Cultivated lentil varieties with planting and harvest time in Godagari, Rajshahi during 2021-22 and 2022-23

Variety		Percentage of cultivation		Planting time	Harvest time
		2021-22	2022-23		
BARI variety	BARI masur-3	23	4.5	10 Nov' to 08 Dec' 2021 05 Nov' to 10 Dec' 2022	27 Feb' to 20 Mar' 2022 26 Feb' to 20 Mar' 2023
	BARI masur-6	12	3.5	09 Nov' to 07 Dec' 2021 28 Nov' to 04 Dec' 2022	26 Feb' to 20 Mar' 2022 06 to 17 Mar' 2023
	BARI masur-7	10	-	15 Nov' to 04 Dec' 2021 -	08 to 21 Mar' 2022 -
	BARI masur-8	33	92	12 Nov' to 08 Dec' 2021 13 Nov' to 08 Dec' 2022	08 to 20 Mar' 2022 27 Feb' to 21 Mar' 2023
		78	100		
Others		22	-	15 Nov' to 09 Dec' 2021	20 Feb' to 17 Mar' 2022

Planting and harvest date: Planting of all lentil varieties started from the 2nd week of November and continued up to the 2nd week of December. The harvest of the varieties was completed within 21 March (Table 1).

Maximum NDVI, and EVI, and their relation with yield of lentil: Before cleaning the data, the maximum NDVI values ranged from 0.341 to 0.828 in 2021-22 and 0.138 to 0.689 in 2022-23, the maximum EVI values ranged from 0.191 to 0.622 in 2021-22 and 0.116 to 0.715 in 2022-23, and the yields of lentils ranged from 0.54 to 2.52 t ha⁻¹ in 2021-22 and 0.56 to 2.40 t ha⁻¹ in 2022-23. After cleaning the data, the ranges of maximum NDVI values were 0.424 to 0.828 in 2021-22 and 0.343 to 0.674 in 2022-23, EVI values were 0.259 to 0.622 in 2021-22 and 0.256 to 0.685 in 2022-23, and the yields were 0.54 to 2.52 t ha⁻¹ in 2021-22 and 0.75 to 2.39 t ha⁻¹ in 2022-23.

The yield of lentils was strongly correlated with EVI_{max} (48% in 2021-22 and 37% in 2022-23) than $NDVI_{max}$ (40% in 2021-22 and 26% in 2022-23) (Table 2). The regression analysis results expressed that yields of lentils were highly dependent on EVI_{max} ($p < 1\%$ in 2021-22 and $p < 0.01\%$ in 2022-23) than $NDVI_{max}$ ($p = ns$ in 2021-22 and $p < 0.01$ in 2022-23) in both years (Table 3).

Table 2. Correlation matrix for NDVI_{max}, EVI_{max} and yield of lentil during 2021-22 and 2022-23

	Yield (t ha ⁻¹)	NDVI _{max}	EVI _{max}
Yield (t ha ⁻¹)	1		
NDVI _{max}	0.399 (2021-22); 0.279 (2022-23)	1	
EVI _{max}	0.475 (2021-22); 0.387 (2022-23)	0.687 (2021-22); 0.912 (2022-23)	1

Table 3. Linear regression model performance in 2021-22 and 2022-23

Independent variable	2021-22				2022-23			
	Default model		Improved model		Default model		Improved model	
	P-value	R ²	P-value	R ²	P-value	R ²	P-value	R ²
NDVI _{max}	0.423427	0.16	0.249536	0.24	0.000885	0.07	0.014445	0.17
EVI _{max}	0.026109		0.001852		0.000208		1.64E-05	

Performance of Linear regression model: The performance of the linear regression model was improved after cleaning the data. The results showed that the model was able to predict yield by 24% for 2021-22 and 17% for 2022-23 (Table 3). However, this model can be improved further, only needing a large number of datasets.

Performance of ML models: The best-performing machine learning model was the support vector model (SVM) in 2021-22 which could predict yield by 41% with the lowest RMSE (Table 4). On the contrary, the ensemble model performed well (28%) in 2022-23.

Table 4. Performance of machine learning models with RMSE

Sl. No.	Model	2021-22				2022-23			
		Default		Improved		Default		Improved	
		R ²	RMSE	R ²	RMSE	R ²	RMSE	R ²	RMSE
1.	Linear	-0.01	0.49	0.23	0.34	0.07	0.31	0.12	0.25
2.	SVM	0.02	0.50	0.41	0.31	0.08	0.30	-1.16	0.32
3.	Random Forest	-0.01	0.51	0.18	0.36	-0.04	0.32	-1.26	0.32
4.	Gradient Boosting	-0.02	0.51	0.002	0.40	-0.21	0.35	-1.55	0.34
5.	SGDRegressor	0.07	0.49	0.28	0.34	0.01	0.32	-0.17	0.23
6.	MLPRegressor (ANN)	0.03	0.50	0.17	0.37	-0.18	0.34	-0.86	0.29
7.	Ensemble	-0.22	0.56	-0.16	0.43	0.01	0.32	0.28	0.19

Conclusion

The study identified that farmers of Godagari, Rajshahi mostly grow BARI masur-8. The yield of lentils highly depended on the maximum EVI rather than the maximum NDVI. However, other indices that could be more responsible for yield prediction must be studied. Linear regression model could predict lentil yield by 17-24%. The best-performing machine learning model for 2021-22 was the support vector model (SVM) and the ensemble model performed best during 2022-23. The study should continue with blending other satellite imagery data to remove data gaps and to get the best model for yield prediction of lentils.

185. YIELD PREDICTION OF MUSTARD BY LINKING CROP CUTS WITH PHENOLOGICAL ANALYSIS OF SENTINEL-2 TIME SERIES AND MACHINE LEARNING TECHNOLOGIES

TASLIMA ZAHAN, APURBO K. CHAKI, AND MD. SHAKHAWAT HOSSAIN

Abstract

A study was conducted to predict the yield of mustard at Godagari Upazila of Barind, Rajshahi during 2023-2024. The sample data was collected by on-field survey at 321 farmer fields using the Kobo Toolbox to get information on cultivated mustard variety, planting and harvest time, and yield. Optical satellite data of Sentinel-2 were extracted and processed for analysis and different vegetation indices were calculated. The study used maximum NDVI and EVI to develop a model for yield prediction of mustard using machine learning techniques. Among the models, the SGD and Linear models predicted yield by 21% and 20% respectively with the default datasets. After cleaning the datasets, the performance of most of the models was improved and the GB model was the best model that predicted yield by 28%. RF model was able to predict mustard yield by 24%. The performance of these models can be improved further by considering or blending other satellite time series data to remove the data gap. In the future, research could be done to develop a robust yield prediction model for mustard for a diversified environment by blending Landsat-8 imageries with Sentinel-2.

Introduction

Mustard (*Brassica* spp.) is the most important oilseed crop in Bangladesh. About 8.22 million metric tonnes of mustard were grown from 6.10 lakh hectares of land during 2021-2022 (BBS, 2023). The production is increasing nowadays than the earlier years due to the availability of high yielding short duration mustard varieties. Bangladesh Agricultural Research Institute (BARI) has developed some high yield potential mustard varieties like BARI sarisha-14, BARI sarisha-16, BARI sarisha-17, BARI sarisha-18 and the latest BARI sarisha-20. Now, the government of Bangladesh is also giving priority to boosting mustard production and is taking several initiatives to improve the annual national production. The record system in the national statistics for any crops is laborious, time-consuming, and sometimes unreliable. The national statistics of only 06 major crops like 03 rice crops (aus, aman, and boro), wheat, potato, and jute are recorded from the 'crop-cuts' following a tedious and time-consuming technique. Moreover, mustard is not enlisted crop for 'crop-cut'. Therefore, the statistical data collection procedure for mustard is very complex and not that much reliable.

Nowadays, in the era of 4th industrial revolution (4IR), we are using remote sensing satellite data to monitor crop growth and phenology (Karmakar et al., 2023; Wang et al., 2022). Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. Satellite crop monitoring is the technology which facilitates real-time crop vegetation index monitoring via spectral analysis of high resolution satellite images for different fields (Pickering et al., 2021; Sishodia et al., 2020) and crops which enables to track positive and negative dynamics of crop development (Galient et al., 2021). Therefore, it is now time-demanding that the growth, yield and area coverage of important crops like mustard could be assess using the advanced technologies like GIS, remote sensing, or machine learning techniques. Importantly, it is also required to predict the yield of BARI released mustard varieties early before harvest that would be helpful for the policy makers to estimate total annual production and the amount of export-import in advance.

There are so many satellites which are collecting and providing images of each and every corner of the world at a specific time interval. Sentinel-2 is an earth observation mission from Copernicus Programme that acquires optical imagery at high spatial resolution (10 m to 60 m) over the land at high temporal resolution (5 day intervals). At the beginning, optical images captured primarily at visible and certain bands of near-infrared (NIR) range of the electro-magnetic spectrum were the only remote sensing data source for various agricultural applications (Cheng and han, 2016). Later on, continuous advancement of the sensor technologies and more efficient computing

devices to process huge amount of data, the availability of remote sensing data such as multispectral, hyperspectral, RADAR, LiDAR, and thermal images are provided diversified information. The multispectral broadband and narrowband of Sentinel-2 images helps us to calculate various vegetation indices considering different property variations that influence the crop growth. Among different vegetation indices, normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) are most commonly used to assess the crop health and vegetation. NDVI and EVI time series are very useful to identify the crop growth process. By considering and comparing the calculated NDVI or EVI values of a particular area for a particular time range in the past year and similarly in the current year, the differences in the growth can be monitored. Similarly, we can consider a particular season and the values with less vegetation than it should be, then it means that the area needs more concern.

Many literatures reported that there is a significant relation between crop yield and vegetation indices, especially NDVI and EVI (Jhajharia and Mathur, 2023; Bolton and Friedl, 2013; Mkhabela et al., 2011; Doraiswamy et al., 2005). Therefore, it would be a great initiative if we can develop a model to estimate mustard yield based on NDVI or EVI and this model will help us to predict mustard yield every year earlier before harvest. However, crop yield prediction is one of the challenging problem in precision agriculture, and many crop simulation models have been developed and validated so far (Thorp et al. 2008). These models require several datasets since crop yield depends on many different factors such as soil, climate, variety, date of planting, and so on (Xu et al., 2019) and consist of several complicated steps to predict yield. After all, these crop prediction models can estimate the actual yield reasonably, but a better performance in yield prediction is still desirable (Filippi et al., 2019). Machine learning (ML), which is a branch of artificial intelligence (AI) focusing on learning, is a practical approach that can provide better yield prediction based on several features. ML can determine patterns and correlations and discover knowledge from datasets. The ML models need to be trained using datasets, where the outcomes are represented based on previous experience. The predictive model is built using several features, and such as, parameters of the models are determined by historical data during the training phase. For the testing phase, part of the historical data that has not been used for the training is used for performance evaluation purposes. Till now, several machine learning models have been used to predict yields of so many crops (Sun et al., 2020; Sun et al., 2019; Villanueva et al., 2018; Witten et al., 2016); however, the methodology and techniques might be different. Therefore, this project was planned and conducted with the objectives of developing a yield predictive model for mustard from Sentinel-2 satellite-based NDVI and EVI time series datasets and to identify a best-fitted yield predictive machine learning model linking with the phenology and yield of mustard. It is expected that this project output will be beneficial for the mustard farmers and policymakers of Bangladesh in the future.

Materials and Methods

The study was divided into two parts viz. (1) real-time mustard field data collection through plot-based survey and (2) data processing, analysis, and model development for mustard yield prediction. The plot-based real-time data of mustard were collected from the fields of Godagari upazila at Rajshahi district during the mustard growing period (October 2023 to March 2024). The area covered for data collection was 24° 36'22" to 24° 55'06" N latitude and 88° 33'09.3" to 88° 66'10.2" E longitude.

Research Part-1

Data collection: The plot-based manual surveys were done to collect data of mustard following Sun et al., 2020. A software was used to collect mustard data named Kobo Toolbox (Fig. 1). Kobo Toolbox is an intuitive, powerful, and reliable software and a free toolkit for collecting, analysing, and managing data for surveys, monitoring, evaluation, and research from field to computer (Fig. 2). A form was generated in the Kobo Toolbox before starting the survey. The data on variety, soil type, planting, maturity and harvest dates, and yield of mustard were collected from the fields of

321 farmers using the Kobo Toolbox (Fig. 3) with the GPS coordinates of each farmer field. The yield of mustard was recorded in kg per hectare.



Fig. 1. Sample data collection from mustard fields by Kobo Toolbox installed in the mobile

The App of Kobo Toolbox was installed in their mobiles and their access was permitted to the pre-generated mustard project in the Kobo Toolbox having the pre-set questionnaire form. One mustard field was considered as one sample data point (Fig. 3). The sample data were collected and information filled in the questionnaire by the Scientific assistants of OFRD, BARI, Barind, Rajshahi and some Sub-Assistant Agricultural Officers (SAAO) of Department of Agricultural Extension, Rajshahi. After filling up information in the questionnaire form, all forms were submitted and the forms with the information were automatically saved in the server of Kobo Toolbox. From the server, the data were downloaded in an Excel file.

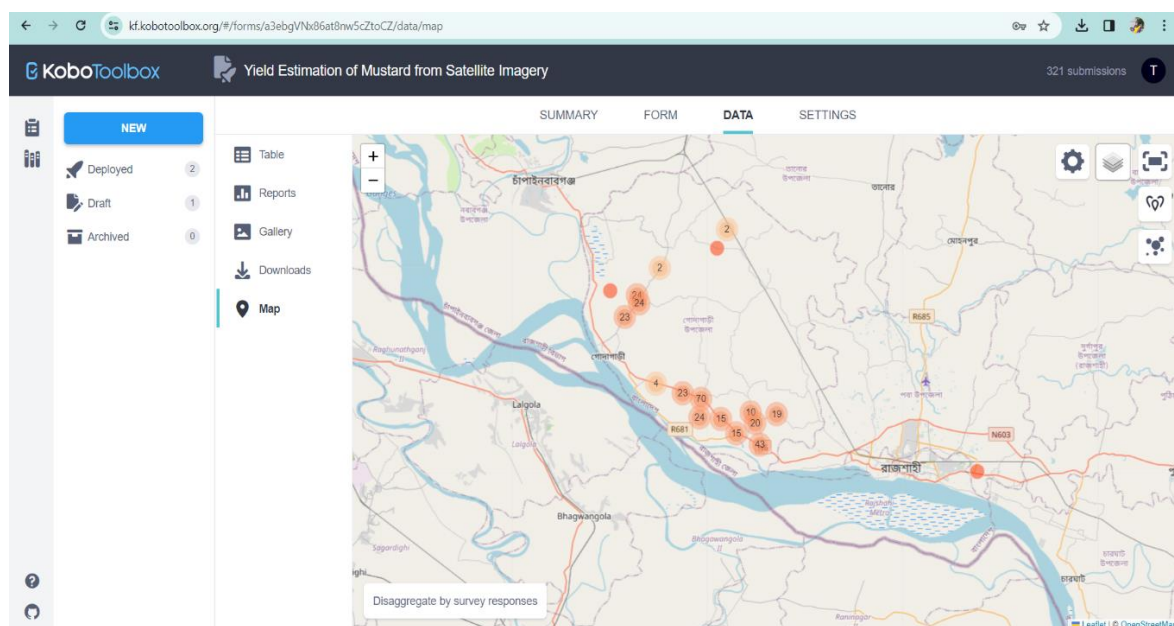


Fig. 3. View of the sample data collection points at the mustard fields of Godagari upazila, Rajshahi using Kobo Toolbox during 2023-2024

Research Part-2

The activities, steps and techniques of data processing, analysis, and model development for mustard yield prediction were presented below.

Data checking and pre-processing: After getting data from Kobo Toolbox into an Excel file format, the data quality was checked at first following some techniques like visually checking data distribution or plotting the dataset in Box-plots. Then the abnormal or outlier data points were cleaned and again checked in QGIS. The data positions were corrected after checking in QGIS to minimize the error in getting normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) values. After data checking and correction in QGIS, new coordinate columns were created in the attribute table and saved as CSV file for final processing.

Data processing: The collected sample data were processed to get the phenology of mustard from satellite-derived NDVI and EVI using Sentinel-2 time-series data. The multispectral data of Sentinel-2 imageries were extracted from the COPERNICUS/S2 hub. The Level-2 (atmospherically corrected) multispectral broadband and narrowband data were acquired for each collected sample data point at 5-day intervals and at 10 m resolution using Python codes in Google Earth Engine (GEE). GEE helps to combine a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. GEE is used to detect changes, map trends, and quantity differences on the earth's surface. Data processing was done with the python codes in the Google colab platform. Using this platform, 55 Sentinel-2 images were collected during the mustard growing period (15 October 2023 to 15 March 2024). The reflectance values of NIR, RED, and BLUE bands were considered to calculate the normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) at each sample point for the study year.

Data cleaning: The data were cleaned by removing the outliers before processing and calculating NDVI and EVI. After getting NDVI and EVI time series values, the data were checked again to remove the anomalies. Then, the correlations of mustard yields with NDVI maximum (NDVI_{max}) and EVI maximum (EVI_{max}) values were done and analysed. Based on the correlation matrix results, the outliers were tried to identify and clean the data to improve the accuracy of the models considering 299 sample data points.

Train and test models using Machine learning: Based on the relation of maximum NDVI (NDVI_{max}) and EVI (EVI_{max}) with yield, eight machine learning models named Linear model (LM), Random forest (RF) regressor model, Support vector machine regressor (SVM) model, Gradient boosting (GB) regressor model, Stochastic Gradient Descent (SGD), Multi-Layer perceptrons (MLP) regressor, the ensemble of RF, SVM, GB, SGD, and MLP models and voting regression (VR) model were run. RF utilizes multiple decision trees for integrated learning, and by randomly selecting features and samples. This model can effectively handle high-dimensional data and large number of samples, and is robust to missing data and noise. SVM has efficient generalization ability and robustness to noise, by effectively finding the best hyperplane to fit the data, can handle complex non-linear relationships in high-dimensional space, and is suitable for both small samples and non-linear data. GB trains weak classifiers iteratively and adjust the sample weights in each iteration to progressively improve the performance of the model, and performs well in dealing with non-linear relationships and data noise. SGD is a powerful optimizing algorithm and it is a variant of the gradient descent algorithm that processes training data in small batches or individual data points instead of the entire dataset at once. MLP is the name of a modern feedforward artificial neural network, consisting of fully connected neurons with nonlinear activation function, organized in at least three layers, notable for being able to distinguish data that is not linearly separable. machine learning Ensemble learning strategy is utilized to combine the prediction results of multiple models to improve the overall performance, where a single model is prone to overfitting or underfitting, integrated learning can reduce this risk by combining the strengths of multiple models to improve the generalization ability of the models (Ju *et al.*, 2023). All the models were trained and tested with NDVI_{max}, EVI_{max}, and yield data at the ratio of 8:2 (256:65).

Evaluation of model accuracy: The performance of the machine learning models was tested based on coefficient of determination (R^2), root mean square error (RMSE) and relative prediction deviation (RPD). The closer the value of R^2 of the determination coefficient is to 1, the stronger the model's ability to fit the data, and its calculation is shown in formula (1). The smaller the RMSE

value is, the smaller the prediction error of the model is. The calculation of RMSE is shown in formula (2). The value of RPD is also a key indicator, when the RPD is less than 1.4, the model is considered to lack predictive ability; between 1.4 and 2.0, the model has estimation ability; and when the RPD is greater than 2.0, it indicates that the model has an excellent predictive ability, which is computed as shown in formula (3).

$$R^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2} \dots\dots\dots (1)$$

$$RMES = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n}} \dots\dots\dots (2)$$

$$RPD = \frac{SD}{RMSE} \times \sqrt{\frac{n}{n-1}} \dots\dots\dots (3)$$

Results and Discussion

Variety: The study identified that the farmers of Godagari, Rajshahi grew 10 varieties of mustard named BARI Sarisha-9, BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-17, BARI Sarisha-18, BINA Sarisha-9, BINA Sarisha-11, Tori-7 and a local variety (Rai Sarisha) during 2023-2024 (Fig. 4). Among those varieties, farmers grew mostly BARI Sarisha-14 (59.8%). The second mostly grown mustard variety was the local Rai Sarisha (16.8%). The chronological order of other mustard varieties based the percentage of cultivation was BARI Sarisha-18 > Tori-7 > BARI Sarisha-9 > BINA Sarisha-9 > BARI Sarisha-17 > BINA Sarisha-11 > BARI Sarisha-11 = BARI Sarisha-15.

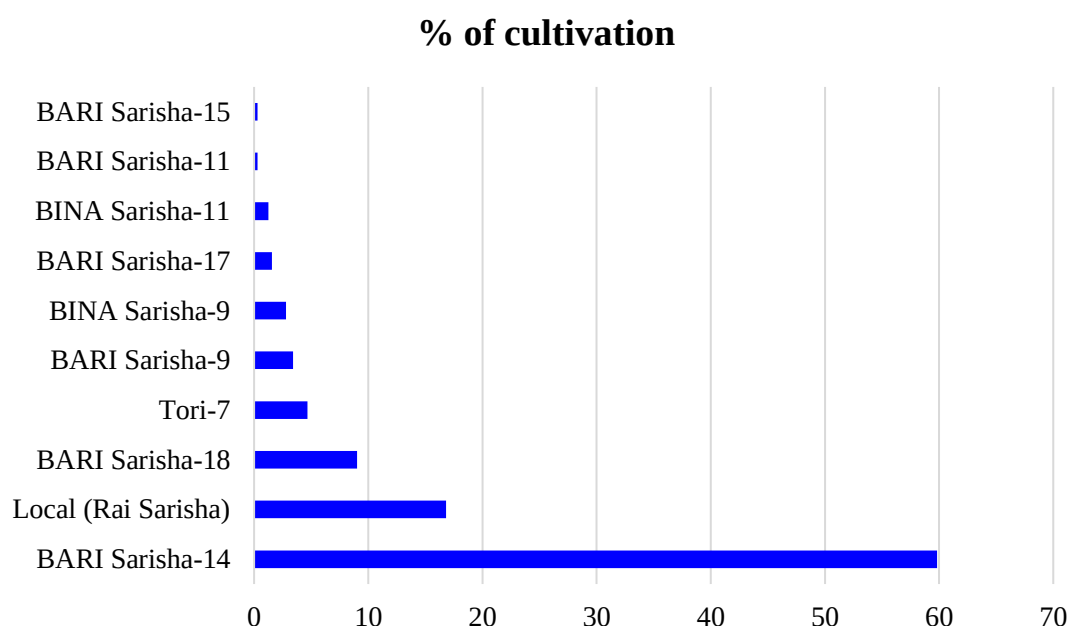


Fig. 4. Percentage of the cultivated mustard varieties in Godagari upazila of Rajshahi district during 2023-2024

Planting and harvest date: The date of planting and harvesting of mustard varies with the varieties (Table 1). The planting of most of the mustard varieties like BARI Sarisha-9, BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-18, Rai Sarisha started from the 2nd week of October and continue up to November and in some cases up to December. BARI Sarisha-11, BARI Sarisha-15, BINA Sarisha-9, and BINA Sarisha-11 were planted during mid to the end of November. All the varieties were harvested within February or in the 1st week of March.

Table 1. The dates of planting and harvest, and yield ranges of mustard varieties in Godagari, Rajshahi during 2023-2024

Mustard variety	Planting date	Date of harvest	Yield range (kg ha ⁻¹)
BARI Sarisha-9	20 Oct' to 03 Dec' 2023	17 Feb' to 03 Mar' 2024	938 to 1200
BARI Sarisha-11	23 Nov' 2023	16 Mar' 2024	1200
BARI Sarisha-14	19 Oct' to 14 Dec' 2023	18 Jan' to 29 Feb' 2024	750-1800
BARI Sarisha-15	30 Nov' 2023	29 Feb' 2024	1800
BARI Sarisha-17	10 Oct' to 14 Nov' 2023	15 Jan' to 20 Feb' 2024	900-1950
BARI Sarisha-18	20 Oct' to 20 Nov' 2023	03 Feb' to 11 Mar' 2024	1200 to 2100
BINA Sarisha-9	02 to 20 Nov' 2023	10 to 27 Feb' 2024	750 to 1950
BINA Sarisha-11	15 to 27 Nov' 2023	08 to 24 Feb' 2024	1500 to 2100
Tori-7	15 to 22 Nov' 2023	10 to 24 Feb' 2024	750 to 1200
Rai Sarisha	18 Oct' to 23 Nov' 2023	04 Feb' to 05 Mar' 2024	750 to 2100

Yield: The study observed that the yields of mustard varieties varied within a wide range (Table 1). The variation might be related to the variation within the field conditions or the management. The highest yield range was recorded from BINA Sarisha-11 (1500-2100 kg ha⁻¹) and then from BARI Sarisha-18 (1200-2100 kg ha⁻¹). The mostly grown variety BARI Sarisha-14 provided yields from 750 to 1800 kg ha⁻¹ and this could be happened due to variation in planting time. Farmers planted BARI Sarisha-14 from mid-October to mid-December which might have an effect on yield variability.

Maximum NDVI, and EVI, and their relation with yield of lentil: The study obtained NDVI and EVI values for each date points at 5 day intervals started from 16 October 2023. Therefore, the growth of mustard varieties was monitored from these NDVI and EVI time series values. However, the yield is mostly correlated with the maximum NDVI and EVI value. The maximum NDVI values ranged from 0.285 to 0.668 and the maximum EVI values ranged from 0.210 to 0.653.

The correlation between yield, NDVI maximum (NDVI_{max}) and maximum EVI (EVI_{max}) was also observed (Table 2). The correlation matrix showed that yield is more correlated with EVI_{max} than the NDVI_{max}. Yield of mustard was correlated with EVI_{max} by 46%. The linear regression analysis results expressed that yields of mustard were highly dependent ($p < 0.01\%$) on EVI_{max} and NDVI_{max} (Table 3).

Table 2. Correlation matrix for NDVI_{max}, EVI_{max} and yield of mustard during 2023-24

Matrix	Yield	NDVI _{max}	EVI _{max}
Yield	1		
NDVI _{max}	0.39	1	
EVI _{max}	0.46	0.96	1

Performance of Linear regression model: The performance of the linear regression model was improved after cleaning the data. The results showed that the model was able to predict yield by 16% depending on NDVI_{max} and 21% depending on EVI_{max} (Table 3).

Table 3. Performance of linear regression model for mustard during 2023-2024

Independent variable	Mustard yield			
	Default model		Improved model	
	P-value	R ²	P-value	R ²
NDVI _{max}	5.61E-12	0.14	3.82E-13	0.16
EVI _{max}	3.3E-17	0.20	7.89E-18	0.21

Performance of ML models: The performance of 10 machine learning (ML) models were evaluated (Table 4). Before cleaning the datasets, SGD regressor model predicted mustard yield by 21% and RF model predicted 20%. After cleaning the datasets, the performance of the models was improved. The best-performing machine learning model was the Gradient Boosting Regressor

model (GB) which predicted yield by 28% with the lowest RMSE and the highest relative prediction deviation (RPD). The RF model also performed well that predicted yield by 24%. On the contrary, the MLP regressor (ANN) model performed very poor to predict yield of mustard.

Table 4. Performance of machine learning models with RMSE

Sl. No.	Model	Default			Improved		
		R ²	RMSE	RPD	R ²	RMSE	RPD
1.	Linear	0.20	337.20	1.13	0.18	308.22	1.11
2.	Random Forest Regressor	0.10	359.57	1.06	0.24	299.39	1.15
3.	Support Vector Machine	0.01	376.95	1.01	0.03	334.58	1.02
4.	Gradient Boosting Regressor	0.05	367.74	1.04	0.28	291.63	1.18
5.	SGDRegressor	0.21	337.07	1.13	0.20	304.93	1.12
6.	MLPRegressor (ANN)	-12.70	1399.02	0.27	-14.66	1344.53	0.26
7.	Ensemble	0.07	364.85	1.04	0.03	334.73	1.02
8.	Voting Regression	0.03	371.85	1.03	0.15	313.89	1.09

Conclusion

The study identified that farmers of Godagari, Rajshahi mostly grow BARI Sarisha-14. The yield of mustard highly depended on the maximum EVI rather than the maximum NDVI. However, some other indices that could be more responsible for yield prediction and need to be studied in future. Linear regression model could predict mustard yield by 21% based on maximum EVI. The best-performing machine learning model was Gradient Boosting regressor model and the Random Forest model. It would be better to blend Landsat-8 data in future to remove the time series data gap considering a large number of datasets and climate parameters for getting a robust yield prediction model for mustard.

186. TEMPORAL CHANGES IN CLIMATE, VEGETATION, AND WATER RECESSION PATTERN IN SYLHET-SUNAMGANJ REGION THROUGH OPTICAL REMOTE SENSING AND GIS

TASLIMA ZAHAN, ISTIAK AHMED AND APURBO K. CHAKI

Abstract

A study was taken to identify the temporal changes in climate, vegetation, and water recession patterns in Sylhet and Sunamganj districts during rabi season (October to March). The study considered 35 years of Bangladesh Meteorological Department data from 1985 to 2020 to detect the changes in maximum temperature, minimum temperature, and rainfall. The changes in vegetation was also evaluated during this period from Landsat satellite-derived vegetation indices like normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI). The study identified that optical remote sensing is useful for detecting the temporal changes in climate, vegetation, and water recession in Sylhet and Sunamganj districts. The study showed that temperatures are increasing compared to the earlier years and the amount of rainfall is also decreasing in the current years. The haor areas of Sunamganj are most covered by boro rice and farmers grow boro rice from January after the recession of water. Vegetation at most of the areas of Sunamganj are started from January because most of the areas get out of the water at that time. This study needs to continue to get more information to identify more cultivable lands for the Sylhet-Sunamganj region.

Introduction

In the past few decades, the global climate has undergone several unprecedented changes, and global warming has become an indisputable fact (Gao et al. 2022). A series of events triggered by climate change, such as temperature changes, precipitation fluctuations, and radiation changes, precipitation fluctuations, and radiation changes, have led to dramatic changes in vegetation

cover in many parts of the globe (Liu et al., 2021a; IPCC, 2022). Significant temperature increases lead to increased evapotranspiration, which may negatively affect vegetation growth, while the change in precipitation distribution pattern may lead to different degrees of vegetation degradation or increase in different areas (Liu et al., 2021b; Yang et al., 2022). Rainfall and temperature are the major factors that affect vegetation dynamics.

Vegetation is one of the most significant components of terrestrial ecosystems on Earth (Zhe and Zhang, 2021; Duveiller et al., 2018; Shen et al., 2016). Vegetation dynamics and its response to climate change are sensitive (Wang et al., 2015) and have been recognized as a core topic in global change research, especially since the satellite-derived Normalized Difference Vegetation Index (NDVI) was available (Piao et al., 2011; Myneni et al., 1997). Nowadays, optical remote sensing is a very useful technique to monitor the changes on Earth including climate, vegetation, and so on. Among the vegetation indices, NDVI and EVI are considered good indicators of vegetation greenness and activity (Guay et al., 2014).

Sylhet and Sunamganj are two northeastern districts of Bangladesh. These haor areas are considered as one of the hotspots of the country. These districts are the habitats of wetlands including rivers, streams, canals, large areas of seasonally flooded cultivated plains, and beels (BHWDB, 2012). In the Sunamganj district, 95 haors are found of which about 70% area has been turned into cultivated land recently. In this district, 2,695,495 people live among which 85% lives in rural areas mainly in haor areas and 32.3% of farmers follow the crop-poultry-agroforestry farming system (Ali et al., 2018). Boro-fallow-fallow, fallow-B. *aman* rice-fallow, and fallow-fallow-T. *aman* rice are the major cropping patterns practiced in this region.

In the haor areas of the Sylhet-Sunamganj region, it is a great challenge for the farmers to grow crops after the recession of water. In some years, it takes longer times for water recession and then farmers face lots of challenges for growing crops. Therefore, a study was conducted to detect the changes in climates, vegetation, and water recession patterns in the Sylhet-Sunamganj region using optical remote sensing and GIS techniques.

Materials and Methods

The study areas were the two north-eastern districts of Bangladesh named Sylhet (24.8949° N, 91.8687° E and elevation 22 m/72 feet) and Sunamganj (25.0667° N, 91.4072° E and elevation 14.42 m/47.31 feet). The climate data of maximum temperature, minimum temperature, and rainfall was collected from the weather station of Bangladesh Meteorology Department (BMD), Sylhet from 1985 to 2020. The optical satellite data of this study period was also extracted from Landsat-8 and processed. The study observed the water recession pattern and the changes in water extent only for Sunamganj district from October 2021 to April 2022. The changes in water extent and water recession pattern were done by processing of the extracted Sentinel-2 level-2A data using EASI_Bangladesh platform developed by Commonwealth Scientific Industries and Research Organizations (CSIRO).

Map preparation:

The following procedure has been followed for map preparation.

1. Making monthly averaged maximum and minimum temperatures and accumulated rainfall (mm) from daily maximum and minimum temperatures, and rainfall data (mm/day) (processed in MS Excel).
2. Calculating 5 yearly average of maximum and minimum temperatures and rainfall for each three (03) month of dry season (October-December and January-March) for the respective years. Such as October-December 1985 rainfall is representing average of October-December rainfall in preceding years (1981-1985) (processed in MS Excel).
3. All the monthly averaged maximum and minimum temperatures and accumulated rainfall (5 yearly average) are organized in columns as "Oct-Dec 1985", "Jan-Mar 1985", "Oct-Dec 1990", ..., "Oct-Dec 2020", "Jan-Mar 2020" in columns.

4. The 5 yearly average monthly averaged maximum and minimum temperatures and accumulated rainfall (mm) in the database is standardized (0 to 1) to make comparable all the rainfall maps in a homogeneous scale.
5. The database is imported ArcGIS environment and interpolated using “Kriging” interpolation tool based on “Ordinary Kriging” method and “Spherical Semivariogram” model.
6. Map layouts are generated in ArcGIS 10.8

NDVI and EVI Map Preparation:

NDVI and EVI maps were prepared using Google Earth Engine. Landsat-8 at 30-meter resolution imageries were used to derive the median NDVI and EVI image (October 1985-March 2020) of Sylhet and Sunamganj districts. The following procedures have been followed here:

1. Import district shapefiles of Sylhet and Sunamganj in GEE.
2. Import USGS Landsat 8 Level 2, Collection 2, Tier 1 images for Bangladesh by filtering cloud cover $\leq 5\%$ within the period of 2020-10-01 to 2021-03-31.
3. Apply scale factor based on Landsat metadata.
4. Calculate median image for the respective dry season of 2020-21 using the following bands: 'SR_B2','SR_B3','SR_B4','SR_B5','SR_B6','SR_B7'.
5. Calculate NDVI from the median image using the following formula:
 - a. $NDVI = ('SR\_B5' - 'SR\_B4') / ('SR\_B5' + 'SR\_B4')$
6. Export the derived image in 30-meter resolution and prepare a Map Layout in ArcGIS 10.8

Results and Discussion

Maximum and minimum temperature: The five-year averages of maximum temperatures and minimum temperatures of the Sylhet-Sunamganj region have been mapped from October 1985 to December 2020 and a significant temporal change was marked out (Fig. 1, Fig. 2, Fig. 3, and Fig. 4). The hottest years for whole Sylhet region considering October-December were 1996-2000, 2006-2010, 2011-2015 and 2016-2020 (Fig. 1). The maximum temperatures were average for most of the study years at Sunamganj. However, 2000 was the hottest year for half of the Sunamganj district.

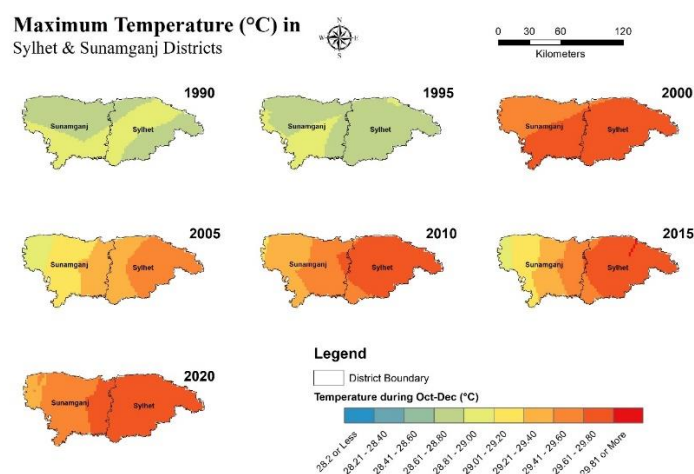


Fig. 1. Five-year averaged maximum temperature maps for Sylhet-Sunamganj region from October 1985 to December 2020

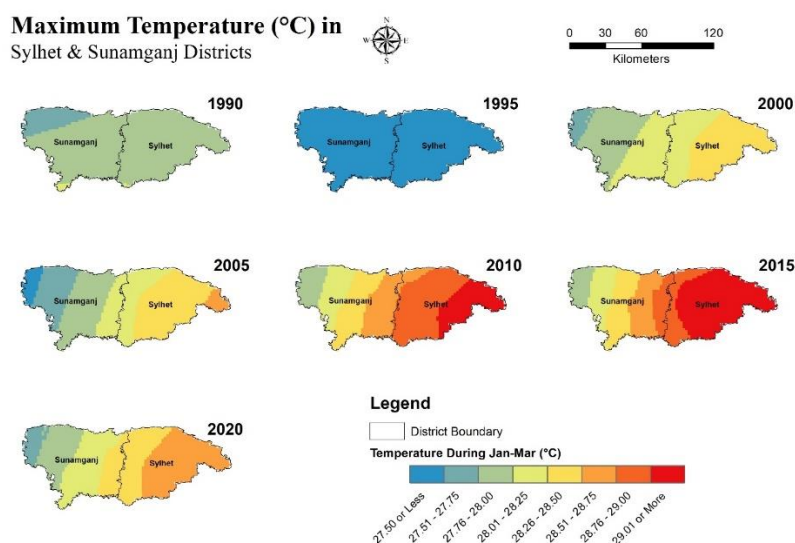


Fig. 2. Five-year averaged maximum temperature maps for Sylhet-Sunamganj region from January 1985 to March 2020

The maximum temperatures from January to March were mostly low below 28.75° C for Sylhet and Sunamganj (Fig. 2). However, 2006-2010 and 2016-2015 were warmer for some parts of the Sylhet region.

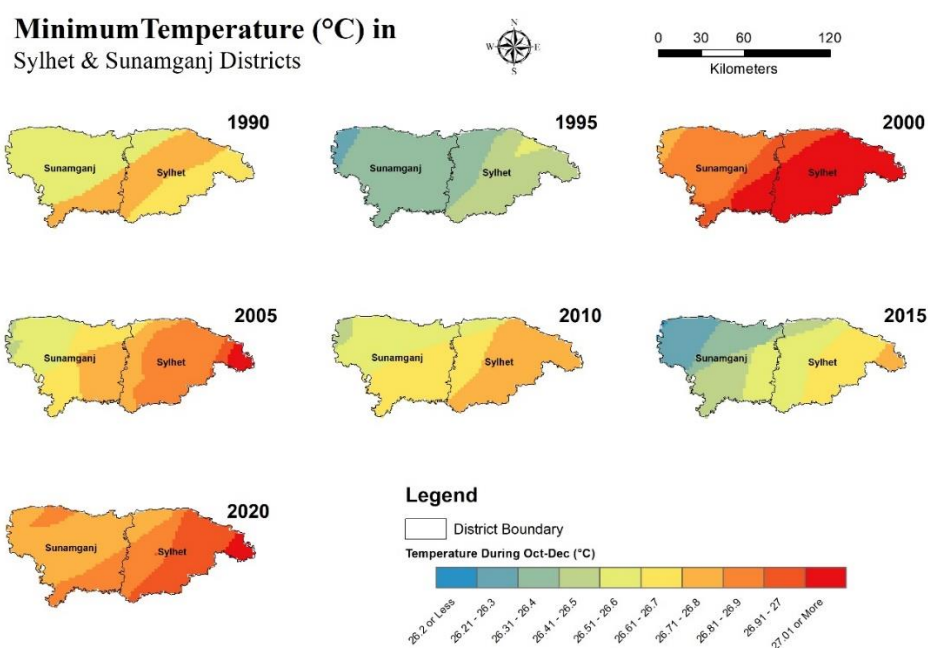


Fig. 3. Five-year averaged minimum temperature maps for Sylhet-Sunamganj region from October 1985 to December 2020

Considering minimum temperatures from October to December, the temperatures ranged from 25° to 27.5° C (Fig. 3) and 25.5° to 29.5°. The year 1996-2000 was the hottest year, and then 2016-2020 was warmer year. From January to March, the minimum temperatures were relatively high during 2006-2010 and 2011-2015 (Fig. 4).

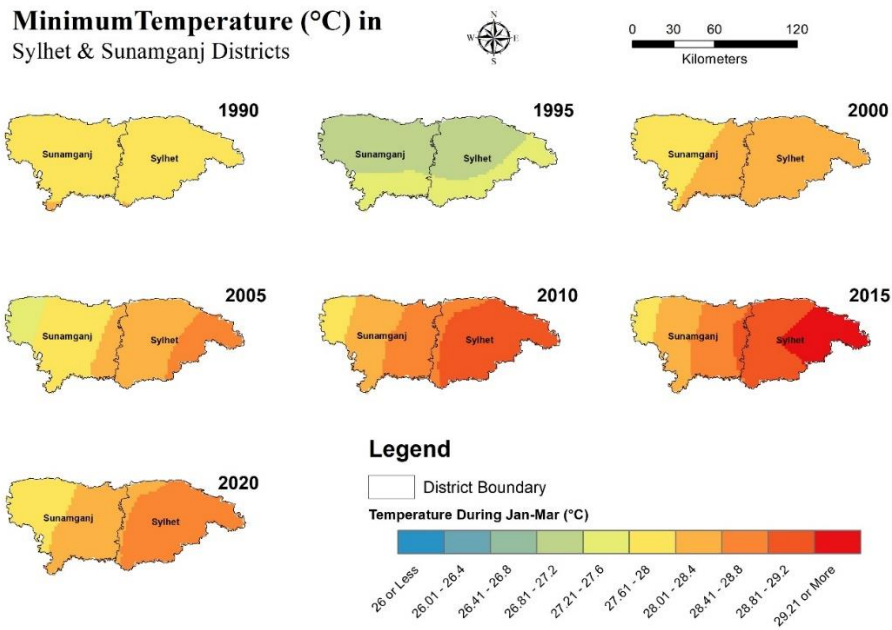


Fig. 4. Five-year averaged minimum temperature maps for Sylhet-Sunamganj region from January 1985 to March 2020

Total rainfall: The total rainfall ranged between 35 to 115 mm from October to December (Fig. 5) and 25 to 65 mm from January to March (Fig. 6).

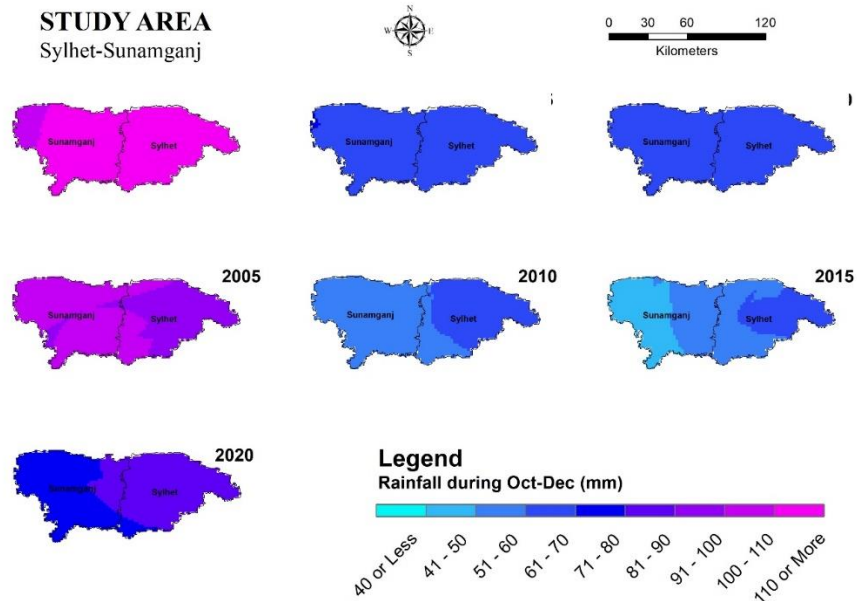


Fig. 5. Five-year averaged total rainfall maps for Sylhet-Sunamganj region from October 1985 to December 2020

Considering October to December, 1986-1990 was the years with high rainfall and the amount of rainfall became less during the next 10 years (1991-2000) (Fig. 5). Then the rainfall was increased during 2001-2005 and again the amount became less from 2006 to 2020.

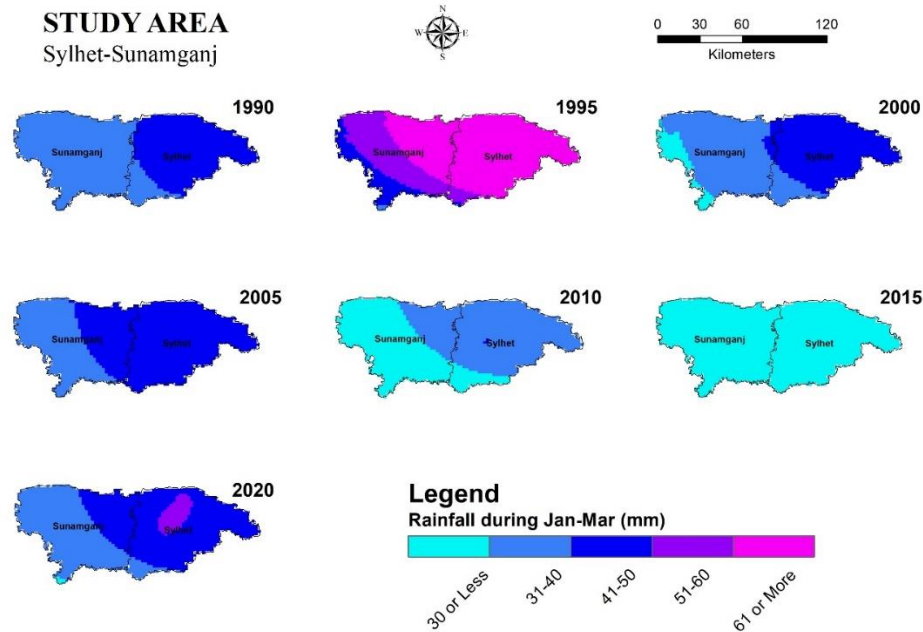


Fig. 6. Five-year averaged total rainfall maps for Sylhet-Sunamganj region from January 1985 to March 2020

Considering January to March, the year 2011-2015 was almost rain less for Sylhet-Sunamganj region (Fig. 6) and 1991-1995 was the year with little higher rainfall.

Vegetation intensity

NDVI: Considering NDVI from October to December, the western part of Sunamganj showed less or no vegetation (Fig. 7). The lowest vegetation was found in 1985-1990. The intensity of vegetation at Sylhet-Sunamganj region slightly increased from 1991-1995 and then again decreased up to 2001-2005. From 2006-2010, the intensity of vegetation started to increase again.

Considering NDVI from January to March, the vegetation was higher in Sunamganj district than in the Sylhet district (Fig. 8). Except the years of 1985-1990 and 2016-2020, the area of Sylhet district had almost no vegetation. These results indicate that almost all of the *rabi* crops in Sylhet district were harvested during March. On the other hand, the vegetation in Sunamganj was high from January to March and this result might be related to the cultivation of *boro* rice after the recession of water.

EVI: The maps of EVI expressed the similar results as NDVI (Fig. 9 and Fig. 10). Considering EVI from October to December, the western part of Sunamganj showed less or no vegetation (Fig. 9). The lowest vegetation was found in 1985-1990. The intensity of vegetation at Sylhet-Sunamganj region slightly increased from 1991-1995 and then again decreased up to 2001-2005. From 2006-2010, the intensity of vegetation started to increase again.

Considering EVI from January to March, the vegetation was higher in Sunamganj district than in the Sylhet district (Fig. 10). Except the years of 1985-1990 and 2016-2020, the area of Sylhet district had almost no vegetation.

Normalized Difference Vegetation Index (NDVI)
during October-December
Sylhet-Sunamganj District

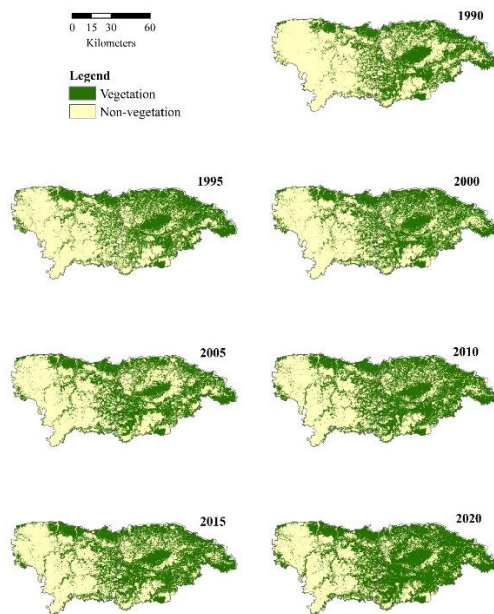


Fig. 7. Five-year averaged NDVI maps for Sylhet-Sunamganj region from October 1985 to December 2020

Normalized Difference Vegetation Index (NDVI)
during January-March
Sylhet-Sunamganj District

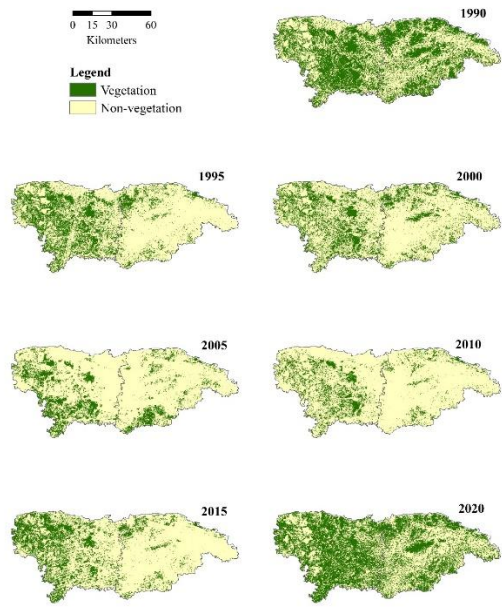


Fig. 8. Five-year averaged NDVI maps for Sylhet-Sunamganj region from January 1985 to March 2020

Enhanced Vegetation Index (EVI)
during October-December
Sylhet-Sunamganj District

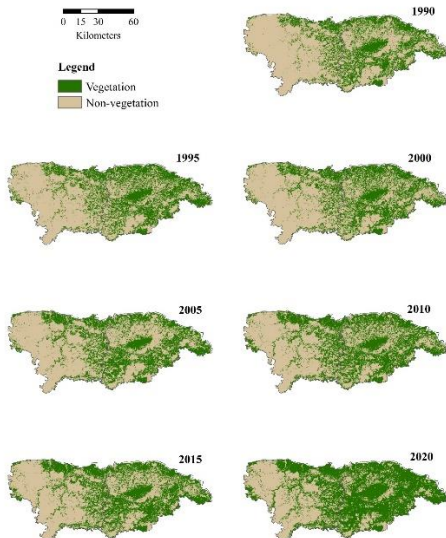


Fig. 9. Five-year averaged EVI maps for Sylhet-Sunamganj region from October 1985 to December 2020

Enhanced Vegetation Index (EVI)
during January-March
Sylhet-Sunamganj District

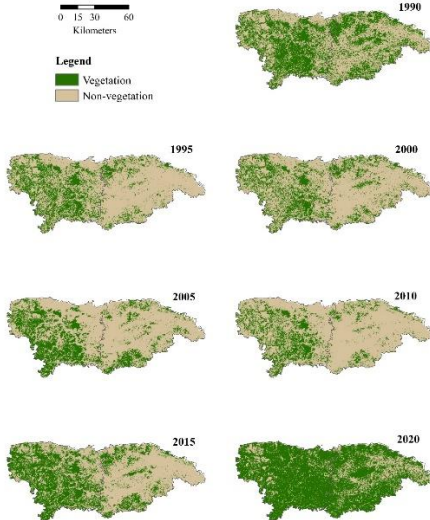


Fig. 10. Five-year averaged EVI maps for Sylhet-Sunamganj region from January 1985 to March 2020

Water Recession Pattern: The study identified the changes in water extent at Sunamganj district from October 2021 to April 2022 (Fig. 11). The area under permanent water was 143.08 km². The area under water recession was 1950.64 km² and this large area got out of water from Oct to

April. This period, very small area (2.19 km²) found under water and these areas might be the temporary water bodies. Fig. 12 showed that most of areas were under water during October and water recession occurred in most the areas during April. In April, water was only found in some permanent water bodies (Fig. 13).

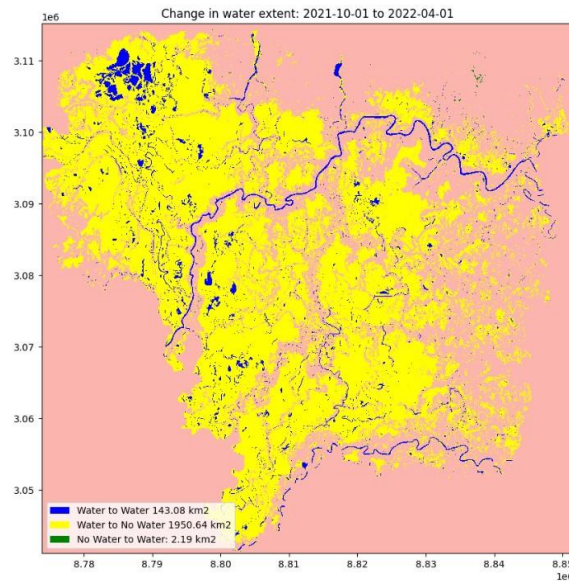


Fig. 11. The change in water extent in Sunamganj during October 2021 to April 2022

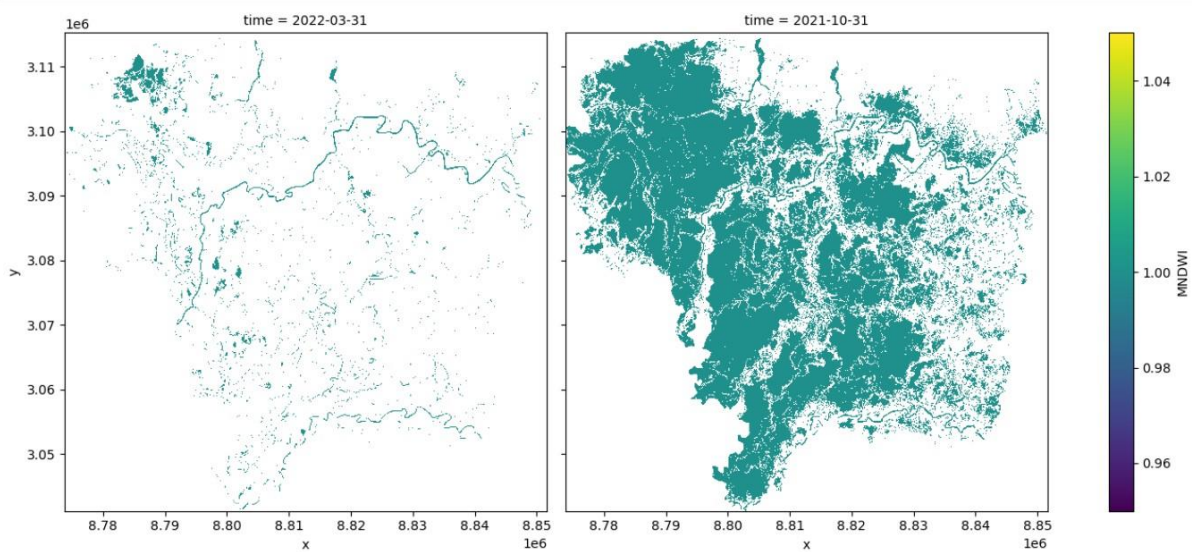


Fig. 12. Maximum and minimum water extent in Sunamganj district during October 2021 to March 2022

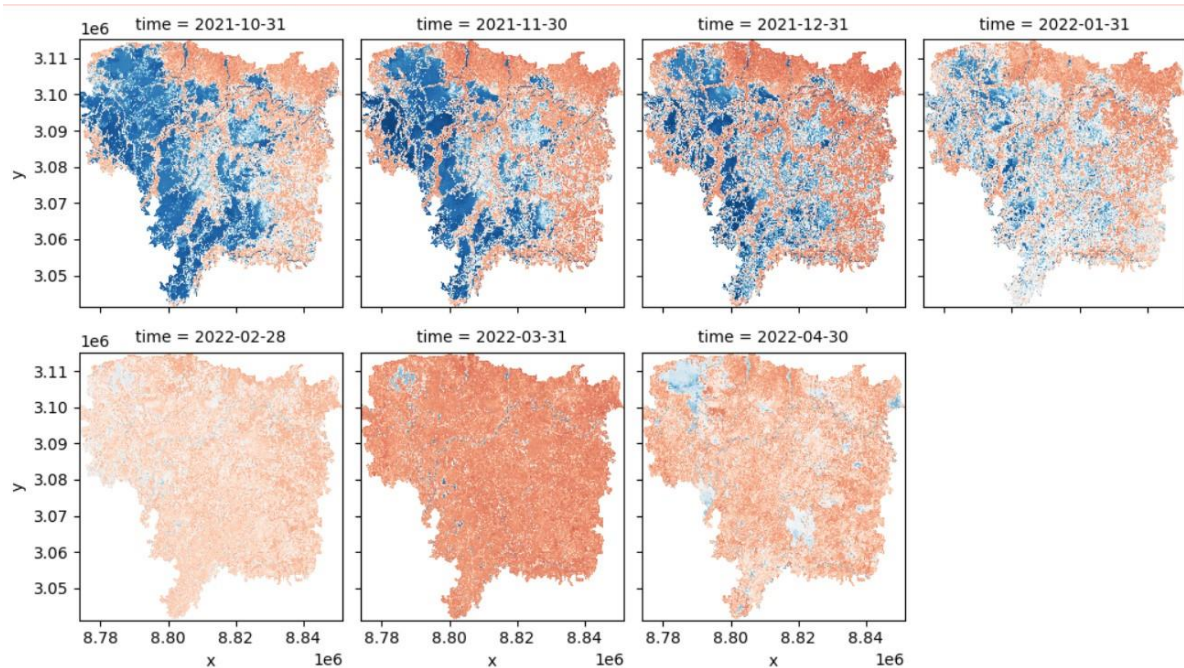


Fig. 13. Water recession pattern in Sunamganj during October 2021 to April 2022

Conclusion

Optical remote sensing is useful to detect the temporal changes in climate, vegetation and water recession in Sylhet and Sunamganj districts. The study showed that temperatures are increasing compared to the earlier years and the amount of rainfall is also decreasing in the current years. The haor areas of Sunamganj are most covered by *boro* rice and farmers grow *boro* rice from January after recession of water. Vegetation at most of the areas of Sunamganj are started from January because most of the areas get out of the water at that time. This study need to continue for getting more information to identify more cultivable lands for Sylhet-Sunamganj region.

187.ASSESSING CHANGES IN CLIMATE EXTREMES USING CMIP6 AND ITS IMPLICATIONS FOR AGRICULTURE IN THE GANGES DELTA

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Abstract

Climate extremes are the major concerns due to their impact on agriculture and ecosystem services. This study examined the frequency and spatial extent of 9 climate extreme indices relevant to agriculture in the coastal region of the Ganges delta in Bangladesh and India. The study was conducted using the latest projected future climate data from IPCC's sixth assessment report (CMIP6, Coupled Model Intercomparison Project Phase 6). Agriculture in the Ganges delta suffers the most due to less availability of usable water; therefore, the study particularly focused on projected climate changes during the dry season (November-April), at short-term (2021-2040), mid-term (2041-2060) and long-term (2061-2100) basis. The results show an overall increase for both temperature and rainfall, with variations occurring spatially and temporarily. Across the region, projected maximum temperature increases are 1.3°C and 2.2°C for the mid and long-term, respectively under SSP245 (Shared Socioeconomic Pathways). The difference between daily maximum and minimum temperature decreases indicating a higher increase for minimum temperature compared to maximum temperature. At an annual scale, the rainfall increases by 160, 400, and 620 mm under the short, medium and long-term projections, respectively. For the same projection periods, the total rainfall during the dry season rises by 12, 42 and 41 mm respectively. Similar increasing trend was also observed at mid and long-term projections. The intensity of 1-day and 5-day rainfall

increases in both short and long-term compared to the historical average rainfall of the region. While total rainfall increases during the dry season, the number of consecutive wet days remains unchanged and the number of consecutive dry days slightly increases across the region. It implies that shorter but more intense spells of rainfall are likely to occur during the dry season in the Sundarbans. The findings of this study are valuable for adaptation and future planning to minimize climate risks to agriculture.

Introduction

Rising temperatures and extreme precipitation events have a significant impact on agricultural productivity across the world (Islam, 2022; Ozer *et al.*, 2020; Wilson *et al.*, 2022). This problem is exacerbated by poor environmental resource management and a lack of adaptive capacity in developing nations (Croitoru *et al.*, 2016; IPCC, 2014). The agricultural land use and land management practices need to adapt to the changes in climate spur. Therefore, understanding changes in precipitation and temperature extremes is crucial for implementing appropriate strategies to mitigate potential climate impacts on food security.

The Ganges Delta relies heavily on agriculture for food security and livelihoods unlike most of the deltas across the world. However, this region is highly vulnerable to climate change and its ill effects. The region often experiences precipitation and temperature extremes, which can significantly impact agricultural productivity. Recent studies have focused on understanding the changes in precipitation and temperature extremes both inland and coast in Bangladesh. Abdullah *et al.* (2022) have indicated that both coastal and inland areas were warming significantly but the rate of warming was higher in coastal areas. Similarly, Das *et al.* (2022) have estimated that the rate of increase of warm extremes is almost similar all over Bangladesh; however, besides the extreme cold events, increase at a little higher rate in inland than in the coastal region. In both regions (Bangladesh and India), a greater rise in climate extremes is expected in the far future. In the Ganges delta, growing non-rice crops successfully in the dry season depends partially on the rainfall distribution patterns, especially on the occurrences of heavy rainfall (Yu *et al.*, 2019). The heavy rainfall during sowing time delays seeding because of waterlogging or causes failure of seedling emergence and growth. Modest rainfall at sowing or at other growth stages can act synergistically for crop growth and development in dry season (Yu *et al.*, 2019; Paul *et al.*, 2021; Islam *et al.*, 2022). Also, the delayed establishment of crops expose to higher temperature during flowering and grain filling stages which shortened the reproductive period and reduced yield (Paul *et al.*, 2021). So, it is essential to understand the variations in rainfall patterns during dry season.

Significant progress has also been made in projecting the climate of Bangladesh. Kamruzzaman *et al.*, (2021) assessed the relative performance of CMIP6 models, and found the ACCESS-CM2 model was the best that could reliably capture the inter-annual variability of annual and seasonal rainfall and temperature. Das *et al.* (2022) assessed extreme rainfall characteristics using four CMIP6 GCMs (Global Circulation Models) for two emission scenarios. Since the simulation results depend on the models employed, it is more insightful to investigate changes in air temperature and precipitation in Bangladesh from a large set of models and under diverse scenarios.

However, their study estimated overall changes in extreme events without focusing on dry-season extremes which is more important for agricultural production and food security in the region. In this study we have used the latest available climate data based on IPCC's 6th assessment report (AR6) (IPCC, 2018). We have investigated climate extremes most relevant to dry-season agriculture in the Ganges delta and quantified changes at local and regional scales. We identified areas that are most vulnerable to climate risk. This information is crucial for adaptation and future planning to minimize risk and maximize yield.

Materials and Methods

Study area and data: The study includes the southwest coastal region of Bangladesh and the southeast coastal region of West Bengal in India. It lies between approximately 21°30'N to 23°30'N latitude and 88°00'E to 90°30'E longitude and covers an area of 27,200 km². This area is

commonly known as the Ganges delta. It includes 70 Upazillas (third-level administrative unit) in Bangladesh and 19 blocks of South and North 24 Parganas district in the Indian state of West Bengal (Fig. 1). The study area is crisscrossed by several rivers that discharge into the Bay of Bengal. The area is characterized by its proximity to the Bay of Bengal and its intricate network of rivers, estuaries, and tidal flats.

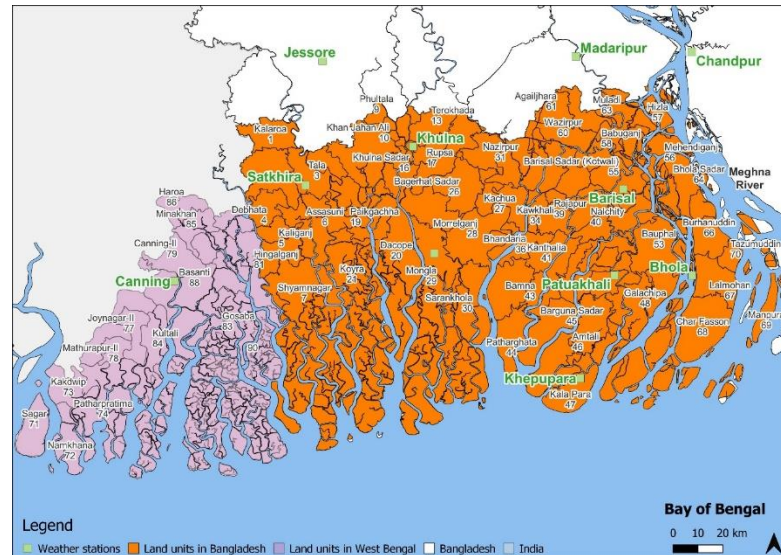


Fig. 1. Study area map showing 90 land units and meteorological stations in the Ganges delta

The study area experiences mean daily temperatures ranging from 30.8°C to 22°C throughout the year. The annual mean precipitation varies across the region, with approximately 2000 mm in the east to 1800 mm in the west (Yu *et al.*, 2019).

Historical climate data: We have used weather station data as well as gridded data for downscaling and bias correction of GCM data. For location-specific future predictions, we have used climate data from 6 gauging stations (5 in Bangladesh and 1 in West Bengal) from 1980 to 2020. The data were obtained from the Bangladesh Meteorological Department (BMD) and ICAR-CSSRI, RRS, Canning Town, India. Figure 2 shows the location of meteorological stations and simulation grids in the global climate models (GCMs). For gridded climate information, we have used satellite-based gridded historical data from the ECMWF Reanalysis v5 (ERA5) global data set, at 0.25° resolution covering the period from January 1940 to the present. ERA5 is the fifth generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climates. The ERA5 is the publicly available data produced by the Copernicus Climate Change Service (C3S) at ECMWF. Based on rainfall and temperature detection metrics, ERA5 demonstrated superior performance for historical climates in Bangladesh (Islam and Cartwright, 2020). Recently, Kamruzzaman *et al.* (2022) used the ERA5 as reference data to evaluate the efficiency of CMIP6 GCMs in modelling rainfall data over Bangladesh. The data were downloaded from the ECMWF website (<https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5>). We have used ERA5 data from 1985 to 2020 for the bias correction of GCM data.

GCM data: We have used future climate data from the IPCC's sixth assessment report (AR6) for the two Shared Socio-Economic Pathways (SSPs) scenarios, SSP245 and SSP585. These data are based on the Coupled Model Intercomparison Project Phase 6 (CMIP6) which is the 5th generation of CMIP products from the World Climate Research Programme (WCRP). All CMIP6 data are available from the World Climate Research Programme for downloading and using at no cost (<https://esgf.nci.org.au/projects/esgf-nci/>). Through the Australian National Computational Infrastructure (NCI, <https://nci.org.au>), we have downloaded and processed daily precipitation, and maximum and minimum temperature from 26 climate models for the period of 1950 to 2100.

Based on the analysis conducted in the previous studies (e.g., Islam and Cartwright, 2020; Kamruzzaman *et al.*, 2022), 18 out of 26 GCMs are used in the study. It is important to note that the spatial resolution of each GCM varies from 100 to 500 km. This study only used the results from the first realization (r1i1p1f1) of each GCM to keep the evaluations consistent and to minimize the model bias.

Downscaling and bias correction of climate data: Daily GCM simulations for the period of 1985 to 2100 were downscaled at 0.25° resolution using the Simple Quantile Mapping (SQM) method (Cannon *et al.*, 2015) and then bias was corrected using ERA5 historical data. The SQM approach uses empirical quantile mapping to refine GCM simulations independently. The method includes (i) extraction of the GCM data corresponding to each target ERA5 grid location, (ii) assessment of GCM's biases, and (iii) bias correction of future climate data. The retroactive period differences between observed and simulated cumulative distribution functions (CDFs) were calculated and applied to future simulations for a particular percentile. The ERA5 and raw GCM data were used as inputs in a non-parametric empirical equation to minimize systematic bias.

Selecting climate indices: The study focused on climate risk during the dry season. To assess changes in extreme temperature and rainfall, 9 climate indices of different climate parameters were computed using the projected temperature and rainfall time series data (**Error! Reference source not found.**).

Table 3. List of temperature and precipitation indices used in this study.

Indices	Definition	Unit	Purpose
TMAXmean	Seasonal average of monthly maximum value of daily maximum temperature	°C	Tendency of maximum monthly temperature
TMINmean	Seasonal average of monthly minimum value of daily minimum temperature	°C	Tendency of minimum monthly temperature
SU25	Seasonal count of days when daily maximum temperature > 25 °C	days	Tendency of days above maximum temperature limits for rice
DTR	Monthly mean difference between daily maximum and minimum temperature	°C	
RX1day	Monthly maximum 1-day precipitation	mm	Examine the extreme rainfall events
RX5day	Monthly maximum consecutive 5-day precipitation	mm	Examine the extreme rainfall events
PRCPtot	Seasonal total precipitation in wet days with precipitation >= 1mm	mm	Tendency of seasonal rainfall
CDD	Seasonal maximum number of consecutive days with precipitation <1 mm	days	Tendency of dry conditions
CWD	Seasonal maximum number of consecutive days with precipitation >=1 mm	days	Tendency of wet conditions

Assessing changes for climate extremes: We have assessed changes in future climate both at local and regional scales. Assessments were conducted for 3 different periods, short-term (2021-2040), mid-term (2041-2060), and long-term (2061-2100). Changes in future climates are evaluated with respect to historical climate from 1995 to 2020. We have investigated changes at monthly, seasonal, and annual scales. We assessed the climate extremes (e.g. maximum temperature, minimum temperature, total rainfall) based on the entire data series, However, changes for 9 agriculture-relevant indices were estimated based on dry season (November-April) data only.

Results and Discussion

Annual and seasonal temperature: Figure 2 shows that maximum and minimum temperatures in the coastal region of Bangladesh and West Bengal are increasing irrespective of GCM selection. While every GCM is different, there are consistently increasing trends for both historical (thick red line) and future projections (green line for SSP245 and blue line for SSP585). There are large

uncertainties among the GCM predictions, and the uncertainties are higher for long-term predictions (e.g. in the period of 2061-2100). For the short-term (2021-2040) similar increases are projected for SSP245 and SSP585. However, for the long-term (2061-2100), maximum and minimum temperature experience a greater increase by about 2 and 1.5°C respectively under SSP585 scenario, compared to SSP245.

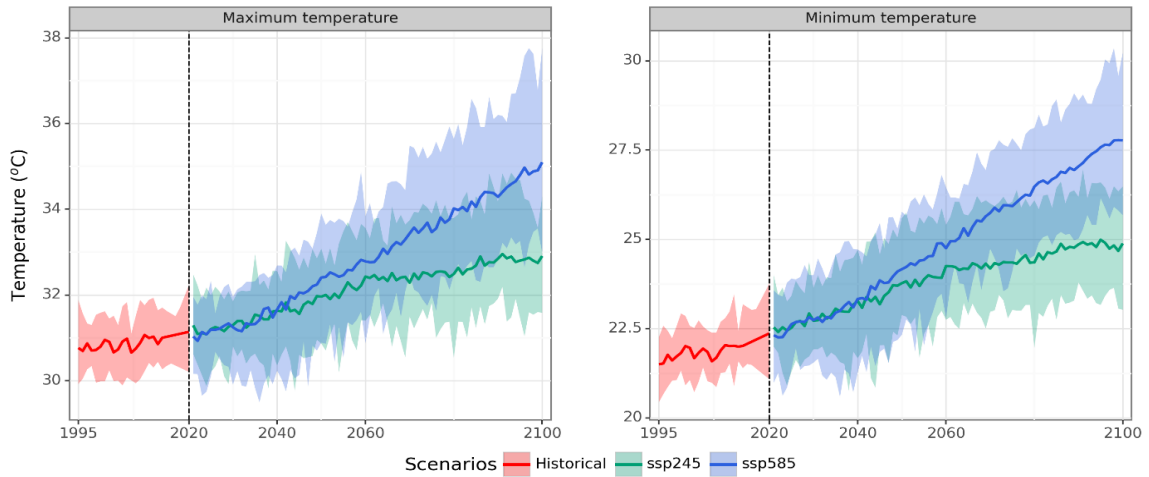


Fig. 2. Historical and projected maximum and minimum temperature in the Ganges delta for the SSP245 and SSP585 scenarios (red line: historical, green line: SSP245, blue line: SSP585, with shades representing range of values)

Like the annual scale, an increase in mean monthly maximum and minimum temperature is predicted by most GCMs (Fig. 3). Compared to the historical monthly average (red line), predicted temperatures are higher for all 12 months of the year and the increase is slightly higher for the SSP585 (blue line) compared to SSP245 (green line). While the trends are similar for the 2021-2040, 2041-2061 and 2061-2100 projection periods, the increase in the period 2041-2060 is higher than 2021-2040. Similarly, the increase in 2061-2100 is higher than in 2041-2060. Comparing with the historical temperature, monthly temperature is projected to increase by 0.5 – 0.7°C, 0.9 – 1.7°C, 1.5 – 4°C in the short, mid and long-term. Abdulla *et al* (2022) also reported based on trend analysis that both coastal and inland areas of Bangladesh were warming significantly but coastal areas exhibited a higher rate of warming.

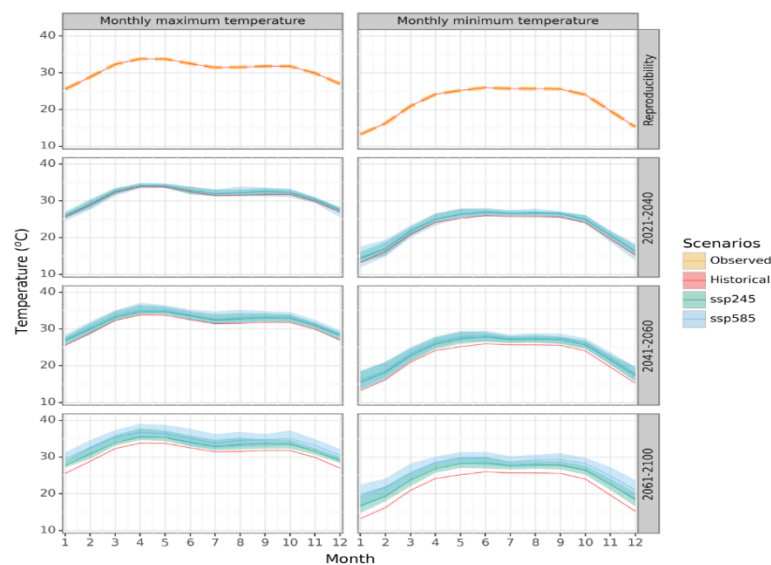


Fig. 3. Historical and projected maximum temperature in the coastal region of Bangladesh and West Bengal for the SSP245 and SSP585 scenarios in the period of 2021-2040, 2041-2060 and 2061-2100.

Changes in temperature extremes: Table 2 and Figure 4 shows the spatial and temporal variations in 4 temperature indices, extracted for the dry season (November to April) at Khepupara, Barisal and Satkhira in Bangladesh and Canning in West Bengal, India. Three temperature indices (TMAXmean, TMINmean and SU25) show increasing trends under projected future climate. Across the region, for all gauges and projection periods, the increase in TMAXmean is higher for SSP585 compared to SSP245. TMAXmean increases in the range of 0.6°C to 1.4°C with an average of 1.0°C in the period of 2041-2060 for the SSP245. The average increases are 0.3°C and 1.9°C in the period 2021-2040 and 2061-2100 respectively. The increase in maximum temperature slightly differs spatially. As the distance from the coast increase, the rise in the maximum temperature decreases. For example, in the period of 2041-2060 for the SSP245, the increase in TMAXmean with respect to the historical is 1.4°C at Khepupara, and 0.6°C at Barisal which is the minimum. Similar to TMAXmean, the increase in TMINmean also varies spatially and temporarily and the increase is higher for the long-term projection (e.g. 2061-2100). In general, the increase in TMINmean is higher compared to TMAXmean for all gauging sites.

Table 4. Projected increase and decrease for four temperature indices in the Ganges delta for dry season (November-April)

		SSP245			SSP585		
		2021-2040	2041-2060		2021-2040	2041-2060	2061-2100
Barisal	DTR	-0.5	-0.7	-1.0	-0.3	-0.7	-1.9
	SU25	3.9	9.3	13.5	2.0	9.9	16.9
	TMAXmean	0.0	0.6	1.4	0.3	1.1	2.8
	TMINmean	0.7	1.3	2.2	0.5	1.6	4.1
Canning	DTR	-0.4	-0.7	-0.9	-0.4	-0.8	-1.3
	SU25	5.7	13.6	19.8	3.6	14.9	25.0
	TMAXmean	0.4	1.1	1.9	0.4	1.5	3.3
	TMINmean	0.8	1.6	2.9	0.8	2.2	5.5
Khepupara	DTR	-0.6	-1.1	-1.7	-0.6	-1.4	-2.6
	SU25	5.6	9.8	12.9	3.8	9.9	14.8
	TMAXmean	0.5	1.4	2.4	0.6	2.0	4.0
	TMINmean	0.9	1.8	3.0	0.9	2.4	6.3
Satkhira	DTR	-0.5	-0.8	-1.0	-0.5	-0.9	-1.9
	SU25	3.0	10.5	15.8	1.0	11.7	20.7
	TMAXmean	0.3	1.0	1.9	0.3	1.4	3.4
	TMINmean	0.8	1.5	2.6	0.7	2.0	5.0

The days with maximum temperature greater than 25°C (SU25) increases temporally. The increase varies between 9 to 14 days across the region with an average of 11 days in the period 2041-2060 for the SSP245. The increases are 5 and 15 days in the period 2021-2040 and 2061-2100 respectively. Unlike the TMAXmean and TMINmean, the variations in SU25 exhibit spatial difference from west to east, with the largest increase of 25 days at Canning, and the smallest of 15 days at Khepupara in the long-term projection under SSP585.

While TMAXmean, TMINmean and SU25 increases in the future, the difference between daily maximum and minimum temperature (DTR) decreases (Fig. 5). Negative DTR as shown in Figure 5 indicates that the increase in minimum temperature is greater than in maximum temperature. Across the region, DTR varies in the range of -0.7°C to -1.1°C with an average -0.8°C in the period of 2041-2060 for the SSP245. The average DTR in the periods of 2021-2040 and 2061-2100 are -0.5°C and -1.1 °C respectively. Compared to SSP245, DTRs for SSP585 are slightly larger for all gauging sites. The average DTR in the periods 2021-2040, 2041-2060 and 2060-2100 are -0.5°C, -0.9°C and -2.0°C respectively. This finding implies that winter is becoming much shorter than the earlier period. Similar scenario is already existing in USA that winter is becoming warmer by 2.7 degrees over the normal average (ABC News, 2023).

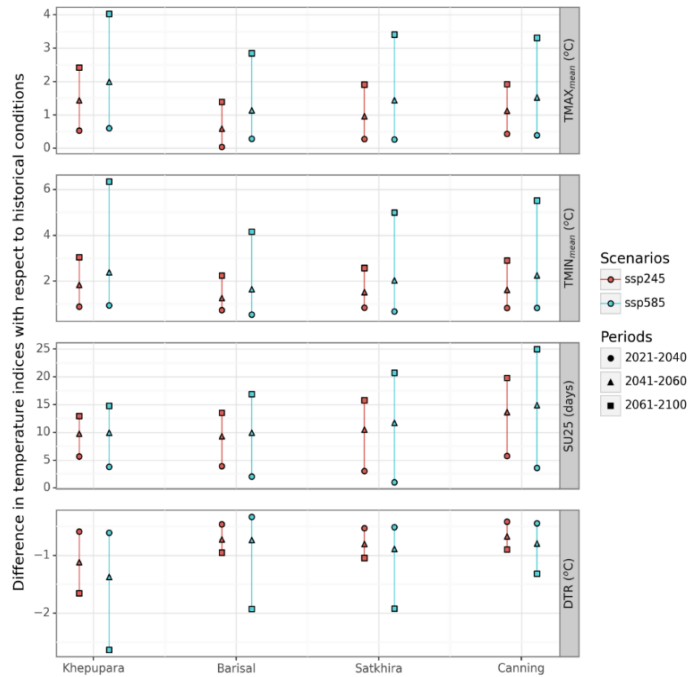


Fig. 4 Projected changes in 4 temperature indices for dry season (November-April) compared to historical conditions in the Ganges delta

Annual and seasonal rainfall: Across the Ganges delta, increase in annual rainfall is projected by most GCMs with a clear increasing trend for both future scenarios as shown in 5. Thick red, green and blue lines represent average of 18 GCMs for the historical climate, SSP245 and SSP585 scenarios, respectively. Results show large uncertainties in the GCM predictions for seasonal rainfall, and the uncertainties are higher for long-term predictions (e.g. in the period of 2061-2100). While some GCM predicts decrease in rainfall, majority of the models predicts increase in rainfall and there is an overall increasing trend in annual mean rainfall. Future predictions are 2700, 2940 and 3160 for the periods 2021-2040, 2041-2060 and 2061-2100 respectively for SSP245, showing an increase of 160, 400 and 620 mm respectively compared to historical average of 2540 mm.

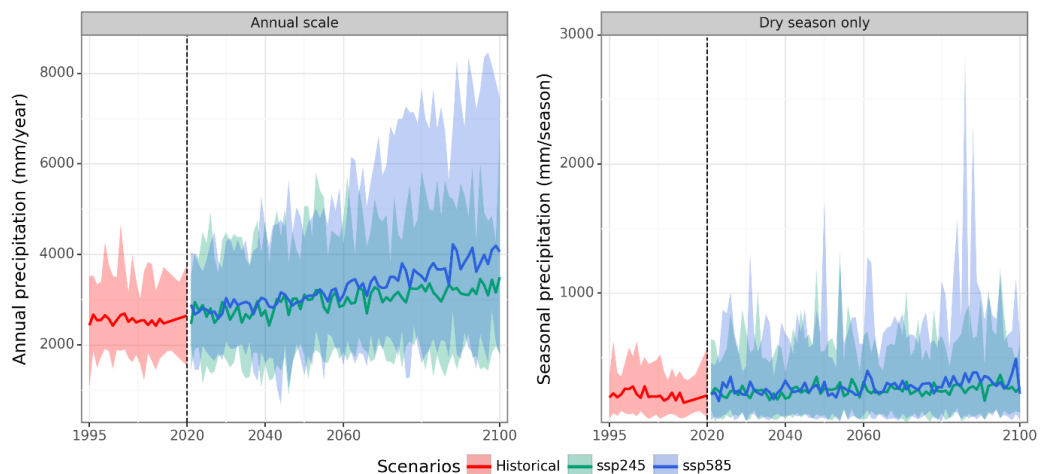


Fig. 5. Historical and projected future rainfall in the Ganges delta for the SSP245 and SSP585, (left) annual rainfall and (right) dry season (November-April) rainfall.

Although there is a clear increasing trend for the annual mean rainfall, increase is small in the dry season (Fig. 5, right panel). At a regional scale, mean annual dry season rainfall are 224 mm (minimum: 173 mm, maximum 283 mm) for 2021-2040, 259 mm (minimum: 193 mm, maximum

351 mm) for 2041-2060 and 258 mm (minimum: 168 mm, maximum 368 mm) for 2061-2100 whereas the historical mean of 206 mm (minimum: 152 mm, maximum 278 mm) for the SSP245.

Table 5. Projected changes for rainfall indices during dry season (November-April) at selected gauging sites in the Ganges delta

		SSP245			SSP585		
		2021-2040	2041-2060	2061-2100	2021-2040	2041-2060	2061-2100
Barisal	CDD	1	0	-1	1	1	0
	CWD	0	0	0	0	0	0
	PRCptot	10	47	51	40	39	93
	Rx1day	2	12	13	12	7	16
	Rx5day	8	25	27	29	23	40
Canning	CDD	2	2	1	2	3	1
	CWD	0	0	0	0	0	1
	PRCptot	16	39	29	34	26	73
	Rx1day	6	8	6	10	8	13
	Rx5day	15	26	16	24	17	38
Khepupara	CDD	3	3	3	3	7	2
	CWD	0	0	0	0	0	1
	PRCptot	12	51	45	42	39	102
	Rx1day	4	15	14	16	12	24
	Rx5day	15	37	31	38	31	62
Satkhira	CDD	1	0	0	2	2	1
	CWD	0	0	0	0	0	1
	PRCptot	11	31	40	30	37	85
	Rx1day	5	9	9	10	11	18
	Rx5day	10	18	21	22	24	39

Most GCMs predicted increases for mean monthly rainfall for all 12 months and the increase is higher for long term prediction. Fig. 6 shows the monthly average rainfall in the study area for the short-term (2021-2040), mid-term (2041-2061) and long-term (2061-2100). Compared to historical monthly average, predicted rainfalls are higher for all 12 months of the year and the increase is higher for the SSP585 (blue line) compared to SSP245, particularly in the long-term. However, most increases occur during the wet season months, especially between July and September.

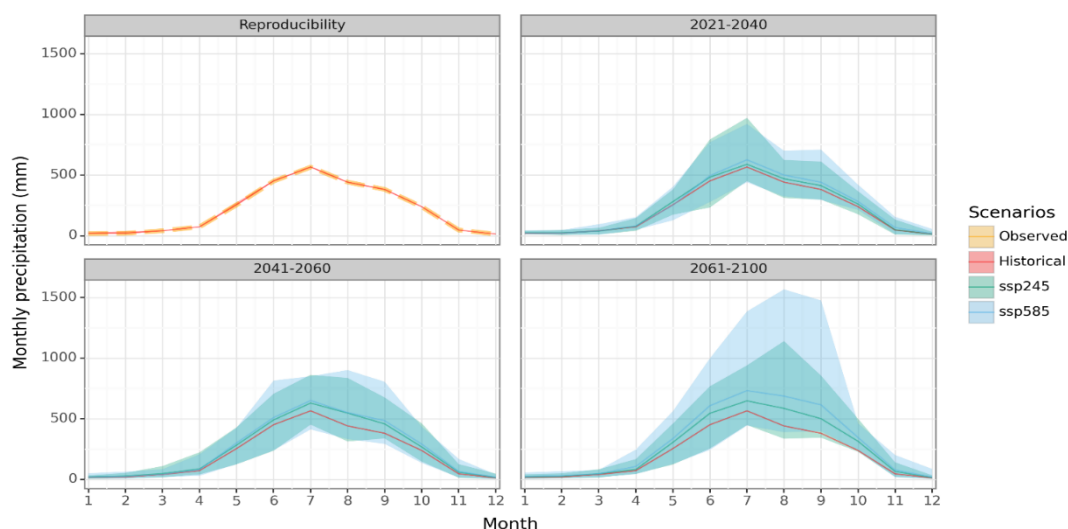


Fig. 6. Historical and projected future monthly rainfall in in the coastal region of Bangladesh and West Bengal for different periods (rainfall are averaged in the periods 2021-2040, 2041-2060 and 2061-2100).

Changes in rainfall extremes: Figure 7 shows spatial and temporal changes for five rainfall indices (RX1day, RX5day, PRCPtot, CDD and CWD) relevant to agriculture. Results show an increase in dry season rainfall at all gauging sites for short-term as well as long-term projections. For both future scenarios, dry season rainfall increases in the range of 31 to 51 mm across the region with an average of 42 mm in the period of 2041-2060 with respect to historical average dry-season rainfall of 206 mm. These increases are 12 mm for 2021-2040 and 41 mm for 2041-2100 (Table 3). It is important to note that at a longer time scale (2061-2100), rainfall increase is nominal compared to mid-term projection for SSP245.

The intensity of 1-day and 5-day rainfall increases both at short-term and long-term compared to historical climate. One-day rainfall (RX1day) increases in the range of 8 to 15 mm with an average of 11 mm for the period 2041-2060 for SSP245, compared to historical mean of 60 mm. The increases are 4 mm and 11 mm for the 2021-2040 and 2061-2100, respectively. Similar to total rainfall increase in the dry season, one-day maximum rainfall in the period of 2061-2100 is similar to 2041-2060. The 5-day rainfall (RX5day) increases by 26 mm for the period 2041-2060 for SSP245 compared to historical mean of 102 mm. The increases are 12 mm and 24 mm for the 2021-2040 and 2061-2100 respectively (Table 3). It is important to note that 5-day rainfall increase for long range projection is slightly less than the mid-range projection at some stations. Results are consistent with other rainfall indices but different than temperature indices.

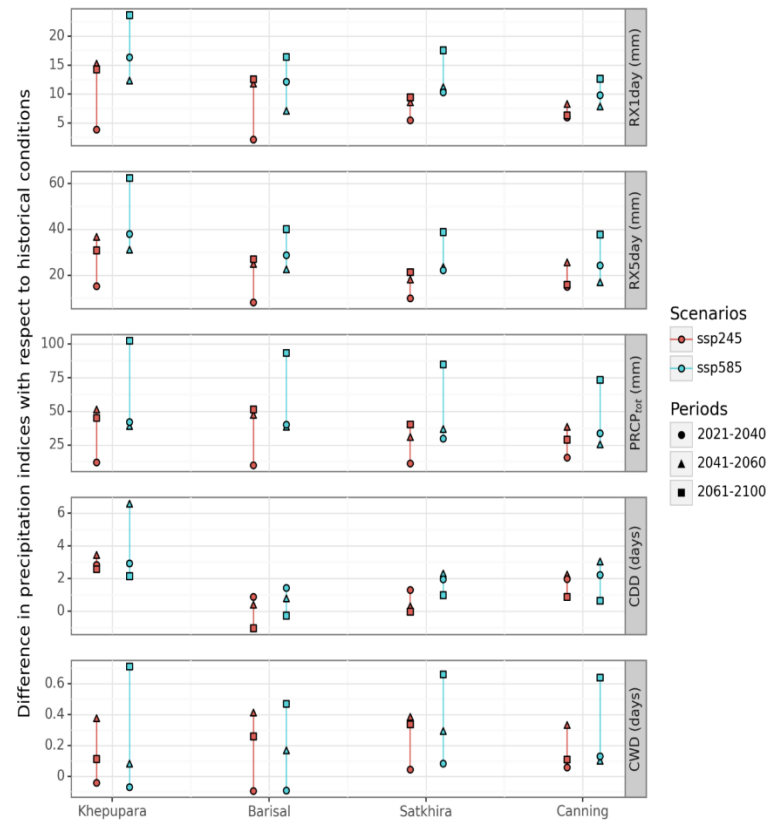


Fig. 7. Changes to rainfall indices for the dry season (November-April) in the Ganges delta.

While total rainfall increases during the dry season, the number of consecutive wet days (CWD) is about 4 days, which remains similar to historical condition. The consecutive dry days (CDD) however, slightly increase across the region. For the 2041-2060 period, CDD increases by approximate 2 days for the SSP245 compared to historical mean of 53 days. The increases are 2 and 1 days for 2021-2040 and 2061-2100, respectively (Table 3) which indicates that there will be a longer consecutive dry period between November and April in the study area, although the total rainfall is projected to increase.

Uncertainty in climate extremes: The box and whisker plot in Figure 8 shows estimated climate indices (4 for temperature and 5 for rainfall) using downscaled results from 18 GCMs. The horizontal line in the figure represents the 50th percentile of all GCMs, while top and bottom lines represent 75th and 25th percentile respectively. For all indices the uncertainty is higher for predictions (SSP245 and SSP585), compared to GCM simulations for historical climate (red boxes). Among all indices, the TMAXmean is relatively less spread out and doesn't have outliers, implying a more consistent and homogenous outcome.

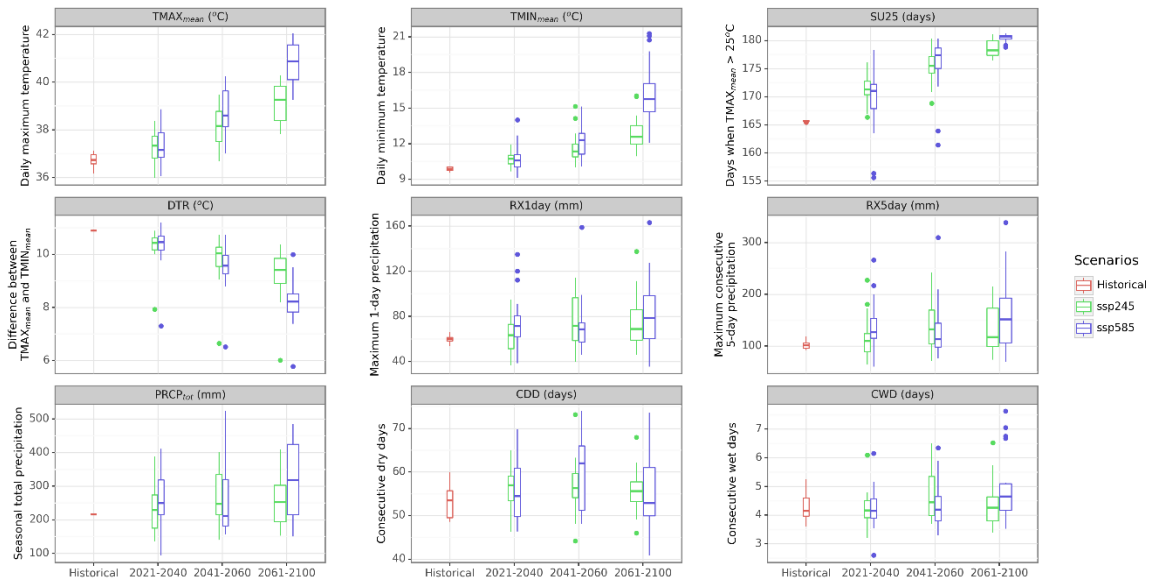


Fig. 8. Boxplot showing uncertainties for 9 climate indices for the dry season in the Ganges delta (Khepupara) for SSP245 and SSP585 scenarios.

Conclusion

The study identified a decrease in the difference between daily maximum and minimum temperatures which is an indication of a higher increase for minimum temperature compared to maximum temperature. While there is a large increase in annual rainfall (e.g. 400 mm for the period 2041-2060), only 42 mm is increased in the dry season for the same period. The intensity of 1-day and 5-day rainfall increases both short-term and long-term future. While total rainfall increases during the dry season, the number of consecutive wet days remains similar to historical but consecutive dry days slightly increase across the region.

The mitigation and adaptation strategies for agriculture are strongly dependent on the magnitude and rate of climate change and are also associated with climate risks. The assessment of temperature and rainfall extremes provides insights into the challenges faced by the agricultural sector in coastal Bangladesh and West Bengal, especially during the dry season when freshwater is insufficient. The findings emphasize the need for climate adaptation strategies that enhance the resilience of agricultural systems. By implementing appropriate measures, such as improved water management, crop diversification, and capacity building for farmers, the region can enhance its agricultural resilience and ensure food security for the region.

188.IMPACT OF NITROGEN FERTILIZER AND WEED MANAGEMENT ON NITROUS GAS EMISSION AND YIELD OF STRIP-PLANTED WHEAT UNDER CONSERVATION AGRICULTURE SYSTEMS

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Abstract

Nitrogen and weed management can significantly improve wheat yield; however, it might impact greenhouse gas emissions. Therefore, a study was done for two consecutive years (2022-23 and 2023-24) in the research field of On-farm Research Division, BARI, Gazipur, Bangladesh to evaluate the effect of nitrogen and weed management on nitrous gas emission and yield of strip-planted wheat in T. *aman* rice-wheat-mungbean cropping pattern under conservation agriculture systems. The study considered two factors as the treatments viz., level of nitrogen fertilizer and weed management. Three levels of nitrogen fertilizer viz., $N_0 = 0 \text{ Kg N ha}^{-1}$, $N_1 = 92 \text{ Kg N ha}^{-1}$ (recommended rate), and $N_2 = 184 \text{ Kg N ha}^{-1}$ and four weed management treatments viz., $W_0 = \text{No weeding}$, $W_1 = \text{Weed-free (2 times hand weeding at 25 and 45 DAS)}$, $W_2 = \text{Pre-emergence herbicide (pendimethalin)}$, and $W_3 = \text{Pre-emergence (pendimethalin) followed by (fb) Post-emergence (carfentrazone-ethyl) herbicides}$ were tested. The study was designed followed by a factorial randomized complete block design (RCBD) with three replications. Application of double (184 kg ha^{-1}) the recommended N fertilizer had a positive effect on grain yield of strip-planted wheat; however, it influenced greater N_2O gas emission. Weed management had a great influence on grain yield and N_2O gas emission. Therefore, the study suggests the application of 92 kg N ha^{-1} in strip-planted wheat with pre-emergence herbicide application or pre-emergence followed by post-emergence herbicide application to emit less N_2O gas with better yield.

Introduction

Wheat is one of the most important crops in Bangladesh. Usually, wheat grows in our country in heavily tilled soils. Heavy tillage and intensive crop cultivation are the main reasons for soil health and quality degradation. To improve soil quality as well as soil health, conservation agricultural (CA) systems can be a better option (Bell and Haque, 2017). CA is a package of technologies that based on three principles: (i) minimum soil disturbance, (ii) crop residue retention and (iii) crop rotation (FAO, 2011). Minimum tillage helps to reduce soil erosion as well as reduces cultivation cost as it requires less fuel, labour and also less time (Hossain et al., 2015). Minimum tillage also conserves soil moisture and keeps soil micro-environment cool (Salahin et al., 2017). Addition of previous crop residue enriches soil quality through enhancing soil organic matter content. Moreover, crop performed better under conservation agricultural systems (Bell et al. 2017; Hossain et al., 2014).

Nitrogen (N) is an essential nutrient for crop growth and yield (Xu et al., 2012). Besides having an influence on crops, nitrogen has a significant impact on weeds. Booth et al. (2003) mentioned that weed germination is triggered by various factors like soil temperature, soil moisture, light, and N. Sweeney et al. (2008) and Travlos et al. (2018) reported that N fertilizer applications increase weed growth, but the influence of N on weed emergence is dependent on the weed species, seed source, and environmental condition. Blackshaw and Brandt (2017) evaluated the effect of N fertilizer rate on the competitive ability of weed species in wheat and identified a significantly high N-responsive weed species to the increased N fertilizer rate. Information regarding N fertilizer effects on crop-weed competitive interactions might help to develop improved weed management programs. Several studies have reported that effective nutrient management practices can have a significant impact on reducing GHG emissions (Haque et al., 2023) and improving overall agricultural sustainability. Moreover, weed management has a strong role for obtaining optimum yield of wheat and even under conservation agriculture systems.

Strip-planting of wheat is getting popularity in Bangladesh because of yield benefits, soil conservation, and increased water productivity (Mahmud et al. 2017). However, weed

management plays a vital role to get targeted wheat yield under the strip planting system (Zahan et al, 2021). The use of herbicides is common in strip planting wheat cultivation (Zahan et al, 2022; Zahan et al. 2021). Effective weed management significantly improves the yield of strip-planted wheat (Zahan et al, 2022; Zahan et al. 2021). However, there is no evidence found on the influence of herbicides on greenhouse gas emissions. On the other hand, nitrogen is an essential nutrient for plant growth which has an influence on greenhouse gas (GHG) emissions. Therefore, a study was designed and executed to evaluate the effect of nitrogen fertilizer management and weed management on yield and greenhouse gas emissions of strip-planted wheat.

Materials and Methods

The study was conducted at the on-station research field of On-farm Research Division, Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2022-2023. Texturally the soil was sandy clay loam with pH 6.8, organic matter 1.86%, total nitrogen 0.10%, available phosphorus 54.0 ppm, potassium 0.174 meq/100 ml, sulphur 27.4 ppm.

The study considered two factors as the treatments *viz.*, level of nitrogen fertilizer and weed management. Three levels of nitrogen fertilizer *viz.*, $N_0 = 0 \text{ Kg N ha}^{-1}$, $N_1 = 92 \text{ Kg N ha}^{-1}$ (recommended rate), and $N_2 = 184 \text{ Kg N ha}^{-1}$ and four weed management treatments *viz.*, $W_0 =$ No weeding, $W_1 =$ Weed-free (2 times hand weeding at 25 and 45 DAS), $W_2 =$ Pre-emergence herbicide (pendimethalin), and $W_3 =$ Pre-emergence (pendimethalin) followed by (fb) Post-emergence (carfentrazone-ethyl) herbicides were tested. The study was designed followed by factorial randomized complete block design (RCBD) with three replications. The unit plot size was 2.5 m $\times$ 4.0 m. BARI Gom-33 was the used wheat variety planted on 15 November 2023 in the strips apart by 20 cm. The seed rate was 150 kg ha⁻¹. The soil was fertilized @ 32-50-20-1.1-2.6 kg ha⁻¹ P-K-S-B-Zn, respectively in the form of urea, triple super phosphate, muriate of potash, and gypsum in accordance with the Fertilizer Recommendation Guide-2018. Nitrogen fertilizer was applied as the treatment required in the form of urea and the amount of urea was applied into two splits, one as a basal dose and another half at the maximum tillering stage. The full amount of triple superphosphate, muriate of potash, gypsum, boric acid, and ZnSO₄ fertilizers were applied as a basal dose during final land preparation. The crop received three shallow irrigations over its whole life cycle during emergence period, early vegetative stage and at the maximum tillering stage of wheat. Intercultural operations like weeding in the weed-free plots, and fungicides application were done as when necessary. The crop was harvested at maturity on 12 March 2023.

Data on weed density and dry matter were collected at 40 and 55 DAS from randomly selected 50 cm $\times$ 50 cm quadrat spots. Weed species were identified and the weed populations of each species were counted from a 1m² area. The heights of wheat plants were measured at 30, 45, 55, 65, and 90 DAS and at 115 DAS (2 days before harvest) from randomly selected ten plants per plot. Data on yield contributing characters were recorded from randomly selected ten plants. Data on NDVI were collected at 55, 65, and 75 DAS from 1.5 m² area of each plot by a handheld crop sensor GreenSeeker® (made by Trimble company). Leaf chlorophyll content (SPAD value) at 30, 45, and 60 DAS were measured by SPAD meter of Konica Minolta company. Yield data were collected from the central 2m $\times$ 3m area of each plot and converted into t ha⁻¹.

Sampling for nitrous oxide (N₂O) gas emission in the wheat field was done by following static closed-chamber method (Haque et al. 2020, 2021, 2023). The acrylic column chambers having 20 cm diameter and 40 cm height were placed in between two rows of wheat for evaluating N₂O gas emission rates during the cultivation period (Lou et al. 2004; Haque et al. 2023). The bottom 20 cm of each chamber was interred into the soil surface for gas sample collection. A total of 36 chambers were used in the study. All chambers were kept open throughout the investigation period except during gas samplings. The samples were collected using 50 ml gas-tight syringes at 0 and 30 min after chamber closing at 7-day intervals. Gas samplings were carried out at three times (8 o'clock in the morning, 12 o'clock at noon, and 4 o'clock in the afternoon) in a day to get average gas emission rates. Collected gas samples were immediately transferred into 20 ml air-

evacuated glass vials sealed with a butyl rubber septum for gas analysis. The N_2O gas concentrations in the collected air samples were measured by Gas Chromatography (Shimadzu, GC-2014, Japan) with a Porapak NQ column (Q 80-100 mesh). A Ni electron capture detector (ECD) was used for quantifying N_2O gas concentration. The emission rate of N_2O gas was calculated as per the equation followed by Haque et al. 2021 and the seasonal total N_2O gas fluxes were computed according to Singh et al. (1999).

The collected data were analyzed by analysis of variance using ANOVA following the procedure for Randomized Complete Block design. The means were separated by least significant difference at the 5% level of probability. Data were analyzed using computer-based software "RSudio" version 4.1.2.

Materials and Methods

The study was conducted at the on-station research field of On-farm Research Division, Bangladesh Agricultural Research Institute, Gazipur (23°59'13.2978" N and 90°24'36.33695" E) during *rabi* season of 2022-2023. Texturally the soil was sandy loam (55.28% sand, 38% silt, and 6.72% clay) with pH 6.8, organic matter 1.86%, total nitrogen 0.10%, available phosphorus 54.0 ppm, potassium 0.174 meq/100 ml, sulphur 27.4 ppm.

The study considered two factors as the treatments *viz.*, level of nitrogen fertilizer and weed management. Three levels of nitrogen fertilizer *viz.*, $N_0 = 0$ Kg N ha⁻¹, $N_1 = 92$ Kg N ha⁻¹ (recommended rate), and $N_2 = 184$ Kg N ha⁻¹ and four weed management treatments *viz.*, W_0 = No weeding, W_1 = Weed-free (2 times hand weeding at 25 and 45 DAS), W_2 = Pre-emergence herbicide (pendimethalin), and W_3 = Pre-emergence (pendimethalin) followed by (fb) Post-emergence (carfentrazone-ethyl) herbicides were tested. The study was designed followed by factorial randomized complete block design (RCBD) with three replications. The unit plot size was 2.5 m × 4.0 m. BARI Gom-33 was the used wheat variety planted on 15 November 2022 and 16 November 2023 in the strips apart by 20 cm. The seed rate was 150 kg ha⁻¹. The soil was fertilized @ 32-50-20-1.1-2.6 kg ha⁻¹ P-K-S-B-Zn, respectively in the form of urea, triple super phosphate, muriate of potash, and gypsum in accordance with the Fertilizer Recommendation Guide-2018. Nitrogen fertilizer was applied as the treatment required in the form of urea and the amount of urea was applied into two splits, one as a basal dose and another half at the maximum tillering stage. The full amount of triple superphosphate, muriate of potash, gypsum, boric acid, and $ZnSO_4$ fertilizers were applied as a basal dose during final land preparation. The crop received three shallow irrigations over its whole life cycle during emergence period, early vegetative stage and at the maximum tillering stage of wheat. Intercultural operations like weeding in the weed-free plots, and fungicides application were done as when necessary. The crop was harvested at maturity on 12 March 2023 and 13 March 2024.

Data on weed density and dry matter were collected at 40 and 55 DAS from randomly selected 50 cm × 50 cm quadrat spots. Weed species were identified and the weed populations of each species were counted from a 1m² area. The heights of wheat plants were measured at 30, 45, 55, 65, and 90 DAS and at 115 DAS (2 days before harvest) from randomly selected ten plants per plot. Data on yield contributing characters were recorded from randomly selected ten plants. Data on NDVI were collected at 55, 65, and 75 DAS from 1.5 m² area of each plot by a handheld crop sensor GreenSeeker® (made by Trimble company). Leaf chlorophyll content (SPAD value) at 30, 45, and 60 DAS were measured by SPAD meter of Konica Minolta company. Yield data were collected from the central 2m × 3m area of each plot and converted into t ha⁻¹.

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The collected data were analyzed by analysis of variance using ANOVA following the procedure for Randomized Complete Block design. The means were separated by least significant difference at the 5% level of probability. Data were analyzed using computer-based software "RSudio" version 4.1.2.

Results and Discussion

The strip-tilled wheat field was infested by fifteen (15) weed species among which four were grass weeds (*Cynodon dactylon*, *Echinochloa colona*, *Eleusine indica* and *Digitaria sanguinalis*), one sedge weed (*Cyperus rotundus*) and eleven broadleaf weeds (*Eclipta prostrata*, *Physalis heterophylla*, *Ludwigia decurrens*, *Jussiaea kaber*, *Gnaphalium album*, *Lindernia procumbens*, *Chenopodium album*, *Portulaca oleracea*, *Enhydra fluctuans*, and *Alternanthera sessilis*). The most infested weed species was *Echinochloa colona*.

The weed biomass was significantly affected by nitrogen rate and weed management and by their interaction effect (Table 1). The highest weed biomass was recorded from the unweeded plots with 192 kg N application ha⁻¹ (Table 2). Application of pre-emergence (pendimethalin) followed by post-emergence (carfentrazone-ethyl) herbicides with 184 kg N ha⁻¹ had the lowest weed biomass (Table 2).

Table 1. Effect of nitrogen rate and weed management on total weed biomass at 35 days after sowing and on grain yield of strip-tilled wheat during 2022-23 and 2023-24

	2022-23		2023-24	
Treatment	Total weed biomass	Grain yield	Total weed biomass	Grain yield
Nitrogen rate (N)	***	***	***	***
Weed management (W)	***	***	***	***
N×W	***	ns	***	ns

Here, fb = followed by, HW = hand weeding, CV = co-efficient of variance, *** = 0.1% level of significance

The grain yield of strip-planted wheat was also significantly affected by nitrogen rate and weed management and by their interaction (Table 1). The highest grain yield (3.62 t ha⁻¹ in 2022-23 and 4.00 t ha⁻¹ in 2023-24) was obtained from the application of pre-emergence followed by post-emergence (carfentrazone-ethyl) herbicides with 184 kg N ha⁻¹ (Table 2). On the other hand, no weeding with no N fertilizer application produced the lowest grain yield (1.30 t ha⁻¹ in 2022-23 and 0.65 t ha⁻¹ in 2023-24).

Table 2. Effects of nitrogen rate and weed management and their interaction on total weed biomass at 35 days after sowing and grain yield of strip-tilled wheat during 2022-23 and 2023-24 at Gazipur

Treatment	2022-23		2023-24	
	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)
0 kg N ha ⁻¹ + No weeding control	30.44 c	1.30 f	18.7 b	0.65 d
0 kg N ha ⁻¹ + Weed-free control	15.46 ef	2.27 d	3.9 g	1.67 c
0 kg N ha ⁻¹ + PRE herbicide	21.75 d	1.69 ef	12.4 cd	1.50 c
0 kg N ha ⁻¹ + PRE fb POST herbicides	19.33 de	1.77 e	12.5 cd	1.76 c
92 kg N ha ⁻¹ + No weeding control	42.16 b	2.37 d	22.0 b	1.09 cd
92 kg N ha ⁻¹ + Weed-free control	20.53 d	2.83 c	4.3 fg	3.09 b
92 kg N ha ⁻¹ + PRE herbicide	15.64 ef	2.82 c	9.5 de	2.96 b

Treatment	2022-23		2023-24	
	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)	Total weed biomass (g m ⁻²)	Grain yield (t ha ⁻¹)
92 kg N ha ⁻¹ + PRE fb POST herbicides	13.89 f	3.21 abc	5.6 fg	3.52 ab
184 kg N ha ⁻¹ + No weeding control	48.85 a	3.03 bc	43.9 a	1.45 cd
184 kg N ha ⁻¹ + Weed-free control	34.44 c	3.58 a	7.6 fg	3.50 ab
184 kg N ha ⁻¹ + PRE herbicide	31.07 c	3.36 ab	14.5 c	3.75 ab
184 kg N ha ⁻¹ + PRE fb POST herbicides	22.17 d	3.62 a	3.3 g	4.00 a
CV (%)	9.96	9.58	15.52	19.79

In a column, means with the similar letter(s) are identical as per LSD_{0.05}

Total Nitrous oxide gas flux: The effects of nitrogen and weed management were significant; however, the interaction effect of nitrogen and weed management was non-significant (Table 3). The highest N₂O flux was calculated from 184 kg N ha⁻¹ during both years. The rate of N fertilizer greatly influenced N₂O gas emission which is mainly associated with aerobic crop culture (Haque et al, 2023; Biswas et al, 2021). The lowest N₂O flux was recorded from weed-free control plots. Application of pre-emergence herbicide had the highest N₂O flux in 2022-2023; whereas, pre- fb post-emergence herbicide treated plots had the highest flux in 2023-2024.

Among the treatments, the total N₂O flux ranged between 730.7 to 881.7 g ha⁻¹ season⁻¹ in 2022-2023 and 766.8 to 1021.4 g ha⁻¹ in 2023-2024 depending on the adopted N fertilizer and weed management options (Table 3). The highest N₂O flux was observed in the plots received 184 kg N ha⁻¹ with pre-emergence weed control by pendimethalin in 2022-2023 and the plots with 184 kg N ha⁻¹ and pre- followed by post-emergence herbicides in 2023-2024. The lowest N₂O flux was found in the plots with 0 kg N ha⁻¹ having no weed management during both years. This result reflects that the use of herbicide along with N fertilizer might influence N₂O gas emission. Application of 92 kg N ha⁻¹ and 184 kg N ha⁻¹ with different weed management practices increased N₂O flux over 0 kg N ha⁻¹ application by 8.5-15.1% and 1-20.1% in 2022-2023 and 16.9-26.0% and 20.8-33.2% in 2023-2024, respectively.

Table 3. Interaction effect of nitrogen fertilizer and weed management on N₂O gas flux and emission rate in strip-tilled wheat during *rabi* season 2022-2023 and 2023-24

Treatment	2022-2023		2023-2024	
	N ₂ O flux (g ha ⁻¹)	% increase over control	N ₂ O flux (g ha ⁻¹)	% increase over control
N level (N)				
0 kg N ha ⁻¹	748.01b	-	801.31 b	-
92 kg N ha ⁻¹	814.97 a	8.95	944.17 a	17.82
184 kg N ha ⁻¹	819.25 a	9.52	952.01 a	18.81
Level of significance	**	-	***	-
Weed management (W)				
No weeding control	753.40 b	-	863.32 c	-
Weed-free control	793.43 ab	5.31	903.16 ab	4.61
PRE herbicide	820.94 a	8.96	896.42 bc	3.83
PRE fb POST herbicides	808.53 a	7.32	933.76 a	8.16
Level of significance	*	-	**	-
Interaction (N×W)				
0 kg N ha ⁻¹ + No weeding control	730.65	-	766.78	-
0 kg N ha ⁻¹ + Weed-free control	784.48	7.37	809.80	5.61
0 kg N ha ⁻¹ + PRE herbicide	739.91	1.27	815.26	6.32
0 kg N ha ⁻¹ + PRE fb POST herbicides	737.02	0.87	813.41	6.08
92 kg N ha ⁻¹ + No weeding control	792.65	8.49	897.05	16.99
92 kg N ha ⁻¹ + Weed-free control	802.33	9.81	961.19	25.35
92 kg N ha ⁻¹ + PRE herbicide	841.25	15.14	951.97	24.15
92 kg N ha ⁻¹ + PRE fb POST herbicides	840.75	15.07	966.47	26.04
184 kg N ha ⁻¹ + No weeding control	736.89	0.85	926.14	20.78
184 kg N ha ⁻¹ + Weed-free control	793.49	8.60	938.48	22.39
184 kg N ha ⁻¹ + PRE herbicide	881.67	20.67	922.03	20.25

Treatment	2022-2023		2023-2024	
	N ₂ O flux (g ha ⁻¹)	% increase over control	N ₂ O flux (g ha ⁻¹)	% increase over control
184 kg N ha ⁻¹ + PRE fb POST herbicides	847.83	16.04	1021.39	33.20
Level of significance	ns	-	ns	
CV (%)	6.19	-	4.14	

System Productivity: The highest system productivity of *T. aman* rice-wheat-mungbean (R-W-M) cropping pattern was calculated from application of double recommended N rate with pre-followed by post-emergence herbicides during 2022-2023 (Table 4). In 2023-2024, the highest system productivity was obtained from recommended N rate with pre followed by post-emergence herbicides (Table 5).

Table 4. System productivity of *aman* rice-wheat-mungbean cropping pattern affected by nitrogen fertilizer rate and weed management during *rabi* season 2022-2023

Treatment	Yield (t ha ⁻¹)			
	<i>T. aman rice</i>	Wheat	Mungbean	System productivity
No N + No weeding control	2.05	1.30	0.40	4.41
No N + Weed-free control	3.55	2.27	0.42	6.97
No N + PRE herbicide	3.51	1.69	0.41	6.30
No N + PRE fb POST herbicides	3.84	1.77	0.48	6.89
RD N + No weeding control	2.77	2.37	0.67	6.90
RD N + Weed-free control	5.07	2.83	0.93	10.32
RD N + PRE herbicide	5.22	2.82	0.74	10.02
RD N + PRE fb POST herbicides	6.74	3.21	0.96	12.48
2RD N + No weeding control	4.16	3.03	0.85	9.43
2RD N + Weed-free control	5.63	3.58	0.76	11.28
2RD N + PRE herbicide	6.60	3.36	1.04	12.70
2RD N + PRE fb POST herbicides	6.97	3.62	0.94	13.10

Selling price (Tk./kg): Rice = 33, Wheat = 35, Mungbean = 80

Table 5. System productivity of *aman* rice-wheat-mungbean cropping pattern affected by nitrogen fertilizer rate and weed management during *rabi* season 2023-24

Treatment	Yield (t ha ⁻¹)			
	<i>T. aman rice</i>	Wheat	Mungbean	System productivity
0 kg N ha ⁻¹ + No weeding control	1.23	0.65	0.95	4.42
0 kg N ha ⁻¹ + Weed-free control	3.50	1.67	0.89	7.71
0 kg N ha ⁻¹ + PRE herbicide	3.05	1.50	1.16	7.74
0 kg N ha ⁻¹ + PRE fb POST herbicides	3.48	1.76	1.13	8.36
92 kg N ha ⁻¹ + No weeding control	2.38	1.09	1.08	6.40
92 kg N ha ⁻¹ + Weed-free control	3.90	3.09	0.97	9.92
92 kg N ha ⁻¹ + PRE herbicide	4.02	2.96	1.19	10.47
92 kg N ha ⁻¹ + PRE fb POST herbicides	5.05	3.52	1.28	12.35
184 kg N ha ⁻¹ + No weeding control	2.30	1.45	0.94	6.37
184 kg N ha ⁻¹ + Weed-free control	4.71	3.50	1.00	11.29
184 kg N ha ⁻¹ + PRE herbicide	4.19	3.75	1.29	11.79
184 kg N ha ⁻¹ + PRE fb POST herbicides	4.66	4.00	1.15	12.17

Selling price (Tk./kg): Rice = 35, Wheat = 40, Mungbean = 90

Conclusion

Applying pre-and post-emergence herbicides with recommended and double recommended nitrogen fertilizer rates offered higher system productivity in rice-wheat-mungbean (R-W-M) cropping pattern under CA systems. However, the study suggests recommended nitrogen rate application (85 kg N ha⁻¹ for rice and 92 kg N ha⁻¹ for wheat) considering less N₂O gas emission in strip-planted wheat without sacrificing system yield of R-W-M pattern under CA systems.

189.EVALUATION OF LONG-TERM SOC AND CROP PRODUCTIVITY WITHIN CONSERVATION AGRICULTURE SYSTEMS UNDER CLIMATE CHANGE USING THE APSIM MODEL

Abstract

Conservation Agriculture (CA) has been researched and advocated across the globe as a way of maintaining high soil organic carbon (SOC) and high yields simultaneously. However, there has to date been no research on the efficacy of CA practices for coping with the effects of climate change on rice-maize systems in Bangladesh. The Agricultural Production Systems sIMulator (APSIM) model was driven by 29 general circulation models (GCMs) to predict the effect of tillage on rice-maize productivity and SOC in conventional tillage (CT) vs. CA systems. The study periods considered were the baseline (1980–2009), mid- century (2040–2069) and end of century (2070–2099) under two Representative Concentration Pathways (RCPs; RCP4.5 and RCP8.5). Five climate models captured a representative subset of temperature and precipitation changes in the CMIP5 ensemble. CA emerged as more effective than CT in enhancing SOC and grain yield across all time periods and RCPs. Rice yields consistently increased across all time periods and RCPs due to CO₂ fertilisation. Maize yields decreased consistently across all time periods and RCPs due to increased temperatures, leading to a shortened growing season. Yields were lowest at end of century with RCP8.5.

Introduction

Rice and maize systems play a key role in providing food security in Bangladesh. Rice, maize, and wheat together comprise over 95% of cereal growing areas (Sarwar, 2021), and demand for maize is growing (Ali et al., 2008; Timsina et al., 2018). However, existing cultivation methods in rice-based systems (e.g. rice-wheat, and rice-maize systems) are labour, water, and energy-intensive (Gathala et al., 2020; Ladha et al., 2009; Erenstein et al., 2012). The deterioration of soil physical, chemical, and biological properties caused by puddling (tillage in flooded soil) during the rice phase, in conjunction with poor crop management methods, has resulted in declining soil fertility (Zhou et al., 2014; Alam et al., 2018). Puddling during the growing of transplanted rice also has negative impacts on subsequent upland crop growth and production (maize) due to changes in the soil physical characteristics, including soil compaction and poor soil structure (Gathala et al., 2011a). Furthermore, climate change is expected to exacerbate the region's water scarcity. (IPCC, 2014).

The APSIM model is used in this study to estimate the potential of rice-maize cultivation based on CA-principles and its impact on rice-maize productivity and soil organic carbon in Northwest Bangladesh. Furthermore, it will assist decision-makers in determining the future direction of agronomic systems and resource preservation in achieving food security under climate change. The particular objectives of this investigation were (i) to calibrate and evaluate the APSIM crop model for rice-maize systems under CA and CT management techniques and (ii) to assess the long-term impact of climate change and CA and CT management on rice-maize productivity and soil organic carbon (SOC) stock.

Materials and methods

Experimental site

A field experiment was undertaken in the experimental farm of the Bangladesh Agricultural Research Institute (BARI), Dinajpur, located in Bangladesh's northwestern region at 88.65–25°63' N latitude and 88°38' E longitude and 40 m above sea level

Description of the experimental datasets

To produce accurate simulation results for local conditions, it is necessary to gather the appropriate input data and parameters (daily climate data, crop management, experimental measurements, soil characteristics) and calibrate the cultivar coefficients (Jones et al., 2003). These parameters were taken from data published in Sarker et al. (2022) and used for model calibration and evaluation in our work.

Table 1. Description of experimental treatments.

Name of the treatments	Descriptions
PTR/CTM + 0% residue (CT)	Puddled Transplanted Rice – Conventional till Maize
DSR/STM + 50% residue (CA)	Direct Seeded Rice – Strip till Maize

APSIM calibration

The first step in the calibration process involved adjusting the crop phenological parameters (for maize: these are emergence, flowering, physiological maturity, and harvest; for rice, these are sowing, transplanting, panicle initiation, flowering, physiological maturity, and harvest), and the second step involved adjusting parameters representing the growth and yield characteristics of the tested crop varieties (grain growth rate, grain number) based on the experimental or estimated information. The genetic coefficients that impact the phenological development of maize include variables such as the period from emergence to the end of the juvenile stage (*tt_emerg_to_endjuv*), the duration from flowering to maturity (*tt_flower_to_maturity*), etc. was modified in accordance with the phenological data obtained from the field trial. In a similar manner, the genetic coefficients maximum grain number per head (*head_grain_no_max*) and period from flowering to start of grain filling (*tt_flower_to_start_grain*) were employed to match the measured grain yield.

The crop genetic coefficients were iteratively adjusted to reduce the RMSE between observed and simulated values of different crop phenological parameters and yield (days to anthesis, days to maturity, yield, biomass, etc.). For example, the genetic coefficient for grain growth rate was iteratively adjusted in the range from 8.2 to 10.2 in increments of 0.1 (Wang et al., 2018) with twenty one iterations. The best parameter value from this range (9.1) was selected due to its low RMSE between the observed and simulated yield. For the genetic coefficients of emergence to the end of the juvenile stage, the parameter value was adjusted iteratively in the range from 240 to 262 in increments of 1.0 (Arya et al., 2015). After twenty-three iterations, the best parameter value from this range (250) was chosen because it had the lowest RMSE between observed and simulated flowering days. Similarly, in the genetic coefficients for the flowering to maturity stage, the value of the parameter was adjusted iteratively in the range from 850 to 1000 in increments of 5.0 (Wang et al., 2018). The best parameter value from this range (960) was chosen after thirty one iterations due to its low RMSE between the observed and the simulated maturity days.

Table 2. Observations from experiments that were used to calibrate the model and their simulated values for CT treatment.

Crops	Years	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs
		Days to anthesis		Days to maturity		Yield (kg/ha)		biomass (kg/ha)	
Rice	2019	80	78	106	107	3903	3824	1054	8988
Maize	2019	103	101	162	161	7941	7989	18056	18189

Table 3. Observations from experiments that were used to calibrate the model and their simulated values for CT treatment

Crops	Years	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs
		Days to flowering		Days to maturity		Yield (kg/ha)		biomass (kg/ha)	
Rice	2019	74	72	99	100	4282	3740	9926	9078
Maize	2019	92	91	153	151	7547	7920	20573	18610

APSIM evaluation

One treatment from CT practices (PTR/CTM + 50% residue) and one treatment from CA practices (DSR/STM + 50% residue) was used to calibrate the model. To evaluate the two calibrations, the model was next evaluated using all other data for CT and CA (i.e. other years and treatments). The results of the simulated models were compared to the observed data for several variables, including crop phenology dates, grain yield, and dry matter, for both rice and maize.

Statistical evaluation methods used

The calibrated model was assessed by calculating the coefficient of determination (R^2) using the linear regression of observed against modelled data. The model performance was also evaluated through the comparison of the absolute root mean square error (RMSE, Eq. (1)), normalized root mean square error (RMSEn, Eq. (2)) and mean bias error (MBE, Eq. (3)) between simulated and observed values. The higher value of R^2 indicates a stronger agreement in the observed and simulated results. The root mean square error (RMSE) was computed using Equation (1):

$$RMSE = \sqrt{\sum_{i=1}^n \frac{(S_i - O_i)^2}{n}} \dots\dots\dots(1)$$

' S_i ' is simulated, ' O_i ' is the observed value, ' n ' is the number of pairs. A lower value of the root mean square error (RMSE) indicates that the model's performance is better. The nRMSE was determined by applying Equation (2):

$$RMSEn (\%) = \left(\frac{\text{Absolute RMSE}}{\text{Mean of the observed}} \right) \times 100 \dots\dots\dots(2)$$

The nRMSE provides a measure of the relative difference, expressed as a percentage, between the values that were observed and those that were simulated. (Soler et al., 2007).

Excellent predictions are indicated by values less than 10%, while values between 10 and 20% are considered to be good (Jamieson et al., 1991). The Mean Bias Error was determined by applying Eq. (3).

$$MBE = \frac{1}{n} \sum_{i=1}^n (S_i - O_i) \dots\dots\dots(3)$$

n denotes the total number of observations, S_i represents the predicted values, O_i indicates the measured values.

General circulation models (GCMs)

Future climate scenarios were derived from 29 general circulation models (GCMs) from the Fifth Coupled Model Inter-comparison Project [CMIP5] (Table 5). In the current study, A representative subset including 5 General Circulation Models (GCMs) was chosen from the group of 29 GCMs utilizing the Representative Temperature and Precipitation (T&P) Subsetting method (Ruane and McDermid 2017). Fig. 2 displays the five quadrants of the 29 GCMs that were so derived for the research location.

Table 4. Descriptions of the 29 GCMs used in this study to assess the effects of climate change (Ruane and McDermid 2017)

Symbols	GCM	Horizontal resolution
A	ACCESS1-0	$1.25^\circ \times 1.875^\circ$
B	BCC-CSM 1-1	$\sim 2.8^\circ \times 2.8^\circ$
C	BNU-ESM	$\sim 2.8^\circ \times 2.8^\circ$
D	CanESM2	$\sim 2.8^\circ \times 2.8^\circ$
E	CCSM4	$\sim 0.9^\circ \times 1.25^\circ$
F	CESM1-BGC	$\sim 0.9^\circ \times 1.25^\circ$
G	CSIRO-Mk3-6-0	$\sim 1.9^\circ \times 1.875^\circ$
H	GFDL-ESM2G	$\sim 2.0^\circ \times 2.5^\circ$
I	GFDL-ESM2M	$\sim 2.0^\circ \times 2.5^\circ$
J	HadGEM2-CC	$1.25^\circ \times 1.875^\circ$
K	HadGEM2-ES	$1.25^\circ \times 1.875^\circ$
L	INM-CM4.0	$1.5^\circ \times 2.0^\circ$
M	IPSL-CM5A-LR	$\sim 1.9^\circ \times 3.75^\circ$
N	IPSL-CM5A-MR	$\sim 1.3^\circ \times 2.5^\circ$
O	MIROC5	$\sim 1.4^\circ \times 1.4^\circ$
P	MIROC-ESM	$\sim 2.8^\circ \times 2.8^\circ$

Symbols	GCM	Horizontal resolution
Q	MPI-ESM-LR	$\sim 1.9^{\circ} \times 1.875^{\circ}$
R	MPI-ESM-MR	$\sim 1.9^{\circ} \times 1.875^{\circ}$
S	MRI-CGCM3	$\sim 1.1^{\circ} \times 1.125^{\circ}$
T	NorESM1-M	$\sim 1.9^{\circ} \times 2.5^{\circ}$
U	FGOALS-g2	$\sim 2.8^{\circ} \times 2.8^{\circ}$
V	CMCC-CM	$\sim 0.75^{\circ} \times 0.75^{\circ}$
W	CMCC-CMS	$\sim 1.875^{\circ} \times 1.875^{\circ}$
X	CNRM-CM5	$\sim 1.4^{\circ} \times 1.4^{\circ}$
Y	HadGEM2-AO	$1.25^{\circ} \times 1.875^{\circ}$
Z	IPSL-CM5B-LR	$\sim 2.5^{\circ} \times 1.26^{\circ}$
1	GFDL-CM3	$2^{\circ} \times 2.5^{\circ}$
2	GISS-E2-R	$2^{\circ} \times 2.5^{\circ}$
3	GISS-E2-H	$2^{\circ} \times 2.5^{\circ}$

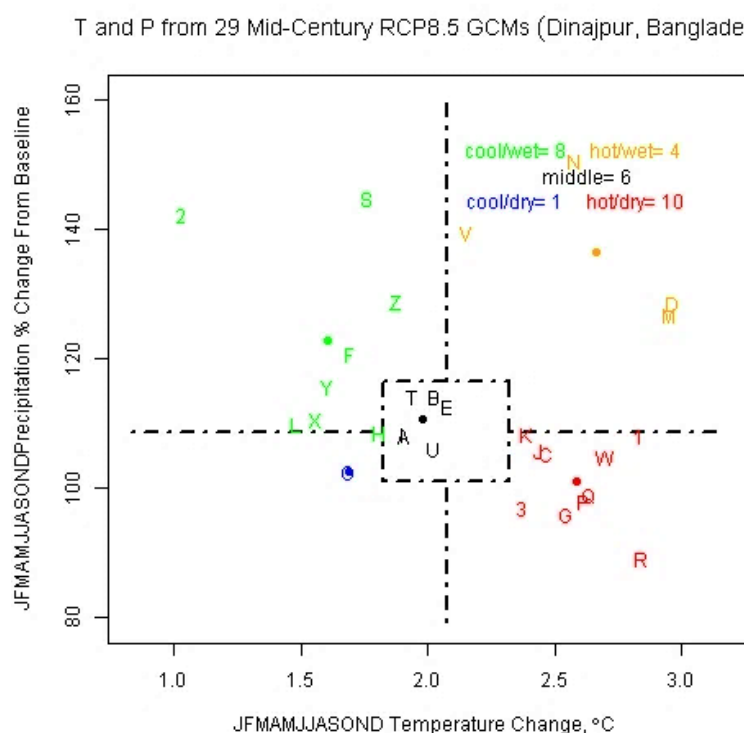


Fig. 1. Five quadrants of 29 general circulation models for the middle of the century and RCP8.5. Numbers 1 to 3 and the letters A to Z (26) stand for 29 GCMs. (as shown in Table 5), and their color corresponds to their classification. The dots show each category's median GCM value.

The General Circulation Model (GCM) that exhibits the anticipated change in temperature and rainfall closest to the median value within each quadrant has been chosen. These 5 GCMs were selected: D (CanESM2), Q (MPI-ESM-LR), F (CESM1-BGC), O (MIROC5) and B (BCC-CSM1-1), and they are hereafter referred to by the names associated with their Fig.2 quadrant, as shown in Table 6.

Table 5: GCMs chosen by subsetting for climate change effect study

Sl. No.	Quadrant	GCM
1	Hot Wet	CanESM2
2	Hot Dry	MPI-ESM-LR
3	Cool Wet	CESM1-BGC
4	Cool Dry	MIROC5
5	Middle	BCC-CSM1-1

Future climate scenarios

The mean seasonal rainfall, average maximum temperature (T max), and average minimum temperature (T min) were determined for the rice and maize growing seasons in the baseline using observed data and the future years with GCMs on an annual basis. According to the width of box plots, the RCP8.5 scenario (for both the mid and end of the century) had more projected seasonal rainfall, Tmax and Tmin variability during the rice and maize growing season than the RCP4.5 scenario

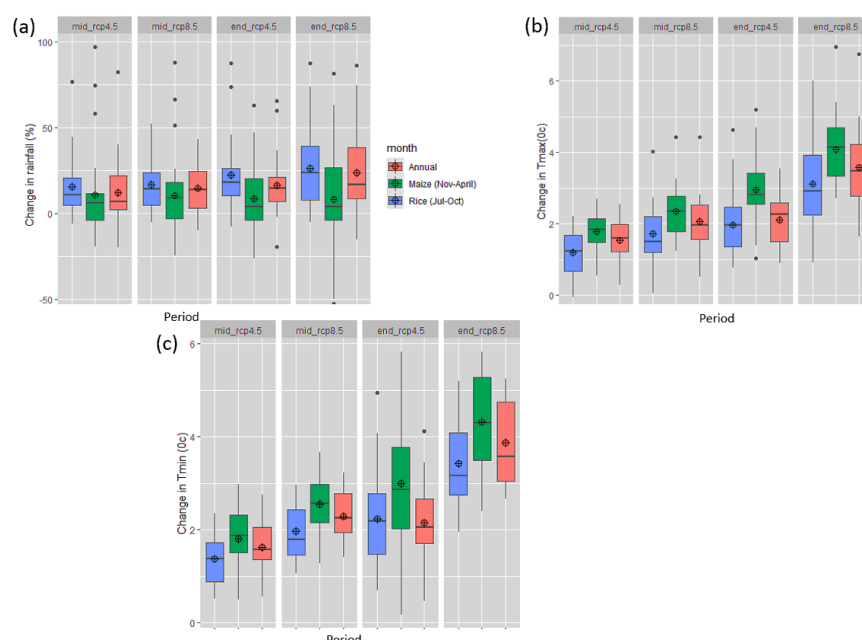


Fig. 3. Changes in (a) rainfall, (b) mean maximum temperature, and (c) mean minimum temperature anticipated to occur during the rice cultivation season and maize growing season, as well as on a yearly basis. The analysis is based on data from 29 General Circulation Models (GCMs) and encompasses four future scenarios: mid of the century RCP4.5, mid of the century RCP8.5, end of the century RCP4.5, and end of the century RCP8.5. The multi-model median and mean are shown by black lines and crosshairs in each box.

Results

Crop model evaluation

The model performed well in simulation of CT and CA rice and maize crops in terms of duration of the flowering, maturity, grain and biomass.

Table 6. Statistical comparison of APSIM performance with respect to observed versus simulated grain and biomass yields for the CT treatment in Dinajpur, Bangladesh

Crops	Xsim	Xobs	RMSE	nRMSE (%)	MBE	R ²
Rice						
Days of flowering	79	77	2.09	2.71	-2.0	0.89
Days of maturity	105	106	0.89	0.83	0.8	0.86
Grain	3764	3978	245	6.15	243	0.97
Biomass	9712	9627	240	2.49	-84	0.98
Maize						
Days of flowering	104	102	2.64	2.58	-2.2	0.98
Days of maturity	160	159	0.77	0.48	-0.6	0.90
Grain	8053	7640	561	7.34	-412	0.62
Biomass	17908	17057	920	5.39	-851	0.69

Table 7. Statistical comparison of APSIM performance with respect to observed versus simulated grain and biomass yields for the CA treatment in Dinajpur, Bangladesh

Crops	Xsim	Xobs	RMSE	nRMSE (%)	MBE	R ²
Rice						
Days of flowering	72	69	3.2	4.63	-3.2	0.90
Days of maturity	99	98	1.0	1.02	0.2	0.92
Grain	4045	3669	428	11.6	-406	0.67
Biomass	9331	8797	652	7.41	-534	0.69
Maize						
Days of flowering	93	94	1.26	1.34	1.2	0.97
Days of maturity	151	152	2.82	1.84	0.4	0.92
Grain	8674.6	7908	987	12.48	-766	0.71
Biomass	19874.4	17806	2099	11.78	-2067	0.65

Xsim, average of simulated values; Xobs, average of observed values; RMSE, absolute root mean squared error; RMSEn, normalized root mean squared error; Mean bias error.

Impact of projected climate on soil carbon dynamics

Tillage with residue retention methods had the highest influence on SOC stock in rice-maize cropping systems, according to the current study (Figs. 4 & 5). For all scenarios, the SOC value was higher under CA practices than that under CT.

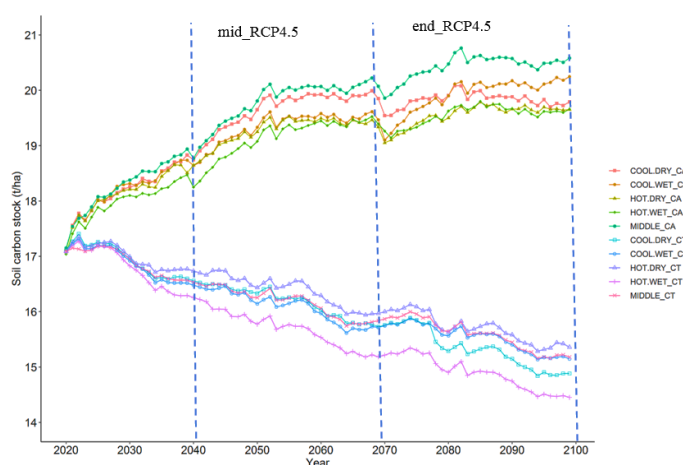


Fig. 4. Projected total soil carbon stock under different management scenarios CT vs CA in mid RCP4.5 and end RCP4.5 emission scenarios with five climates at 0-20 cm soil layer.

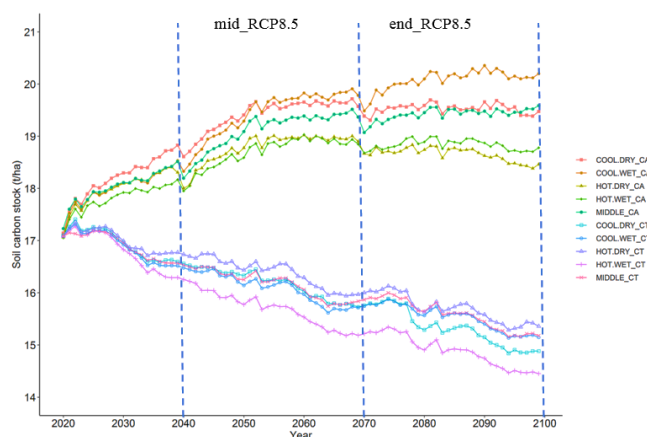


Fig. 5. Projected total soil carbon stock under different management scenarios CT vs CA in mid RCP8.5 and end RCP8.5 emission scenarios with five climates at 0-20 cm soil layer.

Effects of climate projections on phenology

For each of the future scenarios, the effects of climate change on phenology were simulated (mid RCP4.5 & end RCP4.5; mid RCP8.5 & end RCP8.5), with the findings given in Figs. 6 and 7. The range of days to anthesis changes for CT practices was between - 2 (Hot Dry) to +2 (Cool Wet) under RCP4.5 and +1 (Middle) to -3 (Hot Dry) in RCP8.5 throughout the mid century compared to the baseline (Fig. 6).

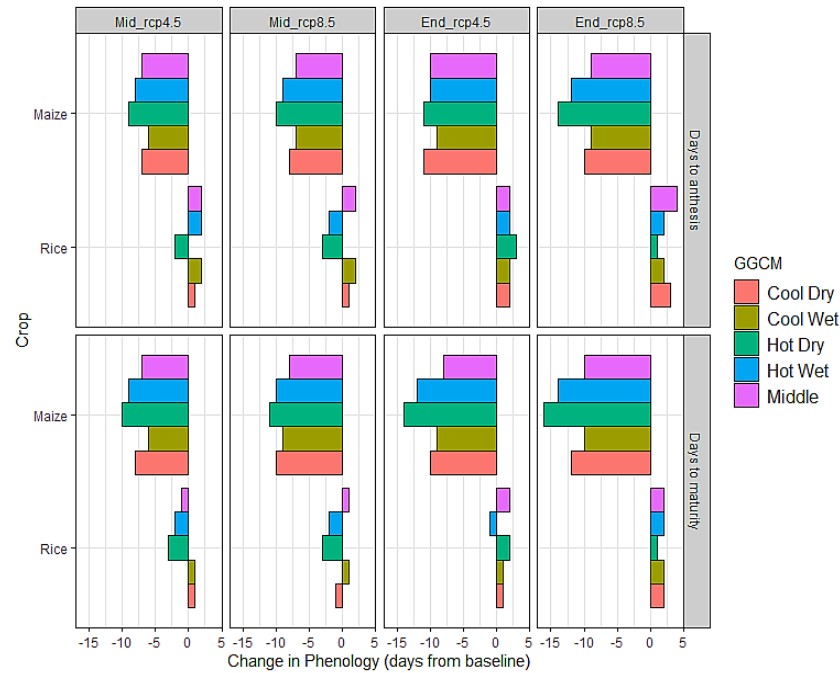


Fig. 6. The impact of projected climate conditions on the timing of flowering and maturity (phenology) relative to the baseline in the rice-maize cropping system at the middle and end of the century, under the RCP4.5 and RCP8.5 in CT practices.

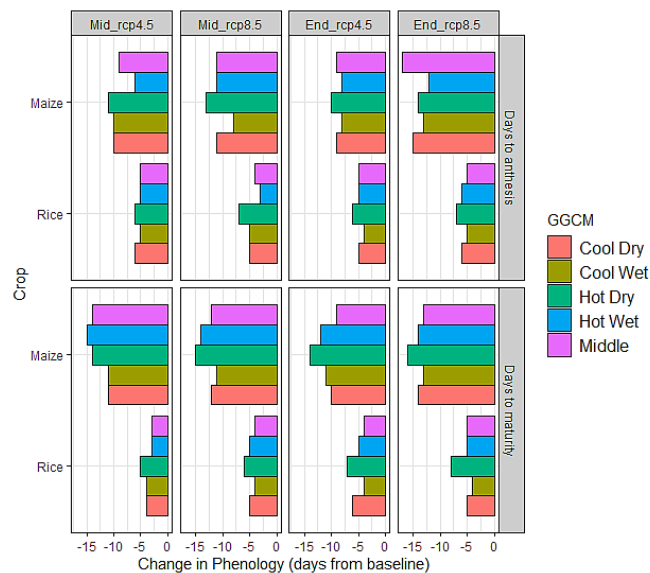


Fig. 7. The impact of projected climate conditions on the timing of flowering and maturity (phenology) relative to the baseline in the rice-maize cropping rotation at the middle and end of the century, under the RCP4.5 and RCP8.5 in CA practices

In the case of CA practices, rice anthesis was projected to advance by 5 (Middle) to 6 (Hot Dry) and 4 (Middle) to 7 (Hot Dry) days by mid-century under RCP4.5 and RCP8.5 respectively. The days to anthesis of maize were simulated to decrease by 11 (Hot Dry) to 7 (Hot Wet) and 8 (Cool Wet) to 13 days (Hot Wet) by mid century under RCP4.5 and RCP8.5 respectively. On the other hand, during the end century, it decreased by 8 (Cool Wet) to 10 (Hot Wet) days and 11 (Cool Wet) to 14 (Hot Wet) days in RCP4.5 and RCP8.5 scenarios.

The impact of projected climate change on yield

Five future climate models and two RCPs were used to simulate the effects of expected climate on CT practice yield, and the results are shown in box plots. (Fig.10). The mean baseline rice yield from 1980 to 2009 was 3477kg ha⁻¹. Rice yield was projected to increase by 5% to 8% under the RCP4.5 scenario at mid-century (range represents the maximum and lowest % simulated by 5 GCMs). (Fig.10).

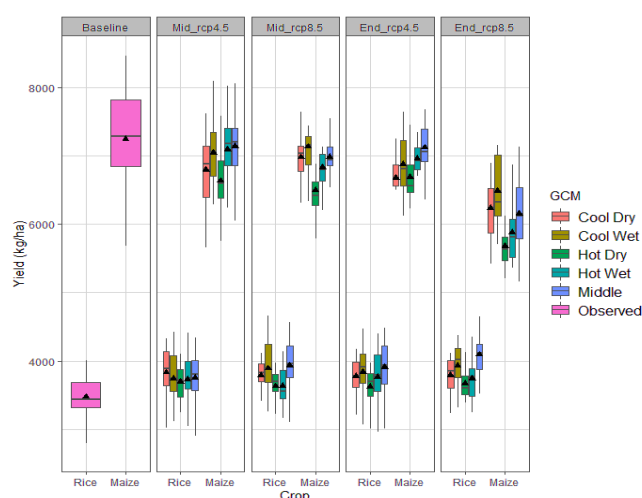


Fig. 10. Effect of projected climate on rice-maize crop yield in RCP4.5, RCP8.5, RCP4.5, and RCP8.5 for the middle and end of the century The black triangle and line within each box diagram represent the mean and median values for the past 30 years (CT).

The yield for maize was predicted to decrease between 10% and 20% relative to the baseline. Five future climate models and two RCPs were used to simulate the effects of projected climate on yield in the context of CA practices. The findings are shown as box plots. (Fig.11).

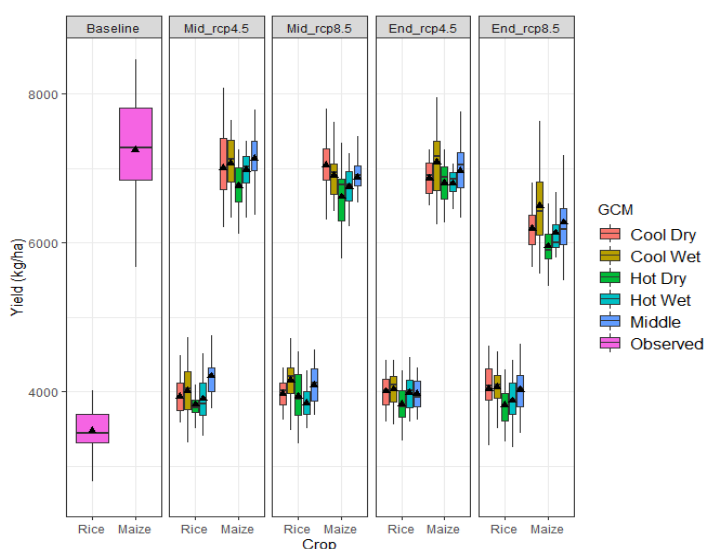


Fig. 11. Effect of projected climate on rice-maize crop yield in RCP4.5, RCP8.5, RCP4.5, and RCP8.5 for the middle and end of the century The black triangle and line within each box diagram represent the mean and median values for the past 30 years (CA).

Discussion

Impact of CA and future climate on soil organic carbon stock: Our findings showed that the SOC stocks increased in future under CA in all climate scenarios. In contrast, the SOC of the CT systems decreased over time. This finding showed the importance of strip tillage and residue retention as mulch in order to gain the advantages of CA.

Effects of climate projections on phenology: In the current study, temperature rise had a great influence on rice flowering in Cool Wet climates (slightly delayed) while it was advanced in Hot Dry climates under RCP4.5 and RCP8.5 over the mid century and end century period. In the case of maize in CT, under RCP4.5 and RCP8.5, the days of anthesis and maturity were advanced in all climate scenarios for the mid century and end century periods.

Effect on crop yield: This study showed that CA practices gave higher rice yields than CT practices, especially in Middle and Hot Dry climates. The fundamental reason is that CA methods improve biomass production, which allows for more residue to be left into the field and, as a result, increases crop productivity.

Conclusions

We were able to show how CA based practices help to make rice-maize production more resilient to climate change and increase the SOC content in the soil through the APSIM process-based cropping system model. The current study also reveals that the greatest increase in seasonal average Tmax and Tmin occurred during the maize season, negatively affecting maize yields. The severity of the decline in maize biomass and yield could be minimised by changing current agronomic management strategies, particularly those used in CA. To more comprehensively assess model and parameter uncertainty, multi-crop model and multi-GCM ensemble forecasts need to be tested in different soil and cultivar conditions across the region.

190.APSIM-MAIZE: A VALIDATION AND CALIBRATION TOOL FOR MAIZE CULTIVATED WITH VARYING NITROGEN LEVELS

Abstract

Maize cultivation, including nitrogen (N) management and crop modelling provides numerous benefits, such as increased yield, resource efficiency, climate resilience, research innovations and sustainable agriculture practices. In this aspect a field experiment was conducted at the On Farm Research Division (OFRD) research field, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur from October 2022 to April 2023 to evaluate the performance of APSIM model through calibration and validation on maize yields. The experiment was laid out in a randomized complete block (RCB) design with five treatments ie. N₀ - No nitrogen (control), N₁- Half of recommended nitrogen (125 kg N ha⁻¹), N₂- Recommended nitrogen (250 kg N ha⁻¹), N₃- 1.5 times of recommended nitrogen (375 kg N ha⁻¹) and N₄- 2.0 times of recommended nitrogen (500 kg N ha⁻¹) with three replications. In calibration, the observed grain yield, 11.95 ± 0.14 t ha⁻¹ (mean ± sd) and observed biomass yield, 24.62 ± 0.68 t ha⁻¹ (mean ± sd) was closely associated with the simulated grain yield (12.44 t ha⁻¹) and simulated biomass yield (24.96 t ha⁻¹) respectively. The high value of the correlation coefficient (R²) in validation for both maize yield (R² = 0.953) and biomass yield (R²=0.961) indicated a strong and consistent association between the observed and simulated data.

Introduction

Maize (*Zea mays* L.) comes in third behind rice and wheat as one of the most widely grown crops in the world in terms of overall output and planting area (Erenstein *et al.*, 2022). Worldwide it is being cultivated in over 170 countries representing an area of 193.7 million hectares (ha) with a productivity of 5.75 ton (t) ha⁻¹ (FAOSTAT, 2023). As Bangladesh is situated in a tropical monsoon region characterized by wide seasonal variations, it is an important maize grain-producing

region. The yearly production of maize for the year of 2022-2023 was around 45 lakh metric tons with an area of 4.4 lakh hectares (BBS, 2023). Maize has a promising future in Bangladesh because the country's average annual weather has benefited maize cultivation.

In the Bangladesh context, farmers face several challenges in maize cultivation. Among different obstacles, nitrogen (N) is a key factor for determining yield of maize. N management requires a multifaceted approach that addresses agronomic, environmental, and socio-economic factors. Precision agriculture techniques can be implemented, such as variable rate N application, can optimize fertilizer use efficiency and minimize N losses (Fiorentino et al., 2020).

Based on a field experiment, a maize simulation study is of significant practical value for rational industrial zoning and production management decision-making. Agricultural simulation models, such as the Agricultural Production Systems Simulator (APSIM) are able to convey agro-technology to farmers, policymakers, and planners (Keating *et al.*, 2003). To ensure the validity of the model performances, the parameterization and calibration of the APSIM-Maize models are required for new cultivars, settings, and subsequent model evaluations (Ahmed *et al.*, 2014). Considering mentioned significance, the current research was undertaken with the following objectives:

- To estimate the variation of maize yield under different N rates using the APSIM-MAIZE model.
- To assess the capacity of the APSIM-MAIZE model for simulating maize crop performance

Materials and methods

Experimental site

The present piece of research was carried out at the field of the OFRD, BARI, Joydebpur, Gazipur.

Soil

Soil was strongly acidic in reaction with low status of organic matter, low moisture holding capacity and low fertility level. The land was flat, well drained and above flood level (medium high land). A composite soil sample was collected from 0-15 cm depth of the experimental plot before applying any fertilizer and was analyzed for physical and chemical properties.

weather

The experimental plot is under subtropical climate characterized by moderate high temperature and heavy rainfall during kharif season (April to September) and scanty rainfall with moderately low temperature during rabi season (October to March). Weather data were collected from the Bangladesh Meteorological Department (BMD), Gazipur station.

Experimental treatments

The Following treatments were included in the experiments:

- N₀ - No nitrogen (control)
- N₁- Half of recommended nitrogen (125 kg N ha⁻¹)
- N₂- Recommended nitrogen (250 kg N ha⁻¹)
- N₃- 1.5 times of recommended nitrogen (375 kg N ha⁻¹)
- N₄- 2.0 times of recommended nitrogen (500 kg N ha⁻¹)

Plant material

BARI Hybrid Maize - 16 was the used variety in the experiment.

Data collection

Data on the following plant characters, yield and yield components were collected from the sample plants of each plot.

- i. Plant height (cm)

- ii. Cob length (cm)
- iii. Cob diameter (cm)
- iv. Number of grains cob⁻¹
- v. Weight of 1000-grains (g)
- vi. Grain yield and biomass at harvest (t ha⁻¹)
- vii. Stover yield (t ha⁻¹)
- viii. Biological yield (t ha⁻¹)

Crop modelling

APSIM version used

The APSIM 7.10 model was used to simulate the production of maize crops under different N rates provided a dynamic cropping systems modelling framework, which contained interconnected modules of key farming system components to be plugged in to simulated biophysical process in the systems (Holzworth *et al.*, 2014; Keating *et al.*, 2003; McCrown *et al.*, 1996).

APSIM parameterization

Parameterization was done by assigning values to model parameters that represented the characteristics and behavior of specific crops, soils, and management practices. Model parameters like physiological parameters (e.g., growth rates, phenology), soil properties (e.g., texture, organic matter) and management inputs (e.g., planting date, irrigation, fertilization) (Keating *et al.*, 2003) were used in the APSIM model software as by default data. Parameter values were obtained from previous field experiments, literature reviews and expert knowledge. APSIM made a comprehensive database of default parameter values, but site-specific data which improved model accuracy (Holzworth *et al.*, 2014). Figure 1 displayed the schematic illustration of the APSIM model.

APSIM calibration

Calibration was done by adjusting model parameters to improve the match between simulated and observed data, especially when discrepancies were identified during validation (Keating *et al.*, 2003). Optimization techniques, such as trial-and-error and more advanced algorithms were used to find parameter sets that minimized the difference between simulated and observed values (Holzworth *et al.*, 2014). Calibration was performed cautiously to avoid overfitting the model to specific datasets and the calibrated parameters were justified based on physiological and agronomic principles (Thorburn *et al.*, 2001). In the calibration process, the APSIM model was run with best possible guess values and then model outputs were compared with observed data (crop development stages, grain yield, biomass, soil water, soil NO₃-N) from the selected treatments and the process was repeated with re-estimated values until a satisfactory performance in simulating the output variables of interest (such as, yield) was achieved (Chaki *et al.* 2022).

APSIM validation

Validation was done by assessing the model's performance by comparing simulated results with observed data from independent field experiments (Holzworth *et al.*, 2014, Thorburn *et al.*, 2001). Statistical measures such as root mean square error (RMSE), coefficient of determination (R²) were taken out from the simulated value and those were biased to evaluate the agreement between simulated and observed values. Validation ensured that the model accurately represented real-world processes and helped to identify areas for improvement (Robertson *et al.*, 2002). The well parameterized and calibrated APSIM model was validated against the experimental datasets to check the accuracy of the model's calibration.

Results

The recorded observations in accordance with the purpose of the research were presented and a probable discussion of the results with a probable rationale and applicable interpretation was

put together under this chapter. This portion was described with three different sections. In the first section, conventional effects of treatments on the study place was described, the second section deals with the calibration and validation of the APSIM model. Lastly, the final section analyzed the simulated results for combined effects of the previous two sections.

Evaluation of APSIM-Maize

Calibration

Phenology: APSIM-Maize crop module successfully simulated phenological development stages such as, sowing, emergence, end of juvenile, floral initiation, flowering, physiological maturity and harvest ripe. After calibration, there were good agreements between simulated and observed dates of phonological development stages for selected treatments. From the calibrated graph (Figure 1) it could be interpreted that the observed emergence occurred 9 days after sowing (DAS), however the simulated emergence date was earlier. The observed end of juvenility occurred 1-2 days after the simulated stage and the simulated dates of the later three stages flowering, physiological maturity and harvest ripe were almost the same as observed .

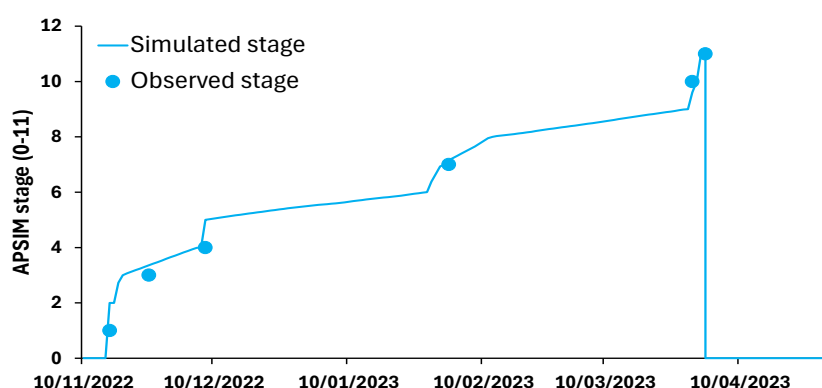


Figure 1. Calibration of APSIM in simulating crop phenological development of maize grown under recommended N management. Simulated data are shown as continuous lines, measured data as discrete points. The Y-axis number refers to crop growth stages, with “0” being sowing, and “11” being harvest.

Biomass and grain yield: There was generally good agreement between simulated and observed grain yield and biomass yield over time which was illustrated in Figure 2. The observed grain yield, $11.95 \pm 0.14 \text{ t ha}^{-1}$ (mean $\pm$ sd) and observed biomass yield, $24.62 \pm 0.68 \text{ t ha}^{-1}$ (mean $\pm$ sd) was closely associated with the simulated grain yield (12.44 t ha^{-1}) and simulated biomass yield (24.96 t ha^{-1}) respectively.

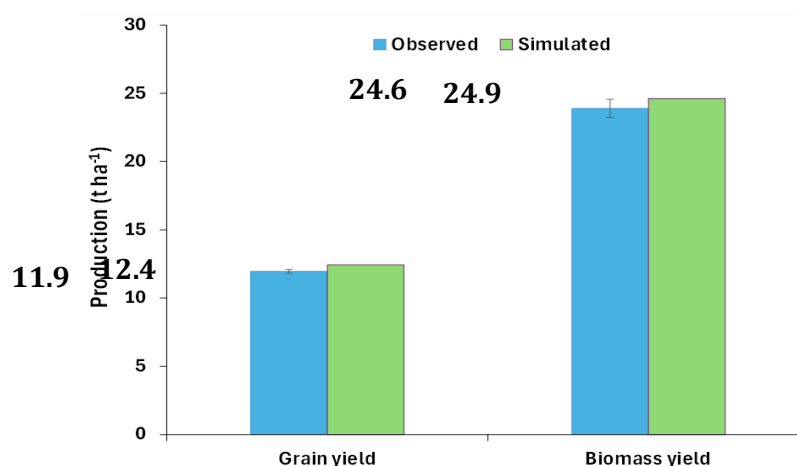


Figure 2. Calibration of APSIM in simulating grain and biomass production for recommended rate of N treatment.

Validation

Once calibrated, the model was undergone rigorous validation using independent datasets to ascertain its predictive accuracy across various N rates. Figure 3(a) under-predict the observed biomass yield with control N treatment; however, the model reasonably simulated the grain yield. The other four illustration, 3(b), 3(c), 3(d), 3(e) were presented under half of recommended, recommended, 1.5 times of recommended and 2.0 times of recommended N dose. The observed grain yield data of half of recommended dose ($8.94 \pm 0.21 \text{ t ha}^{-1}$), recommended dose ($11.95 \pm 0.14 \text{ t ha}^{-1}$), 1.5 times of recommended dose ($12.19 \pm 0.84 \text{ t ha}^{-1}$) and 2.0 times of recommended dose ($12.33 \pm 0.35 \text{ t ha}^{-1}$) of N and the simulated grain yield data of half of recommended dose (9.68 t ha^{-1}), recommended dose (12.44 t ha^{-1}), 1.5 times of recommended dose (12.95 t ha^{-1}) and 2.0 times of recommended dose (12.97 t ha^{-1}) of N were strongly correlated. Similarly, the observed biomass yield at harvest of half of recommended dose ($18.32 \pm 0.14 \text{ t ha}^{-1}$), recommended dose ($24.62 \pm 0.68 \text{ t ha}^{-1}$), 1.5 times of recommended dose ($25.17 \pm 0.27 \text{ t ha}^{-1}$) and 2.0 times of recommended dose ($25.56 \pm 0.50 \text{ t ha}^{-1}$) of N and the simulated biomass data of half of recommended dose (18.32 t ha^{-1}), recommended dose (24.96 t ha^{-1}), 1.5 times of recommended dose (25.16 t ha^{-1}) and 2.0 times of recommended dose (25.27 t ha^{-1}) of N were also strongly associated. The overall interpretation of observed and simulated datasets of grain yield and biomass yield were simulated well by the APSIM model.

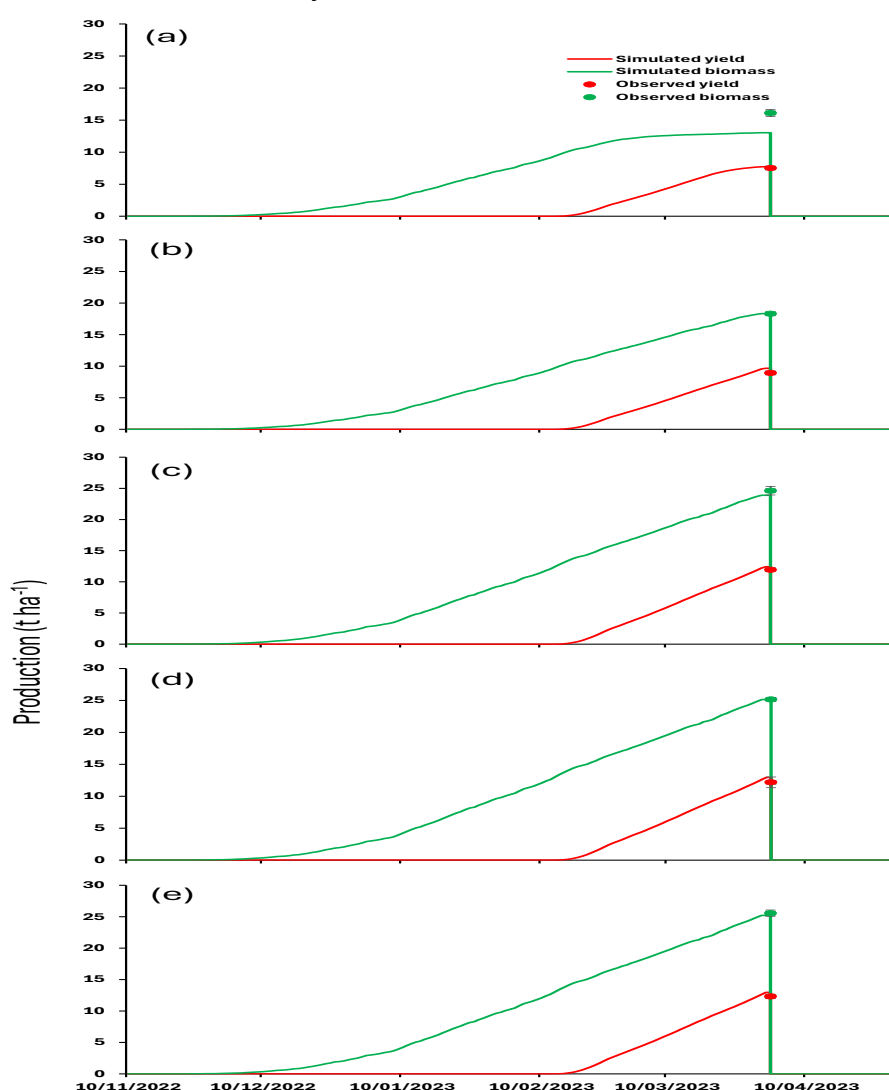


Figure 3. Comparison between measured and simulated crop production across the treatments. Simulated data are shown as continuous lines (solid red line- grain yield; solid green line- above-ground biomass), measured data as discrete points (green - biomass; red - grain yield) with

associated error bars (one standard deviation on either side of the mean). Graphs (a to e) refer to the N rates (control, half of recommended dose of N, recommended dose of N, 1.5 times of recommended dose of N and 2.0 times of recommended dose of N) for maize crop.

The overall model validation was performed using the statistical analysis tool Linear regression. It was initially used to compare paired data points for measured and simulated aboveground biomass and grain yield. The slope (α), intercept (β), and coefficient of correlation (R^2) of the linear regression were computed. When the value of the correlation coefficient (R^2) in model validation became more than 0.7, it indicated a good correlation between observed and simulated datasets. The correlation coefficient (R^2) was high for both calibration and validation datasets of grain and biomass production (grain, $R^2 = 0.953$; biomass, $R^2 = 0.961$), indicating that there was a very strong correlation between them (Figure 4).

For both calibration and validation sets, the grain and biomass yield of maize was closely associated with the simulated value. The model's performance for maize in terms of the evaluation parameters (calibration and validation) was judged to be satisfactory.

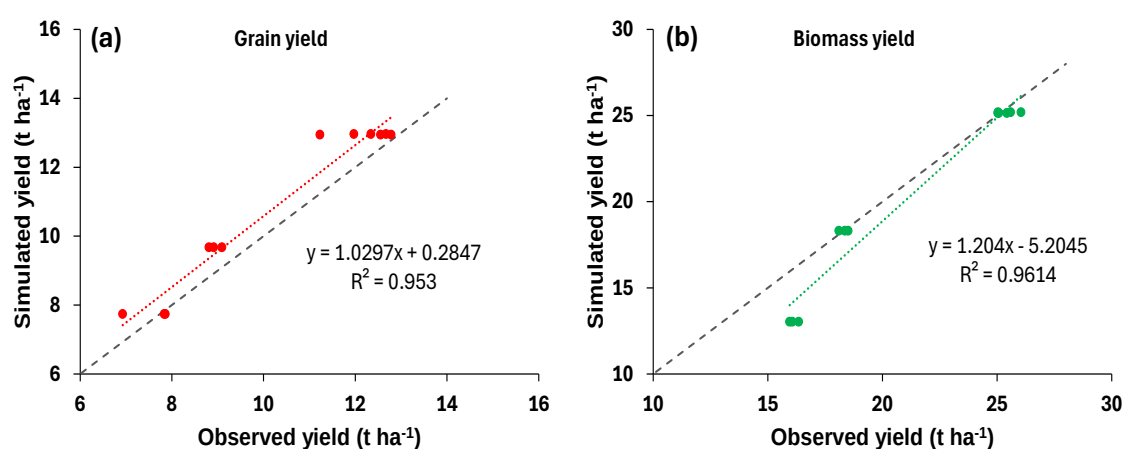


Figure 4. Overall validation performance of APSIM in simulating grain and biomass production across the rest of the treatments.

Discussion

The APSIM-Maize model performed well in terms of simulating biomass, grain yield and different phenological stages. The results of the model evaluation indicated that the model could be used for the preliminary evaluation of crop management and cropping system options involving maize in Bangladesh. There was a strong correlation between the simulated and observed data for every parameter evaluated using APSIM model (Jun-fang *et al.*, 2018; Gaydon *et al.* 2017). The present study computed the correlation coefficient (R^2). For grain yield it was 0.953 and for biomass R^2 value was 0.961 indicating that there was a very strong correlation between observed and simulated datasets. Sarkar *et al.* (2022) reported that the high R^2 value for grain (0.80) and for biomass (0.98) predicted that the APSIM model performance was satisfactory in terms of evaluating the calibration and validation of field datasets. Thus, the present study agreed with the findings. The APSIM-Maize model has been calibrated and validated successfully. The model is now ready for scenario analysis- e.g., optimization of N rates for maize, greenhouse gas emissions, climate change studies, etc.

Conclusion

This research showed that APSIM performed in a statistically robust manner with calibration and validation in simulating cropping system performance of maize over a wide range of N management practices in Bangladesh. The calibration and validation process of the APSIM maize model has yielded promising results, demonstrating its proficiency in accurately simulating maize growth and yield under varying N. The successful calibration and validation of the APSIM maize model signified its reliability as a predictive tool for farmers, researchers, and

polymakers. Its ability to accurately simulate crop growth and yield enables informed decision-making, leading to optimized resource management, enhanced productivity, and improved agricultural sustainability. From this study, it can be concluded that maize production can have a more adaptable, productive and sustainable agricultural future by implementing potent advanced APSIM modelling approaches.

191. EVALUATION OF APSIM MODEL FOR SIMULATING YIELD OF *BORO* RICE UNDER DIFFERENT NITROGEN RATES

Abstract

Rice is an important cereal crop globally, cultivated in several climatic zones, and serves as a staple food for over 165 million people in Bangladesh. Rice cultivation, including nitrogen (N) management and crop modelling provides numerous benefits, such as increased yield, resource use efficiency, climate resilience, research innovations and sustainable agriculture practices. In this respect, a field experiment was conducted at research field of On Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur from November 2022 to May 2023 to study the effect different N rates on yield performance of *boro* rice and to evaluate the capacity of Agricultural Production Systems Simulator (APSIM) in simulating the yield of *boro* rice under different N fertilizer management. Five N treatments viz. control N (0 kg ha^{-1}), half of recommended dose of N (75 kg ha^{-1}), recommended dose of N (150 kg ha^{-1}), 1.5 times of recommended dose of N (225 kg ha^{-1}) and two times of recommended dose of N (300 kg ha^{-1}) were used in the study. The simulated grain yield (7.56 t ha^{-1}) and biomass yield (16.08 t ha^{-1}) obtained from APSIM model calibration were closely associated with the observed grain yield ($7.13 \pm 0.251 \text{ t ha}^{-1}$) and biomass yield ($15.25 \pm 0.302 \text{ t ha}^{-1}$) at recommended of N (150 kg ha^{-1}). The coefficient of correlation for grain yield ($R^2=0.9399$) and biomass yield ($R^2=0.9261$) were observed from validation of the model. The *boro* rice grain and biomass yield for both the calibration and validation showed an excellent relationship with the simulated value.

Introduction

Rice is the staple food of about 165 million people of Bangladesh. It covers about 75% of the total-cropped area (Nasim *et al.*, 2018). *Boro* rice plays a crucial role in ensuring food security in regions where water availability fluctuates significantly. The yearly production of *boro* for the year of 2022-2023 was around 42.6 lakh metric tons with an area of 50 lakh hectares (BBS, 2023). This rice is characterized by its ability to withstand colder temperatures and is typically grown during the dry winter season, utilizing irrigation systems to maintain water supply.

N management in *boro* rice continues to be a topic of research and innovation to improve crop productivity while minimizing environmental impacts (Paul *et al.*, 2020). Managing N effectively in *boro* rice cultivation is crucial for maximizing yields, minimizing environmental impact, and ensuring sustainable agricultural practices. This helps in synchronizing nitrogen availability with the crop's demand, reducing losses through leaching, volatilization, and denitrification. N availability during this critical stage supports panicle development and grain filling. In some cases, a final application of N may be applied post-flowering to support grain filling and maximize yield potential. However, excessive N during this stage can lead to lodging and other agronomic issues, so caution is advised (Mohanty *et al.*, 2019).

Modelling tools and decision support systems are being developed to assist farmers in optimizing N management decisions (Matthies *et al.*, 2007). APSIM model is one such model which allows versatile specification of farming systems (Holzworth *et al.*, 2014). This adds value to system understandings gained from shorter experimental studies. APSIM is a comprehensive model developed to simulate biophysical process in Agricultural production systems. Crop model had been used to assess the impact of different nitrogen level on *boro* rice yield in different aspect of *boro* rice production.

Recent agricultural research projects in Asia have made it easier to evaluate the APSIM model comprehensively, identifying its advantages, disadvantages, and top development goals. Gaydon *et al.*, (2021) evaluated management options for crop production in Asia and their research made augmentation of production systems of crop. In prospect of Bangladesh use of APSIM model particularly for *boro* rice is

is not enough. But application of this model for *boro* rice cultivation is crucial for further prediction. Based on mentioned issues it is hypothesized that APSIM model in production system can simulate the yield of *boro* rice. The research was undertaken with the following objectives.

Research Objectives:

- i. To assess the effect of different N- fertilizer management on *boro* rice yield.
- ii. To evaluate the capacity of APSIM in simulating the yield of *boro* rice under different nitrogen fertilizer management.

Materials and methods

Description of the model (APSIM v7.10)

A computer-based modelling program called APSIM simulates cropping systems by combining organizational and biophysical modules into a single core engine. Although the effects of pests and diseases on crop performance are not taken into account, the crop modules (APSIM rice) can simulate crop phenology, biomass production, yield, and nitrogen accumulation in response to environmental variables like temperature, solar radiation, soil water, and nitrogen supply. Additionally, according to Keating *et al.* (2003), this model can replicate the long-term effects on land productivity of the existing crop residues and manure management procedures. The soil, water, and soil N modules (SOILN, Surface OM, and SOILWAT) as well as the rice and maize modules were used to configure APSIM (version 7.10) in this study. Initially concentrating on cropping systems in Australia, APSIM has developed into an agricultural systems model that is currently utilized in many biophysical conditions and around the globe for a variety of cropping and management systems (Holzworth *et al.*, 2014). Gaydon *et al.* (2017) conducted the most recent and thorough APSIM evaluation for Asian rice-based systems.

Experimental site and soil

The experimental field is part of the Madhupur Tract Agro-ecological Zone (AEZ-28) and was situated at 23° 59'8" N latitude and 90° 24'36" E longitude). It was non calcareous dark grey floodplain under the Chhahata series of red brown terrace soil. The land type was medium high land with sandy loam in texture. The physical and chemical characteristics of the soil of the experimental field have been presented in Appendix I.

Climate

The climate of the locality is tropical in nature and is characterized by high temperature and heavy rainfall during Kharif season (April to September) and scanty of rainfall associated with moderately low temperature during Rabi season (October to March). Daily maximum and minimum temperatures, rainfall, and solar radiation were recorded daily using an automatic weather station (Regional Weather Station, Gazipur) installed at the experimental sites. Long term climate data (1985-2023) for Gazipur were collected from the weather records of the Bangladesh Meteorological Department (BMD). The meteorological data recorded during research period have been presented in Appendix II.

Experimental Treatments

Treatments: Five N rates

No - No nitrogen (control)

N₁ - Half of recommended nitrogen (75 kg ha⁻¹)

N₂ - Recommended nitrogen (150 kg ha⁻¹)

N₃ - 1.5 times of recommended nitrogen (225 kg ha⁻¹)

N₄ - 2.0 times of recommended nitrogen (300 kg ha⁻¹)

Calibration of APSIM

The crop phenological parameters (emergence, flowering, physiological maturity, and harvest for maize, and sowing, transplanting, panicle initiation, flowering, physiological maturity, and harvest for rice) were adjusted in the first step of the calibration process. Based on the measured experimental or estimated data, the second step involved adjusting parameters representing the growth and yield characteristics of the tested crop varieties (grain growth rate, grain number). Based on the phenological data gathered from the field experiment, the genetic coefficients that affect the phenological development of *boro* rice, such as the length of time from emergence to end of juvenile and the length of time from blooming to maturity, were changed. Optimization techniques, such as trial-and-error or more advanced algorithm, are employed to find parameter sets that minimize the difference between simulated and observed values Holzworth *et al.* (2014). In the calibration process, the APSIM model was run with best possible guess values and then model outputs were compared with the first season of observed data such as crop developmental stages, grain yield, biomass, soil water, soil NO₃-N from the selected treatments and the process repeated with re-estimated values until a satisfactory performance in simulating the output variables of interest (such as yield) was achieved (Chaki *et al.*, 2022).

APSIM validation

To verify the accuracy of the model's calibration, the well-parameterized and calibrated (using data from selected treatments from the first year) APSIM model was evaluated against the experimental datasets from all treatments in the second year as well as the remaining treatments from the first year. A variety of output variables, such as crop phenology dates, accumulated biomass over time, grain yield, soil NO₃-N dynamics in the top two soil layers (0–15 cm and 15–30 cm), and soil water content in two soil layers (15–30 cm and 60–75 cm), were compared between the results of the simulated model and the observed data set for the crop *boro* rice for simulation.

Results

Evaluation of APSIM-Boro rice

Crop phenology: Crop phenological development in *boro* rice was significantly influenced by variations in N rates. In simulation, BRR1 dhan100 rice variety was calibrated by varying the APSIM crop phenology parameters until the modelled phenology dates matched the observed dates. APSIM-Oryza can calculate phenological stages based on thermal time accumulation. APSIM-Oryza was successfully simulated with growth stages in accurately such as, floral initiation flowering physiological maturity and harvesting (Figure 1).

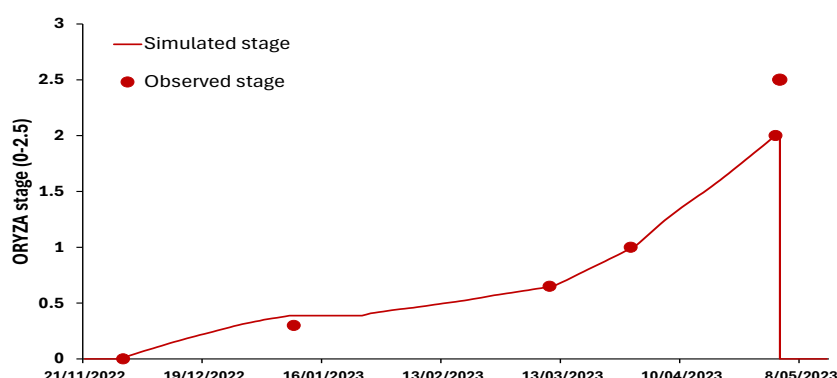


Figure 1. Calibration of APSIM in simulating crop phenological development of rice grown under recommended N management. Simulated data are shown as continuous lines, measured data as discrete points. The Y-axis number refers to crop growth stages, with “0” being sowing, and “2.5” being harvest.

Grain yield: There was good agreement between simulated and observed yield for the recommended N treatments selected for calibration purpose. The observed grain yield of $7.13 \pm 0.251 \text{ t ha}^{-1}$ (mean $\pm$ SD) was closely associated with the simulated (Figure 2).

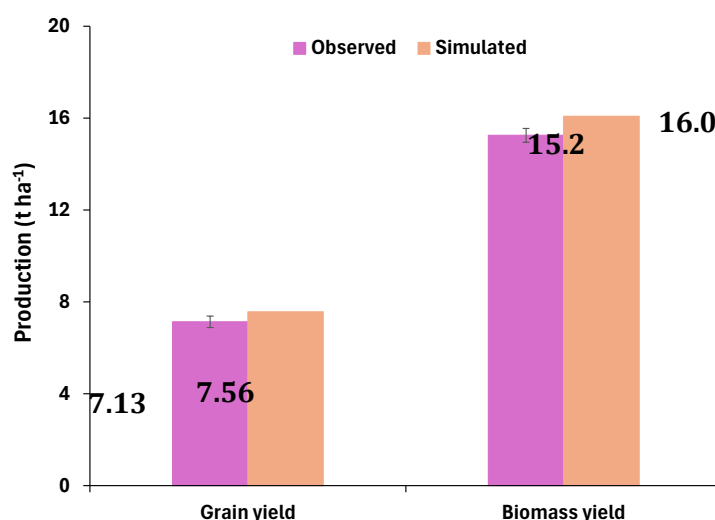


Figure 2. Calibration of APSIM in simulating grain and biomass production for recommended N rate treatment.

Biomass yield

There was generally good agreement between the simulated and observed of biomass at harvest. The observed biomass yield of $(15.25 \pm 0.302 \text{ t ha}^{-1})$ (mean $\pm$ sd) t ha^{-1} was closely associated with the simulated yield of 16.08 t ha^{-1} (Figure 5).

Validation for grain yield and biomass

The observed and simulated yields for crops were compared as a time series for all the treatments imposed in the trials. The graphs (Figure 6 a-e) illustrate the performance of APSIM in simulating crop production in the *boro* rice, (each with five N levels are shown. From Figure 6(a) it was shown that simulated grain yield and biomass matched well even control N treatment. The other four illustration, 6(b), 6(c), 6(d), 6(e) were presented under half of recommended, recommended, 1.5 times of recommended and 2.0 times of recommended N dose. The observed grain yield data of half of recommended dose ($5.96 \pm 0.335 \text{ t ha}^{-1}$), recommended dose ($7.13 \pm 0.251 \text{ t ha}^{-1}$), 1.5 times of recommended dose ($7.4 \pm 0.436 \text{ t ha}^{-1}$) and 2.0 times of recommended dose ($7.64 \pm 0.67 \text{ t ha}^{-1}$) of N and the simulated grain yield data of half of recommended dose (6.08 t ha^{-1}), recommended dose (7.563 t ha^{-1}), 1.5 times of recommended dose (7.796 t ha^{-1}) and 2.0 times of recommended dose (8.03 t ha^{-1}) of N were strongly correlated. Similarly, the observed biomass data of half of the recommended dose ($13.12 \pm 1.058 \text{ t ha}^{-1}$), recommended dose ($15.25 \pm 0.302 \text{ t ha}^{-1}$), 1.5 times of recommended dose ($15.83 \pm 0.924 \text{ t ha}^{-1}$) and 2.0 times of recommended dose ($16.06 \pm 17.61 \text{ t ha}^{-1}$) of N and the simulated biomass data of half of recommended dose (13.75 t ha^{-1}), recommended dose (16.08 t ha^{-1}), 1.5 times of recommended dose (17.07 t ha^{-1}) and 2.0 times (17.61 t ha^{-1}) of recommended N dose were also strongly associated. APSIM model successfully simulated grain yield and biomass for the rest of the treatments of N.

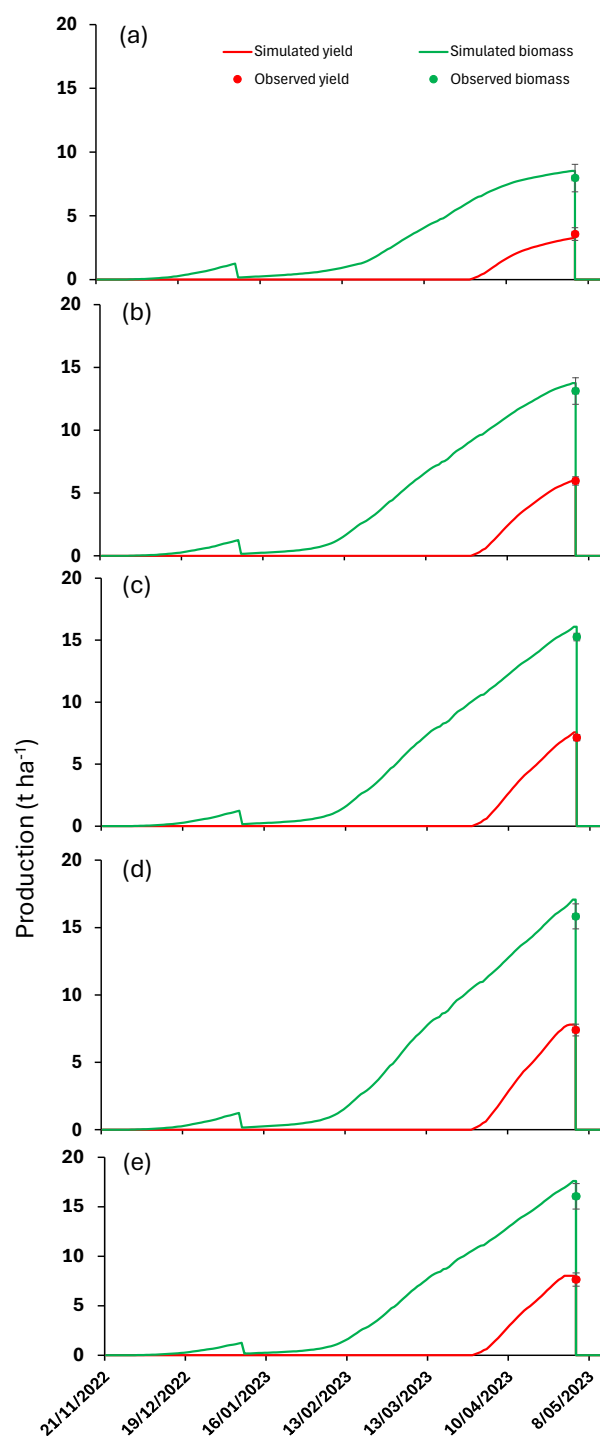


Figure 3. Comparison between measured and simulated crop production across the N treatments. Simulated data are shown as continuous lines (solid red line- grain yield; solid green line- above-ground biomass), measured data as discrete points (green - biomass; red - grain yield) with associated error bars (one standard deviation on either side of the mean). Graphs refer to the N rate (0, 0.5times, 1.0 times, 1.5 times and 2.0 times of recommended N for rice crop).

Overall Model Validation

For validation the APSIM model simulated outputs (grain and biomass yield at harvest) were compared with observed values for a range of crop parameters from all treatments except the recommended N treatment which was used for model calibration. From the figure (Figure 4) the vertical axis shows the simulated yield (t ha^{-1}) and the horizontal axis shows the observed yield (t ha^{-1}).

The slope (α), intercept (β), and coefficient of correlation (R^2) of the linear regression were computed. When the value of the correlation coefficient (R^2) in model validation became more than 0.7, it indicated strong correlation between observed and simulated datasets. The coefficient of correlation ($R^2=0.9399$) for grain yield and biomass yield ($R^2=0.9261$). The rice grain and biomass yield for both the calibration and validation showed an excellent relationship with the simulated value. Regarding the evaluation parameters (validation and calibration), the model's performance for rice was considered acceptable.

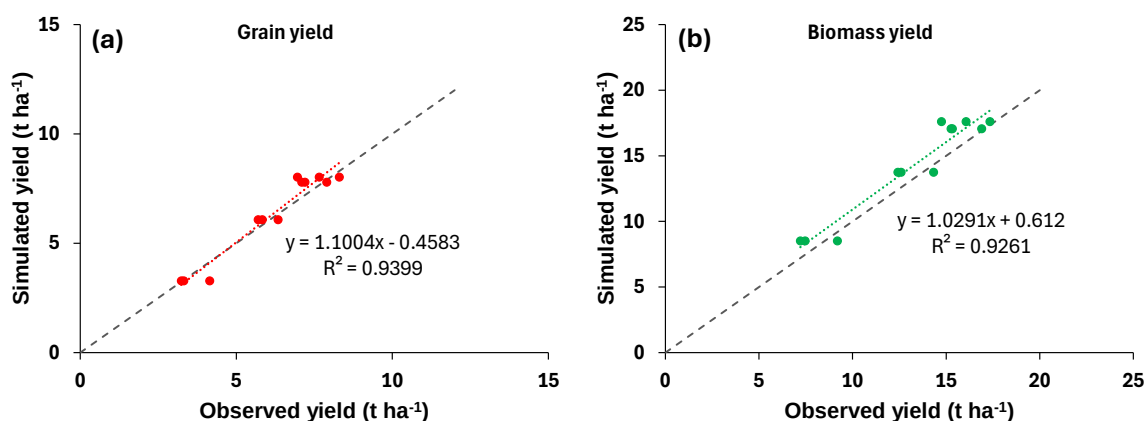


Figure 4. Overall validation performance of APSIM in simulating grain and biomass production of rice across the rest of the treatments.

Discussion

The overall performance of APSIM in simulating *boro* rice crop performance for N treatment was very good. However, there were some conditions under which the model did not perform well in the simulation of N controlled treatment. Grain yield predications were good for rest of the N treatments. An experiment was conducted by Ahmed *et al.* (2023) using APSIM model that was run for different sowing dates using long-term (1981–2021) historical weather data. The evaluations showed that the model performance was satisfactory in predicting crop phenology, total biomass and grain yields. Like most other crop models, APSIM-Oryza calculated phenological stages based on thermal time accumulation (cumulative degree days) (Bouman and Van Laar, 2006). APSIM model is used to simulate performance of conservation agriculture (CA) that report a comprehensive evaluation of the capacity of APSIM for simulating the performance of CA and cropping practices under a diverse range of tillage crop establishment options residue, N rates, and irrigation practices from two sites in the differed in soil type, water table dynamics, and agro-climatic conditions (Chaki *et al.*, 2022). In this study, there was generally an effective relation between simulated and observed accumulation of biomass and grain yield over time.

Conclusions

In calibration and validation, the observed data was significantly related with the simulated data under different N rates which indicated that the performance of APSIM model was satisfactory. The higher correlation coefficient values for grain yield ($R^2=0.9399$) and biomass yield ($R^2=0.9261$) were observed in validation also proved the remarkable acceptance of crop modelling. The performance, dependability, and application of the model in guiding agricultural decision-making for rice production systems can be developed by using APSIM. Finally, APSIM model can be used in investigating the effect of N and crop yield forecasting with the calibrated and validated *boro* rice variety at other locations of Bangladesh.

192. PARAMETERISATION, CALIBRATION, AND VALIDATION OF APSIM-SUNFLOWER FOR VARIOUS SURFACE DRAINAGE DEPTHS IN SOUTHERN BANGLADESH

A J MILA¹, P L C PAUL², A K CHAKI³, R W BELL⁴, D S GAYDON⁵

Abstract

In coastal saline area of Bangladesh, excess soil water at the end of the Kharif 2 season may cause a delay in the establishment of the following Rabi crops. Therefore, surface drainage could be a potential option. This study was conducted to test the APSIM-Sunflower by conducting experiment at the farmer's field of Dacope upazila in Khulna district using the sunflower, with three drainage depths (0 cm; no drain, 15, and 30 cm) replicated thrice. We have made good progress in parameterising APSIM using field experimental data and setting the model for local environmental conditions (soil, climate, etc.). We have started calibration but not been completed yet. In addition, successful calibration and validation of the model can generate more insight for researchers and policymakers about the risks of long-term use of this technique on seed yield, soil health and hydrology.

Introduction

Coastal areas of Bangladesh is vulnerable due to waterlogging at the start of the Rabi season. In this study, we aimed to find the optimum surface drainage depth for the early establishment of sunflower and removing field water after heavy rainfall. Also, to optimize the specific drainage depth for a particular crop through a crop simulation model (APSIM-Agricultural Production Systems Simulator). APSIM is a platform for simulating biophysical processes of crops in cropping systems (Keating et al 2003, Gaydon et al. 2017). This kind of information would help to increase smallholder's farm income through cropping systems intensification while mitigating the risk of crop damage in this vulnerable landscape. The aim is to test the feasibility of surface drainage for winter crops (i.e., sunflower) and using a crop simulation model calibrated by field experimental data to predict drainage requirements for greater resilience of smallholder farm income and food security in Southern Bangladesh. Therefore, the objective is to determine optimal shallow surface drainage for sunflower by testing variations in depth.

Materials and Methods

To test the APSIM-Sunflower model, a field experiment was conducted during 2023 and 2024. The detailed experimental procedure is explained in Mila et al. 2024. Long-term climate data were collected from local weather station. Soil samples were collected in 5 soil layers (0-15, 15-30, 30-50, 50-80, and 80-120 cm) at around 10-15 days intervals and measured using oven dry method. Initial soil salinity ($EC_{1:5}$), pH (1:5 water), OC, boron, CEC, ESP, NO_3 and NH_4 for five layers were determined. Soil salinity ($EC_{1:5}$) was measured in 5 soil layers at around 10-15 day intervals during the season using an EC meter and Chloride deposition in ppm was calculated. APSIM-sunflower phenology has 11 stages. Yield data was collected during harvest (See Fig. 1). Finally, the APSIM-sunflower model was parameterised using the above climate, soil, and crop data.

Results and Discussion

Simulated and observed values of phenology, biomass, and yield and soil water content during the crop season are shown in figure 1 and 2. At this stage 0 cm drainage depth treatment for both locations was selected, which showed fairly good match for phenology, biomass and yield. The 1:1 graph of the above three parameters are also shown in Figure 3. We found r^2 values of 93, and

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50 % for phenology, and yield for regression relationships between simulated and observed values (Fig.3). Similarly, soil water content and chloride content for 0-15, 15-30 and 30-50 cm soil depth for both locations showed fairly good (Fig. 2). However, it needs more work to complete the calibration process and making the model more roust.

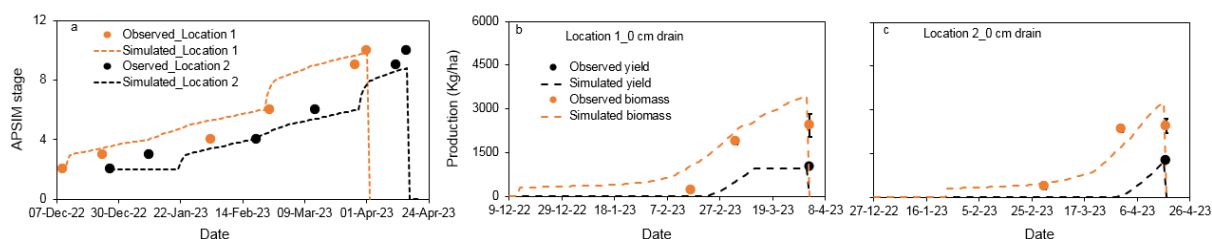


Fig. 1 APSIM simulated versus observed phenology and production (yield and biomass) of sunflower for three drainage depths and two locations at Dacope, Khulna during the crop season 2023.

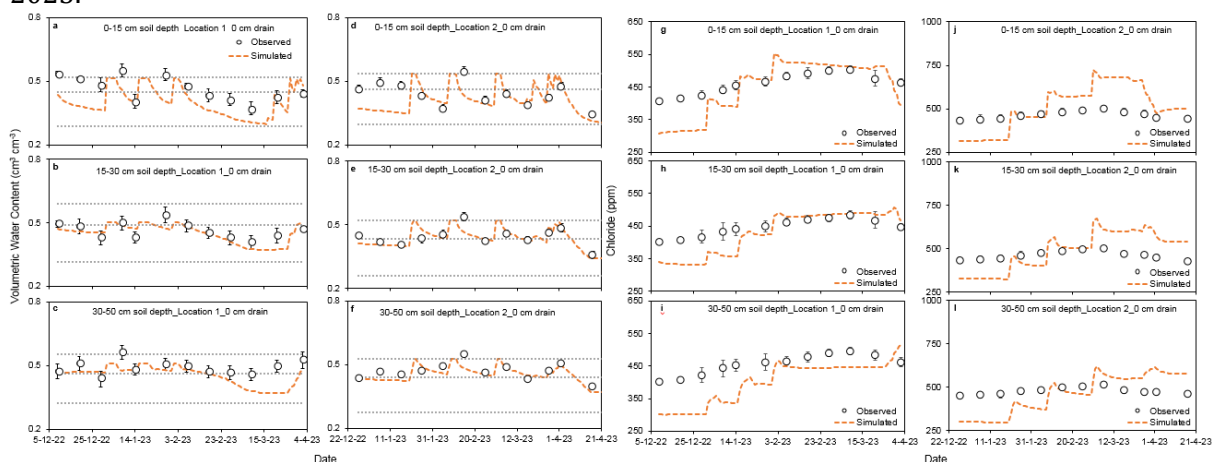


Fig. 2 Simulated and observed volumetric soil water content ($\text{cm}^3 \text{cm}^{-3}$) and chloride (ppm) of sunflower for three drainage depths and two locations at Dacope, Khulna during the crop season 2023. a-c and g-i for location 1 0-50 cm soil depth soil water content and chloride content, d-f and j-l for location 2 0-50 cm soil depth soil water content and chloride content, respectively.

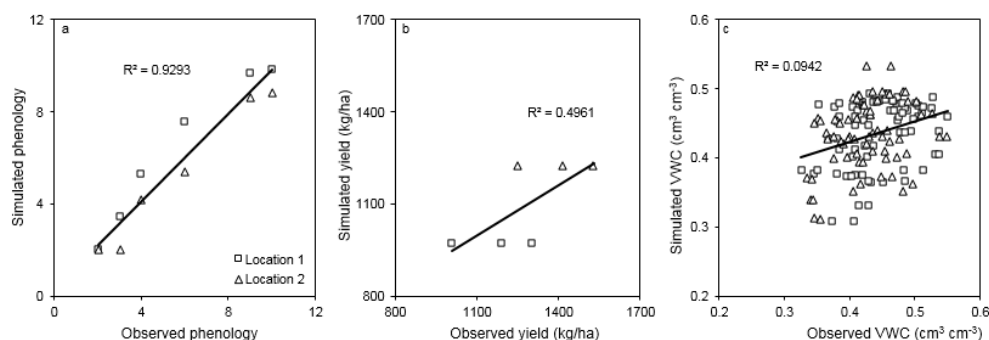


Fig. 3. Simulated vs observed phenology, yield and soil water content

Conclusion

We are still working to calibrate the model and will validate the model in the next year using field experimental data.

Seaweed Cultivation

193. PERFORMANCE OF BARI SEAWEED-1 AND BARI SEAWEED-2 IN DIFFERENT MONTHS IN NUNIARCHARA, COX'SBAZAR

R. A. KANTA, M. S. BHUIYAN AND M. AHMED

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 does not produce the same yield because of variation in water quality and wave pressure from month to month during the cultivation season. Monthly production of BARI Seaweed-1 and BARI Seaweed-2 was carried out at Nuniarchara sand-flat, Cox'sbazar during Rabi season 2023-2024. The estimated total fresh yield of *Gracilaria tenuistipitata* and *Ulva lactuca* was 99.75 ± 8.02 ($\approx 16.32 \pm 2.30$ ton dry) ton and 31.25 ± 4.44 ($\approx 4.25 \pm 0.77$ ton dry) ton per hectare respectively in open sea of Nuniarchara during October/2023 to March/2024.

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. 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. It has evident that people living in coastal areas of Cox's Bazar collected seaweeds from seashore and sold to the ethnic communities of Cox's Bazar, Bandarban, Khagrachari and Rangamati and some were exported to illegally to Myanmar and China. According to seaweed experts, bulk collection from natural habitat may cause extinction of some important seaweed species. Therefore, sustainable cultivation system can be the only way to ensure proper seaweed supply-chain throughout the year for edible and commercial purpose. BARI has developed modern cultivation system of seaweeds and released two very good varieties namely BARI Seaweed-1 and BARI Seaweed-2. So, this experiment was taken to evaluate the yield performance of these two varieties in different months of winter season at Nuniarchara, Cox'sbazar.

Materials and Methods

After cleaning and sorting, seeds of BARI Seaweed-1 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. 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”. BARI Seaweed-2 is cold loving seaweed which cannot be grown in open sea during summer and monsoon. Through gametogenesis and sporogenesis, seeds of this seaweed 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 got a height of about 10 to 15 cm, they were transplanted to the open sea. One-step seeds were made by cutting the plants in to small pieces and attached into ropes (8 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. After one month of seeding crops were harvested. Samples of each rope were weighed separately and after drying we recorded the dry weight. No additional fertilizer was applied. No pesticides and insecticides were also used. 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 being considered as a weed, was carried out once a week. Crops were harvested after one month of seeding. 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, DO, Temperature and pH) were also recorded.

Results and Discussion

Almost all seaweeds prefer winter for their growth and development. Green seaweed *Ulva lactuca* like a relatively cooler environment to adopt in open sea cultivation and December to March was the best season to cultivate sea lettuce in sea. The highest estimated yield of *Ulva lactuca* was obtained in the month of February 2024 which was 8.56 tons per hectare followed by 8.25 t/ha yield in March. Yield gradually increased from October to December. For *Gracilaria tenuistipitata* at Nuniarchara, the yield was also increased from October to February as the cold period increased and the production was observed higher compared to the previous year. The total fresh yield was obtained *Gracilaria tenuistipitata* and *Ulva lactuca* was 99.75 ± 8.02 ($\approx 16.32 \pm 2.30$ ton dry) ton and 31.25 ± 4.44 ($\approx 4.25 \pm 0.77$ ton dry) ton per hectare respectively in open sea of Nuniarchara during October/2023 to March/2024. Rainfall occurred heavily in October and November and as a result, turbidity values for these months ranked the highest positions. With the decrease in turbidity from October to February, the yield gradually increased and maximum production was recorded in February when water turbidity was 28.12 NTU. Throughout the whole growing season, there was no considerable variation in pH value in different months.

Table 1: Monthly variation in yield of *Gracilaria tenuistipitata* and *Ulva lactuca* in relation with different essential water parameters during October 2023 to March 2024 at Nuniarchara, Cox's Bazar.

Month	<i>Gracilaria</i>		<i>Ulva</i>		Temp. (°C)	Salinity (‰)	Turbidity (NTU)	pH
	f. t.(t/ha)	d. wt.	f. wt.	d. wt.				
October 2023	7.52 ± 0.37	1.23 ± 0.06	-	-	29.06 ± 2.71	22.16 ± 1.12	31.10 ± 2.07	7.85 ± 0.12
November 2023	9.09 ± 1.76	1.52 ± 0.32	2.75 ± 0.65	0.38 ± 0.10	27.53 ± 0.79	22.73 ± 0.86	31.52 ± 2.34	7.16 ± 0.07
December 2023	17.27 ± 1.81	2.81 ± 0.34	4.78 ± 1.13	0.68 ± 0.14	25.94 ± 0.86	26.94 ± 1.10	28.30 ± 2.38	8.26 ± 0.09
January 2024	20.75 ± 1.23	3.55 ± 0.57	6.91 ± 0.87	0.98 ± 0.17	27.17 ± 0.56	28.34 ± 0.84	26.70 ± 2.34	8.08 ± 0.12
February 2024	26.58 ± 1.53	4.25 ± 0.39	8.56 ± 1.07	1.15 ± 0.21	28.07 ± 0.32	28.63 ± 0.74	28.12 ± 1.27	8.11 ± 0.09
March 2024	18.54 ± 1.32	2.96 ± 0.62	8.25 ± 0.72	1.06 ± 0.15	30.07 ± 0.76	30.34 ± 0.77	28.70 ± 2.06	8.1 ± 0.12
Total	99.75 ± 8.02	16.32 ± 2.30	31.25 ± 4.44	4.25 ± 0.77				

n=5, f. wt. = fresh weight, d. wt. = dry weight

Conclusion

The estimated total fresh yield of *Gracilaria tenuistipitata* and *Ulva lactuca* was 99.75 ± 8.02 ($\approx 16.32 \pm 2.30$ ton dry) ton and 31.25 ± 4.44 ($\approx 4.25 \pm 0.77$ ton dry) ton per hectare respectively in open sea of Nuniarchara during October/2023 to March/2024.

194. PERFORMANCE OF BARI SEAWEED-1 AND BARI SEAWEED-2 IN DIFFERENT MONTHS IN REJUKHAL, COX'S BAZAR

R. A. KANTA, M. S. BHUIYAN AND M. AHMED

Abstract

Monthly production of BARI Seaweed-1 and BARI Seaweed-2 was carried out at Rejukhal, Ukhiya during Rabi season 2023-2024. The seaweed was cultivated using semi-floating method. The estimated total fresh yield of *Gracilaria tenuistipitata* was 89.95 ± 9.66 ($\approx 14.45 \pm 2.38$ ton dry) ton during October/2023 to March/2024 and 7.72 ± 1.32 ($\approx 1.78 \pm 0.60$ ton dry) ton per hectare for *Ulva lactuca* during November/2023 to March/2024 in open sea of Rejukhal.

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. 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. Searching of potential areas for seaweed cultivation is essential for the expansion of seaweed farming in our country. Rejukhal has high potentiality to grow seaweeds during winter for its favorable climatic condition. Therefore, this study has been conducted to evaluate the yield performance of BARI Seaweed-1 and BARI-Seaweed-2 in Rejukhal, Ukhiya and to evaluate as well the appropriate months to cultivate seaweed.

Materials and Methods

Seeds of BARI Seaweed-1 were collected from 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. 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”. Seeds of BARI Seaweed-2 were also collected from Nuniarchara field. In first two months, this seaweed was tried to grow in semi-floating method, but no production was obtained due to snails’ infestation and unfavorable water conditions. When snails’ infestation became more destructive, floating raft technology was introduced to produce the seaweed where seeded ropes were tied up in raft made of bamboo and then the raft was placed in water with the help of bamboo pole at relatively deep area so that the ropes could not get touched with mud during low tide. After one month of setting the raft, the crops were harvested and data were recorded. No additional fertilizer was applied. No pesticides and insecticides were also used. 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 being considered as a weed, was carried out once a week.

Results and Discussion

The study was conducted to find out the production of BARI Seaweed-1 (*Gracilaria tenuistipitata*) and BARI Seaweed-2 (*Ulva lactuca*) in Rejukhal of Cox’s Bazar during October 2023 to March 2024 using semi-floating long line cultivation technique. In case of production of *Gracilaria tenuistipitata* and *Ulva lactuca* at Rejukhal, the growing season prevails from October to march, when the salinity of the water ranged from 19.58-30.94 ppt. The estimated total fresh yield of *Gracilaria tenuistipitata* was 89.95 ± 9.66 ($\approx 14.45 \pm 2.38$ ton dry) ton during October/2023 to March/2024 and 7.72 ± 1.32 ($\approx 1.78 \pm 0.60$ ton dry) ton per hectare for *Ulva lactuca* during November/2023 to March/2024 in open sea of Rejukhal. The highest yield of *Gracilaria* was found in March which was 24.08 ± 1.43 ($\approx 3.75 \pm 0.38$ ton dry) followed by the yield of February 19.00 ± 1.12 ($\approx 3.04 \pm 0.45$ ton dry) and the lowest yield was found at the early season of October and the yield was 6.83 ± 0.72 ($\approx 1.14 \pm 0.19$ ton dry). Snails’ feeding on seaweeds cultivated in semi-floating system was observed which was the reason for less yield from Rejukhal in the early time of growing season. Yield of *Ulva lactuca* in Rejukhal was also evaluated from November/2023 to March/2024. The highest yield was found in the month of March i.e. 2.12 ± 0.42 ($\approx 0.56 \pm 0.15$ ton dry) and lowest was observed in November 0.92 ± 0.21 ($\approx 0.18 \pm 0.03$ ton dry). Total fresh yield found during the growing period of November/2023 to March/2024 was 7.72 ± 1.32 ($\approx 1.78 \pm 0.60$ ton dry) from *Ulva lactuca* at Rejukhal.

Table 1: Monthly variation in yield of *Gracilaria tenuistipitata* and *Ulva lactuca* in relation with different essential water parameters during October 2023 to March 2024 at Rejukhal, Cox’s Bazar.

Month	<i>Gracilaria</i>		<i>Ulva</i>		Temp. (°C)	Salinity (‰)	Turbidity (NTU)	pH
	f. wt.(t/ha)	d. wt.	f. wt.	d. wt.				
October 2023	6.83 ± 0.72	1.14 ± 0.19	-	-	30.77 ± 0.81	19.58 ± 2.29	19.75 ± 9.86	7.80 ± 0.36
November 2023	8.84 ± 3.45	1.44 ± 0.23	0.92 ± 0.21	0.18 ± 0.03	28 ± 0.75	21.60 ± 0.67	15.43 ± 3.11	8.10 ± 0.15
December 2023	16.07 ± 1.71	2.67 ± 0.32	1.37 ± 0.22	0.26 ± 0.07	26 ± 0.83	24.10 ± 0.84	19.29 ± 2.20	8.09 ± 0.14
January 2024	15.13 ± 1.23	2.41 ± 0.81	1.45 ± 0.28	0.36 ± 0.14	27.82 ± 0.48	28.96 ± 0.74	20.10 ± 1.34	8.18 ± 0.17
February 2024	19.00 ± 1.12	3.04 ± 0.45	1.86 ± 0.19	0.42 ± 0.21	28.88 ± 0.42	28.33 ± 0.43	22.13 ± 1.57	8.10 ± 0.09
March 2024	24.08 ± 1.43	3.75 ± 0.38	2.12 ± 0.42	0.56 ± 0.15	31.07 ± 0.66	30.94 ± 0.87	22.60 ± 2.16	8.15 ± 0.15
Total	89.95 ± 9.66	14.45 ± 2.38	7.72 ± 1.32	1.78 ± 0.60				

n=5, f. wt. = fresh weight, d. wt. = dry weight

Conclusion

Rejukhal can be a good cultivation area of BARI Seaweed-1 and BARI Seaweed-2 since water quality of this area remains congenial to growing seaweeds during winter. However, snails' infestation causing yield loss of seaweeds this year has become an issue of concern. Introduction of newly developed floating raft technique of cultivation can be a good alternative to semi-floating method to produce seaweeds in this area. The estimated total fresh yield of *Gracilaria tenuistipitata* was 89.95 ± 9.66 ($\approx 14.45 \pm 2.38$ ton dry) ton during October/2023 to March/2024 and 7.72 ± 1.32 ($\approx 1.78 \pm 0.60$ ton dry) ton per hectare for *Ulva lactuca* during November/2023 to March/2024 in open sea of Rejukhal.

195.PRODUCTION PROGRAM OF *HYPNEA BOERGESENII* IN OPEN-SEA USING FLOATING RAFT TECHNIQUE

R. A. KANTA, M. S. BHUIYAN AND M. AHMED

Abstract

Hypnea boerGESENII is an indigenous red seaweed species which has high commercial value for its carrageenan content. Due to its fragile body structure, it is very difficult to grow in open sea due to high wave pressure. Floating raft technique is newly introduced seaweed cultivation technology and it has been observed that the yield of BARI Seaweed-1 was relatively higher in this method than other existing methods. Therefore, this study was conducted during Rabi season 2023-24 to find out the feasibility of the technique to grow *Hypnea boerGESENII* and estimate the yield in open sea. The performance of *Hypnea boerGESENII* by floating raft method at Nuniarchara was good and the fresh yield was 11.95 t/ha, dry yield was 1.43 t/ha with an average length of 52 cm.

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. Since we have a long coast line, seaweed cultivation could easily be a new item on our country's limited export basket and would contribute greatly in reducing poverty, persistent unemployment problem and rates of malnutrition. *H. boerGESENII* is a red seaweed which is highly rich in an important phycocolloid compound such as carrageenan massively used in food and

cosmetic industries. Therefore, this production program was taken to find out the possibility of growing *Hypnea boergesenii* in open sea in Nuniarchara using floating raft technique.

Materials and Methods

In this study, raft floating cultivation method was used for producing *Hypnea boergesenii* in open-sea. Naturally grown healthy *H. boergesenii* seeds were collected from the surface of the coral reef or rock at Inani sea beach on 24th January, 2024. After that seeds were sorted to remove other seaweeds, debris and fouling materials and then cleaned thoroughly with clean sea water for the several times. Later, they were rear for one week in seaweed laboratory under controlled environment for acclimatization to adapt in natural condition. Afterward, only healthy seeds were seeded on synthetic ropes having a length of 4.5 m long and a diameter of 1.0 to 1.5 cm. Seeded ropes were placed maintaining a distance of 30 cm between two consecutive ropes. The approximate weight of each seed was 2.0 g on an average. Floating raft system was made of using four bamboos bind terminal end with ropes resulting a square shape structure and plastic containers. Seeded ropes were fitted inside the raft by attaching two distal poles and the raft was placed in areas where there was always standing water with the help of horizontally placed. The distance between seeds was 20 cm. 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. Regularly dirt's, epiphytes and snails that voraciously eaten seaweed were removed by hand. After thirty days, crops were harvested. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface and washed them with clean sea water thoroughly. A digital weight measuring machine was used for their measurement.

Results and Discussion

It was found that the growth and development of *Hypnea boergesenii* was higher in the month of March in all yield and yield contributing characters. The fresh yield was 11.95 t/ha, dry yield was 1.43 t/ha with an average length of 52 cm. All the seaweeds from the both months were harvested in 28 days.

Table 1: Yield performance of *Hypnea boergesenii* in floating raft method at Nuniarchara in March 2024

Rope	Fresh weight of each rope (g)	Dry weight of each rope (g)	Fresh weight (t/ha)	Dry weight (t/ha)	Length of each seaweed (cm)	No. of seaweed in each rope	Duration of cultivation
1	1687	202.4	11.25	1.35	52	25	28 days
2	1820	218.4	12.13	1.46	54	24	
3	1982	237.8	13.21	1.59	50	25	
4	1754	210.4	11.69	1.40	54	26	
5	1725	207.0	11.50	1.38	50	26	
Average	1793	215.2	11.95	1.43	52	25.2	

n=5

Conclusion

The performance of *Hypnea boergesenii* by floating raft method at Nuniarchara was good and the fresh yield was 11.95 t/ha, dry yield was 1.43 t/ha with an average length of 52 cm.

Hill Agriculture

196.PRODUCTION OF MAIZE BY STRIP AND BED PLANTING METHOD IN HILL VALLEYS OF BANDARBAN

M. T. ISLAM, I. HOSSAIN, A. K. CHAKI, T. ZAHAN, M. F. HOSSAIN, and M. M. ANOWAR

Abstract

A field experiment was conducted at Shikdarpara and Sultanpur of Bandarban during the 'rabi' season in 2023-24 to evaluate the performance of different sowing methods of maize by a power tiller-operated seeder (BARI Seeder). The treatments were: Bed planting; Strip planting and traditional method. The experiment was carried out in a randomized complete block design (RCBD) with three replications. There were significant differences among the treatments. Bed planting produced the highest individual cob yield (209.12 g) and average yield (11.47 t ha⁻¹), followed by the traditional method (191.65 g and 10.74 t ha⁻¹, respectively). The lowest cob yield was found in the strip (9.60 t ha⁻¹). From the cost-return analysis, it was found that the highest gross return, net return, and BCR were found from bed planting (Tk.286925 ha⁻¹, Tk.216925 ha⁻¹ and 4.10) and the lowest BCR was found from the traditional method (3.44).

Introduction

Strip tillage is a cropping system for maize that reduces the reworking of the soil to the stripes, in which the seeds are planted. Strip tillage is a mixture between no-tillage and conventional agriculture. Instead of ploughing and harrowing, a special rotary tiller, including a grubber, is used; it is used to avoid soil erosion or for economic reasons. Strip tilling maize rather than conventionally ploughing means the soil is far less disturbed and should maintain a better structure, making it less vulnerable to high rainfall events. Less soil disturbance should also build soil organic matter and soil carbon. Less cultivation should also make establishments cheaper through reduced fuel use and labor hours.

The heavy cultivation used, lack of ground cover, wide rows, shallow roots, and late harvest period combine to leave the soil in maize fields vulnerable to erosion and runoff throughout the long growing season, especially at harvest. However, there are benefits to growing maize. It uses water efficiently, which is important given increasingly unpredictable weather systems. It is also known to sequester high levels of carbon. Maize is a very valuable silage crop due to its high starch, high energy intake potential, and high dry matter yield potential. Despite the many benefits of growing maize, conventional growing practices can lead to negative environmental impacts, particularly regarding soil erosion and runoff.

Traditionally, people in Bandarban prepare land using 2-wheel and 4-wheel tractors, which involves 3-4 full tillage. This conventional method of crop cultivation results in additional fuel, labor, and time. The C-SUCSeS Project promoted a bed planter attached to a 2-wheel tractor for efficient soil tillage, bed formation, fertilizer application, and seed sowing in a single pass. This is a smart method as a simple bed planter attachment is sufficient, eliminating the need for separate tillage, seeding, and fertilizing. The Bed Planting technology significantly reduces the workload and time required for cultivation. The seeding cost of the bed planting system was much lower than the conventional seeding method. Using the 2-wheel or 4-wheel tractors in conventional cultivation methods, the seeding cost (land preparation, seeding, and basal fertilizer application) of different crops (mustard, wheat, maize) ranges from Tk. 8,000- 24,000 per hectare. Bed Planting offers a more cost-effective solution at 4,500-6,500 Taka per hectare. Even though purchasing a 2-wheel tractor may cost one and a half lakh Taka, adding a bed only requires an additional expense of 60,000-70,000 Taka.

Bed Planting technology contributes to the timely sowing and efficient growth of crops, with fewer rounds of soil work, reducing the vulnerability to natural calamities. The bed formation also acts as a barrier, protecting crops from vertebrate pests and weeds. It safeguards crops from damage, making it an ideal choice for smallholder farmers. In areas susceptible to natural

disasters, where conventional farming may result in crop losses due to the tendency of fertilizers to end up far from the seeds, compromising crop growth, Bed Planting technology ensures fertilizers are positioned beside each seed. This not only fosters uniform growth but also prevents environmental pollution.

In conventional farming, water may pool in certain areas, causing uneven irrigation. In contrast, Bed Planting facilitates uniform water flow, preventing waterlogging and optimizing water usage. When irrigation is applied, 25-30% of the water is saved compared to the conventional system. This innovative approach not only reduces diesel consumption but also minimizes environmental impact. In traditional methods, a field requires 22-23 litres of diesel per hectare for the seeding of cereals, while Bed Planters only need 12 litres, reducing greenhouse gas emissions and contributing to the mitigation of climate change. Conservation agriculture is a good practice that can successfully address soil quality improvements and crop productivity using machines. The present experiment was, therefore, undertaken to evaluate the performance and the feasibility of growing maize under different sowing methods in the hill valleys of Bandarban.

Materials and Methods

Field experiments were conducted at Shikdarpara and Sultanpur of Bandarban during the 'rabi' season in 2023-24 to evaluate the performance of different sowing methods of maize by Power tiller operated seeder (BARI Seeder). The treatments were: Bed planting, Strip planting, and traditional methods. The experiment was carried out in a randomized complete block design (RCBD) with three replications. Five days before planting, glyphosate was applied at 3.7 L ha⁻¹ (01 kg a. i. ha⁻¹) using 320–400 L ha⁻¹ of water with a calibrated three-nozzle flat-fan spray boom. All plots were sown by the same experienced PTOS operator in both locations. The basal fertilizer dose in both locations for maize was 80 kg nitrogen, 45 kg P₂O₅, 65 kg K₂O ha⁻¹. Diammonium Phosphate (DAP) was applied at 50 kg ha⁻¹ in between the line for strip at sowing. A BARI-designed inclined plate PTOS (BARI Bed planter and BARI Seeder), which has T-inverted furrow openers, was used to plant hybrid maize (Uttaron-2) seed at a seed-to-seed spacing of 25 cm in rows, and 60 cm between row intervals. Sowing was done on 06 November 2023. Twenty-five days after sowing, light irrigation was applied in both locations. harvesting was carried out during 20-25 December 2024.

Results and Discussion

Yield and yield attributes: The results reveal that sowing methods significantly influenced the yield of maize. Bed planting produced the highest individual cob yield (209.12 g) and average yield (11.47 t ha⁻¹) followed by the traditional method (191.65 g and 10.74 t ha⁻¹, respectively). The lowest cob yield was found in the strip (9.60 t ha⁻¹) (Table 1).

Cost return analysis: Cost and return analysis revealed that the highest gross return, net return, and BCR were found from bed planting (Tk.286925 ha⁻¹, Tk.216925 ha⁻¹ and 4.10) and the lowest BCR was found from the traditional method (3.44) (Table 2).

Farmer's opinion: Bed planting is a new cultivation technique for hill farmers, and they are happy to save labor and time by using this method of land preparation and seeding. An expert operator is required, which has already been developed through intensive training by the FMDP project.

Table 1. Yield and yield attributing characteristics of maize during the *Rabi* season of 2023-24

Treatments	Plant height (cm)	Cob length (cm)	Cob dia (cm)	Grain/cob	1000 grain wt (g)	Cob yield (g)	Yield (t/ha)
Bed planting	295.67	27.81	18.70	544.44	260.67	209.12	11.47
Strip	279.66	23.46	16.77	527.15	247.33	179.85	9.59
Traditional	303.32	26.25	17.80	559.47	253.67	191.65	10.74
CV%	2.12	4.51	3.13	1.31	2.32	3.41	2.37
LSD (0.05)	14.05	2.64	1.26	16.14	13.37	14.97	0.57

Table 2. Yield, cost and return analysis of maize during the *Rabi* season of 2023-24

Treatments	Yield (t/ha)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	BCR
Bed planting	11.48	286925	70000	216925	4.10
Strip	9.60	239925	65000	174925	3.70
Traditional	10.74	268500	78000	190500	3.44

Unit Price (Tk./kg): 25

197. ZERO TILLAGE MAIZE CULTIVATION BY DIBBLING METHOD

M. T. ISLAM, I. HOSSAIN, A. K. CHAKI, T. ZAHAN, M. F. HOSSAIN, and M. M. ANOWAR

Abstract

Field experiments were conducted at Reicha and Goaliakhola of Bandarban during the 'rabi' season in 2023-24 to evaluate the performance of zero tillage maize production by the dibbling method. The experiment was carried out in a randomized complete block design (RCBD) with three replications. Two hybrid maize varieties i.e. NK 40 and KMHB 410, were used as seeding material. NK 40 variety produced the highest plant height (286.32cm), grain/cob (423.47), 1000 grain weight (257.31g), individual cob yield (176.45 g), and average yield (9.56 t ha⁻¹). The lowest was found in KMHB 410 (271.88 cm, 417.43, 242.56g, 168.33g, and 9.12 t ha⁻¹ respectively). From the cost-return analysis, it was found that the highest gross return, net return, and BCR were found from NK 40 (Tk.239000 ha⁻¹, Tk.194000 ha⁻¹ and 5.31), and the lowest BCR was found from KMHB 410 (5.07).

Introduction

Maize is one of the most important food grains in the world and in developing countries like Bangladesh. The food produced in Bangladesh is not adequate to meet domestic requirements. Rice has been the traditional source of calories in Bangladesh's rural area but now about 10% of the requirement is being met by wheat. These two crops contribute 95% of the requirement for grain production each year. Natural disasters dramatically accentuate the problem, severely affecting those with few resources. The government of Bangladesh's policy has been, and still is, predominantly based upon a wheat and rice HYV approach, where high irrigation and fertilizer inputs are designed to balance the food production equation. In Bangladesh more than 40% of the arable land is under irrigation, leaving 60% of the cultivable land rainfed. Maize can be grown under a wide range of soil conditions. It grows best on fine sandy loam to heavy clay-loam soil and from moderately acidic (pH 5.0) to moderately alkaline (pH 8.5) soil. Large areas of Bangladesh have mainly loamy soils with a pH range from 5.5 to 7.0, ideal for the successful growth and development of maize. Animal feed in the country is severely deficient due to the lack of an organized feed industry and the unavailability of grazing land. Thus, maize could play an important role as animal feed and fodder fed as stover, green fodder, or as silage. One of the important attributes of maize is that even after the cobs are harvested, the remaining plant can be used as fodder. Thus, maize would provide food for humans and feed for the livestock from the same planting and with the same input costs. Maize is also an excellent poultry feed. Yellow maize provides an additional advantage since it contains the fat-soluble vitamin -A precursor, carotene, which is needed to promote normal growth in animals. No doubt, maize production in the country would reduce the drain of foreign exchange and, at the same time, contribute to the growth of the poultry industry. Maize can be grown all year round in Bangladesh and can, therefore be fitted in the gap between the main cropping seasons without affecting the major crops. It can be harvested as fodder within 50 days of planting, as green cobs within 60-80 days, and as grain within 100-130 days of planting. This flexibility allows the crop to fit easily into the cropping pattern. Another advantage of maize is its capacity to germinate under varying conditions. Maize can be dibbled in

flood-prone areas as soon as flood water recedes without waiting for the soil to dry, at a time when no other crop would grow. At the same time, there are some lowland valleys in the hilly areas where land becomes wet at early rabi season and Maize can be grown in these areas without tillage and with minimum inputs. This type of land totals around 2 million ha. In winter, maize may sometimes compete with wheat, pulses, oil seeds, and other rabi crops. Pulses, oil seeds, onion, garlic, and potatoes can be intercropped with maize. The present experiment was, therefore, undertaken to evaluate performance and the feasibility of growing maize under zero tillage dibbling method in hill valleys of Bandarban.

Materials and Methods

Field experiments were conducted at Reicha and Goaliakhola of Bandarban during the 'rabi' season in 2023-24 to evaluate the performance of zero-tillage maize production by the dibbling method. Two hybrid maize varieties, NK 40 and KMHB 410, were used as seeding materials. The trial was laid out in a randomized complete block design with three replications.

Before sowing, seeds were treated with 2 g/L Bavistin to reduce disease-causing organisms on the seed surface. The seed rate was 22 kg/ha, and the spacing was 60cm x 25cm. The seed was sown on 10 December 2023. Urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulfate, and boric acid were applied at 600, 250, 250, 220, 12, and 10 kg, respectively. All the TSP, gypsum, zinc sulfate, boric acid, and one-third of MOP were applied during land preparation (5 days before sowing). The total volume of Urea and the remaining MOP were applied in four equal installments at 35, 55, and 75 days after seed sowing. Two times, weeding was done after each top dress. The crop was irrigated at 8-10 leaves and grain filling stage where irrigation water was available.

Results and Discussion

NK-40 variety produced the highest plant height (286.32cm), grain/cob (423.47), 1000 grain weight (257.31g), individual cob yield (176.45 g) and average yield (9.56 t ha⁻¹). The lowest was found in KMHB 410 (271.88 cm, 417.43, 242.56g, 168.33g, and 9.12 t ha⁻¹, respectively) (Table 1).

The highest gross return, net return, and BCR were found from NK 40 (Tk.239000 ha⁻¹, Tk.194000 ha⁻¹ and 5.31), and the lowest BCR was found from KMHB 410 (5.07) (Table 2).

Table 1. Yield and yield attributing characteristics of maize during the *Rabi* season of 2023-24

Variety	Plant height (cm)	Cob length (cm)	Cob dia (cm)	Grain/cob	1000 grain wt (g)	Cob yield (g)	Yield (t/ha)
NK 40	286.32	23.25	16.23	423.47	257.31	176.45	9.56
KMHB 410	271.88	24.52	17.12	417.43	242.56	168.33	9.12

Table 2. Yield, and cost-return analysis of maize during the *Rabi* season of 2023-24

Variety	Yield (t/ha)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	BCR
NK 40	9.56	239000	45000	194000	5.31
KMHB 410	9.12	228000	45000	183000	5.07

Unit Price (Tk./kg): 25

Conclusion

The result showed that maize could be grown as a zero-tillage dibbling method to achieve higher grain yield and economic return in different lowland hill valleys of Bandarban.

198. STRIP PLANTING OF MUSTARD IN HILL VALLEYS OF BANDARBAN

M. T. ISLAM, I. HOSSAIN, A. K. CHAKI, T. ZAHAN, M. F. HOSSAIN, and M. M. ANOWAR

Smallholder agriculture of the Asian continent faces a significant challenge of declining soil productivity and an acute shortage of agricultural labor. Reduced tillage and crop residue application is an integrated approach to preserving soil health and addressing the labor crisis to maintain farm sustainability. Conservation agriculture is a good practice that can successfully address soil quality improvements and crop productivity using machines. We undertook this study to evaluate the effect of strip planting productivity and profitability at the Shikdarpara and Sultanpur hill valleys of Bandarban during 2023-24. Strip-planted line seeding of mustard with BARI Seeder (Power-tiller operated seeder) was used as testing material. BARI Sarisha-14 was used as a mustard variety. The crop was sown on 05 December 2023 and was harvested on 15 February 2024. Fertilizer and other management practices were done following BARI Krishi Projukti Hatboi 2020. The amounts of fertilizer applied (kg/ha) are as follows- Urea: 300; TSP: 180; MoP: 100; Gypsum: 180; zinc sulphate: 7; Boric acid: 10. Total amount of cowdung, half of the urea, TSP, gypsum and boric acid were applied in the plot during sowing. The rest half of the urea was applied in strips before flowering. The field was irrigated on the same day of top dressing before flowering. Weeding was done before top dressing. The collected data were averaged and converted into tons per hectare, were presented in Table 1.

Results and Discussion

The average yield, gross return, net return, and BCR of BARI Sarisha-14 in the strip method were 1.28 t ha⁻¹, 102400 Tk. ha⁻¹, 67400 Tk. ha⁻¹ and 2.93, respectively. After seed sowing, there was sudden rain the following day, which affected some strips, which might be responsible for a slightly lower yield, or it might be due to the planting method. The effect of the strip planting method for this region will be understood after several consecutive years of experimentation. This experiment is just the start, and it will be continued the following year.

Farmer's opinion

This planting method is new to them. It certainly will reduce the labor and time required for land preparation. An expert operator and an efficient seeder machine are required for the expected output.

Table 1. No. of the farmer, area, yield, cost and return analysis of mustard during the *Rabi* season of 2023-24

Variety	No. of Farmers	Area (Dec.)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	BCR
BARI Sarisha-14	3	70	1.28	102400	35000	67400	2.93

Floating Agriculture

199.INTERCROPPING OF NON-CREEPERS WITH CREEPER VEGETABLES ON FLOATING BED CUM TRELLIS (NON-TIDAL MODEL) IN NOAKHALI AND KISHOREGANJ

M.S. ISLAM, M. M. BASHIR, M. MOHIUDDIN AND M. Y. H. RAYHAN

Abstract

The experiment was conducted at Ramgong and Kishoreganj sadar under OFRD, Noakhali and Kishoreganj during the cropping season of 2023-24 to increase the crop productivity of floating bed agriculture system as well as to increase the economic return of farmers. Four treatments were tested viz., T₁: Bottle gourd + Radish, T₂: Cucumber+ Red amaranth, T₃: Sweet gourd + Coriander leaf, and T₄: Yard long bean + Indian spinach. The variety of creeper vegetables were for bottle gourd (BARI Lau-4), sweet gourd (Maya), cucumber (Alavi green) and yard long bean (BARI Borboti-1) and non-creeper vegetables were like radish (BARI Mula-1), red amaranth (BARI lalshak-1), coriander leaf (var. local) and Indian spinach (var. local). Among the creeper vegetables, yield sweet gourd and bottle gourd were obtained highest in Kishoreganj (36.97, 35.48 t ha⁻¹) and Cucumber and yard long bean was found highest in Noakhali (26.09, 7.23 t ha⁻¹), respectively. Results revealed that the average gross return and gross margin was calculated highest in Cucumber+ Red amaranth (460850 Tk. ha⁻¹ and 206400 Tk. ha⁻¹) due to high price and market demand followed by Sweet gourd + Coriander leaf (425350 Tk. ha⁻¹ and 224900 Tk. ha⁻¹) and Bottle gourd + Radish (402475 Tk. ha⁻¹ and 202025 Tk. ha⁻¹), respectively.

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. In Noakhali and Kishoreganj districts, there are many water bodies or canals near road side that are connected to Meghna, Dakatia Brahmaputra rivers. Water bodies remain fallow and unused from long time especially in monsoon period. 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 which is made between two floating beds. In this system, different non-creeper vegetables could be cultivated as intercrops (red amaranth, radish, Indian spinach and 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 as well as farmers' income generating effort of the floating agriculture system under flooded ecosystem of non-tidal area. In this respect, the present experiment was undertaken to evaluate the intercropping performances of different non-creeper vegetables on "Floating Bed cum Trellis (non-tidal model)" under flooded ecosystem in non-tidal areas of Noakhali and Kishoreganj.

Materials and Methods

The experiment was conducted at Ramgong and Kishoreganj sadar upazilla of Laxmipur and Kishoreganj districts during November 2023 to March 2024 to increase the crop productivity on floating agriculture system and to increase the crop intensity and economic return of farmers. The work was conducted on floating bed and each floating bed considered as one treatment. Four treatments were considered as T₁: Bottle gourd + Radish, T₂: Cucumber+ Red amaranth, T₃: Sweet gourd + Coriander leaf, and T₄: Yard long bean + Indian spinach. The size of each floating bed was 9.15 m × 1.37 m (30ft long × 4.5ft wide) and size of whole trellis (between two floating beds) were 30 ft long × 18 ft wide. The two rows of creeper crop were grown on each floating bed maintaining 1m plant to plant distance for all crops. The seedlings per hill was two for bottle gourd and sweet gourd and four for cucumber and yard long bean. Uniform size, healthy 10-12 days old seedlings of bottle gourd (BARI Lau-4), sweet gourd (Maya) and cucumber (Alavi green) plants were transplanted on 01-06 November 2023. The intercropped vegetables like radish (BARI Mula-1),

red amaranth (BARI Lalshak-1), coriander leaf (local) and Indian spinach (local) were grown in between two rows of creeper vegetables on 08-15 November 2023. The fertilizer doses were different based on crops requirements like bottle gourd: 53g urea, 135g DAP, 30g MoP, 33g gypsum, 2g zinc sulphate, 4 g boric acid, cucumber, 57g urea, 64g DAP, 18g MoP, 28g gypsum, 2g Zinc sulphate, 5g boric acid and sweet gourd: 53g urea, 135g DAP, 30g MoP, 33 g gypsum, 2g zinc sulphate, 4g boric acid. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAT) except in cucumber. In cucumber fertilizers were applied in four equal splits at 15, 25, 35 and 45 DAT. The liquid form of plant nutrients were applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphate 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. Harvesting was started from 07 December 2023 and continued up to 19 March 2024 for different crops. Data on yield and yield attributes were recorded.

Result and Discussions

Performance of creeper and non-creeper vegetables were presented in Table 1 and Table 2. The fruit yield of creeper vegetables obtained from bottle gourd, cucumber, sweet gourd and yard long bean were 34.92, 26.09, 35.98 and 7.23 t ha⁻¹ in Noakhali and 35.48, 24.69, 36.97 and 7.05 t ha⁻¹ in Kishoreganj, respectively. Sweet gourd yield was the highest. Sweet gourd is very suitable for floating bed cultivation. It can tolerate adverse condition more than cucumber, bottle gourd and yard long bean. Powdery mildew attacked in sweet gourd and virus attacked cucumber and protective measures were done to save the crop. The yard long bean yield was the lowest among all the planted creeper vegetables due to leaf miner attack. Performance of non-creeper vegetables were presented in Table 2. The fruit yield of non-creeper vegetables obtained from Indian spinach, radish, red amaranth and coriander leaf were 12.62, 8.07, 7.35 and 1.88 t ha⁻¹ in Noakhali and 16.06, 12.12, 8.65 and 2.16 t ha⁻¹ in Kishoreganj, respectively. Among the non-creeper vegetables Indian spinach gave the highest yield (16.06 t ha⁻¹) followed by radish (12.12 t ha⁻¹) and red amaranth (8.65 t ha⁻¹). Indian spinach can tolerate moisture stress more than red amaranth and coriander leaf.

Cost and return analysis: In cost and return analysis cucumber and red amaranth intercropping combination gave the highest gross return (460850 Tk. ha⁻¹) due to higher price and demand (Table 3). Gross margin was also the highest (206400 Tk. ha⁻¹) from the same combination. A considerable gross return and gross margin was obtained from all the combinations. Yard long bean and Indian spinach combination produced the lowest gross return (393300 Tk. ha⁻¹) and gross margin (192850 Tk. ha⁻¹) due to lowest yield of yard long bean. But it was still considerable as profitable from the economic point of view.

Table 1. Yield of Creeper vegetables grown on floating bed during 2023-24

Treatments	Creeper Vegetables Fruit Wt./bed (kg)		Yield (t ha ⁻¹)	
	Noakhali	Kishoreganj	Noakhali	Kishoreganj
T ₁ (Bottle gourd)	43.82	44.52	34.92	35.48
T ₂ (Cucumber)	32.74	30.98	26.09	24.69
T ₃ (Sweet gourd)	45.15	46.39	35.98	36.97
T ₄ (Yard long bean)	9.07	8.85	7.23	7.05

Table 2. Yield of non-creeper vegetables grown on floating bed as intercropped during 2023-24

Treatments	Creeper Vegetables Fruit Wt./bed (kg)		Yield (t ha ⁻¹)	
	Noakhali	Kishoreganj	Noakhali	Kishoreganj
T ₁ (Radish)	10.13	15.21	8.07	12.12
T ₂ (Red amaranth)	9.22	10.85	7.35	8.65
T ₃ (Coriander)	2.36	2.71	1.88	2.16
T ₄ (Indian Spinach)	15.84	20.15	12.62	16.06

Table 3. Cost and return analysis of vegetables cultivation on floating bed during 2023-24

Treatments	Gross Return		TVC		Gross margin	
	Noakhali	Kishoreganj	Noakhali	Kishoreganj	Noakhali	Kishoreganj
Bottle gourd+ Radish	389550	415400	195300	205600	194250	209800
Cucumber+ Red amaranth	464850	456850	195300	205600	269550	251250
Sweet gourd+ Coriander leaf	416200	434500	195300	205600	220900	228900
Yard long bean+ Indian Spinach	379250	407350	195300	205600	183950	201750

Price kg⁻¹ of Bottle gourd= 10/-, Sweet gourd= 10/-, Cucumber =15/-, Yard long bean = 35/-, Radish=5/-, Red amaranth= 10/-, Coriander =30/-, and Indian spinach= 10/-

Farmers' Opinion

- Yield of all vegetables obtained higher over conventional practice.
- Higher demand to customers along with higher market price due to pesticide free production.
- Initial invest and other cost are higher.
- Less availability of water hyacinth in dry season as a result repair or refill of floating bed is troublesome.
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed culture.

Conclusion

It may be concluded that floating bed cum trellis (non-tidal model) is an effective production practice of creeper vegetables with non-creeper simultaneously. The technology is suggested to disseminate through pilot production program.

200.INTERCROPPING OF NON-CREEPERS WITH CREEPER VEGETABLES ON FLOATING BED CUM TRELLIS (NON-TIDAL MODEL)

M. MOHIUDDIN, T.S. MUNMUN, M.K. ISLAM, M.H. RASHID AND M. RAHMAN

Abstract

An intercropping based activity was conducted at Dumuria, Khulna district and Fakirhat, Bagerhat district during the Kharif II and *Rabi* season, 2023-24 to increase the crop productivity and intensity of farmers by floating agriculture system. Two treatments were considered as T₁ = Bottle gourd + Red amaranth and T₂ = Sweet gourd + Red amaranth. The variety of creeper vegetables were for bottle gourd Jhinia (F1) and sweet gourd (Bengle sweet (F1) and non-creeper vegetables were like Red amaranth (var. BARI lalshak-1). The fruit yield of creeper vegetable was 42.65t h⁻¹ and 33.3t h⁻¹ for bottle gourd and sweet gourd at Dumuria Khulna and yield of bottle gourd and sweet gourd were 44.63t ha⁻¹ and 31.34t ha⁻¹ respectively. Bottle gourd performed better followed by Sweet gourd. Among the non-creeper vegetables, red amaranth was (8.56t h⁻¹ and 10.5 t h⁻¹) at Dumuria and Fakirhat respectively. Among the intercropping of bottle gourd with red amaranth in Kharif II season showed the best performance in floating agriculture system.

Introduction

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. In Bangladesh, farmers generally cultivated vegetables crops and seedlings in the homestead or nearby homestead or in the crop field. There is a scope to introduce forage as fodder of cattle in the southern areas. Currently the floating garden is practiced to a limited extent (only about 275 hectares) in southern districts due to lack of modern technologies and farmers' knowledge, although the floating system has the potential to provide a means of income and food security for the millions of small households who have no access to land but live close to large bodies of water. It is found that out of 2619 ha of land, only 146 ha in Khulna district generally produce vegetable

and spices crops on floating garden which are generally 6-8 months under inundated water in a year. In Dumuria upazila, 400 ha lands are suitable for floating agriculture but only 80 ha lands occupied under floating bed and produced seedlings (vegetable and spices crops) on the same. In Bagerhat (Fakirhat) upazila, 100 ha lands are suitable for floating agriculture but only 01 ha occupied under floating bed. Additionally, the river “Chitra” at Fakirhat upazila, is fully occupied of water hyacinth. This river is suitable for crop production on floating bed in round the year. The Food and Agriculture Organization of the United Nations (FAO) recently has recognized the “Floating Garden Agricultural Practices” in the southern region of Bangladesh as “Globally Important Agricultural Heritage System (GIAHS) (FAO, 2015).

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 case 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.

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 of Dumuria, Khulna and Fakirhat, Bagerhat.

Materials and Methods

An intercropping based activity was conducted at Dumuria, Khulna district and Fakirhat at Bagerhat district during the Kharif II and rabi season, 2023-24 to increase the crop productivity and intensity of farmers of floating agriculture system and to increase the cropping intensity and economic return of farmers. The work was conducted in floating bed and each floating bed considered as one treatment. Two treatments were considered as T_1 = Bottle gourd + Red amaranth and T_2 = Sweet gourd + Red amaranth. The variety of creeper vegetables were for bottle gourd (Jhinia (F1) and sweet gourd (Bengle sweet (F1) and non-creeper vegetables were like Red amaranth (var. BARI lalshak-1). The size of each floating bed was 9.15m X 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) were different according to crops like for bottle gourd: 9.15m x 6m (30ft long x 20 ft wide) and for sweet gourd and ash gourd was 9.15m x 4.57m (30ft long x 15 ft wide). The two rows of creeper crop were grown on each floating bed maintaining 1.5m 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. In terms of treatment, T_1 = Bottle gourd + Red amaranth and T_2 = Sweet gourd + Red amaranth were transplanted on 26 June, 2021 at Dumuria and 23 June, 2021 at Fakirhat. The intercropped

vegetables like Red amaranth (var.BARI lalshak-1) was grown in between two rows of creeper vegetables with same date. The fertilizer dose (For 10 sqm floating bed area) were different applying on vegetables basis like Bottle gourd: 53g urea, 135g diammonium phosphate, 30g muriate of potash, 33g gypsum, 2g zinc sulphate, 4g boric acid, Sweet gourd and ash gourd: 53g urea, 135g diammonium phosphate, 30g muriate of potash, 33g gypsum, 2g zinc sulphate, 4g boric acid, cabbage: 300g urea, 200g TSP and 250g MP. and Potato: 325g urea, 200g TSP, 250g MP, 95g gypsum, 10g $ZnSO_4$ and 10g boric acid. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied following application schedule. 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. Harvesting was started Dumuria, Khulna (03.09.23-12.10.23) and Fakirhat, Bagerhat (01.09.2023-11.10.2023). 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.

Result and Discussions

Performance of creeper vegetables were presented in Table 1. In Dumuria, the plant populations at harvest period per plot were 12 and 12 bottle gourd, and sweet gourd, respectively, for each of creeper vegetables. The fruits plant⁻¹ (no) were 11.4 and 10.3 for bottle gourd and sweet gourd, respectively. The single fruit weight was 2.75 kg and 3.11 kg for bottle gourd and sweet gourd respectively. The highest yield was obtained from bottle gourd ($42.65\ t\ ha^{-1}$). The sweet gourd yield ($33.43\ t\ ha^{-1}$) was the lowest among 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 gourds was harvested. Performance of non-creeper the plant populations at harvest period of bottle gourd and sweet gourd were $44.63\ t\ ha^{-1}$ $31.34\ t\ ha^{-1}$, respectively. Performance of non-creeper vegetables are presented in Table 2. In Fakirhat, the plant populations at harvest period per plot were 12 and 12 bottle gourd, and sweet gourd, respectively for each of creeper vegetables. The fruits plant⁻¹ (no) were 10.8 and 9.2 for bottle gourd and sweet gourd, respectively. The single fruit weight was 2.65 kg and 3.4 kg for bottle gourd and sweet gourd respectively. The highest yield was obtained from bottle gourd ($44.63\ t\ ha^{-1}$). The sweet gourd yield ($31.34\ t\ ha^{-1}$) 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 sweet gourds was harvested. Performance of non-creeper vegetables are presented in Table 2. The highest BCR obtain from Bottle gourd+ Red Amaranth (3.3).

Table 1. Growth and yield of creeper vegetables grown on floating bed at Dumuria, Khulna during Kharif II, 2023-24

Crop	Plant pop. Bed ⁻¹ (no.)	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Fruit diameter (cm)	Single fruit wt. (kg)	Fruit yield ($t\ ha^{-1}$)
Bottle gourd	12	11.4	38.3	39.50	2.75	42.65
Sweet gourd	12	10.3	14.5	43.6	3.11	33.43

Table 2. Yield of non-creeper vegetables grown on floating bed as intercropped at at Dumuria, Khulna during Kharif II, 2023-24

Treatments	Vegetables wt/bed (kg)	Yield ($t\ ha^{-1}$)
T ₁ (BARI Lalshak-1)	8.56	8.56

Table 3. Growth and yield of creeper vegetables grown on floating bed at Fakirhat, Bagerhat during rabi, 2023-24

Crop	Plant pop./ bed (no.)	Fruits/ plant (no.)	Fruit length (cm)	Fruit diameter (cm)	Fruit wt. (kg)	Fruit yield ($t\ ha^{-1}$)
Bottle gourd	12	12.5	37.2	37.6	3.21	44.63
Sweet gourd	12	9.4	18.6	40.6	2.90	31.34

Table 4. Yield of non-creeper vegetables grown on floating bed as intercropped at Fakirhat, Bagerhat during rabi, 2023-24

Treatments	Vegetables wt./bed (kg)	Yield (t ha ⁻¹)
T ₁ (BARI Lalshak-1)	10.5	1.5

Table 5. Yield and economic analysis of vegetables grown on water hyacinth based floating bed at Dumuria Khulna and Fakirhat Khulna, during 2023-24

Crop	Location	Fruit yield (t ha ⁻¹)		Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	BCR
		Creeper	Non-Creeper			
Bottle gourd+ Red Amaranth	Dumuria,	42.65	8.56	938600	302700	3.1
Sweet gourd +Red Amranth	Khulna	33.43	8.56	668600	302700	2.2
Bottle gourd+ Red Amaranth	Fakirhat,	44.63	10.5	997600	302000	3.3
Sweet gourd+ Red Amaranth	Khulna	31.34	10.5	731800	302000	2.4

Farmers' Opinion

- 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 very higher
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed
- The test of these vegetables was better than other vegetables.

Conclusion

From one year study It may be concluded that Floating Bed cum Trellis (non-tidal model)" is good way for production of creeper vegetables with non-creeper simultaneously. Bottle gourd performed better followed by Sweet gourd. For further verification the trial may be repeated in next year.

201.INTERCROPPING OF SNAKE GOURD WITH KANGKONG ON MODERN VS TRADITIONAL FLOATING BED CUM TRELLIS IN MADARIPUR

M. MOHIUDDIN, SELIM AHMED

Abstract

An intercropping based activity was conducted at Tetulbari area under Rajoir upazila in Madaripur district during Kharif-I season, 2023 to select the best one floating bed for crop productivity & to find out the cost and return both bed. Two treatments were considered as T₁ = Modern floating bed cum trellis, T₂ = Improved traditional floating bed cum trellis. Here, in modern system has bamboo structure beneath the floating bed whereas, improved traditional system doesn't possess any such structure beneath the floating bed. Three replications were placed. The variety of creeper vegetable was snake gourd (BARI Chichinga-1) and non-creeper vegetable was Kangkong (BARI Gimakolmi-1). Vegetables production using modern floating bed showed somehow higher compared to the improved traditional in terms of higher number of fruits plant⁻¹, larger fruit and higher yield. Improved traditional floating produced 256 kg together Sanke gourd and Kangkong whereas modern floating bed produced 246 kg. Only 5% vegetable increased over traditional. But improved traditional bed was more profitable in terms of economy because setting up a bamboo structure requires extra money. The gross margin was -3450 taka in modern but 955 taka was in improved traditional method.

Introduction

In Rajoir upazila of Madaripur district, many water bodies or canals are located near road side that are connected to Lower Kumar River. Water bodies remain unusable especially in monsoon period. Some enthusiastic farmers like farmers of Gopalganj grow creeper vegetables on floating bed made of conventional way. Recently, a modern technology of Floating Bed cum Trellis (non-tidal model) has been developed for growing creeper vegetables. This technology is composed of

floating bed supported by bamboo structure below and a trellis. The conventional method possesses floating bed and trellis but no bamboo support. Bamboo is not sufficiently available and buying cost as well as transportation cost is higher. Besides, making and placing a bamboo structure also needs labor. That means, modern technology is costlier than traditional one. In this respect, the present experiment was undertaken to evaluate the cost effectiveness of modern floating system over improved traditional system growing both creepers and non-creepers under flooded ecosystem in non- tidal areas of Madaripur.

Materials and Methods

The activities were conducted at Tetulbari area under Rajoirupazila of Madaripur district during Kharif I season, 2023. Two treatments were considered as T_1 = Modern floating bed cum trellis, T_2 = traditional floating bed cum trellis. The size of the bed of each improved traditional floating bed was 8 m X 1.35m (10m^2) but 9.15m x1.37m (12.5m^2) in modern floating bed. The size of both trellis (between two floating beds) was 8m x 5m (40m^2). The two rows of creeper crop (Snake gourd) were grown on each floating bed maintaining 1m plant to plant distance. The seedling per hill was 1 for all. Uniform size, healthy 15 days old seedlings of creeper plants were selected for transplanting. The intercropped non-creeper vegetable like Kangkong was grown in between two rows of creeper vegetables. The agronomic management (date of planting, age of seedling and fertilizer dose) was showed in Table 1. The fertilizer dose (For 10sqm 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. Harvesting date was also stated on Table 1.

Data were calculated both types of bed from 10m^2 and trellis from 40m^2 on plant population, 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.

Result and Discussions

Vegetables cultivation on improved traditional gave the highest yield. Traditional floating produced total 259 kg together snake gourd and Kangkong whereas modern floating bed produced 246 kg. The vegetable increased 5.28% in traditional over traditional (Table 3). Traditional bed was profitable in terms of economy because setting up a bamboo structure requires extra money (Table 2a and 2b). The gross margin was -3450 taka in modern but 955 taka was in improved traditional method (Table 4).

Table1. Agronomic management of snake gourd with kangkong during Kharif I, 2023

Crops and variety	Planting date	Age of seedling (days)	Fertilizer dose (kg ha^{-1})	Harvesting date
Snake gourd (BARI Chichinga-1)	12 April, 2023	15	$\text{N}_{80}\text{P}_{35}\text{K}_{75}\text{S}_{18}\text{Zn}_{4}\text{B}_{1.7}$	57-110 DAP
Kangkong (BARI Gimakolmi-1)	12 April, 2023	broadcast		36-110 DAS

Table 2a. Expenditure of floating bed during Kharif I, 2023

Modern				Improved traditional			
Item	Unit price (Tk.)	No.	Total (Tk.)	Item	Unit price (Tk.)	No.	Total (Tk.)
Bamboo(borak)	500	12	6000	Labor	500	12	6000
Nylon net, rope	-	-	2000	Seed & Fertilizer			200
Labor	12	500	6000				
Seed &Fertilizer	-	-	200				
Total Cost (Tk.) $14200.00/2= 7100.00$				Total Cost (Tk.) $6200.00/2=3100$			

N.B. One bed can be used continuing 2 times

Table 2b. Expenditure of trellis during Kharif I, 2023

Modern or Improved traditional			
Bamboo(borak)	500/ bamboo	6 pc.	3000
Bamboo (tolla)	300/ bamboo	6 pc.	1800
Net	300/net	1 kg	300
Total Cost (Tk.) 5100.00/3=1700.00			

N.B. one trellis can be used for continuing 3 times

Table 3. Yield of Snake gourd on floating bed during Kharif I, 2023

Treatments	Pl. pop bed ⁻¹	Fruits plant ⁻¹ (no)	Single fruit wt.(g)	Fruit length (cm)	Fruit dia. (cm)	Fruit weight (kg dec. ⁻¹)	Fruit weight (kg dec. ⁻¹)
Modern	16	58.0	119.0	28.63	5.03	110	136
Traditional	16	59.33	121.0	29.07	5.10	115	144

Table 4. Cost and return of floating agriculture during Kharif I, 2023

Treatments	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Modern	83826	137085	53259
Traditional	88843	74100	14743

Output price: Snake gourd 25tk/kg, Kangkong 20 tk/kg.

Farmers' Opinion

- Modern floating bed requires more bamboo but bamboos don't grow in their region. So, bamboo needs to be collected from distant place which requires more money.
- Modern and traditional floating bed produce more or less similar amount of product.
- Farmers were interested to the improved traditional floating bed

Conclusion

Improved traditional floating bed produced higher yield and profit than Modern bed modern. floating bed is not suitable at Rajoir upazila in Madaripur. So, improved traditional floating bed should be promoted in this location for sustainability.

202.INTERCROPPING OF WATERMELON WITH RED AMARANTH & KANGKONG ON TRADITIONAL FLOATING BED CUM TRELLIS IN MADARIPUR

M. MOHIUDDIN, SELIM AHMED

Abstract

An intercropping based activity was conducted at Aamgram area under Rajoir upazila of Madaripur district during the Kharif II season, 2023 to evaluate the performance of vegetables as intercrops growing on improve traditional bed and to find out cost and return. Two treatments were considered as treatment, T₁ = Water melon with red amaranth and T₂ = Water melon with kangkong. The variety of creeper vegetable was for Water melon (BARI Tormuj-1) and non-creeper vegetables were like Red amaranth (var. BARI Lalshak-1) and Kangkong (var. BARI Gimakolmi-1). Three replications were conducted. The result reveals that, the highest yield was obtained Water melon intercropped with Kangkong. The income increased 30.43% in Water melon with Kangkong intercropped combination in against of Water melon with Red amaranth.

Introduction

In Rajoir upazila of Madaripur district, there are many water bodies or canals near road side that are connected to Lower Kumar River. Water bodies remain unusable especially in monsoon period. Some enthusiastic farmers like farmers of Gopalganj 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. So, some improvement was made in the traditional system. In this improved 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 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 “Improved Traditional Floating Bed cum Trellis (non-tidal model)” under flooded ecosystem in non-tidal areas of Madaripur.

Materials and Methods

The activities were conducted at Aamgram area under Rajoir upazila of Madaripur district during Kharif II season, 2023-24 to evaluate the performance of vegetables as intercrop growing on improve traditional bed and to find out cost and return. Each floating bed was considered as one treatment. Two treatments were evaluated as T_1 = Water melon + Red amaranth, T_2 = Water mel+ Kangkong. The size of each floating bed was 8 m x 1.3m (10m²) and size of whole trellis (between two floating beds) were 40 m² (8m long x 5m wide). The two rows of creeper crop were grown on each floating bed maintaining 1.0 m plant to plant distance. The seedlings per hill was 1 for all. Uniform size, healthy 12-15 days old seedlings of creeper plants were selected for transplanting. The intercropped non-creeper vegetables like Red amaranth and Gimakolmi 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 1. The fertilizer dose (For 10 sqm floating bed area) were 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. Harvesting date was also stated on Table 1. 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.

Result and Discussions

Performance of creeper vegetables were presented in Table 2. The plant populations at harvest period per plot were 16 for each of creeper vegetables. The fruits plant⁻¹(no) was 7.86 and 7.82 for ash gourd intercropped with red amaranth and gimakolmi, respectively. Yield performance non-creeper vegetables were presented in Table 3. The single fruit weight was 1.29 kg and 1.27 kg for ash gourd intercropped with red amaranth and gimakolmi, respectively. The highest yield was obtained from T_2 .

Table1. Agronomic management of creeper and non-creeper vegetables on traditional floating bed at Tetulbari under Rajoir, Madaripurkharif II, 2023

Crops and variety	Planting date	Age of seedling	Fertilizer dose (kg ha ⁻¹)	Harvesting date
Water melon (BARI Tormuj-1)	24 July 2023	12-15 DAS	N ₁₁₅ P ₅₀ K ₁₀₀ S ₁₈ Zn ₄ B ₂	12-15 Oct.2023 (80-83 DAP)
Red amaranth (BARI Lalshak-1) and Kangkong (BARI Gimakolmi-1)	24 July 2023	--	--	23 Aug.to 12 Oct. 2023 (30-85 DAS)

Table 2. Yield of Watermelon on floating bed at Rajoir upzilla, Madaripur kharif II, 2023

Pl. pop plot ⁻¹ (m ²)	Fruits pl ⁻¹ (no)	single fruits wt (g)	Fruit length (cm)	Fruit dia (cm)	yield (ton ha ⁻¹)	Fruit wt/dec (kg)
16	2.71	2482	18.75	49.62	26.83	107.33
16	2.63	2472	18.67	47.48	26.00	104.00

Table 3. Yield of Red amaranth and Kangkong at Rajoirupzilla, Madaripurkharif II, 2023

Non-creeper	Yield (kg dec ⁻¹)
Red amaranth	70
Gimakolmi	109

Table 4. Yield and cost & return of intercropping creeper and non-creeper vegetables at Tetulbari under Rajoir upzilla, Madaripur kharif II, 2023

Treatments	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Remarks
T1 (Watermelon + Red amaranth)	109606	74100	35506	20% yield & 30% income increased in T ₂ over T ₁
T2 (Watermelon + Gimakolmi)	120413	74100	46313	

Input price (TVC): Bed cost: Tk. 6200/bed (Seed & Fertilizer: 200; labor, 12 person: Tk.6000). One structure can be used continuing 2 times, so one time preparing cost is Tk. 3100.00 (i.e.6200/2); Input price (TVC): Trellis cost: Tk. 5100.00 (Net: 300, bamboo (borok): Tk.3000, bamboo (Tolla): Tk.1800.).One trellis can use continuing 3 times, so one time preparing cost is Tk. 1700.00 (i.e. 5100/3). So, Total cost (Bed cost + Trellis cost): 3100+1700= Tk.4800.00; Output price (Tk kg⁻¹):Water melon: 50.00, Gimakolmi: 25.00 and Red amaranth: 25.00

Farmers' Opinion

- Yield of Gimakolmi with water melon was higher
- Higher demand to customers along with higher market price due to pesticide free production
- More profitable
- 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 on floating bed

Conclusion

From the two years study it reveals that “improved floating bed cum trellis (non-tidal model)” was a good way for production of creeper vegetables with non-creeper simultaneously. The income increased 30.43% in Water melon with Gimakolmi as intercropped combination in against of water melon with Red amaranth.

203. ON-FARM ASSESSMENT OF YIELD AND RETURN FROM VEGETABLE AND SPICES UNDER FLOATING BED IN NORTH-EASTERN PART OF BANGLADESH

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Abstract

This trial was conducted at waterlogged haor ecosystem of Fenchuganj upazilla under Sylhet district during two consecutive years of 2022-23 and 2023-24 to evaluate the performance of vegetable and spices under floating beds cultivation. Relay intercropping of seven different crops have been selected based on the previous performance trial and farmers' choice. Two sets of trials with five crop sequences including farmers practice viz. set-A [CS₁: sweet gourd (var. BARI Mistikumra-2) + tomato (var. BARI Hybrid Tomato-4) + kangkong (var. BARI Gimakol-1); CS₂: sweet gourd (var. BARI Mistikumra-2) + brinjal (var. BARI Begun-8) + kangkong (var. BARI Gimakol-1); CS₃: sweet gourd (var. BARI Mistikumra-2) + onion (var. BARI Pijaj-3) + kangkong (var. BARI Gimakol-1); CS₄: sweet gourd (var. BARI Mistikumra-2) + chilli (var. BARI Morich-2) + kangkong (var. BARI Gimakol-1); and CS₅ (FP): sweet gourd

(local cultivar) + kangkong (local cultivar)]; set-B [CS₆: bottle gourd (var. BARI Mistikumra-2) + tomato (var. BARI Hybrid Tomato-4) + kangkong (var. BARI Gimakol-1); CS₇: bottle gourd (var. BARI Mistikumra-2) + brinjal (var. BARI Begun-8) + kangkong (var. BARI Gimakol-1); CS₈: bottle gourd (var. BARI Mistikumra-2) + onion (var. BARI Piaj-3) + kangkong (var. BARI Gimakol-1); CS₉: bottle gourd (var. BARI Mistikumra-2) + chilli (var. BARI Morich-2) + kangkong (var. BARI Gimakol-1); and CS₁₀(FP): bottle gourd (BARI Lau-4) + kangkong (local cultivar)] were used in this experiment. The yields of each non-creeper crops were determined in terms of respected creeper vegetables (sweet gourd and bottle gourd) equivalent yields (EY), which was computed by converting the yields based on the existing market price of each non-creeper crops. The highest fruit yields of sweet gourd (44.63 t ha⁻¹) and bottle gourd (54.36 t ha⁻¹) was observed in CS₄ (sweet gourd + chilli + kangkong) and CS₆ (bottle gourd + tomato + kangkong), which were statistically higher over other treatments whereas farmer's practices CS₅ (sweet gourd + kangkong) and CS₁₀ (bottle gourd + kangkong) gave the lowest fruit yields of 36.57 and 41.00 t ha⁻¹, respectively. The component crops performed better and produced higher yields in sequence of sweet gourd as compared to bottle gourd. Among the ten cropping sequences, the higher total equivalent yields 98.27 and 98.61 t ha⁻¹ and BCR 2.00 and 2.21 were obtained from CS₁ followed by CS₆, respectively. Based on the yields and monetary benefits, CS₁ (sweet gourd + tomato + kangkong) followed by CS₆ (bottle gourd + tomato + kangkong) is more suitable crop sequences for floating cultivation in haor region.

Introduction

Floating garden under hydroponics system in Bangladesh is recognized as a Globally Important Agricultural Heritage System (GIAHS) for innovation, sustainability, and adaptability by the United Nations' Food and Agricultural Organization (FAO); but these ancestral agricultural systems are threatened by many factors including climate change and increased competition for natural resources. It has a history of about 300-400 years, people have been following an age-old traditional method of cultivation called as baira, kandi, vasomanchash and floating agriculture referred as hydroponics in south-central districts.

Floating agriculture can be a good option for successful vegetable and seedling production by smallholder farmers, whose lands have been waterlogged for most of the time in each year. It is also an environmentally sustainable way to make wise-use of wetlands for poverty alleviation and also as an important adaption measure to cope with the possible climate change. The region Sylhet is in northeast corner of Bangladesh, consisting of more than 300 haors with a different wetland ecosystem. Most of the lands remain submerged for a long time during the monsoon season as a result scarcity of vegetables in market and less consumption resulted malnutrition is a serious problem in poor haor dwellers. The haor farmers' effort to produce vegetables through "Vasoman Chash" following the practice exists in southern part of the country. But the monsoon agro climatic condition is quite different between two regions, which need scientific improvement of this innovative technology as per need of haor farmers. The wetland areas of north eastern (NE) parts of Bangladesh often severely affected by flash floods. Floating cultivation is a means to rehabilitate their livelihoods after devastating flood. So, the floating bed or bio-land trial was conducted to develop economically viable cultivation and to introduce different vegetables and spices over the season.

Materials and Methods

The climate of experimental location is humid sub-tropical with a predominantly hot and humid summer and a relatively prolong cool winter with three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. The experiment was conducted at haor ecosystem at Fenchuganj, under Sylhet district. The waterlogging period of experimental location starts from early May and stays up to mid-October. The monthly air temperature (°C) and rainfall (mm) for the experimental site are indicated in figure 1. The average climatic data of Sylhet shows that the mean annual minimum temperature is 11.64 °C and the mean annual maximum temperature is 34.06 °C and the annual mean temperature nearly 18.62 °C. As indicated in Figure 2, rainfall of

the area is uni-modal, usually occurring during April to October, and total annual rainfall reached 4217 mm; whereas in December no rain at all and lowest amount of rainfall occurs in January followed by February. However, in rest of the month's total rainfall was ranged from 100 mm to just below 800 mm. Rainfall increases gradually from the month of May and continued up to September.

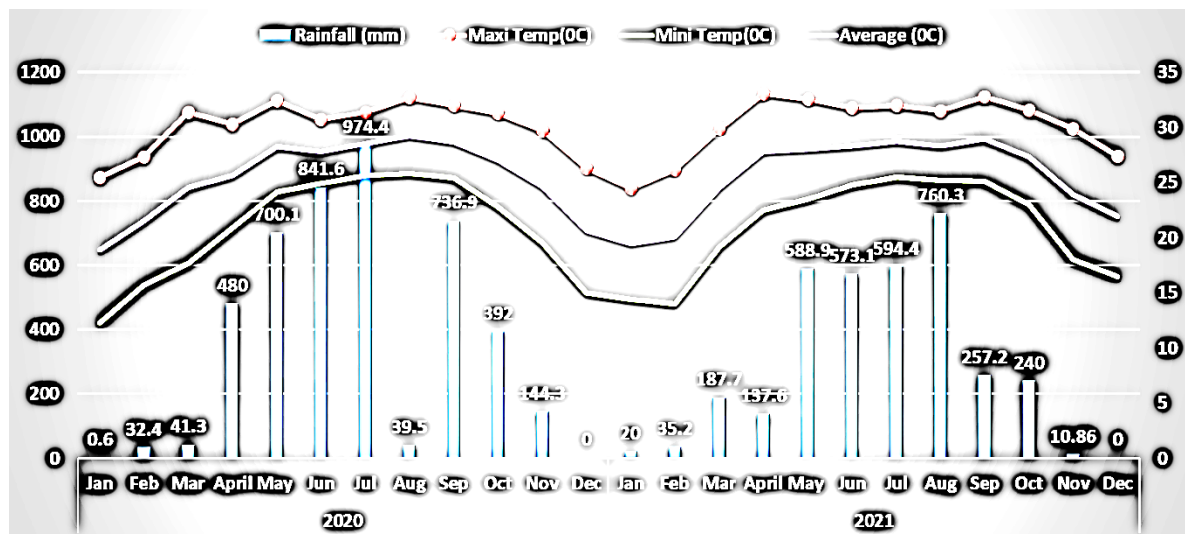


Fig. 1. Annual Rainfall (mm), Maximum, Minimum, and Average Air Temperature in Sylhet, Bangladesh

Floating garden involves growing crops on soilless floating rafts in waterlogged areas. Generally, these rafts are made up of abundantly available water hyacinth and other aquatic weeds. The shape and size of the floating rafts vary according to the farmer's choice, demand, and economic capacity but small platform or bed is easier to manage for better crop production. But seven crops have been brought under two trials based on the previous on-farm trial and farmers' choice. Relay/inter cropping of vegetable and spices crops and variety under two sets of experiments in haor region of Sylhet. Such as set A [CS₁: Sweet gourd + tomato + kangkong; CS₂: Sweet gourd + brinjal + kangkong, CS₃: Sweet gourd + onion + kangkong, CS₄: Sweet gourd + chilli + kangkong and CS₅ (FP): Sweet gourd + kangkong] and set B [CS₆: Bottle gourd + tomato + kangkong; CS₇: Bottle gourd + brinjal + kangkong, CS₈: Bottle gourd + onion + kangkong, CS₉: Bottle gourd + chilli + kangkong and CS₁₀ (FP): Bottle gourd + kangkong]. Each trial was replicated four times.

The volume of each rectangular floating bed was 9.0 m × 1.5 m × 1.25 m depth. Between two floating beds a length wise arch shape structure (9 m × 4 m) was prepared and placed above the water level supported with 9-12 bamboo pillars for cucurbit vegetables. The beds (9.0 m × 1.5 m) and trellis were made of bamboo slices and reusable/decomposable net. It was basically a stack of matured decomposed water hyacinth on to the rectangular bamboo frame and indigenous floating algae.

The beds were prepared on mid-May in each year with water hyacinth and the left few days for decomposition before sowing the seeds or planting the seedlings. Fifteen to twenty-five days old seedlings of each crop were transplanted in beds on 20-25 June with maintaining the recommended spacing. Bamboo trellis were made and placed between two beds supporting with the bamboo pillars for each vine crops. A mixture of NPKS (200-250 g) was applied in each bed during cultivation. Watering, weeding and plant protection were carried out as and when needed, especially at the early stage of seedling establishment. The products were harvested at marketable stage during August to last week of November in each year. The yields of crops grown in different relay intercropping combinations of floating bed practice were recorded and converted into hectare. The yields of each non-creeper crops converted the yields based on the existing market price. Benefit cost ratio (BCR) was computed to evaluate the profitability of different treatments applied in floating bed agriculture.

Results and Discussion

Sweet gourd based relay intercropping

There was a significant effect was observed on the yields of sweet gourd and kangkong under different crop sequences, which reflect on the total equivalent yields. The maximum fruit yield (44.63 t ha^{-1}) of sweet gourd was achieved from CS₄ (sweet gourd + chilli + kangkong) and it was statistically similar to other treatments except CS₅ (sweet gourd + kangkong) which produced the lowest fruit yield (36.57 t ha^{-1}). The harvest yields (28.36 , 18.15 , 6.85 and 7.13 t ha^{-1}) of tomato, brinjal, onion and chilli were obtained from crop sequences CS₁, CS₂, CS₃ and CS₄, respectively. The biomass yields of kangkong was varied significantly with different combinations and the maximum yield (35.41 t ha^{-1}) was recorded from CS₃, which was followed by CS₄, CS₂, and CS₁. The lowest biomass yield (27.62 t ha^{-1}) was recorded from farmers practice. This yield gap might be due to lack of good agricultural practice (GAP) done by farmers own initiatives.

Equivalent Yield: Total productivity of different cropping sequences was evaluated in terms of sweet gourd equivalent yield (SGEY) which was calculated from yield of component crops. The yields were varied due to different cropping sequences (Table 2). The higher SGEY (98.27 t ha^{-1}) was recorded from CS₁; comprise of three crops such as tomato, kangkong with sweet gourd, followed by CS₂ (sweet gourd + brinjal + kangkong). The crop sequence CS₃ (sweet gourd + onion + kangkong) and CS₄ (sweet gourd + chilli + kangkong) also showed reasonable SGEY (74.67 and 78.05 t ha^{-1} , respectively). On the contrary, relay intercropping sequence under farmers practice (CS₅) is composed of sweet gourd and kangkong provided lower equivalent yield (53.14 t ha^{-1}) of sweet gourd. Results revealed that due to inclusion of one more crop in CS₁-CS₄ increased total equivalent yield 40.52 to 82.93% compared to existing farmer's practice (CS₅). It is noted that inclusion of tomato in CS₁ showed much higher total SGEY (98.27 t ha^{-1}) than other relay intercrop sequences (Table 1).

Monetary advantage: Productivity of five cropping sequences was differed from each other. The highest gross return (Tk. 1965400 ha^{-1}) was recorded from CS₁ (sweet gourd + tomato + kangkong). CS₂ (sweet gourd + brinjal + kangkong) showed gross return of Tk. 1699800 ha^{-1} followed by CS₄ with reasonable gross return but much less than CS₁. The crop sequence, sweet gourd + kangkong gave the lowest gross return of Tk. 1062800 ha^{-1} . Total cost was lower in CS₅ (Tk. 980860 ha^{-1}) followed by CS₄. The highest total cost was found in CS₃, might be due to higher seed cost of onion. The higher gross margin was obtained from CS₁ (Tk. 972586 ha^{-1}) followed by CS₂ (Tk. 716678 ha^{-1}) and CS₄ (Tk. 579690 ha^{-1}); while farmers practice (CS₅) gave the lowest gross margin (Tk. 81940 ha^{-1}). The higher benefit cost ratio (2.00) was found in CS₁ followed by CS₂ (1.73) and CS₄ (1.59). whereas, farmers practice (CS₅) gave the lowest BCR (1.08). The cost benefit analysis showed that introduction of one more crop in the existing pattern exhibited higher benefit.

Bottle gourd based relay intercropping

The fruit yields of bottle gourd and biomass yields of kangkong were varied significantly with variation of relay intercropping sequences which was reflected on to the total equivalent yields of patterns (Table 3). The highest fruit yield (54.36 t ha^{-1}) of bottle gourd was obtained from CS₆ (bottle gourd + tomato + kangkong) followed by CS₈ and CS₇ and these were statistically similar to others treatments but higher over CS₁₀ (bottle gourd + kangkong) and it produced the lowest fruit yield (41.00 t ha^{-1}). The yields 25.93 , 14.53 , 7.45 and 7.96 t ha^{-1} was produced by tomato, brinjal, onion and chilli under relay intercrop sequences of CS₆, CS₇, CS₈ and CS₉, respectively. The biomass yields of kangkong was varied significantly with different combinations and the maximum yield (31.42 t ha^{-1}) was recorded from CS₉, which was followed by CS₈, CS₇, and CS₆. The lowest yield (23.28 t ha^{-1}) was recorded in CS₁₀ might be due to improper management done by farmers.

Equivalent yield: Economic profitability of different relay intercropping sequences (CS₆-CS₁₀) were evaluated in terms of bottle gourd equivalent yield (BGEY) and it has been enumerated from

yields of component crops. The equivalent yields of bottle gourd were varied due to variation of crops grown in cropping sequences (Table 2). The higher BGEY (98.61 t ha⁻¹) was recorded from CS₆; be composed of tomato and kangkong with bottle gourd, followed by CS₇ (bottle gourd + brinjal + kangkong). Acceptable total equivalent yields of bottle gourd 77.58 and 75.01 t ha⁻¹ were observed in CS₈ (bottle gourd + onion + kangkong) and CS₄ (bottle gourd + chilli + kangkong), respectively; and the lowest total equivalent yield (53.69 t ha⁻¹) of bottle gourd was recorded in farmers practice (CS₁₀). It is noticeable that total equivalent yield of bottle gourd was increased 39.71 to 83.66 % due to addition of one more crop in existing CS₁₀(Table 3).

Monetary advantage: Cost and return analysis were done based on the existing market price of crops during season. From the economic point of view, cropping sequences (CS₆-CS₉) showed their superiority over existing FP (CS₁₀). The gross return of the CS₆ (bottle gourd + tomato + kangkong) was Tk.2169420 ha⁻¹, which was 83.67 % higher than that of FP (bottle gourd + kangkong). The higher gross margin was achieved from CS₆ (Tk.1187125 ha⁻¹) followed by CS₇ (Tk. 793158ha⁻¹) and CS₈ (Tk.720773ha⁻¹), while CS₁₀ (FP) gave the lowest gross margin of Tk.200320 ha⁻¹. The highest BCR was found in CS₆ (2.21) followed by CS₇ (1.81) and CS₈ (1.73). The lowest BCR (1.20) was gained from farmers practice (CS₁₀). It has been reported that leafy vegetables intercropped with mung bean in a floating garden provided higher yield and economic returns [11].

Table 1. Yield performance of different crops grown under five cropping sequences at floating bed, Sylhet region (pooled).

Treatments	Crop wise yields of five cropping sequences (t ha ⁻¹)						Total SGEY (t ha ⁻¹)
	S. gourd	Tomato	Brinjal	Onion	Chilli	Kangkong	
CS ₁	43.94	28.36 (35.45)	-	-	-	31.47 (18.88)	98.27
CS ₂	41.45	-	18.15 (22.69)	-	-	34.76 (20.85)	84.99
CS ₃	43.63	-	-	6.85 (11.98)	-	35.41 (21.24)	74.67
CS ₄	44.63	-	-	-	7.13 (12.47)	34.93 (20.95)	78.05
CS ₅ (FP)	36.57	-	-	-	-	27.62 (16.57)	53.14
CV (%)	4.13	-	-	-	-	6.48	-
LSD (0.05)	3.26	-	-	-	-	4.01	-

SGEY: Sweet gourd equivalent yield; FP: Farmer's Practice; The values within parenthesis are equivalent yields of respective crops. Price (Tk.kg⁻¹): Sweet gourd(fruit)-20, Tomato(fruit)-25, Brinjal(fruit)-25, Onion(bulb)-35,Chill (fruit)-35, Kang Kong(Biomass)- 12.

Table 2. Percent increase of SGEY, and economic performance of five crop sequences (CS₁-CS₅) at floating bed, Sylhet region (pooled).

Treatments	EY increase over FP (%)	Gross return (Tk.ha ⁻¹)	Total cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
CS ₁	82.93	1965400	983814	972586	2.00
CS ₂	59.94	1699800	983122	716678	1.73
CS ₃	40.52	1493400	985987	507413	1.51
CS ₄	46.87	1561000	981310	579690	1.59
CS ₅ (FP)	-	1062800	980860	81940	1.08

CS₁: sweet gourd + tomato + kangkong; CS₂: sweet gourd + brinjal + kangkong, CS₃: sweet gourd + onion + kangkong, CS₄: sweet gourd + chilli + kangkong and CS₅ (FP): sweet gourd + kangkong

Table 3. Yield performance of different crops grown under five cropping sequences at floating bed, Sylhet region (pooled).

Treatments	Crop wise yields of five cropping sequences (t ha ⁻¹)						Total BGEY (t ha ⁻¹)
	Bottle gourd	Tomato	Brinjal	Onion	Chilli	Kangkong	
CS ₆	54.36	25.93 (29.46)	-	-	-	27.12(14.79)	98.61
CS ₇	48.60	-	14.53 (16.51)	-	-	28.67(15.63)	80.74
CS ₈	49.59	-	-	7.45 (11.85)	-	29.60(16.14)	77.58
CS ₉	45.22	-	-	-	7.96 (12.66)	31.42(17.13)	75.01
CS ₁₀ (FP)	41.00	-	-	-	-	23.28(12.69)	53.69
CV (%)	5.75	-	-	-	-	6.80	-
LSD (0.05)	5.17	-	-	-	-	3.58	-

BGEY: Bottle gourd equivalent yield; FP: Farmer's Practice; The values within parenthesis are equivalent yields of respective crops. Price (Tk.kg⁻¹): Bottle gourd(fruit)-22, Tomato(fruit)-25, Brinjal(fruit)-25, Onion (bulb)-35, Chilli(fruit)-35, Kang Kong (biomass)-12. CS₆: Bottle gourd + tomato + kangkong; CS₇: Bottle gourd + brinjal + kangkong, CS₈: Bottle gourd + onion + kangkong, CS₉: Bottle gourd + chilli + kangkong and CS₁₀(FP): Bottle gourd + kangkong

Table 4. Percent increase of BGEY, and economic performance of five crop sequences(CS₆-CS₁₀) at floating bed, Sylhet region (pooled).

Treatments	EY increase over FP (%)	Gross return (Tk.ha ⁻¹)	Total cost (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
CS ₆	83.66	2169420	982295	1187125	2.21
CS ₇	50.38	1776280	983122	793158	1.81
CS ₈	44.51	1706760	985987	720773	1.73
CS ₉	39.71	1650220	981310	668910	1.68
CS ₁₀ (FP)	-	1181180	980860	200320	1.20

Conclusion

Among the treatments,CS₁(sweet gourd + tomato + kangkong) and CS₆ (bottle gourd + tomato + kangkong) intercropping system was the most productive and profitable (BCR 2.00 and 2.21) than other combinations.Floating agriculture in waterlogged ecosystem of northeastern region has a huge prospect for improving the livelihood of marginal farmers. People have limited homestead areas for vegetable and spices cultivation during summer. So, floatinggardening, could be a good option to ensure their food and nutritional outcome, and also the financial support to the haordwellers.

204.PERFORMANCE OF DIFFERENT INTERCROPPING SYSTEM RED AMARANTH WITH COLE CROPS IN FLOATING BED AT GOPALGANJ REGION

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Abstract

Three intercropping system viz. cauliflower + red amaranth, cabbage + red amaranth and knolkhol + red amaranth were taken to test the suitability for intercrop in floating agriculture. The experiment was conducted at Tungipara and Sadar, Gopalganj during the rabi season of 2023-24. Among the three intercropping cauliflower + red amaranth gave the highest red-amaranth equivalent yield (9.93 t ha⁻¹), Gross return (248465Tk. ha⁻¹) and BCR (2.17) while the lowest red-amaranth equivalent yield (8.50 t ha⁻¹), gross return (222425Tk. ha⁻¹) and BCR (1.94) was recorded from cabbage + 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 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 Sadar and Tungipara, Gopalganj during the rabi season of 2023-'24. The size of each bed was 9.15mx 1.37m and the

number of bed ha⁻¹ was 62. Three intercrop viz. cauliflower + red amaranth, cabbage + red amaranth and knolkhol + red amaranth were tested under this study. Seeds and seedlings were sown and planted at 25 November and 2 December 2023 at different location. Cauliflower, cabbage and knolkhol were transplanted with the spacing of 60cm x 40cm and seeds of red amaranth were broadcasted between spacing of two rows. All kinds of intercultural operations were done as and when necessary. The harvesting date of amaranth was 22-30 December and other crops (Cabbage, cauliflower and knolkhal) were 8-15 February 2024.

Result and discussion

There was a significant difference among the intercropping systems (Table-1). The highest red amaranth equivalent yield (9.93t ha⁻¹) was found from cauliflower+red amaranth intercropping which gross return (248465Tk. ha⁻¹) and BCR (2.17) were also highest. At the same time, amaranth equivalent yield, gross-return and BCR of knolkhol+red amaranth intercropping were 9.63kg ha⁻¹, 240870Tk. ha⁻¹ and 2.10, respectively. The lowest red-amaranth equivalent yield, gross return and BCR 8.50t ha⁻¹, 222425Tk./bed and 1.94 were recorded from Cabbage + Red amaranth intercropping.

Table 1. Yield and profitability of the different intercropped in floating bed during rabi 2023-24

Treatments	Locations	Yield (t ha ⁻¹)		Red am. Eq. yield	GR (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	GM (Tk ha ⁻¹)	BCR
		Cabbage/Cauliflower/Knolkhol	Red amaranth					
Cauliflower + red amaranth	Tungipara	7.13	1.73	10.29	257300	114700	142600	2.24
	Sadar	6.70	1.55	9.58	239630	114700	124930	2.09
	Mean	6.92	1.64	9.93	248465	114700	133765	2.17
Cabbage + red amaranth	Tungipara	7.75	1.24	9.00	224750	114700	110050	1.96
	Sadar	7.44	1.36	8.80	220100	114700	105400	1.92
	Mean	7.60	1.30	8.50	222425	114700	107725	1.94
Knolkhol + red amaranth	Tungipara	6.51	1.90	10.08	252030	114700	137330	2.20
	Sadar	6.07	1.58	9.18	229710	114700	115010	2.00
	Mean	6.30	1.74	9.63	240870	114700	126170	2.10

Cost (Tk./bed): 1850/-, Price (Tk./kg): Cauliflower=30/-, Cabbage=25/, Knolkhol=30/- and Red amaranth=25Tk.

Farmers' opinion

Farmers and their neighbours choose cauliflower + red amaranth intercrop for its best performance in respect of gross-return with BCR.

Conclusion

Among the three intercropping system, red amaranth with cauliflower was more suitable in the context of the yield and profitability.

205. ADAPTIVE TRIAL OF WINTER ONION VARIETIES ON FLOATING BED IN THE LAXMIPUR DISTRICT

M. MOHIUDDIN, M.S. ISLAM AND M.M. BASHIR

Abstract

Adaptive trial of winter onion varieties was conducted at Ramgong upazilla under Laxmipur district during 2023-24 to examine a suitable winter onion variety for the floating bed in the area. One BARI developed variety BARI Peaz-1 and Local were tested. Yield and yield contributing characters were observed higher in BARI Peaz-1. Bulb yield from BARI Peaz-1 was 9.74 t ha⁻¹ next to from local variety (7.52 t ha⁻¹). As output price was same for the two varieties cost and return performance followed the bulb yield. Gross return (Tk. 292200 ha⁻¹), gross return (Tk. 124800 ha⁻¹) and BCR (1.75) was found from BARI Peaz-1.

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial product which is used as spices, vegetable and salad in Bangladesh. Annually 17.04 mt of onion is produces from 4.19 lakh acres of land (BBS, 2018). The average yield of onion in Bangladesh is far below from the potentiality. It is about 8 t ha⁻¹ (BBS, 2018) as compared to the world average yield 19.3 t ha⁻¹. Onion is mainly produced in the winter season but cultivating summer onion is constrained due to adverse weather and proper cultural management (Islam *et al.*, 2018). In Bangladesh there is an acute shortage of onion with compared to its total annual requirement (Ullah *et al.*, 2008; Alam *et al.*, 2009). So a huge amount of onion is imported every year to meet up the demand of Bangladesh. BARI has released six onion varieties (BARI Peaz-1 to 6) for cultivating in the winter season. At the time of April to September this low lying area seems to be a sea and spice cultivation and availability is very hard because the shortage of high land. Floating agriculture is one of the best solutions to provide the opportunities of cultivating different spices at monsoon period. Therefore, winter onion cultivation on floating bed can be a new way to increase onion production in the project area of Laxmipur district.

Material and Methods

An adaptive trial was conducted at the Kazirkhil area of Ramgong upazilla under Laxmipur district during 2023-24 to examine the suitable variety of winter onion for that area. The experiment was laid out in a randomized complete block design with six dispersed replications. Varieties were BARI Peaz-1 and Local. The unit bed sizes were 9.15 m × 1.37 m (30 ft long × 4.5 ft wide). Collected seeds of winter onion and Local varieties were sown on 1st week of December 2023 in the protected seed bed in dry soil. Seedlings of 35 days old were transplanted in the floating bed on 10 January 2024 by maintaining 20×10 cm spacing. The recommended fertilize doses were applied as urea 95g, DAP 90g, MoP 105g, gypsum 47g and boric acid 7g per bed. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in three equal splits at 25 days interval after 30 days of transplanting. The liquid form of plant nutrients was applied to around the plants standing on the floating bed. Gap filling, irrigation, weeding, plant protection measures and other intercultural operations were done as and when necessary. During the growing period no major disease of onion was noticed. Nevertheless Mancozeb and Otostine were applied to control leaf blotch and bulb rot of onion. Bulb of BARI Peaz-1 and Local varieties were harvested on 15 April 2024. Data on yield and yield contributing characters were recorded and mean value were presented in the tables.

Results and Discussion

Yield and yield contributing characters of onion were presented in Table 1. Comparatively higher yield contributing characters like plant height (43.7 cm), leaves plant⁻¹ (4.22), bulb diameter (5.24 cm) and bulb length (3.91 cm) were observed in in BARI Peaz-1. The cumulative effect of yield attributes made a difference in bulb production per unit area (9.74 t ha⁻¹) which was 29.5% higher as compared to local variety. It might be due to the varietal potentiality of BARI Peaz-1.

Cost and return analysis: As variable production cost and output price were same for the two onion varieties cost and return analysis performance followed the bulb yield (Table 2). The higher the bulbs yield the higher the benefit. Gross return from BARI Peaz-1 was observed Tk. 292200 ha⁻¹. Gross return was also higher in the same variety and it was Tk. 124800 ha⁻¹ which was 114% higher than local variety. Benefit cost ratio (BCR) was 1.75 in BARI Peaz-1.

Table 1. Yield and yield contributing characters of winter onion in Laxmipur in 2022-2023

Treatments	Plant height (cm)	Leaves/plant (No.)	Bulb diameter (cm)	Bulb length (cm)	Bulb Yield (t ha ⁻¹)
BARI Peaz-1	43.7	4.22	5.24	3.91	9.74
Local	35.4	3.51	4.75	3.08	7.52

Table 2. Cost and return of winter onion in Laxmipur in 2022-2023

Treatments	Bulb yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk.ha ⁻¹)	Gross margin (Tk.ha ⁻¹)	BCR
BARI Peaz-1	9.74	292200	167400	124800	1.75
Local	7.52	225600	167400	58200	1.35

TVC includes Labour, Bed preparation, Seed, Fertilizers and Insecticides, Price of BARI Peaz-1 and Local was Tk. 30 kg⁻¹

Farmer's opinion: Between the varieties farmers had chosen BARI Peaz-1 for its high yielding potentiality.

Conclusion

BARI Peaz-1 is suitable as spice crop at the extrapolation area of Chatkhil and Ramgongupazilla for its high yielding potentiality.

206. ADAPTIVE TRIALS OF CREEPER VEGETABLES ON FLOATING BED CUM TRELLIS (NON-TIDAL MODEL)

M.S. ISLAM, M.M. BASHIR, M M. HOWLADER, D HALDER, M. MOHIUDDIN AND M. Y. H. RAYHAN

Abstract

The experiment was conducted at laxmipur, Gopalganj and Kishoreganj districts during the cropping season of 2023-24 to increase the crop productivity of floating bed agriculture system as well as to increase the farmers' income. The variety of creeper vegetables were for bottle gourd (BARI Lau-4), sweet gourd (BARI hybrid Misti Kumra-1 and sweety), bitter gourd (Tiya), cucumber (Alavi green) and yard long bean (BARI Borboti-1). In case of Noakhali, the fruits yield of creeper vegetables obtained from bottle gourd, sweet gourd, bitter gourd, cucumber and yard long bean were 31.08, 26.43, 12.16, 20.64 and 6.72 t ha⁻¹, respectively. In case of Gopalganj, the fruits yield obtained from bottle gourd, sweet gourd and bitter gourd were 8.43, 5.95 and 3.78 t ha⁻¹, respectively. In case of Kishoreganj, the fruits yield obtained from bottle gourd, sweet gourd, bitter gourd, cucumber and yard long bean were 54.68, 39.64, 23.65, 22.82 and 8.17 t ha⁻¹, respectively. Bottle gourd produced the highest gross return, gross margin and BCR in all location.

Introduction

Farmers are traditionally produced seedlings of different vegetables like okra, bottle gourd, bitter gourd, sweet gourd etc.) on water hyacinth made floating bed in Gopalganj, Barishal and Pirojpur districts. However, cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lacking 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 which made between two floating beds. In this system, they would increase the crop productivity; enhance food and nutrition security and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment was taken to evaluate the performance of some creeper vegetables on "Floating Bed cum Trellis (non-tidal model)" under flooded ecosystem in non-tidal areas of Bangladesh.

Materials and Methods

The experiment was conducted at Hanubaish, Ramgongupazilla, Laxmipur district during February to June 2024 to increase the crop productivity on floating agriculture system and to increase the crop intensity and economic return of farmers. The trial was conducted on floating bed and each floating bed considered as one treatment. Five treatments were considered as T₁: Bottle gourd, T₂: Cucumber, T₃: Sweet gourd, T₄: Bitter gourd and T₅: Yard long bean. The size of each floating bed was 9.15 m × 1.37 m (30ft long × 4.5ft wide) and size of whole trellis (between two floating beds) were different according to crops like for Bottle gourd and Sweet gourd: 9.15

m × 4.57 m (30 ft long × 15 ft wide) and for yard long bean and cucumber was 9.15 m × 4.57 m (30 ft long × 12 ft wide). The two rows of creeper crop were grown on each floating bed maintaining 1m plant to plant distance for all crops. The seedlings per hill was two for bottle gourd, sweet gourd and bitter gourd and four for cucumber and yard long bean. Uniform size, healthy 10-12 days old seedlings of bottle gourd (BARI Lau-4), sweet gourd (BARI Hybrid Misti Kumra-1), bitter gourd (Tia a commercial hybrid) and cucumber (Alavi green a commercial hybrid) plants were transplanted on 15 to 20 February 2024 in Noakhali, 15-25 November, 2023 in Kishoreganj and 15-20 July 2023 in Gopalganj. The fertilizer dose were different on the basis of crops requirements like bottle gourd and sweet gourds: 53 g urea, 135 g DAP, 30 g MoP, 33 g gypsum, 2 g zinc sulphate, 4 g boric acid, cucumber, 57 g urea, 64 g DAP, 18g MoP, 28g gypsum, 2 g Zinc sulphate, 5 g boric acid; for bitter gourd: 53 g urea, 135 g DAP, 30g MoP, 33 g gypsum, 2g zinc sulphate, 4 g boric acid. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAT) except in cucumber. In cucumber fertilizers were applied in four equal splits at 15, 25, 35 and 45 DAT. The liquid form of plant nutrients were applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphatic 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. Harvesting was started from last week of February to April, 2024 in Kishoreganj, 25 September to 13 October 2024 in Gopalganj and last week of April and continued up to 25 June 2024 in Noakhali for different crops. Data on plant population (m^{-2}), fruits plant⁻¹ (no), individual fruit weight (kg) and fruit yield ($t\ ha^{-1}$) were recorded.

Result and Discussions

Performance of creeper vegetables were presented in Table 1. In case of Noakhali, the fruit yield obtained from bottle gourd, sweet gourd, bitter gourd, cucumber and yard long bean were 31.08, 26.43, 12.16, 20.64 and 6.72 tha^{-1} , respectively. In case of Kishoreganj, the fruit yield obtained from bottle gourd, sweet gourd, bitter gourd, cucumber and yard long bean were 54.68, 39.64, 23.65, 22.82 and 8.17 tha^{-1} , respectively. In case of Gopalganj, the fruits yield obtained from bottle gourd, sweet gourd and bitter gourd were 8.43, 5.95 and 3.78 $t\ ha^{-1}$, respectively. Bottle gourd yield was the highest. Bottle gourd is very suitable for floating bed cultivation. It can tolerate adverse condition more than cucumber, sweet gourd and yard long bean. Powdery mildew attacked in sweet gourd and virus attacked cucumber and protective measures were done to save the crop. The yard long bean yield was the lowest among all the planted creeper vegetables due to leaf miner attack.

Cost and return analysis: Total variable cost (TVC) varied due to seed, fungicide price and fertilizer doses. In case of Noakhali, Gross margin (GM) was obtained highest from bottle gourd (Tk. 282700 ha^{-1}) next to sweet gourd (Tk. 212950 ha^{-1}). The highest benefit cost ratio (BCR) was also observed in bottle gourd (2.54) and it was lowest from bitter gourd (1.27). Bitter gourd and yard long bean produced BCR <1.5. In case of Gopalganj, the highest gross return (Tk. 210800 ha^{-1}), gross margin (Tk. 80600 ha^{-1}) and BCR (1.62) were obtained from bottle gourd and lowest from bitter gourd. In case of Kishoreganj, gross return (Tk. 546800 ha^{-1}) and gross margin (Tk. 354215 ha^{-1}) was obtained from bottle gourd but BCR from bitter gourd due to lower input cost and more price of output.

Table 1. Yield, cost and return of creeper vegetables production on floating bed during 2023-24

Treatments	Yield (kg bed ⁻¹)	Yield (t ha ⁻¹)	Gross Return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Noakhali						
Bottle gourd	46.67	31.08	466200	183500	282700	2.54
Sweet gourd	39.68	26.43	396450	183500	212950	2.16
Bitter gourd	18.26	12.16	243200	187400	55800	1.30
Cucumber	30.99	20.64	309600	188100	121500	1.65
Yard long bean	10.09	6.72	235200	184800	50400	1.27

Gopalganj						
Bottle gourd	10.58	8.43	210800	130200	80600	1.62
Sweet gourd	4.74	3.78	151280	130200	21080	1.16
Bitter gourd	7.47	5.95	178560	130200	48360	1.37
Kishoreganj						
Bottle gourd	68.61	54.68	546800	192585	354215	2.84
Sweet gourd	49.74	39.64	396400	192585	203815	2.06
Bitter gourd	29.67	23.65	473000	152800	320200	3.10
Cucumber	28.63	22.82	456400	152800	303600	2.99
Yard long bean	10.25	8.17	245100	152800	92300	1.60

TVC includes Labour, Bed preparation, Seed, Fertilizers and Insecticides, Price kg⁻¹ (Noakhali) of Bottle gourd= 15/-, Sweet gourd= 15/-, Cucumber =15/-, Yard long bean = 35/-; Gopalganj- Bottle gourd-25/-, Bitter gourd-35/- and Sweet gourd-30/- and Kishoreganj -Bottle gourd= 10/-, Sweet gourd= 10/-, Bittergourd= 20/-, Cucumber =20/-, Yard long bean = 30/-

Farmers' Opinion

Demand of floating bed vegetables was higher in the local market due to safe food practices. Initial investment for bed preparation was higher. Less availability of water hyacinth in dry season as a result repair or refill of floating bed is troublesome. Neighbouring farmers showed interest to grow vegetables following modern technique of floating bed culture.

Conclusion

It may be concluded that floating bed cum trellis (non-tidal model) is an effective production practice of creeper vegetables. The technology is suggested to disseminate through pilot production program.

207. 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 upazilla of Kishoreganj district during 2023-24 to examine a suitable tomato variety for the area. Two BARI developed varieties such as BARI tomato-19 and BARI tomato-21 were tested. The significantly highest yield was found from BARI tomato-21 (47.56 t ha⁻¹) and the lowest from BARI tomato-19 (44.94 t ha⁻¹). From financial analysis, BARI tomato-21 gave the highest gross return (332920 Tk. ha⁻¹), gross margin (159420 Tk. ha⁻¹) and benefit cost ratio (1.92) followed by BARI tomato-19.

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. 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. Bangladesh Agricultural Research Institute (BARI) has developed a good number of high yielding varieties of tomato. However, BARI developed tomato varieties are yet not to be tested on floating bed. Therefore, the experiment has been undertaken to find out the suitable varieties of tomato. 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 upazilla of Kishoreganj district during 2023-24 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-19 and BARI tomato-21. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 10 November 2023 followed by 60 cm x 40 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. 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-19 and BARI tomato-21 were started to harvest at 15-23 February 2024 to 03-10 April 2024, respectively. Data on yield were recorded and presented in the table.

Results and Discussion

The highest yield per ha was recorded from BARI tomato-21 (47.56 t ha⁻¹) and lowest from BARI tomato-19 (44.94 t ha⁻¹). BARI tomato -21 gave the highest gross return Tk. 332920 ha⁻¹, gross margin Tk. 159420 ha⁻¹ and BCR 1.92 followed by BARI Tomato-19.

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, 2023-24

Treatments	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
BARI tomato-19	44.94	292110	173500	118610	1.68
BARI tomato-21	47.56	332920	173500	159420	1.92

Conclusion

The variety BARI Tomato-21 gave the highest yield (47.56 t ha⁻¹) and financial return (332920 Tk. ha⁻¹) followed by BARI tomato-19 (44.94 t ha⁻¹ and 292110 Tk. ha⁻¹).

208.ADAPTIVE TRIAL OF SELECTED TURMERIC VARIETIES ON FLOATING BED

M M HOWLADER, D HALDER AND M. MOHIUDDIN

Abstract

The experiment was carried out on water hyacinth based floating bed at Gopalganj and Kishoreganj during the cropping season 2023-24. Under this experiment four turmeric varieties in Gopalganj and Two varieties in Kishoreganj were used to evaluate their performance viz. BARI Holud-3, BARI Holud-4, BARI Holud-5 and local variety. Among the varieties, the highest yield was found from BARI Holud-4 (17.04 t ha⁻¹) in Kishoreganj and BARI Holud-5 (7.06t ha⁻¹) in Gopalganj.

Introduction

In Bangladesh total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Turmeric (*Curcuma longa*) is one of the most important spice crops in Bangladesh as well as in south Asia. The farmers generally produce the local variety of turmeric 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 turmeric production in this season. Cultivation of turmeric on floating bed will make available in the market during monsoon season. 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. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected turmeric varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Materials and Methods

The experiment was carried out on water hyacinth based floating bed at Tungipara and Gopalganj Sadar and Karimganj and sadar in Kishoreganj during the year of 2023-24. The size of bed was 9.15m x1.37m (30 feet×4.5 feet). BARI developed three turmeric varieties viz. BARI Holud-3, BARI Holud-4, BARI Holud-5 and local were taken as treatment in the study. Rhizome of the turmeric varieties were sown on 12 April 2023 in Kishoreganj and 18-24 June 2023 in Gopalganj followed by 60 cm x 25 cm spacing. The recommended fertilize doses were applied Urea-95gm, DAP-90g, MoP-105g, Gypsum-47g and Boric acid-07g per bed respectively. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in five equal splits at 1 month interval after 15 days of transplanting. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. Any major disease of turmeric was not appeared. Nevertheless mancozeb and otostine were applied to control leaf blotch and rhizome rot of turmeric. All kinds of intercultural operations were done as and when necessary. The harvesting date was 08-10 January 2024 in Kishoreganj and 25-28 March 2024 Gopalganj.

Result and discussion

Significant difference was found among the tested turmeric varieties in respect of yield and profitability (Table-1). BARI Holud-4 gave the highest yield 17.04 t ha⁻¹ followed by BARI Holud-5 (12.50 t ha⁻¹) in Kishoreganj. BARI Holud-5 gave the highest yield 7.31 t ha⁻¹ followed by BARI Holud-4 (6.32 t ha⁻¹) where lowest yield 4.55 t ha⁻¹ from local variety. Average gross return (426000 Tk. ha⁻¹), gross margin (280350 Tk. ha⁻¹) and BCR (2.92) was found highest from BARI holud-4 in Kishoreganj and gross return (353400 Tk. ha⁻¹), gross margin (179800 Tk. ha⁻¹) and BCR (2.04) was found highest from BARI holud-5 in Gopalganj.

Farmers' opinion

Among the varieties, farmers have chosen BARI holud-4 for its high yielding potentiality, excellent colour and market demand in Kishoreganj. Farmers of Gopalganj Sadar, Tungipara and their neighbours chose BARI Holud-5 for its higher yield and lucrative color.

Table 1.Yield and profitability of different turmeric varieties grown on floating bed, 2023-24

Varieties	Yield (t ha ⁻¹)	Gross Return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross Margin (Tk ha ⁻¹)	BCR
Gopalganj					
BARI Holud-3	5.20	260400	173600	86800	1.50
BARI Holud-4	6.32	316200	173600	142600	1.82
BARI Holud-5	7.06	353400	173600	179800	2.04
Local	4.55	227850	173600	54250	1.31
Kishoreganj					
BARI Holud-4	17.04	426000	145650	280350	2.92
BARI Holud-5	12.50	312500	145650	166850	2.15

Price (Tk./kg): Turmeric-50 in gopalganj and 25/- in Kishoreganj.

Conclusion

From the study it can be concluded that turmeric was profitable for cultivation on floating bed.

209.ADAPTIVE TRIAL OF DIFFERENT LEAFY VEGETABLES ON FLOATING BED

M. MOHIUDDIN, M M Howlader and D Halder

Abstract

The experiment was carried out on water hyacinth based floating bed at Metrodanga, Tungipara, Gopalganj during the cropping season 2023-24. The aim of the study was to identify the suitable leafy vegetable for floating bed and increase farmers income. Three leafy vegetables viz. Red amaranth, Amaranth and Spinach were tested under this experiment.

Among the leafy vegetables red amaranth gave highest gross return and BCR which were 181350 Tk. ha⁻¹ and 1.63.

Introduction

Vegetables are important part of healthy diet 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 to 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. But the floating bed crops should be diversified to make profitable of the traditional floating agriculture practices. In this respect, adaptation of leafy vegetables can be introduced in floating agriculture system. So this program was taken to identify the suitable leafy vegetables for floating agriculture system.

Material and Methods

The experiment was carried out on water hyacinth based floating bed at Metrodanga, Tungipara, Gopalganj during the year of 2023-24 with three replications. Three leafy vegetables Red amaranth (BARI lalshak-1), Amaranth (Gheekanchan) and Spinach (BARI Palanshak-1) were tested under this experiment. The unit size of bed was 9.15m x1.37m. During the growing period Red amaranth and Amaranth were sown three times; spinach was sown in two times with the spacing of 30 cm line sowing. The first sowing date of Red amaranth, Amaranth and Spinach were 25/12/2023. Second and last sowing date of Red amaranth and Amaranth was 29/01/24 and 01/03/24 respectively. The second sowing date of Spinach was 12/02/24. 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 harvesting dates of different leafy vegetables were 24/01/2024 to 25/03/2024.

Result and Discussion

A significant difference was found among the tested leafy vegetables in respect of yield and profitability (Table-1). Among these leafy vegetables, red amaranth gave the highest gross return (181350 Tk. ha⁻¹) and BCR (1.63) and amaranth gave the lowest gross return (140244 Tk. ha⁻¹) and BCR (1.26), respectively.

Farmers' opinion: Farmers and their neighbours are interested to cultivated red amaranth in floating bed for its higher profitability.

Table1. Yield and profitability of different leafy vegetables on floating bed during 2023-24

Treatments	Yield (t ha ⁻¹)	Gross Return (Tk ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross Margin (Tk ha ⁻¹)	BCR
Red amaranth	6.04	181350	111600	69750	1.63
Amaranth	4.67	140244	111600	28644	1.26
Spinach	8.60	172112	111600	60512	1.54

Price (Tk/kg): Red amaranth =30/-, Amaranth= 30/- and Spinach-20/-

Conclusion

From the study it can be concluded that red amaranth was profitable among the three leafy vegetables viz. Red amaranth, Amaranth and Spinach for cultivation in floating bed.

210. PRODUCTION PROGRAM OF DIFFERENT NON-CREEPER WITH GREEN AMARANTH AS INTERCROPPED ON TRADITIONAL BED IN MADARIPUR

M. MOHIUDDIN, SELIM AHMED

Abstract

Production program of creeper (Water melon, Bottle gourd, Sweet gourd and Yard long bean) and non-creeper vegetable (Green Amaranth) as intercropped system like Sweet gourd with Red amaranth, was conducted on traditional floating bed at Tetulbari area under Rajoir upazila of Madaripur during the year 2023-24 to study the performances of selected vegetables on floating bed system and to popularize those varieties among the farmers. The program was performed with improved floating bed. An improved floating bed is to be made by only using of water hyacinth but water hyacinth is to be gathered on bamboo made platform in modern floating bed. As a result, production cost becomes lower in improved floating bed than modern bed. The size of each improved floating bed was 10 m² (7.5m x 1.3m) and trellis was 40 m² (8mx5m). The number of rows of sweet gourd per bed was 2, plant to plant distance was 1.5m and number of seedling/hill was 2. Weeding and cleaning of bed was done timely and pest management was also done by use of organic pesticide like sex pheromone trap, bio-pesticide etc.

Results and Discussions

The yield and cost & return performances of different creeper and non-Creeper vegetables were presented in Table 2 and Table 3. Among the crops BARI Mistikumra-2+ Green amaranth gave the highest yield (226 kg dec.⁻¹) and monetary return (1215 Tk dec.⁻¹) followed by BARI Lau-4+ Green amaranth. The lowest yield was obtained from BARI Barbato-1+ Green amaranth (152 kg dec.⁻¹). So, sweet gourd intercropped with green amaranth was the best among all combination.

Farmers' opinion: Farmers were happy to observe the performance of sweet gourd intercropped with green amaranth.

Table 1. Agronomic management of different creeper vegetables with red amaranth grown on traditional floating bed cum trellis at Madaripur during 2023-24

Inter-cropping	Crops and Variety	Planting date	Age of seedling DAS	Fertilizer dose (kg ha ⁻¹)	Harvesting date
Creeper	Watermelon (BARI Tormuj-2)	24 July, 2023	12-15	N ₁₁₅ P ₅₀ K ₁₀₀ S ₁₈ Zn ₄ B ₂	11-13 Oct. 2023 (78-81 DAT)
	Bottle gourd (BARI Lau-4)	01 Nov. 2023	12-15	N ₂₄ P ₂₇ K ₁₅ S ₆ Zn ₁ B ₁	28 Dec. 2023 to 26 Feb. 2024 (58-116 DAT)
	Sweet gourd (BARI Misti kumra2)	01 Nov. 2023	12-15	N ₂₄ P ₂₇ K ₁₅ S ₆ Zn ₁ B ₁	30 Dec. 2023 to 28 Feb. 2024 (60-118 DAT)
	Yard long bean (BARI Borboti-1)	01 Nov. 2023	10-15	N ₂₀ P ₁₆ K ₁₆ S ₅ Zn ₁ B ₁	18 Dec. 2023 to 05 March. 2024 (48-116 DAT)
Non-creeper	Green amaranth (Ghreeto kanchon)	24 July to 01 Nov. 2023	--	--	22 August to 18 Dec, 2024 (26-48 DAS)

Table 2. Yield of non-creeper and creeper vegetables at Aamgram area under Rajoir upzilla, Madaripur during 2023-24

Creeper	Yield (kg dec. ⁻¹)	Non Creeper	Yield (kg dec. ⁻¹)
BARI Tormuj-2	97	Green amaranth	71
BARI Lau-4	147	Green amaranth	74
BARI Misti kumra2	155	Green amaranth	71
BARI Borboti-1	80	Green amaranth	72

Table 3. Cost and Return of non-creeper and creeper vegetables on floating bed cum trellis

Crops and Variety	Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
Water melon +Green amaranth	102273	74100	28173
Bottle gourd+Green amaranth	91158	74100	17058
Sweet gourd+Green amaranth	92857	74100	18757
Yard long bean+ Green amaranth	95095	74100	20995

Input price (VC): Trellis cost: Tk. 5100 (Net: 300, bamboo (borok): Tk. 3000, bamboo (Tolla): Tk.1800).One trellis can use continuing 3 times, so one time preparing cost is Tk. 1700 (i.e. 5100/3). So, Total cost (Bed cost + Trellis cost): 3100+1700= Tk.4800; Output price (Tk kg⁻¹):Water melon: 50, Bottle gourd:25, Sweet gourd :25, Yard long bean: 50 and Green amaranth: 30.

Conclusion

Sweet gourd with green amaranth combination was profitable in floating bed and may sustain due to low input cost.

211.PRODUCTION PROGRAM OF DIFFERENT SPICES ON PLAIN LAND USING DECOMPOSED WATER HYACINTH IN MADARIPUR

M. MOHIUDDIN, SELIM AHMED

Abstract

Production program of different spices (garlic and onion) were conducted at Aamgram,Rajoir, Madaripur during 2023-24. All spices were grown on plain land mixing decomposed water hyacinth that was used in floating bed material. The objective was to observe the performances of selected spices and to popularize BARI varieties among the neighbour farmers. Intercultural operation (weeding and watering etc.) weres done timely and pest management was also done by use of organic pesticide like sex pheromone trap, bio-pesticide etc.

Fertilizer dose: The fertilizer dose for 40m² area of ex situ bed was 1080g urea, 40g TSP, and 1020g MoP for garlic, 1000g urea, 1040g TSP, and 600g MoP, 4400g gypsum, 22g zinc sulphate mono hydrate and 24g boric acid for onion. All kinds of fertilizer were applied as liquid form but two equal splits at 25 and 50 days after planting (DAP) for garlic, 15 and 35 days after transplanting (DAT) for onion. The agronomic management of different spices was given in Table 1. Data of yield (kgdec.⁻¹) were recorded.

Results and Discussions

The yield and economy performances of different spices were presented in Table 2. Among the spices, BARI Piaz-4 gave the highest yield (76 kg from 40 m² bed) and profitable (2810 Tk dec⁻¹.) followed by BARI Piaz-6 (70 kg from 40 m²bed). The lowest yield was obtained from BARI Rasun-1 (35 kg from 40 m²bed).

Farmers' Opinion: Farmers and neighbouring farmers showed interest to grow spices using decompose water hyacinth.

Table 1. Agronomic management of different spices at Amgram, Rajoir, Madaripur, 2023-24

Crop	Variety	Planting date	Plot size (m ²)	Spacing	Fertilizer dose (kg ha ⁻¹)	Harvesting date
Garlic	BARI Rasun-1	05 Nov. 2023	40	20cm*10cm	N ₁₂₅ P ₅₂ K ₁₆₅	28 March, 2024 (144 DAP)
Onion	BARI Piaz-1,4 & 6	17-29 Dec. 2023	40	15cm*10cm	N ₁₁₅ P ₅₂ K ₇₅ S ₂₀ Zn ₂ B ₁	20-28 March 2024 (90-94 DAT)

Table 2. Yield and cost & return of spices at Amgram, Rajoir, Madaripur during 2023-24

Variety	Yield (kg dec ⁻¹)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
BARI Rasun-1	35	8.645	691600	432250	259350
BARI Piaz-1	62	15.314	918840	432250	486590
BARI Piaz-4	76	18.772	1126320	432250	694070
BARI Piaz-6	70	17.29	1037400	432250	605150

Input price: Tk. 1750/plot. (seed+ fertilizer: Tk.250, Land and mixing of rotten water hyacinth (Dhap) labour 2 *500 : Tk.1000, Transplanting labour1*500: Tk. 500), Output price (Tk kg⁻¹): Garlic: 80, Onion: 60.

Conclusion

From the study, it reveals that decomposed water hyacinth was a good way for production of spices crop. The variety of BARI Piaz-4 showed the best performance in terms of yield and economy. So, there is a large possibility to meet the demand of vegetables and spices of a family in bad days

212. PERFORMANCE OF SELECTED VEGETABLE AND SPICES IN FLOATING BED IN BRAHMANBARIA

M. MOHIUDDIN, M. JAMAL UDDIN, M. M. R. TALUKDAR

Abstract

A performance trial was carried out on floating bed at the village of Kulikonda under Nasirnagor upazilla in Brahmanbaria district during 2023-24 under floating agriculture project with view to observe the performance of suitable Sweet gourd, Bottlegourd and Chilli hybrid variety in-terms of profitability and adaptability in that area. The hybrid variety sweetgourd variety (Chita), Bottlegourd (Badsha) and Chill(1701) at the floating bed. Results shows that the hybrid bottlegourd (Badsha) gave the highest yield (52.0 t ha⁻¹) followed by Hybrid Misty Kumra Chita, 46.42 t ha⁻¹ and 42.29t ha⁻¹ green chilly for hybrid(1701). The highest benefit cost ratio (BCR) was found to 3.66 from Chilli follwed hybrid bottlegourd 2.70 and 1.97 for sweetgourd.

Introduction

Farmers in Nasirnagor upazilas Brahmanbaria are 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. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for cucumber production in this season. Cultivation of cucumber on floating bed was made available in the market during monsoon season. Considering the facts, the experiment was undertaken to To select the suitable variety of cucumber for growing in floating bed as well as to increase the yield and income of farmer through cucumer cultivation in floating bed in low-lying areas in Nasirnagor, Brahmanbaria.

Material and Methods

The performance trial was carried out at the village of Kulikunda, Nasirnagor upazilla in Brahmanbaria district during 2023-24 to show the performance of the suitable variety of sweetgourd, bottle gourd and Chilli on floating bed for that area. The experiment was laid down in a randomized complete block design with three treatment (Variety) in replications using floating bed. The hybrid sweet gourd variety (Chita), Bottle gourd (Badsha) and Chilli (1701) were used for the performance trial. The unit bed sizes were 9.15 m x 1.37 m. Seedling were transplanted on 5-13 February 2024 for three crops in ball making by rotten water hyacinth followed by 45 cm x 30 cm spacing. The recommended fertilize doses were applied Urea-60gm, DAP-220g, MoP-60g, Gypsum-30g, Zinc-02g and Boric acid-05g per bed respectively. All the

chemical fertilizers were applied on the floating bed in liquid form. All kinds of fertilizers were applied in three equal splits at 15, 25 and 35 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 these crops. The harvest was started on 20 April 2024. Data on yield and income were recorded and presented in the Table1 and Table 2.

Results and discussion

The results are shown in Table1 and Table2. Findings revealed that the hybrid sweetgourd (Chita) was perform better which yield was recorded 52.02 t ha⁻¹ followed by 46.42 t ha⁻¹ for hybrid bottlegourd (Badsha). The highest benefit cost ratio (BCR) was found to be 2.70 from hybrid sweetgourd and lowest from hybrid Chilli 1.76.. Kabir et al., 2019 reported that floating agriculture shows wide range of benefit cost ratio (BCR) in different regions. In Pirojpur district, for example, the BCR was calculated 1.43. In haor region, on the other hand, NGO-facilitated floating agriculture practice had BCR around 2.7, with a range of 0.9-3.7 (Pavel et al., 2014)

Farmer's opinion: Farmers are very much interested to know the new technology on floating bed agriculture. They are trying to continue it if they have opportunity to grow the crops with technical and financial (loan) support.

Table 1. Yield and yield contributing characters of selected crop varieties on floating bed at Nasirnagar areas in Brahmanbaria, 2023-24

Treatment (Variety)	No. of plant /bed	No. fruit/ plant	Av. wt. of fruit (kg)	Yield (t ha ⁻¹)
Hybrid Misty kumra (Chita)	14.0	6.4.0	3.22	52.02
Hybrid Bottlegourd (Badsha)	15.0	5.5.0	3.28	46.42
Hybrid Chill (1701)	-	-	-	24.29

Table 2. Cost return analysis of selected crop varieties on floating bed at Nasirnagar areas in Brahmanbaria, 2023-24

Treatments (Variety)	Yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	TVC (Tk ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	BCR
Hybrid misty kumra (Chita)	46.42	1856800	688403	1168397	2.70
Hybrid Bottlegourd (Badsha)	52.00	1560000	688403	871597	2.27
Hybrid Chill (1701)	42.29	1214500	688403	526097	1.76

* TVC includes cost of bed preparation, labour, price of seedlings, fertilizers and insecticides, price of hybrid misty kumra= Tk.40./kg; Bottle gourd Tk.30 and Chilly (green) @Tk. 50/kg

Conclusion

It might be concluded that hybrid sweet gourd was perform better comparatively rather than two other crops in the floating bed.

213.PRODUCTION PROGRAMME OF VEGETABLES AND SPICES ON FLOATING BED IN BANGLADESH

M. MOHIUDDIN, SELIM AHMED, M M HOWLADER AND D HALDER, T.S. MUNMUN, M.K. ISLAM, M.H. RASHID AND M. RAHMAN

Abstract

The Production programme for creeper, non-creeper vegetables and spices were conducted at 3 districts of Bangladesh such as Faridpur, Gopalganj and Khulna during 2023-2024 to popularize different varieties of creeper and non-creeper vegetables and spices at the farmers' field condition on floating bed. Tested all varieties were performed well.

Introduction

Farmers are traditionally produced seedlings of different vegetables like okra, bottle gourd, bitter gourd, sweet gourd etc.) on water hyacinth made floating bed in Gopalganj, Barishal and Pirojpur districts. However, cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lacking 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 which made between two floating beds. In this system, they would increase the crop productivity; enhance food and nutrition security and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment was taken to evaluate the performance of some creeper and non-creeper vegetables on floating Bed under flooded ecosystem in non-tidal areas of Bangladesh.

Material and Methods

The experiment was conducted at Gopalganj, Khulna and Faridpur during 2023-24 to popularize of different creeper and non-creeper vegetables in floating bed for the area and to increase the crop intensity and economic return of farmers. The experiment was conducted in floating bed and two floating bed considered as one treatment. 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) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of each crop was grown on each floating bed maintaining 1.75 ft plant to plant distance. Seedlings of vegetables per hill was 2. All the chemical fertilizers will be applied on the floating bed in application of liquid form. The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphate fertilizer. The zinc sulphate and boric acid can be applied as foliar spray. Intercultural operation was done to each of the crop as when necessary. Data on yield and economic return were recorded and presented in tabular form.

Results and discussion

Khulna: Among the non-creeper vegetables, the highest yield was obtained from knolkhol (28.65 t ha⁻¹) followed by spinach (27.79 t ha⁻¹) and ghee kanchan (27.27 t ha⁻¹) (Table 1). The lowest yield was obtained from red amaranth (19.49 t ha⁻¹). Among the creeper vegetables, the highest yield was obtained from bottle gourd (41.88) followed by yard long bean (11.42 t ha⁻¹) (Table 1). Among the spices, the highest yield was obtained from coriander (30.50 t ha⁻¹) followed by turmeric (18.35 t ha⁻¹). It was found that fruit like water melon gave satisfactory yield (28.29 t ha⁻¹).

Faridpur: Among the non-creeper vegetables, the highest yield was obtained from kangkong (44.46 t ha⁻¹) followed by okra (20.75 t ha⁻¹) (Table 1). It was found that, summer tomato gave a good yield (20.75) which was profitable to the farmer. Among the spices, turmeric gave the highest yield (35.57 t ha⁻¹) followed by summer onion (27.66 t ha⁻¹) (Table 1).

Gopalganj: Among the creeper vegetables, the highest yield was obtained from bottle gourd (9.34) followed by ash gourd (8.21 t ha⁻¹) (Table 1). The lowest yield was obtained from snake gourd (4.96 t ha⁻¹). Among the non-creeper vegetables, the highest yield was obtained from gima kolmi (11.16 t ha⁻¹) followed by tomato (9.16 t ha⁻¹) (Table 1).

Farmer's opinion

Farmers like all vegetables for its high yielding potentiality, profitability and their different types of preferences in floating bed system.

Table 1. Agronomic management and yield of different vegetables and spices on floating bed during 2023-24

Crops	Variety	Sowing/trans date	Harvesting date	Yield (t ha ⁻¹)
Khulna				
Red amaranth	BARI Lalshak-1	25-10-2023	22-11-2023	19.49
Ghee Kanchan	Local	20-10-2023	18-11-2023	27.27
Spinach	BARI Palong-1	29-11-2023	25-1-2024	27.79
Knolkhol	Local (Challenger)	15-10-2023	10-01-2024	28.65
Turmeric	BARI Holud-4	02-07-2023	06-03-2024	18.35
Coriander	BARI Dhonia-1	15-10-2023	25-01-2024	30.5
Brinjal	Local	18.09.2023	26.01.2024	19.04
Yard long bean	Local	06.08.2023	24.11.2023	11.42
Bottle gourd	BARI Lou- 4	06.08.2023	18.11.2023	41.88
Water melon	BARI Tormuj 2	09.07.2023	18.09.2023	28.29
Faridpur				
Okra	BARI Dherosh-2	12-04-2023	06-06-2023 to 31-07-2023	20.75
Kangkong	BARI Gimakolmi-1	24-07-2023	23-08-2023 to 31-10-2023	44.46
Turmeric	BARI Halud-4	25-07-2023	20-02-2024	35.57
Onion	BARI Piaz-5	08-10-2023	03-03-2024	27.66
Tomato	BARI Hybrid Tomato-8	15-10-2023	19-01-2023 to 20-02-2024	20.75
Gopalganj				
Bottle gourd	BARI Lou- 4	15-07-2023	25-09-2023 to 20-10-2023	9.34
Ash gourd	Local	15-07-2023	22-09-2023 to 15-10-2023	8.21
Sweet gourd	Hybrid Black super	10 September 2023	19 to 28 November 2023	7.44
Snake gourd	Hybrid Rohini	15/07/ 2023	18-29/11/2023	4.96
Gima kolmi	BARI Gima kalmi-1	5/02/2024	24-March to 22 June 2024	11.16
Tomato	Bipul plus	10 October 2023	22/12/2023 to 03/02/2024	9.16

Conclusion

Floating system is new in water logged areas, so it will take time to accept and unavailability of high yielding variety seeds at growing season were the main problem for farmers in sub-merged condition. Seed supply should be ensured during the production season to expand the BARI variety at farmers' level in floating agricultural system.

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30. Dr. Md. Jahangir Alam, SSO

GOPALGANJ

31. Dr. Md. Mohsin Howlader, SSO
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Md. Abdul Hye, SA, Muktagacha
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Md. Selim Jahangir, SA, Trishal
Md. Asaduzzaman, SA, Trishal
Mofidul Islam, SA, Tarakanda
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Nurul Hasan, SA, MLT site, Nikli

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Md. Abu Taher, SA, MLT site, Gabtali
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 Md. Shahab Uddin, SA, MLT site Kaliganj, Jhenidah

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 Md. Mahbubur Rahman, SA, Onstation
 Md. Sadekur Rahman SA, MLT site, Chandina
 Md. Jamal Hossain SA, MLT site, Debidwar
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SYLHET

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BANDARBAN

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 Sujan Das, SA

COX'S BAZAR

Md. Ekram Hossain Siddique, SA

BHOLA

Fakir Md. Balayeat Hossain, SA
 Md. Neshur Uddin, SA (temporary suspended), Bhola
 Md. Abdul Hai, SA, MLT site Daulatkhan, Bhola
 Md. Omar Faruque, SA, MLT site Charfashion, Bhola

List of FSRD and 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. Chandradigholia, Gopalganj Sadar, Gopalganj

B. MLT SITES

Region-1

Pabna	: Atghoria (11&12), Sujanagar (10,11&12), Kashinathpur (11&12) of Pabna, Sirajganj (4,5,7&12)
Shyampur, Rajahahi	: Shibpur, Puthia, Rajshahi (AEZ-11) & Paba, Rajshahi (AEZ-11)
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)
Gaibandha	: Gaibandha (3)
Bogura	: Sherpur (4,25), Shibganj (3,4,25), Gabtali (3,4) Sonatola (3,4), of Bogura and Joypurhat (3,25)
Rajbari, Dinajpur	: Kishanbazar, Sadar and Jogdal, Birgonj, Dinajpur
Thakurgaon	: Munshirhat (Thakurgaon sadar)

Region-2

Sherpur	: Nalitabari (8&9), Jhenaigati (8&9) of Sherpur, Sarishabari of Jamalpur
Tangail	: Ghatail (9,28), Dhanbari(9,28), Bhuyapur (7,8), Mirzapur (8,9), Delduar (7,8) Tangail Sadar (7,8), Tangail.
Mymensingh	: Trishal (8, 9), Muktagacha (8, 9 & 28), Tarakanda (9) & Netrakona (9)
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	: Munshiganj (8,10,12,19) and Dhirashram (28)
Manikganj	: Manikganj (7, 8 & 12)

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), Pirojpur, Tungipara (12 & 14) & Muksudpur (12, 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) of Chandpur & Brahmanbaria sadar (16,19)
Sylhet	: Moulivibazar (20, 29), Zokiganj (20), Sunamganj (20, 21) & Habiganj (20, 21, 22)
Bandarban	: Limujiri (29), Buhalong
Cox's Bazar	: Cox's bazar sadar (23) & Chokoria (23) of Cox's bazar

Note: Numerical figure in parenthesis is no. of AEZ