ANNUAL RESEARCH REPORT

2022-2023

Program Leader

Dr. Sujit Kumar Biswas

Chief Scientific Officer (In-charge & Head)

Irrigation and Water Management Division

Bangladesh Agricultural Research Institute

Joydebpur, Gazipur-1701

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Edited by

Dr. Sujit Kumar Biswas, CSO (Incharge)
Dr. Dilip Kumar Roy, SSO
Dr. Khokan Kumer Sarker, SSO
Dr. Afrin Jahan Mila, Agril. Engg
Farzana Akter, SO
Khandakar Faisal Ibn Murad, SO
Md. Panjarul Haque, SO

Irrigation and Water Management Division
Bangladesh Agricultural Research Institute
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Word Processing

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Published by

Irrigation and Water Management Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701
Phone: +88 0249270175, Cell: +8801816880562
E-mail: cso.iwm.bari.gov.bd

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List of Contributors

Dr. Sujit Kumar Biswas, CSO (In-charge)
Dr. Dilip Kumar Roy, SSO
Dr. Khokan Kumer Sarker, SSO
Dr. Afrin Jahan Mila, Agril. Engg.
Farzana Akter, SO
Khandakar Faisal Ibn Murad, SO
Md. Panjarul Haque, SO
Tasnia Hossain Munmun, SO
Chitra Rani Paul. SO

PREFACE

The principal objective of irrigation and water management research is to determine how best the water resources, be it from underground, surface or rainfall can be utilized for crop production and how to minimize the harmful effect of this water. This inevitably demands research on how to exploit available sources of water, convey and distribute them to farms and apply the same to the individual crop field. The next important aim is to increase the crop water use efficiency in order to obtain maximum production per unit drop of water thereby increasing economic return and improving livelihood of the farmers. To achieve this goal, research need to be conducted on when and how much water should be applied, and when irrigation is not necessary at all.

The general objectives of the division are to conduct research on: a) proper irrigation scheduling and rain water management of the upland crops and drainage thereof, b) finding climate smart irrigation technologies for crop production, c) management of surface water and groundwater for sustainable agricultural use, d) water management in fragile ecosystems e) wastewater management f) micro irrigation, g) application of artificial intelligence and data science for irrigation planning and g) assessment of climate change on irrigated agriculture.

Amid climate change, many parts of the country are already facing water shortages threatening the sustainability of agriculture that could be overcome through demand management rather than supply management. The supply-side management is structure-oriented and costly as it focuses on providing water and related services to capture, store and deliver water to the field effectively. While demand management approach is non-structural and less costly, it focuses on development of water-efficient technologies, training, education and persuasion to the users. IWM division with its limited number of scientists have developed and are trying to develop water-efficient technologies addressing SDGs, BDP 2100, 2030 WRG, Perspective plan 2041 and 4AR as well.

There are great potentialities that need to be developed in the management of ground and surface water resources. In many crops improved irrigation system has the potential to double the production. Rice crop, on average, require 1000 mm of water for the growing season whereas most upland crops require 200 to 500 mm water when applied efficiently. All these indicate that there remains tremendous possibility of increasing crop production by bringing more upland crops under irrigation and by properly controlling and managing the available water resources.

Research and development activities of Irrigation and Water Management Division are directed towards the economic development of the country. The division is working to help the nation becoming self-sufficient in food, to generate employment in agriculture and to increase income of farmers through the development of appropriate water management practices and techniques widely acceptable to all categories of farmers. This report presents the findings of both on-station and on-farm studies conducted during 2023-24. This year, the division carried out researches in the areas of crop water requirement and irrigation scheduling, water application and distribution methods, on-farm water management, saline and wastewater management, groundwater management and dissemination of developed water saving technologies at the farmer's level and improvement of farmers' traditional irrigation practices.

Finally, I would like to express my sincere thanks to the scientists/staffs concerned with these studies and to all who helped in bringing out this report.

Dr. Sujit Kumar Biswas
Chief Scientific Officer (in-charge) and Head

CONTENTS

RESPONSE OF BARLEY TO DIFFERENT IRRIGATION REGIMES

K.F.I. MURAD[1], M.P. HAQUE[1], M.A. HOSSAIN[1], F AKHTER[1], S.K. BISWAS[1]

Abstract

This study aimed to examine the effects of irrigation level and stage on barley growth, yield, and water productivity for the first time in Bangladesh. Nine irrigation regimes with varying levels and stages were considered as treatments. Full irrigation (L_1) resulted in the best figures for both growth and yield attributes, while reduced irrigation decreased these figures ($L_1 > L_2 > L_3$). Likewise, irrigation stages also significantly influenced the growth and yield attributes of barley with irrigation at three growth stages (S_1) producing the highest values. Between the two 2-irrigation treatments, S_2 showed better results for the growth attributes, whereas the yield parameters were higher in S_3. Irrigation water use was significantly lower in deficit irrigation treatments, thereby they showed higher WP. The highest significant WP and second lowest irrigation water use figures in L_3S_3 suggest 50%-irrigation at vegetative and booting stages is effective for barley cultivation under water-scarce conditions.

Introduction

Bangladesh's agriculture sector has grown remarkably due to irrigation development. However, heavy reliance on irrigation, coupled with reduced rainfall and river flows, has depleted groundwater, risking water shortages (Mainuddin et al., 2020). Shifting to less water-intensive crops like barley is crucial to overcome the future challenge of sustainable food production (Mojid et al., 2021). Barley, with its higher nutritional values, drought tolerance, and adaptability, can be an effective alternative to boro rice. However, information on the irrigation sensitivity of the local barley varieties is absent, which is vital for optimum irrigation scheduling. To address this research gap, this study aims to assess the impacts of different irrigation regimes on the growth and yield of barley. The results will benefit farmers and inform future planning for climate change challenges.

Materials and Methods

The experiment was conducted in the research field of the Irrigation and Water Management Division of Bangladesh Agricultural Research Institute (BARI) in Gazipur, during the rabi season of 2022-2023. The experiment followed a randomized complete block design (RCBD) with nine treatments, consisting of two factors: irrigation level and irrigation stage, each replicated three times. The irrigation levels were set at 100%, 75%, and 50% of the field capacity (L_1, L_2, and L_3), while the irrigation stages included vegetative, maximum tillering, and booting stages (S_1 = vegetative + maximum tillering + booting, S_2 = vegetative + maximum tillering, S_3 = vegetative + booting). BARI barley-7 variety was used, and standard crop establishment and management practices were followed. Soil samples were collected for moisture content measurement. Irrigation was calculated based on soil moisture and characteristics. Various growth and yield attributes were recorded at harvest. Harvest index and water productivity were also calculated. The data were analyzed using two-way ANOVA and Tukey's HSD posthoc tests, with results displayed using R and Python libraries.

Results and Discussion

The growth attributes of barley, including tillers per plant, plant height, spike length, biomass weight per plant, and grains per spike, were significantly influenced by both irrigation level and irrigation stage. However, the interaction between these terms was not significant (Table 1). Full irrigation (L_1) produced the highest tiller numbers, tallest plants, longest spikes, and highest biomass weight. Conversely, 50% irrigation (L_3) led to a decrease in these attributes by approximately 8.5%, 9.2%, 1.6%, and 11.5%, respectively. Three irrigations (S_1) consistently resulted in the highest significant figures for all growth attributes, while the lowest values for tillers, plant height, and biomass were found in S_3, and spike length and grains per spike in S_3, respectively. The 1000-grain weight also showed a statistically significant trend among the treatments. Regarding yield attributes, grain yield was significantly influenced by both irrigation level and irrigation stage, but the interaction effects were non-significant (Table 2). L_1 resulted in significantly higher grain yield compared to lower levels, around 4.7% and 11.5% higher than L_2 and L_3, respectively. Meanwhile, S_3 displayed roughly 6% and 7.5% higher grain yield and harvest index (HI), respectively. Similarly, both irrigation level

[1] *Irrigation and Water Management Division, Bangladesh Agricultural Research Institute (BARI), Gazipur 1701, Bangladesh*

and stages of application significantly affected the amount of irrigation applied and water productivity (Figure 1). The highest water productivity of around 1.5 kg/m3 was found in L_3S_3 and L_3S_1, however, L_3S_1 received significantly higher irrigation than L_3S_3. On the contrary, the lowest figures (1-1.12 kg/m3) were observed in treatments receiving 100% irrigation (L_1S_1 followed by L_1S_3 and L_1S_2).

Table 1. Effect of irrigation level and irrigation stage on growth parameters of Barley

Parameters	Tillers per plant (nos)	Plant height (cm)	Spike length (cm)	Weight of biomass per plant (g)	Grains per spike (nos)	1000-grain weight (g)
Mean over Irrigation Levels (p=o.o5)	*	*	*	*	*	ns
L_1	7.06a	86.17a	16.37a	23.67a	50.60a	267.70a
L_2	6.69b	82.08b	16.24ab	22.20b	48.25a	262.10a
L_3	6.46c	78.26c	16.10b	20.95b	45.29b	257.00a
Mean over of Irrigation Stages (p=o.o5)	*	*	*	*	*	ns
S_1	7.10a	87.74a	16.48a	24.97a	51.97a	267.08a
S_2	6.82b	79.62b	16.04b	21.58b	45.00b	255.22a
S_3	6.30c	79.15b	16.18b	20.28b	47.18b	264.49a

Table 2. Effect of irrigation level and irrigation stage on yield parameters of Barley

Parameters	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
Mean over Irrigation Levels	*	*	ns
L_1	1.92a	2.47a	0.44a
L_2	1.83ab	2.42ab	0.42a
L_3	1.70b	2.31b	0.42a
Mean over of Irrigation Stages	*	*	*
S_1	2.08a	2.53a	0.45a
S_2	1.63b	2.37b	0.40c
S_3	1.73b	2.31b	0.43b

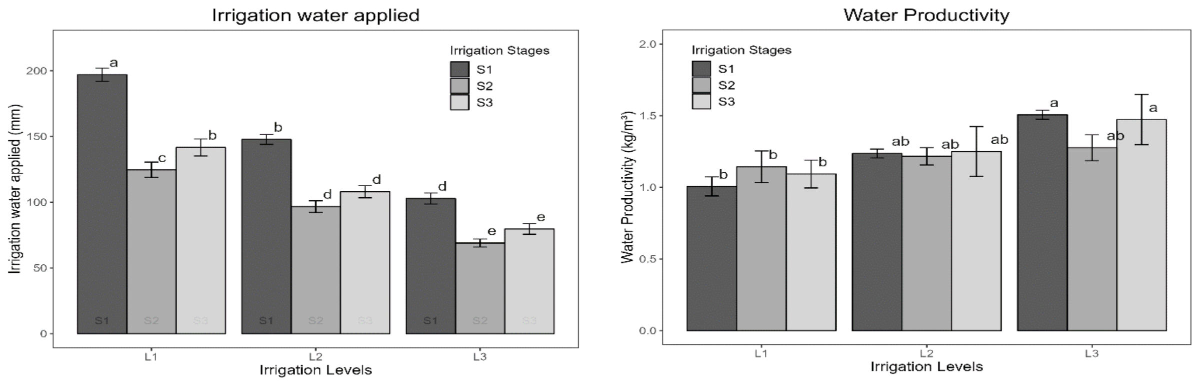

Figure 1. Water uses and water productivity of barley as influenced by different irrigation regimes

Conclusion

In conclusion, this study found that different irrigation regimes significantly impacted barley growth, yield, and water productivity. Full irrigation consistently yielded the best results, while reduced irrigation at 75% also showed promising outcomes. Irrigation at maximum tillering improves the growth attributes, whereas irrigation at the booting stage improves the yield attributes. When water saving is the priority, 50%-irrigation at vegetative and booting stages is suggested as it produced the highest water productivity. Further research is needed to validate and expand upon these findings for barley cultivation.

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MODELLING POTATO-MAIZE-AMAN CROPPING SYSTEM AS INFLUENCED BY SOWING DATES AND CLIMATE CHANGE

K.F.I. MURAD[2], M.B. HOSSAIN[3], D.K. ROY[1], K.K. SARKER[1], M.H. RASHID[4], S.K. BISWAS[1]

Abstract

The aman-potato-maize system offers improved water productivity, especially in the water-scarce northwestern region of Bangladesh. This study calibrates and validates a crop simulation model for the system, estimating crop yields and water usage across different sowing dates. Results reveal significant effects of sowing dates on potato growth, yield, and water use. Delayed sowing leads to shorter growth duration, accelerated tuber formation, and reduced tuber weight per plant. The calibrated model demonstrates good agreement with observed data for BARI Alu-7, indicating accurate simulation of tuber yield and irrigation water productivity. The model will be further validated using additional data and extended to other crops to develop resilient and sustainable agricultural practices in Bangladesh.

Introduction

Bangladesh, a densely populated and climate-vulnerable country, urgently needs sustainable crop production (Roy & Sims, 2021). The aman-potato-maize system offers improved water productivity compared to traditional methods, especially in the water-scarce northwestern region (Khatun et al., 2016). However, to effectively manage this cropping system and ensure its resilience under changing climatic conditions, comprehensive research and optimization efforts are required. This study has two main objectives: calibrating and validating a crop simulation model for the potato-maize-aman system, ensuring its accuracy, and estimating crop yields and water usage across different sowing dates to devise effective adaptive strategies. Climate change impacts on C_3 and C_4 crops in this system add complexity, and incorporating climate scenarios will help assess long-term effects on yields and water utilization.

Materials and Methods

The study utilized the DSSAT crop simulation model, involving three interconnected steps: model parameterization, model calibration, and validation. During parameterization, input parameters from field observations, such as climate data, soil properties, and management information, were incorporated into the simulation model. Some coefficients were adjusted through model calibration, an iterative process where estimated values were manually entered and compared to observed data. The coefficients were adjusted until the simulated and observed values aligned within an acceptable range. The calibration data were obtained from a field experiment at Gazipur with sequential cultivation of potato (BARI Alu-7), maize (Kaveri), and aman rice (BRRI dhan52) at different sowing dates. After calibration and parameterization, the model will be validated against a different set of experimental data from another year or location. If the simulation outputs match the observed data statistically, the model will be deemed suitable for actual simulations under projected climate scenarios.

Results and Discussion

In the field experiment during 2022-2023, we observed the physiological attributes of potatoes (Table 1). While some attributes, such as the number of stems, tubers, plant height, and biomass, were not significantly influenced by sowing dates (T_1-T_4), others showed significant variations ($p \leq 0.05$). Early sowing resulted in longer growth duration, whereas delayed sowing led to reduced days to emergence, stolonization, tuber formation, and maturity (T_3 and T_4). The weight of tubers per plant also varied significantly across growth stages (Table 2), with later sowing showing earlier tuber formation but lower weights (T_2 and T_3). Consequently, tuber yield varied significantly among treatments, with T_2 being the highest, similar to T_1, and T_4 showing the lowest figure. Irrigation water productivity displayed similar trends across all treatments. Using the experimental data along with expert knowledge, we modified the genetic coefficient values of the default cultivar "Red Lasoda" within the DSSAT genotype list (Table 4). Five sensitive genetic coefficients were denoted as G2 (Leaf area expansion rate after tuber initiation, cm2/m2/d), G3 (Potential tuber growth rate, g/m2/d),

[2] *Irrigation and Water Management Division, Bangladesh Agricultural Research Institute (BARI), Gazipur 1701, Bangladesh*
[3] *Irrigation and Water Management Division, Bangladesh Rice Research Institute (BRRI), Gazipur 1701, Bangladesh*
[4] *Tuber Crop Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur 1701, Bangladesh*

PD (The index that suppresses tuber growth during the period that immediately follows tuber induction), P2 (Tuber initiation sensitivity to long photoperiods), and TC (The upper critical temperature for tuber initiation, ˚C). The simulated tuber yield and irrigation water productivity were fitted with observed data from the field experiment (Table 3). The calibration of BARI Alu-7 showed satisfactory statistical parameters, with prediction error (P_e = 6.73%), coefficient of determination (R^2 = 0.93), nRMSE (6.9%), and index of agreement (d = 0.95). Similarly, the simulated and observed irrigation water productivity also showed good agreement in terms of these statistical indices.

Table 1. Effect of sowing dates on physiological attributes of potato

Treatments	Number of stems per hill	Number of tubers per plant	Plant height at 65DAS(cm)	Biomass weight at 65DAS(g)	Physiological stages (DAS)			
					Emerge	Stolon	Tuber	Maturity
T_1	4.94	8.95	60.60	306.24	14a	31a	35a	91a
T_2	5.07	9.01	59.60	302.68	14a	30ab	35a	90a
T_3	4.87	8.96	57.37	288.78	13b	28bc	32b	82b
T_4	4.71	8.82	55.56	261.96	12b	26c	30c	77c
p-value (0.05)	ns	ns	ns	ns	*	*	*	*

(**NB**: T1, T2, T3, and T4 represent treatments having sowing dates on 21 November, 29 November, 10 December, and 20 December, respectively)

Table 2. Effect of sowing dates on yield and water attributes of potato

Parameters	Weight of tubers per plant (g)				Tuber yield (t/ha)	Irrigation (mm)	Water Productivity Kg/m³
	45DAS	55DAS	65DAS	Harvest			
T_1	44.26c	120.27b	257.67b	478.30a	25.96a	253	10.26a
T_2	50.50c	139.36b	260.40b	480.97a	26.42a	270	9.79a
T_3	97.20b	197.37a	292.90a	425.98b	23.27b	281	8.28b
T_4	117.98a	201.17a	298.63a	388.46b	19.10c	289	6.61c
p-value (0.05)	*	*	*	*	*	-	*

Table 3. Statistical evaluation of observed and simulated yield and irrigation water productivity of BARI ALu-7 for different treatments

Parameters	Tuber yield (kg ha^{-1})			Irrigation water productivity (kg m^{-3})		
	Observed	Simulated		Observed	Simulated	
		Default	BARI Alu-7		Default	BARI Alu-7
T_1	25960	12321	28027	10.26	4.87	11.08
T_2	26420	11845	27537	9.79	4.68	10.88
T_3	23270	11746	25023	8.28	4.64	9.89
T_4	19100	10361	20543	6.61	4.10	8.12
P_e (%)		51.10	6.73		47.70	14.40
R^2		0.87	0.93		0.88	0.89
nRMSE (%)		52.10	6.90		49.40	14.90
d		0.80	0.95		0.82	0.97

Conclusion

Based on the information generated so far from this study it is clear that the delaying sowing dates have significant effects on potato growth, yield, and water use. In the next stage, the calibrated DSSAT model will be validated using a different set/s of observed data. Similar works will be repeated for the other two crops (maize and rice) in the system. Finally, DSSAT will be calibrated and validated considering the whole pattern before simulating it using the downscaled climate projection data.

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RESPONSE OF MUNGBEAN TO DIFFERENT LEVELS OF IRRIGATION

F. AKTER, S. S. A. KAMAR, S. K. BISWAS, M. A. HOSSAIN, AND M. A. RAHMAN

Abstract

This research study investigated the impact of different irrigation treatments on BARI mug-8, a stress-tolerant crop variety. Treatments included no irrigation (control), early vegetative stage irrigation, early vegetative stage + flowering stage irrigation, and early vegetative stage + pod formation stage irrigation. The study indicated that irrigation during the early vegetative stage and flowering stage led to the highest plant height, number of pod/plant, number of seed/pod, 1000 seed weight, and yield in the first and second years, respectively, at both locations. On the other hand, the control treatment (T1) resulted in the lowest values for these parameters in both years. In conclusion, the study established that irrigation, especially during the early vegetative stage and flowering stage, had a positive impact on mungbean yield. These findings hold practical implications for farmers aiming to enhance crop productivity and water management in mungbean cultivation.

Introduction

Mungbean (Vigna radiata) is a widely cultivated pulse crop, known for its nutritional value as an important source of plant protein, containing 19.5 to 28.5% proteins. It is particularly popular in the Asian sub-continent, including Bangladesh (Lambrides and Godwin, 2006). However, mungbean cultivation faces challenges due to various stresses, both biotic and abiotic, which negatively impact its growth and development. Among the abiotic stresses, drought is a significant constraint, causing more than 50% of yield loss in mungbean production (Gaur et al., 2012). The southern region of Bangladesh is particularly affected by water limitations, significantly hampering mungbean production. Addressing this issue is crucial to mitigate the impact of drought stress and ensure sustainable crop production in the area.

Materials and methods

The test crop was BARI mug-8. This variety become popular due to the stress tolerant characteristics. The recommended doses of urea, triple super phosphate, muriate of potash, gypsum and boron at the rate of 45, 90, 45, 55 and 10 kg/ha were applied at the time of land preparation. The first weeding was done manually at 20 DAS and also the thinning was done; The irrigation treatments were allocated to the plot through flood irrigation. The irrigation treatments were:

1. Control (No Irrigation)
2. Early vegetative stage (10-15 days after emergence)
3. Early vegetative stage (10-15 days after emergence) + Flowering stage (35-40 days after emergence)
4. Early vegetative stage (10-15 days after emergence) + Pod formation Stage (45-50 days after emergence)

Results and discussion

Table 1 presents the results of the IWMD research field for 2021-22. Plant height (38.33 cm, 34.55 cm) and number of pod/plant (40.00, 35.00 respectively) varied significantly across different irrigation levels, with treatment T3 showing the highest values. In Gazipur, Treatment T2 had the lowest plant height (32.33 cm) in the first year, while treatment T1 had the lowest (27.56 cm) in the second year, along with the lowest number of pod/plant (25.00) in both years. The number of seed/pod showed no significant difference in both years, and 1000 seed weight and yield were only statistically significant in the second year. Treatment T3 had the highest 1000 seed weight (36.03 g) and yield (1215.94 kg/ha), while treatment T1 had the lowest yield (1029.00 kg/ha) in the second year.

In Barishal, the results showed that all parameters were varied significantly at different irrigation levels and the highest plant height (58.33 cm, 44.58 cm), number of pod/plant (148.00, 49.00), number of seed/pod (13, 14), 1000 seed weight (31.20 g, 30.20 g) and yield (1434.67 kg/ha, 1020.00 kg/ha) was found in the 1st and 2nd year respectively at treatment T3. On the other hand, treatment T1 showed the lowest values for these parameters in both years. Control treatment exhibited higher water productivity compared to other treatments. In Gazipur, water productivity was 0.92 kg/m3 and 0.88 kg/m3, while in Barishal, it was 1.98 kg/ha and 2.27 kg/m3 for treatment T1 during both years.

Table 1. Yield and yield contributing characters of mungbean cultivation at IWMD research field

Treatments	Plant height (cm)		Number of pod/plant		Number of seed/pod		1000 seed weight (gm)		Yield (kg/ha)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1	33.78	27.56	25.00	25.00	10.00	9.0	33.67	29.15	1029.00	983.00
T_2	32.33	30.29	28.00	27.00	11.00	10.0	32.33	32.41	1029.35	1011.0
T_3	38.33	34.55	40.00	35.00	11.00	11	32.33	36.03	1215.94	1175.2
T_4	34.22	30.95	28.00	29.00	11.00	10	32.33	32.37	1035.77	1001.0
CV(%)	7.27	4.48	7.28	5.16	6.28	6.02	3.02	7.82	9.76	10.17
LSD	5.04	2.66	4.41	2.86	NS	NS	NS	4.32	-	27.77

Table 2. Yield and yield contributing characters of mungbean cultivation at RARS, Barishal research field

Treatments	Plant height (cm)		Number of pod/plant		Number of seed/pod		1000 seed weight (gm)		Yield (kg/ha)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T1	43.13	40.58	43	41	10	10	31	26.2	1077.67	858
T2	49	43.14	98	42	12	13	31.03	28.2	1211.33	907
T3	58.33	44.58	148	49	13	14	31.2	30.2	1434.67	1020
T4	57.27	43.24	138	42	13	13	30.63	29.4	1256.67	998
CV(%)	7.67	5.33	7.67	4.69	4.56	5.12	1.26	2.3	3.47	4.73
LSD	7.96	1.25	43	5.56	1.09	0.96	0.78	0.99	86.37	64.82

Conclusion

Irrigating mungbean cultivation has a significant positive impact on increasing yield, particularly two irrigations (during the early vegetative stage and flowering stage) to boost mungbean production in Gazipur and Barishal.

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AUTOMATED MODEL SELECTION USING BAYESIAN OPTIMIZATION AND ASYNCHRONOUS SUCCESSIVE HALVING ALGORITHM (ASHA) FOR PREDICTING DAILY MINIMUM AND MAXIMUM TEMPERATURES

D. K. ROY, S. K. BISWAS AND M. A. HOSSAIN

Abstract

State-of-the-art machine learning (ML) algorithms were employed to provide multi-step ahead daily maximum (T_{max}) and minimum (T_{min}) temperatures at three weather stations in Bangladesh. The top-performing ML algorithms were selected automatically through tuning of the relevant hyperparameters using the Bayesian optimization and Asynchronous Successive Halving Algorithm (ASHA). Although both Bayesian and ASHA optimizations produced satisfactory performance, they differ with respect to computational time requirements, with ASHA algorithm took less time to converge to finding the best model. The forecasting accuracy of the models decreased with the increase in the forecasting horizon. This study shows the promise of the automated model selection using the Bayesian and ASHA optimization algorithms for multi-step ahead forecasting of daily T_{max} and T_{min}. This work has potential applications to other geographic locations.

Introduction

Daily maximum (T_{max}) and minimum (T_{min}) temperatures are good indicators of crop growth and yield, since they can be used to predict the irrigation water requirements of the crops. Machine Learning (ML)-based models have been a promising alternative approach to forecast weather parameters (Deng et al., 2022). However, training several models and finding their optimal parameters is a challenging and time consuming task. To address this limitation, we propose an automated model selection technique to enhance forecasting accuracy and streamline the modelling process. Therefore, the contribution of this study includes (a) building multiple regression models for a given dataset of T_{max} and T_{min} through optimizing their hyperparameters using Bayesian and Asynchronous Successive Halving Algorithm (ASHA) algorithms, and (b) selecting the top-performing models for multiple forecast horizons.

Materials and Methods

Our proposed approach automated and eliminated manual steps required to go from a data set to a predictive model. We presented a novel approach that automated the model selection process for temperature forecasting, providing a more objective and efficient alternative to manual model selection. To demonstrate our proposed approach, daily T_{max} and T_{min} data were collected from three meteorological stations (Barishal, Gazipur, and Ishurdi stations) representing three distinct climatic regions of Bangladesh. The missing data (< 2%) were imputed using 'moving median' technique, which employed a moving median with a predetermined window length. Time lagged information was gathered from the collected time series of the daily T_{max} and T_{min} data. The dataset was divided into training (80%) and testing (20%) sets. The most significant input variables from the 30 initially guessed candidate inputs (based on PACF) were selected based on the combination of F-tests, Minimum Redundancy Maximum Relevance (MRMR), and Neighborhood Component Analysis (NCA) selected variables. Next, forecasting models were developed by tuning hyperparameters of seven commonly used ML algorithms and finding the best model for the daily T_{max} and T_{min} dataset at each station. The hyperparameters were tuned using both the Bayesian and ASHA optimization algorithms, and a comparison was performed with respect to training time and accuracy. The selected best model was one that produced the lowest training and test errors with either Bayesian or ASHA optimization algorithms.

Results and Discussion

The ASHA algorithm showed promising performance in converging to finding out the optimal model parameters (600–1200 sec) when compared to the Bayesian algorithm. However, time requirement for the Bayesian algorithm to converge was also found within the tolerable limits (5000–12000 sec). Therefore, in situations where training time is not an issue, Bayesian optimization can be used to find the optimal model parameters with a view to selecting the best models for a particular task. In applications where training time is more important than the model accuracy, ASHA optimization is advisable. After selecting the top-performing models, they were employed to forecast multi-step ahead T_{max} and T_{min} values on the test dataset at the weather stations. Figures 1 and 2 present performances of the best models on test dataset to forecast T_{max} and T_{min} under the five forecast horizons at the weather stations. It is observed from Figures 1 and 2 that the selected models produced acceptable values of the performance indices. In general, T_{min} forecast results outperformed T_{max} forecast. The quality and volume of the collected data may be responsible for this improved performance. It is also inferred that forecast performance slightly decreased with respect to increase in the forecast horizon (Rahman et al., 2020; Barzegar et al., 2017).

Conclusion

The findings demonstrated the ability and practical applicability of the proposed models in forecasting days ahead T_{max} and T_{min} values at the weather stations. ASHA optimization required less time to select the best model compared to the Bayesian optimization. In general, the forecasting accuracy decreased with the increased forecasting horizon.

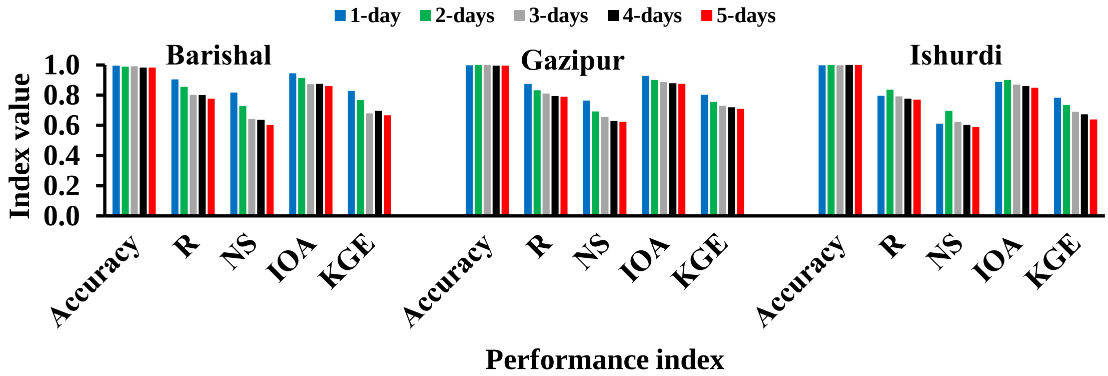

Figure 1. Performance of the best models on test dataset to forecast T_{max}

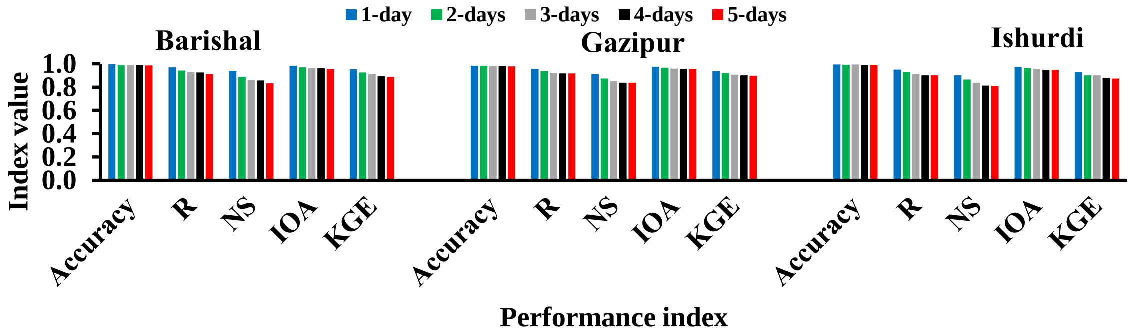

Figure 2. Performance of the best models on test dataset to forecast minimum temperatures T_{min}

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OPTIMUM WATER AND UREA MANAGEMENT OF DWARF SUNFLOWER USING APSIM (FIELD EXPERIMENT)

A. J. MILA, R. W. BELL, D. GAYDON, E. B. LENNARD, S. K. BISWAS, M. A. HOSSAIN

Abstract

Proper sowing along with appropriate use of irrigation urea at actual crop growth stages can minimise misuse of these costly inputs and can increase water productivity. Dwarf sunflower (BARI Surjamukhi 3) was grown at three sowing dates (Factor A) using four irrigation combinations with full and 70% of full irrigation urea at 3 crop growth stages (Factor B). 19 Nov sowing gave the significantly highest seed yield. Three irrigation at vegetative, pre-flowering, and flowering with full urea produced the highest yield. Higher water productivity was found by mid-Nov sowing, and 70% of full irrigation urea at vegetative, pre-flowering, and flowering. Therefore, it can be concluded that dwarf sunflower can be irrigated at 70% of full irrigation urea at three growth stages to get higher water productivity in central Bangladesh.

Introduction

Options for improved resource use efficiency for agricultural crop production can be assessed by using crop simulation models. Water (and fertilizer) is an important input for the growth and development of most crops and efficient use of these resources can increase system efficiency. However, the sowing date is another parameter that also influences crop water use. The Agricultural Production Systems Simulator model (APSIM) is a platform for simulating the biophysical processes of crops in cropping systems. Sunflower is a promising new crop in Bangladesh, but there is still limited field evaluation of its yield potential. Therefore, this study was conducted to parameterize, calibrate, and validate the model using field experimental data, and finally to simulate the model.

Materials and Methods

The experiment was conducted at the experimental field of the IWM division, BARI, Gazipur during the Rabi season of 2022-23. The experimental design was RCBD 2 factors with three replications; Factor A: Sowing date (19 Nov, 29 Nov and 9 Jan) and Factor B: Irrigation urea (total 4; two were full irrigation urea at three crop growth (vegetative, pre-flowering and flowering or grain filling), and another were 70% of full irrigation urea.

Before sowing, two sets of urea with other fertilizers were applied. The rest half of the urea was divided into two equal splits; one was on days 24-25 and another was on days 40-42. BARI recommended fertilizer dose was: Urea, TSP, MoP, gypsum, $ZnSO_4$, H_3BO_3, $MgSO_4$, and cowdung @ 200 kg ha^{-1}, 180 kg ha^{-1}, 170 kg ha^{-1}, 170 kg ha^{-1}, 10 kg ha^{-1}, 12 kg ha^{-1}, 100 kg ha^{-1} and 10000 kg ha^{-1} (BARI Agricultural technology handbook 2020). The Basin irrigation method was used. Irrigation was applied based on soil moisture deficit up to field capacity at crop growth stages and the formula for calculating irrigation depth and volume was done by following Mila 2021. The sunflower crop was harvested on 28 February to 22 March 2023.

During harvest 10 plants were collected to record yield and yield attributes. Soil moisture was collected at ~2 weeks intervals. Finally, data were analysed using statistical software (Team, R.C., 2013).

Results and Discussion

ANOVA results for two factors showed that yield and yield attributes were poorly significant for the irrigation urea (IU) treatments. However, the mean significant difference showed no significant difference among IU treatments. The highest yield (~2.2 t ha^{-1}) was recorded for FIU at the vegetative (V), pre-flowering (PF) and flowering (F) stages. On the other hand, yield and yield attributes were highly significant for the sowing dates. Mid-November sowing gave the significantly highest yield and yield attributes (Fig. 1a-c and 1e-f).

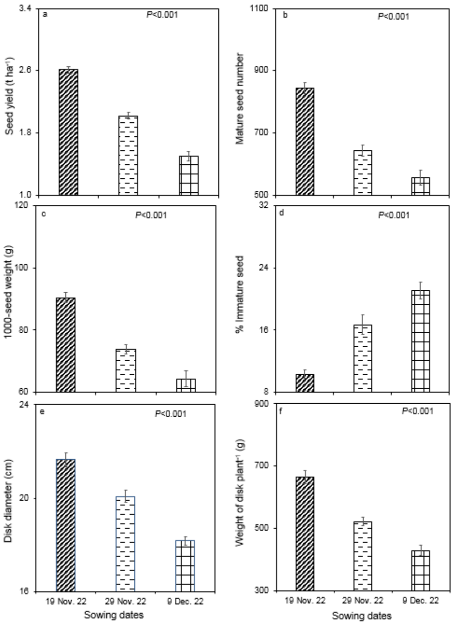
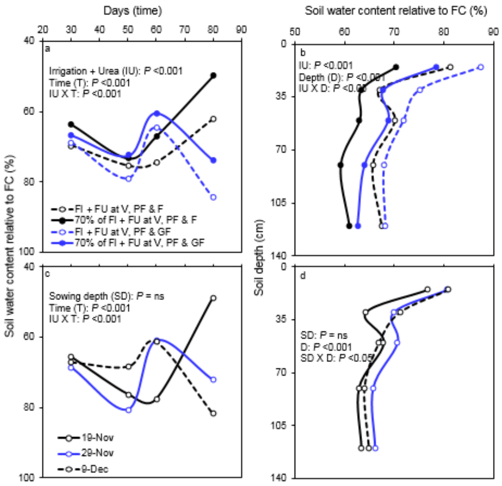


Fig. 1 Yield and yield attributes against sowing dates.

Changes in SWC with time (T) and depth (D) are summarized in Fig. 2. For both IU and SD with T interactions, SWC remained 60-80% within 30-60 days (Fig. 2a, c). The pattern of SWC within soil depth remained 8-13% higher at FIU treatments than 30% lower IU treatments. For both IU and SD with D interactions, SWC remained 60-80% within 15-120 cm soil depth (Fig. 2b, d). The pattern of SWC for 29 Nov sowing within soil depth remained 4-9 % higher than 19 Nov sowing (Fig. 2d). Both SD_1 and 70% of FIU at V, PF & F used comparatively lower amounts of water and gave higher water productivity (Fig.3).



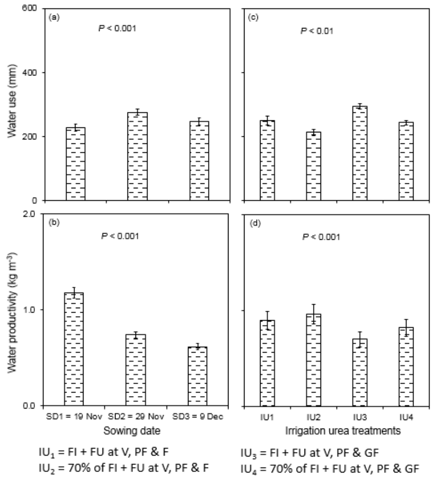


Fig. 2 Effect on soil water content of IU and SD with T and with D.

Fig. 3 Water use and water productivity against SD and IU treatments.

Conclusion

The highest yield of 2.2 t ha^{-1} was recorded for FIU at vegetative, pre-flowering and flowering. 19 November sowing gave 29 and 74% higher seed yield than the successive sowings. 70% of FIU at three growth stages saved 12-27% of seasonal water and gave 8-38% higher water productivity.

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VALIDATION OF BARI IRRIGATION ADVISORY FOR SUNFLOWER AT GAZIPUR

A. J. MILA, S. K. BISWAS, N. A. SHAWN, I. AHMED, A. F. M. T. ISLAM, T. MUNMUN

Abstract

BARI irrigation advisory is a tool that will operate through mobile and give information to farmers or irrigation managers. It was validated for the first time with BARI released dwarf sunflower variety (BARI Surjomukhi 3). Here the test crop was validated with the existing irrigation practice-commonly known as crop growth stage-based irrigation. There were two irrigation treatments, replicated thrice in the research field of IWM Division, BARI, Gazipur during the Rabi season in 2022-23. BARI irrigation advisory produced a 13% lower yield using a 60% lower amount of irrigation water and gave a 62% higher water productivity than the crop growth stage-based irrigation.

Introduction

During the expansion of the industrial revolution, the options for using smart technology in irrigated agriculture turned to time demand. Till now in irrigated agriculture for upland crops, farmers are depending on crop growth stage-based irrigation. This practice is uneconomic in terms of resource use efficiency and water productivity. Besides, crop water demand at different AEZs of Bangladesh is varied due to the variability of land type, soil health and climatic conditions. Therefore it is important to validate the smart irrigation technology for a particular crop at a particular location. Sunflower was selected to validate this device at the Gazipur field.

Materials and methods

The dwarf sunflower variety of BARI *Surjomukhi* 3 was sown on 22 November 2022. Intercultural operation and BARI-recommended fertilizer was used following BARI Agricultural Technology Handbook, 2020. The crop was harvested on 28 Feb 2023. Irrigation was started based on the experimental design. The design was RCBD with 3 replications and two treatments (T_1 = Irrigation based on and T_2 = Irrigation based on BARI irrigation Advisory). For crop growth stage-based irrigation, irrigation was applied at the vegetative, pre-flowering and grain filling stages based on soil moisture deficit up to field capacity. Irrigation amount, seasonal water use and water productivity were calculated followed by Mila, 2021. While for BARI irrigation Advisory based irrigation, irrigation was applied based on crop ET and the irrigation information was sent to the farmers through mobile SMS. The timing of the irrigation application was similar for both types of irrigation. For the advisory, crop sowing date, crop stress coefficient (K_s = 0.5), and mobile number of the farmer (here for the researchers) were used. First Crop coefficient values of sunflower data (Mila et al. 2016) were incorporated in the model to create a similar environment. The data on soil moisture was collected around two weeks intervals. After harvest, the data on yield and yield attributes were collected and analysed using R software (R Core Team, 2013) and Excel.

Results and discussions

For crop growth stage-based irrigation, the pre-flowering and grain filling stage needed more than twice as much water as the vegetative stage. While BARI advisory-based irrigation for the three irrigation events was 3-23% lower than the vegetative crop growth stage irrigation. Finally, the total irrigation amount for crop growth stage-based irrigation accounted for 60% higher than the BARI Advisory-based irrigation (Fig. 1).

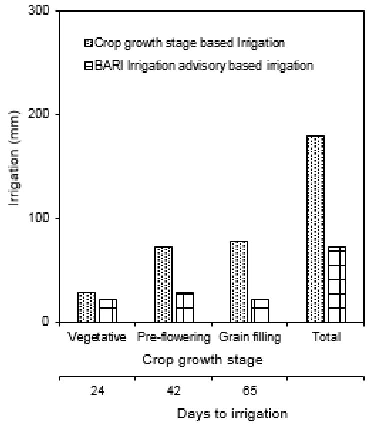
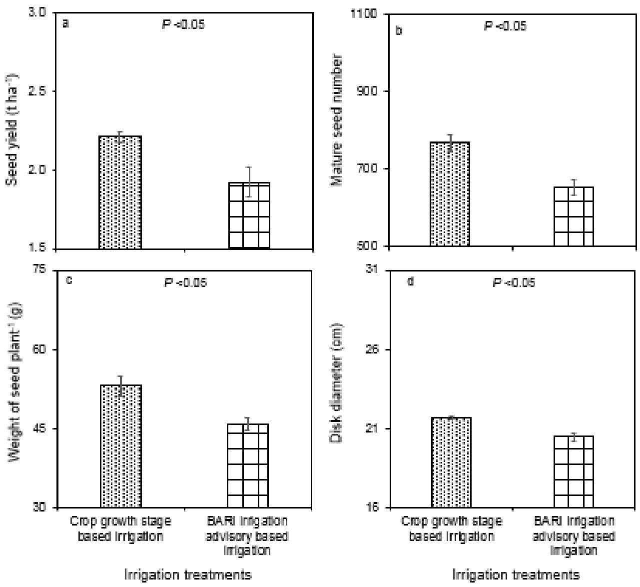


Fig. 1 Amount of irrigation at crop growth stages or days to irrigation

Soil water for the crop growth stage-based irrigation was 18-47 % higher than that of the BARI Advisory-based irrigation. Seed yield was significant at a 5% level due to the effect of different irrigation amounts. The significantly highest yield was recorded for irrigating crop growth stage-based irrigation (Fig. 2a). However, the yield gap was only 0.3 t ha^{-1}. The yield attributes were also significant at a 5% level and found a similar pattern (Fig. 2b-e). Figure 3 shows the water use and water productivity of two types of irrigation. BARI irrigation advisory used 46% less water over the growing season than that of the crop growth stage-based irrigation (Fig. 3a). By contrast, it gave 62 and 115% higher water productivity and irrigation water productivity (Fig. 3b, c).



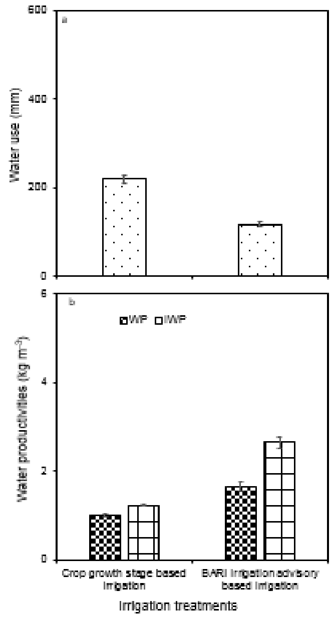


Fig. 2 Effect of irrigation amount on yield and yield attributes

Fig. 3 Water use and water productivity of crop growth stage and BARI advisory-based irrigation

Conclusions

Results from the year 1 field trial of sunflower showed that BARI irrigation advisory used a 60% lower amount of irrigation water to produce a 13% lower yield and 62% higher water productivity.

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FEASIBILITY OF SURFACE DRAINAGE FOR WINTER CROP FOR GREATER RESILIENCE OF SMALLHOLDER FARM INCOME AND FOOD SECURITY IN SOUTHERN BANGLADESH

A. J. MILA, P. L. C. PAUL, A. K. CHAKI, R. W. BELL, D. S. GAYDON

Abstract

Waterlogging at the end of the Kharif 2 season makes early Rabi crop establishment delay and faces plant other abiotic stresses that decreased yield. Therefore, surface drainage before early crop establishment would be a potential option. This study was conducted at the farmer's field at Dacope, Khulna at two locations with three drainage depths and replicated thrice. 30 cm surface drain gave the significantly highest yield for both locations followed by 15 cm drainage depth. It released comparatively more water in lesser time than the 15 cm drainage depth. The SEW_{30} was higher at no drain and gradually decreased with the increase of drainage depth. Farmers of Bangladesh can increase smallholder farm income using this surface drainage technique, consequently increasing food security in Southern Bangladesh.

Introduction

Late-sown winter crops are then at risk from elevated water and soil salinity, drought and late-season heavy rainfall (Mila et al., 2021; Paul et al., 2021a, 2021b). This constraint can be partly overcome by sowing early maturing rice varieties. However, early sowing (after monsoon) without surface drainage is also risky because of post-monsoon heavy rainfall on heavy textured clay soil. The project aims to test the feasibility of surface drainage for sunflower through a crop simulation model by using field experimental data. It has two objectives: determine the optimal surface drainage for sunflower (Activity 1) and determine the long-term crop yield variability of sunflower (Activity 2).

Materials and methods

The field experiment was conducted on sunflower during the winter season in farmer's fields at two locations at Dacope, Khulna. The sunflower seed (Hysun 33) was sown on 9 and 27 December 2022 at two locations. Each experimental plot was prepared by inserting 3 internal and 1 external drain and isolated by polythene sheet. Three perforated pipe was installed within each experimental plot. At each site, there were three drainage depth treatments 0 (control), 15 and 30 cm applied at two locations with 3 replications. Irrigation was applied with a combination of fresh and groundwater. There was no heavy rainfall during this crop season. As a result, artificial waterlogging was applied for a day at the vegetative emergence, 14 and 28 or 32 days after vegetative emergence. The soil moisture and soil salinity was collected at around 10-15 day intervals during the season. An index of waterlogging, known as the SEW_{30} value, was calculated. The salinity level of drainage water was recorded. Crop biomass data were collected during pre-flowering (star-like shape), flowering and harvest. The sunflower crop was harvested on 23 March-3 April 23 and 7-15 April at locations 1 and 2. The data on yield and yield attributes were analysed using R software (R Core Team, R. 2013).

Results and discussion

30 cm surface drain gave the significantly highest seed yield for both locations followed by 15 cm drainage depth (Fig. 1). The significantly lowest yield was recorded for no drain treatments. Similar trend was recorded for yield attributes. A highly significant positive relationship was shown for leaf area and disk diameter with r^2 values of 0.60 and 0.72 for the individual effect of drainage depth and location. 0 cm drainage depth kept the plot under waterlogged for 4-6 days, while 15 and 30 cm drainage depths were kept around 4-5 and 3-4 days respectively (Fig. 2). 30 cm drainage depth treatment released comparatively more water in lesser time than the 15 cm drainage depth treatment. The lowest water released happened on no drain treatment. The SEW_{30} was higher at no drain and gradually decreased with the increase of drainage depth (Fig. 3).

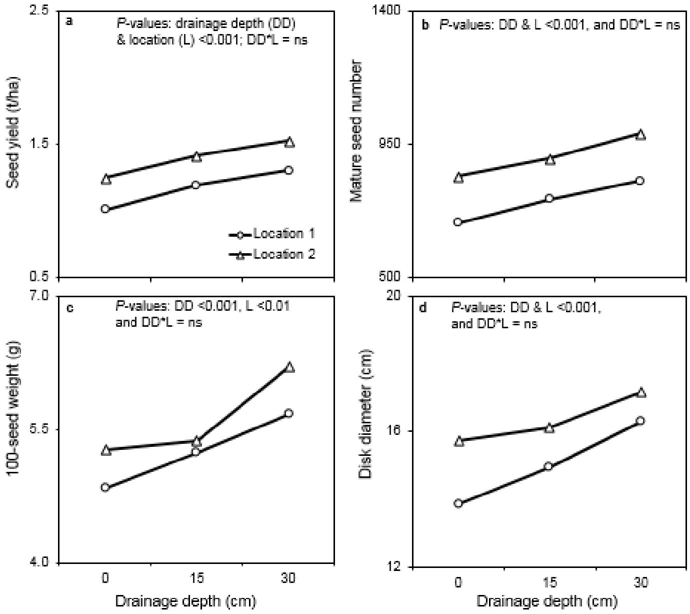

Fig. 1. Changes in yield and yield attributes due to interaction effect of drainage depth and location.

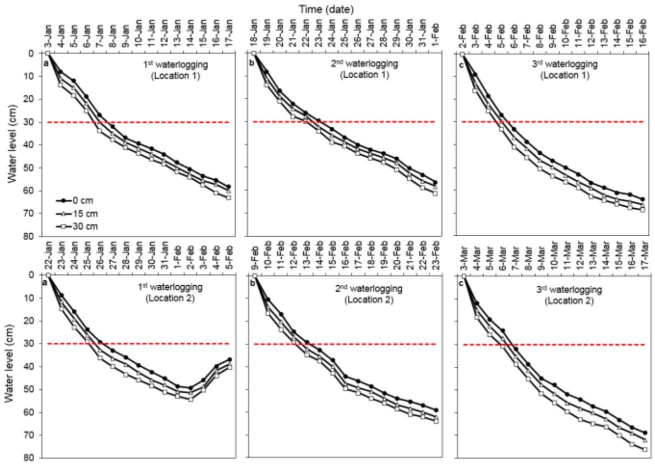

Fig. 2. Variation in water level over time after the release of drainage water.

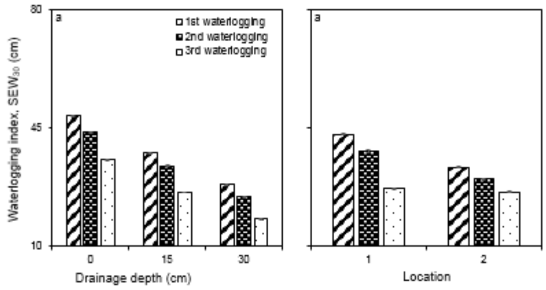

Fig. 3. Waterlogging indexes against individual effects of drainage depth and location.

Conclusion

30 cm surface drain is the optimum drainage depth to get a comparatively higher yield under three waterlogging events during the vegetative stage. Therefore, sunflower can be grown early using 30 cm drainage depth to alleviate waterlogging stress and other abiotic stresses to get an optimum yield in Southern Bangladesh.

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GROWTH AND YIELD OF CHILLI AS INFLUENCED BY DIFFERENT LEVELS AND INTERVALS OF DRIP IRRIGATION

A.J. MILA, K. F. I MURAD, S. BRAHMA, F. AKHTER

Abstract

Irrigation at the proper time and amount is important to get a good yield of shallow-rooted plants like chilli. There were two factors RCBD: irrigation intervals (every alternate day and 3 days) and irrigation amounts (100%, 75% and 50% of ET_c) replicated thrice. 3 days irrigation interval gave ~37% higher chilli yield than every alternate day irrigation. It gave ~116% and 50% higher irrigation water productivity using 50% of crop ET_c than 100% and 75% of crop ET_c. It also gave ~37%, 176% and 37% higher gross return, net return and benefit-cost ratio than every alternate day irrigation. Therefore, it is recommended to irrigate chilli at similar agro-climatic conditions at 3 days intervals with 50% of crop ET to get higher irrigation water productivity and net return.

Introduction

Chilli is a water-sensitive crop, its production can be influenced largely by the change in soil moisture status. Generally, furrow irrigation is used as common practice for chilli production in Bangladesh, which has less control over maintaining root-zone soil moisture levels. Whereas a more controlled irrigation method like drip can provide an opportunity to maintain desired/ optimum moisture level according to the need of the plants. Therefore, a comprehensive study is needed to study the effect of drip irrigation with varying amounts of water and different application intervals. Therefore, this study was conducted to determine an efficient and economic irrigation schedule for chilli with the use of drip irrigation at different amounts and timing.

Materials and Methods

The experiment was conducted at the research farm of IWM Division, BARI, Gazipur. The crop (variety: BARI *Morich* 1) was transplanted on 6 January 2022. Recommended fertilizer was applied based on the BARI recommended fertilizer (Krishi Projukti Hatboi 2020). The Irrigation was started using the drip irrigation method and applied based on crop growth stages. Irrigation amount was applied based on crop evapotranspiration (ET_c). The crop evapotranspiration was calculated by multiplying reference ET (ET_o) and crop coefficient (K_c) values and these values were taken from Islam et al., 2020. The experimental design was 2-factors RCBD; Factor A—two irrigation intervals (every alternate day and 3 days interval) and Factor B—three irrigation amounts (100, 75 and 50% of ET_c) with 3 replications. The crop was harvested six times. After harvest, yield and yield attributes data of chilli were recorded. Soil moisture was collected at 0-15 and 15-30 cm soil depth during sowing and harvest. Six drip irrigation sets with 200 L tanks were installed at the height of 1 m. The dripper discharge was 3.5 L/hr/plant. The plant was irrigated based on the time passed to meet the required amount of water. Crop water use, and water productivity were calculated based on the formula used in Mila 2021. Economic analysis was done and data were analysed using statistical tools.

Results and discussion

3 days irrigation interval gave ~37% higher yield than every alternate day irrigation (Fig. 1a). Similar result was recorded for the yield attrinutes (Fig. 1b and 1c). Irrigation with 100% of ET_c recorded the significant highest irrigation water use of ~200 mm. It used ~32% and 48% higher irrigation water than 75% and 50% of crop ET (Fig.2b). Similar trend was found for seasonal water use. 3 days irrigation interval gave ~26% and ~20% higher water productivity and irrigation water productivity than every alternate day irrigation (Fig. 2e, g). 50% of crop ET_c gave ~116% and 50% higher irrigation water productivity than 100% and 75% of crop ET_c (Fig. 2h). Similar trend was found for water productivity although they are not significant (Fig. 2f). Overall, three days irrigation interval

gave ~37, 176 and 37% higher gross return, net return and benefit-cost ratio than that of every alternate day irrigation (Table 1). However, the variation in total cost was negligible due to the variation in irrigation amount and intervals.

Conclusion

3 days irrigation intervals gave ~37%, ~37%, 176% and 37% higher yield, gross return, net return and benefit-cost ratio than every alternate day. It also gave ~116% and 50% higher irrigation water productivity using 50% of crop ET_c than that of 100% and 75% of crop ET_c.

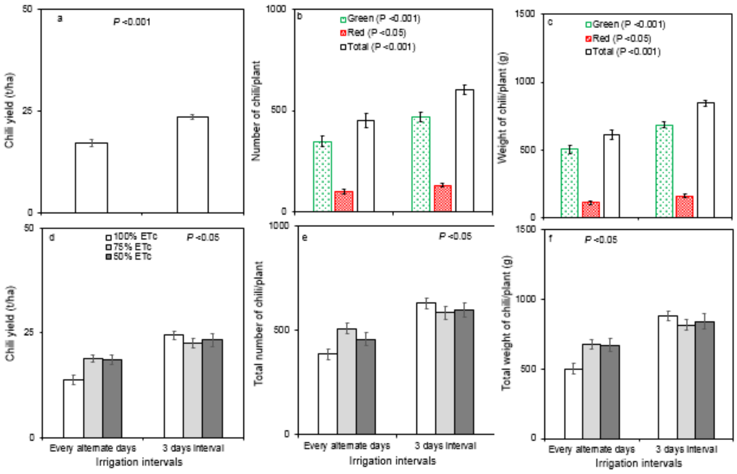

Fig. 1 Chilli yield and yield attributes for the individual effect of irrigation intervals and combined effect of irrigation intervals and amounts.

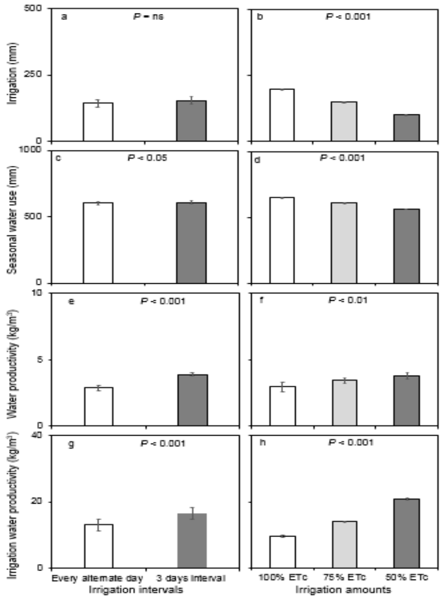

Fig. 2 Crop water-related terminology used in chilli for the effect of irrigation intervals and irrigation amounts.

Table 2
Total cost, gross and net return of chilli for different irrigation intervals and amounts for 1000 m^2 of land

Name of the treatment	Total cost	Gross return	Net return	Benefit-cost ration
Every alternate day at 100% ETc	331015	339882	8867	1.0
Every alternate day at 75% ETc	330837	462569	131731	1.4
Every alternate day at 50% ETc	330659	456119	125460	1.4
Three days interval at 100% ETc	331060	598537	267476	**1.8**
Three days interval at 75% ETc	330871	555297	224426	**1.7**
Three days interval at 50% ETc	330682	573097	242415	**1.7**

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EFFECT OF IRRIGATION INTERVAL AND MULCHING ON GROWTH, FLOWER AND CORM PRODUCTION OF GLADIOLUS IN WINTER SEASON

F. AKTER[5], S.K. BISWAS[6], M. A. HOSSAIN[7], K.F.I. MURAD[1], AND F.N. KHAN[8]

Abstract

This research aimed to evaluate the influence of different irrigation intervals and mulching on the growth and yield of gladiolus (BARI Gladiolus-4). Nine treatments were tested, varying irrigation intervals (5, 10, 15, and 20 days) and mulching practices. The study found that the combination of irrigation at every 10 days with mulching resulted in the highest plant height, spike length, and floret count. However, for corm production, the best results were obtained with a 15-day irrigation interval and no mulching. More frequent irrigation (every five days) led to excessive water use and reduced yield, while longer intervals (15 and 20 days) resulted in higher yields despite consuming lower water consumption. Farmers' practice showed comparable results to the FTDII (5 days irrigation interval) with mulching treatment in terms of spike yield, but its water usage resembled the more frequent irrigation approach.

Introduction

Gladiolus (Gladiolus spp.) is a popular ornamental flower known for its vibrant colors and impressive spikes of blooms. It holds significant economic importance in the global floriculture industry, as well as being a favored choice for floral displays, decorations, and cut flower arrangements. To ensure consistent and robust production of Gladiolus during the winter season, factors such as irrigation management and mulching techniques play crucial roles in influencing plant growth, flowering, and corm production. This research aims to determine the best irrigation schedule and the impact of mulching on Gladiolus performance during the winter season. The results of this research will be highly beneficial to farmers who are interested in improving their gladiolus irrigation practices.

Materials and Methods

Designed treatments for the experiment: T1 = Irrigation up to FC at 5-days interval, T2 = Irrigation with mulching up to FC at 5-days interval, T3 = Irrigation up to FC at 10-days interval, T4 = Irrigation with mulching up to FC at 10-days interval, T5 = Irrigation up to FC at 15-days interval, T6 = Irrigation with mulching up to FC at 15-days interval, T7 = Irrigation up to FC at 20-days interval, T8 = Irrigation with mulching up to FC at 20-days interval, T9= Farmers practice (whenever top soil dried up). The method of irrigation used was flood irrigation, and paddy straw was utilized as the mulching material. Recommended dose of fertilizers were applied @ 300 kg N, 375 kg P, 300 kg K, 30 kg S, 8 kg Zn, 12 kg B per hectare and cow-dung 1t/ha. During land preparation, full doses of P, K, S, Zn, B and cow-dung were properly mixed with the soil. Half of the nitrogen was applied at 25 days after planting and the rest half of the nitrogen was applied at flower initiation period. Corms were sown on 02 December, 2022 at a spacing of 15 cm plant to plant and 25 cm line to line. Flowers were harvested from 24 February to 05 March, and corms and cormels were harvested from 03 June to 05 June, 2023.

Results and discussion

The TDII treatments resulted in significantly improved growth, including plant height (62.00 cm), spike length (44.36 cm), rachis length (34.27 cm), number of florets (10.67), and spike weight (66.07 gm). This growth can be attributed to sufficient soil moisture achieved through 10-day interval irrigation. Adequate soil moisture and favorable environmental factors enhance gladiolus plants' commercial quality, increasing flower quantity, size, and stem length (Pereira et al., 2016). Excess or deficit moisture, on the other hand, can lead to lower plant growth (Yadav et al, 2020 and Mazzini-Guedes et al, 2017). Mulching, in particular, contributed to better results in all parameters compared

[5] SO, IWM Division, BARI, Gazipur
[6] PSO and Head, IWM Division, BARI, Gazipur
[7] PSO, Soil & Water Section, HRC, BARI, Gazipur
[8] PSO, Floriculture Division, BARI, Gazipur

to the no mulch as it helps preserve soil moisture, control weeds and pests, regulate soil conditions, and promote nutrient recycling and organic matter accumulation (Patra et al, 2022). Farmers practice was significantly comparable with treatment FTDII. However, treatment FTDII yielded the highest number of corms (2.50), corm weight (83.24 t/ha), corm diameter (59.11 mm), number of cormels (70.78), and cormel weight (18.43 g). Mulching treatment did not benefit corm production. Watering the plants every 10 days with 317.07 mm of water for spike and 668.54 mm for corm resulted in better yields. Mulching also improved yield with reduced water usage (302.37 mm for spike and 621.09 mm for corm). The farmer's practice yielded similarly to the FTDII treatment with or without mulching for spike yield, but their water utilization matched the FDII treatment.

Table 1. Effect of irrigation interval and mulching on vegetative and flowering charecteristics of gladiolus

Treatments	Plant peight (cm)	Spike length (cm)	Rachis length (cm)	No of florets	Spike wt. (gm)	No. of corm	Wt. of corm (gm)	Dia of corm mm	No. of cormel / plant	Wt. of cormel /plant(g)
FDII	59.73	38.30	27.23	8.67	50.01	1.83	69.32	56.28	47.38	12.11
TDII	62.00	44.36	34.27	10.67	66.07	1.83	73.28	57.17	54.90	12.53
FTDII	60.07	43.13	32.20	10.13	62.80	2.50	83.24	59.11	70.78	18.43
TWDII	58.40	39.97	29.20	9.27	58.27	1.78	68.58	55.03	43.83	12.06
FP	59.48	41.46	31.37	9.73	59.33	1.88	74.79	57.31	60.44	14.25
CV	1.56	2.49	3.34	3.77	4.07	19.81	7.84	8.36	10.94	15.22
LSD	1.13**	1.24**	1.24**	0.44**	2.90**	0.47*	6.97*	5.74	7.31**	2.54**
NM	59.39	40.17	29.16	9.29	54.10	2.02	75.36	57.70	57.13	13.98
PSM	60.69	42.42	32.55	10.09	64.49	1.91	72.33	56.26	53.81	13.77
CV	1.56	2.49	3.34	3.77	4.07	19.81	7.84	8.36	10.94	15.22
LSD	0.72**	0.79**	0.79**	0.28**	1.84**	0.30	4.41	3.63	4.62	1.61**

*FDII= 5 days irrigation interval, TDII= 10 days irrigation interval, FTDII= 15 days irrigation interval, TWDII= 20 days irrigation interval, FP= farmers' practice, PSM= paddy straw mulch and NM= no mulch

Conclusion

The research findings indicate that adopting irrigation at 10-day intervals with mulching can be a promising approach for gladiolus cultivation, providing significant improvements in growth and yield while optimizing water usage.

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EFFECT OF IRRIGATION ON MANGO FRUIT CRACKING IN CHATTOGRAM REGION

M.P. HAQUE, M. F. ZAMAN, S.K. BISWAS, AND M. S. RAHMAN

Abstract

The study was conducted at the existing HRC Mango Orchard of Regional Agricultural Research Station, Hathazari, Chattogram during the Rabi season of 2019-20, 2020-21, 2021-22, and 2022-23 to explore the optimal period of irrigation to mitigate mango fruit cracking. Five treatments were applied: T_1 (rain-fed i.e. local practice), T_2 (irrigation at full bloom), T_3 (irrigation at fruiting setting), T_4 (irrigation at full bloom and fruit setting), and T_5 (irrigation at 2 weeks intervals). The highest yield was found at higher frequency irrigation (T_5). The maximum irrigation (average 1865 liters plant^{-1}) was applied at two weeks interval irrigation (T_5). In rain-fed condition (T_1), yield was lowest. The lowest number of fruits dropping (average 18 no. fruits) had occurred in irrigation at full bloom and fruit setting (T_4). The lowest number of cracking (average 14no.fruits) as well as the highest sweetness (average TSS=24%) occurred through irrigation at fruit setting (T_3) and the benefit-cost ratio was also higher in this treatment.

Introduction

In the Chattogram region, farmers are still empirically applying water based upon experiences, without technical criteria. As a result, chances are that the mango crop cannot uptake enough water for its development and production due to soil water stress or excess. This kind of irrigation management may also lead to an increase in production costs due to an excess amount of water applied that affects the sustainability of water resources. Therefore irrigation management for the mango crop should follow technical criteria so that water is applied at the right time and in the right amount. Alam et al. (2017) found that the fruits dropping and cracking of mangoes cause four reasons-diseases, insects, nutrient deficiency, and water scarcity in Bangladesh. Mango fruit cracking occurs in the Chattogram region during the dry season (Nov-March). The cracked fruits lose keeping quality and are unsuitable for transportation and consumption. There is also water scarcity during this period in the Chattogram region. So, Optimal stages of irrigation in mango production may save water and boost up quantity and quality (fruit cracking) of mango. This experiment aims to find out the critical stage of irrigation to mitigate mango fruit cracking of mango.

Materials and Methods

A field experiment was conducted at the existing HRC Mango Orchard (BARI Aam-4, Age 5-7 years), Hathazari, Chattogram during the rabi season (from November to June) of 2019-20, 2020-21, 2021-2022, and also 2022-23. The design of a randomized complete block was performed with three replication and five treatments. The five irrigation treatments are: 1) Rainfed condition i.e. Local practice (T_1), 2) Irrigation at full bloom (T_2), 3) Irrigation at fruit setting (T_3), 4)Irrigation at full bloom and fruit setting (T_4), 5) Irrigation at 2 weeks intervals (T_5)

Results and Discussion

The highest yield and fruit weight per plant were obtained at two weeks intervals of irrigation (T_5) and the lowest yield was in rainfed condition (T_1). The more frequent irrigation was more responsive to yield. One irrigation event occurred at both full bloom and fruit setting. The fruiting stage irrigation was responsive to yield which was more yield than full bloom irrigation (Table 1). The fruits' cracking at two weeks interval irrigation (T_5**)** was also the highest level of any other treatments. The lowest number of fruits cracking occurred at fruit setting irrigation. The results revealed that less irrigation and excessive irrigation than a certain level may cause more fruit cracking. The highest number of fruit dropping was obtained at rainfed condition (T_1) which was the control treatment in comparison to other treatments. The lowest number of fruit dropping (average 18 no. Fruits in successive years) occurred in irrigation at full bloom plus fruit setting stage (T_4). So, irrigation at both full bloom and fruit setting stage was crucial for the reduction of fruit dropping. The percentage of

TSS at rainfed condition (T_1) was less than irrigation at fruit setting (T_3). The sweetness (TSS) was the lowest (average 21%) in two weeks interval irrigation (T_5) and the highest sweetness (24%) was at fruit setting irrigation (T_3). Therefore, the more frequent interval irrigation decreased the sweetness of mango. The benefit-cost ratio of irrigation at fruit setting was highest (average BCR about 3).

Conclusion

However, concerning economic return and fruit cracking, irrigation at fruit setting (T_3) was the more beneficial and suitable stage.

Table 1 Irrigation effect on Mango production

Year	Treatment	No of fruits per plant	Weight per fruit (gm)	Yield per plant (kg)	No of fruits drop	No of fruit cracks	TSS (%)	irrigation (Liters/plant)	Benefit (Tk/plant)	Cost (Tk/plant)	BCR
2019-2020	T_1	160.0	355.0	56.8	38.3	32.7	23.0	0	2272	780	2.91
	T_2	142.3	410.0	58.4	37.7	25.7	22.3	1000	2336	900	2.60
	T_3	147.0	458.3	67.4	24.7	15.0	24.0	1200	2696	900	3.00
	T_4	145.7	485.0	70.6	21.0	25.0	21.7	1300	2824	1300	2.17
	T_5	145.3	526.7	76.5	31.0	39.0	19.3	2000	3048	2000	1.52
	CV (%)	3.8	2.8	4.3	10.8	11.6	4.3				
	LSD	10.7	23.8	5.4	6.2	6.0	1.8				
2020-2021	T_1	165.0	335.0	55.2	33.3	30.3	23.1	0	2210	800	2.8
	T_2	145.7	440.0	64.2	32.7	23.7	22.5	950	2568	950	2.7
	T_3	148.0	456.7	67.6	19.7	13.0	24.0	1130	2702	950	2.8
	T_4	146.3	489.0	71.6	16.0	23.0	21.2	1270	2862	1400	2.0
	T_5	145.7	511.7	74.6	26.0	37.0	22.0	1852	2982	2200	1.4
	CV (%)	4.3	4.8	6.9	12.8	12.7	5.7				
	LSD	12.2	40.6	8.7	6.2	6.0	2.4				
2021-2022	T_1	131.3	509.7	43.5	28.3	26.3	23	0	1740	850	2.05
	T_2	142	479	62.1	27.7	22.3	22.3	700	2484	970	2.56
	T_3	150	450	67.5	14.7	13.3	24	1010	2700	970	2.78
	T_4	152	437.7	72.8	17.3	23	21.7	1108	2912	1250	2.33
	T_5	146.7	331	74.8	29	32.3	22	1743	2992	1900	1.57
	CV (%)	1.9	4.9	4.9	15.3	9.8	5.8				
	LSD	5.1	39.7	5.9	6.7	4.3	2.5				
2022-2023	T_1	152.1	340.3	51.8	33.3	29.8	23.0	0	1990	810	2.44
	T_2	143.3	429.2	61.6	32.7	23.9	22.3	883	2467	940	2.61
	T_3	148.3	455.0	67.5	19.7	13.8	24.0	1113	2699	940	2.85
	T_4	148.0	484.3	71.7	18.1	23.7	21.7	1226	2878	1316	2.22
	T_5	145.9	516.0	75.3	28.7	36.1	21.1	1865	3006	2033	1.51
	CV (%)	3.5	4.2	5.5	12.8	11.5	5.3				
	LSD	5.1	18.4	3.5	3.3	2.9	1.2				

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EVALUATION OF ALTERNATE FURROW IRRIGATION AND IRRIGATION INTERVAL WITH SUPPLEMENTAL EVERY-FURROW IRRIGATION FOR EGGPLANT CULTIVATION

K. K. SARKER, M. A. RAHMAN, M. A. QUDDUS, S. K. BISWAS, A. K. M. QUAMRUZAMAN

Abstract

The study was conducted to evaluate the alternate furrow irrigation (AFI) with 10 and 15-days interval with supplement one every furrow irrigation (EFI) on eggplant yield, water saving, water productivity and benefit cost ratio as compared with AFI without supplement EFI, and EFI with 10 and 15 days interval. The field experiment was laid out in randomized block design with six treatment replicated thrice. The results showed that plant height and SPAD were not significantly different. The yield had significantly different but the yield was not differ between the treatments of AFI with or without supplement one EFI at 10 days interval. AFI saved water by 35% and improved WP by 50%. Benefit-cost ratio of AFI was nearly similar to EFI. AFI with 10-days interval could be an alternative irrigation option.

Introduction

Irrigation water scarcity becomes severe especially during the winter (dry) season in Bangladesh due to the decline in groundwater table, rainfall and drying of surface water resources. Surface flooding irrigation is a common practice in Bangladesh causing excess uses of irrigation water and reduced yield, higher input cost and lower net income. Excess irrigation increase surface runoff, deep percolation, water stagnant and decreases aeration. Therefore, alternate furrow irrigation (AFI) method is now essential in the areas where water resources are limited. Researcher (Reddi and Reddy, 2009) reported that AFI have a great potential to improve WUE as compared with conventional EFI and relatively easy to apply. The study was taken to evaluate the yield, water saving, water productivity and benefit cost ratio of the AFI compared with traditional EFI method.

Materials and method

The experiment was carried out at the research field of HRC under BARI in Gazipur in 2021-2022. Field experiment was conducted in six treatments by randomized complete block design with three replications. The treatments were: T_1: Alternate furrow irrigation (AFI) with 10 days interval with supplement one every furrow irrigation (EFI) at critical growth stage (flowering/1st fruiting stage). AFI indicates that one of the two neighboring furrows is alternately irrigated during consecutive irrigation event, T_2: AFI with 15 days interval with supplement one EFI at critical growth stage (flowering/1st fruiting stage), T_3: AFI with 10 days intervals without supplement EFI, T_4: AFI with 15 days intervals without supplement EFI, T_5: EFI with 10 days interval. EFI is the traditional way where every furrow is irrigated during each irrigation event, T_6: EFI with 15 days intervals. The seedlings were planted on 3 December. The row to row width was 70 cm and plant to plant distance was 100 cm. The recommended fertilizer dose was applied (BARC, 2018). Total seasonal crop water use (SCWU) was calculated expressed by the equation of (Reddi and Reddy (2009) and Sarker et al. (2016). The plant height and SPAD value were measured at different growth stages. Yield contributing characters were determined. Economic analysis was done. Data were statistically analyzed using R at 5% probability level.

Results and discussion

Plant height of the eggplant plant was not significantly different ($P<0.05$) among the treatments at different growth stages. The effect of treatments on SPAD value had no significantly ($P<0.05$) difference among the treatments. The results indicate that AFI method may maintain crop growth and recover the sensitivity of the plant's leaves to the drying soil (Kang et al., 1998). Fruit yield and yield components of eggplant were influenced by the ways of irrigation water application methods and irrigation interval (Table 1). EFI with 15 days interval produced significantly lower yield than AFI at 10 days intervals. This study shows that there was no significant reduction in marketable yield using AFI as against the traditional EFI at field conditions. CWU and WP varied among the treatments due to the variation of water saving technique (Table 4a-b). AFI system gave nearly similar yield to EFI with up to 35% reduction of irrigation water amount when irrigated with 10 days intervals. The BCR of the treatment AFI was similar as compared to EFI. The AFI technique produced lower unit production cost as compared to EFI technique.

Table 1. Yield, water productivity (WP) and water saving of eggplant under irrigation methods in 2021-2022 and 2022-2023

Irrigation treatments	**2021-2022**				**2022-2023**			
	Fruit yield (t/ha)	WP, Kg/m3		Water Saving (%)	Fruit yield (t/ha)	WP, Kg/m3		Water Saving (%)
		CWP	IWP			CWP	IWP	
AFI_1 with one EFI supplement at Flowering/ fruiting	23.4 a	9.0 b	11.11 b	26.6	18.29 b	6.13 b	11.1 b	35
AFI_2 with one EFI supplement at Flowering/ fruiting	21.71 b	9.47 ab	12.9 a	24.7	16.69 c	5.6 c	9.7 c	36
AFI_1 without supplement	24.26 a	9.83 a	12.87 a	30.2	19.47 a	6.6 a	11.8 a	35
AFI_2 without supplement	21.56 b	9.93 a	13.5 a	28.6	16.94 c	5.7 c	9.83 c	36
EFI_1	23.73 a	6.73 d	7.87 d	-	18.62 ab	4.1 d	5.67 d	-
EFI_2	22.03 b	7.23 c	8.83 c	-	16.83 c	3.6 e	4.90 e	-

Conclusion

AFI with 10 days irrigation interval with supplement one EFI at flowering/fruiting stage saves irrigation water by 35% than EFI and substantially improved WP by 50% without significant reduction in yields. This AFI technique have the potential to save water and increase WP and could be an alternative irrigation option.

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FEASIBILITY STUDY OF THE IoT BASED PRECISION AGRICULTURE FOR SUSTAINABLE CROP PRODUCTION IN BANGLADESH

K.K. SARKER, M.N. UDDIN, I. AHMED, A.F.M. TAREQ, N.N. KARIM, M.R. ISLAM, M.S. HASAN, M. T. ALI, S.K. BISWAS

Abstract

Sensor-based precision agriculture (PA) is not in general practice in Bangladesh and its potential is yet to be adequately investigated at crop field conditions. Therefore, this study has been taken to test the feasibility of the Internet of Things (IoT) based PA for predicting water and fertilizer use at field conditions. The field experiment was set up at BARI, Gazipur and the reference database is being created from experiment for testing the IoT-based eggplant production. The IoT based PA software system has been designed, developed and is being tested. Initial machine learning models-irrigation and fertilizer requirement and pest attack have been developed and will be evaluated the performance. A Mobile app has been developed and is being improved for representing the possible interfaces and relative features for the end user.

Introduction

Crop productivity often fluctuates due to the imbalanced use of water, fertilizer and pesticide in production practices. The common agricultural process is based on traditional surface broadcasting fertilizer, flooding irrigation and frequent pesticide application that uses excess fertilizer, water, pesticide and subsequently, decreases yield and overall efficiency and productivity. Considering the prevailing circumstances, this study aims to test the feasibility of Internet of Things (IoT) based precision agriculture for predicting water, fertilizer and pesticide use at field conditions. Therefore, the specific objectives were to (i) develop and test the IoT based machine learning precision agriculture system for improving crop productivity, (ii) monitor and evaluate the water and fertilizer use efficiency using IoT based precision agriculture, (iii) analysis the economic profitability and feasibility of IoT based precision agriculture for crop production.

Materials and Methods

This study was taken by the consortium of BARC, BARI and NDL and implemented their respective activities. The approach of this study was two parts: the first part was to develop an IoT-based machine precision agriculture (PA) by NDL. The second part of the study was to evaluate the IoT-based machine learning PA through field experiment involving soil, water, fertilizer and other agronomic management aspects at field conditions. The eggplant (BARI Begun 10) was used for testing the IoT based PA technique. The research field was set up at BARI. The four treatments (T_1, T_2, T_3, T_4) for eggplant during *Rabi* season (December 2021-April 2022), summer season 2022 (July-November 2022) and *Rabi* season (December 2022-April 2023) were taken. The treatment T_1 without sensor was evaluated by comparing with BARI recommended practices (T_2), drip-fertigation (T_3) and farmers practice (T_4). FGDs were done for setting treatment T_4. In T_1, locally made sensor was tested the performance. The standard agronomic practices were followed as per requirements. The IoT based PA software system were designed and tested for the data stream that received from the IoT system installed in the BARI experimental field. The research were being conducted in developing initial ML models for water use, fertilizer use and pest attack prediction. Android Package/mobile app interfaces and relative features for the end user were improved and Bangla version was introduced.

Results and Discussions

Influence of treatment on plant height and SPAD value

The influence of tretments on plant height and SPAD value are shown in Fig. 1a-b. The figure indicates that the treatments affect the plant height and SPAD value. Among the treatment, the values are nearly same although farmers use greater fertilizer, water and pesticide than other practices. The results indicate that the SPAD value had no more differ under the treatments (Fig. 1b). Greater SPAD value may indicate more survive and predict yield level.

Effects of treatment on fruit yield of eggplant

Fruit yield of eggplant during growing season are shown in Fig. 2a-c. The results indicated that the effect of treatment had nearly similar in all season.

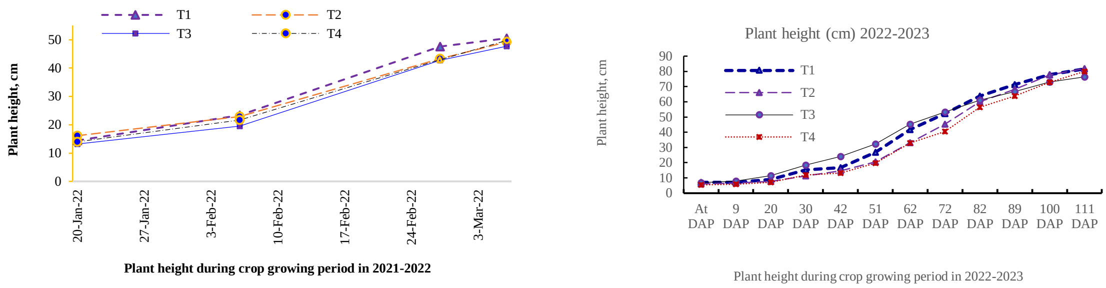

Fig. 1a**.** Effect of treatment on plant height during *Rabi* season in 2022 and 2023 in field conditions

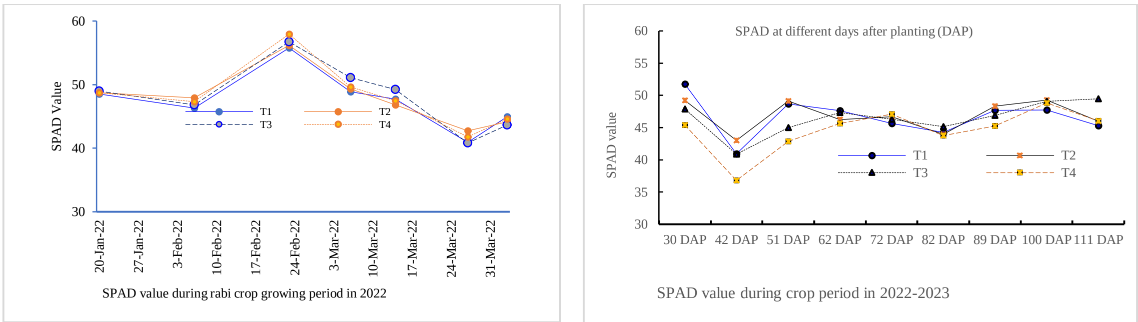

Fig. 1b**.** Effect of treatment on SPAD in *Rabi* season of 2022 and 2023 in field conditions

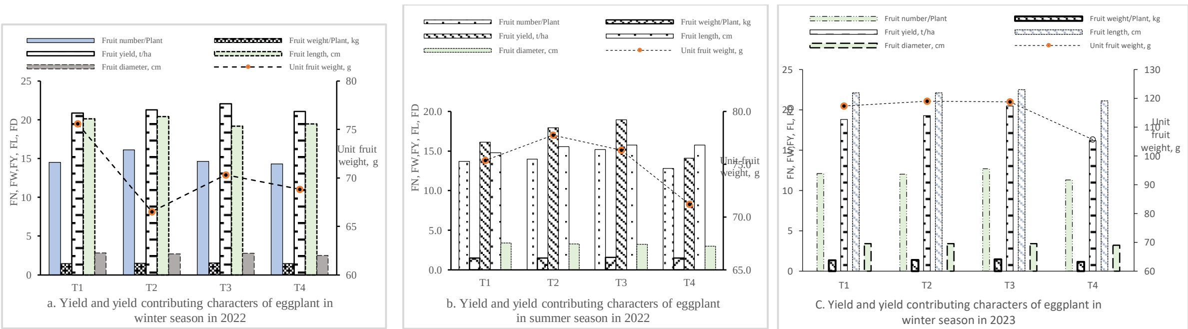

Fig. 2a-c. Yield and yield contributing characters of eggplant in Rabi season of 2021-22, summer season of 2022 and Rabi season of 2022-23

Conclusion

Database are creating to train the IoT based ML program for eggplant production. The treatment effect (without sensor) had no significant difference. IoT related all sensors/equipment were recently procured through OTM system and is being process to set up the sensors for determining water and fertilizer use efficiency.

Reference

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EVALUATION OF SPRINKLER IRRIGATION FOR IMPROVING WATER PRODUCTIVITY OF WATERMELON/ SUNFLOWER IN COASTAL ZONE OF BANGLADESH

K.K. SARKER, S.K. BISWAS; M.A. RAHMAN, M.A. QUDDUS, M.M. ISLAM

Abstract

Sprinkler irrigation is becoming popular for increasing water productivity in the regions where the fresh water availability and resources are scare. Therefore, the objectives of this study were to evaluate the hydraulic performance of sprinkler irrigation, find out the effect of sprinkler irrigation on yield, water use and water productivity of watermelon/sunflower, and introduce/disseminate the water saving technique of sprinkler irrigation. A portable sprinkler irrigation system was developed, installed and evaluated. The results showed that the performance was good and indicated the acceptable for application. Sunflower yield was greater by 6.3% than traditional practice. Sprinkler irrigation saved water by 10.6-19.7% compared to traditional practice. Water productivity was improved by sprinkler irrigation compared to traditional irrigation. Sprinkler irrigation technique could be an option for better irrigation in the coastal zones.

Introduction

Sprinkler irrigation system is a proven technology for reducing water losses and increasing water use efficiency by applying uniform water directly to root zones of the plant, particularly in areas where rainfall and irrigation water is scarce and expensive, although its expansion remains limited due to the lack of information on water distribution, initial investment, power requirement, stable electric and water supply and high winds. Farmers/entrepreneurs are encouraged to cultivate crops using the sprinkler irrigation due to its assured and efficient use of water. Water saving is varied from 40-80% and the yield increase up to 100% for different crops by using micro-irrigation (Rao et al., 2010). Therefore, this study was taken to develop the sprinkler irrigation system and evaluated at field for increasing water productivity.

Materials and Method

Sprinkler irrigation system was developed to apply water directly to the crop field through sprinkler from plastic tubing at flow rates and intervals. Based on development principles, sprinkler irrigation system was evaluated (Fig. 1) based on its hydraulic performance at BARI, Gazipur in 2022-20223. The ASAE standard procedure was followed to determine the hydraulic parameters. The test parameters of the sprinkler system such as co-efficient of variation (CV_m), coefficient of Christiansen's uniformity (CU) and distribution uniformity (DU) were considered. The field validation was conducted at farmers' field of Kalapara in Patuakhali in the rabi seaon of 2022-2023 (Fig. 1). Standard agronomic crop management practices were followed.

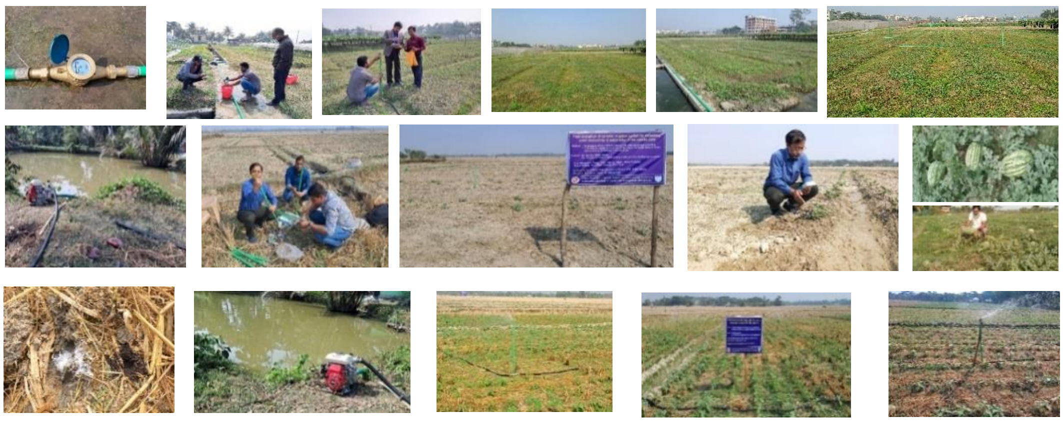

Fig. 1. Photograpic images of sprinkler irrigation system for testing and evaluating conditions at field

The crop was watermelon and sunflower cultivar local hybrid F1 (Pakhija) and F1 (Hisun). Seasonal water use (ETa) was calculated by the equation of Michael (1978) and Sarker et al. (2019). Water productivity was calculated as the ratio of yield and seasonal water use. Data were statistically analyzed using R software.

Results and Discussion

The test parameters for various combination of sprinkler position is shown in Table 1. The results (Table 1) indicate that it performed average, as recommended by the ASAE standard. The hydraulic performance showed that the flow rate of the sprinkler increased with increase in pressure, and the coefficient of variation increased with decrease in pressure. The results indicated that the distribution uniformity is more than 80% (Table 1). The sunflower yield in sprinkler irrigation was greater by 6.3% than in traditional practice. The sprinkler irrigation technique using brackish water with EC of < 4 dS/m could be an option for better irrigation practice in coastal areas.

Table 1. Test parameters of hydraulic performances

Sprinkler riser head (m)	Sprinkler combination	CV_m	CU (%)	CU_{mc} (%)	DU (%)
1.0	C1	0.05	96.8	98.2	93.4
	C2	0.08	92.8	97.7	87.9
	C3	0.11	94.9	97.4	87.5
1.5	C1	0.05	88.9	91.7	95.8
	C2	0.08	85.9	88.8	90.5
	C3	0.10	89.0	89.8	87.1

*Manufacturer's coefficient of variation (CV_m), co-efficient of uniformity (CU) and Distribution uniformity (DU). C1 indicates the rectangular spacing, C2 indicates triangular spacing and C3 indicates the circular spacing.

Yield with sprinkler irrigation was slightly higher than traditional method which maintain the favourable conditions of the crop field. Water productivity were greater in sprinkler irrigation. There was almost 10.9-19.7% reduction in irrigation water and similar trend of yield compared to traditional practice. The results revealed that sprinkler irrigation could be an option for irrigation water supply based on water utilization and yield compared to the traditional irrigation for the saline areas of Bangladesh.

Conclusion

The performance of the sprinkler irrigation with the low-pressure was found satisfactory. The uniformity of water application was more than 80%, indicating the better water application for uniformly distribution to the field. Field validation of the sprinkler irrigation system increases yield, reduce water use, save water and improves water productivity.

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YIELD AND WATER PRODUCTIVITY INDICES OF GARLIC VARIETIES UNDER SPRINKLER IRRIGATION

S.K. BISWAS, M.A. HOSSAIN, D.K. ROY

Abstract
A field study was conducted to develop water – yield relationship for two garlic varieties with different irrigation regimes (0.6, 0.8, 1.0, 1.2 and 1.4 ETo) under sprinkler irrigation to quantify crop water productivity functions (CWPF) for optimum use of irrigation water. Marginal water productivity (MWP) and elasticity of water productivity (EWP) were calculated using the relationship between bulb yield and seasonal evapotranspiration (SET). A continuous increasing trend in yield was recorded with the increase in SET up to 1.0 ETo. The critical levels of SET ranged from 183 – 237 mm for BARI Rashun-1 and from 186 – 243 mm for BARI Rashun-3 for obtaining maximum WP and yield, respectively, indicating almost same irrigation practices is needed for cultivation of these two garlic varieties.

Introduction
Garlic, a key spice, has an enormous importance all over the world for flavoring and seasoning various vegetables and meat dishes. In Bangladesh, it is the second most important bulb crop after onion belonging to family Alliaceae. Although the productivity of garlic is rising, every year the country has to import large quantity of garlic to meet the domestic demand due to an abysmal productivity scenario (6.28 t/ha) compared to the global productivity of 17.08 t/ha (FAOSTAT, 2020). The trail in productivity, among many factors, coupled with poor water and nutrient management. So, there is vast scope for increasing the productivity through innovations in agro-techniques and sustenance of productivity through better water management in the farm. With this view, this study was conducted to find out the comparative performance of two garlic varieties under sprinkler irrigation and to estimate the critical level of ET for obtaining maximum WP and maximum yield.

Materials and Methods

A field study was carried out with two garlic varieties (V_1: BARI Rashun-1 and V_2: BARI Rashun-3) under sprinkler irrigation system during the winter season (November–March) of 2022 – 2023. A total of six irrigation treatments under each garlic varieties replicated thrice with split-plot design. The treatments were as follows: Sprinkler irrigation at 60% ETo (I_1), 80% ETo (I_2), 100% ETo (I_3), 120% ETo (I_4), and at 140% ETo (I_5). Cloves of garlic (cv BARI Rashun-2) were planted at 15 cm × 10 cm spacing on 22 November 2022. During land preparation, recommended dose of fertilizer (N_{100}, P_{54}, K_{167}, S_{18} kg/ha) was properly incorporated with the soil. A light irrigation amounting 20 mm was applied after planting for proper germination and crop establishment. Following the treatments, irrigation was applied at 7- day intervals based on reference evapotranspiration (ETo). Seasonal evapotranspiration (SET) during the entire cropping period was calculated by using the field water balance equation as: ET= IW + P+ - D - R ± ΔSWS, where P is precipitation (mm), IW is irrigation (mm), D is the drainage (mm), R the run-off and ΔSWS is the variation in water content of the soil profile. The bulb yields were recorded at harvested on 22 March 2023. The analysis and interpretation of data were done using the DMRT method of analysis of variance technique.

Results and Discussion

Inter-cultivar variability of garlic in their functional responses to water deficit and well-watered conditions and its relationship with yield and water productivity was analyzed for two garlic varieties (Table 1 & Fig. 1). For both the varieties, the highest bulb yield (7.62 and 8.02 t/ha) was obtained under 120% ETo water regime while the water regime of either 1.0 ETo or 1.2 ETo was the second yielder. In general, medium water regime (0.8-1.0ETo) treatments had higher WP than the lower and higher water treatments. This was due to the fact that the increase in yield was proportional to SET up to a certain level then onward the increasing rate was declined. In general, wetter water regime treatments had higher and drier treatments had lower SET values. To achieve maximum WP, 183-186 mm of SET would require and to maximize yield, SET would need to be 237-243 mm, which is about

20% greater than the water use at maximum WP. Under a limited water supply condition, WP reached a maximum of 3.36 and 3.45 kg/m^3 when SET was equal to 183 and 186 mm, respectively for V_1 and V_2

Table 1. Yield, crop water use (CWU) and water productivity of garlic varieties during 2022 -2023

Treatment	Yield (t/ha)		CWU, mm		Water productivity (kg/m^3)	
	V_1	V_1	V_1	V_2	V_1	V_2
I_1= 0.6ETo	5.08c	5.16c	157	156	3.24	3.30
I_2= 0.8ETo	6.29ab	6.31ab	191	193	3.30	3.31
I_3= 1.0ETo	7.35ab	7.56ab	219	218	3.36	3.45
I_4= 1.2ETo	7.62ab	8.02a	248	250	3.07	3.23
I_5= 1.4ETo	7.34ab	7.57ab	268	267	2.73	2.82

and the corresponding yield was 6.24 and 6.48 t/ha. If the water supply is not limited, then SET would need to be 237-243 mm to obtain maximum yield of 7.32-7.62 t/ha. The range of SET requirement between maximum WP and maximum yield was 183-237 mm for V_1 and 186-243 mm for V_2.

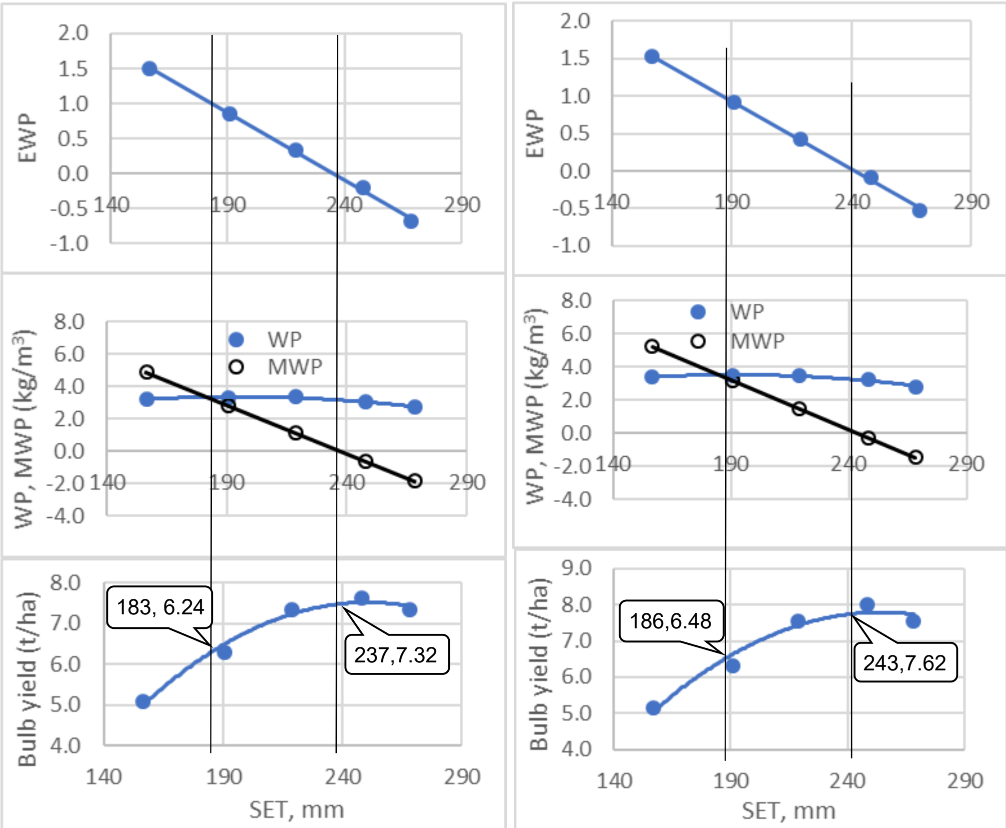

Figure 2. Relationships of yield, WP, MWP, EWP and SET for a quadratic ETPF for sprinkler irrigated garlic (Left: BARI Rashun-1and Right: BARI Rashun-3)

Conclusion

The critical levels of SET obtained for maximum bulb yield or WP were found very close indicating almost same irrigation practices is needed for cultivation of these two garlic varieties.

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EFFECT OF FERTILIZER AND IRRIGATION FREQUENCY ON THE YIELD AND QUALITY OF EXPORT AND PROCESSING POTATO

S.K. BISWAS, M.A. ANOWER, D.K. ROY, K.F.I. MURAD, FARZANA, K.K. SARKER

Abstract

The effects of fertilizer and irrigation on dry matter content, tuber yield and water productivity of an export and processing potato variety (BARI Alu-25) were evaluated. SOP with vermicompost and SOP alone with recommended fertilizer dose were tried under three levels of irrigation to increase the dry matter content and tuber yield of potato. The treatment of recommended dose with 75% MOP + 25% SOP + Vermicompost @2t/ha produced slightly higher tuber yield, tuber dry matter content and water productivity under the irrigation treatment where four irrigations at 30, 45, 60 and 75 days after planting (DAP) were applied with last irrigation up to 50% of field capacity (FC). These results are of considerable importance to the growers of potato and may be preferred for growing export and processing potato in Bangladesh.

Introduction

One of the important quality parameters considered for export and processing potato is dry matter content in tuber. Potato tubers intended for chips should contain 20-22% of dry matter and 14-17% of starch, and for crisps 20-25% of dry matter and 16-20% of starch (Grudzińska *et al.* 2016). Both irrigation and fertilizer are important factors affecting the quantity and quality of tubers yield. The form of potassium, sulphate of potash - SOP (K_2SO_4), has an effect on dry matter. So, it is necessary to find out the optimum irrigation scheduling and potassium fertilizer in order to maximize the economic return from exporting as well as processing. This study was therefore intended to find out the appropriate irrigation and fertilizer management for higher tuber yield, dry matter content and quality of processing potato.

Materials and Methods

The experiment with potato 'BARI Alu-25 (cv. 'Asterix') was laid out in randomized complete block design (RCBD) with nine combinations of three fertilizers levels and three irrigation levels replicated thrice. Three fertilizer levels were: F_1: Recommended fertilizer dose (RFD), F_2: RFD with 75% MOP + 25% SOP + Vermicompost @2t/ha, F_3: RFD with 50% MOP + 50% SOP. Three irrigation levels were: I_1: 3 irrigations at 30, 45 and 60 DAP, I_2: 4 irrigations at 30, 45, 60 and 75 DAP (Last irrigation upto 50%FC) and I_3: 4 irrigations at 30, 45, 60 and 75 DAP (all irrigation up to 100% FC, except last irrigation up to 50%).

Seed potatoes were with the spacing of 60 cm x 15 cm. The recommended doses of fertilizers were applied as basal and top dressing. The calculated amount of irrigation water was supplied to the experimental plot using a polyethene hose pipe connected to a water flow meter. Data on tuber yield and yield attributes and dry matter of potato were collected and statistically analyzed to test the effects of fertilizer and irrigation levels on these parameters using MSTAT-C program. All the treatment means were subjected to analysis of variance (ANOVA) and compared for any significant differences at $P < 0.05$.

Results and Discussion

Fresh tuber yield of export and processing potato

Neither of yield contributing parameters, nor the tuber yield were significantly affected by either the irrigation or the fertilizer treatments. But tuber yield was slightly increased in the irrigation treatment I_2, where last irrigation was applied at 75 days after planting up to 50% of field capacity. Similarly, fertilization treatment F_2 where SOP and vermicompost were applied produced the slightly higher yield than other treatments. Similarly, combination of irrigation and fertilizer had almost similar effect on accumulation of dry matter in tuber as realized by irrigation and fertilizer separately. Slightly increased dry matter percentage (20.05%), total dry matter per plant as well as dry matter yield (5.23 t/ha) were obtained from this treatment I_2F_2 compared to other combinations. A significant and positive effect of vermicompost on dry matter accumulation in potato tuber was reported by Ferdous et al. 2019. Kahlel (2015) also noted the highest percentage of dry matter in tubers resulted from the treatment of organic fertilization by irrigation. Dry matter yield of potato depends on both tuber yield and dry matter percentage as the yield of dry matter is a product of the fresh yield of tubers and the content of dry matter in tubers. Though crop water use (CWU) was same across all fertilizer treatments under a particular irrigation treatment, WPs were varied due to difference in tuber yields. Here too the highest WP obtained from the treatment I_2F_2.

Table 1. Tuber yield, dry matter percentage and water productivity of processing potato (BARI Alu-25) under different irrigation and fertilizer levels over 2021 – 2022 and 2022– 2023

Treatment	**Tuber yield (t/ha)**	**DM yield of tuber (t/ha)**	**IR (mm)**	**CWU (mm)**	**WP (kg/m^3)**
I_1F_1 (3-irri @30,45,60 DAS with RFD)	29.92	4.31	196	252	8.80
I_1F_2 (3-irri with 75% MOP+ 25% SoP + vermicompost)	32.10	4.78	196	252	9.39
I_1F_3 (3-irri with 50% MoP+ 50% SoP)	30.37	4.84	196	252	9.69
I_2F_1 (4-irri @30,40,60,75DAP with RFD)	31.14	4.52	225	267	8.35
I_2F_2 (4-irri with 75% MoP+ 25% SoP + vermicompost)	34.71	5.23	225	267	9.41
I_2F_3 (4-irri with 50% MoP+ 50% SoP)	31.62	5.07	225	267	9.22
I_3F_1 (4-irri@30,45,60,80 DAP with RFD)	31.51	4.40	232	271	8.19
I_3F_2 (4-irri with 75% MoP+ 25% SoP + vermicompost)	32.47	5.28	232	271	9.48
I_3F_3 (4-irri with 50% MoP+ 50% SoP)	32.44	4.92	232	271	9.02
$LSD_{0.05}$	ns	ns	-	-	-
CV(%)	9.02	6.38	-	-	-

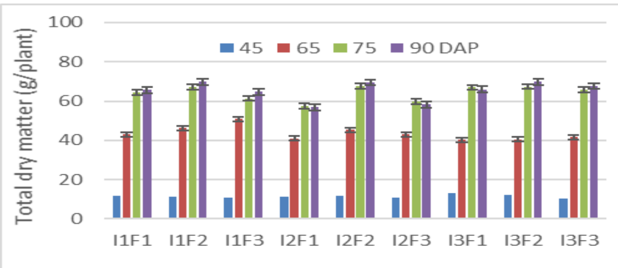

Figure 1. Total dry matter content at different growth stages (days after planting, DAP) of potato

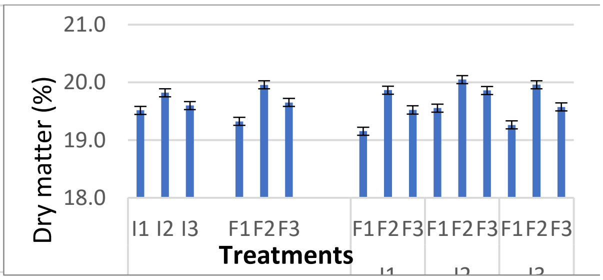

Figure 2 Dry matter percentage of potato tuber as influenced by different fertilizer and irrigation managements

Conclusion

The combination of fertilizer treatment F_2 and irrigation treatment I_2 demonstrated to be the best to increase dry matter, tuber yield and water productivity and may be preferred for growing export and processing potato.

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EFFECT OF SALINE WATER IRRIGATION WITH DIFFERENT DOSES OF POTASSIUM ON CROP GROWTH AND YIELD OF MUNGBEAN

F. AKTER[9], S.K. BISWAS [10], M.A. HOSSAIN [11], K.K. SARKER[12] AND K.F.I. MURAD[1]

Abstract

The experiment was conducted to evaluate the effect of saline water irrigation with different doses of potassium on crop growth and yield of mung bean. The treatments comprised different combinations of three salinity levels (4 dS/m, 8 dS/m and 12 dS/m) with four potassium levels (0%, 100%, 125% and 150% of recommended dose). Results indicate that increasing salinity levels negatively impacted plant growth and yield parameters, including the number of pods per plant, pod length, number of seeds per pod, weight of seeds per pod, hundred seed weight, and seed yield. High salinity adversely affected the plant's physiological processes and nutrient uptake. Similarly, higher levels of potassium application showed negative effects on plant growth and yield.

Introduction

Climate change poses a critical global challenge with severe impacts on humanity and the environment. Among the countries vulnerable to climate change and rising sea levels, Bangladesh stands out due to its susceptibility. Salinity has intensified, affecting about 53% of all irrigated lands in Bangladesh. To combat the detrimental effects of high salt concentrations, potassium fertilization has shown promise by improving crop tolerance to salinity. Potassium's role in regulating osmosis, turgor maintenance in guard cells, and water movement allows for better water absorption and efficient stomatal functioning. Mungbean, known as moog or sonamoog locally, is an advantageous legume species in Bangladesh. By adopting potassium fertilization and cultivating adaptable crops like mungbean, there is hope for mitigating the impact of salinity and promoting sustainable development.

Material and Methods

BARI Mungbean -6 is used for the experiment. The experimental design was in CRD, with four replicates, and the treatments consisted of four levels of irrigation water electrical conductivity - ECw (0, 4, 8 and 12 dS/m) and four K doses (0, 50, 100 and 150% of recommendation). Total sixty four plastic pots (14 L) were used. Each pot was filled with 14 kg soil collected from IWM experiment field and contained two plants. The bottom of the pot was perforated and filled with the coarse aggregate to drain the excess of water to a plate, in order to analyzed their chemical composition. Direct soil EC meter was used to measure in situ soil salinity. The salinity data were measured at two depths (0-5 cm) and (5-15 cm) for each treatment. Four levels of potassium in the form of muriate of potash were applied. The recommended dose of fertilizer was applied to all treatments. Artificially prepared irrigation water with varying ECw values was used to develop and maintain soil salinity in the pots. Seeds were sown and irrigated with fresh water for germination. At the 2nd trifoliate leaf stage, two healthy plants were kept in each pot and the rest were removed. Treatments were applied when the first trifoliate leaf appeared and continued until maturity. Soil salinity was measured after each irrigation for different treatments.

Results and Discussion

Increasing salinity and potassium levels led to a decline in all yield parameters. The highest no. of pods/plant (15.55), pod length (7.54 cm), no. of seeds/pod (10.87), wt. of seeds/pod (0.58 g), 100 seed wt. (5.79 gm) and yield (9.02 g/plant) was achieved from the fresh water treatment. Nevertheless, the various levels of salinity significantly influenced the plant height, root length, number of leaves, as well as the fresh and dry weight of different parts of the mungbean. In contrast, the presence of K did not show any impact on these parameters. Among saline water treatments, S4 (4 dS/m) performed the best, while S8 and S12 performed poorly. Similar findings were reported by Sherawat et al., 2015, and

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[9] SO, IWM Division, BARI, Gazipur
[10] CSO (in-charge), IWM Division, BARI, Gazipur
[11] PSO, HRC, BARI, Gazipur
[12] SSO, IWM, BARI, Gazipur

Ghosh et al., 2015, indicating the negative impact of salt and osmotic stress on mungbean growth and yield during summer. Regarding potassium application, the highest no. of pods/plant (15.36), pod length (7.44 cm), no. of seeds/pod (10.69), wt. of seeds/pod (0.56 g), 100 seed wt. (5.73 g) and yield (8.60 g/plant) was recorded for 100% potassium application treatment (K_{100}), while the highest and lowest levels (K_{150} & K_0) resulted in the lowest values. Yurtseven et al., 2005, and Kabir et al., 2004, also supported these findings.

Conclusion

it can be concluded that increasing salinity and potassium negatively impacts mungbean growth and yield. The interaction between salinity and potassium suggests that potassium application may not help mitigate the detrimental effects of salinity.

Table 1. Two years' average yield and yield components of mungbean as affected by salinity and potassium

Treatments	Number of pod/plant	Pod length(cm)	Number of seeds/pod	Wt. of seeds/pod	100 seed wt. (g)	Seed yield (g/plant)
FW	15.55	7.45	10.87	0.58	5.79	9.02
S_4	14.19	7.45	10.33	0.49	4.89	6.95
S_8	10.33	6.38	9.91	0.40	4.65	4.13
S_{12}	9.75	6.09	8.84	0.33	3.54	3.22
CV	4.85	3.38	7.76	7.69	6.16	5.4
LSD	2.83^{***}	0.58^{*}	1.26^{**}	0.14^{**}	0.99^{**}	1.47^{*}
K_0	11.25	7.46	9.33	0.43	4.34	4.84
K_{50}	12.00	7.44	9.25	0.45	4.55	5.40
K_{100}	15.36	7.44	10.69	0.56	5.73	8.60
K_{150}	10.00	6.45	9.29	0.38	3.92	3.80
CV	4.85	3.38	7.76	7.69	6.16	5.4
LSD	2.72^{**}	0.56^{**}	1.24^{**}	0.12^{**}	9.84^{**}	1.3^{*}
FW* K_0	11.50	7.00	9.50	0.50	5.08	5.75
FW* K_{50}	13.87	7.43	10.52	0.48	4.77	6.66
FW* K_{100}	15.76	7.54	10.95	0.61	5.81	9.61
FW* K_{150}	11.00	7.06	9.33	0.46	4.60	5.06
S_4* K_0	10.25	6.38	9.33	0.43	4.34	4.41
S_4* K_{50}	12.55	6.35	9.68	0.48	4.77	6.02
S_4* K_{100}	14.53	6.48	10.43	0.53	5.12	7.70
S_4* K_{150}	10.25	6.34	9.33	0.39	4.08	4.00
S_8* K_0	10.00	6.26	9.00	0.42	3.55	4.20
S_8* K_{50}	11.25	6.43	9.25	0.42	3.55	4.73
S_8* K_{100}	12.78	6.32	9.33	0.43	3.62	5.50
S_8* K_{150}	10.00	5.88	9.25	0.41	3.55	4.10
S_{12}* K_0	9.88	6.19	8.39	0.35	30.00	3.46
S_{12}* K_{50}	10.00	5.86	8.46	0.33	3.25	3.30
S_{12}* K_{100}	10.25	5.96	8.59	0.34	3.15	3.49
S_{12}* K_{150}	9.45	5.20	8.41	0.30	3.19	2.84
CV	4.85	3.38	7.76	7.69	6.16	5.4
LSD	1.73^{**}	0.86^{*}	1.03^{*}	0.08^{*}	4.04^{*}	3.09^{**}

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ADAPTATION OF RAISED BED FURROW IRRIGATION TECHNIQUE FOR INCREASING YIELD AND WATER PRODUCTIVITY OF SUNFLOWER IN SALINE ZONE

K. K. SARKER, S. K. BISWAS, M. S.I.KHAN, M. MAINUDDIN

Abstract

Water saving technique is now essential in the coastal areas where fresh water resources are limited. Therefore, this study was taken to conduct the field experiment at the salt affected area of Patuakhali. The specific objectives were to (i) find out the effect of planting (top center and side slope of the furrow) and furrow (Skip fixed, alternate and every) irrigation method on yield, water use and water productivity (WP) of sunflower. The results indicated that the yield was found significantly greater in the side slope planting of the skip, alternate and every furrow irrigation (EFI) than top center of the raised bed. The water saving technique of skip fixed and alternate furrow irrigation saved water use by 25-28% and significantly improved WP in AFI compared to EFI.

Introduction

Soil salinity is a constraint for crop production in the southern region of Bangladesh. In coastal areas, soil and water salinity and scarcity of irrigation water make it impossible to grow any crops during the dry season (December-April). Fallow lands can be brought under crop cultivation in the dry season by improved soil and water salinity management techniques. Alternate furrow (AF) or skip fixed furrow (SKF) irrigation has the potential to save water and reduce salt concentrations on the side slope of the raised beds by 2-3 times compared to every furrow irrigation practice and salt concentration towards to the dry side of the furrows (Devkota et al., 2015). Therefore, this study had been taken to increase crop and WP in salt response areas where irrigation water resources are limited.

Materials and method

The field experiment was conducted at the farmers' field of the village of Pankhimara in Kalapara under Patukhali under the project which is situated in the polder no 46 of the coastal regions of Bangladesh. The treatments consisted of two planting method and three irrigation methods were:

Planting method

- Top center of the raised bed (conventional practice)
- Side slope (middle) of the raised bed

Irrigation method

- Raised bed with fixed furrow irrigation (FSFI)
- Raised with alternate furrow irrigation (AFI)
- Raised bed with every furrow irrigation (EFI)

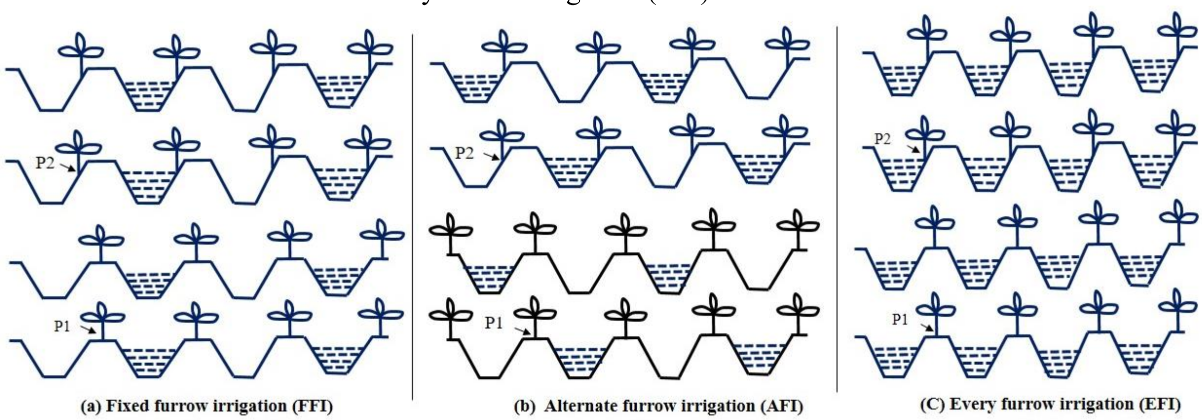

Fig.1. Schematic layout of the field experiments for furrow irrigation and planting method with top corner/side slope of the raised bed (50 cm furrow to furrow center). P_1: Top center of the raised bed; P_2: Side slope (middle) of the raised bed.

Fig. 2. Photographic images of early vegetative stage at the raised bed furrow irrigation and planting technique (Side slope of the raised bed) of sunflower in salt-affected area.

Soil was collected from each treatment to the soil profiles of 0-30 cm to monitor soil moisture, soil salinity and solute potential at different growth stages. $EC_{1:5}$ was determined using portable instrument.

$EC_{1:5}$ was also converted to solute potential (kPa) of field soil solution using the formula derived from Paul (2020) and Rengasamy (2010). Data were statistically analyzed using R.

Results and discussion

Yield and yield components of sunflower

The results indicated that the skip fixed furrow or alternate furrow irrigation with side slope of the raised bed using brackish water (EC<5 dS/m) could be an option for irrigation practices for sunflower cultivation in coastal areas of Bangladesh.

Water use and water productivity of sunflower

Seasonal water use ranged from 166 to 234 mm due to the variation of water saving technique. Water productivity of sunflower under different treatments ranged from 1.24 to 1.67 kg/m^3 and 1.04 to 1.45 kg/m^3 in 2023. The results indicated that SFFI or AFI with side slope planting technique had the potential to increase yield and save irrigation water by 25-28% and may useful irrigation technique at the salt-affected areas of coastal region where water saving technique is limited to irrigation for *Rabi* crops cultivation.

Effect of solute potential

The results indicate that the osmotic pressure was found lower in EFI than SFFI and AFI in soil profiles of 0-30 cm depth with 10 cm increments. The higher osmotic pressure (-kPa) was found in later growth stages of crop and highest in all treatments due to more soil water uptake and soil moisture evaporation from the soil surface. This study indicated that the solute potential ranged in all treatments is lower from sowing to maturity stage.

Conclusion

The water saving technique of skip fixed and alternate furrow irrigation with side slope planting of the raised bed have the potential to save water saved seasonal crop water use by 26-28% and significantly improved water productivity in SFFI and AFI compared to traditional every furrow irrigation for sustainable food security.

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EFFECT OF CYCLIC USE OF NON-SALINE AND SALINE WATER IRRIGATION ON YIELD, WATER PRODUCTIVITY AND SOLUTE POTENTIAL OF ZERO-TILLED POTATO

K. K. SARKER, S. K. BISWAS, K.F.I. MURAD, M.S.I.KHAN, M. H. RASHID, M. MAINUDDIN

Abstract

Cyclic use of non-saline (NS) and saline water (SW) is a technique to irrigate crops in the salt affected where fresh water is not available. The objectives were to find out the response of tuber yield, water productivity and solute potential to the cyclic use of NS and SW at different growth stages of potato. Two field experiments were laid out in Dacope and Kalapara. Results showed that the cyclic use of NS and SW irrigation treatment had significant (P<0.01) difference on potato tuber yield and WP (P<0.001). The greater solute potential was found in mid-February to March. The response of potato tuber yield to the cyclic use of NS (EC<2 dS/m) and SW (2<EC<5 dS/m) irrigation could be an alternative irrigation optioned in the coastal zones.

Introduction

Zero-tilled potato is a promising technology for cropping intensification in the coastal saline region, with limited use of irrigation water and higher yield. Zero-tilled potato has been successful in the Ganges delta. Zero-tilled potato with mulch could be an alternative way of crop production in that region for increasing cropping intensity. Recently, Sarangi et al. (2021) proved that potato has the potential to be cultivated in the fallow lands of the salt-affected coastal zones. In coastal regions, cultivation of short duration Rabi crops, like potato is very limited in the coastal areas due to inadequate fresh irrigation. Therefore, the response of tuber yield, water productivity and solute potential to the cyclic use of NS and SW at different growth stages of potato in the salt-affected areas of Bangladesh.

Materials and method

Two field experiments on zero-tilled potato were carried out in two locations in the *Rabi* season of 2021-2022 and 2022-2023. The treatments were as follows (Table 1).

Table 1. Irrigation treatment at different growth stages of potato tuber

	Treatment	Initial (Stolanization) stage (15-20 DAP)	Tuber initiation (40-45 DAP)	Tuber development stage (60-65 DAP)
T_1	NSW (0.1 - <2 dS/m)+NSW+NSW	NSW	NSW	NSW
T_2	NSW +SW (2–5 dS/m)+NSW	NSW	SW	NSW
T_3	0 + NSW + SW	0	NSW	SW
T_4	NSW + 0 + NSW	NSW	0	NSW
T_5	NSW + SW + 0	NSW	SW	0
T_6	NSW + 0 + SW	NSW	0	SW
T_7	0 + SW + NSW	0	SW	NSW
T_8	0 + 0 + 0	0	0	0
*T_9	Fallow	0	0	0

*T9 was considered only for DualEM survey.

Fig. 1. Photographic images of zero-tilled potato cultivation

$EC_{1:5}$ was determined and converted to EC_e (dS/m) of soil water content while using the formula derived from Richards (1954). The soil samples were taken from each plot in 10 cm increments, $EC_{1:5}$ was also converted to solute potential (kPa) of using the formula derived from Rengasamy (2010). $EC_{1:5}$ was determined using portable instrument. Crop water productivity (WP) was calculated as the ratio of tuber yield (t ha^{-1}) and CWU, and expressed as kg m^{-3}. Data on tuber yield and yield attributes of potato were statistically analysed using R statistical software.

Results and discussion

Response of tuber yield of potato to the cyclic use of non-saline and saline irrigation
The cyclic use of NS and SW irrigation treatment had significantly ($P<0.01$) effect on the tuber yield of potato in both years. The cyclic use of NS and SW irrigation treatment of T_2 and T_5 produced similar yield like as control irrigation treatment of T_1. Similar trends were observed in both locations.

Fig. 2. Photographic images of zero-tilled potato using cylic use of low saline and medium saline irrigation

Water productivity of potato
WP significantly ($P<0.001$) affected by the treatments. WP was greater at Kalapara than Dacope due to greater tuber yield response to better utilization of soil moisture. The results indicate that cyclic use of non-saline and saline water irrigation maintained the tuber yield. The cyclic use of NS and SW irrigation at different growth stages of potato have the potential to maintain yield and WP of potato for intensifying cropping option in the salt-affected zones.

Variations of solute potential
The solute potential among the treatments were similar trends over the periods and soil profiles with 10 cm increments. On average, the solute potential was found to be -500 to -1200 kPa at during the growing season from December to March and highest solute potential observed in mid-February to March. There was significant ($P=0.042$) correlation between the mean values of yield and solute potential in the top soil layer (0-10cm).

Conclusion

The response of potato tuber yield to the cyclic use of NS ($EC < 2$ dS/m) and saline water ($EC \geq 2$ and $EC < 5$ dS/m) could be optioned for expanding potato and developing better irrigation practices at the salt-affected areas in coastal zones of Bangladesh.

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RESPONSE OF ZERO-TILLED GARLIC WITH AND WITHOUT MULCH TO SALINE WATER IRRIGATION IN COASTAL SALINE SOIL

K. K. SARKER, S. K. BISWAS, M. S.I.KHAN, M. H. RASHID, M. MAINUDDIN

Abstract

Straw mulch and irrigation plays a crucial role in enhancing yield and water productivity of zero-tilled garlic in the salt affected coastal zones. The specific objectives of this study were to find out the response of garlic yield under mulch and irrigation interval and the interaction effect of mulch and irrigation interval on yield and water productivity. A factorial field experiment was laid out in eight treatments. The results indicate that plant height and bulb yield of garlic were significantly different among the treatments. The straw mulch with 10 days irrigation intervals produced greater bulb yield relative to non-mulch with other irrigation interval. The interaction effect of straw and irrigation interval had no significant differences. WP significantly varied among the treatments. Solute potential (-kPa) negatively increased as yield decreased.

Introduction

Straw mulching play a vital role in better root growth, increase yield by controlling soil cracking, weeds, soil temperature and conserving soil moisture. Garlic can be cultivated under zero tillage through straw mulching to reduce the turnaround time (Rahim and Fordham (1988), salinity and conserve moisture in the root zone. Late harvest of T. aman rice takes more days for land preparation which causes late planting of *rabi* crops as well as yield reduction. Drought/lack of fresh water, waterlogging, long duration and late harvest of Transplanted Aman rice, and varying degrees of salinity might be causes to produce lower yield. Therefore, a field experiment was taken to identify the better irrigation schedule with straw mulching on yield and water productivity of garlic in coastal clay soils.

Materials and method

The field experiment was conducted in farmer' fields at Dacope in Khulna during *Rabi* season of (November–April). The treatments consisted of eight combinations of two straw levels and four irrigation days' interval (Fig. 1). Factor A: Mulching: NS: Non mulch; SM: Straw mulch; Factor B: Irrigation days interval, I_0: No irrigation, I_1: irrigation 5 days interval (DI), I_3: irrigation 10 DI, I_4: irrigation 15 DI.

Fig. 1. Photographic images of zero-tilled garlic under different treatments

Standard crop management practices and irrigation scheduling based on treatments were followed. Garlic (cv. BARI Roshun-1), a variety was planted at the rate of 450 kg/ha on 28 December 2022 and 23 December 2023 with a row spacing of 15 cm (row to row) and 10 cm (plant to plant) in dibbling technique under zero-tilled system. Garlic was harvested on 7 April 2022 and 8 April 2023. Soil was collected from each treatment to the soil profiles of 0-30 cm to monitor soil moisture, soil salinity and solute potential at different growth stages. $EC_{1:5}$ was determined using portable EC meter. $EC_{1:5}$ was also converted to soil salinity and solute potential (kPa) using the formula derived from Paul (2020) and Rengasamy (2010). Data were statistically analyzed s using R.

Results and discussion

Effect of straw and irrigation on plant height of garlic

The effect of straw had significant difference on plant height in both years. The effect of irrigation intervals had also significant difference but the effect of straw and irrigation interval had no found significant difference. Plant height was no significant difference among the treatment of 5 and 10 days irrigation interval with straw mulch.

Effect of straw and irrigation on bulb yield of garlic

The bulb yield of garlic was significantly ($P<0.01$) different among the straw mulch and irrigation treatments (table 1). There were no significant differences among the treatment of 5 and 10 days interval with mulch. The interaction effect of straw and irrigation interval had no significant difference among the treatments in both years.

Water productivity

WP significantly varied among the treatments due to the variation of irrigation water applied mulch with or without mulch. The results indicate that straw mulch with 10 days irrigation intervals technique produced the greater WP as compared to non-mulch with different irrigation intervals.

Variations of solute potential

Variations of solute potential (-kPa) was negative correlation between yield and ECe under different irrigation intervals with non-mulch and mulch at different soil depths. The solute potential (-kPa) negatively increased as yield decreased at different soil depths.

Conclusion

The straw mulch with 10 days irrigation intervals produced better bulb yield and water productivity relative to non-mulch with other irrigation intervals that could be the favorable for intensifying the cropping option in the coastal zones of Bangladesh.

Table 1**.** Yield and water productivity (WP) of garlic under different treatments

Treatment		2021-2022		2022-2023	
		Bulb yield (t/ha)	WP (kg/m^3)	Bulb yield (t/ha)	WP (kg/m^3)
Mulching (M)		**	**	**	**
Mean		4.64	3.37	5.39	4.45
CV		10.9	11.6	10.9	12.1
NS		3.54 b	2.25b	4.11 b	3.13b
SM		5.75 a	4.50a	6.67 a	5.77a
Irrigation (I)		***	***	***	***
Mean		4.64	3.37	5.39	4.45
CV (%)		6.1	7.5	6.17	8.12
I_1		3.4 c	4.6 a	3.97 c	5.2 a
I_2		5.3 a	3.0 b	6.17 a	3.95 b
I_3		5.2 a	3.1 b	6.02 a	4.33b
I_4		4.7b	2.8 b	5.42 b	4.30b
Treatments (M × I)		***	ns	ns	
NS	I_1	2.56 d	2.7c	2.97	3.83
	I_2	4.30 b	2.3cd	5.00	2.87
	I_3	3.93 b	2.2de	4.57	2.97
	I_4	3.36 c	1.8e	3.90	2.83
SM	I_1	4.26 a	6.5a	4.97	6.60
	I_2	6.33 a	3.7b	7.33	5.03
	I_3	6.43 a	4.1b	7.45	5.70
	I_4	5.96 a	3.8b	6.93	5.80

NS: Non mulch; SM: Straw mulch; Irrigation days interval, I_0: No irrigation, I_1: irrigation 5 days interval (DI), I_3: irrigation 10 DI, I_4: irrigation 15 DI.

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EFFECT OF MULCH AND IRRIGATION INTERVAL ON YIELD AND WATER PRODUCTIVITY OF WATERMELON IN COASTAL SALINE SOIL

K. K. SARKER, S. K. BISWAS, A. MILA, M. H. RASHID, M. KAMAL, M. MAINUDDIN

Abstract

Mulch and irrigation is necessary to sustain coastal agriculture in southern Bangladesh. Therefore, a field experiment was carried out to investigate the response of watermelon at mulch and irrigation interval on yield and water productivity in the salt-affected coastal zone. A field experiment was conducted in Dacope. The experiment was laid out in a randomized complete block design with six treatments and replicated thrice. The treatments were as follows: factor a: mulch: (i) plastic mulch, (ii) no mulch; factor b: irrigation interval: I_1: 5 days interval, I_2: 10 days interval and I_3: 15 days interval. The cultivar (Sweet dragon) was tested. The better fruit yield and water productivity of watermelon was found at 5 days irrigation interval with plastic mulch in the salt-affected saline soils of Dacope in Bangladesh.

Introduction

Watermelon is becoming more popular and new areas are being included for the cultivation of this crop. Recently, the cultivation of a wide range of crops such as sweat gourd, watermelon, mungbean, wheat, sunflower and vegetables after the T.aman harvest are expanding around some surface water sources and shallow wells with low salinity water. The regions where fresh water is a scarce, appropriate water management and cultural practices must be included in production system to reduce soil salinization and maintain crop productivity. Mulching generally is a beneficial practice for crop production and uniformly maintained the soil moisture (Parmar et al., 2013). Therefore, a field experiment was conducted to identify the effect of plastic mulch and irrigation interval on yield and water productivity of watermelon with medium saline water.

Materials and method

A field experiment was conducted in Dacope in Khulna during the *Rabi* season of 2022 and 2023. The field experiment was laid out in six treatments and replicated thrice. The treatments were as follows: Factor A: Mulch: (i) Plastic mulch, (ii) No mulch; Factor B: Irrigation Interval: I_1: 5 days interval, I_2: 10 days interval, and I_3: 15 days interval. The cultivar of was Local Hybrid F1: Sweet dragon) was sown.

Fig. 1. Photographic images of watermelon layout with and without mulch

Watermelon was planted in pits spaced at 1.5 m × 1.5 m on 1 March, 2022 and 5 February in 2023. One seed per pit. Surface drainage system were done before sowing the watermelon seeds. Watermelons were harvested from 9 April to 19 May as the fruits matured. The number of watermelon fruits per plot, average weight of fruit, and fruit yield were determined at harvest. Water productivity (WP) of watermelon was calculated as the ratio of seed yield and total seasonal water use. Mean values of watermelon fruits yield and yield contributing characters were done by Microsoft excel.

Results and discussion

Yield and yield contributing parameters of watermelon

The greater fruit yield of watermelon was around 29.9 t/ha in 2022 and 26.6 t/ha with 5 days irrigation interval (Table 1a-b). There was large effects of frequent irrigation frequency with mulch on fruit yield than lower irrigation frequency without no mulch. Yield with mulch irrigation at 5 days irrigation interval was better than 15 days irrigation interval.

Water use and water productivity of watermelon

Total water use varied greatly across the treatments, from 182 mm with mulch (I_1) to 244 mm with non-mulch at 10 and 5 days irrigation intervals (Table 1a-b). The seasonal use of water by the highest yielding (29.9 t/ha) treatment was 204 mm which is within the range of 400-600 mm reported by Doorenboss and Kassam (1979) for watermelon cultivation. Water productivity was greater with 5 days irrigation intervals. Increasing irrigation frequency of watermelon may have opportunity to reduce the buildup in soil salinity during the late season, and maintained watermelon yield.

Table 1a. Water use, yield and water productivity of watermelon under different treatments in 2022.

Treatment*		Total irrigation water applied (mm)	Rainfall (mm)	SMC (mm)	TWU (mm)	Fruit yield, (t/ha)	Water productivity (kg/m^3)
Plastic mulch	I_1	201	7.8	-5	204	29.9	14.6
	I_2	189	7.8	-3	194	26.4	13.6
	I_3	176	7.8	-2	182	20.0	11.0
No mulch	I_1	232	7.8	4	244	28.9	11.8
	I_2	217	7.8	3	228	24.3	10.6
	I_3	203	7.8	2	213	15.9	7.5

Table 1b. Water use, yield and water productivity of watermelon under different treatments in 2023.

Treatment*		Total irrigation water applied (mm)	Rainfall (mm)	SMC (mm)	TWU (mm)	Fruit yield (t/ha)	Water productivity (kg/m^3)
Plastic mulch	I_1	99	88	-34	153	26.62	17
	I_2	84	88	-30	142	23.26	16
	I_3	66	88	-27	127	16.03	13
No mulch	I_1	125	88	-26	187	25.27	14
	I_2	104	88	-23	169	21.17	13
	I_3	79	88	-21	146	13.47	9

*Treatment mean values. Irrigation Interval: I_1: 5 days interval, I_2: 10 days interval, and I_3: 15 days interval. Cultivar of watermelon, Local Hybrid F1: Sweet dragon.

Conclusion

Increasing the irrigation frequency with mulch and non-mulch from three to ten had effect on the yield and water productivity of watermelon. The better fruit yield of watermelon was observed at 5 days irrigation interval with mulch, while the lower irrigation frequency with non-mulch produced the lowest yield.

Reference

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DEEP LEARNING EMULATORS FOR SALTWATER INTRUSION MANAGEMENT MODELLING IN COASTAL AQUIFERS

D. K. ROY, S. K. BISWAS AND B. DATTA

Abstract

Deep learning (DL) emulators were developed to replace the simulation model in a coupled simulation-optimization (S-O) approach to develop a saltwater intrusion management model, which provided optimal groundwater pumping to control saltwater intrusion. Among six DL emulators developed at 16 monitoring locations (ML), the Deep Feed Forward Neural Network (DFFNN) provided the superior performance at 13 MLs as indicated by the Shannon's Entropy based decision theory. The simple FFNN for DL was found to be the top-performing model at locations M3, M7, and M12. Consequently, the DFFNN and FFNN appeared to be the best candidate for the S-O approach to develop the management model. The experiment will be continued for the next year to externally link DFFNN and FFNN models with the optimization algorithms to develop the management model.

Introduction

Over-extraction of groundwater in coastal regions disrupts the natural equilibrium of fresh, brackish and saline water and consequently saline water starts intruding into the freshwater zones of coastal aquifers. Assessing the consequences of this anthropogenic activity needs to be evaluated and mitigated through developing an optimal groundwater extraction strategy. Optimal pumping from coastal aquifers can be obtained using a coupled simulation-optimization (S-O) approach, which provides multiple feasible solutions. To achieve computational efficiency in the S-O approach, simulation models are replaced with surrogate models. Previous studies employed either shallow learning algorithms or their ensembles to develop optimal pumping management model (Roy and Datta, 2020). Consequently, the present study aims to propose a deep learning based coupled S-O approach to prescribe optimal abstraction rates to control saltwater intrusion in the coastal aquifers.

Materials and Methods

An integrated simulation-optimization (S-O) approach (Dhar and Datta, 2009) was the core constituent of this research. The study applied this integrated S-O approach to develop optimal pumping management schemes for a real world coastal aquifer system. The basic components of the adopted S-O approach were: (1) a finite element based 3-D numerical simulation model, (2) properly trained and validated surrogate models (deep learning (DL) based emulators), and (3) an optimization algorithm to search the optimal groundwater extraction patterns from the aquifer. A calibrated and validated numerical simulation model's output (which was developed and presented in the report of 2021-2022) was used to train, validate, and test DL-based emulators. The DL algorithms proposed in this study were: (1) Simple Feed Forward Neural Network (FFNN) for DL, (2) Deep FFNN, (3) Long Short-Term Memory Network (LSTM), (4) Bi-directional LSTM, (5) Projected Layer LSTM (Pro-LSTM), and (6) Gated Recurrent Unit (GRU) Neural Network. The selection of the top-performing emulators at each monitoring location (ML) was performed using the Shannon's Entropy (SE) (Shannon, 1948) based decision theory. The selected best models at each ML will be externally linked to the Multiple Objective Genetic Algorithm (MOGA) and Multiple Objective Particle Swarm Optimization (MOPSO) to develop the management model. The outputs of the management models using CEMOGA and MOPSO will be the Pareto optimal fronts, which will be analyzed for their accurateness and global optimality.

Results and Discussion

The DFFNN and FFNN models produced higher values of Accuracy, R, and IOA as well as lower values of RMSE, MAE, and MAD. For instance, at ML15 (Table 1), the DFFNN provided Accuracy, R, and IOA values of 1.0. 0.998, and 0.999, respectively whereas the RMSE, MAE, and MAD values were 0.817 mg/L, 0.646 mg/L, and 0.330 mg/L, respectively. In general, this performance was better than that provided by the FFNN model. Recurrent Neural Network based DL models such as LSTM, Bi-LSTM, Pro-LSTM, and GRU appeared to be the worst performing models in predicting saltwater concentrations in coastal aquifers (Table 1). The similar trend was obtained at all the other MLs. Nevertheless, prediction models showed contradictory performance with respect to different evaluation indices. To address this prediction contradiction, SE value was computed using several performance evaluation indices to rank the models according to their prediction performance (Table 2). It is apparent from Table 2 that the DFFNN and FFNN secured the top two positions when findings from all the MLs (ML1-ML16) were considered. The Pro-LSTM was found to be the third best model at all MLs except at ML5 where it was the second best model. The fourth, fifth, and sixth positions were shared by the LSTM, Bi-LSTM, and GRU models. Results revealed that the DFFNN and FFNN were the best candidates for the S-O based management model.

Table 1. Performance of the DL-based models at monitoring location ML15. Boldface indicates the best values

Performance indices	DL-based models					
	Bi-LSTM	DFFNN	GRU	LSTM	Pro-LSTM	FFNN
Accuracy	0.998	**1.000**	0.999	0.999	0.999	1.000
R	0.496	**0.998**	0.403	0.444	0.946	**0.998**
IOA	0.618	**0.999**	0.475	0.566	0.932	0.998
RMSE, mg/L	12.062	**0.817**	11.840	11.117	5.736	0.982
MAE, mg/L	9.813	**0.646**	9.564	8.928	4.466	0.752
MAD, mg/L	4.680	**0.330**	4.704	4.531	2.098	0.372

Table 2. Performance ranking of the DL-based surrogate models using Shannon's Entropy

Models	Monitoring locations															
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16
Bi-LSTM	6	4	5	4	5	4	5	4	4	4	4	4	4	5	5	4
DFFNN	1	1	2	1	1	1	2	1	1	1	1	2	1	1	1	1
GRU	4	5	4	5	4	5	6	5	5	6	5	5	5	6	6	6
LSTM	5	6	6	6	6	6	4	6	6	5	6	6	6	4	4	5
Pro-LSTM	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
FFNN	2	2	1	2	3	2	1	2	2	2	2	1	2	2	2	2

Conclusion

DL-based emulators adequately captured the saltwater intrusion processes in coastal aquifers and the ranking of the models was DFFNN>FFNN>Pro-LSTM>Bi-LSTM>GRU>LSTM. The experiment will be continued for the next year where the top-performing models at each ML will be used in the S-O approach to develop the saltwater intrusion management model.

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INTERPRETABLE AND EXPLAINABLE MACHINE LEARNING ALGORITHMS FOR PREDICTING SALTWATER INTRUSION IN COASTAL AQUIFERS

D. K. ROY, S. K. BISWAS, M. A. HOSSAIN AND B. DATTA

Abstract

While some models are inherently interpretable, most of them are black-box in nature which cannot provide relative predictor importance in producing the output. Interpretable and explainable machine learning models were developed, for the first time, to predict saltwater intrusion in coastal aquifers. The Gaussian Process Regression (GPR) model outperformed the Artificial Neural Network (ANN) and Support Vector Regression (SVR) models at the monitoring locations ML2, ML4, and ML5. On the other hand, the ANN model outperformed the GPR and SVR models at the other monitoring locations (ML1 and ML3). Once evaluated, the interpretability of the developed models was assessed through Partial Dependence Plot (PDP), Local Interpretable Model-Agnostic Explanations (LIME), and Shapely plots. Results revealed that the proposed approaches can adequately provide the model-predictor relationships in producing the desired output.

Introduction

The emulators in a coupled simulation-optimization approach are based on machine learning (ML) algorithms, which are generally 'black-box' in nature. While prediction accuracies of these 'black-box' type ML-based algorithms are important, their interpretability and explainability remain unexplored especially in the saltwater intrusion prediction and management models. The hindrance towards using any ML-based model in real-world scenarios is the lack of transparency, explainability, interpretability, and trust, due to the black-box nature of the ML-based models (Chakraborty et al., 2021; Dikshit and Pradhan, 2021). To overcome this limitation, this study intends to explore the interpretability and explainability of the commonly used ML algorithms in saltwater intrusion prediction in coastal aquifers.

Materials and Methods

A previously published saltwater intrusion simulation model (Roy and Datta, 2017) was used to generate the input-output patterns to train three 'black-box' ML models. The input-output dataset was partitioned into two sets: 80% of the data was used for training the models whereas the remaining 20% was employed to test the developed models. The ML-based models developed were Artificial Neural Network (ANN), Gaussian Process regression (GPR), and Support Vector regression (SVR). The optimal parameters of these models were obtained through optimizing the tunable parameters using Bayesian optimization. The performance evaluation and comparison of the three proposed models were performed by observing the Root Mean Squared Error (RMSE) computed on the test dataset. Three basic methods of model interpretability were used to explain the contribution of individual predictors to the predictions of the trained ML-based 'black-box' models. These were: (1) Local Interpretable Model-Agnostic Explanations (LIME); (2) Partial Dependence (PDP) and Individual Conditional Expectation (ICE) Plots; and (3) Shapley Values. The explainable and interpretable ML-based model development and comparative analysis was performed using known understandings drawn from physical-based models (saltwater intrusion simulation model). Finally, the developed models were used as a computationally efficient substitute of the physically-based saltwater intrusion simulation model in the development of a robust saltwater intrusion management model using the concept of a coupled S-O approach.

Results and Discussion

Among the three ML-based models developed at the five monitoring locations (MLs), the GPR model was found to be the top-performing model at the monitoring locations ML2, ML4, and ML5 whereas the ANN model provided the better performance at the monitoring locations ML1 and ML3 (Table 1). The SVR model appeared to be worst performing model with respect to the computed RMSE values on the test dataset. Other performance evaluation indices will be computed in the next year to provide a through performance comparison of the developed models. Model interpretability with respect to Shapely and LIME plots for the ANN model developed at ML1 is graphically illustrated in Figure 1. The left figure shows the Shapely explanation with respect to the Query point and average prediction for the first observation. The Shapley values indicate how much each predictor deviates from the average prediction at the point of interest, indicated by the vertical line at zero. The second figure shows the LIME coefficient values for the first 20 important variables. LIME was used to approximate the complex ANN model in the neighborhood of the prediction of interest with a simple interpretable linear model. The linear model was then used as a surrogate to explain how the original (ANN) model works.

Conclusion

LIME and Shapely values provided the interpretability of the developed 'black-box' models. The study will be continued for the next year to provide in-depth and through understanding of the interpretability of the proposed models and to develop an ensemble-based saltwater intrusion management model.

Table 1. Model prediction errors on the test dataset

Monitoring locations	Prediction error: Root Mean Squared Error, mg/L		
	ANN	GPR	SVR
ML1	0.3442	0.6590	0.8094
ML2	24.1858	11.0007	24.9060
ML3	8.2089	8.9774	17.8457
ML4	15.7201	8.1075	16.4103
ML5	4.6926	3.3133	4.5210

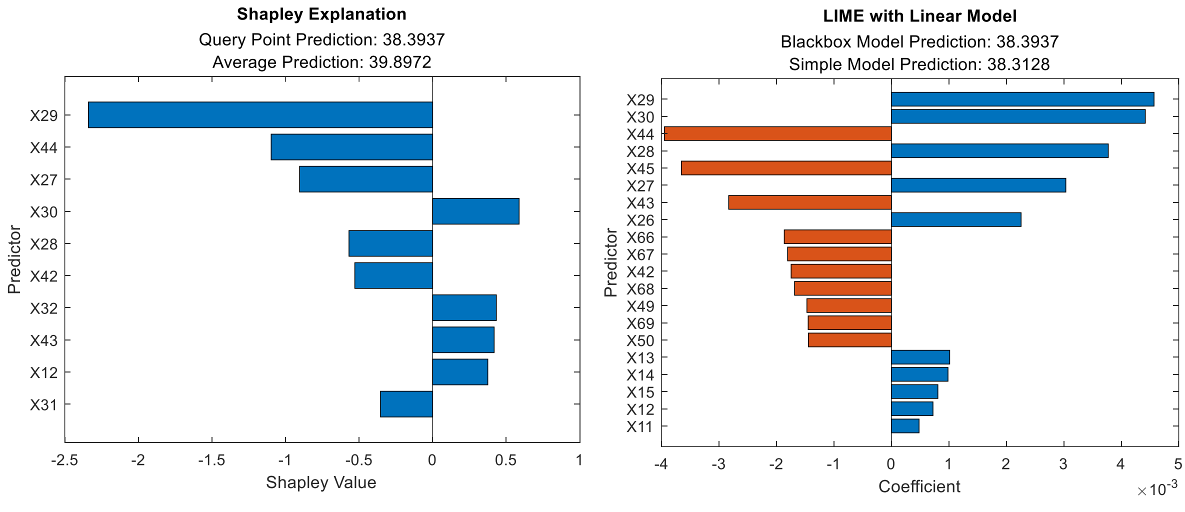

Figure 1. Shapely and LIME plots for the black box ANN model at the monitoring location ML1

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ACCURACY AND COMPUTATIONAL TIME OF GA AND PSO BASED MULTI-OBJECTIVE OPTIMIZATION ALGORITHMS FOR SALTWATER INTRUSION MANAGEMENT MODEL IN COASTAL AQUIFERS

D. K. ROY, S.K. BISWAS, B. DATTA

Abstract

A heterogeneous ensemble of several surrogate models (emulators) was created using the Dempster-Shafer theory (DST) of evidence based weighting scheme to develop a multi-objective saltwater intrusion management model. Results revealed the acceptable performance of the ensemble candidates consisting of 11 different machine learning algorithms developed at each of the five monitoring locations (ML). The first five top-performing models were selected using Shannon's Entropy, which incorporated a set of different performance evaluation indices. The performance sequence of the top five models at ML1, for instance, were ANFIS>ANN>GPR>FIS>PLR. The top five models thus obtained were integrated using the DST computed model weights. The performance of the DST ensemble was compared with the Random Forest (RF)-based ensemble approach. Results indicated the superior performance of the DST ensemble over the RF ensemble.

Introduction

The accuracy and robustness of any emulator based multi-objective saltwater intrusion management model depends largely on the accuracy of the emulators as well as the search capabilities of the optimization algorithm. Although accuracy of this approach has been investigated in recent studies with either a standalone (Lal and Datta, 2018) or a heterogeneous ensemble of few models (Roy and Datta, 2020), the robustness and computation time as well as stochastic nature of the multi-objective optimization algorithms have not yet been evaluated for saltwater intrusion management problems. To fill this research gap, the present study intends to i. determine the accuracy and robustness of multiple objective optimization algorithms in a coupled simulation-optimization framework; and ii. address the stochastic nature of multi-objective optimization algorithms in obtaining global optimal solutions.

Materials and Methods

To address prediction uncertainty of the surrogate models, a heterogeneous ensemble of commonly used machine learning (ML) algorithms was proposed in this effort to develop an efficient saltwater intrusion management model. A total of 11 ML-based models was developed from which the top-performing five models were selected using the Shannon's Entropy (SE) based decision theory. The Dempster-Shafer theory (DST) of evidence (Dempster, 2008) was employed to compute the weights of the standalone models to form the heterogeneous ensemble, the performance of which was compared with a Random Forest based ensemble approach using a number of statistical performance evaluation indices. Then, the ensemble model will be linked externally to two multi-objective optimization algorithms: Genetic Algorithm (GA) and Particle Swarm Optimization (PSO). The time required to obtain the global optimal solution using the ensemble assisted coupled S-O approach will be noted. The ensemble assisted coupled S-O will be run multiple times using GA and PSO separately but using similar optimization parameters at each optimization run. To address stochastic nature of the optimization algorithms, a weighted average of the individual solutions of each optimization algorithm will be generated to provide decision makers with the global optimal solutions. A post-Pareto analysis will be performed to assist decision makers to select the best alternatives from a set of several feasible alternatives in the Pareto optimal front.

Results and Discussion

The proposed ML-based saltwater intrusion prediction models provided higher accuracy as indicated by the computed statistical performance evaluation indices. The models produced higher values of R, NS, IOA, and KGE as well as lower values of NRMSE, MAE, MAD, and RSR (Table 1 for ML1). The models produced R, NS, IOA, and KGE values of >0.8 except for GMDH (NS = 0.741) and RT (R = 0.661, NS = 0.412, IOA = 0.785, KGE = 0.581). The results for the other four MLs followed the similar trend. The performance ranking using the SE revealed that ANFIS was the top-performing model for the first four MLs whereas GPR appeared to be the best-performer at ML5. The performance sequences of the top five models were ANFIS>ANN>GPR>FIS>PLR at ML1; ANFIS>GPR>MARS>PLR>ANN at ML2; ANFIS>GPR>MARS>SVR>FIS at ML3; ANFIS>GPR>MARS>PLR>FIS at ML4; and GPR>ANFIS>PLR>ANN>FIS at ML5. The top five models at each ML were selected for the ensemble formation using the DST-based weighting scheme. The results indicated the superior performance of the DST ensemble against the RF ensemble with all considered performance indices (Figure 1). The DST ensemble produced higher values of R, NS, IOA, and KGE (the higher the better) than the RF ensemble while the DST ensemble's NRMSE, MAE, MAD, and RSR (the lower the better) values were lower than those of the RF ensemble. The experiment will be continued for the next year.

Conclusion

The ML-based surrogate models are able to capture the true trends of the salinity concentrations. The DST ensemble outperformed the standalone models as well as the RF ensemble. As such, the DST ensemble can be considered as an ideal candidate for the S-O based saltwater intrusion management model.

Table 1. Performance of the individual prediction models at the monitoring location ML1

Indices	Performance of the prediction models										
	ANFIS	ANN	FIS	GMDH	GPR	M5Tree	MARS	PLR	RT	RVR	SVR
R	0.998	0.995	0.985	0.868	0.992	0.985	0.984	0.985	0.661	0.978	0.985
NS	0.995	0.990	0.970	0.741	0.984	0.958	0.965	0.970	0.412	0.950	0.969
IOA	0.999	0.998	0.992	0.921	0.996	0.989	0.991	0.992	0.785	0.987	0.992
KGE	0.985	0.990	0.979	0.802	0.988	0.976	0.982	0.978	0.581	0.957	0.970
NRMSE, %	0.793	1.159	1.993	5.895	1.466	2.387	2.162	1.994	8.884	2.581	2.023
MAE, mg/L	0.248	0.362	0.554	1.854	0.413	0.675	0.601	0.553	2.846	0.776	0.540
MAD, mg/L	0.122	0.166	0.259	0.827	0.187	0.294	0.258	0.259	1.321	0.351	0.265
RSR	0.068	0.100	0.172	0.508	0.126	0.206	0.186	0.172	0.766	0.222	0.174

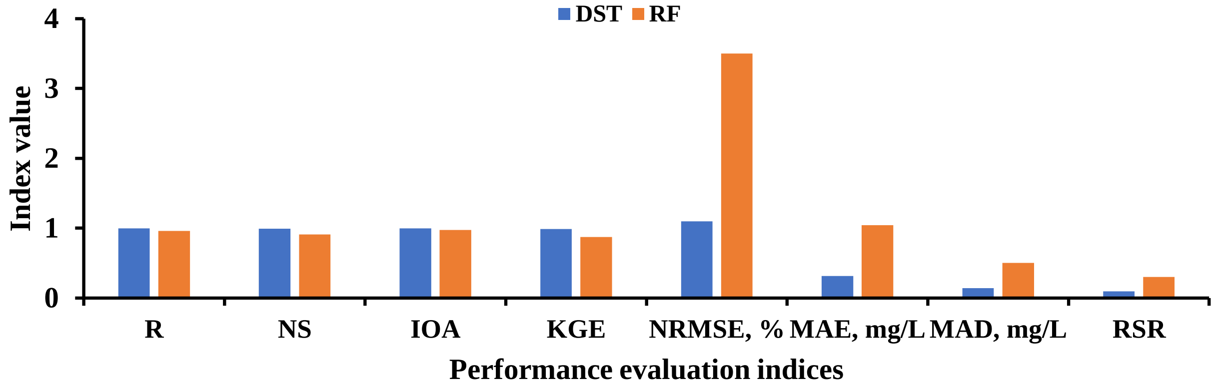

Figure 1. Performance comparison of the DST and RF based ensemble approaches at ML1

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ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION AND DRINKING PURPOSES IN SOME SELECTED BARI RESEARCH STATION

S. K. BISWAS, D. K. ROY AND M.A. HOSSAIN

Abstract

The present investigation is aimed at understanding the temporal and spatial variability of groundwater quality for its use in irrigation and drinking purposes in different regional station of BARI. Water quality indices, namely sodium adsorption ratio (SAR), exchangeable or soluble sodium percent (SSP or %Na), residual sodium carbonate (RSC) and Kelly's ratio (KR) were calculated for STWs, DTWs and HTWs that used for irrigation and domestic uses. Besides, the composite influence of different water quality parameters on the overall quality of water was also assessed using water quality index (WQI). According to the WQI values, all the samples were found to be "excellent" except few were found "good" in post-irrigation season. Thus, the majority of the area is occupied by good water in both pre- and post-irrigation season.

Introduction

Assessment of groundwater quality is essential to identify its suitability for various purposes such as domestic, irrigation and industrial uses. Groundwater quality in an area is influenced mainly by two processes like rock/soil-water interaction during recharge and groundwater flow, and time when it is supplied through improper canals for irrigation and drinking purposes. Temporal changes in the constitution and origin of the water recharged, and human factor, frequently cause periodic changes in groundwater quality. Poor quality water affects human health and damages the crop yield in several ways. Therefore, it is necessary to perform a regular assessment to check its suitability prior to its use in any purposes. In view of this, this study is proposed to analyze the groundwater quality of some research stations of BARI to determine the physico-chemical parameters with special emphasis on its irrigation and drinking suitability.

Materials and Methods

In this investigation, groundwater samples of HTWs, STWs and DTWs were collected during the pre-irrigation season (November – December) and the post-irrigation (April – May) season. Each of the groundwater samples was analyzed for various physicochemical parameters such as pH; electrical conductivity at 25^0C; total dissolved solids (TDS); major cations—sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}); major anions—bicarbonate (HCO_3^-), chloride (Cl^-), nitrate (NO_3^-) and sulphate (SO_4^{2+}); components such as iron (Fe), manganese (Mn), arsenic (As) and zinc (Zn). Groundwater suitability for irrigation and drinking purposes were assessed using SAR (Sodium Adsorption Ratio), RSC (Residual Sodium carbonate), SSP (Soluble Sodium percentage) and KR (Kelly's ratio). Besides, to get a comprehensive picture of overall quality of groundwater, the water quality index (WQI) was determined. The computed WQI values are classified into five categories: excellent water (WQI < 50); good water (WQI = 50–100); poor water (WQI = 100–200); very poor water (WQI = 200–300); and water unsuitable for irrigation (WQI > 300).

Results and Discussion

Suitability of groundwater for irrigation and drinking purposes

Groundwater of the study areas were classified into different categories by using different quality indices such as SAR, SRC, SSP, KR and WQI (Table 1). As per SAR values, all samples collected from DTWs, STWs and HTWs were fall in excellent category both in pre-irrigation and post-irrigation seasons as SAR values determined as <10. As per RSC values of all samples except one STW of Rajshahi fall into permissible category in both pre- and post-irrigation seasons. One sample from HTW of Ishurdi and another from DTW of Bogura were found permissible for irrigation as SRC value was greater than 2.5. But all other samples of DTWs, STWs and HTWs were found suitable for irrigation purpose in both pre- and post-irrigation season. In respect of sodium hazards (SSP), all water samples were fall under excellent category. Irrespective of DTW, STW or HTW, KR values of all groundwater samples were less than 1.0 indicate low Na+ ion in water; hence it was suitable for irrigation (Ehya and Saeedi, 2018). The estimation of water quality index (WQI) of all samples collected in pre- and post-irrigation seasons showed that almost all HTWs, STWs and DTWs water was excellent, except water samples of Rajshahi which was found good for irrigation. None of the samples were exceed the allowable limit for drinking purposes (WHO, 1997; DoE, 1989).

Table 1. Water quality indices for suitability assessment of different water sources for irrigation

Location	Source	Pre-irrigation				Post-irrigation			
		SAR	RSC	SSP	KR	SAR	RSC	SSP	KR
Bogura	DTW	0.27	2.02	13.68	0.164	0.28	2.13	14.13	0.170
	STW	0.23	1.41	10.39	0.118	0.23	1.75	10.65	0.122
	HTW	0.25	1.96	11.54	0.133	0.25	1.95	11.20	0.129
Ishurdi	DTW-1	0.28	1.99	14.02	0.166	0.31	2.26	15.98	0.195
	DTW-2	0.26	1.46	11.57	0.133	0.33	2.28	16.77	0.206
	HTW	0.27	2.49	13.41	0.158	0.28	2.64	13.81	0.163
Rajshahi	DTW	0.38	2.42	16.15	0.195	0.41	2.56	16.86	0.205
	STW	0.37	2.74	16.09	0.194	0.40	2.78	17.06	0.208
Jashore	DTW	0.26	2.43	10.53	0.119	0.26	2.44	10.14	0.114
	STW	0.27	2.01	14.06	0.166	0.27	1.51	13.50	0.159
Range		0.23-0.38	1.41-2.74	11.77-15.20	0.139-0.230	1.22-1.48	1.51-2.78	10.14-17.06	0.114-0.208
Average		0.28	2.09	13.14	0.15	0.30	2.23	14.01	0.17

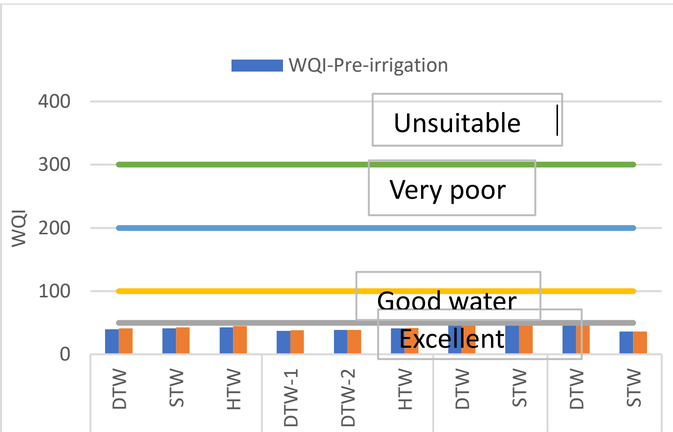

Figure 1. Water quality index (WQI) of groundwater at different location of the study area (solid line represents the range of different categories of water quality)

Table 2: Comparision of the groundwater samples with WHO (1997) and DoE (1989) for drinking water purposes

Parameter	WHO (1997)	(DoE, 1989)	Average
pH	6.5-8.5	6.5-8.5	7.34
EC	400	-	383.0
TDS	500-1000	500-1500	255.0
Na	200	200	5.67
K	12	12	1.18
Ca	75-200	75-200	31.60
Mg	50-150	30-50	1.32
Cl	250	150-600	1.69
SO_4	250	400	7.41
NO_3	50	10	0.74
HCO_3	125-350	-	227.0
Fe	0.3	0.3-1.0	0.16
Zn	0.01-3.0	1.0	0.011

Conclusions

In respect of all evaluating criteria, groundwater of the study area was found suitable and can safely be used for both irrigation and drinking purposes.

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PROJECT: CONSERVATION OF GROUNDWATER AND RAISING ITS USE EFFICIENCY AND PRODUCTIVITY IN IRRIGATED AGRICULTURE IN BANGLADESH

S.K. BISWAS, G.W. SARKER, M. ASADUZZAMAN

Abstract

Baseline survey of 2500 farm households in BADC, BMDA and privately owned DTWs and STWs irrigation schemes was conducted electronically using TAB to collect information on various aspects of irrigation water use in Boro rice production, such as AWD technology, water user associations, use of smart cards, irrigation water distribution system, production cost of Boro rice, irrigation cost, irrigation water pricing method, etc. Data analysis shows that about 30% farmers have educated experience/guess on AWD technology and they follow the AWD technique without using the plastic pipe. In irrigation schemes of BMDA and BADC, the buried pipe covers only 60-80% as compared to the requirement. Earthen canals are mainly used for privately owned DTWs and STWs to distribute irrigation water. About 53% farmers of BMDA DTWs scheme have their own smart card while in BADC schemes it is totally absent. Irrigation costs are the lowest for volumetric pricing with own controlled smart card. However, in BADC and BMDA areas, irrigation charges are determined mainly on volume basis. In private DTWs and STWs, irrigation charges are almost entirely based on land area. Water user association (WUA) exists only 23.1% in BADC DTW schemes, 31.4% in BMDA irrigation schemes, 28.5% in privately owned DTW irrigation schemes and only 0.6% in STW irrigation schemes. Total production costs and cost patterns are broadly similar across management group. Labor costs account for 45-50%, fertilizer and manures and irrigation account for similar levels and proportion of costs, broadly 12-14%.

Introduction

The Government of Bangladesh, after consulting with relevant stakeholders within the government, private sector and civil society, and supported by the 2030 Water Resources Group, World Bank, established the Bangladesh Water Multi-Stakeholder Partnership (BWMSP) with the objective of contributing to addressing challenges in the Water Sector. The EPI (Economic Policy Incentive) study made the five recommendations (volumetric water pricing, AWD, buried pipe, smart card, WUA) for a transition from a low-productivity, low-efficient and wasteful use of irrigation water to one with higher productivity, higher efficiency and less wasteful system. With this view in mind, the present study has been carried out to examine how far their combinations support the hypothesis of a change from a low productivity, low efficiency and wasteful water use to a better one.

Methodology

This project is being implemented collectively by BARI, DAE, BADC and BMDA under MoA. The main task of the project is to conduct baseline survey, mid-term monitoring and end line survey in different irrigation schemes of Bangladesh. Thus, a socio-economic, institutional and technical survey has been conducted to understand the effectiveness of the five elements of a proposed necessary interventions as indicated above for ground water conservation, raising water use efficiency and water productivity in BADC and BMDA deep tube well (DTW) areas particularly for dry period Boro rice production which is the main user of irrigation water. Additionally, information was too collected for shallow tube well (STW) and private deep tube well (DTW) water markets for possible future intervention for attaining the objectives. Multi-stage sampling method has been used for data collection for the study. At first, 23 upazilas of 15 districts have been selected from 7 divisions using Stratified Random Sampling method. In the second phase, the BMDA and BADC DTW areas were selected purposively to reflect the various combinations of facilities and technology. In these areas, farmers were chosen at random. For STW and private DTWs, the areas as well as farmers were chosen based on ready availability. A total of 2500 respondents were interviewed through electronic device (TAB).

Results and Discussion

Farmers numbering 2,500 under different irrigation management systems, viz., BMDA and BADC DTWs, private DTWs and STWs have been surveyed. Most survey farms were in Rajshahi Division because BMDA farms were confined only to that division. In case of pricing system, it has been found that while volumetric pricing with own smart cards, although practiced most in BMDA DTWs, manager controlled smart cards for volumetric and more by area is the preferred method. For STW and private DTW, it is pricing by area served, interestingly, in case of 13% of farmers pricing by area is the stated preferred method in BMDA DTW area.

For volumetric pricing with own smart cards, 3 types of advantaged have cited by BMDA farmers. These are lower water use without any reduction in yield, lower cost and control by farmers over the application of water. For manager controlled smart cards, for both BMDA and BADC, the overriding concern is saving of hassles be it on the field, topping up of cards or other technical issues.

Pricing of water by area is the norm in case of all privately-owned irrigation particularly STWs but we find this practice also in case of BMDA and BADC and more so for the latter. As farmers opine, the great advantage, not unsurprisingly, is the simplicity of the method. Particularly saving the hassle of regular field visits as well as simple payment system are what attract farmers most. However, farmers are also concerned about high costs incurred in case of pricing by area. On the other hand, they are also concerned about lack of control over supply of water, particularly its timeliness.

Given the above, while scientists had been prescribing AWD as the method that takes care of farmers' and national concerns, so far among the sample farmers, very few (<1%) practice this method. But many farmers (>30%) have educated experience/guess on this technology and they follow the AWD technique without using the plastic pipe.

Water quality problems mostly relate to existence of iron in water. Arsenic issue has been raised by very few. Prevention of percolation and evaporation of water supplied to the field by using buried pipes with or without earthen canals are practiced in BMDA and BADC areas. But earthen canals are also substantially the only method in BADC cases and also in case of private DTWs and STWs. Water user associations do exist in up to 30% cases in BADC, BMDA and private DTW areas but are practically absent in case of STWs.

Total production costs are broadly similar across irrigation management groups and so are the distributions of costs. Labor costs in transplanting, weeding, harvesting and related activities account for 45-50% of costs. Fertilizer and manures and irrigation account for similar levels and proportion of costs, broadly 12-14%. However, there are finer differences. Particularly BMDA farmers report lower irrigation costs per unit of land and for own land particularly. For shared or rented in land, the irrigation costs are somewhat lower across all farmers.

When analyzed by pricing mechanism, irrigation costs are the lowest for volumetric pricing with manager controlled smart card. As we have found there are a lot of hassles for keeping and operating own smart cards and despite several advantages. This issue needs to be investigated more thoroughly as to how these hassles may be reduced or eliminated so that farmers have direct control over their water use without hassles.

Conclusions

Farmers are aware of the disadvantages of traditional method of flooded rice but they do not use water saving methods like AWD. While smart cards are helpful, they also want simpler methods of payment and less hassles regarding field checking of water. On the other hand, they are aware of advantages of WUAs but this is not in existence in most cases. The preference for area-based pricing is basically for its lower hassles although farmers are also aware that this is costlier. This issue needs to be investigated more thoroughly as to how these hassles may be reduced or eliminated so that farmers have direct control over their water use without hassles. At the same time own smart cards must continue and be made simpler in terms of topping up which can be decided based on consultation with farmers, again an issue which needs collective action through WUAs.

PROJECT (SACP-IWM PART):

DISSEMINATION OF WATER SAVING IRRIGATION TECHNOLOGIES FOR NON-RICE CROPS IN SALINE PRONE AREAS OF BANGLADESH

In this project, field demonstrations were conducted with different water saving irrigation technologies to evaluate their performance for growing high value crops. The major aim of the project is to motivate farmers to adopt these technologies to cope with water scarce situation prevailing in the coastal areas of Bangladesh. Location wise demonstrations and details of crop/variety during 2022-2023 growing season are presented in the following table.

Location wise demonstrations and crop/variety details during 2022-2023 growing season

Sl. No.	Technology	Crop	Farmers' name	Farmers' address (Vill., Union, Dist.)	Mobile No.	Area covered
01	Solar powered drip irrigation	Watermelon (cv. Big family)	Md. Al Amin	Fasipara, Kuakata, Patuakhali	01774938831	33 decimals
02	Do	Watermelon (cv. Big family)	Md. Abdul Huq	Tulatoli, Kuakata, Patuakhali	01725965976	33 decimals
03	Alternate furrow irrigation (AFI)	Sunflower (BARI Surjomukhi-2)	Md. Kabir Hossain	Fasipara, Kuakata, Patuakhali	01754312388	50 decimals
04	Solar powered drip irrigation	BARI Bt-brinjal- 2	Md. Rasel Molla	Ghotkhali, Amtali, Barguna	01761597247	20 decimals
05	Do	Watermelon (cv. Big family)	Md Jahurul Haque	East Nuru Patuary Hat, Char Oabda, Noakhali Sadar	01641105295	50 Decimals

In this project, the solar-powered drip irrigation system developed by the IWM division was used to irrigate different crops at various locations in the salt affected areas of Bangladesh. Although the installation cost of the system was a little higher, the cost was less than an LLP installation cost. Farmers can use this portable solar panel for multiple purposes including household use, electricity storage in batteries to use electric bulbd and fans, and irrigating vegetables grown in the yards. The specification and cost of the solar irrigation system (excluding tanks, main and lateral lines, and drippers) are as follows: a 300 watts solar panel will cost Tk. 12000, a 180 watts DC pump would cost around Tk.7000, and the accessories would cost around Tk. 1000. Therefore, the total cost of the solar panel system will be Tk. 20000.

Figure: Watermelon cultivation using solar-powered drip irrigation system (Kuakata, Patuakhali)

DISSEMINATION OF SOLAR-POWERED DRIP IRRIGATION SYSTEM FOR WATERMELON CULTIVATION IN SALINE PRONE AREAS OF BANGLADESH (KUAKATA AND NOAKHALI)

S. K. BISWAS, D. K. ROY, M. A. HOSSAIN, K. F. I. MURAD AND M. P. HAQUE

Abstract

Traditionally farmers irrigate watermelon by carrying water in a container from a small pond which is laborious work and labor-intensive. Therefore, field demonstrations were conducted with solar-powered drip irrigation system to mitigate the laborious work of water application, save water and energy for irrigation. There were two treatments with four replications: solar-powered drip irrigation system (T_1) and farmer's practice as a control treatment (T_2). The demonstrations were conducted from 2019-20 to 2022-23 growing seasons. The results revealed that treatment T_1 was highly responsive to yield and more profitable than T_2. The solar powered drip irrigation treatments provided the highest BCR for the consecutive growing seasons. The farmers were benefited and interested in using this promising water and energy saving irrigation technology.

Introduction

Soil as well as water salinity is a major problem in the coastal region during the dry period. Farmers grow T. Aman during July-December and the lands remain fallow due to salinity development and scarcity of water during other periods of the year. To minimize water application losses and increase water use efficiencies in the saline areas of Bangladesh, BARI developed modern irrigation technologies that are suitable for non-rice crops should be disseminated in the farmer's field. The promising water management technologies are: (i) drip fertigation that is recommended for high value vegetable and fruit crops, and (ii) alternate furrow irrigation suitable for both field crops and vegetables planted in rows. Consequently, the present study aims to disseminate drip fertigation technology to cultivate watermelon in the Kuakata and Noakhali districts in Bangladesh.

Materials and Method

The field demonstrations were conducted at Patuakhali, Borguna, Bhola, Noakhali, and Khulna regions. In Patuakhali district, there were three drip irrigation demonstrations in 2019-2020 whereas 3 drip irrigation demonstrations were carried out in 2020-2021. There were two drip irrigation demonstrations conducted in 2021-2022. At Borguna district there were one drip irrigation experiment in 2019-2020, 2020-2021, and 2021-2022 growing seasons. Although two drip irrigation demonstrations were conducted in the Khulna district during 2019-2020, there were no drip irrigation demonstrations in the Khulna district in 2020-2021. In Bhola district, 3 solar-powered drip irrigation demonstrations were conducted during both the 2020-2021 and 2021-2022 growing seasons. One solar-powered drip irrigation demonstration was also conducted in Noakhali district during 2020-2021, 2021-2022 and 2022-2023 growing seasons. In addition, 6 solar powered irrigation pumps and 6 solar panels were provided to 30 farmers of the Kaliganj upazila, Satkhira district to facilitate irrigation in the Gher boundaries, and during 2021-2022, and 2022-2023 six sets of drip irrigation systems were provided to Kaliganj upazila, Satkhira to facilitate the irrigation in Gher boundaries. During 2022-2023, three demonstrations of watermelon using solar-powered drip irrigation system were conducted (one in Noakhali district and two were in Kuakata). There were two irrigation treatments with four replications in the demonstrations: (i) irrigation with solar-powered drip system (T_1), and (ii) Farmer's practice (T_2) as control treatment.

Results and Discussion

The findings obtained from the demonstrations for 2019-2020, 2020-2021, 2021-2022, and 2022-2023 growing seasons are presented in Tables 1 and 2. Table 1 presents the yield and yield attributing characters while the profitability of the demonstrations is shown in Table 2. The vine length, number of fruits per plant, individual fruit weight, and yield were found comparatively high at treatment T_1. Drip irrigation performed better than conventional irrigation in all demonstrations in the farmer's fields. The vine length and yield of watermelon were found statistically significant at a 5% level of significance between the treatments. Also, the water productivity of the treatment T_1 was higher than that obtained from treatment T_2. The BCR of the drip irrigated treatments was also found higher than the conventional irrigation method.

Table1.Yield and yield components of Watermelon from 2019-20 to 2022-23

Treatment	Vine Length (cm)	Number of Fruits/ Plant	Individual Fruit Weight (kg)	Yield (t/ha)	Water productivity (kg/m^3)
Year: 2019-2020					
T_1	292.47	1.83	6.18	35.51	6.79
T_2	280.17	1.40	5.41	29.91	4.41
F	12.01	0.95	59.20	115.0	
Prob.>F	0.08	0.53	0.15	0.01	
Year: 2020-2021					
T_1	287.33	1.96	6.23	36.63	6.11
T_2	281.67	1.64	5.89	28.98	4.02
F	4.66	21.53	1.71	346.1	
Prob.>F	0.097	0.0097	0.2616	0.00049	
Year: 2021-2022					
T_1	281.67	1.85	5.12	32.53	5.61
T_2	263.85	1.77	4.00	22.59	3.40
F	14.76	0.83	57.93	124.8	
Prob.>F	0.0184	0.4131	0.0016	0.0004	
Year: 2022-2023					
T_1	295.52	1.95	6.25	36.12	5.95
T_2	270.05	1.35	5.75	28.35	4.58
F	15.02	1.09	58.13	113	
Prob.>F	0.02	0.63	0.09	0.005	

Table 2. Benefit-Cost Ratio (BCR) of Watermelon from 2019-20 to 2022-23

Treatment	Land preparation (tk/ha)	Seed (tk/ha)	Fertilizer (tk/ha)	Pesticide (tk/ha)	Irrigation (tk/ha)	Labor (tk/ha)	Total Cost (tk/ha)	Total return (tk/ha)	BCR
2019-2020									
T_1	11250	16875	32400	30000	14600	75000	180125	400000	2.22
T_2	11250	16875	32400	30000	28000	95000	213525	311300	1.46
2020-2021									
T_1	11475	17213	33048	30600	14892	76500	183728	412000	2.24
T_2	11475	17213	33048	30600	28560	96900	217796	320639	1.47
2021-2022									
T_1	11878	17213	33048	30600	15892	78500	187131	381743	2.04
T_2	11878	17213	33048	30600	28960	97900	219599	268194	1.22
2022-2023									
T_1	12370	17213	33048	30600	16390	79000	188621	429283	2.28
T_2	12370	17213	33048	30600	29460	97900	220591	378897	1.72

Conclusion

Solar power drip irrigation system was found more water productive and profitable than farmers' practice. The findings not only provide a valuable insight regarding crop production under water scarcity but also motivate the farmers of the project site in using water saving irrigation technologies to achieve higher yields.

DISSEMINATION OF SOLAR-POWERED ALTERNATE FURROW IRRIGATION METHOD FOR SUNFLOWER CULTIVATION IN SALINE PRONE AREAS OF BANGLADESH (KUAKATA)

S. K. BISWAS, D. K. ROY, M. A. HOSSAIN, K. F. I. MURAD AND M. P. HAQUE

Abstract

Farmers usually apply irrigation water with flooding and furrow methods in sunflower production requiring more water which is a rearly attainable goal in the saline prone areas of Bangladesh . Therefore, to motivate farmers to use water saving irrigation technologies, a demonstration of solar-powered Alternate Furrow Irrigation (AFI) was carried out with BARI Surjomukhi-2 in the Kuakata district of the southern Bangldesh during 2019-20 to 2022-23 growing seasons. Two treatments were selected: (i) alternative furrow irrigation (T_1) and (ii) farmer's practice (T_2). Results revealed the superiority of treatment T_1 than treatment T_2 in terms of profitability and water saving. AFI treatments provided the highest BCR for the consecutive growing seasons. The farmers were benefited and interested in using this promising water and energy saving irrigation technology.

Introduction

Soil as well as water salinity is a major problem in the coastal region during the dry period. Farmers grow T. Aman during July-December and the lands remain fallow due to salinity development and scarcity of water during other periods of the year. To minimize water application losses and increase water use efficiencies in the saline areas of Bangladesh, BARI developed modern irrigation technologies that are suitable for non-rice crops should be disseminated in the farmer's field. The promising water management technologies are: (i) drip fertigation that is recommended for high value vegetable and fruit crops, and (ii) alternate furrow irrigation suitable for both field crops and vegetables planted in rows. Consequently, the present study aims to disseminate drip fertigation technology to cultivate watermelon in the Kuakata and Noakhali districts in Bangladesh.

Materials and Method

Field demonstrations were conducted at Kalapara and Fasipara, Patuakhali regions. In Kalapara, Patuakhali district, there was one Alternate Furrow Irrigation (AFI) demonstration in 2019-2020 whereas 3 AFI demonstrations were conducted during 2020-2021, 2021-22, and 2022-23 growing seasons, respectively at Fasipara, Patuakhali. There were two irrigation treatments with four replications in the demonstrations: (i) irrigation with solar-powered AFI (T_1), and (ii) Farmer's practice (T_2) as control treatment. BARI Surjonikhi-2 was used for the demonstration of the AFI method. BARI recommended fertilizers were applied for the development of the sunflower crop. Insects and pests were controlled by using BARI recommended insecticides and pesticides.

Results and Discussion

Table 1 shows the yield and yield components of sunflower (BARI Surjomukhi – 2) from 2019-20 to 2022-23 growing seasons. The plant population, plant height, head diameter, number of seeds per head, 1000 seed weight, and yield were found comparatively higher in treatment T_1 than treatment T_2. The AFI technique performed better than conventional irrigation methods at both locations and for all demonstrations during 2019-20 to 2022-23 growing seasons. The head diameter, number of seed per head, 1000 seed weight, and yield were statistically significant at the 5% level of significance. Significantly higher yield was obtained from treatment T_1 (1.89 t/ha) than treatment T_2 (1.69 t/ha) during 2022-23 growing season. Table 2 showed that the BCR of sunflower production using AFI was more profitable (BCR>1) than the farmer's practice. For instance, during 2022-23 growing season, the BCR of treatment T_1 (1.023) was slightly higher than that of treatment T_2 (0.835). The demonstration will be continued for the 2023-24 growing season.

Conclusion

Solar powered AFI method was found more water productive and profitable than farmers' practice. The farmers were benefited and interested in using this promising water and energy saving irrigation technology. Therefore, we need to disseminate AFI method covering a range of locations within the salt affected southern parts of Bangladesh.

Table 1. Yield and yield components of sunflower from 2019 to 2023

Treatment	Plant Population/m^2	Plant Height (cm)	Head Diameter (cm)	Number of Seed/ Head	1000 Seed Weight (gm)	Yield (t/ha)
2019-2020						
T_1	7.00	143.57	59.47	464.67	88.00	1.99
T_2	6.67	139.90	50.35	420.00	77.67	1.73
F	3.50	235.01	155.20	2.21	115.01	3.9
Prob.>F	0.15	0.009	0.005	0.0002	0.0003	1.1
2020-2021						
T_1	6.85	145.61	60.12	471.24	89.56	2.31
T_2	6.38	139.85	53.98	455.32	81.02	2.12
F	3.44	230.6	153.01	229.85	114.24	3.09
Prob.>F	0.1374	0.0001	0.0002	0.0001	0.0004	0.1536
2021-2022						
T_1	6.80	144.16	60.21	471.42	89.65	2.11
T_2	6.31	138.15	53.89	455.23	81.02	2.02
F	3.44	230.6	153.01	229.85	114.24	3.09
Prob.>F	0.1374	0.0001	0.0002	0.0001	0.0004	0.1536
2022-2023						
T_1	7.00	142.11	60.01	463.88	89.02	1.89
T_2	6.67	140.05	51.15	417.00	75.70	1.65
F	2.51	225.01	154.01	225.02	115.09	4.23
Prob.>F	0.15	0.0025	0.009	0.0002	0.0005	1.20

Table 2. Benefit-Cost Ratio (BCR) of Sunflower from 2019 to 2020

Treatment	Land preparation (tk/ha)	Seed (tk/ha)	Fertilizer (tk/ha)	Pesticide (tk/ha)	Irrigation (tk/ha)	Labor (tk/ha)	Total Cost (tk/ha)	Total return (tk/ha)	BCR
2019-2020									
T_1	9375	3000	23400	0	24000	18800	78575	99500	1.27
T_2	9375	3000	23400	0	28000	20000	83775	86500	1.03
2020-2021									
T_1	9563	3060	23868	2040	24480	19176	82187	102485	1.25
T_2	9563	3060	23868	2040	28560	20400	87491	89095	1.02
2021-2022									
T_1	9658	3060	23868	2040	25480	20176	84282	93611	1.11
T_2	9658	3060	23868	2040	29560	21400	89586	84892	0.95
2022-2023									
T_1	9760	3060	23868	2040	24480	19176	82384	84294	1.023
T_2	9760	3060	23868	2040	28560	20400	87688	73203	0.835

DISSEMINATION OF SOLAR-POWERED DRIP IRRIGATION SYSTEM FOR BRINJAL CULTIVATION IN SALINE PRONE AREAS OF BANGLADESH (Amtali, Barguna)

S. K. BISWAS, D. K. ROY, M. A. HOSSAIN, K. F. I. MURAD AND M. P. HAQUE

Abstract

Abstract

Farmers irrigate brinjal fields mostly with furrow irrigation methods, which need more irrigation water. Therefore, field demonstrations were performed with a solar-powered drip irrigation system to minimize water loss and save energy. The demonstrations were conducted during 2020-21 to 2022-23 growing seasons in the southern region of Bangladesh. There were two irrigation treatments with four replications: (i) solar-powered drip irrigation system (T_1) and (ii) farmer's practice (T_2) as a control treatment. The results revealed that treatment T_1 was highly responsive to yield and more profitable than T_2. The solar powered drip irrigation treatments provided the highest BCR (~2.0) for the consecutive growing seasons. The farmers were benefited and interested in using this promising water and energy saving irrigation technology.

Introduction

Soil as well as water salinity is a major problem in the coastal region during the dry period. Farmers grow T. Aman during July-December and the lands remain fallow due to salinity development and scarcity of water during other periods of the year. To minimize water application losses and increase water use efficiencies in the saline areas of Bangladesh, BARI developed modern irrigation technologies that are suitable for non-rice crops should be disseminated in the farmer's field. The promising water management technologies are: (i) drip fertigation that is recommended for high value vegetable and fruit crops, and (ii) alternate furrow irrigation suitable for both field crops and vegetables planted in rows. Consequently, the present study aims to disseminate drip fertigation technology to cultivate watermelon in the Kuakata and Noakhali districts in Bangladesh.

Materials and Method

Field demonstrations were conducted using brinjal (bt-Brinjal-2) at Ghotkhali, Amtali, Barguna during 2020-2021, 2021-22, and 2022-23 growing seasons. There were two irrigation treatments with four replications in the demonstrations: (i) irrigation with solar-powered drip system (T_1), and (ii) Farmer's practice (T_2) as control treatment. BARI recommended fertilizers were applied for the development of the brinjal crop. Insects and pests were controlled by using BARI recommended insecticides and pesticides.

Table 1. Yield and yield components of Bt-brinjal during 2020-21 to 2022-23

Treatments	Length of fruit, cm	Diameter of fruit, cm	Unit weight of fruit, g	Yield, t/ha
2020-2021				
T_1	7.53	6.52	435	30.64
T_2	6.98	6.19	412	27.37
F	41.63	5.32	10.73	84.85
Prob.>F	0.003	0.0823	0.0306	0.0008
2021-2022				
T_1	8.09	7.02	452	31.46
T_2	7.02	6.05	427	29.07
F	116.11	15.87	12.98	52.84
Prob.>F	0.001	0.0163	0.0227	0.0023
2022-2023				
T_1	8.59	7.12	450	31.64
T_2	7.12	6.35	425	29.37

F	116.11	15.87	12.98	52.84
Prob.>F	0.001	0.0163	0.0227	0.0023

Results and Discussion

The findings obtained from the demonstrations for 2020-2021, 2021-2022, and 2022-2023 growing seasons are presented in Tables 1 and 2. Table 1 presents the yield and yield attributing characters while the profitability of the demonstrations is shown in Table 2. The length of fruit, diameter of fruit, unit weight of fruit, and yield were found comparatively high at treatment T_1 than treatment T_2. Drip irrigation performed better than conventional irrigation in all demonstrations at the farmer's fields. The yield and yield attributing characters were found statistically significant at a 5% level of significance between the treatments. Also, the water productivity of the treatment T_1 was higher than that obtained from treatment T_2. The BCR of the drip irrigated treatments was also found higher than the conventional irrigation method.

Table 2. Benefit-Cost Ratio (BCR) of Bt-brinjal during 2020-21 to 2022-23

Treatment	Land preparation (tk/ha)	Seed (tk/ha)	Fertilizer (tk/ha)	Pesticide (tk/ha)	Irrigation (tk/ha)	Labor (tk/ha)	Total Cost (tk/ha)	Total return (tk/ha)	BCR
2020-2021									
T_1	10455	2550	17228	5610	17850	54876	108569	309165	2.85
T_2	10455	2550	17228	5610	25296	66096	127235	264823	2.08
2021-2022									
T_1	10955	2550	17228	5610	18750	55825	110918	302520	2.73
T_2	10955	2550	17228	5610	26225	68090	130658	253101	1.94
2022-2023									
T_1	10000	2550	17228	5610	17850	54876	108114	304250	2.81
T_2	10000	2550	17228	5610	25296	66096	126780	282422	2.23

Conclusion

Solar powered drip irrigation system was found more water productive and profitable than farmers' practice. It provided the highest yield and BCR for the brinjal crop cultivated during the consecutive three growing seasons. The findings provided a valuable insight regarding crop production under water scarcity and motivate farmer's of the project area.

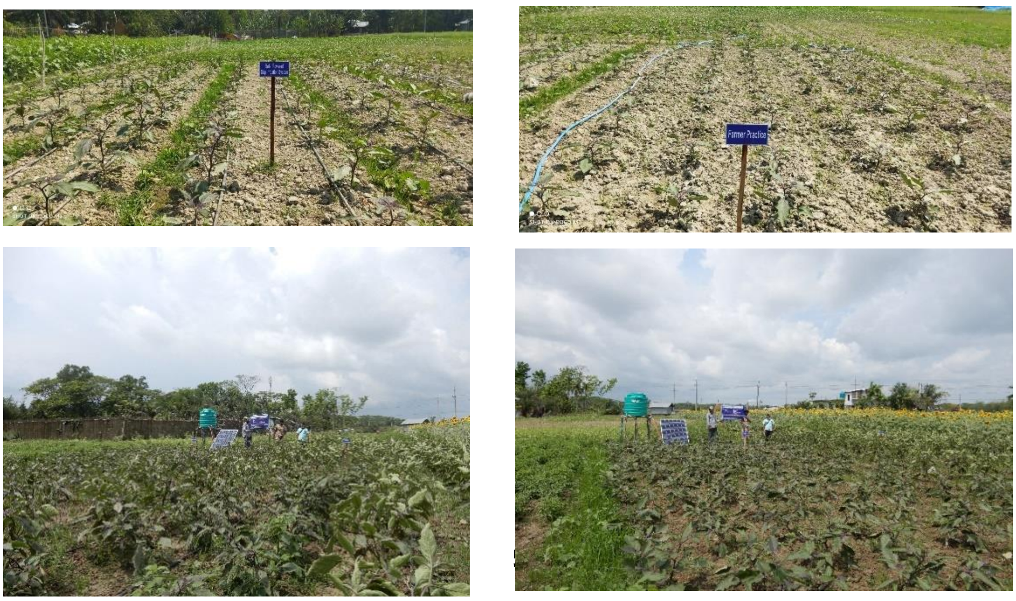

Figure: Watermelon cultivation using solar-powered drip irrigation system (Amtali, Barguna)