ANNUAL RESEARCH REVIEW WORKSHOP
2024-25

XII. RICE FARMING SYSTEMS DIVISION

Bangladesh Rice Research Institute

Gazipur-1701

ANNUAL RESEARCH REVIEW WORKSHOP
2024-25

XII. RICE FARMING SYSTEMS DIVISION

Bangladesh Rice Research Institute

Gazipur-1701

15-22 January 2026

CONTENTS

Title	Page
RICE FARMING SYSTEMS PROGRAMME AREA	iv
RICE FARMING SYSTEMS PERSONNEL	v
SUMMARY	vi
TRANSFERABLE TECHNOLOGY	vi
USEFUL SCIENTIFIC INFORMATION	ix
SUB-PROGRAMME I. CHARACTERIZATION OF FARMING SYSTEM	
Project 1. Survey	1
1.1. Changing trends and opportunities for optimizing rice-based cropping patterns in Kushtia district	1
SUB-PROGRAMME II. DEVELOPMENT OF CROPPING SYSTEMS AND COMPONENT TECHNOLOGIES FOR DIFFERENT ECOSYSTEMS	8
Project 2. Development of Cropping System and Component Technology for Favorable Environment	8
2.1. Performance evaluation of three-cropped cropping pattern for irrigated medium high land ecosystem	8
2.2. Performance evaluation of four-cropped cropping pattern for irrigated medium high land ecosystem	14
2.3. Feasibility of Boro ratooning and mustard inclusion in Boro-Fallow-T. Aman cropping pattern in irrigated medium highland ecosystem	19
2.4. Effect of fertilizer management of late Boro rice under Potato-Boro-T. Aman cropping pattern	29
2.5. Management of aged seedlings to minimize the yield loss of T. Aman rice	32
2.6. Evaluation of newly released BRRI varieties under Boro-Fallow-T. Aman cropping pattern	35
Project 3. Development of Cropping System and Component Technology for Stress Prone Area	38
3.1. Intensification of Watermelon-Fallow-T. Aman cropping pattern by inclusion of Aus rice	38
3.2. Improvement of Boro-Fallow-T. Aman cropping pattern with BRRI newly released rice varieties in saline coastal area	40
3.3. Improvement of Fallow-Fallow-T. Aman cropping pattern by inclusion of Boro rice/Mungbean/Sweet Gourd in non-saline tidal ecosystem	41
3.4. Improvement of Mungbean-Fallow-T. Aman cropping pattern by the inclusion of Aus rice in non-saline tidal ecosystem	43
3.5. Transformation of waterlogged wetland into three-tier production system for integrated rice-fish, vegetables and fruit cultivation	45
3.6. Modification of waterlogged fallow land into integrated agroforestry and fishery production system	47
Project 4. Development of Cropping System Technologies for Hill Ecosystem	54
4.1. Exploring the hills for rice research: Feasibility of Boro rice cultivation in fringe land at Rangamati district	54
4.2. Improvement of Jhum production system through the introduction of modern HYV Aus varieties in hilly areas	56
SUB-PROGRAMME III. FARMING SYSTEMS TECHNOLOGY TRANSFER	58
Project 5: Validation and Delivery of Cropping System Technology	58

5.1. Validation of pair row potato+pair row Maize-T. Aus-T. Aman cropping pattern in Northern region of Bangladesh	58
5.2. Intensification of Boro-Fallow-T. Aman cropping pattern through the inclusion of mustard in irrigated ecosystem of Madhupur Tract	59
5.3. Piloting of Mustard-Boro-T. Aman cropping pattern in irrigated medium highland ecosystem	63
5.4. Piloting of improved cropping pattern in rainfed lowland ecosystem in Sylhet region	76
5.5. Improvement of Boro-Fallow-T. Aman cropping system through Aus inclusion and varietal replacement in irrigated ecosystem in Mymensingh region	80
5.6. Improvement of Fallow-Fallow-T. Aman Cropping system through Rabi crop inclusion in Chattogram region	82
5.7. Farmers' group discussion, training and field days	84
SUB-PROGRAMME IV. INTEGRATED FARMING SYSTEMS	86
Project 6. Integrated farming research and development for livelihood improvement in the plain land eco-system	86
6.1. Crops and cropping pattern	86
6.1.1. Intensification of Boro-Fallow-T. Aman cropping pattern through the inclusion of oil crop in irrigated ecosystem	86
6.1.2. Introducing newly released BRRI rice varieties for the improvement of major cropping patterns in FSRD site, Kaliganj, Gazipur	90
6.1.3. Farmers' participatory evaluation of recently released BRRI varieties for Boro and T. Aman season at FSRD site, Kaliganj, Gazipur	92
6.1.4. Farmers' participatory quality seed production of recently released BRRI varieties for Boro and T. Aman season at FSRD site, Kaliganj, Gazipur	94
6.1.5. Evaluation of intercropping under mixed orchard in Madhupur tract	96
6.2. Homestead Production System	99
6.2.1. Year-round vegetables production in homestead area	99
6.2.2. Performance of turmeric and ginger in shady place of homestead	101
6.2.3. Fruit tree plantation in homestead area	103
6.2.4. Compost production using household waste	104
6.3. Livestock Production System	105
6.3.1. Performance of Sonali chicken in homestead area	105
6.3.2. Small scale pigeon rearing in farmer's household	107
6.3.3. Goat rearing in homestead area	108
6.3.4. Vaccination program for livestock and poultry birds	109
6.4. Aquaculture System	109
6.4.1. Semi-aquatic integrated production system of vegetables and fish	109

RICE FARMING SYSTEMS PROGRAMME AREA

Leader: Dr. Md. Ibrahim
Chief Scientific Officer and Head
Rice Farming Systems Division, BRRI

Members:

1. Head, Plant Breeding Division, BRRI
2. Head, Adaptive Research Division, BRRI
3. Head, Soil Science Division, BRRI
4. Head, Training Division, BRRI
5. Head, Irrigation and Water Management Division, BRRI
6. Head, Farm Machinery and Post Harvest Technology Division, BRRI
7. Head, Agricultural Economics Division, BRRI
8. Head, Agricultural Statistics Division, BRRI

RICE FARMING SYSTEMS PERSONNEL

Name and designation	Working days
Md. Ibrahim, PhD, *Chief Scientific Officer*	365
Amina Khatun, PhD, *Chief Scientific Officer*[a]	87
Md. Harun-Ar-Rashid, PhD, *Principal Scientific Officer*[b]	38
Md. Khairul Quais, PhD, *Principal Scientific Officer*	365
S M Shahidullah, PhD, *Principal Scientific Officer*[a]	321
Nargis Parvin, PhD, *Senior Scientific Officer*	365
ABM Jamiul Islam, MS, *Senior Scientific Officer*	365
Md. Amanut Ullah Razu, PhD, *Scientific Officer*	365
Deluwar Hossen Payel, B. Sc. Ag (Hons), *Scientific Officer*	365
Tasnima Husna, MS, *Scientific Officer*	365
Tafsin Araf, MS, *Scientific Officer*	365
Taslima Akhter, Dip. in Ag, *Scientific Assistant*	365
Md Mustafizur Rahman, Dip. in Ag, *Scientific Assistant*	365
Md Rakibul Ahmed, Dip. in Ag, *Scientific Assistant*	365
Hasan Toufiqur, *Steno-typist Cum Computer Operator*[c]	126
Jahirul Islam, *Office Assistant Cum Computer Operator*[d]	237

[a] transferred to BRRI R/S, Gopalganj
[b] transferred to BRRI R/S, Rajshahi
[c] joined from ARD, BRRI
[d] transferred to transport section

Summary

Transferable technology

Brief Overview of the Technology

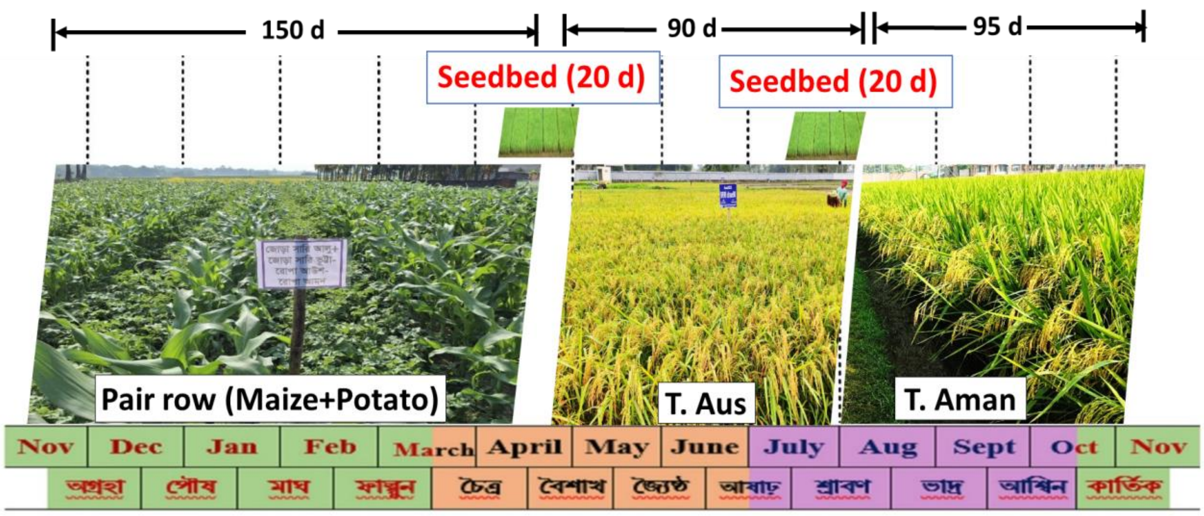
Name of the Technology: Pair row model of four-crops cropping pattern

Improved cropping attern: Pair row Potato+Pair row Maize (Rabi)-T. Aus-T. Aman

Existing cropping pattern: Potato-Maize (Kharif-1)- T. Aman and

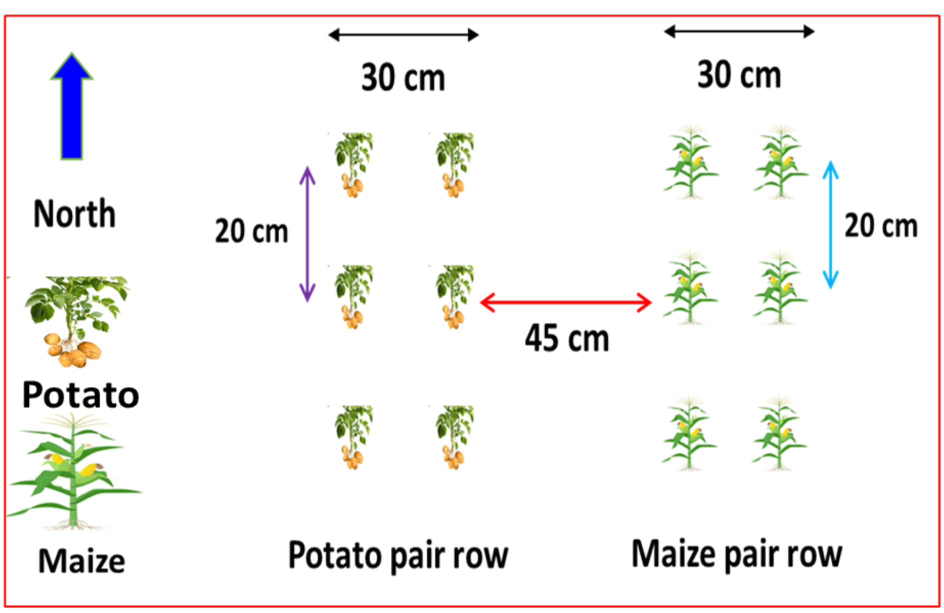
Maize (Rabi)-Fallow-T. Aman

Variety: Potato: BARI Potato-25; Maize: Adventa (hybrid); T. Aus: BRRI dhan82, BRRI dhan98; T. Aman: BRRI dhan71, BRRI dhan75



Salient features of the Technology

- Potato and Rabi maize are cultivated simultaneously using a paired-row system with closer spacing - 30 cm spacing within the same crop and 45 cm between different crops - while maintaining 20 cm plant-to-plant spacing to ensure the same population as in sole cropping (66,666 plant/ha).



Schematic view of pair row Potato+Pair row Maize

- In the paired row cropping system of potato and maize, fertilizer management involves applying 100% of the recommended dose of potato (N-P-K-S-Zn-B: 151-44-150-22-4-2 kg/ha) and 50% of the recommended dose of maize (N-P-K-S-Zn-B: 119-25-55-23-2-1 kg/ha). All P, K, S, Zn, B and $\frac{1}{3}^{rd}$ N are applied as basal. Rest $\frac{1}{3}^{rd}$ N is applied 35 days after sowing and remaining $\frac{1}{3}^{rd}$ urea is applied after potato harvest (at 85 DAS).

- In paired row system, potato yield decreased by approximately 15-20%, but a 5-85% increase in maize yield results in an overall productivity gain of 26-97% compared to traditional Maize-Fallow-T. Aman and Potato-Maize-T. Aman cropping patterns.
- Short duration T. Aman varieties (duration upto 120 days) are well- suited for this pattern.
- Total field duration of this developed four-cropped cropping pattern is about 335 days.
- Land utilization index for improved cropping pattern was 92% which is 18-37% higher than the existing Potato-Maize (Kharif-1)-T. Aman and Maize (Rabi)-Fallow-T. Aman, respectively.

Economic benefit of the technology

The improved cropping pattern yielded a gross margin of Tk. 4,96,000/ha, which is 43-83% higher than that of existing cropping patterns, generating a marginal benefit cost ratio ranging from 1.78 to 2.60.

Table 1. Yields and economics of four cropped technology compared to check cropping patterns, Godagari, Puthia, Rajshahi, 2021-22 to 2024-25

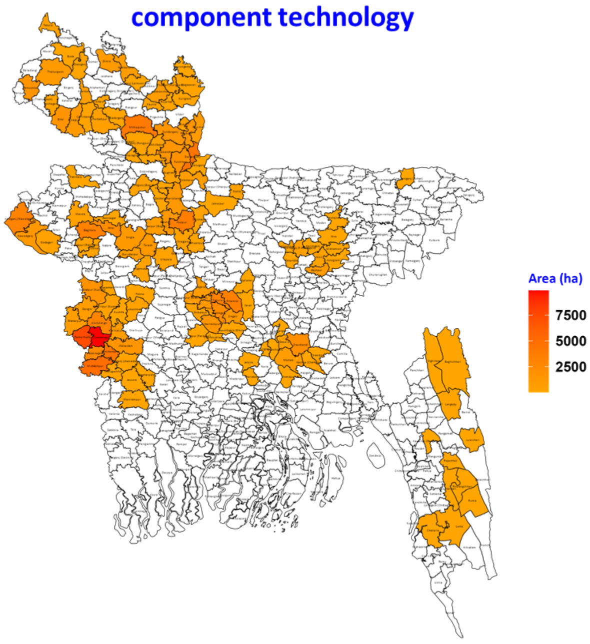
Cropping pattern	Yield (t/ha)					TVC ('000 Tk./ha)	GM ('000 Tk./ha)	MBCR
	Potato	Maize	T. Aus	T. Aman	REY			
Pair row potato+pair row maize-T. Aus-T. Aman	24.72	13.03	5.11	5.61	34.34	547	496	2.60 (CK_1) 1.78 (CK_2)
Potato-Maize-T. Aman (CK_1)	29.92	7.05	-	5.52	27.16	454	347	
Maize-Fallow-T. Aman (CK_2)	-	12.35	-	5.69	17.40	257	271	

Price (Tk/Kg): Potato=12-15, Maize=20-30, Rice=24-32

Extrapolation domain of the Technology

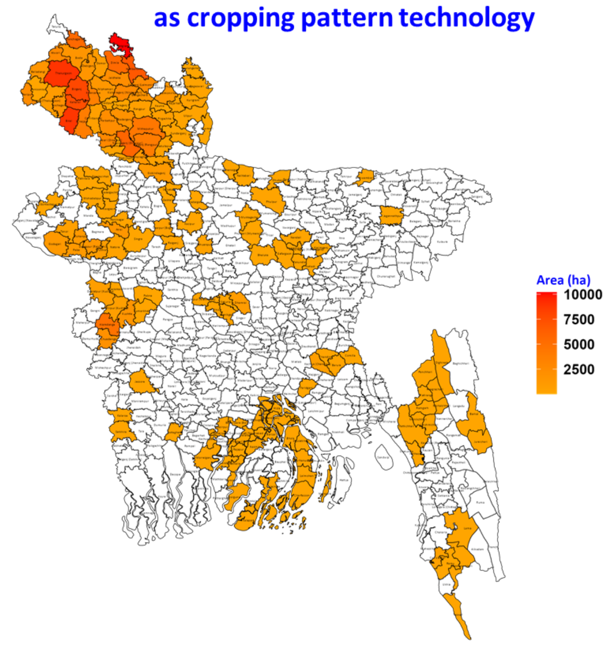
- Partial-irrigated high land and medium highland (Phase-I) ecosystem
- South-Western, Central and North-Western part with sandy loam to silty loam soil
- Maize-Fallow-T. Aman (1,01,460 ha; 39 district, 126 upazila), Potato-Maize-T. Aman (47690 ha; 19 district, 68 upazila), Maize-T. Aus-T. Aman (2970 ha; 17 district, 27 upazila)

Pair row Potato+Pair row Maize as component technology



Area= 1,16,705 ha (0.117 million ha)
133 Upazilas of 37 Districts

Pair row Potato+Pair row Maize-T. Aus-T. Aman as cropping pattern technology



Area= 1,49,945 ha (0.15 million ha)
152 Upazilas of 41 Districts

Risk factor management strategy

Success of this new technology (Pair row Potato+pair row Maize-T. Aus-T. Aman four crops cropping pattern) depends on managing the following risk factor:

Risk factor	Management
Timely planting of Potato and Maize	• Using short duration high yielding Aman rice variety (growth duration ≤ 120 days) • Select highland or medium highlands for pair row model of four crops cropping pattern to avoid the excessive moisture due to heavy rainfall in late monsoon. • Communication should be made in advance for potato seed.
Timely transplanting of Aus rice	• Ensure availability of irrigation facilities
Bird damage of Aus rice	• Large scale production of Aus rice in a locality
Timely transplanting Aman rice	• Availability of irrigation facility
Pest infestation due to early maturity of short duration Aman rice variety	• Proper pest management and using rat trap
Land inundation	• Using the CP in high land to medium highland phase-I
Timely land preparation	• Available farm machinery specially power tiller

Useful scientific information

- The Survey on different cropping patterns shows that rice-based cropping systems in Kushtia District have shifted from traditional rice–fallow patterns to more intensive, diversified, and market-oriented systems between 2014-15 and 2023-24. Increased inclusion of Aus rice, jute, oilseeds, pulses and high-value crops such as onion, maize, potato and vegetables has reduced fallow periods and improved land-use efficiency. While tobacco-based systems remain important in some upazilas, their overall dominance is declining, with gradual replacement by wheat-, rice-, and pulse-based systems. The findings highlight strong potential for further optimization through short-duration and stress-tolerant rice varieties, crop diversification, reduced fallow periods, and location-specific interventions to enhance productivity, sustainability, and farm income under limited land and changing climatic conditions.
- The four-year study (2021-2025) showed that three-cropped systems significantly outperformed the traditional Boro-Fallow-T. Aman pattern in productivity and efficiency under irrigated medium highland conditions. Onion-Jute-T. Aman was the most productive and profitable system, while Potato-Boro-T. Aman and Mustard-Boro-T. Aman also demonstrated strong economic potential. In contrast, Boro-T. Aus-T. Aman provided the highest yield stability and best overall nutritional performance. Cropping patterns with lentil and mungbean were less stable due to climatic and management constraints.
- The three-year evaluation (2022-25) showed that four-cropped systems significantly increased productivity and profitability over the conventional three-crop pattern under irrigated medium highland conditions. High-intensity patterns such as Tomato-Mungbean-T. Aus-T. Aman and potato-based systems produced the highest rice equivalent yield, production efficiency and gross margin but were less stable and required higher inputs. In contrast, mustard-based four-crop systems were more stable and resilient though less productive, while the three-crop control remained the most stable but lowest yielding. Nutritional performance varied markedly, with Potato+Maize-T. Aus-T. Aman providing the highest protein, fiber, carbohydrate and energy output.
- This study assessed the feasibility of intensifying the dominant Boro–Fallow–T. Aman system through mustard inclusion and Boro ratooning under irrigated medium highland conditions at BRRI, Gazipur. Results showed that intensifying Boro-Fallow-T. Aman system through mustard inclusion and Boro ratooning can enhance system productivity under irrigated medium highland conditions. Mustard-Boro-T. Aman pattern proved to be the most profitable and practical option, effectively utilizing the fallow period. Although ratoon-based systems increased rice equivalent yield, low ratoon productivity and higher management costs reduced economic benefits; however, Mustard-Boro-Ratoon Boro-T. Aman pattern showed promise, especially with Salibu ratooning and varieties BRRI dhan100 and BRRI dhan74.
- The study evaluated fertilizer management strategies for late-transplanted Boro rice in the Potato-Boro-T. Aman cropping pattern at BRRI, Gazipur. Grain yield was highest with BRRI-recommended fertilizer combined with basal nitrogen splits, while omitting basal N reduced yields across all treatments. Basal nitrogen is critical for sustaining yield and optimized fertilizer management can improve cost efficiency.

- The study assessed strategies to reduce yield loss in T. Aman rice from aged seedlings at BRRI, Gazipur. Seedling age significantly affected yield: BRRI dhan71 performed best with 30-day-old seedlings, while BRRI dhan75 with 20-day-old seedlings. Laddering practices and extra nitrogen (up to 40% above recommended) did not significantly improve yields.
- The study evaluated newly released BRRI rice varieties under the Boro-Fallow-T. Aman cropping pattern to identify high-yielding and profitable combinations at BRRI, Gazipur. Short-duration T. Aman varieties (BRRI dhan71 and dhan75) followed by Boro rice showed that BRRI hybrid dhan8 consistently produced the highest Boro yields, with BRRI dhan75-Fallow-BRRI hybrid dhan8 offered the best economic return. Similarly, medium-duration T. Aman varieties (BRRI dhan87, 95, 103) followed by Boro rice showed that BRRI dhan95-Fallow-BRRI hybrid dhan8 combination achieved the highest total grain yield and profitability. Overall, integrating high-yielding Boro varieties, especially BRRI hybrid dhan8, with suitable T. Aman varieties significantly enhances productivity and farm profitability under this traditional rice-based system.
- The inclusion of Aus rice in the existing cropping pattern of Watermelon-Fallow-T. Aman in Batiaghata, Khulna resulted in Gross Margin and MBCR were (10.7 t/ha), 1,29,760 (tk/ha) and (1.82), respectively.
- A trial was conducted at Batiaghata, Khulna to find out the suitable BRRI released salt tolerant rice varieties for Boro-Fallow-T. Aman cropping pattern. BRRI dhan99-Fallow-BRRI dhan103 turned out a total grain yield of 12.42 t/ha generating gross margin of Tk 1,79,000/ha with a MBCR 2.09.
- An experiment was conducted at the farmers' field of Charamoddi, Bakerganj, Barishal to evaluate the productivity and economic viability through including Boro rice, mungbean, or sweet gourd in the Fallow–Fallow–T. Aman cropping pattern under non-saline tidal ecosystem. Considering total productivity, Sweet gourd-Fallow-BRRI dhan74 performed well among the tested cropping patterns. This pattern resulted in a REY of 12.42 t/ha, generating a gross margin of Tk. 3,00,080/ha with an MBCR 3.36.
- A study was conducted at the farmers' field of Vorpasha, Bakerganj, Barishal to increase the productivity of the existing Mungbean-Fallow-T. Aman cropping pattern with the inclusion of T. Aus rice. BARI Mung-6-BRRI dhan98-BR23 cropping pattern resulted in a REY of 13.71 t/ha generating gross margin of Tk 1,72,260/ha with a MBCR 2.00.
- An experiment was conducted at BRRI, Gazipur to explore the best adaptive practices of fish, vegetables, and fruit production for increasing productivity in waterlogged wetland ecosystem. From the dykes, a total of 189 kg vegetables were produced annually per decimal area. Among the six crop combinations tested on dyke, the Mango+(Field pea-Rice) combination followed by Jujube+(Cabbage-Chili) performed well, achieving gross returns of Tk 10,175, and Tk. 6,537 per decimal, respectively. Though some fishes got away due to inundation, from the ditches, a total of 132 Kg/decimal fish were harvested annually per decimal area generating gross return of Tk 29,800. Among the six combinations on ditches, the Rohu+Mirror carp followed by Pabda+Shorputi produced better fish production, generating gross returns of Tk 12,000, and 5,920 per decimal, respectively.

- Among the five tested varieties in fringe land, BRRI dhan74 (6.06 t/ha) fitted better followed by BRRI dhan102 (5.20 t/ha).
- All the HYV varieties performed better than the local varieties in the hilly districts during Aus season. The grain yield of BRRI dhan48, BRRI dhan82 and BRRI BRRI dhan83 ranged from 3.65 to 3.82 t/ha, 3.40 to 3.67 t/ha, and 3.74 to 4.09 t/ha, respectively. Whereas different local varieties yielded 1.89-3.17 t/ha.
- Considering total productivity in Panchagrah, Pair row Potato+Pair row Maize-T. Aman is a potential system as it generated the highest REY of 28.78 t/ha.
- Considering total productivity, BRRI dhan75-Mustard-BRRI dhan108 performed well among three crops cropping patterns in Dhamrai. This pattern resulted in a REY of 19.67 t/ha, generating a gross margin of Tk. 2,15,400 per ha with an MBCR 1.64.
- Mustard-Boro-T. Aman Cropping pattern was piloting in different region of Bangladesh. Considering MBCR, at Kaliganj, Gazipur, BARI Sarisha-14-BRRI dhan100-BRRI dhan103 pattern found as economically viable options. At Sadar, Rangpur, BARI Sarisha-17-BRRI dhan107-BRRI dhan103 while at Horinakundo, Jhenaidah, BARI Sarisha-14-BRRI dhan102-BRRI dhan103, BARI Sarisha-14-BRRI dhan104-BRRI dhan103, were identified as economically viable options among the evaluated systems.
- A total of three trials were conducted in farmers' fields of Kamolganj, Moulovibazar to improve the existing single T. Aman cropping pattern through the inclusion of high yielding T. Aus and rabi crop and the replacement of existing T. Aman with high yielding modern T. Aman variety. In activity I, among the tested cropping patterns, Fallow-BRRI dhan98-BRRI dhan103 gave the highest system yield (11.09 t/ha) with an MBCR 3.02, while in activity II, BARI Sarisha18-BRRI dhan98-BRRI dhan103 provided the maximum turnout of 15.32 t/ha with an MBCR 2.87. In activity III, the improved cropping pattern of BARI Sarish-14-Fallow-BRRI dhan103 gave 9.67 t/ha system yield, with an MBCR 2.96.
- A trial was conducted at Sadar, Mymensingh to intensify the Boro-Fallow-T. Aman cropping pattern with inclusion of Aus rice. BRRI dhan100-BRRI dhan98-BRRI dhan103 resulted in the highest grain yield of 19.09 t/ha generating gross margin of Tk 2,81,000/ha with a MBCR 2.68.
- An experiment was conducted at the farmers' field of Sitakundu, Chattogram to intensify Country bean-T. Aus cropping pattern by integrating relay Yardlong bean with country bean. BARI hybrid Maize-16 - Fallow- BRRI dhan46 resulted in the highest REY of 11.13 t/ha generating gross margin of Tk 1,35,000/ha with a MBCR 1.82.
- In the farming systems research and development site, Muktarpur, Kaliganj, Gazipur, inclusion of mustard/sunflower increased the productivity of Boro-Fallow-T. Aman cropping pattern. Trials were conducted with newly released BRRI rice varieties in single and double rice ecosystems, BRRI dhan100 in Boro and BRRI dhan103 in T. Aman season significantly increased the productivity of the Boro-Fallow-T. Aman cropping pattern. Whereas BRRI dhan92 exhibited excellent performance in a single rice ecosystem. Farmers' participatory evaluation of recently released BRRI varieties revealed that BRRI dhan71 and BRRI dhan87 in T. Aman and BRRI dhan92, BRRI dhan96, BRRI dhan100, and BRRI dhan102 in Boro

season were suitable in that area. Moreover, the productivity of the mixed orchard was increased with the introduction of vegetables and spices. Different crops, homestead vegetables, livestock, fisheries and agroforestry interventions resulted in an annual profit of Tk 73,481 per farmer.

SUB-PROGRAMME I. CHARACTERIZATION OF FARMING SYSTEM

Project 1. Survey

Activity. 1.1. Changing trends and opportunities for optimizing rice-based cropping patterns in Kushtia district

N Akter, MK Quais and MMR Dewan

Introduction

Kushtia District, comprising five upazilas - Kushtia Sadar, Khoksa, Kumarkhali, Mirpur and Daulatpur - is characterized by highly diversified cropping patterns and intensive land use. Previous studies reported a wide range of cropping intensity in the region, varying from 175% to 286%, indicating multiple cropping practices and efficient utilization of agricultural land (Dewan *et al.*, 2017). Owing to its favorable agro-ecological conditions, the region plays a significant role in agricultural production in Bangladesh. However, the Kushtia region experiences comparatively drier climatic conditions and higher temperatures than many other parts of the country, which pose challenges to sustainable crop production. At the same time, the cultivable land area in Bangladesh is steadily declining due to population pressure and urbanization, increasing the need to enhance productivity from limited land resources rather than expanding cultivated area.

Under these circumstances, improving system productivity through the optimization of existing cropping patterns has become a critical priority. Introducing newly released high-yielding and stress-tolerant rice varieties, along with suitable non-rice crops, can help diversify cropping systems, reduce risk, and improve overall farm income. Therefore, understanding the dynamics and recent changes in cropping patterns is essential for identifying opportunities to intensify and diversify existing systems. This study aims to analyze the changes in cropping patterns across the major upazilas of Kushtia District over time and to explore potential avenues for improving current cropping systems through crop diversification and varietal interventions to enhance productivity and sustainability.

Objectives

i) To analyze the dynamics and changes in cropping patterns in Kushtia District over time.
ii) To identify opportunities for improving existing cropping patterns through the introduction of newly released rice varieties and suitable non-rice crops in order to enhance overall system productivity.

Methodology

Information on rice-based cropping patterns for the upazilas of Kushtia Sadar, Khoksa, Kumarkhali, Mirpur, and Daulatpur in Kushtia District was collected from the Department of Agricultural Extension (DAE). The collected data were subsequently verified through group discussions with farmers and Sub-Assistant Agricultural Officers (SAAOs) to ensure accuracy and reliability. Data for the base year (2014-15) were obtained from the published source Bangladesh Rice Journal, Volume 21 (2), which was published in 2017.

Results and Discussion

The changes in the top ten cropping patterns of Kushtia Sadar Upazila between 2014-15 and 2023-24 are presented in Table 1. A notable shift is observed in the dominance of rice-based cropping systems over time. In 2014-15, Boro-Fallow-T. Aman was the leading cropping pattern, occupying 35.08% of the net cropped area (NCA). However, by 2023-24, the inclusion of Aus rice within this pattern resulted in the emergence of Boro-Aus-T. Aman as the dominant cropping pattern, covering 28.62% of the NCA, while Boro-Fallow-T. Aman declined to the second position (26.69% of NCA). This indicates an overall intensification of land use and reduced fallow periods. A similar transformation is observed in maize-based systems. The earlier Maize-Fallow-T. Aman pattern has been largely replaced by Maize-Jute-T. Aman, reflecting the incorporation of jute as a cash crop and increased cropping intensity. Consequently, Maize-Jute-T. Aman emerged as one of the major maize-based patterns in 2023-24. Government policy support has encouraged the expansion of oilseed crops, particularly mustard. As a result, Mustard-Boro-Aus-T. Aman and Mustard-Boro-T. Aman cropping patterns have gained prominence in recent years, whereas mustard-based patterns occupied relatively smaller areas in the base year. Wheat-based cropping patterns also show diversification. While Wheat-Fallow-T. Aman was common in 2014-15, the inclusion of Aus and Jute in wheat-based systems (e.g., Wheat-Jute-T. Aman) indicates better utilization of land and growing emphasis on crop diversification. Furthermore, the area under Onion-Jute-T. Aman has increased considerably, rising in rank and area over time, which highlights farmers' increasing preference for high-value crops. The emergence of new multi-crop patterns such as Linseed-Vegetable-Jute-T. Aman, Potato-Maize-Aus-T. Aman, and Sunflower-Jute-T. Aman in 2023-24 further reflects a trend toward diversification, intensification, and market-oriented agriculture in Kushtia Sadar Upazila.

Overall, the changes in cropping patterns indicate a shift from simpler rice-fallow systems to more intensive, diversified, and economically profitable cropping systems over the study period.

Table 1. Dynamices of major cropping patterns of Kushtia sadar upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
	Base year (2014-15)				Existing (2023-24)		
01	Boro−Fallow−T. Aman	8100	35.08	01	Boro- Aus- T. Aman	6652	28.62
02	Boro−Aus−T. Aman	3300	14.29	02	Boro- Fallow- T. Aman	6203	26.69
03	Maize−Fallow−T. Aman	1300	5.63	03	Wheat- Jute- T. Aman	1127	4.85
04	Vegetab−Maize−T. Aman	880	3.81	04	Mustard- Boro- Aus- T. Aman	1023	4.40
05	Wheat−Fallow−T. Aman	770	3.33	05	Maize- Jute- T. Aman	1019	4.38
06	Wheat−Jute−T. Aman	580	2.51	06	Mustard- Boro- T. Aman	850	3.66
07	Onion−Aus−T. Aman	500	2.17	07	Onion- Jute-T. Aman	693	2.98
08	Mustard−Boro−T. Aman	450	1.95	08	Linseed-Veg.- Jute- T. Aman	644	2.77
09	Vegetab−Vegetab−Vegetab	420	1.82	09	Potato- Maize- Aus- T. Aman	631	2.71
10	Onion−Jute−T. Aman	400	1.73	10	Sunflower- Jute- T. Aman	527	2.27

The changes in the top cropping patterns of Khoksa Upazila between 2014-15 and 2023-24 are presented in Table 2. A pronounced shift in cropping dominance is evident over the study period. In the base year (2014-15), wheat-based cropping patterns were predominant, with Wheat-Jute-T. Aman occupying the largest area (16.84% of NCA). However, by 2023-24, the area under wheat-based systems declined substantially and wheat-based patterns fell in rank, indicating a reduced importance of wheat cultivation in the upazila. In contrast, onion-based cropping systems expanded markedly and became dominant. Onion-Jute-T. Aman emerged as the leading cropping pattern in 2023-24, covering 22.75% of the net cropped area, followed by Onion-Aus-T. Aman (11.37% of NCA). This substantial increase reflects farmers' growing preference for high-value and market-oriented crops. Rice-based systems also underwent significant modification. The traditional Boro-Fallow-T. Aman pattern observed in 2014-15 was replaced by more intensive systems through the inclusion of Aus rice and Jute, resulting in the emergence of Boro-Jute-T. Aman and Boro-Aus-T. Aman patterns in 2023-24. This change indicates reduced fallow periods and improved land-use intensity.

Additionally, diversification toward oilseed and pulse-based cropping is evident. Patterns such as Mustard-Sesame-T. Aman gained importance in the existing year, while lentil-based systems became less prominent. Overall, the observed changes suggest a transition in Khoksa Upazila from wheat-dominated systems to more diversified, intensive and economically profitable cropping patterns, driven by market demand and improved resource utilization.

Table 2. Dynamics of major cropping patterns of Khoksa upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
	Base year (2014-15)				Existing (2023-24)		
01	Wheat–Jute–T. Aman	1300	16.84	01	Onion- Jute- T. Aman	2000	22.75
02	Boro–Fallow–T. Aman	1200	15.54	02	Onion- Aus- T. Aman	1000	11.37
03	Onion–Jute–T. Aman	800	10.36	03	Boro- Jute- T. Aman	604	6.87
04	Lentil–Jute–T. Aman	700	9.07	04	Boro- Aus- T. Aman	561	6.38
05	Boro–Aus–Fallow	600	7.77	05	Wheat- Jute- T. Aman	468	5.32
06	Wheat–Sesame–T. Aman	500	6.48	06	Mustard- Sesame- T. Aman	465	5.29

The dynamics of the top cropping patterns of Kumarkhali Upazila between 2014-15 and 2023-24 are presented in Table 3, revealing substantial changes in crop composition and land-use intensity over time. In the base year, Boro-Fallow-T. Aman was the dominant cropping pattern, occupying 19.30% of the net cropped area (NCA). By 2023-24, this pattern underwent notable transformation through the inclusion of jute, resulting in Boro-Jute-T. Aman, which emerged as the leading cropping pattern, although with a reduced share of NCA (9.53%). This shift indicates a decline in fallow land and increased emphasis on jute cultivation. Onion-based systems also show significant intensification. The earlier Onion-Fallow-T. Aman pattern has largely been replaced by Onion-Jute-T. Aman, which ranked second in 2023-24 and covered 9.02% of the NCA. Similarly, wheat-based systems experienced diversification, with Wheat-Sesame-T. Aman evolving into Wheat-Jute-T. Aman, reflecting a considerable increase in jute inclusion and improved cropping intensity. Mustard cultivation has gained importance in recent years, particularly through its incorporation into rice-based systems such as Mustard-Boro-Fallow and Mustard-Boro-T. Aman, which were absent or minor in the base year. The emergence of these patterns suggests a shift toward oilseed production, likely influenced by policy support and market demand.

Overall, the cropping pattern dynamics in Kumarkhali Upazila indicate a clear transition from fallow-dominated systems to more intensive and diversified cropping patterns, characterized by increased inclusion of jute and mustard, expansion of high-value crops, and improved utilization of available agricultural land.

Table 3. Dynamics of major cropping patterns of Kumarkhali upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
Base year (2014-15)				Existing (2023-24)			
01	Boro−Fallow−T. Aman	3300	19.30	01	Boro-Jute- T. Aman	2315	9.53
02	Onion−Fallow−T. Aman	1500	8.77	02	Onion- Jute- T. Aman	2190	9.02
03	Wheat−Sesame−T. Aman	1100	6.43	03	Wheat-Jute-T. Aman	2001	8.24
04	Lentil−Jute−T. Aman	1000	5.85	04	Sesame- Jute- T. Aman	1404	5.78
05	Boro−Aus−Fallow	750	4.39	05	Vegetables- Boro- T. Aman	1020	4.20
06	Boro−Fallow−Fallow	600	3.51	06	Mustard- Boro- Fallow	950	3.91
07	Wheat−Jute−Fallow	600	3.51	07	Boro- Aus- Fallow	882	3.63
08	Onion−Jute−Fallow	600	3.51	08	Onion- Aus- T. Aman	860	3.54
09	Wheat−Jute−T. Aman	500	2.92	09	Mustard- Boro- T. Aman	630	2.59
10	Boro−Aus−T. Aman	500	2.92	10	Maize- Jute- T. Aman	591	2.43

The dynamics of the top cropping patterns of Mirpur Upazila between 2014-15 and 2023-24 are presented in Table 4, showing both continuity and gradual diversification in the existing cropping systems. Tobacco-based cropping patterns continue to play a major role in the upazila, indicating the sustained dominance of tobacco cultivation due to its high economic return. In the base year (2014-15), Tobacco-Jute-T. Aman was the leading cropping pattern, accounting for 18.91% of the net cropped area (NCA). Although its relative share declined over time, tobacco-based systems remain prominent in 2023-24, with Tobacco-Chilli-T. Aman and Tobacco-Jute-T. Aman ranking second and third, respectively. This suggests diversification within tobacco-based systems through the inclusion of high-value companion crops such as chilli and jute.

Rice-based cropping patterns also remain important. Boro-Fallow-T. Aman emerged as the dominant pattern in 2023-24, covering 17.10% of the NCA, indicating the continued importance of irrigated rice cultivation. However, modifications within this system are evident, as oilseed crops such as sesame (til) have been incorporated, resulting in the expansion of the Boro-Sesame-T. Aman pattern. This reflects improved land use and diversification during the rabi season. Additionally, the appearance of multi-crop patterns such as Mustard-Mung-Aus-T. Aman highlights a growing tendency toward crop diversification and intensification. Overall, despite some diversification and inclusion of oilseed and pulse crops, Mirpur Upazila remains characterized by the strong presence of tobacco-based cropping patterns alongside rice-dominated systems.

Table 4. Dynamics of major cropping patterns of Mirpur upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
Base year (2014-15)				Existing (2023-24)			
01	Tobacco−Jute−T. Aman	4460	18.91	01	Boro- Fallow- T. Aman	3952	17.10
02	Boro−Fallow−T. Aman	3500	14.84	02	Tobacco- Chilli- T. Aman	3335	14.43
03	Boro−Aus−T. Aman	2600	11.02	03	Tobacco- Jute- T. Aman	2660	11.51
04	Tobacco−Aus−T. Aman	2000	8.48	04	Mustard- Mung- Aus- T. Aman	1759	7.61
05	Boro−Sesbania−T. Aman	1600	6.78	05	Boro- Sesame- T. Aman	1630	7.05
06	Tobacco-Sesbania-T. Aman	1600	6.78	06	Boro- Aus- T. Aman	1500	6.49
07	Boro−Fallow−Fallow	1100	4.66	07	Wheat- Aus- Cotton	510	2.21

The changes in the top cropping patterns of Bheramara Upazila between 2014-15 and 2023-24 are presented in Table 5. Overall, the cropping pattern structure of the upazila remained relatively stable over the study period, with no drastic shifts in dominant cropping systems. Wheat-Jute-T. Aman continued to be the leading cropping pattern in both years, although its share of the net cropped area (NCA) declined slightly from 13.26% in 2014-15 to 10.31% in 2023-24. This indicates a marginal reduction in area rather than a structural change. Lentil-based and tobacco-based systems also maintained their importance, with Lentil-Jute-T. Aman retaining a similar rank and area coverage, and Tobacco-Jute-T. Aman increasing in relative importance in the existing year. Some internal adjustments within rice-based systems are evident. The earlier Boro-Aus-Fallow pattern shifted toward more intensive systems such as Boro-Aus-T. Aman and Boro-Jute-T. Aman, reflecting reduced fallow land and improved cropping intensity. Additionally, the emergence of diversified patterns like Mustard-Boro-Aus-T. Aman and Lentil-Boro-Vegetable-T. Aman in 2023-24 indicates a gradual trend toward crop diversification and better land utilization.

In summary, while the overall dominance of major cropping patterns in Bheramara Upazila has remained largely unchanged, modest intensification and diversification within existing systems suggest incremental improvements in cropping intensity and resilience rather than major structural transformation.

Table 5. Dynamics of major cropping patterns of Bheramara upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
	Base year (2014-15)				Existing (2023-24)		
01	Wheat−Jute−T. Aman	1200	13.26	01	Wheat- Jute- T. Aman	1125	10.31
02	Lentil−Jute−T. Aman	600	6.63	02	Tobacco- Jute- T. Aman	765	7.01
03	Boro−Aus−Fallow	500	5.52	03	Lentil- Jute- T. Aman	579	5.31
04	Tobacco−Jute−T. Aman	450	4.97	04	Boro- Aus- T. Aman	537	4.92
05	Vegetab−Vegetab−Vegetab	400	4.42	05	Boro- Jute- T. Aman	525	4.81
06	Wheat−Fallow−T. Aman	400	4.42	06	Mustard-Boro- Aus- T. Aman	508	4.66
07	Boro−Fallow−Fallow	300	3.31	07	Lentil- Boro- Veg- T. Aman	500	4.58

The changes in the top cropping patterns of Daulatpur Upazila between 2014-15 and 2023-24 are presented in Table 6, indicating notable shifts in crop dominance and land-use intensity over time. A major change observed is the substantial reduction in tobacco-based cropping patterns, which dominated the base year. In 2014-15, Tobacco-Jute-T. Aman and Tobacco-Jute-Fallow together occupied a large share of the net cropped area (NCA). By 2023-24, although tobacco-based systems remain present, their overall area and ranking declined significantly, reflecting a reduced dependence on tobacco cultivation. In contrast, wheat-based cropping patterns expanded considerably. Wheat-Jute-T. Aman emerged as the dominant cropping pattern in 2023-24, covering 12.05% of the NCA, compared to a much smaller share in the base year. This indicates a clear shift toward wheat cultivation, likely driven by changing market demand and agronomic suitability. Rice-based systems also became more intensive with the increased inclusion of Aus rice. Patterns such as Boro-Aus-T. Aman gained prominence in the existing year, while several fallow-based systems observed in 2014-15 were replaced by multi-crop sequences. The expansion of Aus rice is further reflected in diversified systems like Lentil-Aus-Vegetable.

Additionally, the emergence of new and diversified cropping patterns - such as Onion-Vegetable-T. Aman, Potato-Boro-B. Aman, and Grasspea-Mustard-T. Aman - suggests a gradual move toward crop diversification and higher cropping intensity. Overall, the observed changes in Daulatpur Upazila highlight a transition away from tobacco-dominated systems toward wheat-, rice-, and Aus-based diversified cropping patterns, contributing to improved land use and agricultural sustainability.

Table 6. Dynamics of major cropping patterns of Daulatpur upazila, Kushtia

Rank	Cropping Pattern	Area (ha)	% of NCA	Rank	Cropping Pattern	Area (ha)	% of NCA
	Base year (2014-15)				Existing (2023-24)		
01	Tobacco−Jute−T. Aman	4000	11.69	01	Wheat- Jute- T. Aman	4310	12.05
02	Tobacco−Jute−Fallow	2400	7.01	02	Lentil- Aus- Vegetable	2220	6.21
03	Lentil−Aus−Fallow	2000	5.84	03	Boro- Aus- T. Aman	2166	6.06
04	Wheat−Jute−T. Aman	1700	4.97	04	Tobacco- Jute- T. Aman	1940	5.43
05	Boro−Fallow−T. Aman	1600	4.67	05	Tobacco- Aus-Blackgram	1298	3.63
06	Mustard−Jute−T. Aman	1500	4.38	06	Onion- Vegetable- T. Aman	1109	3.1
07	Maize−Jute−T. Aman	1500	4.38	07	Maize- Jute- T. Aman	906	2.53
08	Wheat−Jute−Fallow	1400	4.09	08	Boro- Dhaincha- T. Aman	724	2.02
09	Boro−Sesbania−T. Aman	1200	3.51	09	Potato- Boro- B. Aman	720	2.01
10	Vegetab−Vegetab−Fallow	1200	3.51	10	Grasspea- Mustard- T. Aman	558	1.56

Potential avenues for improving existing cropping patterns in Kushtia district

The observed changes in cropping patterns across the upazilas of Kushtia District indicate a gradual transition toward more intensive, diversified and market-oriented cropping systems. Building on these existing trends, several potential avenues can be identified to further improve system productivity, sustainability and farm income under conditions of declining land availability and increasing climatic stress.

i) Reduction of fallow periods through crop intensification

Across all upazilas, traditional Bice-Fallow-T. Aman systems have been progressively replaced by more intensive patterns such as Boro-Aus-T. Aman, Boro-Jute-T. Aman and Mustard-Boro-T. Aman. This indicates substantial scope for further reducing fallow periods by introducing short-duration crops (e.g., Aus rice, mungbean, mustard, sesame, and vegetables) between major rice seasons. Expansion of such systems can enhance cropping intensity and overall land productivity without increasing cultivated area.

ii) Introduction of newly released short-duration and stress-tolerant rice varieties

Given the comparatively dry climate and higher temperatures of the Kushtia region, the introduction of short-duration, heat- and drought-tolerant rice varieties can play a key role in improving cropping systems. Early-maturing T. Aman varieties can facilitate timely planting of rabi crops such as wheat, mustard, onion and pulses, thereby strengthening existing multi-crop sequences.

iii) Expansion of high-value and market-oriented crops

The increasing dominance of onion-, maize-, potato-, and vegetable-based cropping patterns, particularly in Kushtia Sadar, Khoksa, and Daulatpur, highlights strong market responsiveness. Further expansion of these high-value crops within rice-based systems -such as Onion-Aus-T. Aman, Potato-Boro-T. Aman and Vegetable-Boro-T. Aman - can significantly improve farm income and employment opportunities, especially for small and marginal farmers.

iv) Diversification with oilseeds and pulses

The growing presence of mustard, sesame, lentil, mungbean, grasspea and blackgram in existing cropping patterns suggests strong potential for diversification. Inclusion of these crops in rice-based systems can improve soil fertility, enhance nitrogen cycling and reduce production risk while contributing to national oilseed and pulse self-sufficiency.

v) Rationalization of tobacco-based cropping systems

Although tobacco-based cropping patterns remain important in Mirpur and parts of Bheramara and Daulatpur, a declining trend is evident in several upazilas. There is scope to gradually replace tobacco with wheat, maize, pulses, oilseeds and vegetables, which are environmentally safer and nutritionally more beneficial. Policy support, extension services and assured markets will be crucial for facilitating this transition.

vi) Strengthening jute-based cropping systems

The increasing integration of jute into rice-, wheat-, and onion-based cropping patterns across most upazilas demonstrates its economic and agro-ecological suitability. Further improvement in jute-based systems through improved varieties and mechanization can enhance profitability while supporting sustainable cropping patterns.

vii) Location-specific cropping pattern optimization

The variability in dominant cropping patterns among upazilas suggests the need for location-specific interventions rather than a uniform recommendation. For example, onion- and vegetable-based systems are more suitable in Khoksa and Kumarkhali, while wheat- and Aus-based intensification shows greater potential in Daulatpur. Tailored recommendations based on soil type, water availability, and market access can maximize productivity gains.

Overall, the existing cropping patterns of Kushtia District already demonstrate significant progress toward intensification and diversification. Strategic interventions focusing on short-duration rice varieties, high-value non-rice crops, reduced fallow periods and gradual replacement of tobacco can further enhance system productivity, farm profitability and sustainability. These improvements are essential for meeting future food and income demands under conditions of limited land and increasing climatic stress.

SUB-PROGRAMME II. DEVELOPMENT OF CROPPING SYSTEMS AND COMPONENT TECHNOLOGIES FOR DIFFERENT ECOSYSTEMS

Project 2. Development of Cropping System and Component Technology for Favorable Environment

Expt. 2.1. Performance evaluation of three-cropped cropping pattern for irrigated medium high land ecosystem

T Araf, N Parvin, ABM Mostafizur, BJ Shirazy, MK Quais and M Ibrahim

Introduction

With the rapid increase in global food demand, doubling the current level of food production and sustaining it at that level are the major challenges for global food security. These challenges seem to be more difficult for developing countries like Bangladesh with its limited resources. To meet the food demand of the growing population, intensification of agricultural production is needed. Although there has been great success in rice production and the country is about to be self-sufficient in food grain production, there is also a growing concern about how to feed the increasing population in the future where natural resources, particularly agricultural land and water, are shrinking and undergoing degradation. Sustainable crop production in Bangladesh through the improvement of the rice-based cropping patterns is regarded as an important intervention to tackle national issues such as food security and poverty alleviation. With limited land area, horizontal expansion is hardly possible, but an increase in crop production is still possible with vertical expansion through increasing crop yield per unit area, increasing cropping intensity and by reducing production losses.

Objectives

i) To evaluate the agronomic and economic performance of three cropped cropping pattern

ii) To assess the nutritional aspect of three cropped cropping pattern

Materials and Methods

The experiment was conducted at BRRI research farm, Gazipur during 2021-25 (four years) to evaluate the agronomic and economic performance of the following three-cropped cropping patterns:

$CP_{1:}$ Boro-T. Aus-T. Aman,

CP_2: Mustard-Boro-T. Aman,

CP_3: Potato-Boro-T. Aman,

CP_4: Wheat-Mungbean-T. Aman,

CP_5: Sunflower-T. Aus-T. Aman,

CP_6: Onion-Jute-T. Aman,

CP_7: Lentil-T. Aus-T. Aman against the

CP_8: Boro-Fallow-T. Aman (Ck)

Seeding date, transplanting date, harvesting date and field duration are given below (Table 7, 8, 9, 10). All cultural and pest management practices were done according to BRRI and BARI recommendations. The yield of each crop was converted to rice equivalent yield (REY) for comparing the system productivity. Productivity and stability were analyzed following the methodology of Conway (1987). Production efficiency (kg ha^{-1} day^{-1}) was calculated according to Tomer and Tiwari (1990). Nutritionally relevant parameters were estimated following the approaches described by Shaheen *et al*. (2013) and Rahaman *et al*. (2024). MBCR (Marginal Benefit Cost Ratio) and Z score-based comparison were calculated using following equations:

$$\text{MBCR} = \frac{GR\ (Improved) - GR\ (Existing)}{TVC\ (Improved) - TVC\ (Existing)}$$

$$\text{Modified Z score} = 0.6745 \times \frac{xi - Median\ of\ population}{Median\ Absolute\ Deviation}$$

Table 7. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2021-25

Factors	CP_1: Boro-T. Aus-T. Aman			CP_2: Mustard-Boro-T. Aman		
	Boro	T. Aus	T. Aman	Mustard	Boro	T. Aman
Variety	BRRI dhan88	BRRI dhan98	BRRI dhan75	BARI Sarisha-14/ BARI Sarisha-18	BRRI dhan88	BRRI dhan75/ BRRI dhan87
D/S	16-23 Nov	04-09 April	03-04 July	11-15 Nov	30 Dec-13 Jan	25 Jun-7 Jul
D/T	18-30 Dec	18-25 April	24-25 July	-	06-26 Feb	15-25 Jul
D/H	10-23 April	17-22 July	21-22 Oct	31 Jan-19 Feb	15-28 May	08 Oct-7 Nov
FD (days)	113-114	88-90	88-89	81/100	91-98	85/104

Table 8. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2021-25

Factors	CP_3: Potato-Boro-T. Aman			CP_4: Wheat-Mungbean-T. Aman		
	Potato	Boro	T. Aman	Wheat	Mungbean	T. Aman
Variety	Asterix (BARI Alu-25)	BRRI dhan88	BRRI dhan95/ BRRI dhan71	BARI Gom-30/ BARI Gom-33	BARI Mung-6	BRRI dhan75
D/S	15-20 Nov	28 Dec.-16 Jan	25 Jun- 08 Aug	13-20 Nov	15 Mar	25 Jun -08 Aug
D/T	-	10-25 Feb	15 Jul-28 Aug	-	-	15 Jul-28 Aug
D/H	11-21 Feb	05 May	08 Oct- 22 Nov	19 Feb-02 Mar	04 Jun	08 Oct-22 Nov
FD (days)	92-98	82-87	85/87	106/108	81	85-87

Table 9. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2021-25

Factors	CP_5: Sunflower-T. Aus-T. Aman			CP_6: Onion-Jute-T. Aman		
	Sunflower	T. Aus	T. Aman	Onion	Jute	T. Aman
Variety	BARI Surjamukhi-3/ Hysun-33	BRRI dhan48/ BRRI dhan98	BRRI dhan75/ BRRI dhan87	BARI Piaz-4/ BARI Piaz-1	BJRI Tossa Pat-8	BRRI dhan87/ BRRI dhan103/ BRRI hybrid dhan6
D/S	11-15 Nov	04-09 Apr	03-07 Jul	18 Oct -10 Nov	10 Apr	06-25 Jul
D/T	-	18 Apr	24-25 Jul	21 Nov-20 Dec	-	31 Jul- 08 Aug
D/H	07 Feb-15 Feb/ 07 Mar	17 Jul	20 Oct-07 Nov	06-10 Mar	02-07 Aug	20 Oct-14 Nov
FD (days)	88-94/114	90/91	88/104	105/124	114-120	103/106/90

Table 10. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2021-25

Factors	CP_7: Lentil-T. Aus-T. Aman			CP_8: Boro-Fallow-T. Aman	
	Lentil	T. Aus	T. Aman	Boro	T. Aman
Variety	BARI Mashur-8/ BARI Mashur-9	BRRI dhan48/ BRRI dhan98	BRRI dhan87/ BRRI hybrid dhan6	BRRI dhan92	BRRI dhan49
D/S	11-15 Nov	04 -09 Apr	03-07 Jul	16-23 Nov	21-30 Jun
D/T	-	18 Apr	25 Jul	18-30 Dec	11-21 Jul
D/H	6 Mar/15 Feb	17 Jul	20 Oct- 05 Nov	22 Apr-05 May	28 Oct-08 Nov
FD (days)	113/93	90/91	103/88	126-129	109-111

Results

Yield and Rice Equivalent Yield (REY)

Average individual crop yield and REY of respective cropping patterns from 2021 to 2025 are presented in Table 11. Yield of mustard and potato 1.24 and 14.11 t/ha under Mustard-Boro-T. Aman (CP_2) and Potato-Boro-T. Aman (CP_3) cropping pattern, respectively. The average potato yield was low due to a severe outbreak of late blight during the 2023-24 season and a comparatively mild incidence of the disease in 2024-25. Wheat, sunflower, onion and jute yielded 3.50, 1.78, 15.42, and 2.56 t/ha, respectively under respective cropping patterns. Yield of mungbean and lentil was 0.49 t/ha and 1.44 t/ha which belongs to CP_4 and CP_7 cropping pattern respectively and the yield was not satisfactory due to poor germination of mungbean and lentil during the 2023–24 season. Additionally, lentil production was further hampered by waterlogging resulting from road reformation activities near the experimental plot. Yield of Boro rice was in the range of 5.14 to 6.21 t/ha. The highest average yield (6.21 t/ha) of Boro rice was obtained from check pattern (CP_8: Boro-Fallow-T. Aman) cropping pattern. Yield of T. Aus was 4.50, 4.34 and 4.56 t/ha under CP_1: Boro-T. Aus-T. Aman, CP_5: Sunflower-T. Aus-T. Aman and CP_7: Lentil-T. Aus-T. Aman cropping pattern, respectively. Short to medium short duration T. Aman rice varieties were used in all the cropping patterns where CP_2: Mustard- Boro-T. Aman and CP_6: Onion-Jute-T. Aman performed comparatively better yield, 5.91 and 5.36 t/ha respectively. The highest rice equivalent yield (31.29 t/ha) was found from Onion-Jute-T. Aman cropping pattern (CP_6). The near-highest yield (20.07 t/ha) was obtained from the Potato-Boro-T. Aman cropping pattern, while the lowest yield (10.96 t/ha) was recorded in the check pattern.

Table 11. Yield and Rice Equivalent Yield (REY) of different crops combination under three-cropped cropping pattern, BRRI, Gazipur, 2021-25

CP(s)	Yield (Mean±SE t/ha)											
	Mustard	Potato	Wheat	Sunflower	Onion	Lentil	Boro	Mungbean	Jute	T. Aus	T. Aman	REY (t/ha)
CP_1	-	-	-	-	-	-	5.74±0.39	-	-	4.50±0.11	4.60±0.26	16.44c
CP_2	1.24±0.31		-	-	-		5.45±0.13		-		5.91±0.37	15.82c
CP_3	-	14.11±1.25	-	-	-		5.14±0.55		-		5.06±0.22	20.07b
CP_4	-	-	3.50±0.22	-	-			0.49±0.19	-		4.94±0.31	12.88d
CP_5	-	-	-	1.78±0.17	-				-	4.34±0.16	4.66±0.64	13.94d
CP_6	-	-	-	-	15.42±2.41				2.56±0.43		5.36±0.18	31.29a
CP_7	-	-	-	-	-	1.44±0.21			-	4.56±0.25	4.69±0.75	12.65d
CP_8 (Ck.)	-	-	-	-	-		6.21±0.43		-		4.66±0.33	10.96e
CV (%)												**3.92**

CP=Cropping Pattern, CV=Coefficient of Variation, REY=Rice Equivalent Yield.
Price (Tk/kg): Mustard=80, Potato=15, Wheat=40, Sunflower=55, Onion=30, Lentil=85, Mungbean=80, Jute=50, Rice=25

Productivity (t/ha)

In terms of year-wise productivity, Onion-Jute-T. Aman (CP_6) cropping pattern consistently produced the highest yield (26.62-35.25 t/ha) across all experimental years. The next highest productivity (17.64-23.54 t/ha) was recorded under Potato-Boro-T. Aman (CP_3) cropping pattern. In contrast, the check pattern, Boro-Fallow-T. Aman, resulted in significantly lower productivity. Among the remaining cropping patterns, total productivity ranged from 10.30 to 17.27 t ha^{-1}. In the CP_3 cropping pattern, total productivity declined during 2022-23 and 2023-24 due to severe infestation of late blight disease in potato. Similarly, in CP_4, CP_5 and CP_7, total productivity decreased markedly as a result of poor germination of mungbean, damage to lentil crops, and waterlogging caused by Cyclone Hamoon, which ultimately reduced the yield of T. Aman rice.

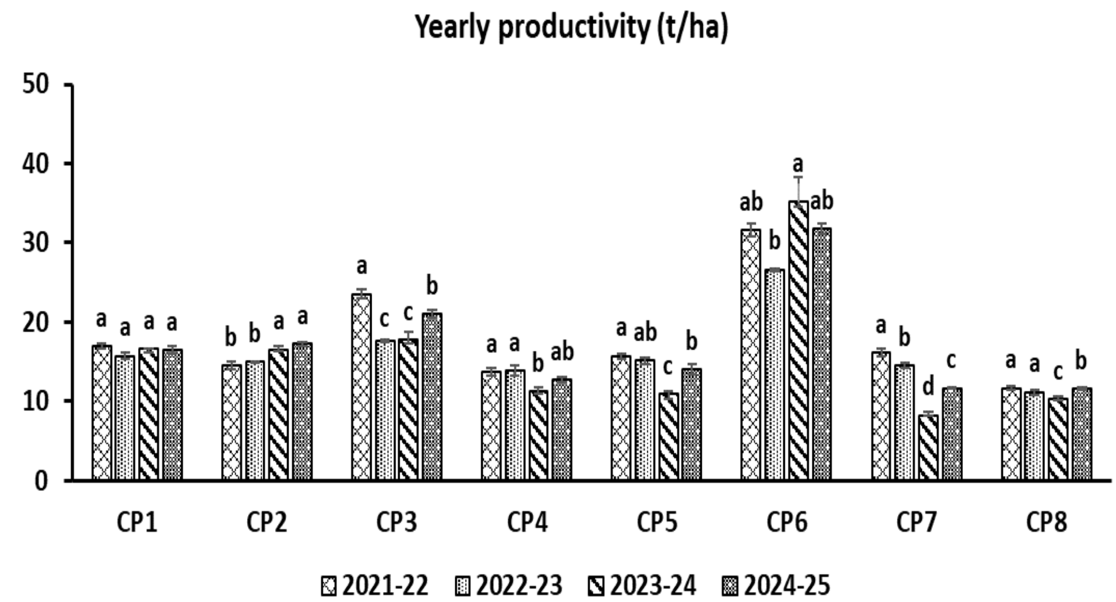


Figure 1. Year wise (2021-2025) productivity of different experimental cropping pattern (2021-2025)

Stability and Production efficiency (kg/ha/day)

Regarding stability, Boro-T. Aus-T. Aman (CP_1) cropping pattern exhibited the highest stability, followed by the check pattern, Boro-Fallow-T. Aman (CP_8). It may be occurred due to relatively stable production of rice and absence of any severe outbreaks of devastating disease occurred during the experimental years. Mustard-Boro-T. Aman cropping pattern also showed potential stability among the remaining cropping pattern. In contrast, CP_7 (Lentil-T. Aus-T. Aman) cropping patterns exhibited the lowest stability, which can be attributed to repeated lentil damage over two consecutive years, resulting in pronounced yield variability across the experimental years.

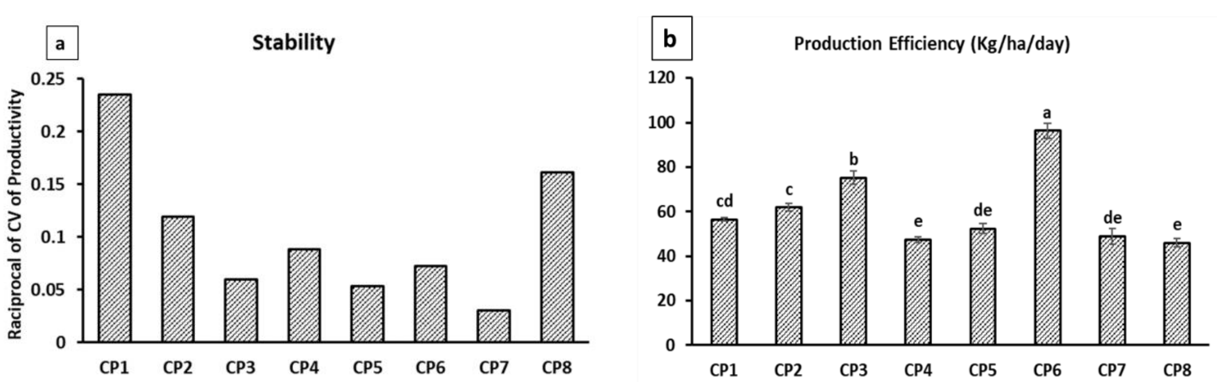


Figure 2. a) Stability and b) Production Efficiency (kg/ha/day) of different cropping patterns (2021-2025)

In terms of production efficiency (kg ha^{-1} day^{-1}), Onion-Jute-T. Aman (CP_6) pattern recorded the highest value (96.27 kg ha^{-1} day^{-1}), closely followed by the Potato-Boro-T. Aman (CP_3) pattern (75.16 kg ha^{-1} day^{-1}). The lowest production efficiency was observed in the check pattern (CP_8) at 51.38 kg ha^{-1} day^{-1}. On average, production efficiency was increased by 36% compared with the Boro-Fallow-T. Aman cropping pattern.

Economic aspect

From an economic perspective, Onion-Jute-T. Aman cropping pattern was the most profitable, with MBCR values ranging from 1.71 to 4.71. Potato-Boro-T. Aman pattern also showed satisfactory profitability (1.02-3.41). Cropping patterns that included oilseed crops Mustard, exhibited favorable MBCR values as well, likely due to its stable higher market price. The negative value comes from CP_7 (Lentil-T. Aus-T. Aman) cropping pattern as earlier mentioned that the damage of lentil in consecutive two years among the four experimental years.

Table 12. Cost-return analysis of different crops combinations under three cropped cropping patterns, Gazipur, 2021-25

CPs	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
CP_1	231-251	154-194	0.87-2.47
CP_2	185-220	154-228	0.84-3.03
CP_3	300-317	141-271	0.84-2.07
CP_4	190-246	61-152	0.18-0.65
CP_5	212-230	46-181	0.25-2.14
CP_6	299-496	367-582	1.71-4.71
CP_7	174-223	-17-229	-0.93-0.62
CP_8 (Check)	167-202	88-174	-

TVC=Total Variable Cost, GM=Gross Margin, MBCR=Marginal Benefit Cost Ratio

Onion-Jute-T. Aman cropping pattern (CP_6) exhibited the highest increase in gross margin and total variable cost compared with the check pattern, averaging 246% and 170% respectively. The Potato-Boro-T. Aman (CP_3) and Mustard-Boro-T. Aman (CP_1) cropping patterns also showed substantial increases in gross margin, at 84% and 48%, respectively, over the check pattern. Gross margin was negative in case of Wheat-Mungbean- T. Aman cropping pattern and Lentil-T. Aus-T. Aman cropping pattern because of the germination problem of mungbean and damage of lentil in consecutive two years. Moreover, water logging effect of cyclone in 2023-24 also reduced the yield of T. Aman. So, average gross margin was negative in those years which leads to average negative gross margin. In case of MBCR value, the highest value (2.86) obtained from Onion-Jute-T. Aman cropping pattern (CP_6) which is followed by Potato-Boro-T. Aman (CP_3) and Mustard-Boro-T. Aman (CP_1) cropping patterns. The negative value (0.05) was spotted from Lentil-T. Aus-T. Aman (CP_7) cropping pattern.

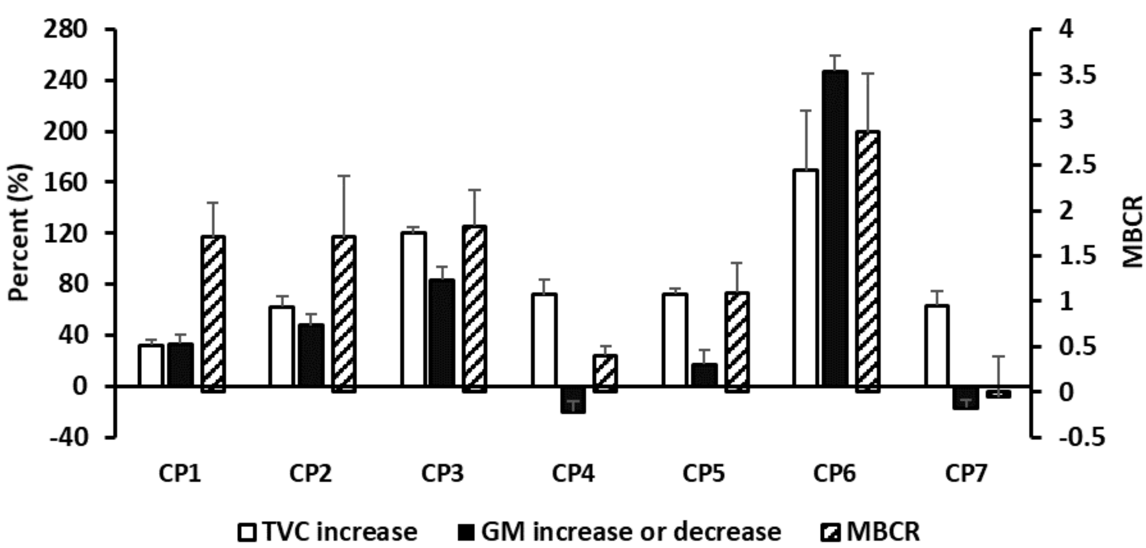


Figure 3. Economic benefit of different three cropped cropping patterns over Boro-Fallow-T. Aman cropping pattern (2021-2025)

Nutritional Aspect

From a nutritional perspective, Boro-T. Aus-T. Aman cropping pattern produced the highest carbohydrate (8096 kg/ha) and energy (193 GJ/ha) yields. Wheat-Mungbean-T. Aman pattern contained the highest protein (1176 kg/ha) and total dietary fiber (491 kg/ha). Maximum fat content was observed in Mustard-Boro-T. Aman and Sunflower-Boro-T. Aman patterns. Although Onion-Jute-T. Aman cropping pattern was highly profitable, it provided lower nutritional value due to the limited macronutrient content of onion and the use of jute stalks as fuel, which contributed no nutritional value.

Table 13. Proximate nutrient composition of the evaluated cropping pattern, BRRI, Gazipur, 2021-25

Cropping pattern	Carbohydrate (kg/ha)	Protein (kg/ha)	Fat (kg/ha)	Total dietary fiber (kg/ha)	Energy (GJ/ha)
CP_1=Boro-T. Aus-T. Aman	8096 a	685 c	42 d	358 d	193 a
CP_2=Mustard-Boro-T. Aman	4475 e	522 f	448 a	277 fg	112 d
CP_3=Potato-Boro-T. Aman	7166 b	606 d	52 d	451 b	152 b
CP_4=Wheat-Mungbean-T. Aman	5103 de	1167 a	139 c	491 a	146 b
CP_5=Sunflower-T. Aus-T. Aman	4927 e	560 e	410 b	290 f	111 d
CP_6=Onion-Jute-T. Aman	3193 g	428 g	28 d	380 c	105 d
CP_7=Lentil-T. Aus-T. Aman	5276 d	814 b	31 d	313 e	109 d
CP_8=Boro-Fallow-T. Aman (Ck)	5974 c	505 f	30 d	264 g	93 e
CV (%)	2.23	2.15	12.8	3.1	3.12

Ref: Shaheen *et al*., 2013. Food Composition Table for Bangladesh, Dhaka, University of Dhaka

System nutritional yield (adults/ha/year)

Nutritional yield (adults/ha/year) indicates the number of adults whose daily nutritional requirements can be met by the production of per hectare of land in a year. The three-rice cropping pattern (CP_1) produced the highest nutritional yield of carbohydrate, supporting 72 adults/ha/year, followed by the Potato-Boro-T. Aman pattern (CP_3). The maximum protein yield, sufficient for 62 adults/ha/year, was obtained from Wheat-Mungbean-T. Aman pattern (CP_4). For fat, the highest nutritional yield (18 adults/ha/year) was observed in the Mustard-Boro-T. Aman pattern (CP_2).

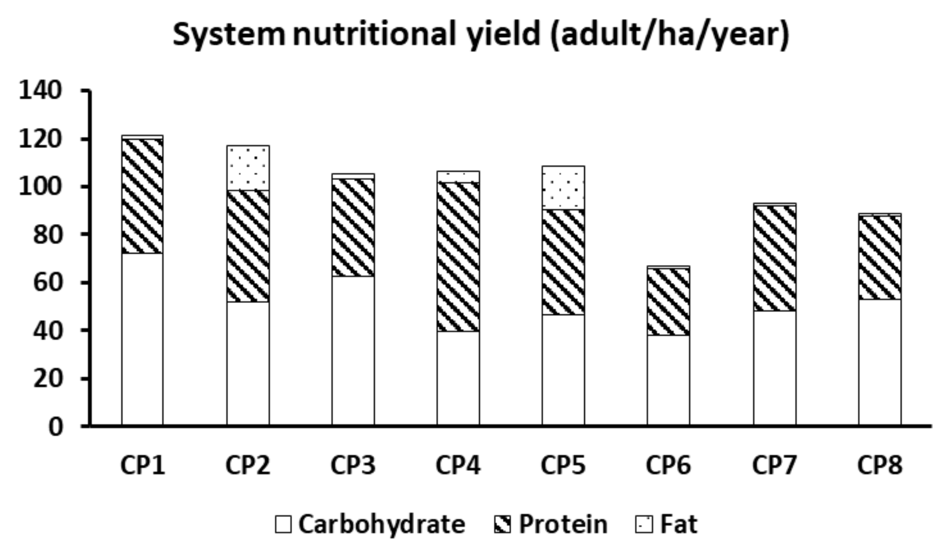


Figure 4. System nutritional yield (adults/ha/year) of different cropping pattern (2021-2025)

Z- score based comparison of different cropping pattern

Since different cropping patterns performed best for different parameters, the overall best cropping pattern according to Z- score based comparison was identified as Boro-T. Aus-T. Aman cropping pattern. The second ranked pattern was CP_3 (Potato-Boro-T. Aman), while the highly profitable and productive CP_6 (Onion-Jute-T. Aman) achieved fourth rank. This may be attributed to the fact that Boro-T. Aus-T. Aman cropping pattern was the most stable and comparatively more productive, while also exhibiting the highest system nutritional yield (adults ha^{-1} $year^{-1}$) and the greatest values for most nutritional parameters. Although Onion-Jute-T. Aman cropping pattern showed the highest profitability, it performed comparatively lower in terms of stability and nutritional attributes.

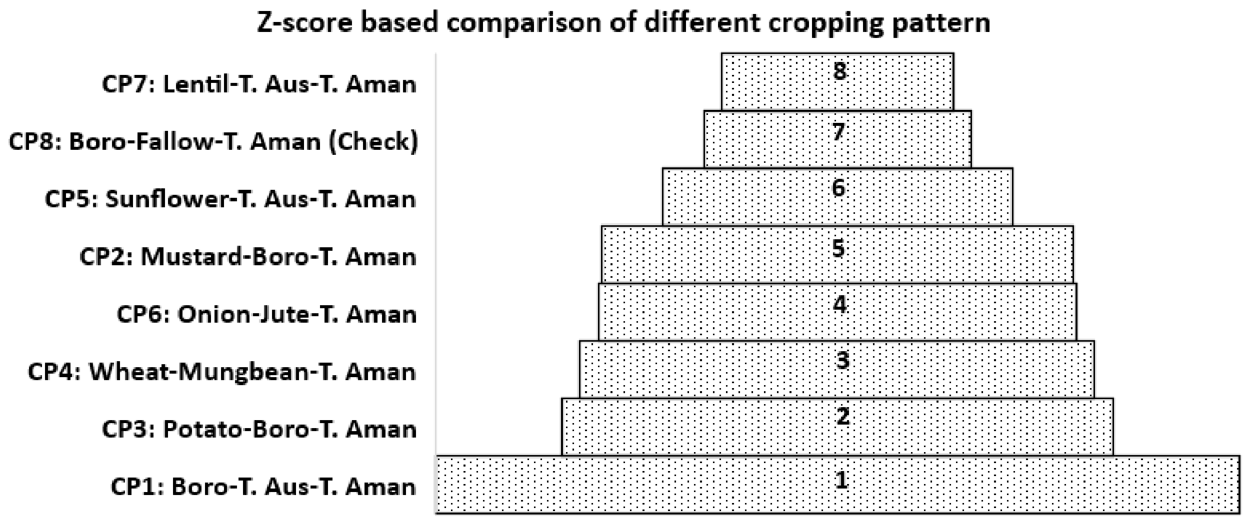


Figure 5. Z- score based comparison of different cropping pattern (2021-2025)

Conclusion

Based on the analysis of cropping patterns from 2021 to 2025, Onion-Jute-T. Aman cropping pattern exhibited the highest profitability, overall productivity, and production efficiency (kg ha^{-1} day^{-1}). However, in terms of stability and nutritional performance, Boro-T. Aus-T. Aman cropping pattern performed best. According to the Z-score–based comparison, the three-rice based cropping pattern ranked first, whereas Onion-Jute-T. Aman pattern ranked fourth among the eight evaluated cropping patterns. According to the Z-score–based comparison, the lowest performance was recorded for Lentil-T. Aus-T. Aman cropping pattern, mainly due to lentil crop damage for two years, which resulted in lower productivity and greater instability compared with the check pattern. Nevertheless, Mustard-Boro-T. Aman and Potato-Boro-T. Aman cropping patterns also demonstrated sustainable profitability potential.

Expt. 2.2. Performance evaluation of four-cropped cropping pattern for irrigated medium high land ecosystem

N Parvin, T Araf, MK Quais and M Ibrahim

Introduction

The land area under double and triple cropped is around 44,55,305 and 19,96,365 ha, respectively, which means that about 52.0% and 24.0% of the country's net cropped area (Nasim *et al.,* 2017) has avenues partly or a major portion to be brought under quadruple cropping system. The area of cropland is decreasing, that is why there is minimum option of horizontal expansion. Focus should be given on intensifying land use system through multiple cropping or by growing more crops on the same piece of land. However, agriculture is heading towards a new paradigm to address the country's food security. Cultivation of modern crop varieties, improvising cultural operations, and crop protection measures as well as increasing cropping intensity are inevitable for doubling the productivity to meet the demand of growing population of the country. Recognizing the magnitude of the above-mentioned issues, the present study was undertaken with the following objective:

-To evaluate the agronomic and economic performance of four cropped cropping patterns.

Materials and Methods

An experiment was conducted at the BRRI research farm, Gazipur during 2022-25 (three years) to compare the yield and profitability of four-cropped cropping patterns viz.

CP_1: Tomato-Mungbean-T. Aus-T. Aman,

CP_2: Mustard-Boro-T. Jute-T. Aman,

CP_3: Mustard-Mungbean-T. Aus-T. Aman,

CP_4: Potato\Pumpkin-T. Aus-T. Aman,

CP_5: Potato+Maize-T. Aus-T. Aman,

CP_6: Mustard-Vegetable-T. Aus-T. Aman,

CP_7: Mustard-Boro-T. Aman (Ck)

Seeding and transplanting date, harvesting date and field duration of different cropping pattern are presented in Table 14, 15 and 16. All cultural and pest management practices were done according to BRRI and BARI recommendations.

Rice Equivalent Yield (REY):

For comparison between cropping pattern, the yield of all crops was converted into rice equivalent yield (REY) on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). Rice Equivalent Yield (t ha^{-1}) = (Yield of individual crop × Market price of that crop)/ Market price of rice.

Productivity and Stability: Productivity and Stability of cropping system were analyzed according to Conway, 1987.

Production efficiency (PE): Production efficiency in terms of Kg ha^{-1} day^{-1} was calculated by total production in a cropping pattern divided by total duration of crops in that pattern (Tomer and Tiwari, 1990).

Production efficiency (PE): $Y_1 + Y_2 + Y_3/d_1 + d_2 + d_3$ (Kg ha^{-1} day^{-1})

Here, Y_1: Yield of first crop; and d_1: Duration of first crop of the pattern; Y_2: Yield of second crop; and d_2: Duration of second crop of the pattern; Y_3: Yield of third crop; and d_3: Duration of first crop of the pattern.

Table 14. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2022-2025

Factor	CP_1: Tomato-Mungbean-T. Aus-T. Aman				CP_2: Mustard-Boro-T. Jute-T. Aman			
	Tomato**	Mungbean*	T. Aus	T. Aman	Mustard	Boro	T. Jute	T. Aman
Variety	BARI Tomato-14, 19, 21	BARI Mung-6	BRRI dhan48, 98	BRRI dhan75	BARI Sarisha-14	BRRI dhan88	BJRI Tossa Pat-8	BRRI dhan71
D/S	16-19 Oct.	20-22 Feb	01-18 Apr	27Jun-21 Jul	11-15 Nov	28 Dec-02 Jan	10-17 Apr	13 Jul-08 Aug
D/T	04-14 Nov		22 Apr-10 May	21 Jul-09 Aug	-	31 Jan-10 Feb	09-11 May	08-16 Aug
D/H	19 Feb-16 Mar	20 April	16-31 Jul	16 Oct-04 Nov	31 Jan-01 Feb	02-08 May	31July-2 Aug	05-12 Nov
FD (days)	102-122	60	82-85	85-87	78-79	87-92	83-86	88-90

*Germination problem in 2023-24, 2024-25; ** Late blight attacked in 2023-24

Table 15. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2022-2025

Factor	CP_3: Mustard-Mungbean-T. Aus-T. Aman				CP_4: Potato\Pumpkin-T. Aus-T. Aman			
	Mustard	Mungbean*	T. Aus	T. Aman	Potato	Pumpkin	T. Aus	T. Aman
Variety	BARI Sarisha-14	BARI Mung-6	BRRI dhan48, 98	BRRI dhan71	Asterix	Hybrid	BRRI dhan98	BRRI dhan90
D/S	11-15 Nov	06-25 Feb	4-18 Apr	03-23 Jul	15-20 Nov	02-08 Dec	01-18 Apr	13-21 Jul
D/T	-	-	22Apr-10 May	24 Jul-8 Aug	-	23-26 Dec	24 Apr- 09 May	08-13 Aug
D/H	29 Jan-01 Feb	01-08 May	16 Jul-11 Aug	22Oct-10 Nov	16-25 Feb	18 Apr-25 Mar	18-30 Jul	06-10 Nov
FD (days)	79-78		82-94	90	90-97	61-90	83-84	89-90

*Germination problem in 2024-25

Table 16. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2022-2025

Factors	CP_5: Potato+Maize-T. Aus-T. Aman				CP_6: Mustard-Veg-T. Aus-T. Aman			
	*Potato	Maize	T. Aus	T. Aman	Mustard	**Indian spinach	T. Aus	T. Aman
Variety	Asterix	BARI Hybrid Maize-16	BRRI dhan98	BRRI dhan71	BARI Sarisha-14, 18	BARI Puishakh-2, Madhuri	BRRI dhan98	BRRI dhan71
D/S	15-20 Nov	24 Dec-4 Jan	18-27 Apr	13-25 Jul	11-15 Nov	06 Feb-1 Mar	18 Apr	16-21 Jul
D/T	-	-	07-19 May	05-13 Aug	-		07-10 May	7-8 Aug
D/H	15-25 Feb	22 Apr-9 May	30 Jul-10 Aug	04-14 Nov	24 Feb-29 Jan	9-10 May	31 Jul-04 Aug	16 Oct-6 Nov
FD (days)	90-97	119-126	83-84	87-91	77-101	63-84	82-87	89-92

Factors	CP_7: Mustard-Boro-T. Aman (control)		
	Mustard	Boro	T. Aman
Variety	BARI Sarisha-14, 18	BRRI dhan88	BRRI dhan75
D/S	11-15 Nov	30 Dec-13 Jan	25-30 June
D/T	-	06-26 Feb	15-21 July
D/H	04-19 Feb	17-28 May	08-20 Oct
FD (days)	80-100	92-100	85-91

***Potato: Damaged due to water logged, 2024-25, ** Indian spinach was damaged due to re-construction of experimental plot, 2024-25

Result and discussion

Yield

Average individual crop yield of respective cropping patterns from 2022 to 2025 are presented in Table 17. The yield of tomato was 22.41 t/ha under Tomato-Mungbean-T. Aus-T. Aman cropping pattern (CP_1). Tomato mean yield was comparatively lower due to a severe outbreak of late blight during the 2023–24. Yield of Mustard were 1.05, 1.43, 1.48 and 1.37 t/ha under CP_2, CP_3, CP_6 and CP_7, respectively. Potato yield was 19.49 t/ha under Potato/Pumpkin-T. Aus-T. Aman (CP_4). On the other hand, potato yield (9.24 t/ha) was lower under Potato+Maize-T. Aus-T. Aman cropping pattern (CP_5) due to water logged condition during reconstruction of experimental plot 2024-24. Maize yielded under Maize+Potato-T. Aus-T. Aman (CP_5) was 7.40 t/ha. Yield of mungbean was 0.24 t/ha under CP_1 that faced heavy rain and damaged in 2023-24 and 2024-25. Again mungbean under CP_3, where germination problem was occurred in 2024-25 and yield was lower. Pumpkin yielded 8.30 t/ha which was intercropped with potato under Potato\Pumpkin-T. Aus-T. Aman (CP_4) cropping pattern. The mean yield of vegetable (Indian spinach) was lower (5.25 t/ha) due to reconstruction of experimental plot under Mustard-Vegetable-T. Aus-T. Aman cropping pattern (CP_6) in 2024-24. Jute yielded 1.54 t/ha under Mustard-Boro-T. Jute-T. Aman (CP_2). The yields of Boro rice were 5.51 and 5.43 t/ha under Mustard-Boro-T. Jute-T. Aman (CP_2) and Mustard-Boro-T. Aman (Ck.) cropping pattern, respectively. Aus rice yielded 4.21 to 4.60 t/ha under different cropping patterns. Short duration T. Aman rice varieties were used in all the patterns which yielded 4.22 to 5.07 t/ha.

Table 17. Yields of different crop under four cropped cropping patterns, BRRI, Gazipur, 2022-25

Cropping pattern	Yield (Mean ± SE t/ha)										
	Tomato	Mustard	Potato	Maize	Mungbean	Pumpkin	Vegetable	Boro	T. Jute	T. Aus	T. Aman
CP_1	22.41±2.25	-	-	-	0.24±0.12	-	-	-	-	4.21±0.09	4.22±1.01
CP_2	-	1.05±0.18	-	-	-	-	-	5.51±0.69	1.54±0.39	-	4.68±0.20
CP_3	-	1.43±0.06	-	-	0.52±0.11	-	-	-	-	4.53±0.12	5.07±0.12
CP_4	-	-	19.49±0.76	-	-	8.30±0.29	-	-	-	4.37±0.11	4.37±0.16
CP_5	-	-	9.24±3.96	7.40±0.42	-	-	-	-	-	4.60±0.14	4.62±0.19
CP_6	-	1.48±0.04	-	-	-	-	5.25±2.28	-	-	4.39±0.05	5.07±0.14
CP_7 (Ck.)	-	1.37±0.07	-	-	-	-	-	5.43±0.11		-	4.54±0.09

Productivity & Production efficiency (PE)

From 2022-23 to 2024-25, all REY of every year were analysed. The highest and statistically similar productivity resulted from CP_1, CP_4, CP_5, followed by CP_2, CP_3 and CP_6 which were also similar with each other. The control three crop (CP_7) had lowest productivity. The trend of production efficiency also same as Productivity (Figure 6).

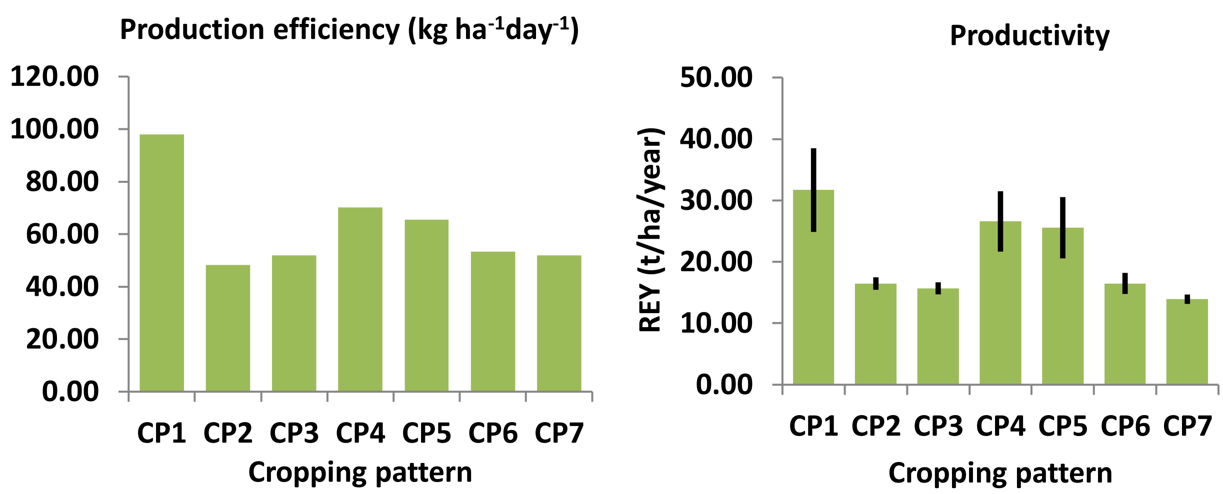


Figure 6. Production efficiency and productivity of different four-cropped cropping patterns (2022-25)

Stability

On the contrary, reverse finding observed from the analysis. The lowest stability resulted from CP_1, CP_4, CP_5 those were already showed highest productivity. whereas, the highest stability obtained from CP_2, CP_3 and CP_6 those were already showed lowest productivity. Again, the three crop (CP_7) had lowest productivity but showed maximum stability (Figure 7).

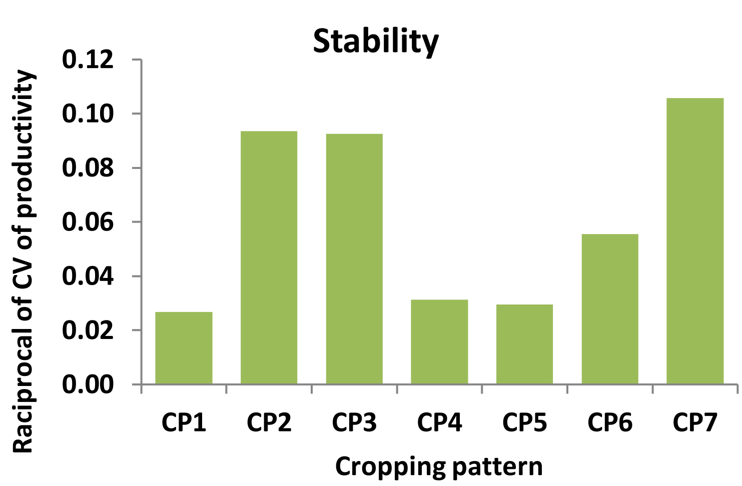


Figure 7. Stability of different four-cropped cropping patterns (2022-25)

Economic aspect

From 2022-23 to 2024-25; all economics of every year were analysed. The highest GM resulted from CP_1 followed by CP_4 and CP_5 and lowest was CP_2. However, tomato (CP_1) and potato-based pattern (CP_4, CP_5) needed the highest variable costs. whereas, CP_2, CP_3, and CP_6 comparatively lower and CP_7 showed lowest variable costs.

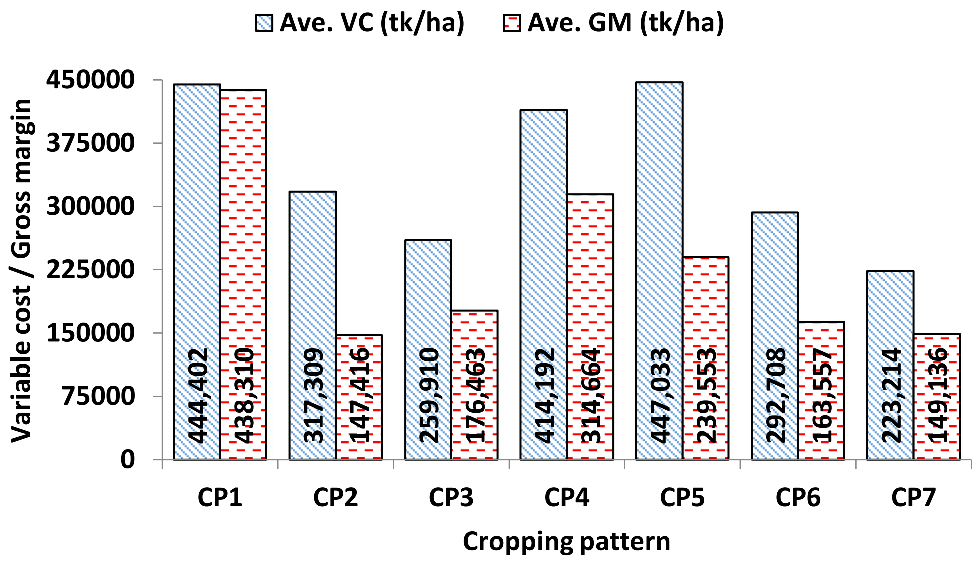


Figure 8. Cost-return analysis of different cropping patterns, 2022-25
Price (Tk/kg): Tomato=15-30, Mustard=80, Potato=15-30, Maize=30, Pumpkin=20, Mungbean=90, Jute=50-60, Vegetable (Indian spinach) =15, Rice=25-32, Rice straw= 4, Jute stick=10, Stover=6

Nutritional yield and energy output

The nutritional composition and energy productivity of seven cropping patterns (CP_1-CP_7) were evaluated in terms of protein, fat, total dietary fiber, carbohydrate yield, and total energy output per hectare. Significant variations were observed among the cropping patterns, indicating strong effects of crop combinations on nutritional and caloric productivity (Table 18).

Among the systems, CP_5 (Potato-Maize-T. Aus-T. Aman) recorded the highest protein yield (1235 kg ha^{-1}), dietary fiber (923 kg ha^{-1}), carbohydrate production (9189 kg ha^{-1}), and energy output (245 GJ ha^{-1}), demonstrating its superior capacity to supply both macronutrients and dietary energy. This performance may be attributed to the inclusion of maize and potato, which are high-yielding and carbohydrate-rich crops. CP_3 (Mustard-Mungbean-T. Aus-T. Aman) also showed comparatively high protein content (1035 kg ha^{-1}) and moderate fiber and energy values, suggesting its potential as a nutritionally balanced cropping system. In contrast, CP_4 (Potato-Pumpkin-T. Aus-T. Aman) exhibited the lowest protein (567 kg ha^{-1}) and fat (85 kg ha^{-1}) yields, despite relatively high carbohydrate production, indicating limited protein contribution. Fat yield varied significantly among cropping patterns, with CP_2 and CP_7 showing comparatively higher fat content, likely due to the inclusion of mustard, an oilseed crop. Check CP Mustard-Boro-T. Aman however, produced the lowest energy output (81 GJ ha^{-1}), reflecting lower overall biomass and nutrient productivity.

Table 18. Proximate nutrient composition of the evaluated cropping pattern, BRRI, Gazipur, 2022-25

Cropping pattern	Protein (kg/ha)	Fat (kg/ha)	Total dietary fiber (kg/ha)	Carbohydrate (kg/ha)	Energy (GJ/ha)
CP_1=Tomato-Mungbean-T. Aus-T. Aman	925 bc	105 de	673 b	5225 cd	121 b
CP_2=Mustard-Boro-T. Jute-T. Aman	725 cd	437 c	353 de	5562 c	136 b
CP_3=Mustard-Mungbean-T. Aus-T. Aman	1035 b	674 a	504 cd	5465 c	135b
CP_4=Potato\Pumpkin-T. Aus-T. Aman	567 d	85 e	386 e	7059 b	167 b
CP_5=Potato+Maize-T. Aus-T. Aman	1235 a	256 d	923 a	9189 a	245 a
CP_6=Mustard-Vegetable-T. Aus-T. Aman	854 c	578 b	563 c	5461 c	131 b
CP_7=Mustard-Boro-T. Aman (Ck)	568 e	634 ab	427 d	4390 d	81 c
CV (%)	6.89	9.23	8.47	8.43	8.38

Conclusion

The evaluation of four-cropped cropping patterns under an irrigated medium high land ecosystem demonstrated a distinct overview among productivity, stability, and economic and input requirements. Cropping patterns CP_1, CP_4, and CP_5 exhibited superior production potential, as reflected by significantly higher rice equivalent yield, production efficiency, and gross margin; however, these systems were associated with higher variable input costs and reduced temporal stability. In contrast, CP_2, CP_3, and CP_6, though comparatively less productive, provided greater yield stability across years, indicating stronger system resilience. The conventional three-crop system (CP_7) remained the most stable and input-efficient, albeit with the lowest productivity. Notable variation was also observed in nutritional and energy outputs among cropping patterns, with CP_5 (Potato-Maize-T. Aus-T. Aman) achieving the highest protein, dietary fiber, carbohydrate, and energy yields, thereby offering superior nutritional performance. Mustard-based systems enhanced fat yield but contributed less to overall energy production. Overall, the findings suggest that selection of an appropriate cropping pattern should be guided by farmers' priorities, balancing productivity, economic return, stability, and nutritional output.

Expt. 2.3. Feasibility of Boro ratooning and mustard inclusion in Boro-Fallow-T. Aman cropping pattern in irrigated medium highland ecosystem

MK Quais, T Araf, T Husna and M Ibrahim

Introduction

In Bangladesh total cultivable land is 8.5 million hectare and it is shrinking day by day. The annual loss of agricultural land is about 0.4% per annum due to construction of houses, roads and industrial infrastructure. There is no other alternative but to increase total productivity per unit area of the prevailing lands. To increase system productivity, it needs to bring diversity in enterprises for better utilization of limited resources. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing more crops in the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices.

The cropping system (CS) of a particular land is the cropping pattern (CP) being practiced and its interaction with the other resources of the farm. Based on the prevailing climatic conditions, Bangladesh has diverse CSs followed across the country. More than 300 CSs are identified across the country, among which rice-based CSs covered nearly 80% of the CSs followed. The most dominant CS is Boro rice-Fallow-T. Aman rice, which covers 27% of the net cropped area. Between T. Aman rice harvest and Boro crop establishment, there is a wet-dry transition period of more than 80 days. Farmers keep their lands fallow during this transition period. But during this transition period farmers can easily grow short duration rabi crops, which may increase the total productivity of the system.

Major oilseed crops cultivated in Bangladesh include Rapeseed mustard/mustard, sunflower, peanut, sesame, and soybeans, of which only Rapeseed mustard/mustard goes to edible oil production. Locally produced oilseeds meet only 15-20 percent of the country's edible oil requirements, and the rest are imported as crude oil or as oilseeds. The government of Bangladesh has set a goal to reduce 40% of oilseed imports by the fiscal 2024-25. Boosting rape seed production and productivity will be achieved through the adoption of improved high-yield varieties and crop management. In addition, the integration of mustard into the Boro-Fallow-T. Aman rice cropping system is one of the interventions to increase mustard production in the country. However, accommodating mustard in the Boro -Fallow-T. Aman rice requires some adjustment with the varieties used for all three crops- Boro, Mustard, and T. Aman rice. Instead of current long-duration varieties, short-duration high-yielding varieties, especially for T. Aman rice and Mustard, are essential. Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Institute (BARI), and Bangladesh Institute of Nuclear Agriculture (BINA) have developed many short-duration T. Aman rice and mustard varieties with higher yield potential.

Mustard-Boro-T. Aman cropping pattern in Bangladesh leaves a fallow period of approximately 60-65 days between the harvesting of Boro rice and the transplanting of T. Aman rice. Additionally, BRRI has developed short-duration, high-yielding T. Aman rice varieties that can be transplanted in the last week of July without significant yield losses. This creates a promising opportunity to utilize the fallow period for cultivating ratoon rice. Alternatively, the productivity of the Boro-Fallow-T. Aman system could be enhanced by omitting T. Aman rice entirely. This would allow for the earlier sowing of high-yielding mustard varieties, even those with slightly longer durations, up to mid-February. In such a case, it becomes essential to identify Boro rice varieties with strong ratooning ability to compensate for the foregone T. Aman yield. With this view in mind the present study was undertaken to intensify the existing Boro-Fallow-T. Aman cropping pattern through the inclusion of mustard and Boro ratoon technology and to increase the productivity of the system as well.

Methodology

The trials are being conducted at the experimental farm, BRRI, Gazipur during 2024-25. The tested cropping patterns (CP) were:

CP_1= Mustard-Boro-T. Aman

CP_2= Mustard-Boro-Ratoon Boro-T. Aman

CP_3= Mustard-Boro-Ratoon Boro

CP_4= Boro- Ratoon Boro-T. Aman

CP_5= Boro-Fallow-T. Aman (Check)

During the T. Aman season, rice varieties BRRI dhan71, BRRI dhan75, and BRRI dhan87 were cultivated. BARI Sarisha-14 and BARI Sarisha-17 were sown following the harvest of the T. Aman crops. During Boro season, BRRI dhan74, 100, 102, and 107 were transplanted. For Boro ratooning two methods were followed viz conventional and salibu technique (Figure 9, 10). In conventional ratooning, the Boro crop is harvested at approximately 80% maturity, maintaining a stubble height of 30 cm, with soil moisture ensured in case of dryness. Post-harvest management includes weeding and the application of 10 kg urea, 6.5 kg TSP and 5.5 kg MoP fertilizers per 33 decimals, three days after harvest under adequately moist soil conditions. A subsequent fertilizer dose, consisting of 10 kg urea and 5.5 kg MoP per 33 decimals, was applied seven days after harvest.

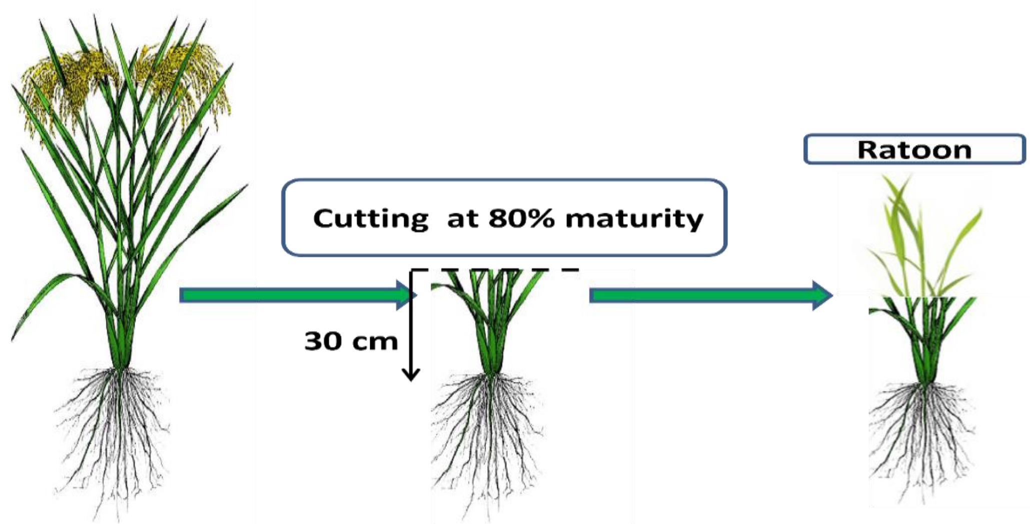


Figure 9. Schematic illustration of the Conventional ratooning

In the Salibu ratooning method, the Boro crop is harvested at approximately 80% maturity, leaving a stubble height of 30 cm and soil moistened with light irrigation. Three days after harvest, weeding is carried out followed by fertilizer application at the rate of 7 kg urea, 6.5 kg TSP and 4 kg MoP per 33 decimals. A second cut is performed 10 days after the initial harvest, reducing the stubble height to 5 cm. Subsequently, fertilizer is applied three days after the second cut at a rate of 6.5 kg urea and 3.5 kg MoP per 33 decimals. An additional fertilizer dose of 6.5 kg urea and 3.5 kg MoP per 33 decimals is applied seven days after the second cut.

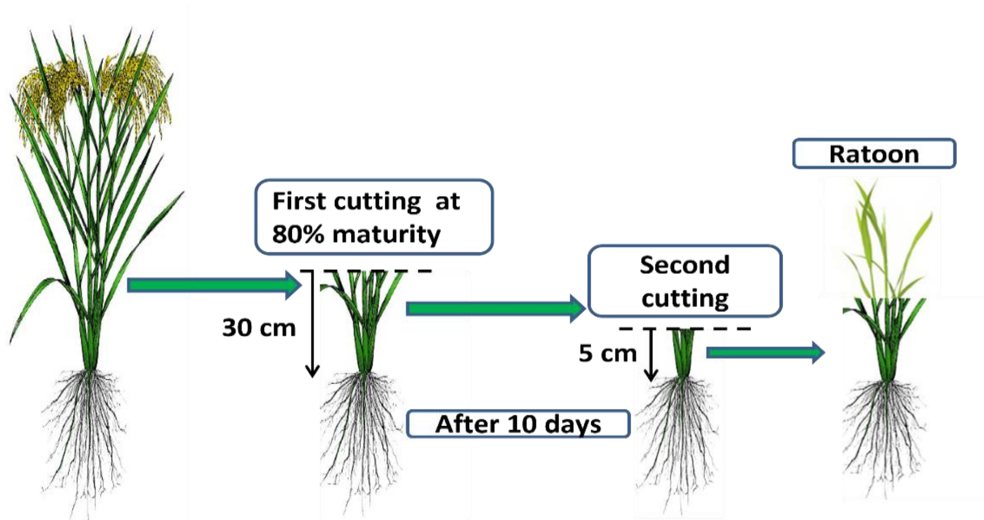


Figure 10. Schematic illustration of the Salibu technology

The experiments were laid on a split-plot design with cropping pattern treatments as the main plot and varieties as subplots. The main plots were not replicated, while subplots were randomized completely within the main plots with three replications. BRRI and BARI recommended management practices were followed for the cultivating the varieties (**Tables 19-22**).

Table 19. Crop management practices adopted in Mustard, Boro, and T. Aman rice cultivation under Mustard-Boro-T. Aman (CP_1) cropping pattern, BRRI, Gazipur 2024-25

Mgt. factors	Mustard		Boro		T. Aman	
Variety	BARI Sarisha-14	BARI Sarisha-17	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan87	BRRI dhan71, 75
Seeding date	08 Nov 2024	08 Nov 2024	23 Dec 2024	23 Dec 2024	30 Jun 2024	30 Jun 2024
Seed rate (kg/ha)	1	1	30	30	30	30
TP date			28 Jan 2025	28 Jan 2025	20 Jul 2024	20 Jul 2024
Spacing (cm×cm)	Broadcasting	Broadcasting	20×20	20×20	20×20	20×20
Seedling/hill	-	-	2-3	2-3	2-3	2-3
Fertilizer (kg/ha): N, P, K, S, Zn& B	115-34-43-24-2-2	115-34-43-24-2-2	138-20-83-18-4.5	121-18-75-18-4.5	76-12-53-11-0-0	69-10-41-10-0-0
Weeding (Times)	1	1	3	2	2	2
Maturity date	22 Jan 2025	23 Jan 2025	03-11 May 2025	29 Apr 2025	02-03 Nov 2024	16-26 Oct 2024
Growth duration (days)	75	76	131-139	127	125-126	108-118

Table 20. Crop management practices adopted in Mustard, Boro, Ratoon Boro and T. Aman rice cultivation under Mustard-Boro-Ratoon Boro-T. Aman (CP_2) cropping pattern, BRRI, Gazipur 2024-25

Mgt. factors	Mustard		Boro		Boro Ratoon		T. Aman	
Variety	BARI Sarisha-14	BARI Sarisha-17	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan87	BRRI dhan71, 75
Seeding date/ main crop cutting date	08 Nov 2024	08 Nov 2024	23 Dec 2024	23 Dec 2024	03-11 May 2025	29 Apr 2025	30 Jun 2024	30 Jun 2024
Seed rate (kg/ha)	1	1	30	30	-	-	30	30
TP date	-	-	28 Jan 2025	28 Jan 2025	-	-	20 Jul 2024	20 Jul 2024
Spacing (cm×cm)	Broadcasting	Broadcasting	20×20	20×20	-	-	20×20	20×20
Seedling/hill	-	-	2-3	2-3	-	-	2-3	2-3
Fertilizer (kg/ha): N, P, K, S, Zn& B	115-34-43-24-2-2	138-36-50-29-3-3	138-20-83-18-4.5	121-18-75-18-4.5	69-10-41.5-0-0	60.5-9-37.5-0-0	76-12-53-11-0-0	69-10-41-10-0-0
Weeding (Times)	1	1	3	2	2	2	2	2
Maturity date	22 Jan 2025	23 Jan 2025	03-11 May 2025	29 Apr 2025	21 Jul-21 Aug 2025	20 Jul-06 Aug 2025	03 Nov 2024	16-26 Oct 2024
Growth duration (days)	75	76	131-139	127	79-103	82-99	126	108-118

Table 21. Crop management practices adopted in Mustard, Boro and Ratoon Boro rice cultivation under Mustard-Boro-Ratoon Boro (CP_3) cropping pattern, BRRI, Gazipur 2024-25

Mgt. factors	Mustard		Boro		Boro Ratoon	
Variety	BARI Sarisha-14	BARI Sarisha-17	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan100, 102, 107	BRRI dhan74
Seeding date/ main crop cutting date	02 Nov 2024	02 Nov 2024	15 Dec 2024	15 Dec 2024	28 Apr-08 May 2025	24 Apr 2025
Seed rate (kg/ha)	1	1	30	30	-	-
TP date	-	-	21 Jan 2025	21 Jan 2025	-	-
Spacing (cm×cm)	Broadcasting	Broadcasting	20×20	20×20	-	-
Seedling/hill	-	-	2-3	2-3	-	-
Fertilizer (kg/ha): N, P, K, S, Zn& B	115-34-43-24-2-2	138-36-50-29-3-3	138-20-83-18-4.5	121-18-75-18-4.5	69-10-41.5-0-0	60.5-9-37.5-0-0
Weeding (Times)	1	1	3	2	2	2
Maturity date	18 Jan 2025	19 Jan 2025	28 Apr-08 May 2025	24 Apr 2025	15 Jul-21 Aug 2025	16 Jun-07 Aug 2025
Growth duration (days)	77	78	134-144	130	79-107	53-105

Table 22. Crop management practices adopted in Boro, Ratoon Boro and T. Aman rice cultivation under Boro-Ratoon Boro-T. Aman (CP_4) and Boro-Fallow-T. Aman (CP_5) cropping pattern, BRRI, Gazipur 2024-25

Mgt. factors	Boro		Ratoon Boro		T. Aman	
Variety	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan100, 102, 107	BRRI dhan74	BRRI dhan87	BRRI dhan71, 75
Seeding date	05 Dec 2024	05 Dec 2024	25 Apr-04 May 2025	17 Apr 2025	10 Jul 2024	10 Jul 2024
Seed rate (kg/ha)	30	30	-	-	30	30
TP date	09 Jan 2025	09 Jan 2025	-	-	30 Jul 2024	30 Jul 2024
Spacing (cm×cm)	20×20	20×20	-	-	20×20	20×20
Seedling/hill	2-3	2-3	-	-	2-3	2-3
Fertilizer (kg/ha): N, P, K, S, Zn& B	138-20-83-18-4.5	121-18-75-18-4.5	69-10-41.5-0-0	60.5-9-37.5-0-0	76-12-53-11-0-0	69-10-41-10-0-0
Weeding (Times)	3	2	2	2	2	2
Maturity date	25 Apr-04 May 2025	17 Apr 2025	27 Jun-19 Aug 2025	22 Jun-7 Aug 2025	11 Nov 2024	26 Oct-01 Nov 2024
Growth duration (days)	141-151	133	63-109	66-112	124	108-114

Results and Discussion

The grain yield of T. Aman varieties is summarized in **Table 23**. No significant differences were observed in yield among the treatments; however, significant differences were noted among the varieties within each treatment. Across all treatments, BRRI dhan71 and BRRI dhan87 consistently outperformed BRRI dhan75. Notably, BRRI dhan71 exhibited a shorter growth duration, maturing 8-10 days earlier than BRRI dhan87, which could facilitate the timely sowing of mustard. However, this advantage could not be harvested due to an unusual rainfall event during the last week of October. Panicle lengths were higher in BRRI dhan71 and BRRI dhan87 relative to BRRI dhan75. Conversely, BRRI dhan75 exhibited a higher panicle density (panicles m^{-2}) than the other two varieties. Despite this, BRRI dhan71 and BRRI dhan87 had a greater number of filled grains per panicle, whereas the number of unfilled grains was markedly higher in BRRI dhan87 compared to both BRRI dhan71 and BRRI dhan75.

Table 23. Yield and yield components of T. Aman rice under different cropping pattern combinations, BRRI Gazipur, 2024

Treatments	Variety	Panicle length (cm)	Panicle/ m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
CP_1= Mustard-Boro-T. Aman	BRRI dhan71	26.75	255	91	23	23.93	5.44 Aa
	BRRI dhan75	22.01	297	80	27	21.07	4.64 Ab
	BRRI dhan87	27.51	253	92	44	23.39	5.20 Aab
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BRRI dhan71	26.67	253	92	21	23.96	5.57 Aa
	BRRI dhan75	22.24	290	79	25	20.90	4.37 Ab
	BRRI dhan87	27.04	255	90	46	24.00	5.18 Aab
CP_3= Mustard-Boro-Ratoon Boro							-
CP_4= Boro-Fallow-T. Aman (Check)	BRRI dhan71	26.40	265	94	22	24.00	5.83 Aa
	BRRI dhan75	21.88	304	81	25	21.03	4.89 Ab
	BRRI dhan87	28.05	251	95	41	24.01	5.50 Aa

Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at $P < 0.05$.

Effect of transplanting date on grain yield of T. Aman rice

This analysis examines the impact of transplanting date on the grain yield of three rice varieties: BRRI dhan 71, BRRI dhan 75, and BRRI dhan 87. Two transplanting dates—July 20 and July 30—were compared using linear regression models to assess yield trends. All three varieties showed a slight increase in grain yield when transplanted on July 30, suggesting a potential benefit of delayed transplanting within this time window. BRRI dhan75 demonstrated the most noticeable positive trend, followed by BRRI dhan87 and BRRI dhan71 (**Figure 11**).

Despite the upward trends, all R^2 values remained low, indicating that transplanting date alone accounts for only a small portion of the variability in grain yield. These weak correlations suggest that additional factors may play a more significant role in determining yield performance during this period. Transplanting on July 30 may offer a marginal yield advantage for BRRI dhan71, dhan75, and dhan87.

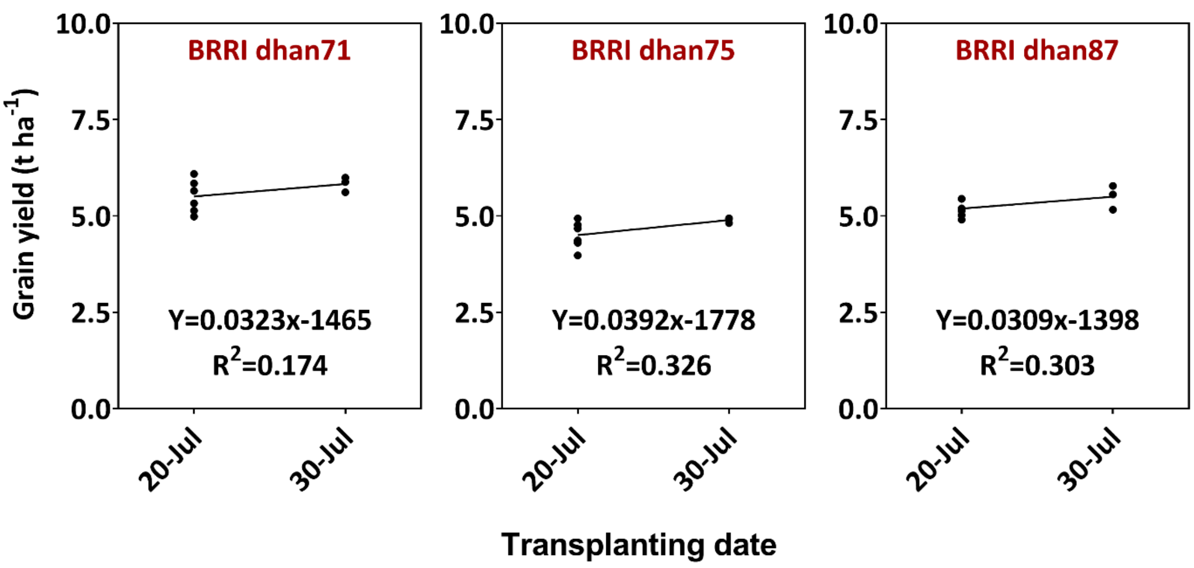


Figure 11. Relationship between grain yield of T. Aman rice varieties and transplanting dates in Gazipur. Dots represent individual values, and lines indicate fitted simple linear regressions

During the Rabi season of 2024-25, BARI Sarisha-14 and BARI Sarisha-17 were sown under cropping patterns CP_1, CP_2, and CP_3. There was no significant difference in grain yield or crop duration between the two varieties across the different cropping pattern treatments. However, the early sowing treatment resulted in lower yields, likely due to poor crop growth caused by excessive soil moisture from rainfall in late October 2024. The lower yield observed in the CP_3 pattern can be attributed to a reduced plant population, fewer pods per plant, and fewer seeds per pod (**Table 24**).

Table 24. Grain yield and yield components of mustard under different cropping pattern combinations, BRRI Gazipur, 2024-25

Treatments	Variety	Plant/m^2	Pod/plant	Seed/pod	1000-SW (g)	Yield (t/ha)
CP_1= Mustard-Boro-T. Aman	BARI Sarisha-14	60	39	22	2.92	1.47 Aa
	BARI Sarisha-17	67	28	26	2.95	1.44 ABa
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BARI Sarisha-14	68	34	23	2.85	1.45 Aa
	BARI Sarisha-17	72	29	26	2.95	1.52 Aa
CP_3= Mustard-Boro-Ratoon Boro	BARI Sarisha-14	58	30	21	2.99	1.08 Ba
	BARI Sarisha-17	65	26	24	2.95	1.18 Ba
CP_4= Boro-Ratoon Boro-T. Aman						-
CP_5= Boro-Fallow-T. Aman (Check)						-

Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at $P < 0.05$.

Effect of sowing time on the grain yield of mustard

This analysis explores the impact of sowing date on the grain yield of two mustard varieties: BARI Sarisha-14 and BARI Sarisha-17. Yield data were collected for two sowing dates- November 2 and November 8- and analyzed using linear regression models. For both varieties, grain yield increased with the later sowing date. BARI Sarisha-14 demonstrated a more pronounced increase, indicating a moderately strong linear relationship. BARI Sarisha-17 followed a similar trend, though with a slightly smaller slope (Y = 0.0497x - 2267) and a comparable model fit (R^2 = 0.676).

Sowing on November 8 produced higher grain yields than sowing on November 2 for both mustard varieties. BARI Sarisha-14 responded more strongly to delayed sowing, suggesting it may be more adaptable or better suited to slightly later planting dates (**Figure 12**).

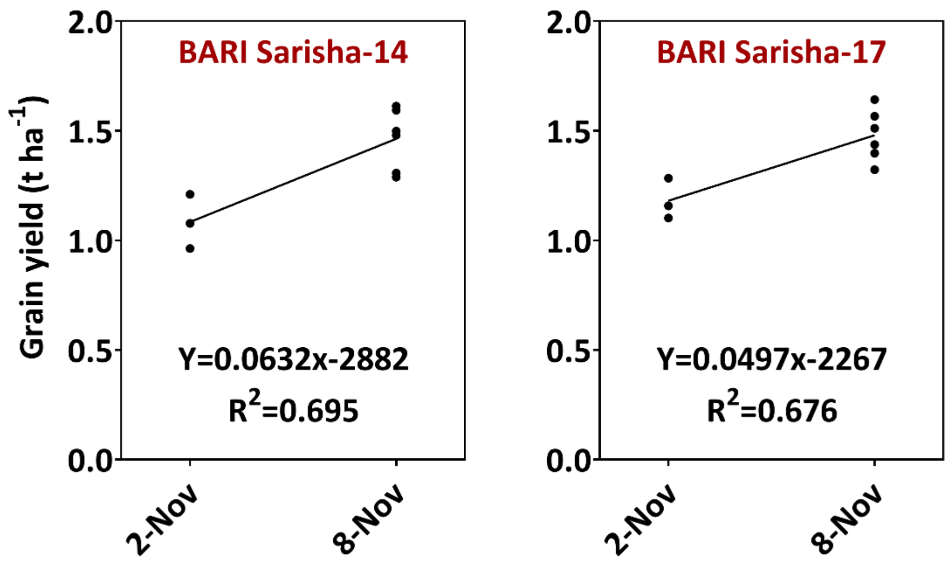


Figure 12. Grain yield of mustard varieties affected by sowing time in Gazipur. Dots represent individual values, and lines indicate fitted simple linear regressions

The grain yield and yield components of Boro varieties under different cropping pattern are summarized in **Table 25**. All varieties produced higher yields when transplanted earlier, specifically in the CP_3 and CP_4 treatments. Within the treatment, BRRI dhan74 performed particularly well in treatments involving mustard inclusion, indicating that BRRI dhan74 is better suited for late Boro planting conditions. In contrast, under the Boro-Fallow-T. Aman pattern, BRRI dhan102 and BRRI dhan107 outperformed the other varieties.

Table 25. Yield and yield components of Boro rice under different cropping pattern combinations, BRRI Gazipur, 2024-25

Treatments	Variety	Panicle length (cm)	Panicle/m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
CP_1= Mustard-Boro-T. Aman	BRRI dhan74	23.34	243	92	17	31.62	6.63Ca
	BRRI dhan100	23.52	280	106	15	21.34	5.69Bc
	BRRI dhan102	24.10	351	82	33	23.69	6.26Cb
	BRRI dhan107	31.16	295	79	32	28.33	6.27Cb
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BRRI dhan74	22.76	270	91	19	30.39	6.73BCa
	BRRI dhan100	22.59	267	112	21	19.94	5.80Bc
	BRRI dhan102	23.86	369	71	34	24.38	6.32Cb
	BRRI dhan107	30.23	302	68	45	30.23	6.37Cb
CP_3= Mustard-Boro-Ratoon Boro	BRRI dhan74	24.91	322	93	12	30.29	7.23Aa
	BRRI dhan100	23.95	306	117	17	19.27	6.38Ac
	BRRI dhan102	24.91	319	88	23	25.55	6.88Bb
	BRRI dhan107	28.89	324	79	32	28.97	6.89Bb
CP_5= Boro-Fallow-T. Aman (Check)	BRRI dhan74	23.13	283	96	16	32.30	6.97ABb
	BRRI dhan100	23.91	330	126	14	19.49	6.49Ac
	BRRI dhan102	24.03	363	104	43	25.66	7.38Aa
	BRRI dhan107	27.62	389	93	38	28.18	7.45Aa

Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at $P< 0.05$.

Effect of transplanting date on grain yield of Boro rice

The influence of different transplanting dates on the grain yield of four BRRI Boro rice varieties-BRRI dhan74, BRRI dhan100, BRRI dhan102, and BRRI dhan107. The data were analyzed using quadratic regression models, and the resulting trends are illustrated in Figure 13. Across all four varieties, grain yield was highest when transplanting occurred around mid-January and declined with further delay. BRRI dhan74 and BRRI dhan100 showed moderate declines in yield with delayed transplanting, with R^2 values of 0.732 and 0.774, respectively, indicating a reasonably good model fit. BRRI dhan102 demonstrated a strong response to transplanting date, with the highest model fit ($R^2 = 0.939$), suggesting high sensitivity to timing. Its yield dropped significantly when transplanting was delayed beyond January 19. BRRI dhan107 exhibited the least sensitivity to transplanting date, with a gentle decline in yield and a strong model fit ($R^2 = 0.912$). This suggests greater adaptability to suboptimal transplanting dates compared to the other varieties. Optimal transplanting around January 09-19 ensures higher grain yields across all varieties. However, BRRI dhan107 appears to be the most resilient to transplanting delays, while BRRI dhan102 is the most sensitive. These findings underscore the importance of aligning agronomic practices with varietal characteristics to maximize productivity.

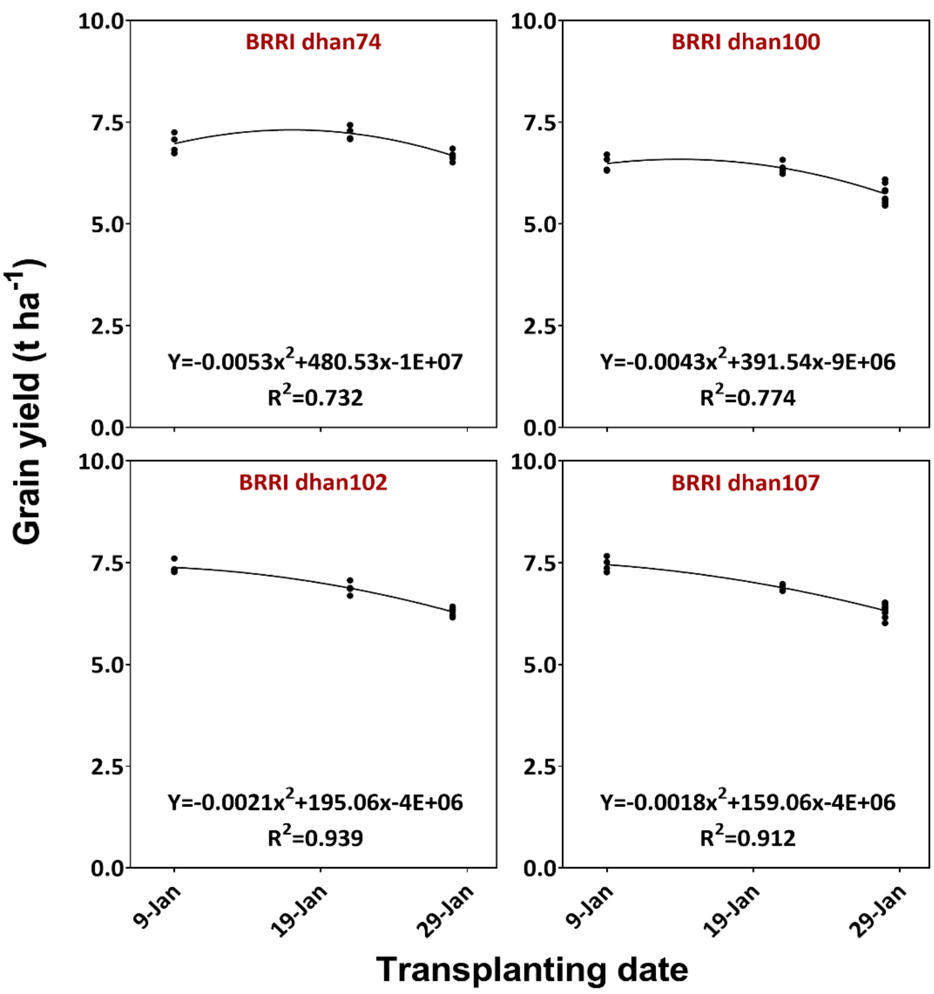


Figure 13. Effect of transplanting dates on grain yield of Boro rice varieties in Gazipur. Dots represent individual values, and lines indicate fitted polynomial quadratic regression

The yield and yield components of conventional and Salibu ratooned Boro rice under different cropping pattern combinations are summarized in **Table 26**. Significant differences were observed across varieties and management practices. In conventional and Salibu ratooning, BRRI dhan74 and 100 consistently outperforming other varieties under different cropping patterns. Panicle length of all varieties was markedly higher under the Salibu system compared with conventional ratooning, whereas panicle number tended to be higher in the conventional system. The number of filled grains per panicle was substantially higher in Salibu ratooning, while unfilled grains were more prevalent under conventional management. Thousand-grain weight (1000-GW) remained relatively stable between systems. These results demonstrate that Salibu ratooning offers a clear advantage over conventional ratooning, particularly in terms of yield potential and grain-filling efficiency.

Table 26. Yield and yield components of conventional and Salibu Boro ratoon rice under different cropping pattern combinations, BRRI Gazipur, 2025

Treatments	Variety	Panicle length (cm)	Panicle/m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
Conventional ratooning							
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BRRI dhan74	20.71	304	45	27	26.85	1.35 Aab
	BRRI dhan100	21.04	346	61	30	15.19	1.37 Aa
	BRRI dhan102	23.01	244	53	40	20.19	1.23 Aab
	BRRI dhan107	30.49	226	56	58	24.52	1.12 Ab
CP_3= Mustard-Boro-Ratoon Boro	BRRI dhan74	18.49	248	47	16	27.46	1.34 Aa
	BRRI dhan100	20.60	341	54	22	15.18	1.41 Aa
	BRRI dhan102	24.05	202	56	40	21.88	1.18 Aab
	BRRI dhan107	30.52	218	50	59	25.77	1.07 ABb
CP_5= Boro- Ratoon Boro-T. Aman	BRRI dhan74	17.47	270	46	19	26.76	0.96 Ba
	BRRI dhan100	20.12	326	51	31	16.02	1.01 Ba
	BRRI dhan102	22.86	201	56	50	20.29	1.09 Aa
	BRRI dhan107	22.88	253	43	20	26.89	0.85 Ba
Salibu ratooning							
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BRRI dhan74	24.14	292	53	41	25.77	1.68 Aa
	BRRI dhan100	23.45	262	87	37	15.69	1.67 Aa
	BRRI dhan102	23.90	214	59	36	21.86	1.32 Ab
	BRRI dhan107	31.09	203	66	45	25.82	1.45 Ab
CP_3= Mustard-Boro-Ratoon Boro	BRRI dhan74	25.82	199	64	48	26.73	1.48 Bb
	BRRI dhan100	24.13	266	74	32	15.91	1.70 Aa
	BRRI dhan102	24.54	198	66	33	20.92	1.37 Abc
	BRRI dhan107	35.01	187	62	39	26.14	1.30 ABc
CP_5= Boro- Ratoon Boro-T. Aman	BRRI dhan74	23.20	235	66	20	25.93	1.52 Ba
	BRRI dhan100	25.19	238	85	43	15.93	1.60 Aa
	BRRI dhan102	24.17	189	68	41	20.78	1.48 Aa
	BRRI dhan107	31.48	212	60	33	26.03	1.17 Bb

Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at $P< 0.05$.

Ratooning ability of Boro rice varieties varied across cropping pattern combinations at BRRI, Gazipur in 2025 (**Table 27**). BRRI dhan100 exhibited the highest ratooning ability, followed by BRRI dhan74, whereas BRRI dhan102 and BRRI dhan107 showed comparatively poor ratooning performance. Across cropping patterns, ratooning ability was highest under Mustard-Boro-Ratoon Boro-T. Aman (CP_2), moderate under Boro-Ratoon Boro-T. Aman (CP_4), and lowest under Mustard-Boro-Ratoon Boro (CP_3).

Table 27. Ratooning ability of different Boro varieties under different cropping pattern combinations, BRRI Gazipur, 2025

Treatments	Variety	Main crop harvesting date	Duration (Day)	Ratooning ability
CP_2= Mustard-Boro-Ratoon Boro-T. Aman	BRRI dhan74	29 Apr 2025	63	1.13
	BRRI dhan100	03 May 2025	68	1.30
	BRRI dhan102	11 May 2025	75	0.66
	BRRI dhan107	10 May 2025	70	0.75
CP_3= Mustard-Boro-Ratoon Boro	BRRI dhan74	24 Apr 2025	60	0.77
	BRRI dhan100	27 Apr 2025	66	1.11
	BRRI dhan102	08 May 2025	71	0.63
	BRRI dhan107	06 May 2025	68	0.67
CP_4= Boro- Ratoon Boro-T. Aman	BRRI dhan74	17 Apr 2025	55	0.95
	BRRI dhan100	25 Apr 2025	60	0.99
	BRRI dhan102	04 May 2025	69	0.55
	BRRI dhan107	04 May 2025	63	0.65

Ratooning ability is the ratio of panicles of main crop and ratoon crop

The rice equivalent yield (REY) of different cropping pattern combinations is shown in **Figure 14**, while the best varietal combinations with associated economic parameters are summarized in **Table 28**. Among the evaluated systems, the Mustard-Boro-T. Aman pattern was identified as the most profitable. Although the integration of mustard and ratoon technology into the traditional Boro-Fallow-T. Aman system substantially increased REY, the relatively low yield of ratoon rice combined with the additional management costs rendered this option less profitable. Similarly, incorporation of ratooning alone increased the productivity of the Boro-Fallow-T. Aman system, but the improvement was modest. Exclusion of T. Aman while retaining mustard and ratooning further reduced profitability, as ratoon rice yields were insufficient to sustain system productivity. Overall, the Mustard-Boro-T. Aman system remained the most advantageous, while the Mustard-Boro-Ratoon Boro-T. Aman pattern provided a promising intensification strategy and may become highly productive with the development of superior ratooning varieties.

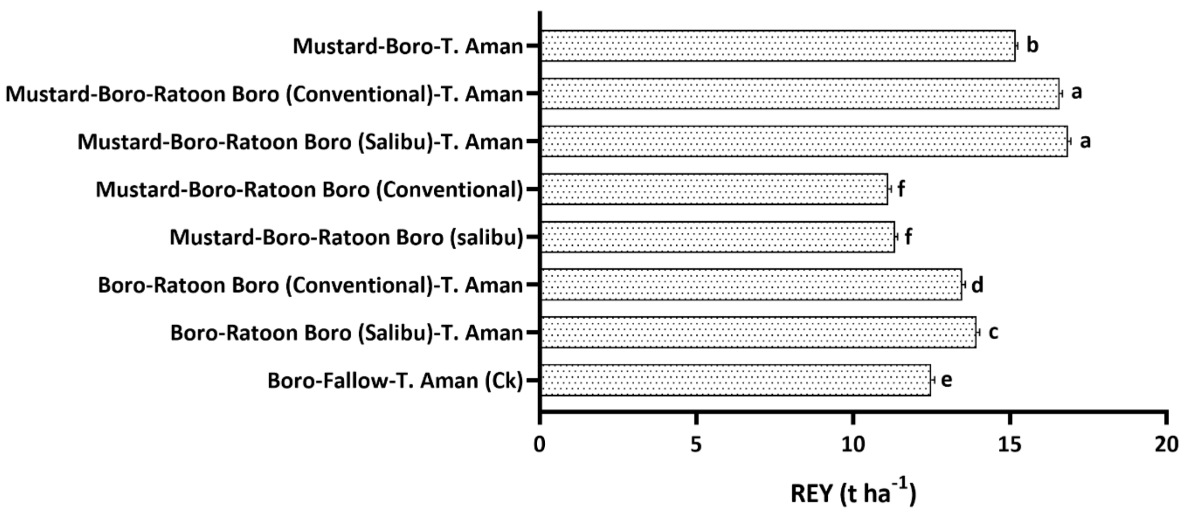


Figure 14. Rice equivalent yield (REY) under different cropping patterns, BRRI, Gazipur, 2024-25

Table 28. Rice equivalent yield (REY) and economics of different varietal combinations under different cropping patterns, BRRI, Gazipur, 2024-25

Cropping pattern	Varietal combination	REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
Mustard-Boro-T. Aman	BARI Sarisha-14-BRRI dhan71-BRRI dhan74	15.99	394	167	1.24
	BARI Sarisha-14-BRRI dhan87-BRRI dhan74	15.75	399	167	1.23
Mustard-Boro-Ratoon Boro-T. Aman	BARI Sarisha-17-BRRI dhan74-Boro Ratoon (Salibu)-BRRI dhan71	18.05	461	166	1.12
	BARI Sarisha-14-BRRI dhan74-Boro Ratoon (Conv.)-BRRI dhan71	17.75	445	169	1.16
Mustard-Boro-Ratoon Boro	BARI Sarisha-17-BRRI dhan74-Boro Ratoon (Salibu)	11.87	331	54	-3.76
	BARI Sarisha-17-BRRI dhan74-Boro Ratoon (Conv.)	11.73	316	64	-17.24
Boro-Ratoon Boro-T. Aman	BRRI dhan102- Boro Ratoon (Salibu)-BRRI dhan71	14.73	376	137	0.84
	BRRI dhan74- Boro Ratoon (Conv.)-BRRI dhan71	13.77	360	125	0.53
Boro-Fallow-T. Aman (Ck)	BRRI dhan107-Fallow-BRRI dhan71	13.30	311	147	

Conclusion

The present study evaluated the potential of intensifying the dominant Boro-Fallow-T. Aman cropping system in Bangladesh through the inclusion of mustard and ratoon Boro rice, using five cropping patterns. The findings demonstrate that significant opportunities exist to increase annual system productivity and improve resource-use efficiency; however, the success of these interventions depends strongly on varietal choice, sowing/transplanting windows, climatic events, and ratooning potential. Mustard-Boro-T. Aman (CP_1) system consistently produced the highest profitability and competitive rice equivalent yields (REY), reaffirming its suitability as the most practical intensification option under current varietal performance and input costs. Although cropping patterns incorporating ratoon Boro (CP_2, CP_3, CP_4) demonstrated higher total system productivity, the additional management cost and comparatively low ratoon yields reduced overall economic advantage. Nonetheless, Mustard-Boro-Ratoon Boro-T. Aman (CP_2) pattern exhibited promising yield potential and superior ratoon performance relative to CP_4 and CP_3, suggesting that ratoon-based intensification could become viable once varieties with stronger ratooning ability are developed.

Expt. 2.4. Effect of fertilizer management of late Boro rice under Potato-Boro-T. Aman cropping pattern

DH Payel, T Araf, ABMJ Islam, MK Quais and M Ibrahim

Introduction

Sustainable intensification of rice-based cropping systems is a national priority in Bangladesh to ensure food security, alleviate poverty, and mitigate land degradation and environmental pollution. With cultivable land steadily declining, future gains in rice production must primarily come from increasing productivity per unit area rather than horizontal expansion. It has been projected that per unit yield must increase substantially to meet the growing food demand under limited land resources, placing considerable pressure on existing production systems and management practices. In this context, the role of agronomic interventions that enhance system productivity and resource-use efficiency has become increasingly important.

Boro rice, the major irrigated rice crop in Bangladesh, is typically cultivated from November to March (Chowhan *et al*., 2019). However, the inclusion of Rabi crops such as potato in rice-based cropping systems often delays Boro transplanting, pushing the crop into a late establishment window. Late transplanting exposes Boro rice to higher temperatures during critical growth and reproductive stages, which can adversely affect tillering, spikelet formation and grain filling. Consequently, late-transplanted Boro rice frequently suffers yield penalties, threatening the overall productivity and profitability of Potato-Boro-T. Aman cropping pattern.

Another important limitation of intensified cropping systems is the prevailing fertilizer management approach, which is largely based on the nutrient requirement of individual crops without adequately considering the residual and carryover effects of fertilizers applied to preceding crops. In cropping patterns such as Potato-Boro-T. Aman, substantial amounts of nutrients are applied to potato, which may influence nutrient availability for the subsequent Boro rice crop. Failure to account for these residual effects may lead to inefficient fertilizer use, increased production costs and potential environmental risks. Although earlier studies have explored the inclusion of potato or mustard as intervening crops between Boro and T. Aman rice, limited attention has been given to optimizing fertilizer management for late-transplanted Boro rice following such Rabi crops.

Recent advances in decision-support tools, such as the BARC Khamari App and the development of pattern-based fertilizer recommendations offer opportunities to refine nutrient management by accounting for cropping sequence, soil nutrient dynamics and site-specific conditions. Evaluating these alternative fertilizer management options against conventional BRRI-recommended doses is therefore essential to identify economically viable fertilizer management option for late-transplanted Boro rice. Therefore, the present study was undertaken to evaluate the yield performance of late Boro rice under different fertilizer management options and nitrogen application schedules within the Potato-Boro-T. Aman cropping pattern.

Objectives

i) To evaluate the performance of late-transplanted Boro rice under pattern-based and BARC Khamari App–based fertilizer management options in comparison with the BRRI-recommended fertilizer dose within Potato-Boro-T. Aman cropping pattern.
ii) To assess the effects of different nitrogen fertilizer application schedules on the productivity of late Boro rice following potato cultivation.
iii) To identify an efficient and economically viable fertilizer management strategy for late Boro rice cultivated after Rabi crops in an intensified rice-based cropping system.

Materials and Methods

The field experiment was conducted at East Byde, BRRI, Gazipur during the Boro, 2025. Following the harvest of potato, 40-day-old seedlings of BRRI dhan74 and BRRI dhan98 were transplanted on 1 March 2025. Transplanting was carried out at a spacing of 20 cm × 20 cm with 2–3 seedlings per hill. The experiment was laid out in a split-plot design with three replications. Fertilizer management options were assigned to the main plots, while nitrogen (N) fertilizer application schedules were allocated to the subplots. Phosphorus (P), potassium (K), and sulfur (S) were applied as full basal doses during final land preparation according to the respective fertilizer management treatments.

The main-plot factor consisted of three fertilizer management options:

i) F_1= BRRI-recommended fertilizer dose

ii) F_2= Pattern-based fertilizer dose

iii) F_3= Fertilizer dose recommended by the BARC Khamari App

The subplot factor comprised three nitrogen application schedules:

i) $N_1 = \frac{1}{4}$ N basal + $\frac{1}{4}$ N top dress at active tillering + $\frac{1}{4}$ N top dress at maximum tillering + $\frac{1}{4}$ N top dress before 5 days at PI

ii) $N_2 = \frac{1}{3}$ N basal + $\frac{1}{3}$ N top dress at maximum tillering + $\frac{1}{3}$ N top dress before 5 days at PI

iii) $N_3 = \frac{1}{3}$ N top dress at 7 DAT + $\frac{1}{3}$ N top dress at maximum tillering + $\frac{1}{3}$ N top dress before 5 days at PI

All intercultural operations and crop management practices were followed in accordance with BRRI recommendations (**Table 29**).

Table 29. Crop management practices adopted in late Boro rice under Potato-Boro-T. Aman cropping pattern, BRRI, Gazipur, 2025

Treatments	Boro	
Variety	BRRI dhan74	BRRI dhan98
Date of sowing	20 Jan. 2025	20 Jan. 2025
Date of transplanting	01Mar. 2025	01 Mar. 2025
Date of maturity	13 June 2025	28 May 2025
Field duration (days)	103	88
Fertilizer (kg/ha): N, P, K, S		
F_1=Recommended dose	138-20-83-18	138-20-83-18
F_2=Pattern based dose	144-8-60-4	144-8-60-4
F_3=BARC Khamari App dose	158-12-36-6	158-12-36-6

A comparative assessment of fertilizer application scenarios and their associated cost implications under pattern-based and BARC Khamari App- recommended doses relative to the BRRI-recommended fertilizer dose for late Boro rice in Potato-Boro-T. Aman cropping pattern is presented in Table 30. Under the pattern-based fertilizer dose (F_2), nitrogen application was increased by 6 kg ha^{-1}, while phosphorus, potassium and sulfur applications were reduced by 12, 23, and 14 kg ha^{-1}, respectively, compared to BRRI recommendation. This adjustment resulted in a net reduction in total fertilizer cost of Tk 3,744 ha^{-1}. While BARC Khamari App-based fertilizer dose (F_3) recommended a higher increase in nitrogen (20 kg ha^{-1}) accompanied by larger reductions in phosphorus (8 kg ha^{-1}), potassium (47 kg ha^{-1}) and sulfur (12 kg ha^{-1}), leading to a total fertilizer cost saving of Tk 3,122 ha^{-1}.

Table 30. Fertilizer application scenarios and associated cost variation under pattern-based and BARC Khamari App doses relative to BRRI-recommended fertilizer dose for late Boro rice in the Potato-Boro-T. Aman cropping pattern, BRRI, Gazipur, 2025

Treatments	**Fertilizer (kg/ha)**				**Total Cost (Tk/ha)**
	N	P	K	S	
F_2=Pattern based Dose	+6	-12	-23	-14	-3,744
F_3=BARC Khamari App Dose	+20	-8	-47	-12	-3,122

Price (Tk/kg): Urea=27, TSP=27, MoP=20, Gypsum=20

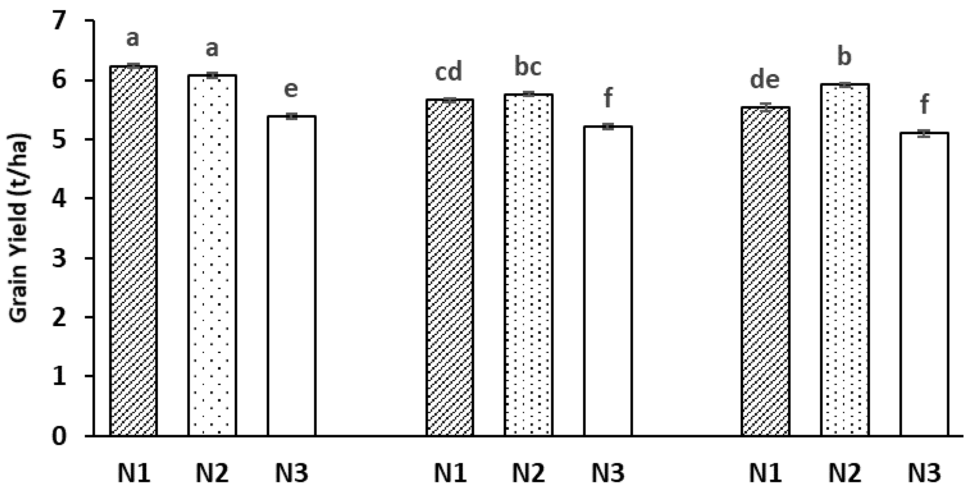
Result and Discussion

The yield data for BRRI dhan98 were not included because the crop lodged completely at the ripening stage due to adverse weather conditions and continuous heavy rainfall. Grain yield of late-transplanted Boro rice (BRRI dhan74) was significantly influenced by fertilizer management options and nitrogen (N) application schedules, and their interaction effect was also statistically significant (Figure 15). Across all fertilizer doses, N application schedules that included basal N application resulted in higher grain yields than the schedule without basal N.

Under BRRI-recommended fertilizer dose (F_1), grain yield was significantly higher with N_1 and N_2, and no significant difference was observed between these two basal-inclusive N application schedules, as indicated by similar statistical groupings. In contrast, omission of basal N application (N_3) under F_1 led to a marked and significant reduction in grain yield.

When pattern-based fertilizer doses were applied (F_2), grain yield varied significantly among N application schedules. The N_2 schedule produced the highest yield, followed by N_1, while N_3

resulted in a significantly lower yield, indicating a strong dependence of pattern-based fertilizer management on appropriate N splitting. A similar trend was observed under the BARC Khamari App–based fertilizer dose (F_3), where basal-inclusive N schedules outperformed the schedule without basal N, although yield levels were comparatively lower than those obtained with the recommended fertilizer dose.



**Means with the same letter are not significantly different at P<0.05

Figure 15. Effect of fertilizer management on grain yield of late Boro rice under Potato-Boro-T. Aman cropping pattern

Overall, the highest grain yield was recorded from the interaction of the BRRI-recommended fertilizer dose with basal-inclusive N application schedules ($F_1 \times N_1$ and $F_1 \times N_2$), whereas the lowest yields were consistently associated with treatments lacking basal N application across all fertilizer management options ($F_1 \times N_3$, $F_2 \times N_3$, and $F_3 \times N_3$). These results clearly demonstrate the critical role of basal N application in sustaining grain yield of late-transplanted Boro rice under Potato-Boro-T. Aman cropping pattern.

Expt. 2.5. Management of aged seedling to minimize the yield loss of T. Aman rice

DH Payel, T Husna, N Parvin, MK Quais and M Ibrahim

Introduction

Bangladesh is an agro-based developing country where rice is the dominant crop; and it is the staple food for this country. Aman rice is one of the major crops of Bangladesh contributing approximately 38.8 % of the nation's total rice production (BBS, 2021). T. Aman rice is cultivated in rainfed condition in Bangladesh. When rainfall is normally low, Bangladesh experiences a dry period for several months in every year. However, in the pre-monsoon (March–May) and post-monsoon (October-November) periods, drought mostly affects this country. It causes significant destruction to the T. Aman crop, during the kharif season, in approximately 2.32 million ha every year (Hosain *et al*., 2018). In the Rabi season, about 1.2 million ha of agricultural land face droughts of different magnitudes (Dey *et al*., 2011). Timely transplanting is an important issue for good production. Due to unfavorable conditions, when main field is not ready for transplanting while the seedlings become aged in seedbed that hamper good production. This could be overcome by proper fertilizer and crop management techniques like laddering practices.

Objective

To minimize the yield loss due to use of aged seedling of T. Aman rice through nitrogen fertilizer and laddering crop management techniques

Materials and Methods

The field experiment was conducted at the experimental farm of the Bangladesh Rice Research Institute (BRRI), Gazipur, during the T. Aman season of 2024. Two rice varieties, BRRI dhan71 and BRRI dhan75, were used as test materials. Seeds of both varieties were sown in a wet seedbed on 5 July 2024. Seedlings of three different ages (20, 30, and 40 days) were transplanted on 25 July, 5 August and 15 August 2024, respectively. Transplanting was performed at a spacing of 20 cm × 20 cm, using 2-3 seedlings per hill. The experiment was laid out in a split-plot design with three replications. Fertilizer management was assigned to the main plots, while seedling age and seedling management practices were allocated to the subplots.

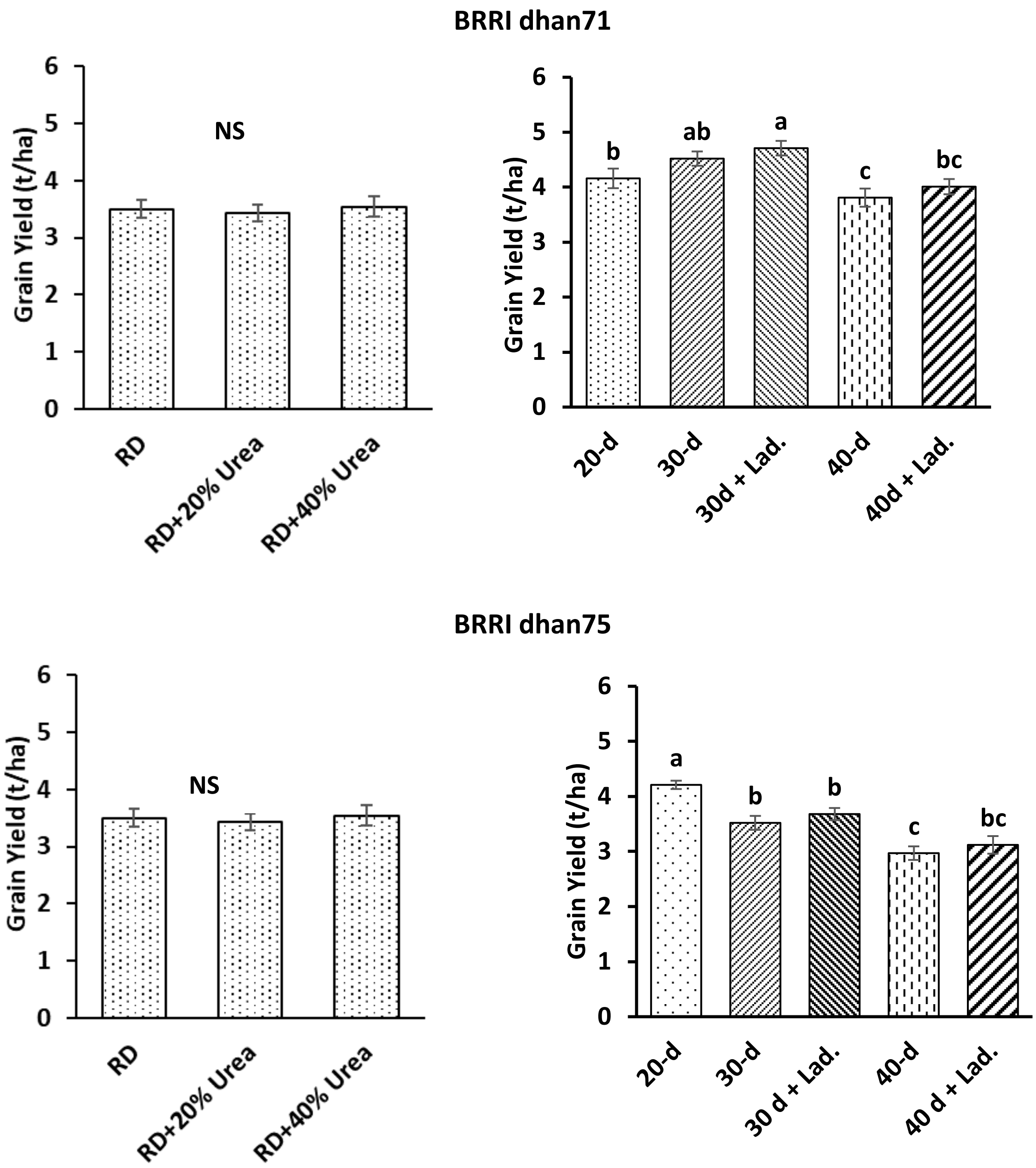
Factor A: Fertilizer management (main plot)
F_1: Recommended fertilizer dose
F_2: Recommended fertilizer dose + 20% additional nitrogen
F_3: Recommended fertilizer dose + 40% additional nitrogen

Factor B: Seedling age and management (subplot)
S_1: 20-day-old seedlings
S_2: 30-day-old seedlings
S_3: 40-day-old seedlings
S_4: 30-day-old seedlings with laddering at 10 days after transplanting (DAT)
S_5: 40-day-old seedlings with laddering at 10 DAT

The full doses of phosphorus (P), potassium (K), sulfur (S), and zinc (Zn) were applied during final land preparation according to the respective treatment specifications. Nitrogen was applied as per treatment combinations.

Result and Discussion

Grain yield of BRRI dhan71 and BRRI dhan75 was not significantly affected by the interaction between fertilizer management and seedling age, indicating that the response of grain yield to seedling age was consistent across fertilizer treatments. Likewise, fertilizer management alone had no statistically significant effect on grain yield in either variety, as evidenced by the non-significant (NS) differences among the recommended dose (RD), RD + 20% N, and RD + 40% N treatments (**Figure 16**). This suggests that increasing nitrogen beyond the recommended level did not confer additional yield advantages under the prevailing T. Aman season conditions.



*Means with the same letter are not significantly different at P<0.05

Figure 16. The yield performance of BRRI dhan71 and BRRI dhan75 aged seedlings using crop management techniques and nitrogen fertilizer

Seedling age exerted a significant influence on grain yield in both rice varieties, although the magnitude and pattern of response differed between BRRI dhan71 and BRRI dhan75. In BRRI dhan71, grain yield differed significantly among seedling age treatments, with 40-day-old seedlings producing significantly lower yields than younger seedlings. Although 30-day-old seedlings recorded higher grain yield than 20-day-old seedlings, the difference between these two treatments was not statistically significant. The apparently higher yield observed in treatments with laddering practice; however, this practice did not result in statistically significant yield differences compared with their respective non-laddered treatments. These results indicate that laddering did not confer a measurable yield advantage under the conditions of this study.

In contrast, BRRI dhan75 exhibited a distinct response to seedling age. The highest grain yield was recorded from 20-day-old seedlings, which was significantly higher than yields obtained from 30- and 40-day-old seedlings. Laddering practice did not significantly influence grain yield at any seedling age, as yields from laddered and non-laddered treatments were statistically similar. Grain yield declined progressively with increasing seedling age, indicating that BRRI dhan75 is more sensitive to delayed transplanting and performs best when younger seedlings are used.

The contrasting varietal responses highlight the importance of variety-specific seedling age management under T. Aman conditions. BRRI dhan71 achieved optimum yield with moderately aged seedlings (30 days), BRRI dhan75 favored younger seedlings (20 days). The absence of a significant fertilizer effect suggests that the recommended fertilizer dose was sufficient to meet crop nutrient demand, and additional nitrogen did not translate into higher grain yield. These findings emphasize that appropriate seedling age selection, rather than increased nitrogen application, plays a more critical role in maximizing grain yield of T. Aman rice varieties.

Expt. 2.6. Evaluation of newly released BRRI varieties under Boro-Fallow-T. Aman cropping pattern

ABMJ Islam, MK Quais and M Ibrahim

Introduction

Agriculture, with crop production as its dominant component, remains central to food security and rural livelihoods in Bangladesh. Cereals account for approximately 75% of the total cropped area, of which rice alone occupies about 96%, underscoring its overwhelming importance in the national food system. The rice sector contributes nearly 70% of agricultural gross domestic product and around one-sixth of national revenue, reflecting its critical role in economic development as well as social and political stability. As the staple food for the majority of the population, sustained increases in rice productivity are essential to meet the growing demand arising from population growth and diminishing cultivable land.

Boro-Fallow-T. Aman cropping pattern is one of the most widespread and traditional rice-based systems in Bangladesh. This pattern occupies approximately 2.3 million ha, representing about 27% of the national net cropped area. Despite its wide adoption, productivity of this system often remains suboptimal due to the continued use of older varieties. Recent releases of high-yielding BRRI rice varieties offer opportunities to optimize varietal combinations, improve cropping system productivity and enhance farm profitability without altering the existing cropping system. Therefore, systematic evaluation of varietal combination and performance within Boro-Fallow-T. Aman cropping pattern is required to identify the most productive and economically viable varietal combinations.

Objectives

i) To evaluate the productivity and profitability of newly released BRRI rice varieties under Boro-Fallow-T. Aman cropping pattern.
ii) To identify suitable Aman–Boro varietal combinations Boro-Fallow-T. Aman cropping pattern.

Materials and Methods

The study was conducted at BRRI, Gazipur, to identify suitable crop sequences for Boro-Fallow-T. Aman cropping pattern. During the T. Aman season, five rice varieties were evaluated, comprising two short-duration varieties (BRRI dhan71 and BRRI dhan75) and three medium-duration varieties (BRRI dhan87, BRRI dhan95 and BRRI dhan103). In the subsequent Boro season, five rice varieties (BRRI dhan98, BRRI dhan100, BRRI dhan107, BRRI hybrid dhan7 and BRRI hybrid dhan8) were transplanted to assess their productivity following both short- and medium-duration T. Aman rice. In total, 10 cropping pattern combinations were evaluated for short-duration T. Aman rice followed by Boro rice, while 15 combinations were evaluated for medium-duration T. Aman rice followed by Boro rice. All the combinations were compared against BRRI dhan49-Fallow-BRRI dhan29. BRRI recommended management practices were followed for the cultivating the varieties (**Tables 31**).

Table 31. Crop management adopted for Boro-Fallow-T. Aman cropping pattern, BRRI, Gazipur 2024-25

Management factors	Boro	T. Aman
Variety	BRRI dhan29, 98, 100, 107, BHD7 & BHD8	BRRI dhan49, 71, 75, 87, 95, 103
Seed rate (kg/ha)	30	30
Seeding date	26 November 2024	15-18 July 2024
Seedling age (day)	40	20-23
Spacing (cm×cm)	20×15	20×15
Transplanting date	05 January 2025	07 August 2024
Seedling/hill	2-3	2-3
Fertilizer (kg/ha): N,	BRRI dhan29, 107: 138-21-80-20-3*	BRRI dhan87, 95, 103: 83-16-52-12-0
P, K, S & Zn	BRRI dhan98, 100, BHD7, BHD8: 124-25-60-20-3**	BRRI dhan71, 75: 69-10-41-11-0
Weeding (times)	2	2
Maturity date	22 Apr - 03 May 2025	05 November-27 November 2024
Growth duration (days)	147-158	113-135

Results and Discussion

Combinations with short duration Aman variety followed by Boro rice

The grain yield and economic performance of short-duration T. Aman rice followed by Boro rice under Boro-Fallow-T. Aman cropping pattern are presented in Table 32. Data revealed that in T. Aman season BRRI dhan71 producing marginally higher yields than BRRI dhan75 across most combinations. During Boro season, BRRI hybrid dhan8 consistently produced the highest grain yields, significantly outperforming all inbred Boro varieties and the control. Among the inbred varieties, BRRI dhan98 performed better than other tested varieties. Considering the best combinations, the highest total yield was achieved by BRRI dhan75-Fallow-BRRI hybrid dhan8, closely followed by BRRI dhan71-Fallow-BRRI hybrid dhan8. Total variable cost (TVC) across treatments remained relatively stable. Consequently, variations in gross margin were largely driven by yield differences. The highest economic return obtained from BRRI dhan75-Fallow-BRRI hybrid dhan8, followed by BRRI dhan71-Fallow-BRRI hybrid dhan8. Both combinations generated substantially higher profitability compared to other tested combinations. Overall, the results demonstrate that integrating short-duration T. Aman rice with high-yielding Boro varieties, particularly BRRI hybrid dhan8, offering a viable alternative to the existing farmers' practice.

Table 32. Grain yield and economic performance of short-duration T. Aman rice followed by Boro rice under the Boro-Fallow-T. Aman cropping pattern, BRRI, Gazipur, 2024-25

Cropping pattern	Yield (t ha^{-1})			TVC ('000 Tk/ha)	GM ('000 Tk/ha)
	T. Aman	Boro	Total grain yield		
BRRI dhan71-Fallow-BRRI dhan98	4.50	7.06 b	11.57 b	260	158
BRRI dhan71-Fallow-BRRI dhan100	4.47	5.74 e	10.21 c	259	113
BRRI dhan71-Fallow-BRRI dhan107	4.41	6.08 c	10.50 cd	260	121
BRRI dhan71-Fallow- BRRI hybrid dhan7	4.39	5.28 f	9.67 d	260	92
BRRI dhan71-Fallow- BRRI hybrid dhan8	4.39	8.05 a	12.45 a	258	190

BRRI dhan75-Fallow-BRRI dhan98	4.32	7.05 b	11.37 b	258	153
BRRI dhan75-Fallow-BRRI dhan100	4.40	5.86 de	10.26 c	256	117
BRRI dhan75-Fallow-BRRI dhan107	4.40	6.22 c	10.62 c	258	127
BRRI dhan75-Fallow- BRRI hybrid dhan7	4.45	5.39 f	9.84 d	258	100
BRRI dhan75-Fallow- BRRI hybrid dhan8	4.40	8.06 a	12.46 a	256	193
BRRI dhan49-Fallow-BRRI dhan29 (Ck)	4.42	6.42 bc	10.84 c	257	137
CV (%)	4.16	2.76	2.04	-	-

Means with the same letter(s) are not significantly different.
Price (Tk./kg): Rice=32.50; Straw: Boro=2, T. Aman=6.

Combinations with medium-duration T. Aman variety followed by Boro rice

The grain yield and economic performance of medium-duration T. Aman rice followed by Boro rice under the Boro-Fallow-T. Aman cropping pattern are presented in Table 33. The results indicate clear varietal effects on both productivity and profitability of the system. During the T. Aman season, BRRI dhan95 produced significantly higher grain yields than BRRI dhan87 and BRRI dhan103 across most combinations, reflecting the yield advantage of this medium-duration variety. BRRI dhan103 showed intermediate performance, while BRRI dhan87 consistently recorded comparatively lower grain yields. In Boro season, BRRI hybrid dhan8 consistently achieved the highest grain yield irrespective of the preceding Aman variety, significantly outperforming all inbred Boro varieties as well as the control. Among the inbred Boro varieties, BRRI dhan98 generally performed better than BRRI dhan100 and BRRI dhan107. Considering the overall system performance, the highest total grain yield was obtained from the BRRI dhan95-Fallow-BRRI hybrid dhan8 combination, followed by BRRI dhan103-Fallow-BRRI hybrid dhan8. These combinations markedly outperformed the control cropping pattern which produced a total yield of 10.84 t ha^{-1}. Total variable cost (TVC) remained relatively similar across all treatments, while gross margin varied widely among combinations. The highest economic return was recorded for BRRI dhan95-Fallow-BRRI hybrid dhan8, followed by BRRI dhan103-Fallow-BRRI hybrid dhan8. All these combinations generated substantially higher gross margins compared to the control and other tested sequences.

Overall, the results demonstrate that integrating medium-duration T. Aman rice- particularly BRRI dhan95- with high-yielding Boro varieties, especially BRRI hybrid dhan8, significantly enhances system productivity and profitability, offering a superior and economically viable alternative to the existing farmers’ practice under Boro-Fallow-T. Aman cropping system.

Table 33. Grain yield and economic performance of medium-duration T. Aman rice followed by Boro rice under the Boro-Fallow-T. Aman cropping pattern, BRRI, Gazipur, 2024-25

Cropping pattern	Yield (t ha^{-1})			TVC ('000 Tk/ha)	GM ('000 Tk/ha)
	T. Aman	Boro	Total grain yield		
BRRI dhan87-Fallow-BRRI dhan98	4.49 cde	6.96 b	11.45 e	259	155
BRRI dhan87-Fallow-BRRI dhan100	4.47 de	5.68 e	10.15 l	258	111
BRRI dhan87-Fallow-BRRI dhan107	4.47 de	6.06 c	10.54 hi	259	123
BRRI dhan87-Fallow- BRRI hybrid dhan7	4.44 e	5.30 d	9.74 m	259	95
BRRI dhan87-Fallow- BRRI hybrid dhan8	4.42 e	8.05 a	12.47 c	258	192
BRRI dhan95-Fallow-BRRI dhan98	5.40 a	7.12 b	12.52 c	259	195
BRRI dhan95-Fallow-BRRI dhan100	5.43 a	5.73 e	11.16 f	258	150
BRRI dhan95-Fallow-BRRI dhan107	5.33 a	6.06 c	11.38 ef	259	156
BRRI dhan95-Fallow- BRRI hybrid dhan7	5.36 a	5.35 d	10.71 gh	259	133
BRRI dhan95-Fallow- BRRI hybrid dhan8	5.37 a	8.04 a	13.41 a	258	228
BRRI dhan103-Fallow-BRRI dhan98	4.82 b	6.99 b	11.81 d	259	169
BRRI dhan103-Fallow-BRRI dhan100	4.68 bc	5.73 e	10.41 ijk	258	121
BRRI dhan103-Fallow-BRRI dhan107	4.65 bcd	6.16 c	10.81 g	259	133
BRRI dhan103-Fallow-BRRI hybrid dhan7	4.75 b	5.35 d	10.09 l	260	109
BRRI dhan103-Fallow-BRRI hybrid dhan8	4.72 b	8.08 a	12.80 b	258	204
BRRI dhan49-Fallow-BRRI dhan29 (Ck)	4.42 e	6.42 bc	10.84g	257	137
CV (%)	2.63	1.87	1.4	-	-

Means with the same letter(s) are not significantly different.
Price (Tk./kg): Rice=32.50; Straw: Boro=2, T. Aman=6.

Project 3. Development of Cropping System and Component Technology for Stress Prone Area

Expt. 3.1. Intensification of Watermelon-Fallow-T. Aman cropping pattern by inclusion of Aus rice

N Parvin, ME Uddin, MAU Razu and M Ibrahim

Introduction

In Bangladesh total cultivable land is 8.5 million hectares and it is shrinking day by day. The annual loss of agricultural land is about 0.73% per annum due to construction of houses, roads and industrial infrastructure and so on. There is no other alternative but to increase total productivity per unit area of the prevailing lands. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing more crops in the same piece of land in a year. Watermelon-Fallow-T. Aman cropping pattern is dominant cropping pattern under Khulna district. There is a fallow period of about 3.5 to 4.0 months after watermelon harvesting and before T. Aman in the existing system. Therefore, it is possible to grow short duration T. Aus rice in the present system. Keeping this view in mind, the present study was undertaken to intensify the existing Watermelon-Fallow-T. Aman cropping pattern through the inclusion of modern T. Aus rice variety and to increase the productivity of the system as well.

Objective

To increase the productivity of the existing two crop system with the inclusion of Aus rice

Material and methods

The study was conducted in the farmers' field of Batiaghata upazila in Khulna district during 2024-25. This activity was executed in collaboration with Department of Agricultural Extension at Batiaghata, Khulna. Modern T. Aus rice variety was included to intensify the existing cropping pattern treatments as follows:

• Improved cropping pattern (ICP): Watermelon-T. Aus (BRRI dhan98)-T. Aman (BR10)

• Existing cropping pattern (ECP): Watermelon-Fallow-T. Aman (BR10)

Ten different farmers' fields were used in the trial where each field was considered as one replication. In fallow period T. Aus was transplanted on 30/05/2024 and harvested on 25/08/2024. After then T. Aman variety BR10 was transplanted on 7/09/2024 with 37 days old seedling and harvested on 18/12/2024. Planting time of watermelon was 10/02/2025. Other cultural and pest management practices were performed accordingly to BRRI recommendations. The yield of each crop was converted to rice equivalent yield (REY) for comparing the system productivity. MBCR (Marginal Benefit Cost Ratio) were also calculated using following equations:

$$MBCR = \frac{GR\ (Improved) - GR\ (Existing)}{TVC\ (Improved) - TVC\ (Existing)}$$

Results and Discussion:

In T. Aman season, the average yield of BR10 was 6.10 t/ha under Watermelon-T. Aus -T. Aman cropping pattern. Due to high pest infestation and unfavorable weather (inadequate rain, increased soil salinity) the water melon field was damaged. T. Aus was cultivated in fallow period which yielded 4.6 t/ha in Watermelon-T. Aus-T. Aman cropping pattern. The inclusion of T. Aus, the total rice productivity (TRP) increased by 104% in existing system. Total rice productivity (TRP) was 10.7 t/ha, Gross Margin and MBCR were 1,29,760 Tk./ha and 1.82 respectively in the Watermelon-T. Aus-T. Aman cropping pattern. (Table 34).

Table 34. Yields and economics of different crops under Watermelon-based cropping pattern, Surkhali, Batiaghata, Khulna, 2024-2025

Cropping pattern	Yield (t/ha)				TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Watermelon	T. Aus	T. Aman	TRP (t/ha)			
ICP= Watermelon (hybrid)-T. Aus (BRRI dhan98)-T. Aman (BR10)	**Damaged	*4.6	6.10	10.7	177.86	129.76	1.82
ECP= Watermelon (hybrid)-Fallow-T. Aman (BR10)	Damaged	-	5.25	5.25	91.96	58.98	

Price (Tk/kg): Rice (Average Aus and Aman) = 29; Here, watermelon was excluded from pattern due to extreme poor yield in cost-return analysis

ICP=Improved Cropping Pattern, ECP=Existing Cropping Pattern, TRP=Total Rice Productivity, TVC=Total Variable Cost, GM=Gross Margin, MBCR=Marginal Benefit Cost Ratio

Expt. 3.2. Improvement of Boro-Fallow-T. Aman cropping pattern with newly released BRRI rice varieties in saline coastal area

N Parvin, ME Uddin, MAU Razu and M Ibrahim

Introduction

Agricultural land use in the coastal districts of Bangladesh is very poor, mainly due to soil salinity in dry season and unavailability of quality irrigation water. The increased pressure of growing population demands more food that brings attention to explore the possibilities of increasing the potential of the saline lands for increased production of crops. Most of the coastal areas are dominated by medium highlands, which are Suitable for cultivating minimum two crops and sometimes three crops. Boro-Fallow-T. Aman is the dominant cropping pattern in the Khulna region. In this pattern farmer often used BRRI dhan28 or hybrid in Boro season and local (very poor yield) in T. Aman season. That is why there was a scope of cultivating newly released HYP BRRI rice varieties in Boro-Fallow-T. Aman cropping system specially there is a huge scope for using salt tolerant Boro variety in Boro season and high yielding T. Aman variety in the Boro-Fallow-T. Aman cropping pattern. Therefore, this study was designed to increase the productivity of the coastal saline environment of Bangladesh by including salt tolerant Boro rice variety in Boro season and modern T. Aman variety against local Aman variety in the Boro-Fallow-T. Aman cropping pattern.

Objectives

i) To evaluate the performance of BRRI newly released rice varieties in Boro- Fallow-T. Aman cropping pattern
ii) To increase the productivity of the existing two crop system

Materials and Methods

The study was conducted in the farmers' field of Batiaghata upazila of Khulna district during 2024-2025. The proposed cropping pattern Boro-Fallow-T. Aman was improved with BRRI newly released rice varieties to maximize the productivity and farm income with ten replicated farmers. Salt tolerant modern Boro variety and HYV Aman variety were included to construct the cropping pattern treatments as follows:

Proposed: Boro (BRRI dhan99)-Fallow-T. Aman (BRRI dhan103)

Existing: Boro (BRRI dhan28/hybrid)-Fallow-T. Aman (local)

Ten different farmers' fields were used in the trial where each field was considered as one replication. BRRI dhan103 was transplanted on 8-12 August, 2024 with 27 to 30 days old seedling and harvesting was done on 17 November, 2024. BRRI dhan99 was transplanted on 7-10 January, 2025 with 35-38 days old seedling and harvesting was done on 27 April, 2025. Local Ranisalute variety was cultivated as an existing cropping pattern at T. Aman season. Other agronomic and pest management practices were done according to BRRI recommendations. MBCR (Marginal Benefit Cost Ratio) were calculated using following equations:

$$\text{MBCR} = \frac{GR\ (Improved) - GR\ (Existing)}{TVC\ (Improved) - TVC\ (Existing)}$$

Results and Discussion:

The average grain yield of salt tolerant Boro variety BRRI dhan99 was 7.41 t/ha against BRRI dhan28 (5.07 t/ha). On the other hand, the average grain yield of BRRI dhan103 was 5.01 t/ha against the local variety Ranisalute (2.22 t/ha). The results showed that maximum gross margin (179,000 Tk/ha) and MBCR (2.09) obtained from the cropping pattern BRRI dhan99-Fallow-BRRI dhan103 cropping pattern against the existing BRRI dhan28-Fallow-Ranisalute cropping pattern (GM 138000 Tk./ha) (Table 35).

Table 35. Yield and economics of Boro-Fallow-T. Aman cropping pattern, Batiaghata, Khulna, 2024-2025

Cropping pattern	Yield (t/ha)		TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
	Boro	T. Aman			
Boro (BRRI dhan99)-Fallow-T. Aman (BRRI dhan103)	7.41	5.01	209	179	2.09
Boro (BRRI dhan28)-Fallow-T. Aman (Ranisalute)	5.07	2.22	171	138	-

Average Rice Price:31 Tk/kg; local Ranisalute:42 Tk/kg; TVC=Total Variable Cost, GM=Gross Margin, MBCR= Marginal Benefit Cost Ratio

Expt. 3.3. Improvement of Fallow-Fallow-T. Aman cropping pattern by inclusion of Boro rice/Mungbean/Sweet Gourd in non-saline tidal ecosystem

T Husna, ABMJ Islam, MAI Khan and M Ibrahim

Introduction

The non-saline tidal ecosystem, widely distributed in the coastal and low-lying floodplain areas of Bangladesh and similar South and Southeast Asian regions, is characterized by seasonal tidal inundation with fresh water during the monsoon, followed by natural drainage in the dry season. This unique hydrological regime supports rainfed Transplanted Aman (T. Aman) rice cultivation as the dominant monsoon crop. However, due to prolonged water stagnation during the wet season and poor drainage management in the post-monsoon period, vast areas remain uncultivated for most of the year, leading to a prevalent Fallow-Fallow-T. Aman cropping pattern. Under this system, land remains idle for nearly eight months annually, resulting in low land-use efficiency, low annual cropping intensity and sub-optimal farm income.

While T. Aman remains the staple and most adapted crop for the monsoon season, the extensive fallow periods before and after its cultivation represent a substantial underutilization of agricultural potential. Climatic conditions in the non-saline tidal zones during the rabi (dry) season and pre-monsoon period are suitable for growing a range of short- and medium-duration crops, including Boro rice (irrigated dry-season rice), mungbean (a short-duration pulse with high nutritional and soil-improving value), and sweet gourd (a high-value vegetable crop with good market demand). Incorporating one or more of these crops into the existing Fallow-Fallow-T. Aman system could enhance land productivity, increase farmers’ income, and improve soil health through diversification. Boro rice utilizes residual soil moisture and supplemental irrigation, providing an additional cereal crop for food security. Mungbean matures within 60-70 days, fits well before T. Aman planting, and fixes atmospheric nitrogen, thereby reducing fertilizer needs. Sweet gourd can be cultivated on raised beds or bunds, allowing utilization of residual moisture and generating high cash returns.

By introducing such crops into the fallow periods, the cropping intensity in the non-saline tidal ecosystem could be increased from around 100% to 200-300%, improving food security, income generation, and resilience to climatic variability. Additionally, crop diversification reduces the risk of total crop failure, spreads labor demand more evenly across the year, and enhances dietary diversity in farming communities.

Therefore, the present study was undertaken with the following objectives:

i) To evaluate the productivity and economic viability of including Boro rice, mungbean, or sweet gourd in the Fallow-Fallow-T. Aman cropping pattern under non-saline tidal ecosystem conditions.
ii) To identify the most suitable crop inclusion strategy for improving land-use efficiency, cropping intensity, and farmers' income in the non-saline tidal ecosystem.

Materials and Methods

The study was conducted in the farmers' field of Charamoddi, Bakerganj, Barishal during 2024-25. The experiment was laid out in RCB design where the unit plot size was about one bigha of land. There were twenty dispersed replications in the case of Boro and Mungbean and five in Sweetgourd, with four treatments, i.e., three improved cropping patterns (Boro/Mungbean/Sweet Gourd-Fallow-T. Aman) and farmers' existing cropping pattern (Fallow-Fallow-T. Aman). In the improved cropping pattern (ICP), the variety BRRI dhan74 for Boro rice, BARI Mung-6 for Mungbean, Victoria black and Victoria super for Sweet Gourd, and BR23, BRRI dhan52 for Aman rice were cultivated. In the existing cropping pattern (ECP), the variety Moulota in T. Aman rice was used. Fertilizer management and intercultural operations were done according to the BRRI and BARI recommendations (Table 36).

Table 36. Management practices followed for different crops under Boro rice/Mungbean/Sweet Gourd-Fallow-T. Aman cropping pattern, Charamoddi, Bakerganj, Barishal 2024-25

Factors	Existing pattern	Improved pattern			
	T. Aman	Mungbean	Boro	Sweet Gourd	T. Aman
Variety	Moulota	BARI Mung-6	BRRI dhan74	Victoria black, Victoria super	BR23, BRRI dhan52
Seeding date	01 July 24	Early Jan-Mid Feb 25	05 Jan 25	20 Jan 25	21 Jun-02 Jul 24
Transplanting date	25-30 July 24	-	15 Feb 25	-	31 Jul-15Aug 24
Spacing (cm×cm)	Not specific	Broadcasting	20×20	2 m (pit to pit)	20×20
Seedling/hill	2-3	-	2-3	3	2-3
Fertilizer (Kg/ha): Urea, TSP, MoP, Gypsum, $ZnSO_4$	Not fixed	45-90-40-55-0	262-98-120-112-10	175-175-150-100-12.5	180-98-68-60-12
Irrigation	2 times	1 time	5-6 times	10 times	2 times
Weeding	No weeding	1 time	3 times, at urea top dressing	2-3 times	3 times at 7, 25 & 40 DAT
Maturity date	25-30 Nov 24	End of April 2025	07 May 25	15-24 April 25	15 Nov-01 Dec 24
Field duration (days)	123-128	60-65	82	95	107-108

Rice equivalent yield (REY): For comparison between cropping patterns, the yield of all crops was converted into rice equivalent yield (REY) based on the prevailing market price of the individual crop (Verma and Modgal, 1983).

Rice equivalent yield (t ha^{-1}) = $\frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of rice}}$

Marginal Benefit Cost Ratio (MBCR)

MBCR (Marginal Benefit Cost Ratio) was calculated using the following equations:

MBCR = $\frac{\text{GR (Improved)} - \text{GR (Existing)}}{\text{TVC (Improved)} - \text{TVC (Existing)}}$

Profitability analysis: The economic indices like total variable cost and gross return were also calculated based on the prevailing market price of the products and by-products. For economic evaluation of two tested cropping patterns, average data of three crop cycles were used.

Results and Discussion

Individual crop yield and REY, GR, TVC, GM, and MBCR of respective cropping patterns are presented in Table 1. The average yields of Boro, Mungbean, Sweet gourd, and T. Aman were 6.36, 1.4, 9.5, and 4.37 t/ha, respectively, in the improved cropping pattern, while in the existing cropping pattern, T. Aman rice grain yield was 2.13 t/ha. The rice equivalent yield (12.42 t/ha) and gross margin (3,00,080 Tk) of ICP 3 were higher than the other treatments (Table 37).

Table 37. Yields and economic analysis of different crops under Boro/Mungbean/Sweet Gourd-Fallow-T. Aman cropping pattern Charamoddi, Bakerganj, Barishal, 2024-2025

Cropping pattern	Yield (t/ha)				REY (t/ha)	TVC (000 Tk/ha)	GR (000 Tk/ha)	GM (000 Tk/ha)	MBCR
	Boro	Mung bean	Sweet Gourd	T. Aman					
ICP 1: Boro-Fallow-T. Aman	6.36	-	-	4.35 a	10.7 b	212.00	392.85	180.85	1.64
ICP 2: Mungbean-Fallow-T. Aman	-	1.40	-	4.36 a	9.65 b	208.08	336.96	171.12	1.35
ICP 3: Sweet gourd -Fallow-T. Aman	-	-	9.5	4.40 a	12.42 a	136.92	437.00	300.08	3.36
ECP: Fallow-Fallow-T. Aman (Ck.)	-	-	-	2.13 b	2.67 c	36.45	104.37	67.92	-
CV (%)				3.47	10.97				

Means with the same letter(s) are not significantly different.
ICP=Improved Cropping Pattern, ECP=Existing Cropping Pattern, REY=Rice Equivalent Yield, TVC=Total Variable Cost, GR=Gross Return, GM=Gross Margin, MBCR=Marginal Benefit Cost Ratio
Price (Tk/kg): Rice = 32, Rice (Moulota)=40; Mungbean = 113; Sweet gourd = 27; Straw: Aman=6, Boro=2

Expt. 3.4. Improvement of Mungbean-Fallow-T. Aman cropping pattern by the inclusion of Aus rice in non-saline tidal ecosystem

T Husna, ABMJ Islam, MAI Khan, and M Ibrahim

Introduction

The tidal non-saline ecosystem of coastal Bangladesh offers a unique opportunity for sustainable intensification of cropping systems. Traditionally, a Mungbean-Fallow-T. Aman pattern is widely practiced in these regions specially in Vorpasha, Bakerganj, Barishal. In this sequence, Mungbean is cultivated during the rabi season (January-April), followed by a fallow period in the early monsoon (June-July), and then T. Aman rice is grown during the main monsoon (August-November). Although this system is well-adapted to local soil and water conditions, the extended fallow period between Mungbean harvest and T. Aman transplanting remains underutilized, leading to a suboptimal use of available natural resources such as rainfall, sunlight, and residual soil fertility.

The inclusion of Aus rice, an early-maturing rice crop grown during the pre-monsoon to early monsoon season-into this gap has the potential to enhance land productivity, improve food security, and increase farmers' income without compromising the T. Aman yield. In tidal non-saline areas, rainfall patterns and tidal water inflows during April to July create favorable conditions for Aus cultivation, particularly with short-duration, high-yielding varieties. This adjustment can make more efficient use of land and water, reduce weed pressure during the fallow period, and contribute to increased annual rice production in the country.

Furthermore, the integration of Aus rice into the Mungbean-fallow-T. Aman pattern aligns with national goals for cropping intensity enhancement and climate-resilient agriculture. By diversifying the cropping sequence, farmers can spread production risks, utilize labor more evenly throughout the year, and improve soil health through continuous crop cover. However, the success of this modification depends on careful selection of Aus varieties, suitable agronomic practices, and the synchronization of planting and harvesting schedules to avoid overlap with T. Aman establishment.

Objectives

i) To increase the productivity of the existing two-crop system with the inclusion of T. Aus rice

ii) To evaluate the performance of the newly released rice varieties in Mungbean-T. Aus-T. Aman cropping pattern

Materials and Methods

The study was conducted in the farmers' field of Vorpasha, Bakerganj, Barishal during 2024-25. There were twenty dispersed replications in the case of Boro and Mungbean with two treatments, i.e., improved cropping pattern (Mungbean-T. Aus-T. Aman) and farmers' existing cropping pattern (Mungbean-Fallow-T. Aman). In the improved cropping pattern (ICP), the variety BARI Mung-6 for Mungbean, BRRI dhan48, BRRI dhan83, BRRI dhan98 for Aus rice, and BR23 for Aman rice were cultivated. In the existing cropping pattern (ECP), farmers cultivated a local Mungbean variety and local Aman rice named Dudhkolom. Fertilizer management and intercultural operations were done according to the BRRI and BARI recommendations (Table 38).

Table 38. Management practices followed for different crops under Mungbean-T. Aus-T. Aman cropping pattern, Vorpasha, Bakerganj, Barishal 2024-25

Factors	Existing pattern		Improved pattern		
	Mungbean	T. Aman	Mungbean	T. Aus	T. Aman
Variety	Local	Dudhkolom	BARI Mung-6	BRRI dhan48,83,98	BR23
Seeding date	Jan-Feb 25	01 July 24	Early Jan-Mid Feb 25	05-09 May 24	21 Jun-02 Jul 24
Transplanting date	-	25-30 July 24	-	24-29 May 24	31 Jul-15Aug 24
Spacing (cm×cm)	Broadcasting	Not specific	Broadcasting	20×20	20×20
Seedling/hill	-	2-3	-	2-3	2-3
Fertilizer (Kg/ha): Urea, TSP, MOP, Gypsum, $ZnSO_4$	Injudicious	Not fixed	45-90-40-55-0	150-53-75-38-6	180-98-68-60-12
Irrigation	No irrigation	2 times	1 time	3 times	2 times
Weeding	No weeding	No weeding	1 time	2 times	3 times at 7, 25 & 40 DAT
Maturity date	Not fixed	25-30 Nov 24	End of April 2025	23-31 Aug 24	15 Nov-01 Dec 24
Field duration (days)	83-90	123-128	60-65	91-94	107-108

Rice equivalent yield (REY): For comparison between cropping patterns, the yield of all crops was converted into rice equivalent yield (REY) based on the prevailing market price of the individual crop (Verma and Modgal, 1983).

$$\text{Rice equivalent yield (t ha}^{-1}\text{)} = \frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of rice}}$$

Marginal Benefit Cost Ratio (MBCR)

MBCR (Marginal Benefit Cost Ratio) were calculated using following equations:

$$\text{MBCR} = \frac{\text{GR (Improved)} - \text{GR (Existing)}}{\text{TVC (Improved)} - \text{TVC (Existing)}}$$

Profitability analysis: The economic indices like total variable cost and gross return were also calculated based on the prevailing market price of the products and by-products. For economic evaluation of two tested cropping patterns, average data of three crop cycles were used.

Results and Discussion

In case of Aus rice, BRRI dhan98 (4.17 t/ha) and BRRI dhan48 (4.08 t/ha) performed better than BRRI dhan83 (3.21 t/ha). In the Aman season, the average yield of BR23 was 4.38 t/ha against the local variety (Dudhkolom) (1.92 t/ha). The average yield of Mungbean was 1.46 t/ha. The Rice Equivalent Yield (REY) (13.71 t/ha) and Gross Margin (1,72,260 Tk/ha) were obtained higher from the Mungbean-T. Aus-T. Aman cropping pattern (MBCR 2) against the existing Mungbean-Fallow-T. Aman cropping pattern (Table 39).

Table 39. Yields and economic analysis of different crops under Mungbean-T. Aus-T. Aman cropping pattern Vorpasha, Bakerganj, Barishal, 2024-2025

Cropping pattern	Yield (t/ha)			REY (t/ha)	TVC (000 Tk/ha)	GR (000 Tk/ha)	GM (000 Tk/ha)	MBCR
	Mung bean	Aus	T. Aman					
ICP : Mungbean-Aus-T. Aman	1.46 a	3.82	4.38 a	13.71 a	306	478.26	172.26	2
ECP: Mungbean-Fallow-T. Aman	0.75 b	-	1.92 b	5.04 b	150	178.83	28.83	-
CV (%)	9.27		18	7.8				

Means with the same letter(s) are not significantly different.

ICP=Improved Cropping Pattern, ECP=Existing Cropping Pattern, REY=Rice Equivalent Yield, TVC=Total Variable Cost, GR=Gross Return, GM=Gross Margin, MBCR=Marginal Benefit Cost Ratio

Price (Tk/kg): Rice = 32, Rice (Dudhkalom)=40; Mungbean = 113; Straw: Boro=2, Aus=2, Aman=6

Expt. 3.5. Transformation of waterlogged wetland into three-tier production system for integrated rice-fish, fruits, and vegetables cultivation

T Husna, T Araf, ABMJ Islam, MK Quais and M Ibrahim

Introduction

Waterlogged wetlands are a common feature across many regions of Bangladesh, particularly in low-lying floodplains and haor basins. Traditionally considered unproductive or underutilized for much of the year, these ecosystems often remain submerged or saturated for extended periods, limiting conventional agricultural activities. Mostly, these lands are only used for Jute, Dhaincha or deep-water Aman cultivation, which minimizes the amount of profit. However, with increasing pressure on arable land and growing demands for food, nutrition, and income diversification, transforming these waterlogged wetlands into productive agricultural systems has become an urgent priority.

One promising and sustainable approach is the development of a three-tier integrated production system, combining rice-fish cultivation at the base level and vegetables and fruit trees on the dykes. This innovative system not only maximizes vertical and horizontal land use but also enhances resource efficiency, biodiversity, and farmers' resilience against climate shocks. By integrating aquaculture with crop and horticultural production, farmers can generate multiple income streams while improving food security and nutrition throughout the year.

In Bangladesh, this transformation aligns with national goals for climate-smart agriculture, rural livelihoods improvement, and environmental sustainability. The integrated model demonstrates how ecological limitations can be turned into opportunities through adaptive management and context-specific innovations. This report explores the methods, benefits, and challenges of implementing such three-tier systems in waterlogged wetlands, with a focus on their viability, productivity, and socio-economic impacts in rural Bangladesh.

Objectives

i) To maximize productivity and production diversity through integrating rice-fish, vegetables, and fruits
ii) To increase income and provide for the farm family's nutritional needs

Materials and methods

A waterlogged uncultivable marshy fallow land (12.02 decimal) was situated in the east byde of BRRI farm. This study was conducted to bring this unproductive fallow land under a three-tier production system, i.e., dyke (3.64 decimal), shallow pond (4.83 decimal) and canal around the pond (3.57 decimal). In the submerged area (shallow pond), Boro (BRRI dhan92) and T. Aman rice (BRRI dhan30, BR23) were cultivated. Different rabi and kharif vegetables were cultivated in the dykes. In west and south dyke, year-round papaya was planted for vegetables and fruit purposes. Okra, brinjal, and chilli were planted in an equal area of the north dyke. In south and west dykes, there were sweet gourd and country bean in Rabi season and snake gourd and wax gourd as well as bitter gourd in kharif season respectively. Some leafy vegetables, i.e., red amaranth, coriander leaves, and spinach, were cultivated in the rabi season and jute, for vegetables, red amaranth as well as water spinach in kharif season equally in the east dyke. Each dyke consists of 0.91 decimal of land. In the shallow pond, CP_1: Boro (BRRI dhan92)-Fallow-T. Aman (BRRI dha30) and CP_2: Boro (BRRI dhan92)-Fallow- T. Aman (BRRI dhan23) cropping patterns were evaluated. Thirty fingerlings of monosex tilapia, sorputi and mirror carp were released in per decimal area. In the dry season, fish took shelter in the canal.

Results and Discussion

From the shallow pond, the CP_1 and CP_2 cropping patterns yielded 9.30 to 9.65 t ha^{-1} of grain with a gross margin of 1,84,680 Tk. ha^{-1} and 1,96,000 Tk. ha^{-1}, respectively. From cost and return analysis, BCR 1.15 was found in CP_2 while it was 1.11in CP_1 (Table 40).

Table 40. Yield and profitability of Boro-Fallow-T. Aman cropping patterns in waterlogged wetland ecosystem, BRRI, Gazipur, 2024-25

Treatment	Boro	T. Aman	Total grain yield (t ha^{-1})	TVC ('000 Tk. ha^{-1})	GM ('000 Tk. ha^{-1})	BCR
CP_1: BRRI dhan92 -Fallow-BRRI dhan30	6.10	3.2	9.30	167	184.68	1.11
CP_2: BRRI dhan92 -Fallow-BR23	6.15	3.5	9.65	170	196	1.15

Price (Tk./kg): Rice: 32, Straw; Boro=2.5, Aman=6.5

The cropping patterns include combinations such as Tomato-Okra, Cauliflower-Brinjal, Cabbage-Chilli, Red amaranth-Jute, Coriander-Stem amaranth, Spinach-Water spinach, Sweet gourd-Snake gourd, and Country bean-Wax gourd-Bitter gourd. Each row records the production of individual crops within the pattern, followed by the total production and the corresponding gross return (Table 41). Overall, 676 kg of rabi and 369.42 kg of kharif vegetables per decimal were obtained from the dykes. The highest gross return (14,800 Tk) was obtained from the Tomato-Okra pattern (Table 41). Thirty fingerlings of monosex tilapia, sorputi and mirror carp were released per decimal area, but due to inundation, they escaped. The papaya plants died due to waterlogging.

Table 41. Yield and profitability of different vegetables cultivated in dyke of a three-tier production system, BRRI, Gazipur, 2024

Dyke	Pattern	Production (Kg/decimal)																	GR (Tk./ dec.)
		Rabi								Kharif									
		Tomato	Cauli flower	Cabbage	Red amaranth	Coriander	Spinach	Sweet gourd	C. Bean	Okra	Brinjal	Chilli	Jute	Stem amaranth	Water spinach	Snake gourd	Wax gourd+ Bitter gourd	Total	
North	Tomato-Okra	266	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	296	14,800
	Cauliflower-Brinjal	-	124	-	-	-	-	-	-	-	32	-	-	-	-	-	-	156	5,320
	Cabbage-Chilli	-	-	108.4	-	-	-			-	-	7	-	-	-	-	-	115.4	3,218
East	Red amaranth-Jute	-	-	-	27.40	-	-	-	-	-	-	-	66.7	-	-	-	-	94.1	3,764
	Coriander-Stem amaranth	-	-	-	-	15.75	-	-	-	-	-	-	-	63	-	-	-	78.75	3,938
	Spinach-Water spinach	-	-	-	-	-	39.55	-	-	-	-	-	-	-	111.12	-	-	150.67	6,027
South	Sweet gourd-Snake gourd	-	-	-	-	-	-	95	-	-	-	-	-	-	-	34.5	-	129.5	4,575
West	Country bean-Wax gourd+Bitter gourd	-	-	-	-	-	-	-	damaged	-	-	-	-	-	-	-	25	25	1,250
Total																			42,892

Price (Tk./kg): Red amaranth=40, Spinach=40, Tomato=50, Coriander leaf=150, Cabbage=20, Cauliflower=30, Brinjal=50, Jute leaf=40, Water spinach=40, Stem amaranth=25, Chili=150, Sweet gourd=30, Snake gourd=50, Wax gourd=50, Bitter gourd=50, Okra=50

Expt. 3.6. Modification of waterlogged fallow land into integrated agroforestry and fishery production system

MAU Razu, T Husna, MK Quais, M Ibrahim

Introduction

In Bangladesh, large areas of low-lying agricultural land remain fallow for extended periods due to seasonal waterlogging, particularly during the monsoon. This underutilization limits agricultural productivity and income opportunities for rural communities. To address this challenge, the modification of waterlogged fallow lands into integrated agroforestry and fishery production systems offers a sustainable and productive solution. This approach combines the cultivation of trees, vegetables, and crops on raised platforms with fish farming in adjacent water channels, allowing for efficient use of both land and water resources. The integration enhances biodiversity, improves soil fertility, provides diversified income streams, and contributes to year-round food and nutritional security. By transforming constraints into opportunities, this system aligns with climate-resilient agricultural practices and holds great potential for improving the livelihoods of small and marginal farmers in waterlogged regions of Bangladesh. Therefore, this study was undertaken with the following objectives.

Objectives

i) To convert waterlogged fallow land into a year-round integrated production system through efficient utilization of different niches

ii) To identify a Suitable agroforestry system for increasing productivity

iii) To explore the best production practices considering total annual income, dietary energy and micronutrition generation

Material and Methods

This experiment was undertaken to convert waterlogged marshy land into a productive system as well as to ensure a pleasant environment. High raised beds (dyke) and deep sinks (ditches) of different sizes were constructed to develop a suitable diversified cultivation system of vegetables, fruits, and fish. In this experiment, the dykes were planted with different perennial fruit trees on 12-20 June 2022, where in between the fallow area of trees, different types of summer (kharif) and winter (rabi) crops and vegetables were intercropped (Table 42, Figure 17). Besides, in the deep sink (1m water depth), different fish species with six combinations were released on 11 September 2023 with different sizes and stocking densities. Intercultural operations were followed accordingly by respective components (Table 43).

Table 42. Catalog of crops and fishes at different niches of integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25

Agroforestry at dyke		Fishery at ditch
Fruit tree	Rabi-Kharif crops	Fish combination
Mango	Red amaranth-Brinjal	Rohu+Mirror carp
Jujube	Spinach-Jute leaf	Pabda+Shorputi
Custard apple	Tomato-Kangkong	Gulsha+Magur
Guava	Coriander leaf-Stem amaranth	Tilapia+Mrigal
Malta	Cabbage-Chili	Tengra+Silver carp
Dragon fruit	Field pea-Aman rice	Shol+Shing

Planting date of fruit trees: 12-20 June 2022
Date of fish release: 11 September 2023

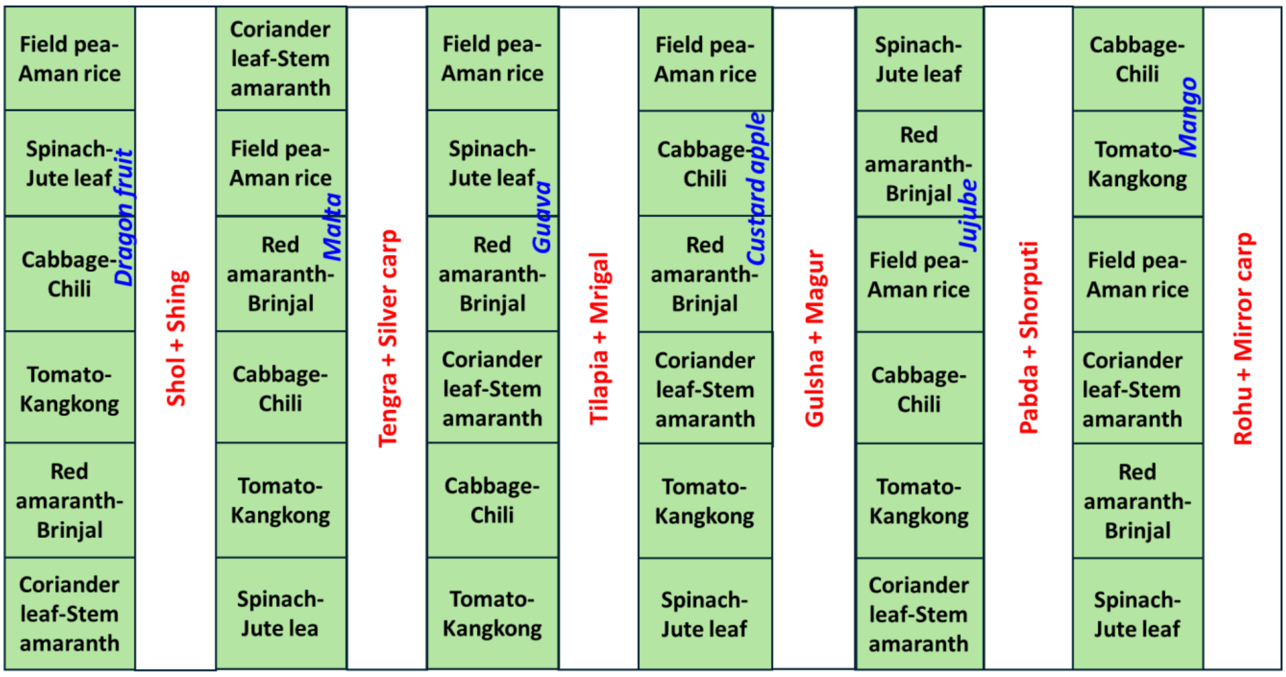


Figure 17. Layout of crops and fishes under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25

Table 43. Crop management practices under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25

Season	Crop	Variety	Cultivation method	Seed rate (kg/ha)	Seedling age	Spacing (cm×cm)	Field duration (days)
Rabi	Red amaranth	Achia-1	Broadcasting	2.5	-	-	62
	Spinach	Kopipata	Broadcasting	35	-	-	74
	Tomato	BARI tomato-21	Transplanting	-	30	60×50	98
	Coriander leaf	Morokko Sobuj Shopno	Broadcasting	40	-	-	37
	Cabbage	Atlas 70	Transplanting	-	30	60×40	102
	Field pea	BARI motor-3	Broadcasting	80	-	-	90
Kharif	Brinjal	Shingnath	Transplanting	-	30	60×60	93
	Jute leaf	BADC deshi patshak-1	Broadcasting	7	-	-	98
	Kangkong	Nice green	Broadcasting	6	-	-	115
	Stem amaranth	Sobujshathi	Broadcasting	25	-	-	123
	Chili	Current	Transplanting	-	-	-	124
	Aman rice	BRRI dhan71	Line sowing	30	-	20×20	105

Results and Discussion

Agroforestry at dykes

An integrated scenario of major fruit tree species grown at dykes, highlighting their specific contributions to production, and Mango Equivalent Yield (MEY) is presented in Figure 18. From the production system, a total of 1,542 kg/dec. MEY was generated, and among all the patterns, and the highest amount of 135 kg/dec. MEY was generated from the Coriander leaf-Stem amaranth pattern followed under mango tree. Among the fruits, the highest production was generated from guava (19 kg/dec.), followed by mango (18 kg/dec.). Fruits, rabi and kharif vegetables 3% to 32%, 43% to 74%, and 22% to 35%, respectively in MEY generation throughout the production system. Among the fruits, the highest contribution of 32% was observed in mango, followed by guava (30%). The highest contribution of 74% to MEY generation was observed in the rabi vegetables cultivated under jujube tree, and that in kharif vegetables (35%) was observed under both malta and custard apple.

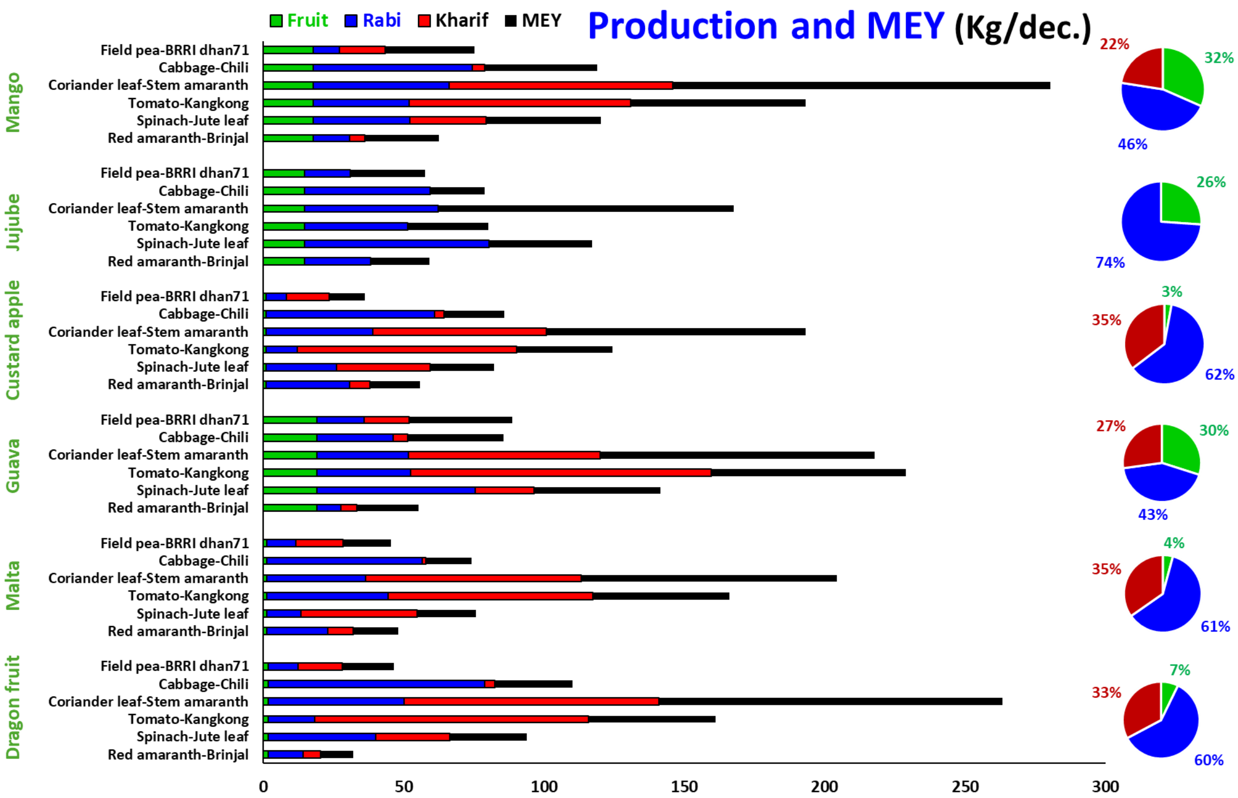
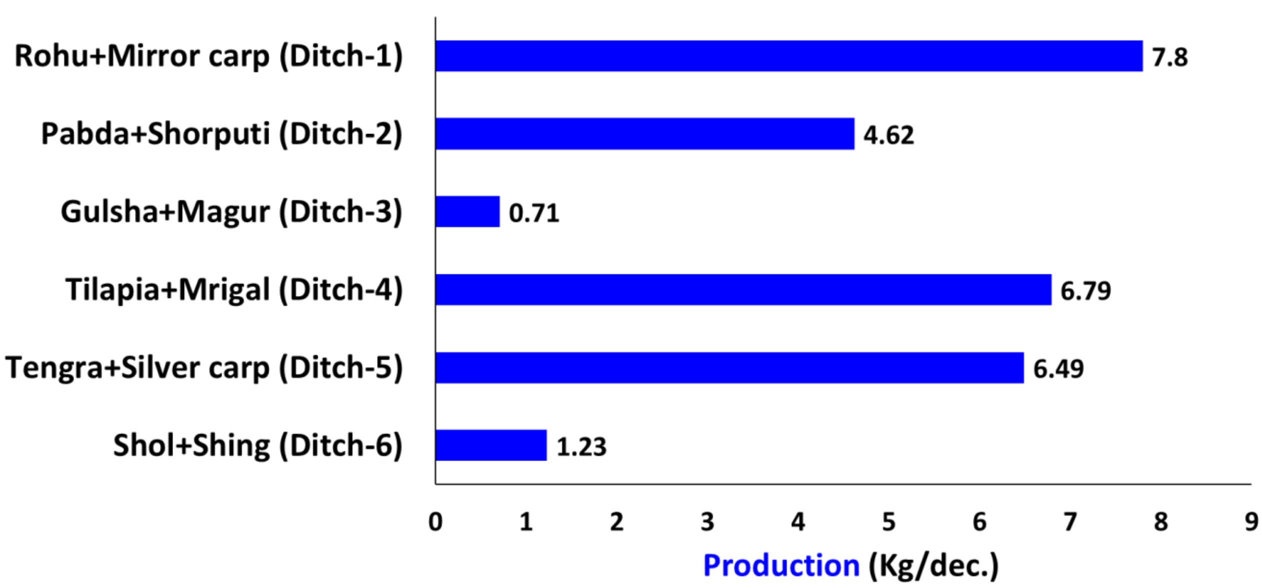


Figure 18. Scenario of production, and mango equivalent yield of fruit trees and vegetables at dykes under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25. Each stacked bar in the figure shows the relative contributions of fruit and vegetables to total production for specific crops, with pie charts providing proportional breakdowns of the mango equivalent yield.

Fishery at ditches

The production of various fish combinations at the nearby ditches of different fruit tree-based cropping systems at dykes are illustrated in Figure 19. Fish fingerlings were released in different combinations on 11 September 2023. Combination of two fish species living in different niches was maintained in each ditch. Most of the fish were swept away by the heavy rainwater during the monsoon. From rest amount of the fish, a total of 28 kg/dec. fish were harvested and among all the combinations the highest amount of 8 kg/dec. fish were produced from the Rohu+Mirror carp, followed by the combination of Tilapia+Mrigal (7 kg/dec.).



Date of fish release: 11 September 2023

Figure 19. Production of fish at ditches under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25. Value in each stacked bar shows the production of the respective fish combinations in kg/dec.

Overall scenario of the production system

Macronutrients generation

The macronutrients generation scenario for different fruit tree-based cropping systems at dykes with respective fish combinations at the nearby ditches and total contributions of various components are shown in Figure 20. From the production system, a total of 245 kg/dec. macronutrients were generated and among all the patterns the highest amount of 25 kg/dec. macronutrients were generated from the Field pea-BRRI dhan71 pattern followed under guava tree at dyke with Tilapia+Mrigal fish combination at the nearby ditch. Among the fruits, the highest macronutrients were generated from guava (2.36 kg/dec.), followed by mango (2.35 kg/dec.). Among the fish combinations, the highest macronutrients of 1.20 kg/dec. was generated from Pabda+Shorputi combination, followed by the combination of Shol+Shing (0.83 kg/dec.). Fruits, rabi and kharif vegetables along with fish contributed 1% to 32%, 26% to 56%, 36% to 59%, and 2% to 18%, respectively in macronutrients generation throughout the production system. Among the fruits, the highest contribution of 32% was observed in jujube, followed by mango (28%). Among the fish combinations, the highest contribution of 18% was observed in Tengra+Silver carp combination, followed by the combination of Tengra+Silver carp (12%). The highest contribution of 56% to macronutrients generation was observed in the rabi vegetables cultivated under jujube tree at dyke with Pabda+Shorputi fish combinations at the nearby ditch, and that in kharif vegetables (59%) was observed under custard apple at dyke with Gulsha+Magur fish combination.

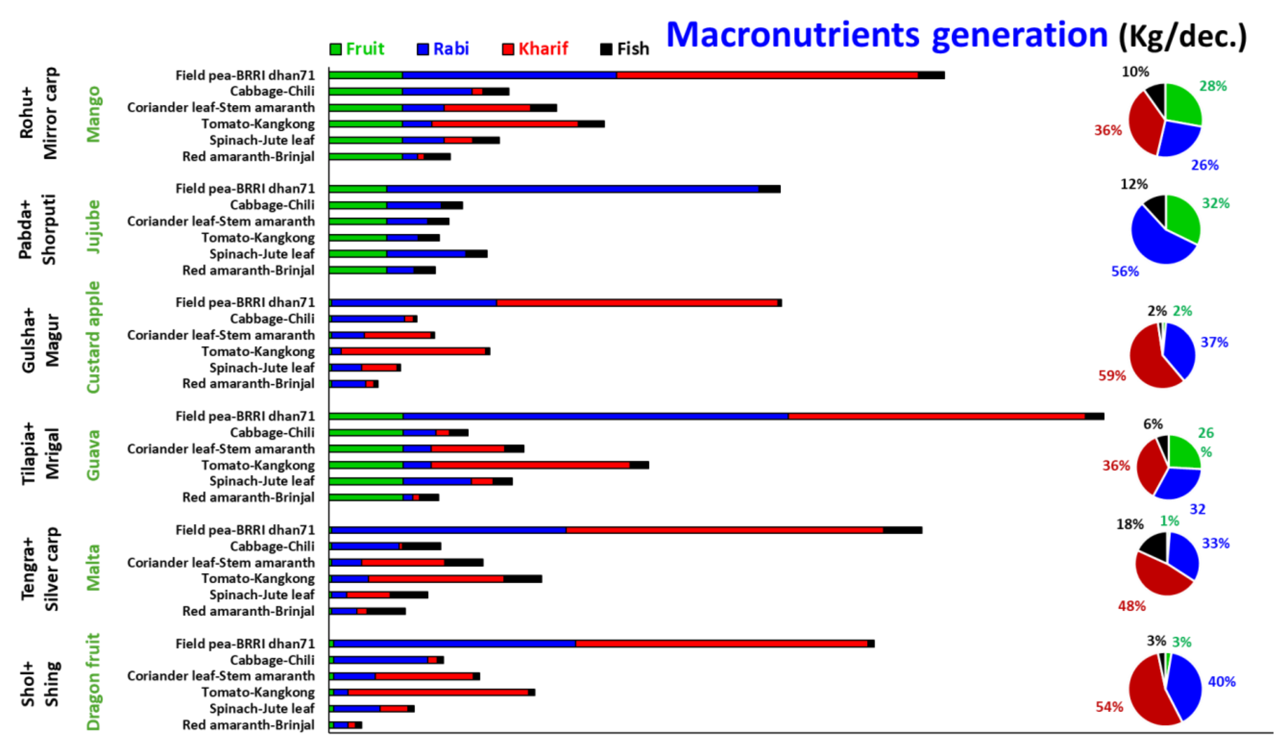


Figure 20. Macronutrients generation scenario under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25. Each stacked bar in the figure shows the relative contributions of fruit, vegetable, and fish to total macronutrient yield for specific crops or categories, with pie charts providing proportional breakdowns.

Dietary energy generation

The dietary energy generation scenario for different fruit tree-based cropping systems at dykes with respective fish combinations at the nearby ditches and total contributions of various components are illustrated in Figure 21. From the production system, a total of 4941 MJ/dec.

energy was generated and among all the patterns the highest amount of 454 MJ/dec energy was generated from the Field pea-BRRI dhan71 pattern followed under guava tree at dyke with Tilapia+Mrigal fish combination at the nearby ditch. Among the fruits, the highest energy was generated from guava (50 MJ/dec.), followed by mango (42 MJ/dec.). Among the fish combinations, the highest energy of 26 MJ/dec. was generated from Tengra+Silver carp combination, followed by the combination of Pabda+Shorputi (16 MJ/dec.). Fruits, rabi and kharif vegetables along with fish contributed 1% to 27%, 29% to 59%, 34% to 56%, and 2% to 19%, respectively in energy generation throughout the production system. Among the fruits, the highest contribution of 27% was observed in both guava and jujube. Among the fish combinations, the highest contribution of 19% was observed in Tengra+Silver carp combination, followed by the combination of Pabda+Shorputi (14%). The highest contribution of 59% to energy generation was observed in the rabi vegetables cultivated under jujube tree at dyke with Pabda+Shorputi fish combinations at the nearby ditch, and that in kharif vegetables (56%) was observed under custard apple at dyke with Gulsha+Magur fish combination.

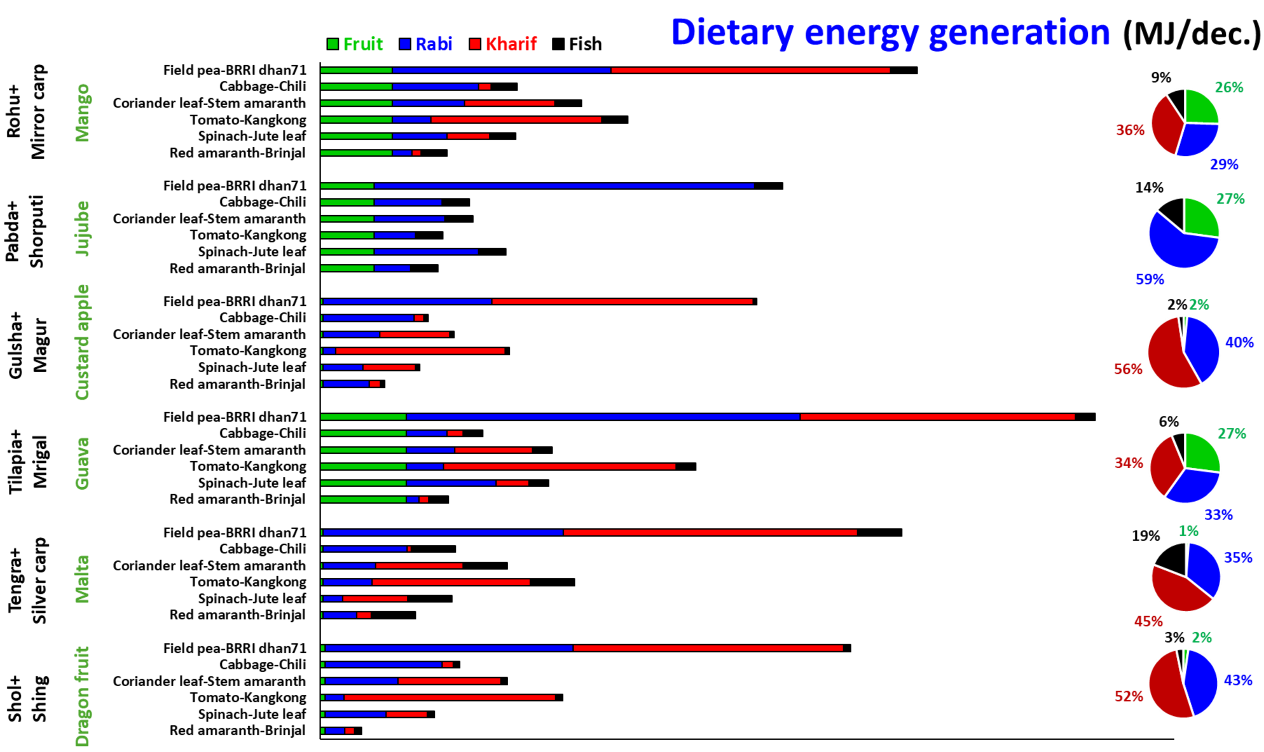


Figure 21. Dietary energy generation scenario under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25. Each stacked bar in the figure shows the relative contributions of fruit, vegetable, and fish to total dietary energy generation for specific crops or categories, with pie charts providing proportional breakdowns.

Gross Return

The gross return for different fruit tree-based cropping systems at dykes with respective fish combinations at the nearby ditches and total contributions of various components are shown in Figure 22. From the production system, a total of 2,03,411Tk./dec. gross return was generated and among all the patterns the highest amount of 15,620 Tk./dec. gross return was generated from the Coriander leaf-Stem amaranth pattern followed under mango tree at dyke with Rohu+Mirror carp fish combination at the nearby ditch. Among the fruits, the highest gross return was generated from mango (1,770 Tk./dec.), followed by guava (1,521 Tk./dec.). Among the fish combinations, the highest gross return of 2,169 Tk./dec. was generated from Rohu+Mirror carp combination, followed by the combination of Tilapia+Mrigal (2049 Tk./dec.). Fruits, rabi and kharif vegetables along with fish contributed 3% to 23%, 31% to 57%, 16% to 32%, and 8% to 34%, respectively in gross return generation throughout the production system. Among the fruits, the highest contribution of 23% was observed in mango, followed by guava (21%). Among the fish combinations, the highest contribution of 34% was observed in Tengra+Silver carp combination, followed by the combination of Tilapia+Mrigal (29%). The highest contribution of 57% to gross return generation was observed in the rabi vegetables cultivated under custard apple at dyke with Gulsha+Magur fish combinations at the nearby ditch, and that in kharif vegetables (32%) was observed under the same combination.

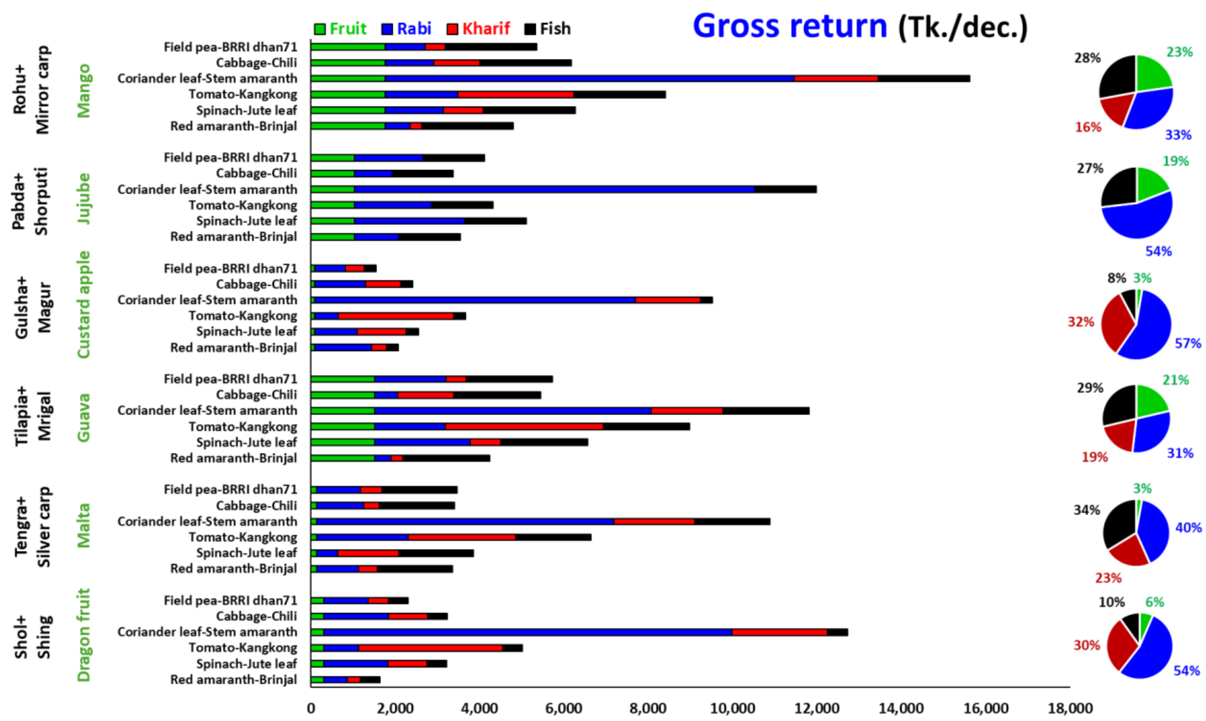


Figure 22. Gross Return scenario under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25. Each stacked bar in the figure shows the relative contributions of fruit, vegetable, and fish to total gross return for specific crops or categories, with pie charts providing proportional breakdowns. Price (Tk./kg): Dragon fruit=180, Malta=130, Guava=80, Custard apple=100, jujube=70, mango=100, red amaranth=45, spinach=40, tomato=50, coriander leaf=200, Cabbage=20, Field pea=100, Brinjal=50, Jute leaf=35, kangkong=35, Stem amaranth=25, Chili=250, Aman rice=30; Rohu=250, Mirror carp=300, Pabda=370, Shorputi=290, Gulsha=350, Magur=400, Tilapia=350, Mrigal=180, Tengra=280, Silver carp=270, Shol=400, Shing=350.

Pattern-wise performance

The pattern-wise overall performance ranking of fruit tree-crop combinations at dykes, using Z-score standardization across Mango Equivalent Yield (MEY), Gross Return (GR), dietary energy generation, and micronutrient generation is presented in Figure 23. Top-ranked patterns are Mango-Coriander leaf-Stem amaranth (1), Guava-Field pea-BRRI dhan71 (2), Dragon fruit-Coriander leaf-Stem amaranth (3), Guava-Coriander leaf-Stem amaranth (4), Jujube-Coriander leaf-Stem amaranth (5). These combinations offer the highest aggregate performance in yield, profitability, dietary energy, and nutrient output.

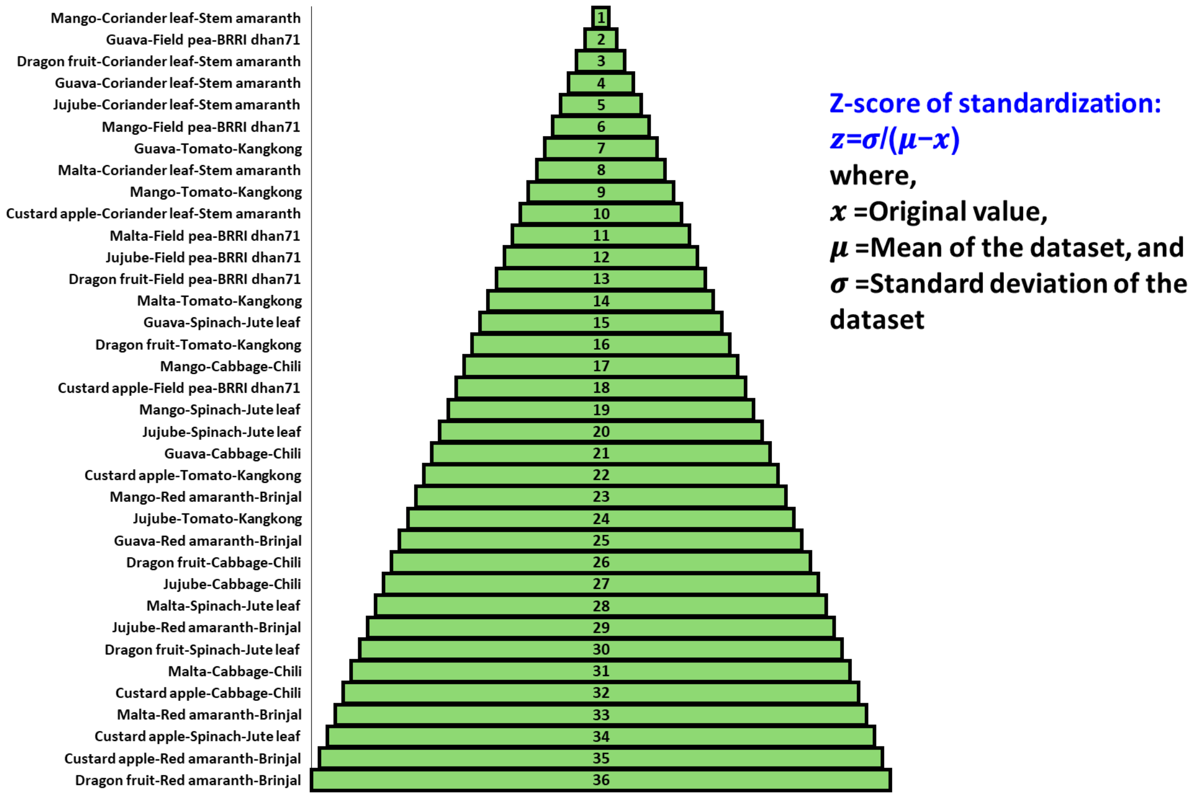


Figure 23. Pattern-wise overall performance ranking using Z-score of standardization under integrated agroforestry and fishery production system, BRRI, Gazipur, 2024-25

Conclusion

Based on a comprehensive analysis of multiple performance indicators of overall production, MEY, GR, dietary energy generation and macronutrients generation, Coriander leaf-Stem amaranth pattern followed by Field pea-BRRI dhan71 performed better and Mango-Coriander leaf-Stem amaranth stand out as the optimal production practices in dyke-ditch agriculture, delivering the highest collective benefits for yield, profit, energy, and nutrition under the study conditions. This evidence underpins strategic recommendations for sustainable intensification and resource-efficient management in integrated farming landscapes.

Project 4. Development of Cropping System Technologies for Hill Ecosystem

Expt. 4.1. Exploring the hills for rice research: Feasibility of Boro rice cultivation in fringe land at Rangamati district

MAU Razu, DH Payel, ABMJ Islam, and M Ibrahim

Introduction

Kaptai Lake is an artificial lake in Rangamati district of Chittagong Hill Tracts of Bangladesh. When the Kaptai Dam was constructed on the Karnaphuli River in 1956 for the Karnaphuli hydroelectric station, 21,862 hectares of agricultural land in the Rangamati district was submerged and this lake was created. Due to this dam, the water level of the lake increases by about 10 meters during the monsoon and the eroded soil from the hills is washed away and falls into the water and siltation begins slowly. On the other hand, the water that comes from the upstream (e.g. Mizoram, Assam, Tripura etc.) accumulates in the lake and siltation occurs in the monsoon. About 18,000 thousand families were displaced and started living on the high hills of the mountain after construction of the Kaptai Lake. They started jhum farming for their livelihood and erosion increased and this soil was washed into the water of the lake. The local people cut the bushes on the banks of the lake to open up the land. As a result, the land erosion is accelerated, and the eroded soil gets deposited for a long time in the water which gradually helps to transform into fringe land. Moreover, there is about 0.0136 M ha culturable wasteland in Kaptai Lake at CHT having the potential for cropping rice and non-rice crops in the dry season (January-May) through rescheduling the time of opening sluice gates for drainage out the water from the Lake. However, lion share of the land remains fallow and a negligible portion is used for winter Vegetables and local Boro rice. An additional 0.0269 million tons of rice could be added to the national rice basket by introducing Boro rice in the 50% of the total culturable waste (0.0067 M ha) land of Kaptai Lake; which can play a vital role in self-sufficiency of CHT in rice production (Nasim *et al.*, 2021).

Objective: To increase the Boro coverage across the fringe land by cultivation of HYV Boro rice varieties

Material and Methods

A total of 60 bigha of fringe land were brought under cultivation in Boro 2024-25 at Borkol upazila of Rangamati district. Promising modern rice varieties like BRRI dhan74, BRRI dhan92, BRRI dhan96, BRRI dhan100 and BRRI dhan102 were evaluated in culturable waste of fringe land of Kaptai Lake. Here varieties indicate treatment and each variety replicated to twelve farmers. This activity was executed in collaboration with the Department of Agricultural Extension. BRRI provided quality seeds, fertilizers, and pest management measures as and when necessary.

Results and Discussion

The varietal effect in terms of grain yield was statistically differed. Among the five varieties BRRI dhan74 performed the highest grain yield (6.06 t/ha). There is no statistical significance among BRRI dhan92, BRRI dhan96 and BRRI dhan102. But the grain yield drastically reduced in case of BRRI dhan100 (4.86 t/ha (Table 44).

Table 44. Performance of Boro varieties in culturable waste of fringe land of Kaptai Lake, Rangamati, 2024-25

Variety	Grain Yield (t/ha)
BRRI dhan74	6.06 a
BRRI dhan92	5.16 b
BRRI dhan96	5.09 b
BRRI dhan100	4.86 c
BRRI dhan102	5.20 b
CV%	7.78

*Means with the same letter are not significantly different at P<0.05

Farmer's reaction

Farmers are highly impressed and they are being encouraged to grow more rice in the dry season. Farmers are more comfortable with BRRI dhan74 than others BRRI varieties. They prefer bold rice and claimed that pest infestation is less in BRRI dhan74 than other varieties.

Expt. 4.2. Improvement of Jhum production system through the introduction of modern HYV Aus varieties in hilly areas

A Khatun, ABMJ Islam, MK Quais, SM Shahidullah and M Ibrahim

Introduction

The Chittagong Hill Tract (CHT) presents unique biophysical characteristics, ethnic diversity and farming practices following certain cropping patterns that have taken care of the lives support of the hill people including dwelling, food, clothing, health care, festivities and other activities (Khisa, 1998). The CHT districts of the country have generally been identified as a disadvantaged region in terms of poverty, food insecurity, environmental vulnerability and limited livelihood opportunities. The stressful environment of the hilly areas of the country received very little attention in the past. The increased pressure of growing population demands more food that brings attention to explore the possibilities of increasing the potential of the hilly lands for increased production of crops. Moreover, cultivable land area is decreasing day by day in the country. In this context, there is no other alternative but to address less favorable and unfavorable environments for food security.

Agriculture is the predominant occupation of the hill people. In the small fraction of land in the valleys rice is the main crop and modern rice production technologies have been adopted there. However, on the vast slopping land, a very primitive type of agriculture is practiced which is called Jhum. Jhum involves clearing of forest following the slash and burn method. The burning of slash returns nutrients to the soil through ash and kills microbes allowing relatively high yields. Aus+non-rice crops are widely practiced in Jhum cultivation system. In this system, rice covered more than 70% and the rest are mixed crops like marfa, chinar, kakrol, sweet gourd, snake gourd, ribbed groud, cucumber, chilli, ginger, turmeric, maize, zoar, kaon, sesame, cowpea, okra, brinjal, taro, banana, sweet potato, simla alo, mesta, cotton etc. But all rice varieties are locally adopted and low yielders. The production of the cropping patterns could be increased by changing cultivars and improving cultural management practices. So, to increase the system productivity, the modern Aus rice varieties were included replacing the local varieties in Jhum cultivation system.

Objective: To increase the system productivity through the introduction of modern HYV Aus varieties and to compare their performance with the local varieties in jhum culture.

Material and Methods

A total of 30 trials in Jhum cultivation system were conducted at Sadar and Panchhari upazilas of Khagrachhari, Baghaichhari and Naniarchor upazilas of Rangamati and Sadar and Ruma upazilas of Bandarban districts under Chittagong Hill Tracts in Aus 2024. Promising modern rice varieties like BRRI dhan48, BRRI dhan82 and BRRI dhan83 were evaluated in the Jhum cultivation system. This activity was executed in collaboration with the Department of Agricultural Extension. In the study areas, Jhumia farmers normally cultivated Khamarang, Khalabadia, Badui, Pidi, Ranqui, Mongthongno, Khoborok, Kokro, Churoi, Kanbui, Gallon, Compani, Amedhan, Gunda, Binni, Rangapati, Surjomani etc. which are low yielders. The majority of the Jhumia farmers did not use any fertilizer, pesticide or any other improved management practices. BRRI provided quality seeds, fertilizers, and pest management measures as and when necessary.

Results and Discussion

The grain yield of BRRI dhan48 ranged from 3.65 to 3.82 t/ha in Jhum system of different upazilas under Khagrachhari, Rangamati and Bandarban districts (Table 45). A higher yield of BRRI dhan83 (3.82 t/ha) was observed in Naniarchor upazila of Rangamati district where the farmer's variety Longur yielded 2.22 t/ha. The grain yield of BRRI dhan82 ranged from 3.40 to 3.67 t/ha under different upazilas of Khagrachhari, Rangamati and Bandarban districts. The higher yield of BRRI dhan82 (3.67 t/ha) was observed at Sadar upazila under Bandarban district where the farmer's local variety Mongthongno gave 3.35 t/ha yield. The grain yield of BRRI dhan83 ranged from 3.74 to 4.09 t/ha. The higher yield of BRRI dhan83 (4.09 t/ha) was observed at Sadar upazila under Bandarban district where the farmer's local variety Binni gave 2.27 t/ha yield. Irrespective of locations and varieties, BRRI dhan83 gave higher grain yield at Sadar upazila under Bandarban district (4.09 t/ha) where the locally adopted Binni produced 2.27 t/ha under Jhum cultivation system. Among the local varieties, higher grain yield of 3.35 t/ha was obtained from Mongthongno followed by Ranqui (3.19 t/ha) and Kanbui (3.17 t/ha) irrespective of different locations.

Table 45. Yield of Aus rice under Jhum cultivation, Chittagong Hill Tract, Aus 2024

Location	MV	Grain yield (t/ha)	Local variety	Grain yield (t/ha)
Sadar, Khagrachhari	BRRI dhan48	3.70	Shonamukhi	2.07
Panchhari, Khagrachhari	BRRI dhan48	3.78	Churoi	2.11
Baghaichhari, Rangamati	BRRI dhan48	3.65	Khalabadia	1.89
Naniarchor, Rangamati	BRRI dhan48	3.82	Longur	2.22
Sadar, Bandarban	BRRI dhan48	3.68	Kanbui	3.17
Ruma, Bandarban	BRRI dhan48	3.81	Bordhan	2.28
Av.		3.74		
Sadar, Khagrachhari	BRRI dhan82	3.46	Gallon	2.23
Panchhari, Khagrachhari	BRRI dhan82	3.55	Company	2.33
Baghaichhari, Rangamati	BRRI dhan82	3.63	Lankapora	1.94
Naniarchor, Rangamati	BRRI dhan82	3.40	Ranqui	3.19
Sadar, Bandarban	BRRI dhan82	3.67	Mongthongno	3.35
Ruma, Bandarban	BRRI dhan82	3.59	Kokro	2.89
Av.		3.55		
Sadar, Khagrachhari	BRRI dhan83	3.84	Amedhan	2.21
Panchhari, Khagrachhari	BRRI dhan83	3.89	Kapali	2.15
Baghaichhari, Rangamati	BRRI dhan83	3.99	Khoborok	1.94
Naniarchor, Rangamati	BRRI dhan83	3.74	Gunda	2.32
Sadar, Bandarban	BRRI dhan83	4.09	Binni	2.27
Ruma, Bandarban	BRRI dhan83	3.79	Kanbui	3.11
Av.		3.89		

Farmer's reaction

The Jhumia farmers showed interest in sticky rice with a little aroma similar to their local varieties Ranqui, Kanbui, Kokro, Pidi and many more. They demand all those varieties specially to celebrate Nobannya. They also demand drought tolerance, high tillering ability and high-yielding variety for the Jhum system.

SUB-PROGRAMME III. FARMING SYSTEMS TECHNOLOGY TRANSFER

Project 5: Validation and Delivery of Cropping System Technology

Expt. 5.1. Validation of pair row potato+pair row Maize-T. Aus-T. Aman cropping pattern in Northern region of Bangladesh

DH Payel, SM Shahidullah, MHA Rashid and M Ibrahim

Introduction

In Bangladesh, *Maize–Fallow–T. Aman* remains a dominant cropping pattern cultivating 101,460 ha land area and 1.184% net cropped area (Nasim et al. 2017) with low cropping intensity and sub-optimal land use. In the context of increasing food demand, shrinking arable land, and the need for sustainable agricultural intensification, improvement of this existing system is essential. The inclusion of potato and maize in a paired-row system after early harvested T. Aman rice, followed by the integration of rainfed T. Aus rice before the succeeding T. Aman season, offers a promising opportunity to transform the existing two-crop system into a four-crop intensive sequence. This proposed intensification is expected to increase cropping intensity, system productivity, and farm income through efficient utilization of land, time, and available resources with minimal additional irrigation requirement. Therefore, systematic evaluation of the proposed four-crop-based intensified cropping system is necessary to assess its agronomic performance, productivity advantage, and suitability for adoption in the northern agro-ecological zone of Bangladesh.

Objectives

i) To validate the profitable cropping pattern under the farmers' field condition

ii) To increase the total productivity of the existing cropping pattern

Materials and Methods

A trial was conducted in farmers' fields at Moulavipara, Sadar, Panchagarh during 2024-25 to improve the existing cropping pattern. The existing Maize-Fallow-T. Aman (CP_3) cropping pattern is modified to improved Pair row Potato + Pair row Maize -T. Aus-T. Aman (CP_1) and Potato-Maize-T. Aman (CP_2) cropping pattern. BRRI dhan103 in T. Aman season, BARI Alu-25 (Asterix) in rabi season, Raja 55 (Hybrid Maize) in kharif season and BRRI dhan98 in Aus season were tested in the improved cropping pattern. The tested cropping pattern were:

CP_1: Pair row Potato + Pair row Maize-T. Aus-T. Aman (BRRI dhan103)

CP_2: Potato-Maize-T. Aman (BRRI dhan103)

CP_3: Maize-Fallow-T. Aman (Local) (check)

Result and Discussion

Individual crops yield and total grain yield in terms of REY (t/ha) of the cropping patterns are presented in Table 46. In the pair row system T. Aus was damaged due to extreme drought condition and lack of rainfall. Yield of individual Potato was found higher in CP_2 than CP_1. The yield of Maize statistically differed among the CP_1, CP_2 and CP_3. Highest yield was obtained in pair row system (15.19 t/ha) and lowest in CP_2 (6.33 t/ha). Total productivity (REY) is highest in CP_1 (28.78 t/ha) followed by CP_2 (24.36 t/ha) and CP_3 (18.14 t/ha). Considering, total productivity, time interval and further intervention of the cropping system, pair row system is a potential system.

As the T. Aus did not perform, further trial may be conducted with suitable kharif crop in pair row system.

Table 46. Yield of crops under different cropping patterns, Moulavipara, Sadar, Panchagarh 2024-2025

Cropping Pattern	Yield (t/ha)				
	Potato	Maize	T. Aus*	T. Aman	REY
CP_1: Pair Row Potato + Pair Row Maize-T. Aus-T. Aman (BRRI dhan103)	19.2	15.19 a	0.00	5.54 a	28.78 a
CP_2: Potato-Maize-T. Aman (BRRI dhan103)	27.9	6.33 c	-	5.35 b	24.36 b
CP_3: Maize-Fallow-T. Aman (Local)(ck)	-	14.37 b	-	4.67 c	18.14 c
CV (%)		11.96	-	4.86	22.51

* T. Aus was damaged due to extreme drought condition; Price (TK/kg): Rice=32, Straw=8, Potato=15, Maize=30, REY=Rice Equivalent Ratio

From the cost return analysis, it was observed that the highest gross margin (GM) was obtained from CP_1 (7,31,000 Tk/ha) followed by CP_2 (5,60,00 Tk/ha). The lowest GM was observed in CP_3 (4,95,000 Tk/ha). The highest MBCR was obtained from CP_1 (2.46) followed by CP_2 (2.02).

Table 47. Cost-return analysis of different crops combinations under improved and existing cropping pattern, Moulavipara, Sadar, Panchagarh, 2024-25

Cropping Pattern	GR (‘000 Tk/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
CP_1: Pair Row Potato + Pair Row Maize-T. Aus-T. Aman (BRRI dhan103)*	851	220	731	2.46
CP_2: Potato-Maize-T. Aman	800	240	560	2.02
CP_3: Maize-Fallow-T. Aman (Local)(ck)	568	105	495	0.00

*T. Aus economics is excluded as it was damaged due to extreme drought condition

Farmers’ Reaction

Participating farmers expressed a high level of satisfaction with the potato–maize paired-row system compared to sole maize cultivation. Although transplanting of T. Aus was conducted following the first shower but, the reporting year experienced irregular and insufficient rainfall distribution in Kharif-1 period. As a result, prolonged moisture stress during the reproductive stage led to poor panicle exertion and consequent crop failure of T. Aus rice. Farmers prefer alternative Kharif crops over T. Aus rice as prolonged drought condition during Kharif-I season.

Expt. 5.2. Intensification of Boro-Fallow-T. Aman cropping pattern through the inclusion of mustard in irrigated ecosystem of Madhupur Tract

A Khatun, ABMJ Islam, MK Quais, SM Shahidullah and M Ibrahim

Introduction

Bangladesh is a land-scarce rice-based country, and the total cultivable land is (7.9 million ha) shrinking day by day. Government of Bangladesh in its sixth five-year plan suggested both the horizontal (i.e., area expansion) and vertical (i.e., yield increase) extension approach to increase the food production in the country to meet up the demand for the growing population from the shrinking land resources. In order to produce more food within a limited area, the important options are to increase the cropping intensity producing more crops in the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices.

Boro-Fallow-T. Aman is the most dominant cropping pattern in Bangladesh which occupy a significantly higher percentage (27%) of net cropped area. This cropping pattern is present in different ecosystems almost in all upazilas in highland to medium highland areas. Intensification of this cropping pattern by inclusion of an additional crop into it can create a big impact in increased production as coverage of this cropping pattern is maximum. In the Madhupur Tract AEZ, Pleistocene Terrace soil is present and soil consisting of slight undulating to evenly plain land, this cropping pattern is also dominantly present there. As for example, in Dhanbari upazila, Tangail, it is the most dominant cropping pattern covering 77% of the cropped area. In this cropping pattern, between T. Aman harvest and Boro crop establishment, there is a wet-dry transition period of about 80 days. Most of the farmers keep their lands fallow during this transition period, however farmers can easily grow short duration mustard, which may increase the total productivity of the system. Farmers are often not aware of the possibility of inclusion of mustard into their existing Boro-Fallow-T. Aman cropping pattern. Scope validation trial of this improved cropping pattern (Mustard-Boro-T. Aman) can demonstrate the feasibility of inclusion of mustard into the existing cropping pattern in real production niches for increasing total production. With this view in mind, the present study was undertaken to intensify the existing Boro-Fallow-T. Aman cropping pattern through the inclusion of short duration mustard by farmers participatory cropping pattern trials and to increase the productivity of the system by community basis through cropping pattern technology scaling up.

Objective: To scale up the Mustard-Boro-T. Aman cropping pattern through farmers participatory cropping pattern trials to increase the productivity of the system by community basis

Materials and Methods

On-farm cropping system research methodology was followed for this study. A study site was selected which consisted of three villages: Bilaspur, Soidorpara and Khamarpara under Dhanbari upazila in Tangail district. As mentioned earlier, the site is in the Madhupur Tract AEZ where Pleistocene Terrace soil is present. A short PRA and FGDs were conducted to characterize the site. On-farm, farmers managed validation trial of improved cropping pattern, Mustard-Boro-T. Aman was conducted in sixty farmers' fields during 2024-25. Based on farmers' interest and field visits, farmers and their plots were selected. BRRI dhan75 and BRRI dhan103 were tested during the T. Aman season. Mustard (BARI Sarisha-14) was a crop grown during the transition period. BRRI dhan102, BRRI dhan104, BRRI dhan105 and BRRI dhan108 were put to the test during Boro season under the tested cropping pattern trial. The tested cropping patterns were:

CP_1= BRRI dhan75-Mustard-BRRI dhan102

CP_2= BRRI dhan75-Mustard-BRRI dhan104

CP_3= BRRI dhan75-Mustard-BRRI dhan105

CP_4= BRRI dhan75-Mustard-BRRI dhan108

CP_5= BRRI dhan103-Mustard-BRRI dhan102

CP_6= BRRI dhan103-Mustard-BRRI dhan104

CP_7= BRRI dhan103-Mustard-BRRI dhan105

CP_8= BRRI dhan103-Mustard-BRRI dhan108

CP_9= BRRI dhan49-Fallow-BRRI dhan28 (Check)

Cropping pattern based recommended fertilizer dose and other recommended management practices were followed. Before going to this intervention, farmers' group discussions (FGDs) with the fifty farmers were arranged. Farmers managed existing cropping patterns, BRRI dhan49-Fallow-BRRI dhan28, adjacent to intervened plots, was monitored. BRRI provided the farmers with quality seeds, fertilizers and pesticides for the improved cropping pattern trial while the management practices were done by the farmers. The activity was executed in collaboration with the Department of Agricultural Extension (DAE). Data were collected following the standard procedure and results were interpreted on an average yield basis. The yield of mustard was converted to rice equivalent yield (REY) for comparing system productivity.

Results and Discussion

The PRA and FGD results indicated that the topography of the experimental site was plain, and the elevation was medium high. Irrigation was widely practiced. Major cropping patterns of the villages were Boro-Fallow-T. Aman, Potato-Boro-T. Aman, Fallow-Vegetable-T. Aman, Chilli-Vegetable-Vegetable, Vegetable-Fallow-T. Aman, and Boro-Aus-T. Aman. Boro-Fallow-T. Aman was the most dominant cropping pattern which covered about 86% of the net cropped area of the site.

Individual crop yield and REY of respective cropping patterns are presented in Table 48. In T. Aman season, grain yields of BRRI dhan75 ranged from 6.18 to 6.37 t/ha. Under the tested cropping pattern, grain yields of of BRRI dhan103 ranged from 6.39 to 6.53 t/ha in different farmers' fields. The average grain yield of BRRI dhan49 was 5.58 t/ha as a check. The yield of mustard ranged from 1.46 to 1.59 t/ha. Under the T. Aman-Mustard-Boro cropping pattern, grain yield of BRRI dhan102 ranged from 7.84 to 7.91 t/ha, whereas grain yields of BRRI dhan104 ranged from 6.79 to 6.85 t/ha and grain yields of BRRI dhan105 and BRRI dhan108 ranged from 7.45 to 7.65 t/ha and 8.06 to 8.24 t/ha, respectively, in different farmers' fields during Boro season. BRRI dhan28 yielded 6.27 t/ha as a check. The effect of the cropping pattern on rice equivalent yield (REY) was significant ($P \leq 0.01$). The higher REY (19.67 t/ha) was observed in CP_4 followed by the pattern CP_8 (19.30 t/ha), CP_1 (19.14 t/ha) and CP_5 (19.07 t/ha). The REY was statistically similar for the patterns CP_3, CP_6 and CP_7. The lowest REY was observed in CP_9 (11.85 t/ha).

Table 48. Yield of T. Aman, Mustard, and Boro under Madhupur Tract, Dhanbari, Tangail, 2024-25

Cropping pattern	Yield (t/ha)			REY (t/ha)
	T. Aman	Mustard	Boro	
CP_1= BRRI dhan75-Mustard-BRRI dhan102	6.33	1.53	7.91	19.14
CP_2= BRRI dhan75-Mustard-BRRI dhan104	6.25	1.46	6.79	17.71
CP_3= BRRI dhan75-Mustard-BRRI dhan105	6.18	1.59	7.45	18.72
CP_4= BRRI dhan75-Mustard-BRRI dhan108	6.37	1.58	8.24	19.67
CP_5= BRRI dhan103-Mustard-BRRI dhan102	6.46	1.49	7.84	19.07
CP_6= BRRI dhan103-Mustard-BRRI dhan104	6.53	1.52	6.85	18.24
CP_7= BRRI dhan103-Mustard-BRRI dhan105	6.39	1.46	7.65	18.71
CP_8= BRRI dhan103-Mustard-BRRI dhan108	6.41	1.51	8.06	19.30
CP_9= BRRI dhan49-Fallow-BRRI dhan28 (Ck.)	5.58	-	6.27	11.85
CV (%)	5.32			
LSD at 0.05%	0.49			

Price (Tk/kg): Mustard = 80, Rice = 25, Mustard: BARI Sarisha-14

From the economic analysis, the higher gross margin (GM) was obtained from CP_4 (2,15,400 Tk/ha) followed by CP_8 (2,06,300 Tk/ha), CP_1 (2,02,100 Tk/ha) and CP_5 (2,00,400 Tk/ha). The lowest GM was observed in CP_9 (1,39,100 Tk/ha). The pattern CP_4, CP_8, CP_1 and CP_5 gave 55%, 48%, 45% and 44% higher GM compared to the existing pattern CP_9 (Table 49). The patterns CP_3, CP_7, CP_6 and CP_2 also performed higher GM in comparison to the existing pattern CP_9. BRRI dhan75 and BRRI dhan103 in T. Aman season, and BRRI dhan102, BRRI dhan104, BRRI dhan105 and BRRI dhan108 in Boro season were quite high yielders and cropping pattern with these varieties provided the higher yield and delivered the higher economic return. Because of the intervention of suitable varieties in Boro and T. Aman and recommended management practices, Boro and T. Aman yields were increased considerably in improved cropping patterns. Together with this, the inclusion of mustard also boosted REY and GM. The productivity of the existing cropping pattern of the irrigated ecosystem of the high and medium-high land of Madhupur Tract soil might be boosted by including mustard in between T. Aman and Boro rice, according to the total production and economic analysis. There is also the possibility of large productivity gains, which will aid crop diversity and food security.

Table 49. Economic performance of different Mustard-Boro-T. Aman cropping pattern under Madhupur Tract, Dhanbari, Tangail, 2024-25

Cropping Pattern	GR ('000 Tk/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
CP_1= BRRI dhan75-Mustard-BRRI dhan102	478.4	276.3	202.1	1.53
CP_2= BRRI dhan75-Mustard-BRRI dhan104	442.8	276.3	166.5	1.23
CP_3= BRRI dhan75-Mustard-BRRI dhan105	468.0	276.3	191.7	1.44
CP_4= BRRI dhan75-Mustard-BRRI dhan108	491.7	276.3	215.4	1.64
CP_5= BRRI dhan103-Mustard-BRRI dhan102	476.7	276.3	200.4	1.51
CP_6= BRRI dhan103-Mustard-BRRI dhan104	456.1	276.3	179.8	1.34
CP_7= BRRI dhan103-Mustard-BRRI dhan105	467.8	276.3	191.5	1.44
-CP_8= BRRI dhan103-Mustard-BRRI dhan108	482.6	276.3	206.3	1.56
CP_9= BRRI dhan49-Fallow-BRRI dhan28 (Ck.)	296.3	157.2	139.1	-

In the study site there were about 750 ha of land, out of which, Boro-Fallow-T. Aman cropping pattern covered 650 ha and other cropping patterns covered 100 ha of land (Table 50). About 6.6 ha of land were brought under improved cropping pattern trial which gave yield advancement and high economic return as discussed in the earlier para. All the lands under Boro-Fallow-T. Aman cropping pattern of the site may not be possible to bring under this improved cropping pattern because of some environmental and socio-economic barriers. Field visit and FGD indicated that about 70% of the land of existing Boro-Fallow-T. Aman cropping pattern can be brought under the improved cropping pattern of Mustard-Boro-T. Aman. If so, 623 tons of mustard and Tk 2.83 crore of GM can be produced from the site which certainly will improve the livelihood of the community.

Table 50. Cropping pattern scenario of the study site after intervention of improved cropping pattern of Mustard-Boro-T. Aman, Dhanbari, Tangail, 2024-25

	Cropping pattern	Area (ha)	Target land area to be intervened (ha, % of the existing CP)	Predicted total mustard yield under ICP of the site (t)	Predicted total GM from ICP of the site (Tk)
ECP_1	Boro-Fallow-T. Aman	650	195, 30	-	42,70,500
ECP_2	Others	100	100, 100	-	-
ICP	Mustard-Boro-T. Aman	6.6	455, 70 (of 650, ie, ECP)	623	2,83,10,100

Total cultivable land: 750 ha, ECP = Existing cropping pattern, ICP = Improved cropping pattern

Farmer's reaction

Farmers are very happy with the mustard yield between the two rice seasons. Most of them did not know that any high-value crops like mustard could be cultivated successfully during this transition period. Rice is their main crop, and they are not interested in sacrificing rice yield. Through this study, they got extra benefits from mustard which helped them to curtail their household costs for edible oil.

Expt. 5.3. Piloting of Mustard-Boro-T. Aman cropping pattern in irrigated medium highland ecosystem

MK Quais, N Akter, S Jahan, MR Islam, MMR Dewan and M Ibrahim

Introduction

In Bangladesh, the total cultivable land is 8.5 million hectares, and it is shrinking day by day. The annual loss of agricultural land is about 0.4% per annum due to the construction of houses, roads, and industrial infrastructure. There is no other alternative but to increase total productivity per unit area of the prevailing lands. To improve system productivity, it is necessary to introduce diversity in enterprises for better utilization of limited resources. In order to produce more food within a limited area, the most important options are to increase the cropping intensity, producing more crops in the same piece of land in a year, and to increase the production efficiency of the individual crop by using optimum management practices.

The cropping system (CS) of a particular land refers to the cropping pattern (CP) being practiced and its interaction with other farm resources. Based on the prevailing climatic conditions, Bangladesh has diverse CSs across the country. More than 300 CSs are identified across the country, among which rice-based CSs covered nearly 80% of the CSs followed. The most dominant CS is Boro rice-Fallow-T. Aman rice, which covers 27% of the net cropped area. Between T. Aman rice harvest and Boro crop establishment, there is a wet-dry transition period of more than 80 days. Farmers keep their lands fallow during this transition period. However, during this transition period, farmers can easily cultivate short-duration rabi crops, which may increase the overall productivity of the system.

Major oilseed crops cultivated in Bangladesh include Rapeseed mustard, sunflower, peanut, sesame, and soybeans, of which only Rapeseed mustard is used for edible oil production. Locally produced oilseeds meet only 15-20 percent of the country's edible oil requirements, and the rest are imported as crude oil or as oilseeds. The government of Bangladesh has set a goal to reduce 40% of oilseed imports by the fiscal year 2024-25. Boosting rape seed production and productivity can be achieved through the adoption of improved, high-yield varieties and effective crop management. In addition, the integration of mustard into the Boro rice-Fallow-T. The Aman rice cropping system is one of the interventions aimed at increasing mustard production in the country. However, accommodating mustard in the Boro rice-Fallow-T. Aman rice requires some adjustment with the varieties used for all three crops- Boro rice, Mustard, and T. Aman rice. Instead of current long-duration varieties, short-duration high-yielding varieties, especially for T. Aman rice and Mustard, are essential. Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Institute (BARI), and Bangladesh Institute of Nuclear Agriculture (BINA) have developed many short-duration T. Aman rice and mustard varieties with higher yield potential. With this view in mind the piloting was undertaken to intensify the existing Boro-Fallow-T. Aman cropping pattern through the inclusion of mustard and to increase the productivity of the system as well.

Methodology

The showcasing Mustard-Boro-T. Aman Cropping pattern were conducted in farmers' fields located in Kaliganj, Gazipur; Sadar, Rangpur; and Horinakundo, Jhenaidah, in collaboration with the Department of Agricultural Extension (DAE) (Figure 24).

Figure 24. Demonstrations held in various locations across the country

The objective was to intensify the Boro-Fallow-T. Aman cropping pattern through the inclusion of mustard and to assess the suitability of newly released BRRI rice varieties under the Mustard-Boro-T. Aman cropping system. Initial soil samples were collected at the beginning of the demonstration. The performance of BRRI Dhan 71 and BRRI Dhan 103 was evaluated in Gazipur and Jhenaidah, while BRRI Dhan 75 and BRRI Dhan 103 were assessed in Sadar, Rangpur, during the T. Aman season. In the Rabi season, BARI Sarisha-14 and BARI Sarisha-17 were sown at all three locations whereas in Boro season, BRRI dhan100, BRRI dhan105 and BRRI dhan107 were demonstrated in Kaliganj, Gazipur; BRRI dhan74, BRRI dhan100 and BRRI dhan107 in Sadar, Rangpur and BRRI dhan102, BRRI dhan104 and BRRI dhan107 in Horinakundo, Jhenaidah. A total of 99 dispersed farmers' fields across the three locations were selected for the evaluation of the aforementioned cropping patterns and varieties, with each field serving as a single replication. The recommended fertilizer doses and management practices for rice and mustard, as suggested by BRRI and BARI, were followed during the demonstrations (**Tables 51-53**).

Table 51. Crop management practices were adopted to evaluate the Mustard-Boro-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2024-25

Mgt. factors	Improved pattern			Farmer's practice	
	Mustard	Boro	T. Aman	Boro	T. Aman
Variety	BARI Sarisha-14, 17	BRRI dhan100, 105, 107	BRRI dhan71, 103	BRRI dhan100, 105, 107	BRRI dhan103
Seeding date	10-20 Nov 2024	16-29 Dec 24	24 Jun-09 Jul 24	05-16 Dec 24	08-12 Jul 24
Seed rate (kg/ha)	7	30	30	30	30
TP date	-	03-15 Feb 25	22 July- 05 Aug 2024	15-28 Jan 25	07-12 Aug 24
Spacing (cm×cm)	Broadcasting	20×Random	20×Random	20×Random	20×Random
Seedling/hill	-	3-5	3-5	3-5	3-5
Fertilizer kg/ha): N, P, K, S, Zn & B	115-34-43-27-2-2	120-18-75-18-4-0	BR71: 69-10-41-10-0-0 BR103: 76-12-53-11-0-0	120-18-75-18-4-0	76-12-53-11-0-0
Weeding (Times)	1	3	3	3	3
Maturity/ harvesting date	24 Jan-04 Feb 25	BR100: 03-20 May 25 BR105: 08-14 May 25 BR107: 13-21 May 25	BR71: 24 Oct-02 Nov 24 BR103: 05-10 Nov 24	BR100: 25 Apr 25 BR105: 25-30 May 25 BR107: 13-19 May 25	12-15 Nov 24
Growth duration (days)	70-79	BR100: 127-139 BR105: 132-137 BR107: 139-149	BR71: 111-118 BR103: 129-135	BR100: 141 BR105: 136-141 BR107: 154	124-127

Table 52. Crop management practices adopted to evaluate the Mustard-Boro-T. Aman cropping pattern, Boikunthopur, Sadar, Rangpur 2024-25

Mgt. factors	Improved pattern			Farmer's practice	
	Mustard	Boro	T. Aman	Boro	T. Aman
Variety	BARI Sarisha-14, 17	BRRI dhan74, 100, 107	BRRI dhan75, 103	BRRI dhan74, 100, 107	BRRI dhan103
Seeding date	04-14 Nov 24	08 Jan 25	30 Jun-03 Jul 24	04 Dec 24	3 Jul 24
Seed rate (kg/ha)	7	30	30	30	30
TP date	-	12-15 Feb 25	22-28 July 2024	15 Jan 25	28 Jul 24
Spacing (cm×cm)	Broadcasting	20×Random	20×Random	20×Random	20×Random
Seedling/hill	-	3-5	3-5	3-5	3-5
Fertilizer kg/ha): N, P, K, S, Zn & B	115-34-43-27-2-2	120-18-75-18-4-0	BR75: 69-10-41-10-0-0 BR103: 76-12-53-11-0-0	120-18-75-18-4-0	76-12-53-11-0-0
Weeding (Times)	0	3	3	3	3
Maturity/ harvesting date	BARI-14: 22-31 Jan 25 BARI-17: 31 Jan-04 Feb 25	BR74: 14-19 May 25 BR100: 16-22 May 25 BR107: 22 May - 3 Jun 25	BR75: 19 Oct 24 BR103: 11 Nov 24	BR74: 2 May 25 BR100: 4 May 25 BR107: 4 May 25	9 Nov 24
Growth duration (days)	BARI-14: 79-83 BARI-17: 82-87	BR74: 126-134 BR100: 128-134 BR107: 134-146	BR75: 111 BR103: 129	BR74: 149 BR100: 151 BR107: 151	129

Table 53. Crop management practices adopted to evaluate the Mustard-Boro-T. Aman cropping pattern, Toilotupi, Harinakundu, Jhenaidah 2024-25

Mgt. factors	Improved pattern			Farmer's practice	
	Mustard	Boro	T. Aman	Boro	T. Aman
Variety	BARI Sarisha-14, 17	BRRI dhan102, 104, 107	BRRI dhan71, 103	BRRI dhan102, 104, 107	BRRI dhan103
Seeding date	14-23 Nov 2024	11 - 14 Jan 25	02 Jul-07 Jul 24	11- 14 Jan 25	02 Jul 24
Seed rate (kg/ha)	7	30	30	30	30
TP date	-	22-27 Feb 25	02 - 04 Aug 2024	23-26 Feb 25	03-04 Aug 24
Spacing (cm×cm)	Broadcasting	20×Random	20×Random	20×Random	20×Random
Seedling/hill	-	3-5	3-5	3-5	3-5
Fertilizer kg/ha): N, P, K, S, Zn & B	115-34-43-27-2-2	120-18-75-18-4-0	BR71: 69-10-41-10-0-0 BR103: 76-12-53-11-0-0	120-18-75-18-4-0	76-12-53-11-0-0
Weeding (Times)	0	3	3	3	3

Maturity/ harvesting date	BARI-14: 08-13 Feb 25 BARI-17: 08-14 Feb 25	BR102: 25-27 May 25 BR104: 25-27 May 25 BR107: 23 May-03 Jun 25	BR71: 25-30 Oct 24 BR103: 03-11 Nov 24	BR102:30 May 25 BR104: 26-28 May 25 BR107: 30 May 25	05-09 Nov 24
Growth duration (days)	BARI-14: 80-88 BARI-17: 82-89	BR102: 131-133 BR104: 131-140 BR107: 133-142	BR71: 110-115 BR103: 124-132	BR102: 136 BR104: 135-137 BR107: 138	126-130

Results and Discusssion

Jamalpur, Kaliganj, Gazipur

T. Aman rice

The grain yield of the T. Aman crop is presented in **Table 54**. The grain yield of BRRI dhan103 in the check pattern was significantly higher than that of BRRI dhan71 in the improved cropping pattern. Results indicated that BRRI dhan 103 consistently outperformed BRRI dhan 71 across most yield-contributing traits. Under ECP, BRRI dhan103 showed the highest yield (5.73 t/ha), significantly greater than BRRI dhan71 under ICP (4.86 t/ha). This higher yield was associated with longer panicles, more panicles per square meter, and higher filled grain count per panicle. The grain yield of BRRI dhan103 appeared to be higher under slightly delayed conditions in existing cropping pattern.

Table 54. Yield and yield components of T. Aman rice under different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2024.

Treatments	Variety	Panicle length (cm)	Panicle/m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-Boro-T. Aman	BRRI dhan71	24.12	223	85	39	24.07	4.86 b
	BRRI dhan103	25.61	229	82	66	23.61	5.31 ab
ECP= Boro-Fallow-T. Aman	BRRI dhan103	27.88	263	90	43	23.53	5.73 a

ICP= Improved cropping pattern, ECP: Existing cropping pattern; Different letters indicate significant difference at $P < 0.05$

Effect of transplanting date on grain yield of T. Aman rice

Grain yield responses to different transplanting dates were evaluated for two rice varieties, BRRI dhan71 and BRRI dhan103. For BRRI dhan71, grain yield showed minimal variation across transplanting windows (20-30 July, 01-05 August, and 06-10 August), with a weak quadratic relationship ($R^2 = 0.038$), indicating that transplanting date had a negligible influence on yield. In contrast, BRRI dhan103 showed a slightly positive linear trend in yield with later transplanting, suggesting a modest improvement in yield with delayed transplanting. However, the strength of this relationship remains weak overall. These findings suggest that BRRI dhan103 may respond slightly better to delayed transplanting compared to BRRI dhan71, whose yield remains largely unaffected by transplanting time within the tested range (Figure 25).

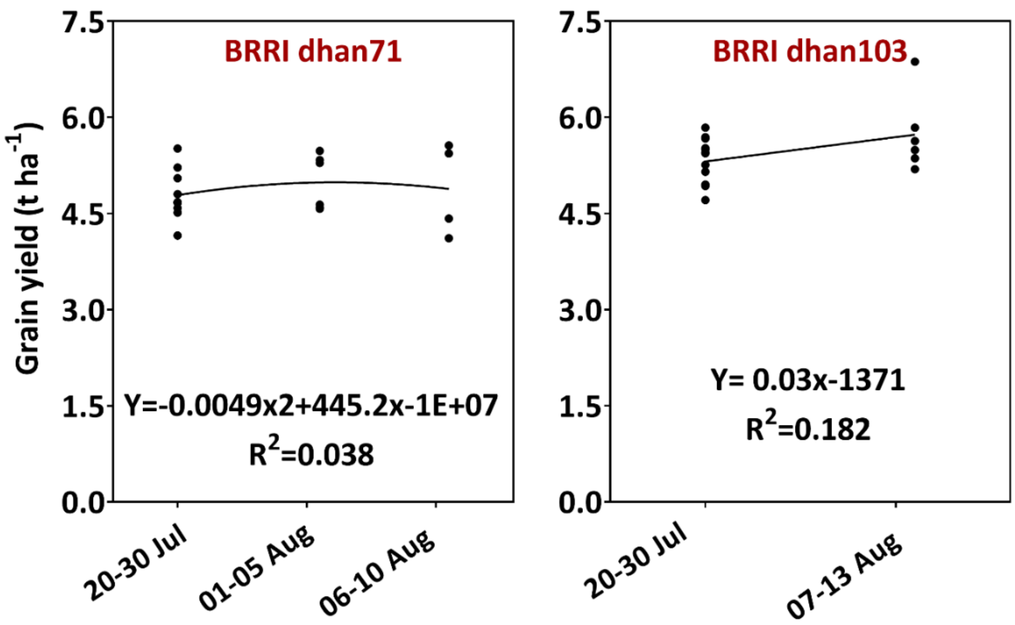


Figure 25. Relationship between grain yield of T. Aman rice varieties and transplanting dates in Kaliganj, Gazipur. Dots represent individual values, and lines indicate fitted simple linear and polynomial quadratic regressions

Farmer's opinion

Although the grain yield of BRRI dhan103 was higher than BRRI dhan71, farmers prefer BRRI dhan71 for it's shorter growth duration and lower sensitivity to insects and diseases compared to BRRI dhan103.

Mustard

During the Rabi season of 2024-25, BARI Sarisha-14 and BARI Sarisha-17 were sown under Mustard-Boro-T. Aman cropping pattern. Yield and yield attributes of mustard varieties is presented in **Table 55**. There was no significant difference in grain yield or crop duration between the two varieties across the different cropping pattern treatments. BARI Sarisha-14 had higher plant density compared to BARI Sarisha-17. BARI Sarisha-17 had fewer pods per plant but higher seed per pod.

Table 55. Grain yield and yield components of mustard under different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2024-25.

Treatments	Variety	Plant/m^2	Pod/plant	Seed/pod	1000-SW (g)	Yield (t/ha)
ICP= Mustard-Boro-T. Aman	BARI Sarisha-14	75	42	23	2.98	1.56
	BARI Sarisha-17	87	30	28	3.05	1.50
ECP= Boro-Fallow-T. Aman						NS

ICP= Improved cropping pattern, ECP: Existing cropping pattern

Effect of sowing time on the grain yield of mustard

The grain yield performance of two mustard varieties was evaluated under varying sowing dates different sowing windows in November (Figure 26). The results indicated that both varieties exhibited relatively stable grain yields across the sowing periods. For BARI Sarisha-14, a slight decline in yield was observed with delayed sowing from 10-15 November to 17-20 November. The regression analysis showed a weak negative relationship between sowing date and yield (R^2 = 0.07), suggesting a minor sensitivity to sowing time. For BARI Sarisha-17, the yield remained largely unaffected by the change in sowing window from 10-14 November to 16-17 November.

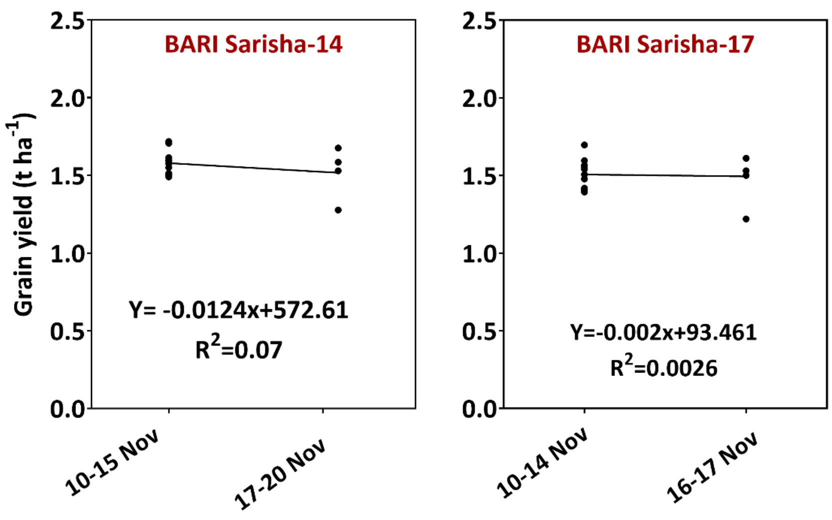


Figure 26. Grain yield of mustard varieties affected by sowing time in Gazipur. Dots represent individual values, and lines indicate fitted simple linear and polynomial quadratic regressions

Farmer's opinion

Although the grain yield and duration of BARI Sarisha-14 and 17 are similar, farmers prefer BARI Sarisha-17 for its demand as "shak" as it has a less bitter taste than BARI Sarisha-14.

Boro rice

Grain yield performance of Boro rice under different cropping systems is presented in **Table 56**. The inclusion of mustard in Boro-Fallow-T. Aman system resulted in a significant reduction in grain yield compared to the existing cropping system. Under the ICP, BRRI dhan100 and BRRI dhan105 produced significantly higher yields than BRRI dhan107, whereas no significant yield differences were observed among varieties under the ECP. The introduction of mustard into the cropping system was associated with a reduction in panicle density and the number of filled grains per panicle, while the number of unfilled grains per panicle increased across all varieties. These findings highlight the yield potential of BRRI dhan100 and BRRI dhan105 under mustard-based cropping patterns.

Table 56. Yield of Boro rice under different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2024-25.

Treatments	Variety	Panicle length (cm)	Panicle/m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-Boro-T. Aman	BRRI dhan100	22.96	345	83	23	18.33	6.07Ba
	BRRI dhan105	23.84	371	71	33	21.45	6.47Ba
	BRRI dhan107	27.62	357	52	43	25.10	5.38Bb
ECP= Boro-Fallow-T. Aman	BRRI dhan100	24.00	392	100	25	17.03	6.82Aa
	BRRI dhan105	23.91	418	82	23	20.48	7.12Aa
	BRRI dhan107	27.45	395	67	27	27.83	6.48Aa

ICP= Improved cropping pattern, ECP: Existing cropping pattern; Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at P< 0.05.

Effect of transplanting date on grain yield of Boro rice

The grain yield response of three Boro rice varieties to different transplanting dates is illustrated in **Figure 27**. All varieties exhibited a yield decline with delayed transplanting; however, the magnitude of reduction varied among genotypes. BRRI dhan 100 showed a quadratic response, with the maximum yield observed around early February. Delaying transplanting beyond this point resulted in a moderate decline in yield. BRRI dhan105 displayed a more consistent negative linear trend, with yield gradually decreasing as transplanting was delayed. In contrast, BRRI dhan107 was highly sensitive to transplanting date, showing a sharp and significant yield decline with later planting. These results suggest that timely transplanting, particularly by early February, is critical for maximizing grain yield.

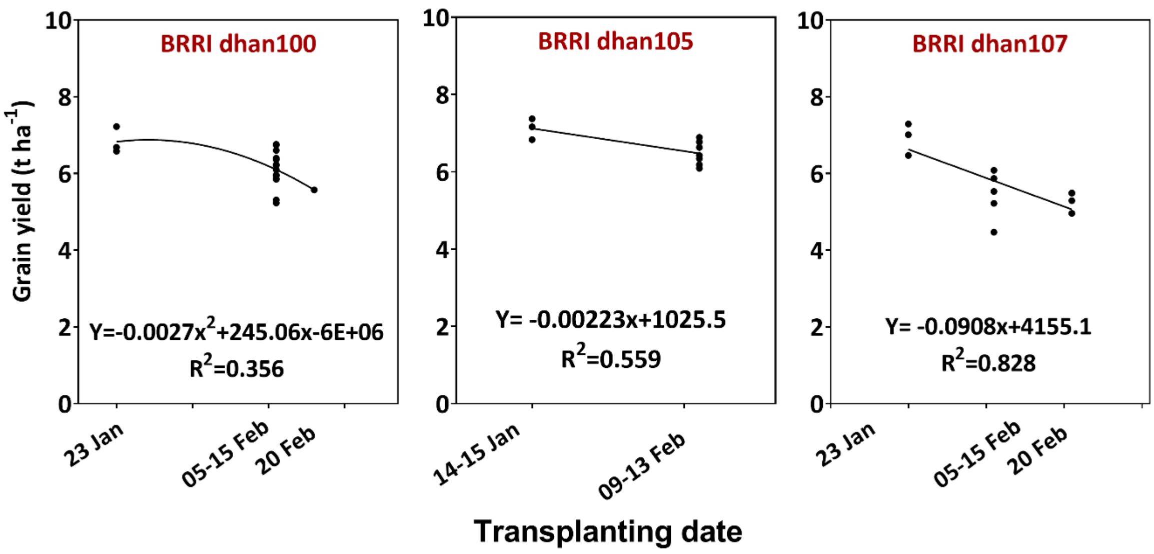


Figure 27. Effect of transplanting dates on grain yield of Boro rice varieties in Kaliganj, Gazipur. Dots represent individual values, and lines indicate fitted simple linear and polynomial quadratic regressions

Farmer's opinion:

Despite the higher grain yield potential of BRRI dhan 105, farmers expressed a preference for BRRI dhan 100 for Mustard-Boro-T. Aman cropping pattern due to its earlier maturity and superior grain quality, particularly the finer grain size, which aligns better with market demand and household consumption preferences.

The rice equivalent yield (REY) and cost-return analysis for different cropping pattern combinations are presented in **Table 57.** The introduction of mustard in Boro-Fallow-T. Aman cropping pattern significantly increased the productivity of the existing cropping pattern. Among the evaluated combinations, the cropping patterns BARI Sarisha-14-BRRI dhan100-BRRI dhan103, BARI Sarisha-14-BRRI dhan105-BRRI dhan103, BARI Sarisha-14-BRRI dhan107-BRRI dhan103, and BARI Sarisha-17-BRRI dhan105-BRRI dhan103 exhibited superior performance in terms of REY. The cost-return analysis revealed that total variable cost (TVC) for all improved cropping patterns was significantly higher than that of the existing pattern due to the added cost of mustard cultivation. When considering the marginal benefit-cost ratio (MBCR), BARI Sarisha-14-BRRI dhan100-BRRI dhan103 and BARI Sarisha-14-BRRI dhan105-BRRI dhan103 patterns found as the economically viable options, demonstrating the higher profitability among the tested systems.

Table 57. Rice equivalent yield (REY) and economics of different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2024-25

Cropping pattern	REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
BARI Sarisha-14-BRRI dhan100-BRRI dhan71	15.10 abc	372a	163b	1.09
BARI Sarisha-14-BRRI dhan105-BRRI dhan71	15.50 a	375a	168b	1.16
BARI Sarisha-14-BRRI dhan107-BRRI dhan71	14.09 cd	374a	157b	1.00
BARI Sarisha-14-BRRI dhan100-BRRI dhan103	15.54 a	377a	185a	1.39
BARI Sarisha-14-BRRI dhan105-BRRI dhan103	15.95 a	380a	190a	1.45
BARI Sarisha-14-BRRI dhan107-BRRI dhan103	14.53 a	379a	180a	1.31
BARI Sarisha-17-BRRI dhan100-BRRI dhan71	14.94 abcd	372a	157b	1.00
BARI Sarisha-17-BRRI dhan105-BRRI dhan71	15.35 ab	375a	163b	1.08

Cropping pattern	REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
BARI Sarisha-17-BRRI dhan107-BRRI dhan71	13.92 d	374a	152c	0.92
BARI Sarisha-17-BRRI dhan100-BRRI dhan103	15.39 ab	377a	179a	1.32
BARI Sarisha-17-BRRI dhan105-BRRI dhan103	15.79 a	380a	185a	1.38
BARI Sarisha-17-BRRI dhan107-BRRI dhan103	14.39 bcd	379a	174ab	1.24
BRRI dhan103-BRRI dhan100 (Ck1)	12.56 e	306b	156b	-
BRRI dhan103-BRRI dhan105 (Ck2)	12.85 e	304b	151c	-
BRRI dhan103-BRRI dhan107 (Ck3)	12.21 e	308b	164b	-

Different letters indicate significant difference at $P < 0.05$.
Price (Tk/kg): Boro rice= 30 to 32.5, T. Aman rice= 32.5 to 35, Boro straw= 2-3, T. Aman straw= 5-7, Mustard= 80, Stover = 02-03

Boikanthopur, Sadar, Rangpur

T. Aman rice

The yield of the T. Aman crop is presented in **Table 58**. There was no significant difference in grain yield of different varieties among the treatments. Unlike the on-station trial, the grain yield of BRRI dhan103 appeared to be higher under slightly delayed conditions. Mustard could not be sown at the optimal time, despite the harvest of Aman rice in mid-October, as farmers typically leave the crop to dry in the field after harvesting. According to the farmers, this practice reduces transportation costs, threshing time, and helps produce high-quality straw.

Table 58. Yield of T. Aman rice under different cropping pattern combinations, Boikanthopur, Sadar, Rangpur, 2024.

Treatments	Variety	Panicle/m^2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-Boro-T. Aman	BRRI dhan75	254	126	39	21.25	5.34
	BRRI dhan103	286	112	54	23.70	5.63
ECP= Boro-Fallow-T. Aman	BRRI dhan103	303	119	56	23.57	5.90
						NS

ICP= Improved cropping pattern, ECP: Existing cropping pattern

Farmer's opinion

Both varieties got a positive response from the farmer. They are willing to grow next year specially BRRI dhan75 because of early maturity.

Mustard

During the Rabi season of 2024-25, BARI Sarisha-14 and BARI Sarisha-17 were sown under Mustard-Boro-T. Aman cropping pattern. Yield and yield attributes of mustard varieties is presented in **Table 59**. There was no significant difference in grain yield or crop duration between the two varieties across the different cropping pattern treatments. BARI Sarisha-17 had higher plant density compared to BARI Sarisha-14. BARI Sarisha-17 had fewer pods per plant but higher seed per pod.

Table 59. Grain yield and yield components of mustard under different cropping pattern combinations, Boikanthopur, Sadar, Rangpur, 2024-25.

Treatments	**Variety**	**Plant/m^2**	**Pod/plant**	**Seed/pod**	**1000-SW (g)**	**Yield (t/ha)**
ICP= Mustard-Boro-T. Aman	BARI Sarisha-14	45	37	22	3.40	1.22
	BARI Sarisha-17	51	31	24	3.26	1.31
ECP= Boro-Fallow-T. Aman						NS

ICP= Improved cropping pattern, ECP: Existing cropping pattern

Effect of sowing time on the grain yield of mustard

The grain yield performance of two mustard varieties was assessed under varying sowing dates in November (Figure 28). The grain yield of BARI Sarisha-14 remained relatively stable across different sowing dates, with no discernible trend observed. In contrast, BARI Sarisha-17 showed a slight reduction in yield with delayed sowing. These results suggest that BARI Sarisha-14 is more stable across varying sowing dates, whereas BARI Sarisha-17 may be marginally sensitive to delayed sowing. However, in both cases, the low R^2 values indicate that sowing date within the described range had minimal influence on yield.

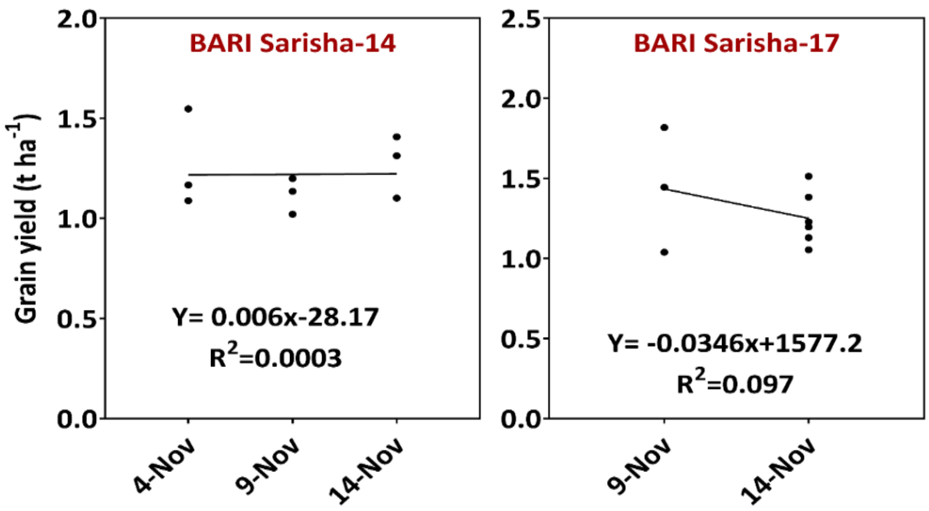


Figure 28. Grain yield of mustard varieties affected by sowing time in Rangpur. Dots represent individual values, and lines indicate fitted simple linear regressions

Farmer's opinion

Although the grain yields of BARI Sarisha-14 and BARI Sarisha-17 are comparable, farmers expressed a preference for BARI Sarisha-14 due to its earlier maturity. At this site, BARI Sarisha-17 exhibited a longer growth duration by 4-5 days compared to BARI Sarisha-14. Farmers are concerned that delayed harvesting of mustard may lead to late transplanting of Boro rice, which, if done after 15 February, could result in reduced Boro yields. Therefore, they are less inclined to adopt BARI Sarisha-17 despite its similar yield potential.

Boro rice

Grain yield performance of Boro rice under different cropping systems is presented in **Table 60**. The inclusion of mustard in Boro-Fallow-T. Aman system resulted in a significant reduction in grain yield compared to the existing cropping system. Both under ICP and ECP, BRRI dhan107 produced significantly higher yields than other varieties. The introduction of mustard into the cropping system was associated with a reduction in panicle density and the number of filled grains per panicle. In contrast, the number of unfilled grains per panicle increased across all varieties. These findings highlight the yield potential of BRRI dhan74 and BRRI dhan107 under mustard-based cropping systems.

Table 60. Yield of Boro rice under different cropping pattern combinations, Boikanthopur, Sadar, Rangpur, 2024-25

Treatments	Variety	Panicle/ m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-Boro-T. Aman	BRRI dhan74	322	98	46	24.16	7.20Bb
	BRRI dhan100	286	119	43	17.26	7.01Ab
	BRRI dhan107	280	94	64	26.31	7.86Ba
	BRRI dhan74	342	107	35	24.23	7.69Ab

ECP= Boro-Fallow-T. Aman	BRRI dhan100	296	121	37	17.80	7.13Ac
	BRRI dhan107	330	111	38	26.17	8.24Aa

ICP= Improved cropping pattern, ECP: Existing cropping pattern; Capital letters indicated the comparison among different cropping patterns of a given variety. Lower case letters indicated the comparison among different varieties within a given cropping pattern. Different letters indicate significant difference at P< 0.05.

Effect of transplanting date on grain yield of Boro rice

The grain yield response of three Boro rice varieties to different transplanting dates is illustrated in **Figure 29**. Grain yield of all three rice varieties exhibited a decreasing trend with delayed transplanting. BRRI dhan107 showed the highest sensitivity to transplanting date, with a strong negative relationship (R^2 = 0.693), indicating substantial yield reduction with delayed transplanting. BRRI dhan74 also exhibited a moderate decline in yield (R^2 = 0.559). In contrast, BRRI dhan100 showed minimal response to transplanting delay, with a weak relationship (R^2 = 0.0316). These results suggest that timely transplanting is crucial for maximizing the yield potential of BRRI dhan107 and BRRI dhan74, while BRRI dhan100 demonstrates greater stability under varying transplanting dates.

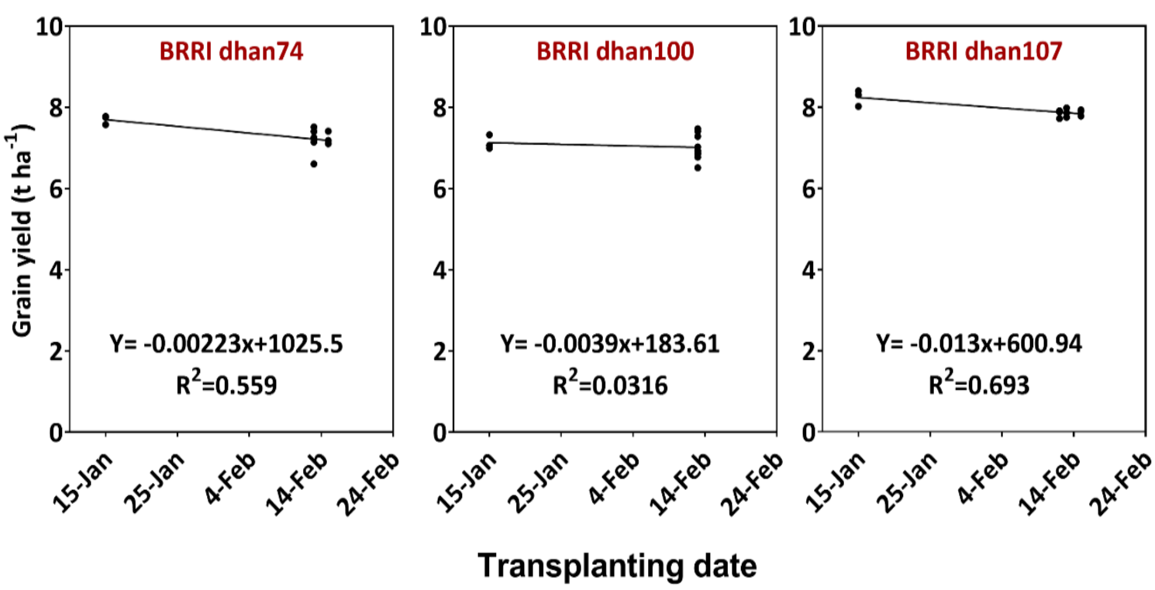


Figure 29. Effect of transplanting dates on grain yield of Boro rice varieties in Sadar, Rangpur. Dots represent individual values, and lines indicate fitted simple linear regressions

Farmer's opinion

Despite the higher grain yield of BRRI dhan107, farmers expressed a preference for BRRI dhan74 for several reasons. Firstly, BRRI dhan74 showed greater resilience to delayed transplanting, which often results from the inclusion of mustard in the cropping pattern. Secondly, farmers noted that BRRI dhan74 commands a higher market price, even though it has bold grains, whereas BRRI dhan107, despite its slender grains, fetched a lower price. Lastly, blast disease incidence was lower in BRRI dhan74 compared to the other tested varieties, making it a more reliable option for farmers.

The rice equivalent yield (REY) and cost-return analysis for various cropping pattern combinations are presented in **Table 61**. The inclusion of mustard in the Boro-Fallow-T. Aman cropping pattern significantly enhanced the overall productivity compared to the existing system. Among the evaluated combinations, BARI Sarisha-17-BRRI dhan107-BRRI dhan103 pattern showed the highest performance in terms of REY. Cost-return analysis indicated that total variable cost (TVC) was notably higher for all improved cropping patterns, primarily due to the additional costs associated with mustard cultivation. However, when assessed through the marginal benefit-cost ratio (MBCR), BARI Sarisha-17-BRRI dhan107-BRRI dhan103 and BARI Sarisha-14-BRRI dhan74-BRRI dhan103 patterns emerged as economically viable options, offering greater profitability among the tested systems.

Table 61. Rice equivalent yield (REY) and economics of different cropping pattern combinations, Boikanthopur, Sadar, Rangpur, 2024-25

Cropping pattern	REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
BARI Sarisha-14-BRRI dhan74-BRRI dhan75	15.77b	373a	165b	1.17
BARI Sarisha-14-BRRI dhan100-BRRI dhan75	15.80ab	355a	157c	1.07
BARI Sarisha-14-BRRI dhan107-BRRI dhan75	16.72ab	368a	172ab	1.28
BARI Sarisha-14-BRRI dhan74-BRRI dhan103	16.06ab	357a	191a	1.67
BARI Sarisha-14-BRRI dhan100-BRRI dhan103	16.09ab	367a	156c	1.04
BARI Sarisha-14-BRRI dhan107-BRRI dhan103	17.02ab	378a	172b	1.24
BARI Sarisha-17-BRRI dhan74-BRRI dhan75	15.78ab	381a	157c	1.05
BARI Sarisha-17-BRRI dhan100-BRRI dhan75	15.81ab	364a	149c	0.93
BARI Sarisha-17-BRRI dhan107-BRRI dhan75	16.73ab	379a	160c	1.09
BARI Sarisha-17-BRRI dhan74-BRRI dhan103	16.07ab	376a	173ab	1.26
BARI Sarisha-17-BRRI dhan100-BRRI dhan103	16.10ab	371a	151c	0.98
BARI Sarisha-17-BRRI dhan107-BRRI dhan103	17.03a	373a	178ab	1.34
BRRI dhan103-BRRI dhan74 (Ck1)	13.60c	301b	165b	-
BRRI dhan103-BRRI dhan100 (Ck2)	13.03c	297b	133d	-
BRRI dhan103-BRRI dhan107 (Ck3)	14.14c	303b	161b	-

Different letters indicate significant difference at $P< 0.05$.
Price (Tk/kg): Boro rice= 27.5 to 30, T. Aman rice= 27.5, Boro straw= 2-3, T. Aman straw= 6-7, Mustard= 80, Stover = 2-3

Toilotupi, Horinakundo, Jhenaidah

The grain yield of the T. Aman crop is presented in **Table 62**. The grain yield of BRRI dhan103 was significantly higher than that of BRRI dhan71. Mustard could not be sown at the optimal time, as farmers typically leave the crop to dry in the field after harvesting and unusual rainfall at the last week of October 2024.

Table 62. Yield of T. Aman rice under different cropping pattern combinations, Toilotupi, Horinakundo, Jhenaidah, 2024.

Treatments	Variety	Panicle/m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-	BRRI dhan71	222	119	17	23.30	5.05 b
Boro-T. Aman	BRRI dhan103	290	149	23	22.51	5.93 a
ECP= Boro-Fallow-T. Aman	BRRI dhan103	338	150	28	22.65	6.23 a

ICP= Improved cropping pattern, ECP: Existing cropping pattern; Different letters indicate significant difference at $P< 0.05$

Farmer's Opinion

Farmers expressed a preference for both BRRI dhan71 and BRRI dhan103. BRRI dhan71 is favored for its early maturity, which facilitates the timely sowing of mustard in Mustard-Boro-T. Aman cropping pattern. On the other hand, BRRI dhan103 is preferred for its superior grain and straw yields, which contribute to overall farm productivity.

Mustard

During the Rabi season of 2024-25, BARI Sarisha-14 and BARI Sarisha-17 were sown under Mustard-Boro-T. Aman cropping pattern. Yield and yield attributes of mustard varieties is presented in **Table 63**. There was no significant difference in grain yield or crop duration between the two varieties across the different cropping pattern treatments. BARI Sarisha-14 had higher plant density compared to BARI Sarisha-17. BARI Sarisha-17 had fewer pods per plant but higher seed per pod.

Table 63. Grain yield and yield components of mustard under different cropping pattern combinations, Toilotupi, Horinakundo, Jhenaidah, 2024-25.

Treatments	Variety	Plant/m^2	Pod/plant	Seed/pod	1000-SW (g)	Yield (t/ha)
ICP= Mustard-Boro-	BARI Sarisha-14	72	32	27	3.04	1.57
T. Aman	BARI Sarisha-17	68	30	30	2.91	1.52
ECP= Boro-Fallow-T. Aman						NS

ICP= Improved cropping pattern, ECP: Existing cropping pattern

Effect of sowing time on the grain yield of mustard

The grain yield performance of BARI Sarisha-14 and BARI Sarisha-17 was assessed across different sowing dates in mid to late November to determine the impact of sowing time on yield stability17 (**Fig. 30**). For BARI Sarisha-14, grain yield exhibited a slight declining trend with delayed sowing from 16 to 22 November. The regression analysis revealed a weak negative correlation ($R^2 = 0.061$), indicating that the effect was not substantial. Similarly, BARI Sarisha-17 showed a slight reduction in yield with delayed sowing between 13 and 19 November. The regression line also indicated a weak negative trend ($R^2 = 0.058$), suggesting minimal sensitivity to sowing date. Overall, both varieties maintained relatively stable yields across the tested sowing windows, with only a marginal decline associated with later sowing.

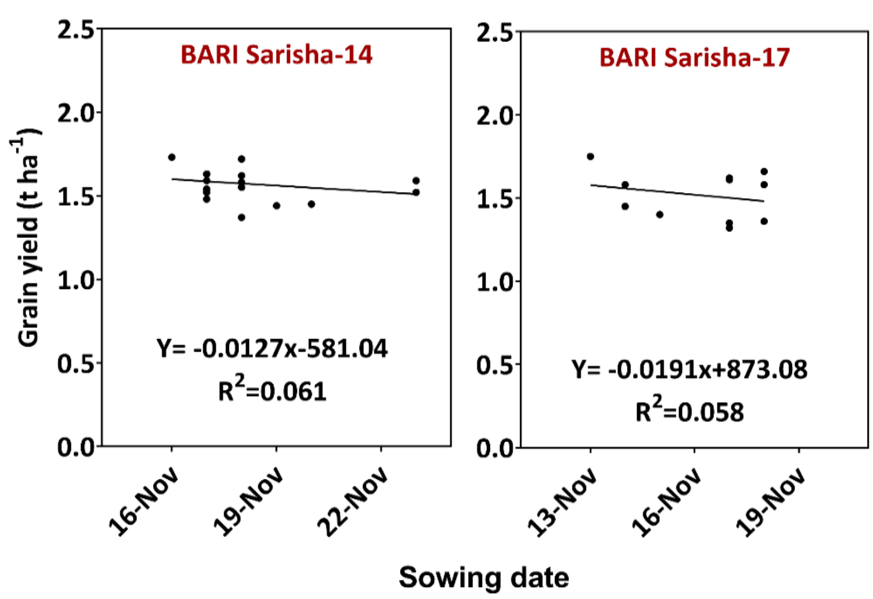


Figure 30. Grain yield of mustard varieties affected by sowing time in Jhenaidah. Dots represent individual values, and lines indicate fitted simple linear regressions

Farmer's opinion

Farmers preferred BARI Sarisha-17 for next year because of higher oil content (About 40%) compared to BARI Sarisha-14.

Boro rice

The grain yield performance of Boro rice under different cropping systems is presented in **Table 64**. Unlike other sites, in Jhenaidah, the inclusion of mustard in the Boro-Fallow-T. Aman system did not result in a significant reduction in Boro rice yield, primarily because the transplanting dates of Boro rice were similar in both ICP and ECP. Additionally, other yield-contributing characteristics of Boro rice were nearly identical between the two cropping systems.

Table 64. Yield of Boro rice under different cropping pattern combinations, Toilotupi, Horinakundo, Jhenaidah, 2024-25

Treatments	Variety	Panicle/ m2	Filled grain/pan.	Unfilled grain/pan.	1000-GW (g)	Yield (t/ha)
ICP= Mustard-	BRRI dhan100	353	87	22	22.43	6.75
Boro-T. Aman	BRRI dhan104	326	82	29	22.55	6.91
	BRRI dhan107	315	82	36	25.46	6.50
ECP= Boro-Fallow-	BRRI dhan100	352	87	17	20.52	6.88
T. Aman	BRRI dhan104	323	78	38	22.61	6.28
	BRRI dhan107	320	74	34	25.12	6.63
						NS

ICP= Improved cropping pattern, ECP: Existing cropping pattern

Farmers' Opinion

Farmers expressed a clear preference for both BRRI dhan102 and BRRI dhan104. BRRI dhan71 was appreciated for its high grain yield and good taste, while BRRI dhan104 was favored for its pleasant aroma and yield potential. In contrast, despite its comparable yield, BRRI dhan107 was not well-received due to its longer growth duration.

The rice equivalent yield (REY) and cost-return analysis of various cropping pattern combinations are presented in **Table 65**. The integration of mustard into Boro-Fallow-T. Aman cropping system significantly improved the overall productivity of the existing pattern. Among the tested combinations, BARI Sarisha-14-BRRI dhan102-BRRI dhan103 sequence exhibited the highest REY. The cost-return analysis revealed that total variable costs (TVC) were substantially higher across all improved cropping patterns, primarily due to the additional expenses associated with mustard cultivation. Nevertheless, gross margins (GM) for the patterns with mustard were markedly higher than those of the existing cropping system. Based on the marginal benefit-cost ratio (MBCR), the cropping patterns BARI Sarisha-14-BRRI dhan102-BRRI dhan103, BARI Sarisha-14-BRRI dhan104-BRRI dhan103, BARI Sarisha-17-BRRI dhan102-BRRI dhan103, and BARI Sarisha-17-BRRI dhan104-BRRI dhan103 were identified as economically viable options, demonstrating enhanced profitability among the evaluated systems.

Table 65. Rice equivalent yield (REY) and economics of different cropping pattern combinations, Toilotupi, Horinakundo, Jhenaidah, 2024-25

Cropping pattern	REY (t/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
BARI Sarisha-14-BRRI dhan102-BRRI dhan71	15.45a	343a	239a	2.16
BARI Sarisha-14-BRRI dhan104-BRRI dhan71	15.66a	347a	240a	2.08
BARI Sarisha-14-BRRI dhan107-BRRI dhan71	15.47a	356a	217a	1.48
BARI Sarisha-14-BRRI dhan102-BRRI dhan103	16.44a	338a	289a	3.69
BARI Sarisha-14-BRRI dhan104-BRRI dhan103	16.27a	342a	290a	3.44
BARI Sarisha-14-BRRI dhan107-BRRI dhan103	15.97a	351a	267a	2.54
BARI Sarisha-17-BRRI dhan102-BRRI dhan71	15.20a	342a	236a	2.13
BARI Sarisha-17-BRRI dhan104-BRRI dhan71	15.45a	346a	238a	2.05
BARI Sarisha-17-BRRI dhan107-BRRI dhan71	15.27a	354a	214a	1.44
BARI Sarisha-17-BRRI dhan102-BRRI dhan103	16.19a	337a	286a	3.71
BARI Sarisha-17-BRRI dhan104-BRRI dhan103	16.11a	341a	288a	3.45
BARI Sarisha-17-BRRI dhan107-BRRI dhan103	15.89a	350a	264a	2.53
BRRI dhan103-BRRI dhan102 (Ck1)	13.11b	299b	205b	-
BRRI dhan103-BRRI dhan104 (Ck2)	12.51b	306b	174b	-
BRRI dhan103-BRRI dhan107 (Ck3)	12.45b	300b	195b	-

Different letters indicate significant difference at $P < 0.05$.
Price (Tk/kg): Boro rice= 37.5, T. Aman rice= 32.5-35, Boro straw= 2, T. Aman straw= 3, Mustard= 85, Stover = 2

Challenges of Mustard-Boro-T. Aman cropping pattern

- T. Aman is commonly cultivated as rain-fed and it was difficult to motivate farmer for supplemental irrigation during land preparation.
- Heavy rainfall at maximum tillering and flowering stage was responsible for high pest and disease infestation like yellow stem borer, green leaf hopper, and Sheath blight.
- Water stagnation at rice field due to heavy rainfall was responsible for lodging of rice plant at the low-lying part of the field and preparation of land for mustard seed sowing was late for this reason.
- Drying of straw at rice field after harvesting for 5-7 days according to weather condition which was responsible for late sowing of mustard seed
- Higher insect and disease infestation of Boro rice specially when cultivated in the late condition under Mustard-Boro-T. Aman cropping pattern

5.4. Piloting of improved cropping pattern in rainfed lowland ecosystem in Sylhet region

ABMJ Islam, SM Shahidullah, MK Quais and M Ibrahim

Introduction

Agriculture is predominantly influenced by the varying environmental and physiographic conditions. The lion share of the total land has been brought under cultivation to satisfy the demand of teeming millions. Despite this achievement, a huge population has a limited access to enough land under their jurisdiction, making agriculture a challenging option. The country experiences a lot of environmental variations, so is the case for land use patterns. Over one-third of its land area faces several unfavourable factors that affect crop production in different dimensions and at different extents. The areas mainly belong to tidal wetland, saline coastal belt, hill tract etc. Nonavailability of groundwater for crops is a common limiting factor in these areas. Therefore, the cropping intensity is much lower than that of favourable ecosystem. With all of constraints there are still some scopes of improvement. These stress-prone areas are mainly covered by single T.Aman crop. This only pattern represents about 6% of the net cropped area in the country. Some winter crops and Aus rice might be incorporated into the cropping pattern through better management of surface water, as well as the proper harvesting of rainwater. The proposed research activities might be capable to formulate some improved cropping patterns for higher productivity and better land utilization.

Objective

To increase the system productivity and income of the farmers through the introduction of site-specific improved cropping systems.

Materials and Methods

A total of three trials were conducted in farmers' fields of Kamolganj, Moulovibazar. The first trial was conducted in sixty bigha of land. The study was initiated to improve the single T. Aman cropping pattern in the Sylhet region. There are two ways for this improvement. One is the utilization of the fallow period through the inclusion of rabi crop viz. mustard; and MV T. Aus in kharif-I season. The other way is the replacement of the existing T. Aman variety by high yielding modern variety. Two activities were done in the Konagaon village of the Adampur union. In activity I, four cropping patterns (CP), viz. CP_1: Fallow-BRRI dhan98-BRRI dhan71, CP_2: Fallow-BRRI dhan98-BRRI dhan75, CP_3: Fallow-BRRI dhan98-BRRI dhan95 and CP_4: Fallow-BRRI dhan98-BRRI dhan103 were tested against the existing CP_5: Fallow-Fallow-Ranjit swarna cropping pattern. In activity-II, eight cropping patterns (CP) of CP_1: BARI Sarisha-17-BRRI dhan98-BRRI dhan71, CP_2: BARI Sarisha-17-BRRI dhan98-BRRI dhan75, CP_3: BARI Sarisha-17-BRRI dhan98-BRRI dhan95, CP_4: BARI Sarisha-17-BRRI dhan98-BRRI dhan103, CP_5: BARI Sarisha-18-BRRI dhan98-BRRI dhan71, CP_6: BARI Sarisha-18-BRRI dhan98-BRRI dhan75, CP_7: BARI Sarisha-18-BRRI dhan98-BRRI dhan95 and CP_8: BARI Sarisha-18-BRRI dhan98-BRRI dhan103 were tested with the existing cropping Fallow-Fallow-Ranjit swarna (CP_9). Another trial was conducted at the Kandigaon village of the Adampur union. In the T. Aman season, the existing Ranjit swarna was replaced by BRRI dhan103 and after harvesting of T. Aman rice, BARI Sarisha-14 was introduced. BRRI recommended fertilizer dose and other management practices were followed while conducting these trials (Table 66-68).

Table 66. Crop management adopted for Fallow-T. Aus-T. Aman cropping pattern, Kamalganj, Moulovibazar, 2024

Factors	T. Aus	T. Aman
Variety	BRRI dhan98	BRRI dhan71, 75, 95 and 103
Seeding date	01-05 April 2024	BRRI dhan71, 75, 95: 15-20 July 24 BRRI dhan103: 05-10 July 24
Transplanting date	20-25 April 2024	BRRI dhan71, 75, 95: 05-10 Aug 24 BRRI dhan103: 1-5 Aug. 24
Spacing (cm×cm)	20×15	20×15
Seedling/hill	2-3	2-3
Fertilizer (kg/ha): N, P, K, & S	78-10-37 & 6	69-12-41-10 & 4* 82-12-52-11 & 4**
Basal (kg/ha): N, P, K, S & Zn	09-10-37 & 06	11-12-41-10 & 4* 11-12-52-11 & 4**
N top dress (Amount & DAT)	$^1/_2$ th each at 15 & 25 DAT	$^1/_2$ th each at 15 & 30 DAT
Weeding		2 times at urea top dressing
Maturity date	25-30 July 2024	BRRI dhan71, 75: 05-11 Nov. 23 BRRI dhan95: 15-20 Nov. 23 BRRI dhan103: 17-22 Nov. 24

*For BRRI dhan71, 75, ** for BRRI dhan95, 103

Table 67. Crop management adopted for Mustard-T. Aus-T. Aman cropping pattern, Kamalganj, Moulovibazar, 2024

Factors	T. Aus	T. Aman	Mustard
Variety	BRRI dhan98	BRRI dhan71, 75, 95 and 103	BARI Sarisha17 and 18
Seeding date	01-05 April 2024	BRRI dhan71, 75, 95: 15-20 July 24 BRRI dhan103: 05-10 July 24	10-15 Nov 2024
Transplanting date	20-25 April 2024	BRRI dhan71, 75, 95: 05-10 Aug 24 BRRI dhan103: 1-5 Aug. 24	-
Spacing (cm×cm)	20×15	20×15	Broadcasting
Seedling/hill	2-3	2-3	-
Fertilizer (kg/ha): N, P, K, & S	78-10-37 & 6	69-12-41-10 & 4* 82-12-52-11 & 4**	115-34-43-24-2 & 2
Basal (kg/ha): N, P, K, S & Zn	09-10-37 & 06	11-12-41-10 & 4* 11-12-52-11 & 4**	58-34-43-24-2 & 2
N top dress (Amount & DAT)	$^1/_2$ th each at 15 & 25 DAT	$^1/_2$ th each at 15 & 30 DAT	$^1/_2$ th at 30-35 DAS
Weeding	2 times at urea top dressing	2 times at urea top dressing	-
Maturity date	25-30 July 2024	BRRI dhan71, 75: 05-11 Nov. 23 BRRI dhan95: 15-20 Nov. 23 BRRI dhan103: 17-22 Nov. 24	BARI Sarisha 17: 5-10 Feb. 2025 BARI Sarisha 18: 15-20 Feb. 2025

*For BRRI dhan71, 75, ** for BRRI dhan95, 103

Table 68. Crop management adopted for Mustard-Fallow-T. Aman cropping pattern, Kamalganj, Moulovibazar, 2024

Factors	T. Aman	Mustard
Variety	BRRI dhan 103	BARI Sarisha14
Seeding date	05-10 July 24	10-15 Nov 2024
Transplanting date	1-5 Aug. 24	-
Spacing (cm×cm)	20×15	Broadcasting
Seedling/hill	2-3	-
Fertilizer (kg/ha): N, P, K, & S	82-12-52-11 & 4	115-34-43-24-2 & 2
Basal (kg/ha): N, P, K, S & Zn	11-12-52-11 & 4	58-34-43-24-2 & 2
N top dress (Amount & DAT)	$^1/_2$ th each at 15 & 30 DAT	$^1/_2$ th at 30-35 DAS
Weeding	2 times at urea top dressing	-
Maturity date	17-22 Nov. 24	BARI Sarisha14: 25-30 Jan. 2025

Results and Discussion

BRRI dhan98 yielded 4.71 to 4.91 t/ha of grain during Aus season. In T. Aman season, BRRI dhan103 gave a significantly higher grain yield (6.18 t/ha) in CP_4 and the other four varieties produced statistically similar grain yield, ranging from 4.27 to 4.96 t/ha in CP_1 to CP_3 and in CP_5. CP_4 gave the highest total grain yield (11.09 t/ha) followed by CP_1 (9.71 t/ha). Statistically similar total grain yields were obtained from CP_1, CP_2 and CP_3, ranged from 9.01 t/ha to 9.71 t/ha). The existing Fallow-Fallow-Ranjit swarna (CP_5) produced the lowest system yield (4.35 t/ha). Cost and return analysis showed that CP_4 had the maximum GM (2,57,287 Tk/ha) followed by CP_1 (2,03,380 Tk/ha) with the highest MBCR (3.02). MBCR 2.34 was obtained from CP_1. The lowest MBCR (2.07) was recorded in CP_2 with a gross margin of 1,78,389 Tk/ha. Existing CP_5 gave the minimum gross margin (94,433 Tk/ha) (Table 69).

Table 69. Yield and profitability of the Fallow-T. Aus-T. Aman cropping pattern compared to the existing single T. Aman rice, Kamolgonj, Moulovibazar district, 2024-25

Cropping patterns	Yield (t/ha)			TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	T. Aus	T. Aman	Total rice yield			
CP_1	4.75	4.96 b	9.71 b	156.81	203.38	2.34
CP_2	4.74	4.27 b	9.01 b	154.47	178.39	2.07
CP_3	4.71	4.41 b	9.13 b	155.88	181.75	2.09
CP_4	4.91	6.18 a	11.09 a	156.20	257.29	3.02
CP_5 (control)	-	4.35 b	4.35 c	75.65	94.43	-
CV (%)	9.18	11.77	8.56	-	-	-

Means with the same letter(s) are not significantly different. Price (Tk./kg): Rice=35, Straw; Aman=4.

In activity-II, BRRI dhan98 produced statistically similar grain yield during Aus season, ranging from 4.34 to 4.97 t/ha. In T. Aman season, BRRI dhan103 yielded the highest grain (6.60 t/ha) in CP_8, which was statistically similar to CP_4 (6.38 t/ha). BRRI dhan71 gave 4.90 t/ha and 4.73 t/ha grain yield in CP_5 and CP_1, respectively, which were statistically similar. The yields of BRRI dhan71 were statistically lower than BRRI dhan103. BRRI dhan95 yielded 4.41 t/ha in CP_7, which was statistically similar to BRRI dhan71 of CP_1 (4.73 t/ha). BRRI dhan75 yielded statistically similar yield in CP_2 (4.31 t/ha) and in CP_6 (4.07 t/ha); a similar yield was found from BRRI dhan95 with CP_3 (4.31 t/ha). The existing variety Ranjit Sarna gave 4.32 t/ha yield, which was statistically similar to BRRI dhan75 of CP_2 (4.31 t/ha) and CP_6 (4.07 t/ha), as well as BRRI dhan95 of CP_3 (4.31 t/ha) and CP_7 (4.41 t/ha). In rabi season, BARI Sarisha-18 gave the highest seed yield (1.57 t/ha) in CP_5, followed by BARI Sarisha-18 (1.52 t/ha) in CP_7 and CP_8. Except CP_3, in all combinations, BARI Sarisha-17 and BARI Sarisha-18 gave statistically similar seed yield. In $CP_{3,}$ BARI Sarisha-17 gave statistically lower seed yield (1.32 t/ha). The Highest Rice equivalent yield (REY) was attained from CP_8 (15.32 t/ha), followed by CP_4 (14.95 t/ha). CP_5 (13.64 t/ha), CP_1 (13.30 t/ha) and CP_2 gave statistically similar REY. CP_7 provided 12.92 t/ha REY, significantly similar REY were gained from CP_6 (12.63 t/ha), CP_1 (13.30 t/ha) and from CP_2 (13.07). The existing cropping pattern (CP_9) gave the lowest REY (4.32 t/ha). Cost and return analysis showed that CP_8 had the maximum GM (3,50,663 Tk/ha) with the highest MBCR (2.87) followed by CP_4 with GM-3,36,789 Tk/ha and MBCR-2.77). The lowest GM was turnout from the existing cropping pattern, CP_9 (93,692 Tk/ha) (Table 70).

Table 70. Yield and profitability of the Mustard-T. Aus-T. Aman cropping pattern compared to the existing single T. Aman rice, Kamolgonj, Moulovibazar, 2024-25

Cropping pattern	Yield (t/ha)				TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	T. Aus	T. Aman	Mustard	REY			
CP_1	4.81	4.73 bc	1.46 ab	13.30 bc	213.86	271.50	2.29
CP_2	4.87	4.31 d	1.51 ab	13.07 bc	211.52	264.03	2.25
CP_3	4.34	4.31 d	1.32 b	12.04 d	212.94	226.57	1.97
CP_4	4.97	6.38 a	1.40 ab	14.95 a	213.26	336.79	2.77
CP_5	4.72	4.90 b	1.57a	13.64 b	213.86	284.12	2.38
CP_6	4.72	4.07 d	1.50 ab	12.63 cd	211.52	247.62	2.13
CP_7	4.59	4.41 cd	1.52 ab	12.92 c	212.94	257.79	2.20
CP_8	4.81	6.60 a	1.52 ab	15.32 a	213.26	350.66	2.87
CP_9 (control)	-	4.32 d	-	4.32 e	75.65	93.69	-
CV (%)	8.79	4.26	8.54	3.6	-	-	-

Means with the same letter(s) are not significantly different. Price (Tk./kg): Rice=35, Straw; Aman=4, Mustard=90

In activity III, the highest grain yield (6.55 t/ha) was attained from BRRI dhan103 during T. Aman season, in Kandigaon village, which was statistically higher than the existing variety Ranjit Swarna (4.82 t/ha). The highest REY (9.67 t/ha) was obtained from CP_1, whereas CP_2 gave 4.83 t/ha grain yield. The improved cropping pattern (CP_1) gave a maximum gross margin of 2,29,954 Tk/ha, whereas the existing pattern, CP_2 gave the minimum (1,13,201 Tk/ha). MBCR 2.96 was recorded from the improved cropping pattern. (Table 71).

Table 71. Yield and profitability of the Mustard-Fallow-T. Aman cropping pattern compared to the existing single T. Aman rice, Kamolgonj, Moulovibazar district, 2024-25

Cropping pattern	Yield (t/ha)			TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	T. Aman	Mustard	REY			
BARI Sarisha-14-Fallow-BRRI dhan103 (CP_1)	6.55 a	1.21	9.67 a	135.35	229.95	2.96
Fallow-Fallow-Ranjit swarna (CP_2)	4.83 b	-	4.83 b	75.65	113.20	-
CV (%)	4.76		4.52	-	-	-

Means with the same letter(s) are not significantly different. Price (Tk./kg): Rice=35, Straw; Aman=4, Mustard=90.

Expt. 5.5. Improvement of Boro-Fallow-T. Aman cropping system through Aus inclusion and varietal replacement in irrigated ecosystem in Mymensingh region

DH Payel, MAU Razu, MK Quais and M Ibrahim

Introduction

In Bangladesh total cultivable land is 8.5 million hectare and it is shrinking day by day. Annual loss of agricultural land is about 0.73% per annum due to the construction of houses, roads and industrial infrastructure (BBS, 2020). There is no other alternative but to increase total productivity per unit area of the prevailing lands. To produce more food within a limited area, the most important options are to increase the cropping intensity producing more crops in the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices (Mondal *et al.,* 2015). Boro-Fallow-T. Aman cropping pattern is the dominant pattern in the greater Mymensingh region where it is distributed to 45 out of 47 upazilas. Generally, land remains fallow for about three and half months after Boro and before Aman in the existing system. Therefore, it is possible to grow short duration Aus rice varieties in the present system. Keeping this view in mind, the present study was undertaken to intensify the existing Boro-Fallow-T. Aman cropping pattern through the inclusion of modern T. Aus rice variety and to increase the productivity of the system as well.

Objectives

i) To evaluate the performance of Aus variety in Boro-Fallow-T. Aman cropping pattern

ii) To increase the productivity of the existing two crop system with the inclusion of Aus rice

iii) To evaluate the performance of the newly released rice variety in Boro-Aus-T. Aman cropping pattern

Material and Methods

The study was conducted in farmers' fields at Beltoli, Sadar, Mymensingh during 2024-25. BRRI released high-yielding rice verities that were tested under proposed Boro-T. Aus-T. Aman cropping pattern against existing Boro-Fallow-T. Aman cropping system. During T. Aman season BRRI dhan71 and BRRI dhan103; Boro season BRRI dhan100, BRRI dhan102 and BRRI dhan105; and in Aus season BRRI dhan98 were tested. Aus rice was cultivated following farmers' practice with their existing varieties (Boro: Chokka (Hybrid) and T. Aman: BRRI dhan49).

Treatments: Cropping pattern

Improvement

CP_1: BRRI dhan100-BRRI dhan98-BRRI dhan71

CP_2: BRRI dhan100-BRRI dhan98-BRRI dhan103

CP_3: BRRI dhan102-BRRI dhan98-BRRI dhan71

CP_4: BRRI dhan102-BRRI dhan98-BRRI dhan103

CP_5: BRRI dhan105-BRRI dhan98-BRRI dhan71

CP_6: BRRI dhan105-BRRI dhan98-BRRI dhan103

Existing

CP7: Chokka (Hybrid)-Fallow-BRRI dhan49(Ck.)

The trial was conducted in RCB design, and each farmer was considered as a replication. Recommended fertilizer doses and other recommended management practices for rice were followed accordingly (Table 72).

Table 72. Management practices followed for different crops under Boro-T. Aus-T. Aman and Boro-Fallow-T. Aman cropping pattern, Belotoli, Sadar, Mymensingh 2024-25

Factors	Existing pattern		Improved pattern		
	Boro	T. Aman	Boro	T. Aus	T. Aman
Variety	Chokka (Hybrid)	BRRI dhan49	BRRI dhan100,102,105	BRRI dhan98	BRRI dhan71,103
Seeding date	5-15 Dec 24	01 July 24	15-31 Dec 24	01-05 May 24	24 Jun-07 Jul 24
Transplanting date	5-15 Jan 25	25-30 July 24	20 Jan-03 Feb 25	20-25 May 24	24-03 Aug 24
Spacing (cm×cm)	20×20	20×20	20×20	20×20	20×20
Seedling/hill	2-3	2-3	2-3	2-3	2-3
Fertilizer (kg/ha): N, P, K, S, Zn	150-60-90-10-0	95-48-22-6-2	140-50-98-18-4	60-25-50-5-2	75-30-60-12-2
Irrigation	5-7 times	2 times	5-6 times	2 times	2 times
Weeding	3 times, at urea top dressing	3 times, at urea top dressing	3 times, at urea top dressing	3 times at 7, 25 & 40 DAT	3 times at 7, 25 & 40 DAT
Maturity date	25-30 April 24	25-30 Nov 23	01-12 May 24	1-05 Aug 23	25-30 Nov 23
Field duration (days)	105-110	123	98-101	73-77	107-112

Results and Discussion

Individual crop yield and total grain yield (t/ha) of the cropping patterns are presented in Table 73. In Boro season, the highest grain yield was obtained from BRRI dhan102 (7.83 t/ha) in CP_4 cropping pattern while the lowest yield was found from the variety Chokka (Hybrid) (6.07 t/ha) in control treatment. In T. Aman season, the highest yield was obtained from BRRI dhan103 under CP_2 followed by BRRI dhan103 under CP_6 and CP_4. The lowest yield was obtained from BRRI dhan49 (5.21 t/ha) which is usually used by farmers under Boro-Fallow-T. Aman cropping pattern in the study area BRRI dhan71 (5.13 t/ha). In consideration of the productivity, the highest grain yield (19.09 t/ha) was observed in CP_2 (BRRI dhan100-BRRI dhan98-BRRI dhan103) which is statistically similar with CP_4 (19.06 t/ha). Significantly the lowest total productivity (11.28 t/ha) was found from CP_7 (Check). In Aus season BRRI dhan98 yielded different grain in different cropping pattern treatment. Significantly highest grain yield was found in CP_3 (5.84 t/ha) and lowest in CP1 (5.21 t/ha). The highest and lowest total productivity was found from CP_4 (19.09 t/ha) and CP_7 (11.18 t/ha) (Check).

Table 73. Yield of different rice varieties under specific cropping system, Beltoli, Sadar, Mymensingh, 2024-25

Cropping Pattern	Grain Yield (t/ha)			
	Boro	T. Aus	T. Aman	Total
CP_1: BRRI dhan100-BRRI dhan98-BRRI dhan71	7.51 b	5.21 d	5.13 f	17.85 e
CP_2:BRRI dhan100-BRRI dhan98-BRRI dhan103	7.12 c	5.54 c	6.43 a	19.09 a
CP_3: BRRI dhan102-BRRI dhan98-BRRI dhan71	7.54 b	5.84 a	5.39 d	18.77 b
CP_4:BRRI dhan102-BRRI dhan98-BRRI dhan103	7.83 a	5.70 b	5.53 c	19.06 a
CP_5: BRRI dhan105-BRRI dhan98-BRRI dhan71	6.93 e	5.71 b	5.28 de	17.92 d
CP_6:BRRI dhan105-BRRI dhan98-BRRI dhan103	6.81 e	5.69 b	6.19 b	18.69 c
CP_7**:** Chokka (Hybrid)-Fallow-BRRI dhan49 (Check)	6.07 f	-	5.21 ef	11.28 f
CV (%)	7.11	5.61	5.59	17.52

*Means with the same letter are not significantly different at P<0.05

From the cost and return analysis it was observed that the highest gross margin (GM) was obtained from CP_4 (2,87,000 Tk/ha) followed by CP_2 (2,81,000 Tk/ha) and CP_3 (2,73,000 Tk/ha) (Table 74). The lowest GM was observed in CP_7 (1,18,000 Tk/ha). The highest MBCR was obtained from CP_4 (2.86) followed by CP_2 and CP_2 (2.68). BRRI dhan103 in T. Aman season, BRRI dhan102 in Boro season and BRRI dhan98 in Aus season were quite high yielders and cropping patterns with these varieties provided the higher yield and produced higher economic returns. Suitable rice varieties in Boro, Aus and T. Aman season along with recommended management practices contributed to increased rice yield in improved cropping patterns that considerably maximized the system productivity. The straw price of Aman rice was higher than Boro and Aus straw.

Table 74. Cost-return analysis of different crops combinations under improved and existing cropping pattern, Beltoli, Sadar, Mymensingh, 2024-25

Cropping Pattern	GR ('000 Tk/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
CP_1: BRRI dhan100-BRRI dhan98-BRRI dhan71	590	341	249	2.47
CP_2: BRRI dhan100-BRRI dhan98-BRRI dhan103	630	349	281	2.68
CP_3: BRRI dhan102-BRRI dhan98-BRRI dhan71	620	347	273	2.63
CP_4: BRRI dhan102-BRRI dhan98-BRRI dhan103	630	343	287	2.86
CP_5: BRRI dhan105-BRRI dhan98-BRRI dhan71	590	345	245	2.37
CP_6: BRRI dhan105-BRRI dhan98-BRRI dhan103	618	348	270	2.58
CP_7: Chokka (Hybrid)-Fallow-BRRI dhan49 (Check)	370	252	118	0.00

*Price (Tk/kg): Rice = 32, Boro straw=5, Aus straw=5, Aman straw=8

Farmers' Reaction

Farmers' are amazed to get excellent yield of the improved cropping pattern. They are satisfied to have the high yield performance of the BRRI released high yielding rice varieties in three rice system as well as new accession of the cropping system. They are interested to cultivate BRRI released HYV and are thirsty to acquire more land with T. Aus rice in the coming season.

Expt. 5.6. Improvement of Fallow-Fallow-T. Aman Cropping system through Rabi crop inclusion in Chattogram region

T Araf, N Parvin, MM Rashid and M Ibrahim

Introduction

Fallow-Fallow-T. Aman is the 3rd most dominant cropping pattern in Bangladesh which occupy significantly higher percentage (5.95%) of net cropped area. In Chattogram district, it is the 2nd most dominant cropping pattern covering 19.15% of the cropped area. In this system, two consecutive seasons of land remain uncultivated before the transplanted aman rice (T. Aman) is sown. While this practice allows the soil to rest, it also contributes to suboptimal land use, underutilizing valuable Rabi season windows. Integrating rabi crops such as mustard, mungbean, lentils, sunflower, felon, maize, and grasspea into the fallow period can be obtained promising results across Bangladesh. These crops not only increase cropping intensity but also enhance soil fertility (especially legumes), diversify farm income, and reduce reliance on monoculture systems. Most of the part of Sitakundu, often sees periods of land lying idle between Aman and the next cropping season. Introducing rabi crops like legumes and oilseeds could optimize land productivity and improve farmers' livelihoods. This aligns with Bangladesh's broader crop diversification goals aimed at reducing dependency on rice and promoting nutritional and agro-ecological resilience.

Objectives

i) To intensify Fallow-Fallow-T. Aman cropping pattern by integrating Rabi crops

ii) To maximize the total productivity and income

Materials and Methods

The study was conducted in the farmers' field situated at foradpur village, Sitakundu upazila of Chattogram district during 2024-2025. The existing cropping pattern Fallow-Fallow-T. Aman was improved through the inclusion of rabi crops such as BARI Surjomukhi-3, BARI Felon-1, and BARI hybrid Maize-16 was introduced in this pattern after the T. Aman harvesting to increase productivity, profitability and cropping intensity.

The tested cropping patterns (CP) were

CP_1: BARI Surjomukhi-3- Fallow- BRRI dhan46,

CP_2: BARI Felon-1- Fallow- BRRI dhan46,

CP_3: BARI hybrid Maize-16 - Fallow- BRRI dhan46,

CP_4: Fallow-Fallow-BRRI dhan22.

Other agronomic and pest management practices were done according to BRRI recommendations.

MBCR (Marginal Benefit Cost Ratio) were calculated using following equations:

$$\text{MBCR} = \frac{GR\ (Improved) - GR\ (Existing)}{TVC\ (Improved) - TVC\ (Existing)}$$

Table 75. Management practices followed for different crops under Rabi crops-Fallow-T. Aman cropping patterns, Sitakundu, Chattogram, 2024-25

Mgt. factors	Sunflower	Cowpea	Maize	T. Aman
Variety	BARI Surjomukhi-3	BARI Felon-1	BARI hybrid Maize-16	BRRI dhan46/ BRRI dhan22
Seed rate (kg/ha)	10	40	20	30
Seedling age (day)	-	-	-	25
Spacing (cm×cm)	50×25	Broadcasting	60×25	20×20
Seeding date	19 Dec.	19 Dec.	19 Dec.	19 July
Fertilizer (kg/ha): N, P, K, S, Zn & B	180-150-120-120-8	30-80-40-40-3	240-180-200-130-10	76-12-53-11-0-0
Weeding (Times)	1	2	3	2
Maturity date	20 March	5 April	8 April	8 Dec.
Growth duration (days)	91	107	110	142

Results

The highest rice equivalent yield (REY) (11.13 t/ha) was observed in CP_3 followed by the pattern CP_2 (9.37 t/ha), and CP_1 (7.43 t/ha) (Table 76). The lowest REY was observed in CP_4 (4.46 t/ha). The highest gross margin (GM) was obtained from CP_2 (1,55,133 Tk/ha) followed by CP_3 (1,35,744 Tk/ha), CP_1 (57,780 Tk/ha) and CP_6 (1,91,800 Tk/ha) (Table 76). The lowest GM was observed in CP_4 (47,933Tk/ha). The highest MBCR was noted from CP_2 (3.14) which was followed by the CP_3 (1.82), and CP_1 (1.11). Findings revealed that crop productivity was higher with Maize inclusion but profitability increased due to inclusion of felon beacuase of its less input cost.

Table 76. Yield and profitability of different crops combination under Rabi crop-Fallow-T.Aman cropping pattern, Sitakundu, Chattogram, 2024-25

Cropping pattern	Yield (t/ha)				REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Sunflower	Cowpea	Maize	T. Aman				
CP_1	1.28	-	-	4.62	7.43 c	180	57	1.11
CP_2	-	1.13	-	4.45	9.37 b	145	155	3.14
CP_3	-	-	7.19	4.4	11.13 a	201	135	1.82
CP_4	-	-	-	4.47	4.46 d	95	47	
CV (%)					5.75			

Price (Tk/kg): Rice=32, Sunflower=70, Cowpea=140, Maize=30, Rice straw=4

Farmer's reaction

Farmers were satisfied with the yields of maize as an extra crop, but they preferred felon due to lower input cost. They showed interest in cultivating felon before cultivating Aman rice.

Activity 5.7. Farmers' group discussion, training and field days

5.7.1. Farmer's Training

A total of 13 training programs were conducted in Khulna, Moulvibazar, Panchagar, Chittagong, Barishal, Gazipur and Tangail districts by the Rice Farming Systems division during 2024-2025. Through these trainings, a total of 610 participants were trained (male 487, female 123) on rice-based cropping patterns and modern rice, mustard production technologies in an advanced manner. The purpose of these training programs was to enhance knowledge of improved cropping pattern technology and maximize total productivity (Table 77).

Table 77. Training conducted by Rice Farming Systems division, 2024-25

Title	No. of training	Participants number			Location
		Male	Female	Total	
Modern rice production technology	2	65	15	80	Surkhali,Batiaghata Khulna
Aus rice production technology and management	1	35	5	40	Rahimpur, Kamalganj, Moulvibazar
Production and management of Mustard- Boro- T. Aman cropping pattern	1	32	18	50	Jamalpur, Kaliganj, Gazipur
Production and management of Mustard- Aus- T. Aman cropping pattern	1	40	0	40	Konagaon, Kamalganj Moulvibazar
Production and management of Sunflower- Boro- T. Aman cropping pattern	1	29	11	40	Borogaon, Kaliganj, Gazipur
Production and management of Mustard- Fallow- T. Aman cropping pattern	1	40	0	40	Kandigaon, Kamalganj, Moulvibazar
Improved technology of crop production and cropping pattern	2	57	23	80	BRRI Regional Station, Panchagar
Intensification of Fallow- Fallow- T. Aman cropping pattern through Boro rice inclusion	1	40	0	40	BRRI Regional Station, Barishal
Modern rice production technology in an advanced manner	2	74	6	80	Batiaghata, Khulna; Sitakundu, Chittagong
Intensification of Boro- Fallow- T. Aman cropping pattern through Mustard inclusion	1	75	45	120	BRRI Regional Station, Dhanbari, Tangail
Total	13	487	123	610	

5.7.2. Field Day

The Rice Farming Systems division conducted field days at different locations of Bangladesh (Gazipur, Khulna, Mymensingh, Rangamati, Moulavibazar and Tangail) during 2024-2025 where total number of participants was 1479 (male 904, female 535). These programs aid in wide dissemination of newly released rice varieties, non-rice crops management practices and adoption of improved cropping pattern technologies in different ecosystems (Table 78).

Table 78. Field day conducted by Rice Farming Systems division, 2024-25

Title	No. of field day	Participants (no.)			Location
		Male	Female	Total	
BRRI dhan74, BRRI dhan89, BRRI dhan92, BRRI dhan100 for farming systems improvement in hilly region	1	118	42	200	Barkal, Rangamati
BRRI dhan100, BRRI dhan102, BRRI dhan104, BRRI dhan105 for the improvement of two cropped cropping pattern to three cropped cropping pattern	1	196	116	312	Kamarpara, Dhanbari, Tangail
Boro- T. Aus- T. Aman cropping pattern to make people popular	1	100	20	120	Beltoli Sadar, Mymensingh
Improvement of Boro- Fallow- T. Aman cropping pattern through mustard inclusion	1	55	52	107	Kamarpara, Dhanbari, Tangail
Introduction of high yielding Aman rice variety BRRI dhan103	1	60	40	100	Batighata, Khulna
Field day and crop cut on BRRI dhan103 in Fallow- T. Aus- T. Aman cropping pattern	1	100	30	130	Konagaon, Komolganj, Moulavibazar
Improvement of two cropped cropping pattern to three cropped cropping pattern through Sunflower inclusion	1	180	130	310	Kaliganj, Gazipur
Improvement of two cropped cropping pattern to three cropped cropping pattern through Mustard inclusion	1	95	105	200	Dhanbari, Tangail
Total	8	904	535	1479	

SUB PROGRAMME IV. INTEGRATED FARMING SYSTEMS

Project 6. Integrated farming research and development for livelihood improvement in the plain land eco-system

6.1. Crops and cropping pattern

Expt. 6.1.1. Intensification of Boro-Fallow-T. Aman cropping pattern through the inclusion of oil crop in irrigated ecosystem

MK Quais, MAU Razu, T Araf and M Ibrahim

Introduction

Increase in oil crop production has become one of the top priorities of our agriculture strategy due to recent unprecedented price hike of soybean oil in the international market. Boro-Fallow-T. Aman is one of the major cropping patterns of Kaliganj upazilla covering 20.06% of the net cropped area. There is an ample opportunity to introduce short duration mustard (BARI Sarisha-14)/sunflower (BARI Surjomukhi-3) in the wet-dry transition period between T. Aman and Boro rice. Introduction of mustard/sunflower in between two rice crops may help to improve land productivity through a desirable shift in wetland soil ecology in one hand and proper utilization of natural resources to increase system productivity on the other. However, considerable yield loss of the late planted Boro rice after rabi crop cultivation is inevitable. Recognizing the magnitude of the above-mentioned situation and the importance of oil crop and Boro rice in the cropping system, the present study was undertaken to evaluate the performance and economic productivity of oil crops under Mustard/Sunflower-Boro-T. Aman cropping pattern.

Materials and Methods

The trial was conducted in farmers' fields at Kaliganj, Gazipur in collaboration with DAE during 2024-25 to intensify Boro-Fallow-T. Aman cropping pattern through inclusion of mustard/sunflower and to find out the suitability of newly released BRRI rice varieties under Mustard/Sunflower-Boro-T. Aman cropping pattern. Therefore, we evaluated the performance of BRRI dhan98, BRRI dhan100, BRRI dhan105, BRRI dhan107 in Boro season and BRRI dhan71, BRRI dhan103 in T. Aman season under Mustard/Sunflower-Boro-T. Aman cropping pattern. Twenty-one dispersed farmer's fields were selected for the evaluation of above-mentioned cropping patterns and varieties with existing popular varieties. Each farmer's field represents one replication. BRRI and BARI recommended fertilizer dose and other management practices for rice and mustard were followed while conducting the trial (Table 79, 80).

Table 79. Crop management practices adopted to evaluate the Mustard-Boro-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2024-25

Mgt. factors	Improved pattern			Farmer's practice	
	Mustard	Boro	T. Aman	Boro	T. Aman
Variety	BARI Sarisha-14	BRRI dhan100, 105	BRRI dhan71	BRRI dhan28	Ranjit
Seeding date	10-20 Nov 2024	18-29 Dec 24	29 Jun-09 Jul 24	27 Nov-03 Dec 24	03-04 Jul 24
Seed rate (kg/ha)	7	30	30	52-71	58-74
TP date	-	07-15 Feb 25	22 July- 06 Aug 2024	13-21 Jan 25	04-07 Aug 24
Spacing (cm×cm)	Broadcasting	20×Random	20×Random	20-22×Random	15-20×Random
Seedling/hill	-	3-5	3-5	4-5	4-5
Fertilizer kg/ha): N, P, K, S, Zn & B	115-34-43-27-2-2	120-18-75-18-4-0	69-10-41-10-0-0	88-15-39-9-0-0	52-11-31-1-0-0
Weeding (Times)	1	3	3	2-3	2
Maturity/ harvesting date	25 Jan-04 Feb 25	BR100: 03-20 May 25 BR105: 08-14 May 25	24 Oct-02 Nov 24	20-21 April 25	23-28 Nov 24
Growth duration (days)	70-79	BR100: 127-139 BR105: 132-137	111-118	139-144	142-147

Table 80. Crop management practices adopted to evaluate the Sunflower-Boro-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2024-25

Mgt. factors	Improved pattern			Farmer's practice	
	Sunflower	Boro	T. Aman	Boro	T. Aman
Variety	BARI Surjomukhi-3	BRRI dhan98, 100	BRRI dhan71	BRRI dhan28	Ranjit
Seeding date	10-17 Nov 24	01-08 Jan 25	30 Jun-03 Jul 24	27 Nov-03 Dec 24	03-04 Jul 24
Seed rate (kg/ha)	12-16	30	30	52-71	58-74
TP date	-	23-25 Feb 25	30 July-08 Aug 24	13-21 Jan 25	04-07 Aug 24
Spacing (cm×cm)	50×20	20-25×Random	20×Random	20-22×Random	15-20×Random
Seedling/hill	-	3-6	3-5	4-5	4-5
Fertilizer kg/ha): N, P, K, S, Zn & B	93-40-75-27-4-2.5	120-18-75-18-4-0	69-10-41-10-0-0	88-15-39-9-0-0	52-11-31-1-0-0
Weeding (Times)	2	2	2	2-3	2
Maturity/ harvesting date	12-15 Feb 25	17-23 May 25	25-28 Oct 24	20-21 April 25	23-28 Nov 24
Growth duration (days)	90-95	129-142	113-117	139-144	142-147

The energy analysis presented in this study compared the energy input, output and use efficiency among the crop sequences. The input amount and energy requirement of each crop from sowing to maturity for each input item was determined and quantified. Energy equivalents derived from the published literature given in Table 81 were used to estimate energy inputs and outputs. An energy equivalent can be defined as input energy used to calculate all kinds of energy for agricultural production. Agronomic inputs were calculated per hectare and multiplied by their corresponding energy equivalent to calculate the energy input of each item. The total energy input was calculated as the sum of energy used in all inputs. We did not consider environmental inputs (solar radiation and wind). The energy output from grain and straw/stover was calculated by multiplying the amount of production by its corresponding energy equivalent.

Table 81. Equivalents for various sources of energy

Particulars	Units	Equivalent energy (MJ)	Reference
Inputs			
Rice seed	Kg	14.70	https://doi.org/10.1016/j.energy.2021.122655
Mustard seed	Kg	22.72	https://doi.org/10.1016/j.jclepro.2018.04.173
Sunflower seed	Kg	25.00	https://doi.org/10.1016/j.still.2015.11.008
Chemical fertilizer			
N	Kg	60.60	https://doi.org/10.1016/j.energy.2019.02.169
P_2O_5	Kg	11.10	https://doi.org/10.1016/j.energy.2019.02.169
K_2O	Kg	6.70	https://doi.org/10.1016/j.energy.2019.02.169
Gypsum	Kg	10.00	https://doi.org/10.1016/j.energy.2017.09.136
Zinc	Kg	8.40	https://doi.org/10.1016/j.energy.2015.03.005
Boron	Kg	4.70	https://doi.org/10.1016/j.fcr.2018.05.018
Granular Chemical	Kg	120.00	https://dx.doi.org/10.1016/j.jclepro.2017.04.170
Liquid Chemical	L	120.00	https://dx.doi.org/10.1016/j.jclepro.2017.04.170
Human labor	H	1.96	https://dx.doi.org/10.1016/j.scitotenv.2023.163102
Tractor hours	H	64.80	https://doi.org/10.1016/j.energy.2020.119286
Farm machinery	H	62.70	https://doi.org/10.1016/j.jclepro.2013.08.019
Irrigation	m^3	1.02	https://dx.doi.org/10.1016/j.jclepro.2017.04.170
Diesel	L	56.31	https://dx.doi.org/10.1016/j.jclepro.2017.04.170
Output			
Rice grain	Kg	14.70	https://doi.org/10.1016/j.energy.2021.122655
Rice straw	Kg	12.50	https://doi.org/10.1016/j.energy.2021.122655
Mustard grain	Kg	22.72	https://doi.org/10.1016/j.jclepro.2018.04.173
Mustard Stover	Kg	12.50	https://doi.org/10.1016/j.jclepro.2018.04.173
Sunflower grain	Kg	25.00	https://doi.org/10.1016/j.still.2015.11.008
Sunflower Stover	Kg	12.50	https://doi.org/10.1016/j.still.2015.11.008

Based on the energy inputs and outputs, we adopted the following efficiency indicators:

Energy use efficiency (EUE) is calculated as the ratio between energy output and energy input. This indicator evaluates the system efficiency in using the energy supplied by crop husbandry.

$$EUE = \text{Energy output (MJ ha}^{-1}\text{) - Energy input (MJ ha}^{-1}\text{)}$$

Where, Energy output = Grain + straw/stover

Energy productivity (EP) is the mass of grain yield per unit of fossil energy input expressed in g grain per MJ energy input. This indicator measures the environmental burdens associated with the production of crops.

$$EP \text{ (g MJ}^{-1}\text{) (system) = Rice equivalent yield (g ha}^{-1}\text{)/ Energy input (MJ ha}^{-1}\text{)}$$

Results and Discussion

The individual crop yields and rice equivalent yield (REY) for the respective cropping patterns are presented in Table 82. Mustard yield ranged from 1.54 to 1.59 t/ha, while sunflower yielded 2.21-2.49 t/ha, sown between November 10 and 20, 2024. Grain yield of Boro rice showed significant variation among the cropping patterns ($F_{4, 34}$ = 11.45, P< 0.001). The introduction of mustard and sunflower into the Boro-Fallow-T. Aman cropping system resulted in a significant reduction in Boro yield, ranging from 4% to 19%. Boro yield reduction is higher in case of sunflower introduction than mustard introduction. During the T. Aman season, BRRI dhan71 yielded significantly more than the existing variety ($F_{4, 34}$ = 7.79, P< 0.001), producing approximately 18% to 27% higher grain yield compared to Ranjit. The REY of different cropping pattern combinations also varied significantly ($F_{4, 34}$ = 103.73, P< 0.001) and BARI Surjomukhi-3-BRRI dhan100-BRRI dhan71 turned out the highest REY among the tested combinations.

Table 82. Grain yield of component crops and REY of different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2024-25

Cropping pattern	Mustard/ Sunflower (t/ha)	Boro (t/ha)	T. Aman (t/ha)	REY (t/ha)
BARI Sarisha-14-BRRI dhan100-BRRI dhan71	1.59	6.12 bc	4.92 a	15.27 c
BARI Sarisha-14-BRRI dhan105-BRRI dhan71	1.54	6.47 ab	4.70 a	15.30 c
BARI Surjomukhi-3- BRRI dhan98-BRRI dhan71	2.21	5.44 d	5.04 a	16.34 b
BARI Surjomukhi-3- BRRI dhan100-BRRI dhan71	2.49	5.84 cd	4.94 a	17.31 a
BRRI dhan28-Ranjit (Ck)	-	6.75 a	3.98 b	10.73 d
CV (%)	-	8.55	10.60	13.84

Different letters indicate significant difference at P< 0.05.
REY calculation price (Tk/kg): Rice = 30, Mustard = 80, Sunflower = 80

The cost-return analysis revealed significant variation in both total variable cost ($F_{4, 34}$ = 587.15, P< 0.001) and gross margin ($F_{4, 34}$ =18.30, P< 0.001) across different cropping pattern combinations. The total variable cost for all improved cropping patterns was significantly higher than that of the existing pattern. Introducing sunflower into the cropping system incurred higher costs compared to mustard. However, all improved pattern combinations yielded a higher gross margin than the existing pattern. When considering the marginal benefit-cost ratio (MBCR), the introduction of mustard was found more profitable than sunflower. Among the tested cropping patterns, the BARI Sarisha-14-BRRI dhan100-BRRI dhan71 combination was identified as the most profitable (Table 83).

Table 83. Cost and return analysis of different cropping pattern combinations, Kaliganj, Gazipur, 2024-25

Cropping pattern	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
BARI Sarisha-14-BRRI dhan100-BRRI dhan71	371 b	168 ab	1.83
BARI Sarisha-14-BRRI dhan105-BRRI dhan71	377 b	158 ab	1.68
BARI Surjomukhi-3- BRRI dhan98-BRRI dhan71	414 a	145 b	1.39
BARI Surjomukhi-3- BRRI dhan100-BRRI dhan71	409 a	182 a	1.69
BRRI dhan28-Ranjit (Ck)	281 c	93 c	-
CV (%)	11.39	22.17	

Different letters indicate significant difference at P< 0.05.
Price (Tk/kg): Boro rice= 30, T. Aman rice= 32.5, Boro straw= 2-4, T. Aman straw= 6-7, Mustard= 80, Sunflower= 80, Stover (mustard and sunflower) = 02

The energy use efficiency and energy productivity of various cropping patterns are summarized in **Table 84**. The analysis revealed that the energy efficiency of Mustard-Boro-T. Aman and Sunflower-Boro-T. Aman cropping pattern were 35% and 38% higher compared to the Boro-Fallow-T. Aman cropping pattern. Among the evaluated cropping systems, the Sunflower-Boro-T. Aman cropping pattern demonstrated superior energy efficiency, being 2% and 38% more efficient than the Mustard-Boro-T. Aman and Boro-Fallow-T. Aman cropping patterns, respectively. Additionally, Sunflower-Boro-T. Aman cropping pattern exhibited the higher energy productivity among the tested cropping systems.

Table 84. Energy use efficiency and energy productivity of different cropping patterns, Kaliganj, Gazipur, 2024-25

Cropping pattern	Energy balance (MJ/ha)			Energy productivity (g MJ^{-1})
	Input	Output	Balance	
Mustard-Boro-T. Aman	90133	392546	302413	170
Sunflower-Boro-T. Aman	87557	395973	308416	193
Boro-Fallow-T. Aman (Ck)	67970	291856	223886	158

Farmer's reaction

Farmers expressed high levels of satisfaction with the performance of mustard and sunflower as transitional crops between T. Aman and Boro rice. Both crops contributed to higher gross margins; however, farmers expressed concerns regarding the increased labor required for sunflower cultivation, specifically in managing axillary flowers and conducting additional intercultural operations such as weeding, thinning, and earthing up. Notably, sunflower cultivation also generated supplementary income through eco-tourism, as farmers earned approximately Tk 74,000 from 5 bigha of land by selling entry tickets to visitors during the flowering period. With respect to rice varieties, farmers expressed a clear preference for BRRI dhan100 in the Boro season and BRRI dhan71 in the T. Aman season, citing their high yield potential and shorter growth duration. Overall, farmers favored both mustard and sunflower as transitional crops between Boro and T. Aman rice.

Expt. 6.1.2. Introducing newly released BRRI rice varieties for the improvement of major cropping patterns in FSRD site, Kaliganj, Gazipur

MK Quais, MAU Razu, DH payel and M Ibrahim

Introduction

Boro-Fallow-T. Aman and Boro-Fallow-Fallow are the major cropping patterns practiced by the farmers at FSR&D site Kaliganj covering 36 and 29% of the net cropped area, respectively. Benchmark survey data reveals that farmers commonly cultivate Ranjit, Swarna, Pajam, Hurabdi and BRRI dhan49 in T. Aman season. In the Boro season, the most popular variety is BRRI dhan29. Farmers also grow other high-yielding varieties (HYVs) such as BRRI dhan28, BR14, and BR16. However, the productivity of these varieties is not satisfactory (on an average 5.55 t/ha in Boro season and 3.14 t/ha in Aman season). Therefore, there is a wide scope to introduce newly released BRRI rice varieties with improved management practices at this site for their rapid dissemination and to increase farmers' income.

Material and Methods

The trials were conducted in farmers' fields located in Kaliganj, Gazipur with the aim of increasing the productivity of double rice and single rice ecosystem by introducing recently released BRRI rice varieties. We evaluated the performance of BRRI dhan100, 102, 105-Fallow-BRRI dhan71, 103 cropping patterns in double rice ecosystem. Additionally, the suitability of BRRI dhan92, 102, 114 was assessed in single rice ecosystem. We selected eighteen dispersed farmer's fields, covering an area of 20 bh for the evaluation of BRRI dhan100, 102, 105-Fallow-BRRI dhan71, 103 cropping patterns. In the case of the single rice ecosystem, we chose eighteen farmer's fields, spanning an area of 18 bh, to determine the suitability of BRRI dhan92, 102, 114. Each farmer's field represents one replication. BRRI recommended fertilizer dose and other management practices were followed while conducting the trials (Table 85 and 86).

Table 85. Crop management practices adopted to evaluate the newly released BRRI rice varieties in Boro-Fallow-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2024-25

Mgt. factors	Improved pattern		Farmer's practice	
	Boro	T. Aman	Boro	T. Aman
Variety	BRRI dhan100, 102, 105	BRRI dhan71, 103	BRRI dhan28	Ranjit
Seeding date	22-28 Nov 24	30 Jun-06 Jul 24	25 Nov-04 Dec 24	03-04 Jul 24
Seed rate (kg/ha)	30	30	50-70	55-70
TP date	13-17 Jan 25	30 Jul-08 Aug 24	08-20 Jan 25	04-07 Aug 24
Spacing (cm×cm)	20×Random	20×Random	20-22×Random	15-20 ×Random
Seedling/hill	3-5	3-5	4-6	4-6
Fertilizer (kg/ha): N, P, K, S & Zn	120-18-75-18-4-0	BR71: 69-10-41-10-0-0 BR103:76-12-52-11-0	99-15-65-3-0	53-11-31-1.5-0
Weeding (Times)	2-3	2-3	2-3	2
Maturity date	18 April-2 May 25	BR71: 25-28 Oct 24 BR103:10-13 Nov 24	13-20 April 25	23-28 Nov 24
Growth duration (day)	143-157	BR71: 116 BR103: 132	137-140	142-147

Table 86. Crop management practices adopted to evaluate the suitability of BRRI dhan92, 102, 114 in single rice ecosystem, Muktarpur, Kaliganj, Gazipur 2024-25

Mgt. factors	Improved variety	Farmer's practice
Variety	BRRI dhan92, 102, 114	BRRI dhan29
Seeding date	02-07 Dec 24	01-06 Dec 24
Seed rate (kg/ha)	30	45-65
TP date	09-15 Jan 25	17-20 Jan 25
Spacing (cm×cm)	20×Random	15-20×Random
Seedling/hill	3-5	4-6
Fertilizer (kg/ha): N, P, K, S & Zn	138-19-82-18-4	84-15-32-7-0
Weeding (Times)	3	2-3
Maturity/ harvesting date	05-15 May 25	13-17 May 24
Growth duration (days)	150-161	160-163

Results and Discussion

In double rice ecosystem, BRRI dhan102 during Boro season and BRRI dhan103 during T. Aman season yielded significantly higher grain yields when compared to the existing varieties, BRRI dhan28 and Ranjit, respectively. The overall productivity of the improved cropping pattern exceeded that of the existing pattern by approximately 34%. A comprehensive assessment, considering gross margin and the MBCR, BRRI dhan102-Fallow-BRRI dhan103 cropping pattern outperformed the existing cropping pattern (ECP), highlighting the profitability of adopting this improved cropping pattern in double rice ecosystem. Meanwhile BRRI dhan92, BRRI dhan102, BRRI dhan114 exhibited notable performance in single rice ecosystem, generating a gross margin that was 53% higher than the existing variety, BRRI dhan29. These findings underscore the potential for uplifting the overall productivity adopting newly released BRRI rice varieties combined with recommended management practices (Table 87).

Table 87. Grain yield and profitability of double and single rice-based cropping patterns, Kaliganj, Gazipur, 2024-25

Cropping pattern		Yield (t/ha)			TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
		Boro	T. Aman	Total productivity			
Double rice	ICP	7.88	4.98	12.86a	323	142	5.07
	ECP	5.64	3.98	9.62b	301	49	-
Single rice	ICP	8.52a	-	8.52a	189	89	5.80
	ECP	7.28b	-	7.28b	182	58	-

Double-rice based cropping Pattern: ICP=BRRI dhan100/102/105-Fallow-BRRI dhan71/103, ECP=BRRI dhan28-Fallow-Ranjit (ck.); Single rice-based cropping pattern: ICP= BRRI dhan92/102/114-Fallow-Fallow, ECP=BRRI dhan29-Fallow-Fallow (ck.), MBCR=Marginal Benefit Cost Ratio; Price (Tk/Kg): Boro = 30, T. Aman = 32.5 to 35, Boro straw= 2-3, T. Aman straw= 5-7

Farmer's reaction

In the double-rice ecosystem, farmers expressed high satisfaction with BRRI dhan102, citing its excellent grain yield and good taste. During the *Aman* season, BRRI dhan103 was well-accepted for its high grain and straw yield; however, farmers noted its susceptibility to stem borer and sheath blight infestations. In the single-rice ecosystem, BRRI dhan92 and BRRI dhan102 were highly regarded, primarily due to their superior grain yield and quality.

Expt. 6.1.3. Farmers' participatory evaluation of recently released BRRI varieties for Boro and T. Aman season at FSRD site, Kaliganj, Gazipur

MK Quais, MAU Razu, T Araf and M Ibrahim

Introduction

The rice yield of outdated cultivars is decreasing day by day because these cultivars has become more sensitive to diseases, insects, and other pests. One of the main reasons for the slow replacement of these poor cultivars is the lack of exposure to newer ones; as a result, old cultivars continue to be farmed on a larger scale. A diverse choice of superior rice varieties must be tested on-farm by involving farmers directly in a participatory way. Using that method, they can select a rice variety based on their preferences. This practical approach is essential to boost the acceptance rates and country-wide dissemination of new superior rice variety(s).

Material and Methods

A participatory demonstration trial on recently released BRRI varieties was carried out at FSR&D site, Kaliganj during the T. Aman and Boro season of 2024-25. We distributed five kg of BRRI dhan71, BRRI dhan75, BRRI dhan87, BRRI dhan90, BRRI dhan95, BRRI dhan103 in the T. Aman season and BRRI dhan89, BRRI dhan92, BRRI dhan100, BRRI dhan102, BRRI dhan104, BRRI dhan105, BRRI dhan107, BRRI dhan108, BRRI hybrid dhan8 in the Boro season to the participatory farmers. Additionally, participatory farmers were trained on recommended management practices of rice cultivation. BRRI recommended fertilizer dose and other management practices were followed while conducting the trials. All the varieties along with existing popular varieties were cultivated side by side in the same block and farmers have evaluated the suitable variety for the location.

Results and Discussion

In T. Aman season, significant variation in yield performance was observed among the evaluated Aman rice varieties (Table 88). BRRI dhan95 produced the highest yield, which was statistically superior to all other varieties. BRRI dhan71 also yielded comparatively well, followed by BRRI dhan75. All tested varieties were susceptible to pest and disease infestation. Stem borer was the most widespread constraint, reported across all varieties. BRRI dhan95 was additionally affected by leaf roller, BRRI dhan75 by rat damage, BRRI dhan87 by tungro virus, and BRRI dhan103 by severe sheath blight. Farmers expressed high satisfaction with BRRI dhan95 and BRRI dhan71, primarily due to their higher yields and favorable growth duration compared with other tested varieties.

Table 88. Grain yield and farmer's opinion on the tested T. Aman varieties, Kaliganj, Gazipur, 2024

Variety	Yield (t/ha)	Observations	Farmer's opinion
BRRI dhan71	4.66 ± 0.08 b	Stem borer infestation high	Farmers are highly satisfied with the yield and growth duration of BRRI dhan95 and 71.
BRRI dhan75	4.21 ± 0.06 bc	• Stem borer infestation high • Rat infestation high	
BRRI dhan87	3.49 ± 0.16 d	• Stem borer infestation high • Sever Tungro infestation	
BRRI dhan90	3.85 ± 0.07 cd	• Stem borer infestation high • Tiller no. comparatively low	
BRRI dhan95	5.68 ± 0.06 a	Leaf roller infestation high	
BRRI dhan103	3.87 ± 0.08 cd	• Stem borer infestation high • Sever sheath blight infestation	
Maloti (ck)	3.66 ± 0.10 d	Stem borer infestation high	

In Boro season, grain yield differed significantly among the tested varieties (Table 89). BRRI dhan102 produced the highest yield, which was statistically superior to most other varieties. Across varieties, stem borer infestation was reported in BRRI dhan89, BRRI dhan92, BRRI dhan100, BRRI dhan104, BRRI dhan105, BRRI dhan107 and BRRI dhan28, with BRRI dhan107 being severely affected. BRRI dhan28 exhibited high blast incidence, whereas BRRI dhan100 showed partial lodging and BRRI dhan108 had a higher proportion of unfilled grains. By contrast, BRRI dhan102 demonstrated strong plant stature with relatively low insect pressure. Farmer preference aligned with yield and quality traits. BRRI dhan92 was favored for its high yield and good taste, BRRI dhan100 and BRRI dhan108 for early maturity and superior grain quality and BRRI dhan102 for its high yield and favorable eating quality. Despite its outstanding yield, hybrid Gazi was not well accepted due to coarse grain and poor taste. Overall, BRRI dhan102 emerged as the most promising variety, combining superior yield performance with desirable quality attributes.

Table 89. Grain yield and farmer's opinion on the tested Boro varieties, Kaliganj, Gazipur, 2024-25

Variety	Yield (t/ha)	Observations	Farmer's opinion
BRRI dhan89	6.84 ± 0.09 bc	• Strong plant stature, • High stem borer infestation	Farmers expressed a preference for BRRI dhan92, 100, 102, and 108. They favored BRRI dhan92 for its high yield and good taste, while BRRI dhan100 and BRRI dhan108 were appreciated for their early maturity and superior grain quality. However, they noted a higher incidence of unfilled grains in BRRI dhan108. BRRI dhan102 was also well-liked
BRRI dhan92	7.41 ± 0.10 ab	• Strong plant stature • High stem borer infestation	
BRRI dhan100	6.88 ± 0.10 bc	• Lodging observed in parts of field • High stem borer infestation	
BRRI dhan102	8.29 ± 0.16 a	Strong plant stature with low insect infestation	
BRRI dhan104	6.99 ± 0.09 bc	High incidence of stem borer infestation	
BRRI dhan105	7.47 ± 0.09 ab	Strong plant stature; stem borer infestation observed	

BRRI dhan107	5.64 ± 0.11 de	Severe stem borer infestation	due to its high yield and favorable taste. Although the hybrid variety Gazi produced an outstanding yield, farmers were not satisfied with its coarse grain and poor taste.
BRRI dhan108	6.40 ± 0.14 cd	High proportion of unfilled grains compared to other varieties	
BRRI hybrid dhan8	7.43 ± 0.14 ab	Lower insect and disease infestation	
BRRI dhan28	5.09 ± 0.12 e	• Blast infection high • High stem borer infestation	
Hybrid Gazi	7.68 ± 0.48 ab	Low insect and disease infestation	

Expt. 6.1.4. Farmers' participatory quality seed production of recently released BRRI varieties for Boro and T. Aman season at FSRD site, Kaliganj, Gazipur

MK Quais, MAU Razu, T Husna and M Ibrahim

Introduction

The significance of high-quality seeds cannot be overstated when aiming to improve crop production. In Bangladesh, only about 40% of rice seeds are supplied by public, non-governmental organizations (NGOs), and private sectors. Consequently, the majority of farmers rely on their own produce seeds. Presently, a substantial yield gap exists between the potential and actual yields in farmers' fields, and one crucial contributing factor to this disparity is the unavailability of good-quality seeds. Therefore, farmers' participatory quality rice seed production is of paramount importance as it empowers local farmers to produce seeds, ensuring higher seed quality and adaptability to local conditions. This practice not only reduces the cost of seed procurement for farmers and the government but also enhances farmers' income by enabling them to sell surplus seeds. Moreover, farmer engagement in seed production strengthens community bonds, promotes knowledge-sharing, and ensures timely access to quality seeds, which ultimately bridging yield gaps, promoting agricultural sustainability, and contributing to food security in the country.

Extensive field visits to the FSRD site in Kaliganj, Gazipur have shown that most farmers utilize paddy seeds from their own stocks, typically without paying special attention to seed quality. Consequently, they don't able to harvest the yield advantages of modern rice varieties. To address this issue and facilitate the distribution of high-quality seeds among the farming community, farmers' participatory quality seed production program was undertaken at FSRD site, Kaliganj, Gazipur.

Material and methods

Farmers' participatory quality seed production program was executed in Jamalpur, Kaliganj, Gazipur during the T. Aman and Boro seasons of 2024-25. In the Aman season, 435 kg of seeds were distributed to 101 farmers, while 1290 kg of newly released Boro varieties were distributed to 262 farmers (Table 90). At the beginning of the season, a farmer's gathering was organized to impart knowledge on quality seed production and recommend management practices.

Table 90. Variety-wise distributed seed amount and the beneficiary farmer number during T. Aman and Boro season, Kaliganj, Gazipur, 2024-25

T. Aman variety	Distributed seed (kg)	Beneficiary farmer no.	Boro variety	Distributed seed (kg)	Beneficiary farmer no.
BRRI dhan71	200	43	BRRI dhan89	100	20
BRRI dhan75	25	07	BRRI dhan100	100	24
BRRI dhan87	60	15	BRRI dhan102	400	85
BRRI dhan90	10	06	BRRI dhan104	300	62
BRRI dhan95	40	10	BRRI dhan105	350	64
BRRI dhan103	100	20	BRRI dhan107	20	03
Total	435	101	BRRI dhan108	20	04
			Total	1290	262

Results and Discussion

The disposal pattern of T. Aman cultivar's seed is displayed in Table 91. Farmers set aside about 3-4% of harvested seed for their own seed requirement and to sell in the upcoming T. Aman season as seed. Additionally, they sold around 6648 kg seed which will be used for seeding purposes. Furthermore, a portion of seed (1075 kg) was exchanged among 220 farmers. Among the varieties, the largest proportion (78.1%) of BRRI dhan87 seeds were sold immediately after harvesting. Farmers preferred BRRI dhan75 for their own consumption. The higher exchange number and sale percentage indicate the popularity of BRRI dhan71 and BRRI dhan90 in that locality. The major portion of BRRI dhan87 and BRRI dhan71 seed were sold in the market, with a small portion being consumed by farmers.

Table 91. Distribution pattern of produced T. Aman seeds, FSRD site, Kaliganj, Gazipur, 2024

Variety	Seed produced (kg/variety)	Store for seed (%)	Consumed as paddy (%)	Sold (%)		Exchanged to the neighboring farmers (%)*
				As seed	As paddy	
BRRI dhan71	16800	3.6	25.7	20.3	48.3	2.1 (68)
BRRI dhan75	2080	3.8	70.2	4.5	20.3	1.2 (05)
BRRI dhan87	5400	3.7	10.6	6.8	78.1	0.8 (10)
BRRI dhan90	765	3.9	16.5	15.4	56.8	7.4 (12)
BRRI dhan95	3900	3.1	17.6	25.1	45.6	8.6 (70)
BRRI dhan103	7500	4.0	25.8	22.4	44.3	3.5 (55)

*Figures in parenthesis indicate no. of farmers

The distribution pattern of Boro cultivar's seed is shown in Table 92. Farmers reserved about 2-22% of harvested seed for own seed requirement and for selling in the next Boro season as seed. They sold about 11646 kg of harvested grain as seed. In addition, a portion of seed (6609 kg) was exchanged among 1372 farmers. The major portion of BRRI dhan107 and 108 grain (50-73%) were sold as seed. BRRI dhan104 was sold immediately after harvesting due to its higher market price. Farmers allocated a considerable portion of BRRI dhan100 and 102 for their own consumption.

Table 92. Distribution pattern of produced Boro seeds, FSRD site, Kaliganj, Gazipur, 2024-25

Variety	Seed produced (kg/variety)	Store for seed (%)	Consumed as paddy (%)	Sold (%)		Exchanged to the neighboring farmers (%)*
				As seed	As paddy	
BRRI dhan89	13050	2.1	24.8	2.5	70.4	0.2 (08)
BRRI dhan100	11480	5.2	59.2	6.8	20.5	8.7 (230)
BRRI dhan102	60000	4.8	65.2	5.2	19.6	5.2 (628)
BRRI dhan104	36000	2.3	14.9	6.3	71.4	5.1 (370)
BRRI dhan105	50600	1.9	13.8	4.8	78.3	1.2 (125)
BRRI dhan107	2310	10.3	23.7	64.5	1.0	0.5 (5)
BRRI dhan108	2460	22.2	25.2	50.1	2.1	0.4 (6)

*Figures in parenthesis indicate no. of farmers

Expt. 6.1.5. Evaluation of intercropping under mixed orchard

MAU Razu, T Araf, MK Quais and M Ibrahim

Introduction

Forest is an important natural resource of any country requiring 25% forest land of the total area of the country for its socio-economic upliftment and maintenance of environmental equilibrium. Of the total geographic area of Bangladesh, agricultural land makes up 65% and forest land accounts only 17.08%; while urban areas cover 8% of the land (FAO, 2021; BBS, 2021). The Madhupur Sal forest is representing the major patches of Bangladesh Sal forests which are valuable in ecological as well as economic aspects that have been degraded due to destructive anthropogenic activities. The local farmer of the Madhupur tract area relies on agroforestry practices that play a vital role in offering multiple alternatives and opportunities with a view to improving farm production and income and providing productive and conservation functions to the ecosystems (Alam *et al.,* 2010). Some researchers have noted the benefits of Mango, Banana, Lemon, Guava, Litchi, and different seasonal crops cultivation along with agroforestry practices are more economically profitable than the cultivation of their non-agroforestry systems. But the practice of agroforestry system and economic aspects of fruit tree-based agroforestry systems in the study area was negligible. Therefore, considering the aforementioned facts, the present study was undertaken with the following objectives.

Objectives

i) To evaluate the performance of different inter-crops under different orchards.
ii) To increase the productivity of the orchard and farmers' income.

Material and Methods

The experiment was carried out at the FSRD site in Kaliganj, Gazipur during the 2024-25 cropping year. The study comprised five treatment combinations involving the cultivation of different summer and winter vegetables in association with turmeric and ginger under various orchard systems (Table 93). The average orchard size per farmer was 8.61 decimals.

Table 93. Patterns followed for intercropping under mixed orchards, Kaliganj, Gazipur, 2024-25

Orchard pattern	Fruit trees	Vegetables		Spice crops	Orchard area (dec.)		
		Rabi	Kharif		Vegetables	Spices	Total
1	Guava, Mango	Tomato, Brinjal, Chili, Pumpkin	Okra, Indian spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric	10	0.43	10.43
2	Mango, Litchi, Malta	Tomato, Cauliflower, Cabbage, Chili, Pumpkin	Okra, Indian spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric	6	0.30	6.30
3	Mango, Jujube	Pumpkin	Okra, Indian spinach, Kangkong, Pumpkin	Turmeric, Ginger	10	0.54	10.54
4	Mango. Litchi	Tomato, Spinach, Red Amaranth, Brinjal, Pumpkin, Cabbage	Okra, Indian spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric, Ginger	10	0.26	10.26
5	Mango	Tomato, Cauliflower, Chili	Okra, Indian spinach, Stem amaranth, Kangkong	Turmeric, Ginger	5	0.5	5.5
Average					8.10	0.41	8.61

Vegetable production

The productivity of year-round vegetables grown under mixed orchard systems at Kaliganj, Gazipur during 2024-25 is presented in Table 94. Five different orchard-based cropping patterns were evaluated across five orchards. On average, a total of 147 kg of vegetables were harvested annually from 9.5 decimals of land under mixed orchard conditions. Vegetable production varied across seasons and orchard patterns. Among the five orchards, Orchard-2 produced the highest total annual vegetable yield (200 kg/9.5 decimals). This orchard integrated a diverse range of year-round vegetables with mango, malta and litchi trees, suggesting that greater crop diversity and compatible tree species can enhance overall productivity. In contrast, the lowest annual production (120 kg/9.5 decimals) was recorded in Orchard-3, mainly due to limited crop diversity and seasonal vegetable coverage. Overall, the results demonstrate that mixed orchard-based vegetable production can provide substantial year-round yields and vegetable combinations playing crucial roles in determining productivity.

Table 94. Productivity of year-round vegetables under mixed orchards, Kaliganj, Gazipur, 2024-25

Orchard pattern	Production (kg/9.5 dec.)												Total
	Rabi							Kharif				Year-round	
	Red Amaranth	Tomato	Cauliflower	Cabbage	Spinach	Brinjal	Chili	Okra	Indian spinach	Stem amaranth	Kangkong	Pumpkin	
1	-	26	-	-	-	23	11	18	12	4	4	57	155
2	-	16	55	79	-	-	11	6	10	17	6	-	201
3	-	-	-	-	13	-	-	21	24	-	17	45	120
4	15	12	-	-	-	17	-	14	12	13	16	29	129
5	-	36	53	-	-	-	22	11	5	3	3	-	133
Average	15	23	54	79	13	20	15	17	14	12	9	44	147

Price (Tk./kg): Red Amaranth=45, Tomato=50, Cauliflower=45, Cabbage=20, Spinach=40, Brinjal=50, Chilli=150, Okra=60, Indian spinach=30, Stem amaranth=25, Kangkong=35, Pumpkin=30

The utilization scenario and economic returns from year-round vegetable production under mixed orchard systems are presented in Table 95. On average, 115 kg of vegetables were consumed at the household level, while 8 kg were distributed and 24 kg were sold, indicating that orchard-based vegetable production contributed both to household nutrition and marketable surplus. The average total variable cost (TVC) for vegetable production was Tk. 3,264 per 9.5 decimals, resulting in an average gross margin of Tk. 4,185. This positive gross margin demonstrates the economic viability of year-round vegetable cultivation under mixed orchards. Overall, the results suggest that mixed orchard-based vegetable systems can enhance farm profitability, simultaneously supporting household consumption.

Table 95. Utilization scenario and economic return of year-round vegetables under mixed orchards, Kaliganj, Gazipur, 2024-25

Orchard pattern	Utilization (kg/9.5 dec.)			TVC (Tk./9.5 dec.)	GM (Tk./9.5 dec.)
	Consumption	Distribution	Sale		
1	141	7	7	2992	4532
2	160	7	34	4209	3929
3	81	6	34	1700	2219
4	91	13	25	3206	5403
5	103	7	23	4212	4840
Average	115	8	23	3264	4185

Spices production

The productivity, utilization pattern, and economic return of spice cultivation under mixed orchard systems are presented in Table 96. On average, 70 kg of spices- comprising 58 kg of turmeric and 12 kg of ginger- were harvested from 0.5 decimals of orchard land. From the five orchards, an average Tk. 3,857 gross margin from 0.5 decimals of spice cultivation, demonstrating the profitability of integrating spices into mixed orchard systems. The utilization pattern indicates that a substantial proportion of the spices was sold, which significantly contributed to increased farm income alongside meeting household consumption needs.

Table 96. Productivity, utilization scenario and economic return of spices production under mixed orchards, Kaliganj, Gazipur, 2024-25

Orchard pattern	Production (kg/0.5 dec.)			Utilization (kg/ 0.5 dec.)		TVC (Tk./0.5 dec.)	GM (Tk./0.5 dec.)
	Turmeric	Ginger	Total	Consumption	Sale		
1	61	0	60	7	53	2286	1342
2	82	13	95	8	123	3412	5298
3	55	18	73	6	67	3063	5435
4	38	15	53	8	45	3165	3493
5	55	13	68	8	60	3353	3717
Average	58	12	70	7	70	3056	3857

Price (Tk./kg): Turmeric=60, Ginger=290

Fruit production

As the average age of fruit saplings ranged from 1 to 2 years, commercial fruit bearing had not yet commenced during the study period.

Overall scenario of integrated vegetables and spices production under mixed orchards

Overall productivity and economic return of vegetables and spices production per 10 decimals of mixed orchard cultivating vegetables in 9.5 decimals and spices in 0.5 decimals, respectively is presented in Figure 31. From the 5 patterns followed at 5 orchards, an average of 217 kg of output was obtained from 10 decimals of orchards, with vegetables and spices contributing 68% and 32%, respectively. Moreover, each orchard yielded a gross margin of Tk. 8041 per 10 decimals on average, with vegetables and spices contributing 52% and 48%, respectively.

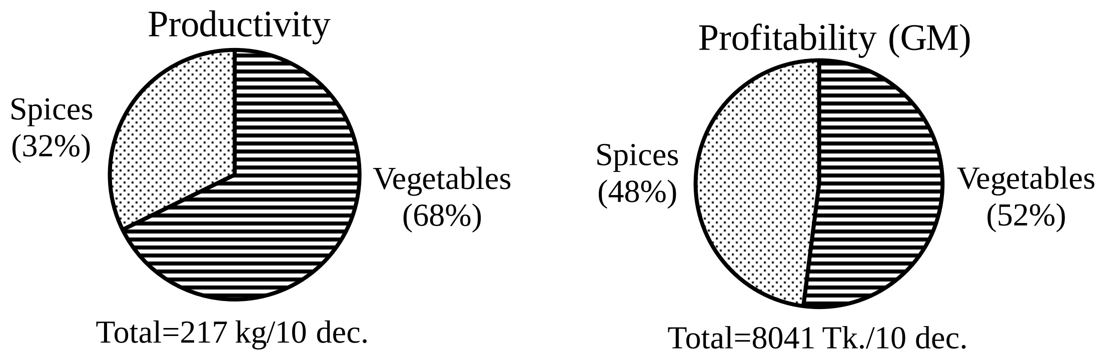


Figure 31. Overall productivity and profitability of intercropping under mixed orchards, Kaliganj, Gazipur, 2024-25. Orchard area: 10 decimals (Vegetables=9.5 decimals, Spices=0.5 decimals).

6.2. Homestead Production System

MAU Razu, T Araf, MK Quais and M Ibrahim

Expt. 6.2.1. Year-round vegetables production in homestead area

Introduction

Bangladesh has about 14.7 million agriculture farm households of which about 80% are small and marginal (BBS, 2018). These groups of farmers usually have limited crop fields. Usually, they have to maintain their livelihood by utilizing the homestead area and crop field. However, most homestead areas of Bangladesh remain underutilized which could be brought under vegetables cultivation round the year to reduce the malnutrition for promoting household food self-sufficiency and cash income as well. In the context of ever-increasing problems of malnutrition and smaller farm size for field crop production, the only feasible option for small and marginal households is to grow vegetables intensively in the homestead areas, which can provide household food and nutritional sufficiency to those farmers. Considering these situations, this program was initiated with the following objectives:

i) To improve vegetables production round the year at homestead area
ii) To generate additional income for farmers by selling surplus vegetables
iii) To meet up the nutritional need of farm family

Material and Methods

The study was conducted during 2024-25 at the FSRD site Muktarpur, Kaliganj, Gazipur. Ten cooperative farmers from marginal (5-50 dec.) and small (51-247 dec.) farmers were selected for homestead vegetables cultivation. Seeds of different high yielding vegetables were supplied to the farmers. For implementing a vegetable production model, beds were prepared at open spaces of different sizes according to space availability at the homesteads of different farmers. Trellis, shady backyard and other production niches were brought under production. Intercultural operation and management practices were done by the farmers following recommended practices. Different vegetables seeds and seedlings were distributed among the farmers (Table 97).

Table 97. Patterns followed for integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Vegetables			Garden area (dec.)		
		Rabi	Kharif	Spices	Vegetables	Spices	Total
Marginal	1	Red amaranth, Spinach, Cabbage, Tomato, Coriander leaf, Country bean, Brinjal, Chili	Okra, Indian spinach, Stem amaranth, Kangkong, Bitter gourd	Turmeric	10.60	0.31	10.91
	2	Red amaranth, Spinach, Cabbage, Tomato, Coriander leaf, Chili	Okra, Indian spinach, Stem amaranth, Kangkong	Turmeric	6.40	0.06	6.46
	3	Spinach, Cabbage, Tomato, Radish leaf, Chili	Okra, Indian spinach, Kangkong, Bitter gourd, Sponge gourd, Yard-long bean	Turmeric	3.98	0.2	4.18
	4	Red amaranth, Spinach, Tomato, Brinjal, Chili	Okra, Indian spinach, Stem amaranth, Kangkong, Sponge gourd	Turmeric, Ginger	3.26	0.39	3.65
	5	Spinach, Cauliflower, Cabbage, Tomato, Chili	Okra, Indian spinach, Stem amaranth, Kangkong	Turmeric, Ginger	7	0.5	7.5
	6	Spinach, Cauliflower, Cabbage, Tomato, Chili	Okra, Indian spinach, Stem amaranth, Kangkong	Turmeric, Ginger	5.30	0.46	5.76
	Average				6.09	0.32	6.4
Small	7	Red amaranth, Spinach, Cauliflower, Cabbage, Tomato, Radish leaf, Bottle gourd, Country bean, Brinjal, Chili	Okra, Indian spinach, Stem amaranth, Jute leaf, Ridge gourd, Kangkong, Snake gourd	Turmeric, Ginger	11.51	0.34	11.85
	8	Spinach, Tomato, Brinjal, Chili	Indian spinach, Stem amaranth, Kangkong, Bitter gourd	Turmeric, Ginger	6.5	0.5	7
	9	Red amaranth, Tomato, Country bean, Brinjal, Chili	Okra, Indian spinach, Snake gourd, Sponge gourd	Turmeric, Ginger	7	0.43	7.43
	10	Red amaranth, Spinach, Tomato, Country bean, Brinjal, Chili	Okra, Indian spinach, Stem amaranth, Kangkong, Bitter gourd, Snake gourd	Turmeric, Ginger	4.13	0.34	4.47
	Average				7.29	0.4	7.69
Cumulative average					6.69	0.36	7.05

Results and Discussion

Vegetable production

Productivity of year-round vegetables under integrated homestead production system is presented in Table 98 and utilization scenario and economic return in Table 99. In the case of marginal farmers, an average of 168 kg vegetables and in case of small farmers, an average of 211 kg vegetables were harvested per 10 decimals of garden cultivating vegetables in 9.5 decimals and spices in 0.5 decimals, respectively. Irrespective of gardens, among all the vegetables, the highest production was obtained from Cabbage (57 kg) and Stem amaranth (46 kg) in Rabi and Kharif seasons, respectively. Irrespective of farmers category, among all the gardens, the highest yearly vegetables production of 461 kg was obtained from Garden-7, where various year-round vegetables along with spices were cultivated. From the gardens, an average gross margin of Tk. 14547 (Tk. 13617 for 6 marginal farmers and Tk. 15943 for 4 small farmers) was obtained from 9.5 decimals of vegetables production. The highest gross margin of Tk. 18351 was produced from Garden-7, where various year-round vegetables along with spices were cultivated.

Table 98. Productivity of year-round vegetables production under integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Production (kg/9.5 dec.)																						
		Rabi												Kharif										Yearly total
		Open sunny space									Trellis			Open sunny space				Trellis			Fence			
		Red Amaranth	Spinach	Cauliflower	Cabbage	Tomato	Radish leaf	Coriander leaf	Chili	Brinjal	Country bean	Bottle gourd	Total	Okra	Indian spinach	Stem amaranth	Kangkong	Yard-long bean	Snake gourd	Ridge gourd	Bitter gourd	Sponge gourd	Total	
Marginal	1	18	28	45	47	19	-	13	11	37	-	-	218	24	65	36	22	-	-	-	19	-	166	384
	2	14	17	50	51	15	-	12	12	-	-	-	171	36	45	32	18	-	-	-	-	-	131	302
	3	11	19	42	58	17	14	-	12	-	-	-	173	21	48	-	15	22	-	-	25	14	145	318
	4	13	18	48	65	22	-	12	16	15	-	-	209	25	30	39	16	-	-	-	-	37	147	356
	5	13	15	46	52	17	-	-	-	-	-	-	143	32	42	44	18	-	-	-	-	35	171	314
	6	-	14	56	58	24	-	-	18	-	-	-	170	26	32	39	15	-	33	7	-	-	152	322
	Avg.	14	22	57	66	23	14	12	14	26	-	-	181	27	44	38	17	22	33	7	22	29	152	333
Small	7	14	26	45	64	21	13	13	28	28	14	47	313	22	33	36	17	-	34	6	-	-	148	461
	8	14	16	60	60	18	-	15	15	15	-	-	213	-	41	61	39	-	-	-	24	-	165	378
	9	20	-	50	57	25	-	12	14	-	23	-	201	28	40	-	-	-	56	-	-	32	156	357
	10	15	13	55	55	23	-	-	18	17	18	-	214	24	43	36	26	-	-	-	33	-	162	376
	Avg.	16	18	53	59	22	13	13	19	20	18	47	235	25	39	44	27	0	45	6	29	32	158	393
Cumulative avg.		13	18	50	57	20	14	13	16	22	18	47	203	26	42	46	21	22	41	7	25	30	154	357

Table 99. Utilization scenario and economic return of year-round vegetables production under integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Utilization (kg/9.5 dec.)			TVC (Tk./ 9.5 dec.)	GM (Tk./ 9.5 dec.)
		Consumption	Distribution	Sale		
Marginal	1	326	9	49	2080	15501
	2	279	6	17	921	13062
	3	271	4	43	874	13436
	4	286	9	61	1232	14788
	5	270	8	36	1854	12276
	6	273	10	39	1854	12636
	Average	284	8	41	1469	13617
Small	7	409	7	45	2394	18351
	8	321	3	54	1250	15760
	9	311	6	40	1850	14215
	10	337	3	36	1475	15445
	Average	345	5	44	1742	15943
Cumulative average		308	7	42	1578	14547

Price (Tk./kg): Red Amaranth=45, Spinach=40, Cauliflower=43, Cabbage=18, Tomato=50, Radish leaf=40, Coriander leaf=200, Chili=145, Brinjal=50, Country bean=40, Bottle gourd=35, Okra=60, Indian spinach=25, Stem amaranth=25, Kangkong=35, Yard-long bean=50, Snake gourd=45, Ridge gourd=50, Bitter gourd=60, Sponge gourd=55

Expt. 6.2.2 Performance of turmeric and ginger in shady place of homestead

Introduction

Turmeric and ginger are important spices in preparing daily food in Bangladesh. But the domestic production of these two spices is not sufficient to meet the demand. As a result, a lot of these spices are imported every year from other countries. To reduce dependency on imports of these two spices need to bring more land under cultivation. But this is not possible because of land limitations. One avenue for increasing their production is the cultivation of turmeric and ginger in homestead areas, especially in partially shady areas. With this view, participatory production trials on turmeric and ginger under the perennial trees at homestead were undertaken with marginal and small farmers at FSR&D site Muktarpur, Kaliganj, Gazipur.

Objectives

i) To utilize unused shady places of homestead area through spices production

ii) To increase the spices production as well as income generation

Material and Methods

The study was conducted at the FSR&D site Muktarpur, Kaliganj, Gazipur during 2024-25. Eight farmers were selected at the FSR&D site for the cultivation of ginger and turmeric in the fallow land under their homestead orchard. Ginger was cultivated in sacks and turmeric in beds. After preparing land, sowing was done by maintaining 50 cm × 25 cm and 60 cm × 25 cm spacing for turmeric, respectively. 250 g of ginger rhizomes per sack were planted in sacks containing 20 kg of well-prepared soil. Before planting, seed treatment was done with Autostin to prevent different seed borne diseases. “Pilaitola” (harvesting of mother ginger) of ginger was done at about 80-90 days after planting.

Results and Discussion

Productivity, utilization scenario and economic return of spices production in shady place of homestead area under integrated homestead production system is presented in Table 100. From the 10 patterns followed at 10 homestead gardens, an average of 119 kg of spices (79 kg Turmeric and 34 kg ginger) were harvested from 10 decimals of garden, where spices were cultivated at 0.5 decimal of land. Among the gardens, the highest spice production of 153 kg was obtained from Garden-7, where Turmeric was cultivated along with various year-round vegetables. From the gardens, an average gross margin of Tk. 9516 (Tk. 8098 for 6 marginal farmers and Tk. 11641 for 4 small farmers) was obtained from 0.5 decimals of spices production. The highest gross margin of Tk. 15420 was produced from Garden-10 where turmeric and ginger were cultivated along with various year-round vegetables.

Table 100. Productivity, utilization scenario and economic return of spices production under integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Production (kg/0.5 dec.)			Utilization (kg/0.5 dec.)		TVC (Tk./ 0.5 dec.)	GM (Tk./ 0.5 dec.)
		Turmeric	Ginger	Total	Consumption	Sale		
Marginal	1	85	-	95	20	75	1400	4125
	2	84	-	84	27	57	1600	3860
	3	75	35	110	32	78	3225	12150
	4	78	18	106	45	61	2770	7700
	5	80	15	115	39	76	3150	6550
	6	77	45	152	41	111	4300	14205
	Average	80	28	110	34	76	2741	8098
Small	7	85	38	153	45	108	5600	11325
	8	83	27	120	42	63	4420	9075
	9	73	35	123	35	78	4500	10745
	10	74	55	134	39	88	5890	15420
	Average	79	39	133	40	84	5103	11641
Cumulative average		79	34	119	37	80	3686	9516

Price (Tk./kg): Turmeric=65, Ginger=300

Overall scenario of integrated vegetables and spices production under homestead production system

Overall productivity and economic return of vegetables and spice production per 10 decimals of mixed homestead garden cultivating vegetables in 9.5 decimals and spices in 0.5 decimals, respectively is presented in Table 101. From the 10 patterns followed at 10 gardens, an average of 476 kg of output was obtained from 10 decimals of orchard, with vegetables and spices contributing 75% and 25%, respectively. Moreover, each garden yielded a gross margin of Tk. 24063 per 10 decimals on average, with vegetables and spices contributing 60%, and 40%, respectively.

Table 101. Overall average productivity and economic return of integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Production (kg/10 dec./yr)			GM (BDT/10 dec./yr)		
		Vegetables	Spices	Total	Vegetables	Spices	Total
Marginal	1	384	95	479	15501	4125	19626
	2	302	84	386	13062	3860	16922
	3	318	110	428	13436	12150	25586
	4	356	106	462	14788	7700	22488
	5	314	115	429	12276	6550	18826
	6	322	152	474	12636	14205	26841
	Average	333	110	443	13617	8098	21715
Small	7	461	153	614	18351	11325	29676
	8	378	120	498	15760	9075	24835
	9	357	123	480	14215	10745	24960
	10	376	134	510	15445	15420	30865
	Average	393	133	526	15943	11641	27584
Cumulative average		357	119	476	14547	9516	24063

Garden area: 10 decimals (Vegetables=9.5 decimals, Spices=0.5 decimals)

Expt. 6.2.3. Fruit tree plantation in homestead area

Introduction

Fruit tree plantation and fruit production under the homestead production system integrates various fruit tree species with agricultural crops, enhancing both productivity and sustainability. The primary fruit trees cultivated in Kaliganj, Gazipur include mango, jackfruit, guava, and litchi, which are strategically planted to optimize land use and improve soil health. The homestead production approach not only supports biodiversity but also contributes to the economic stability of local farmers by providing multiple sources of income. This system's success in Kaliganj serves as a model for sustainable agricultural practices in similar regions.

Objectives

i) To cultivate fruit for farm families, providing them with essential nutrition
ii) To increase the income by selling fruits

Methodology

Ten small and marginal farmers were selected in Muktarpur, Kaliganj, Gazipur under the activity. All the saplings were distributed on 1 June 2025 along with recommended management practice. All the farmers followed proper management practices during and after planting the saplings.

Results and Discussion

Most of the distributed saplings were established in the orchards and fruit bearing has not yet started. All the fruit trees are in good condition. The sapling distributions data are given in Table 102. Saplings of three mango varieties namely BARI Aam-3, and two Litchi varieties namely BARI Lichi-1, BARI Lichi-2 were distributed to the farmers according to their choice and interest. A total of 313 fruit saplings were distributed among the farmers. The mortality rate of the fruit trees is very low due to proper nursing by the farmers.

Table 102. Fruit tree distribution under homestead production system, Kaliganj, Gazipur, 2024-25

Fruits sapling	Variety	Distribution (No.)	Mortality (No.)
Mango	BARI Aam-3	193	4
Lichi	BARI Lichi-1	60	2
	BARI Lichi-2	60	2
Lemon	BARI Lebu-2	25	0
Total		338	8

Distribution date: 1 June 2025

Expt. 6.2.4. Compost production using household waste

Introduction

Composting is a sustainable and environmentally friendly way to manage household waste and create nutrient-rich soil for homestead gardening. Utilizing household waste for composting not only reduces the amount of waste sent to landfills but also produces a valuable resource for gardening and agriculture. To reduce dependency on synthetic fertilizer, participatory compost production and application on homestead gardening was done with marginal and small farmers at FSR&D site Muktarpur, Kaliganj, Gazipur during 2024-25.

Objectives

i) To create awareness among farmers in producing compost using kitchen waste

ii) To reduce the cost and use of synthetic fertilizers

Materials and Methods

Under this activity, compost was produced by the farmers at Kaliganj, Gazipur during 2024-25 by using household waste, vegetable waste, cow dung, poultry litter and other living materials. The average size of the compost pit was 4 m^2.

Results and Discussion

Compost production by individual farmers is presented in Table 103. The annual average amount of compost produced by the farmers was 50 kg/4 m^2. Among the 10 garden patterns, the highest compost production was obtained from Garden-5 (58 kg) whereas the lowest production was found from Garden-3 and Garden-4 (42 kg). Compost was used for vegetables, spices, rice and fish cultivation.

Table 103. Productivity, utilization scenario and economic return of compost production under integrated homestead production system, Kaliganj, Gazipur, 2024-25

Farmers category	Garden pattern	Annual production (kg)	Utilization (kg)			TVC/pit (Tk.)	GM (Tk.)
			Vegetables cultivation	Spices cultivation	Rice cultivation		
Marginal	1	43	36	7	-	47	115
	2	46	38	8	-	45	130
	3	42	20	10	12	52	110
	4	42	37	5	-	50	110
	5	58	37	11	10	55	190
	6	52	21	7	6		
	Average	47	32	8	9	50	131
Small	7	56	25	7	10	52	180
	8	53	19	11	23	48	165
	9	54	30	9	15	51	170
	10	47	27	9	11	49	135
	Average	53	25	9	15	50	163
Cumulative average		50	28	9	12	50	147

Size of compost pit (m^2)=4, Price of compost (Tk./kg)=5

6.3. Livestock Production System

MAU Razu, DH Payel, MK Quais and M Ibrahim

Expt. 6.3.1. Performance of Sonali chicken in homestead area

Introduction

Rearing a small flock of poultry birds is a traditional practice in rural areas making it one of the most productive livestock parts in Bangladesh. It is a golden scope to income and contribute to family with less investment for a small or marginal farmer, especially for women. The production potency of any poultry bird depends on its genetic makeup and nutritional management. Poultry birds increase the subsidiary monetary engagement of rural women as well as serve the purpose of hospitality and emergency family need also. The local (native) chickens are genetically poor producers having a live weight of 1.0 kg to 1.2 kg. Under traditional scavenging management a local chicken produces only 42-45 eggs in a year. Recent studies indicated that egg production at smallholder level could be doubled in the existing production system through intervention of crossbreeding in the semi-scavenging poultry model. Under this activity, improved chicken breed was distributed to the participatory farmers for rearing them in their household condition and to fulfill their nutritional requirements.

Objectives

i) To introduce the improved chicken breed in homestead area
ii) To engage and empowerment the rural women in income generating activities
iii) To assist in meeting the nutritional requirements of farm families

Methodology

The program was executed at FSR&D site, Muktarpur, Kaliganj, Gazipur during 2024-25. Twenty Sonali chicks were distributed to each of 9 interested farmers out of the 10 selected farmers during 2024-25. Chicks were about 30 days old. The male and female ratio was about 1:4. The chicks were vaccinated before giving them to the farmers. The routine works of vaccination were followed regularly. Technical supports (feeding and watering management, vaccination etc.) and advice were provided. Necessary treatment was also given as per the requirement.

Results and Discussion

Productivity of chicken rearing under integrated livestock production system is presented in Table 104. Among the distributed chicken, 90% of chicken survived. The mortality was mainly because of sudden outbreak of fowl pox. Irrespective of farmers category, on average 18 chickens survived per household from which 4 were consumed and 14 were sold to market. Marginal farmers obtained 1032 eggs per household from which 174 were consumed and 858 were sold, respectively from the chicken left after consumption and selling to market. Small farmers obtained 1070 eggs per household from which 140 were consumed and 930 were sold. Irrespective of farmers category, gross margin of Tk. 19283 was earned per household from the produced egg and survived chicken having maximum gross margin from household-8 (Tk. 21445) (Table 105).

Table 104. Productivity of chicken rearing under integrated livestock production system, Kaliganj, Gazipur, 2024-25

Farmers category	Household pattern	Survived chick (No.)	Mortality (%)	Chicken utilization (No.)		Egg production (No.)		
				Consumption	Sale	By consumed chicken	By sold chicken	Total
Marginal	1	19	5	4	15	150	880	1030
	2	18	10	5	13	247	910	1157
	3*	-	-	-	-	-	-	-
	4	16	20	4	12	145	690	835
	5	19	5	5	14	170	950	1120
	6	18	10	4	14	157	860	1017
	Average	18	10	4	14	174	858	1032
Small	7	18	10	4	14	139	780	919
	8	18	10	3	15	121	1053	1174
	9	19	5	3	16	143	847	990
	10	17	15	3	14	158	1041	1199
	Average	18	10	3	15	140	930	1070
Cumulative average		18	10	4	14	157	894	1051

* Chicken was not reared. Date of Chick distribution: 09 July 2024; Egg laying period: Mid-December 2024 to May 2025

Table 105. Utilization scenario and economic return of chicken rearing under integrated livestock production system, Kaliganj, Gazipur, 2024-25

Farmers category	Household pattern	Egg utilization (No.)		GR (Tk./household)			TVC (Tk. /household)	GM (Tk. /household)
		Consumption	Sale	Egg	Chicken	Total		
Marginal	1	371	659	12875	9405	22280	2845	19435
	2	358	799	14463	8910	23373	2590	20783
	3*	-	-	-	-	-	-	-
	4	291	544	10438	7920	18358	3080	15278
	5	360	760	14000	9405	23405	2845	20560
	6	325	692	12713	8910	21623	2590	19033
	Average	341	691	12898	8910	21808	2790	19018
Small	7	319	600	11488	8910	20398	2590	17808
	8	333	841	14675	8910	23585	2140	21445
	9	301	689	12375	9405	21780	2845	18935
	10	341	858	14988	8415	23403	3135	20268
	Average	323	747	13381	8910	22292	2678	19614
Cumulative average		332	709	13140	8910	22050	2740	19283

* Chicken was not reared. Price (Tk./piece): Chicken (1.5 kg wt.) =495, Egg=12.50

Expt. 6.3.2. Small scale pigeon rearing in farmer's household

Introduction

Small-scale pigeon rearing in farmers' households is an age-old practice that has gained renewed interest due to its numerous benefits and low cost. Pigeons are relatively easy to rear, requiring minimal space and resources, making them an ideal choice for small-scale farming. They provide a valuable source of protein through their meat and can also be a source of income through the sale of squabs and adult birds. Additionally, pigeon droppings are an excellent organic fertilizer, enriching the soil and enhancing crop yields. This practice not only supports food security but also contributes to the economic stability of farming households by diversifying their income sources.

Objective: To increase family income through squab production and ensure the nutritional food to family members

Methodology

Two pairs of adult pigeon were distributed to each of 8 interested farmers out of the 10 selected farmers at Kaliganj, Gazipur. Egg, squab production and body weight were monitored regularly. Technical supports (feeding and watering management, vaccination etc.) as well as necessary treatments were provided as per requirement.

Results and Discussion

Productivity, utilization scenario and economic return of pigeon rearing under integrated livestock production system is presented in Table 106. On average, in each household, pigeons and squabs were produced at a rate of 3 squabs per adult pigeon (3 squabs/pigeon for marginal farmers and 3 squabs/pigeon for small farmers) having an average body weight/pigeon of 333 g at the time of selling. From the households, an average gross margin of Tk. 9656 (Tk. 7718 for 4 marginal farmers and Tk. 11593 for 4 small farmers) was obtained. Among the households, the highest gross margin was produced from Household-10 (Tk. 18870), followed by Household-7 (Tk. 13480).

Table 106. Productivity, utilization scenario and economic return of pigeon rearing under integrated livestock production system, Kaliganj, Gazipur, 2024-25

Farmers category	Household pattern	Pigeon and squab production (No.)			Utilization of pigeons and squab (No.)		Remaining pigeon and squab (No.)	Average body weight/pigeon during sale (g)	TVC (Tk./household)	GM (Tk./household)
		Initial (July 2024)	Squab production	Total	Consumption	Sale				
Marginal	1	2	12	14	4	6	4	351	70	3320
	2	12	36	48	11	25	12	307	240	10380
	3*	-	-	-	-	-	-	-	-	-
	4*	-	-	-	-	-	-	-	-	-
	5	8	24	32	6	18	8	308	120	7050
	6	12	34	46	6	30	10	339	170	10120
	Average	9	27	35	7	20	9	326	150	7718
Small	7	16	48	64	12	40	12	339	320	13480
	8	6	18	24	8	12	4	338	120	4920
	9	8	32	40	8	28	4	356	200	9100
	10	22	74	96	26	70	-	324	480	18870
	Average	13	43	56	14	38	5	339	280	11593
Cumulative average		11	35	46	11	29	7	333	215	9656

* Pigeon was not reared. Date of pigeon distribution: 14 September 2022. Price (Tk./piece): Pigeon (>300 g wt.) = 300, Squab =165

Expt. 6.3.3. Goat rearing in homestead area

Introduction

Goat rearing in homestead areas is a practical and beneficial practice for many farming households. Goats are hardy animals that require relatively low maintenance and can thrive in various environments. They provide a valuable source of milk, meat, and fiber, contributing to the nutritional needs of the household. Additionally, goat manure is an excellent organic fertilizer, enhancing soil fertility and crop yields. This practice not only supports food security but also offers an additional income stream for farmers through the sale of milk, meat, and other goat products. The integration of goat rearing into homestead areas exemplifies sustainable agricultural practices that can improve the livelihoods of rural communities.

Objectives

i) To boost the income of farm families
ii) To promote goat rearing as a means of income generation
iii) To empower rural women

Methodology

One Black Bengal doeling was distributed to each of 9 interested farmers out of the 10 selected farmers at Kaliganj, Gazipur. Technical supports (feeding, de-worming, vaccination etc.) and advice were also given regularly. Treatments were also provided as per necessity.

Results and Discussion

Productivity, utilization scenario and economic return of goat rearing under integrated livestock production system is presented in Table 107. All the goats gave birth to kids. On average, in each household, 3 kids were generated per doe (3 kids/doe for marginal farmers and 4 kids/doe for small farmers). From the 9 households, an average gross margin of Tk. 14062 (Tk. 11641 for 5 marginal farmers and Tk. 17087 for 4 small farmers) was obtained. Among the 9 households, the highest gross margin was produced from Household-7 (Tk. 35030), followed by Household-1 (Tk. 17134).

Table 107. Productivity, utilization scenario and economic return of goat rearing under integrated livestock production system, Kaliganj, Gazipur, 2022-25

Farmers category	Household pattern	Goat and kid production (No.)			Sold goat and kid (No.)	Remaining goat and kid (No.)	TVC (Tk./ household)	GM (Tk./ household)
		Distributed doeling	Kid production	Total				
Marginal	1	1	3	4	2	2	866	17134
	2	1	1	2	2	-	944	8056
	3*	-	-	-	-	-	-	-
	4	1	2	3	2	1	995	12505
	5	1	2	3	1	2	993	12507
	6	1	1	2	2	-	997	8003
	Average	1	2	3	1	1	999	11641
Small	7	1	7	8	6	2	970	35030
	8	1	1	2	2	-	910	8090
	9	1	2	3	3	-	991	12509
	10	1	2	3	2	1	780	12720
	Average	1	3	4	3	1	955	17087
Cumulative average		1	3	3	2	1	977	14062

* Goat was not reared. Date of doelings distribution: 27 September 2022; Price (Tk./goat): 4500

Expt. 6.3.4. Vaccination program for livestock and poultry birds

Introduction

Vaccines are expected to reduce the severity of disease in infected animals and/or limit the frequency of disease. Vaccines can prevent a wide range of diseases that cause lower production and fertility or death in cattle, goat and chicken resulting in economic losses to the farmers.

Objective: To reduce the severity of diseases in infected animals or limit the frequency of diseases

Materials and Methods

The vaccination activity was conducted at the FSRD site Muktarpur, Kaliganj, Gazipur. Vaccination by Khuravax, PPR, FMD for cattle, goat and Ranikhet, DPV and Fowl pox for chicken, duck and pigeon were provided. About sixty cattle, one hundred goats, four hundred chickens, one hundred ducks and about two hundred pigeons were vaccinated at FSRD site.

Results

It was found that before vaccination, frequency of different diseases was higher. The disease severity was significantly reduced, and farmers were interested to continue vaccination of livestock and poultry birds (Table 108). If the vaccination service is locally available, farmers will continue vaccination of cattle, goat, chicken, duck and pigeon to reduce mortality.

Table 108. Mortality (%) of livestock and poultry birds before and after vaccination against major diseases, Kaliganj, Gazipur, 2022-25

Animal category	Animal	Name of the disease	Number vaccinated	Percentage of mortality (%)	
				Before vaccination	After vaccination
Livestock	Cattle	Foot and Mouth Disease	60	08-12	00
	Goat	Foot and Mouth Disease	100	9-15	02-03
Poultry bird	Chicken	Ranikhet, Fowl pox	400	35-38	08-10
	Duck	Ranikhet, Fowl pox	100	17-20	03-06
	Pigeon	Ranikhet, Fowl pox	200	15-20	05-07

6.4. Aquaculture System

MAU Razu, T Araf, MK Quais and M Ibrahim

Expt. 6.4.1. Integrated fish and Vegetable production under aquaculture system in Madhupur tract

Introduction

Bangladesh, a country with thousands of rivers and ponds, is notable for being a fish-loving nation. Carp species are the most important fish species in Bangladesh, where more than 80 percent of aquaculture production is from inland ponds. The most farmed carp species are Bighead carp, Rohu, Mrigel, Tilapia, and Sorputi etc. These fish are commonly grown together (known as polyculture), and these multispecies systems are highly productive. These fishes are of great favorite to consumers because of their delicious taste and therefore they have a great demand and fetch high price in the market. About 90% of the 14 million homesteads in Bangladesh have an average area of 810 square meters area. In many of these homestead areas there is a pond whereby establishing a mixed farming system in the pond, a marginal or poor family can grow enough vegetables and fish together. Therefore, aroid can be grown with the fish in a mini pond throughout the year which will meet the family nutritional requirements as well as income generation. Therefore, the present study was undertaken with the following objectives.

Objectives

i) To increase the productivity and farm income under aquaculture system

ii) To maximize the productivity of existing system

Materials and Methods

The program was conducted at the FSRD site, Muktarpur, Kaliganj, Gazipur during 2024-25 to increase productivity of the existing ponds and to increase farm income. Initially, one farmer's pond among the 10 cooperative farmers was selected for the mixed fish cultivation. The size of the pond was about 30 decimals. Before releasing fingerlings, unwanted fish species were removed using rotenone 50 g/dec. About seven days after using rotenone pond was aimed at the rate of 1 kg per decimal. After that, the pond was fertilized with decomposed cowdung, urea and TSP at the rate of 500 g, 150 g and 100 g per decimal, respectively. Three species of fish namely, Tilapia, Thai puti and Mirror Carp were stocked to the farmers' pond after seven days of fertilization. The stocking density of different species was maintained according to Table 109. After three months of fingerling release, aroid (BARI Panikachu-3) was planted accordingly. Recommended management practices were followed for fish and aroid. Growth performance, production and economic return were recorded.

Results and Discussion

The maximum weight of 315 g and maximum length of 30 cm were gained by Mirror Carp (Table 109). Among the 3 fish species, the average initial weight and size of fingerling at release was 17 g and 12 cm, respectively. The average final weight and size of fingerling at harvest was 289 g and 27 cm, respectively. The average weight and length of aroid at harvest were 3.15 kg and 2.13 m, respectively.

Table 109. List of components of integrated fish and Vegetable production under aquaculture system, Kaliganj, Gazipur, 2024-25

Component	Fish/ Vegetable	Stocking density (Fingerlings/dec.)	Average weight (g)		Average length (cm)	
			At release	At harvest	At release	At harvest
Fish	Tilapia	24	19	255	11	25
	Thai puti	15	22	296	12	27
	Mirror Carp	7	11	315	13	30
	Average	15	17	289	12	27
Vegetable	Aroid			3146		213

Date of fish release=16 March 2024, Last date of fish harvest=14 March 2025, Planting date of aroid=15 February 2024, Last date of aroid harvest=17 October 2024

Overall productivity, utilization scenario and economic return of vegetable (aroid) and fish (mixed carp) per 10 decimals of mini pond under aquaculture system is presented in Table 110. A total of 1498 kg of output was obtained from the 10 decimal pond, with aroid and fish. Aroid and fish contributed 94% and 6% to the total gross margin of Tk. 37594 and aroid is much more profitable as it produces 15 times higher gross margin than that of fish.

Table 110. Overall average productivity, utilization scenario and economic return of aquaculture system, Kaliganj, Gazipur, 2024-25

Component	Fish/ Vegetable		Production (kg/10 dec.)	Utilization (kg/10 dec.)		TVC (Tk./10 dec.)	GM (Tk./10 dec.)
				Consumption	Sale		
Fish	Tilapia		24	5	19		
	Thai puti		11	3	8		
	Mirror Carp		13	1	12		
	Total		48	21	51	4355	2365
Vegetable	Aroid	Corm	1418	9	1409		
		Stolon	32	6	26		
		Total	1450	15	1435	8751	35229
Cumulative total			1498	36	1486	13106	37594

Price (Tk./kg): Tilapia=130, Thai puti=150, Mirror Carp=150, Corm of aroid=30, Stolon of aroid=45

Overall scenario of household components under integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25

Energy generation scenario

The overall energy generation scenario of farm households practicing integrated homestead farming is illustrated in Figure 32. The system includes year-round cultivation of vegetables and spices on about 10 decimals of homestead land, along with aquaculture and rearing of livestock. The total energy generation was 6071 MJ/year/household. The Aroid+Fish component was the dominant contributor (supply 70% of total energy), highlighting its key role in energy productivity from limited homestead resources. Livestock and poultry contributed 16%, ranking as the second-largest energy source. Vegetables accounted for 9% of annual energy generation, while spices account for 5%, serving a minor yet notable role in energy contribution.

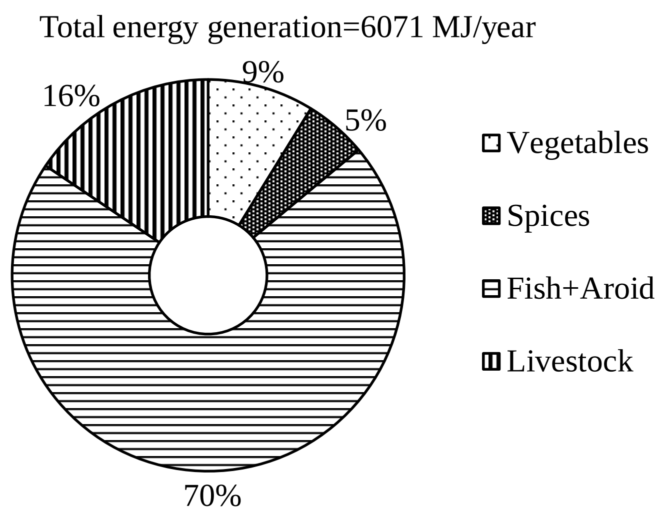


Figure 32. Component-wise energy generated from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25

Figure 33 illustrates the change in annual energy generation from integrated farming systems between 2021-22 and 2024-25. Prior to the intervention, total energy generation was only 340 MJ/year/household, indicating limited productivity from different farming practices. After the introduction of integrated farming interventions, annual energy generation increased sharply to 6071 MJ/year/household during 2024-25. This represents an approximately 17-fold increase in energy output compared to the pre-intervention period. The substantial improvement clearly demonstrates the effectiveness of integrated farming systems in enhancing overall household energy generation. It also reflects better resource use efficiency, diversification of enterprises and improved system productivity.

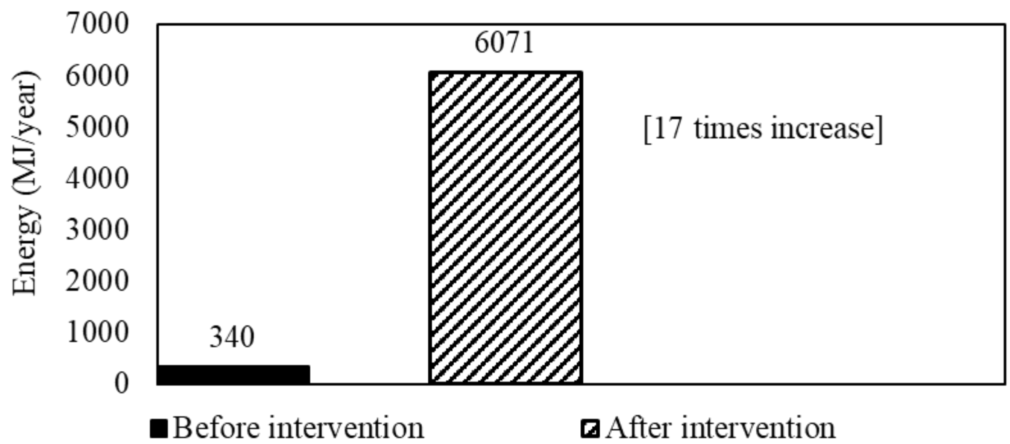


Figure 33. Change in energy generated from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2021-22 to 2024-25

Energy fulfillment scenario

Energy fulfillment by consuming household components produced from integrated farming systems during the period 2021-22 and 2024-25 is presented in Figure 34. Before intervention only 0.13% of the daily per-capita requirement was met from homestead-based production. After intervention the proportion fulfilled increased to 4.63% of the requirement. Although this share appears relatively small, it should be interpreted in context, as rice- the primary source of dietary energy-was not included in the analysis. The observed improvement nonetheless reflects a meaningful enhancement in household-level energy availability from non-rice sources such as fish, vegetables, spices and livestock products. This indicates that integrated farming systems contribute positively to dietary diversification and nutritional energy support.

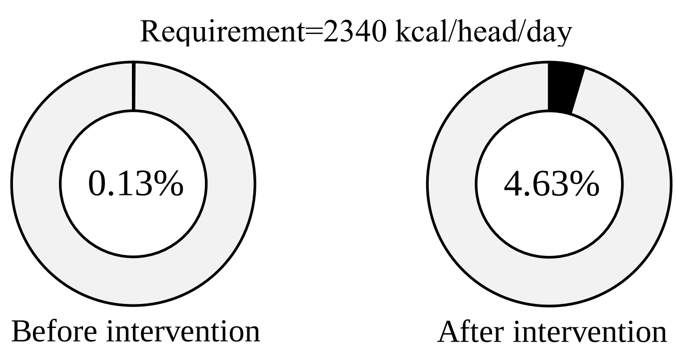


Figure 34. Energy fulfillment by consuming household components produced from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2021-22 to 2024-25

Macronutrient generation scenario

Contribution in total micronutrient generated from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25 is presented in Figure 35 and 36. It was observed that, total macronutrient supply for 2024-25 was 300 kg/year per household, with carbohydrates contributing the largest share (76%), followed by protein (19%) and unsaturated fats (5%). Aroid+Fish emerged as the predominant source of carbohydrates, providing the overwhelming majority (88%), while livestock dominated protein and unsaturated fat production (53% each). Other components (vegetables and spices) played relatively minor, yet still important roles, especially in protein and unsaturated fat supply.

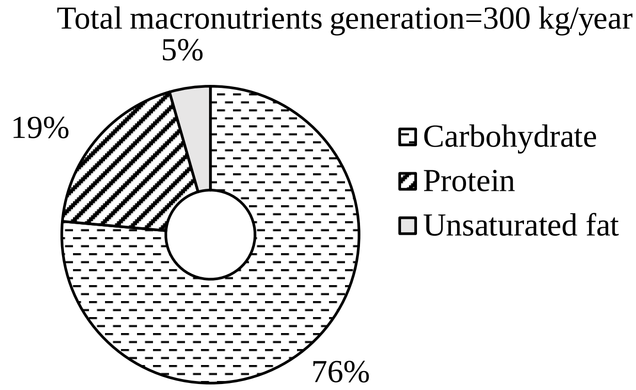


Figure 35. Contribution in total macronutrient generated from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25

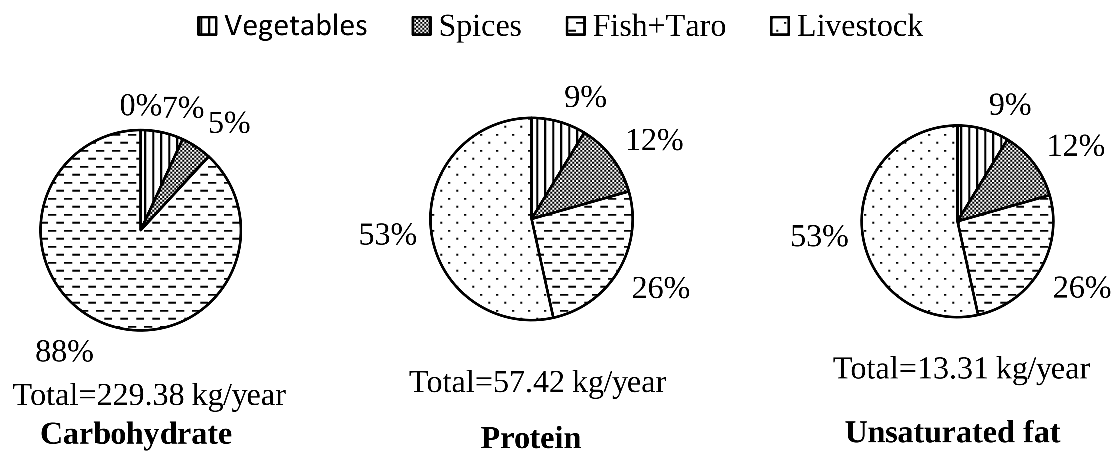


Figure 36. Contribution of components in macronutrient generated from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25

Macronutrient fulfillment scenario

Macronutrient fulfillment by consuming household components produced from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2021-22 to 2024-25 is presented in Figure 37. The results highlight substantial improvements in daily macronutrient intake per person following intervention. Protein intake increased from 6% to 14% of recommended levels, representing the most significant relative gain among macronutrients. The fulfillment rates not up to the mark may be due to persistent gaps in dietary quantity. Carbohydrate and fat showed increases, but both fulfillment rates remained below 5%. The low contribution to carbohydrate intake is mainly attributable to the exclusion of rice, the principal staple food, from the analysis. These results support the need for continued efforts to boost household access to nutrient-rich foods and address dietary deficiencies.

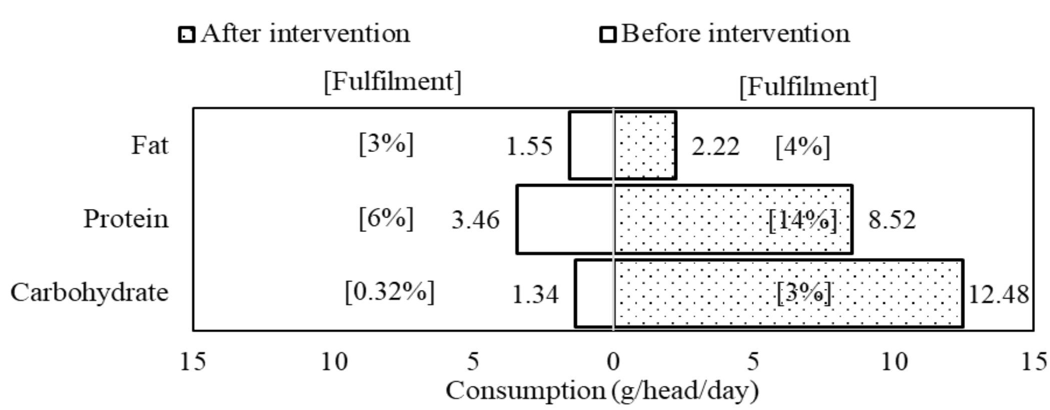


Figure 37. Macronutrient fulfillment by consuming household components produced from integrated farming systems at FSRD site, Kaliganj, Gazipur, 2021-22 to 2024-25

Contribution of household components to annual profit

Overall scenario of contribution of household components to annual profit obtained from 10 decimals of homestead area at FSRD site, Kaliganj, Gazipur during 2024-25 is presented in Figure 38. It was observed that livestock contributes the largest share, accounting for 41% of the annual profit of Tk. 1,04,979/household. This highlights the economic importance of livestock activities in household income generation. Aroid+Fish combination is the second most significant contributor at 36%. Vegetables account for 14% of the annual profit, underlining their supportive but less dominant role in household earnings. Spices constitute 9% of the profit, the smallest share among the components considered, though still a meaningful contributor. These results demonstrate that livestock and aquaculture are the dominant economic activities contributing to household profitability in the studied year. Vegetables and spices, while important for diversification and food security, play relatively smaller roles in direct profit generation. Such findings emphasize the need to strengthen livestock and aquaculture interventions to improve household incomes, while continued support for vegetable and spice production can provide supplemental benefits.

Total annual profit (GM)=Tk. 1,04,979/household

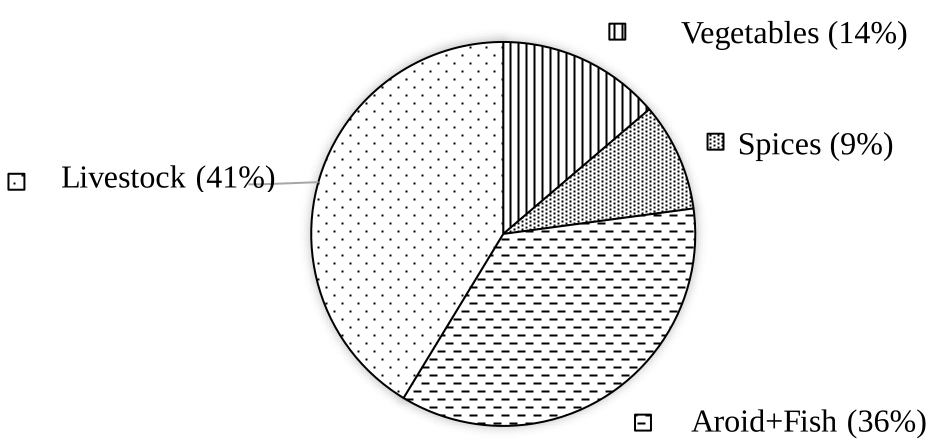


Figure 38. Contribution of household components to annual profit of integrated farming systems at FSRD site, Kaliganj, Gazipur, 2024-25