ANNUAL RESEARCH REVIEW WORKSHOP
2023-24

XII. RICE FARMING SYSTEMS DIVISION

Bangladesh Rice Research Institute
Gazipur-1701

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Summary

Transferable technology

Mustard (BARI Sarisha-14)-Boro (BRRI dhan88)-T. Jute (JRO 524)-T. Aman (BRRI dhan75)

Farmers' practice: Boro (BRRI dhan28)-Jute (JRO 524)-T. Aman (BRRI dhan49)

Salient features

i) Total field duration of this developed four-cropped cropping pattern is about 340 days.

ii) Jute seedlings were transplanted to include mustard in the developed four-cropped cropping pattern.

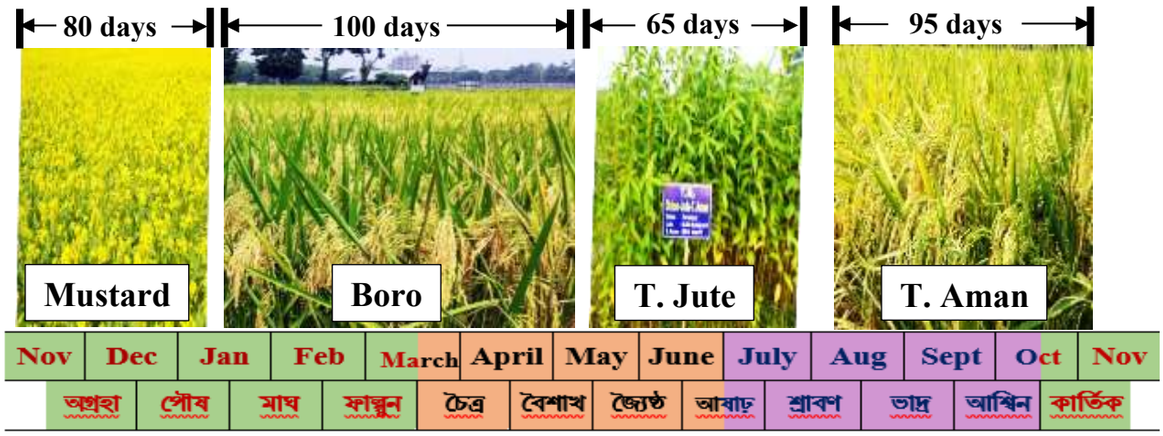
iii) About 20-25 days were saved in the developed cropping pattern for transplanting of jute seedling.

iv) This improved cropping pattern producing Marginal Benefit Cost Ratio (MBCR) of 1.93 can earn 68% more profit than the existing three-cropped cropping pattern (gross margin: Tk. 1,05,000).

v) Transplanted jute of this developed cropping pattern produces about 16% more fiber than the conventional broadcasting method.

vi) This developed cropping pattern will increase crop diversity, intensity and productivity as well.

vii) This developed four-cropped cropping pattern will improve soil health and environment due to jute cultivation and having a great scope of producing oilcake and honey in addition to oil from mustard.



Economic benefit of the technology

The overall rice equivalent yield of this developed four-cropped cropping pattern is 25.60 tons per hectare which is about 27% higher than the existing three-cropped cropping pattern.

Cropping pattern	Yield (t/ha)				REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Mustard	Boro	Jute	T. Aman				
Mustard-Boro-T. Jute-T. Aman	1.51	6.23	3.23	5.86	25.60	495	176	1.93
Boro-Jute-T. Aman (Ck)	-	6.00	2.86	5.34	20.09	419	105	-

Price (Tk/Kg): Mustard=60, Jute fiber=60, Jute stick=8, Rice=26

Extrapolation domain: This cropping pattern is quite suitable in the irrigated high land to medium highland of the central north, central and southwestern regions of Bangladesh, particularly in areas with silty loam soil; where jute is cultivated between Boro and T. Aman (40,440 ha; 19 Districts, 56 Upazilas). It is to be noted that the implementation of this improved cropping pattern will be easier if the farmer has keen interest, readily available irrigation facility and other inputs (labor, seed, fertilizer, farm machinery etc.) (Figure 1).

Fig. 1. Red marked districts indicate the extrapolation domain of Mustard-Boro-T. Jute-T. Aman cropping pattern across the country

Risk management: Success of this new technology (Mustard-Boro-T. Jute-T. Aman) depends on managing the following risk factors.

Risk factor	Management
Timely transplanting of Aman rice	• Available irrigation facility
Timely transplanting of jute	• Using short duration high yielding Boro rice variety (Growth duration ≤ 145 days) to make space for jute • Available irrigation facility
Yield reduction due to late transplanting of Boro rice	• Using short duration high yielding Mustard variety (Growth duration ≤ 80 days) • Mustard sowing in time (within 1st week of November)
Land inundation	• Using the CP in high land to medium highland phase-I
Timely land preparation	• Available farm machinery specially power tiller

Upcoming technology

Evaluation of pair row potato/pair row maize technique under Maize-Fallow-T. Aman cropping pattern in Northern part of Bangladesh

The trial was conducted at farmer's fields of Dhokrakul, Puthia, Rajshahi during 2020-23 to increase the profitability and diversity of the existing cropping pattern. The cropping patterns were:

ICP: Pair row Potato/pair row Maize-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan75)
ECP: Maize-Mungbean-T. Aman (BRRI dhan75) (Check)

The adjusted three-year pooled data revealed that the REY of the pair-row potato/pair-row maize–T. Aus–T. Aman cropping pattern was 68% higher than the existing cropping pattern. Although maize yield was slightly lower compared to the control pattern, the contributions of potato and T. Aus rice significantly boosted overall productivity of the improved cropping pattern.

Table 1. Individual yield and Rice Equivalent Yields (REY) (adjusted 3-year pooled mean) of component crops under different cropping systems, Puthia, Rajshahi, 2020-2023

Cropping pattern	**REY of components crops (t/ha)**					**REY (t/ha)**
	T. Aman	**Potato**	**Maize**	**Mungbean**	**T. Aus**	
Pair row potato/pair row maize-T. Aus-T. Aman	5.52	24.59	9.44	-	4.87	31.14a
Maize-Mungbean-T. Aman	5.58	-	10.99	1.10	-	18.53b

Price (Tk/Kg): Potato=13, Maize=24, Mungbean=73, Rice=26

The total variable cost of the improved cropping pattern was 97% higher than that of the existing pattern. However, the improved pattern resulted in 50% higher gross margin with an MBCR of 1.62 (Table 2).

Table 2. Cost and return (adjusted 3-year pooled mean) of tested cropping pattern, Puthia, Rajshahi, 2020-2023

Cropping pattern	**TVC ('000 Tk/ha)**	**GM ('000 Tk/ha)**	**MBCR**
Pair row potato/pair row maize-T. Aus-T. Aman	440760	403159	1.62
Maize-Mungbean-T. Aman	223830	268683	

Useful scientific information

- Field survey on charland agriculture executed in Char Gadai, Kawnia, Rangpur; Maijbari, Kazipur, Sirajganj and Urirchar, Sandip, Chattogram. Twenty-five farmers were randomly selected in each site for detail interview. Surveys were conducted with structured questionnaire through focus group discussion. Integrated rice and fish in gher system and introduction of grasspea in southern char might be an option. Replacement of local rice varieties by HYV and introduction of other high yielding crop variety can boost up the overall productivity.
- An experiment was conducted with seven different cropping patterns at BRRI, Gazipur to find out the profitable four-cropped cropping pattern in irrigated medium high land ecosystem. Potato (BARI Alu-25)- Relay pumpkin (BARI Hybrid Mistikumra-2) - T. Aus (BBRI dhan48) - T. Aman (BBRI dhan90) resulted in a remarkable REY of 35.92 t/ha, generating a gross margin of Tk. 5,36,000 per ha with an MBCR 3.72.
- An experiment was conducted with eight different cropping patterns at BRRI, Gazipur to find out the profitable three-cropped cropping pattern in irrigated medium high land ecosystem. Onion (BARI Piaz-4)-Jute (BJRI Tosha Pat-8)-T. Aman (BRRI hybrid dhan6) cropping pattern resulted 50.52 t/ha REY with a gross margin of Tk. 9,99,300/ha which representing an increase of 332% and 474% compared to the REY and gross margin of the control pattern, respectively. Considering rice productivity, Boro-T. Aus-T. Aman performed well among the tested cropping patterns having minimum two rices.
- An experiment was conducted at BRRI, Gazipur to find out the suitable rice varieties in different planting windows under Mustard-Boro-T. Aman cropping pattern. BARI Sarisha-14 performed well when sown between 01-15 November. In Boro season, BRRI dhan89 turned out higher grain yield when transplanted from 10 January to 09 February and BRRI dhan98 was found suitable from 15 February to 01 March when transplanted after mustard. In T. Aman season, BRRI dhan71 and BRRI dhan87 performed well at all planting dates. Considering the cropping pattern, the recommended planting windows for T. Aman, Mustard and Boro rice were identified as 22 July-2 August, 01-06 November and 27 January-01 February, respectively.
- An experiment was conducted at BRRI, Gazipur to find out the suitable fertilizer management option for Boro rice under Potato-Boro-T. Aman cropping pattern. There was no notable difference in grain yield of BRRI dhan74 and BRRI dhan98 between the BRRI recommended dose and the pattern-based dose. Regarding nitrogen application timing, applying a portion of the nitrogen (25%-33%) as a basal treatment significantly improved the grain yield compared to the recommended practice.
- An experiment was conducted at BRRI, Gazipur to evaluate the yield performance of aged seedlings of T. Aman rice (BRRI dhan71) under different nitrogen fertilizer and crop management techniques. Regarding N fertilizer doses, increasing the amount of nitrogen did not significantly enhance grain yield. In terms of seedling age, older seedlings yielded better than younger seedlings. For the laddering technique, significant yield improvements were observed when 30-day-old seedlings were laddered 14 days after transplanting. However, this technique did not improve yield when applied to 40-day-old seedlings.

- Newly released Boro and T. Aman rice were evaluated in different combinations in Boro-Fallow-T. Aman cropping pattern at BRRI, Gazipur. Results showed that a combination of BRRI dhan92 & BRRI dhan102 with BRRI dhan103 showed a higher gross margin of 2,36,880 to 2,49,109 Tk/ha with MBCR of 14.09 to 18.80.
- An experiment was conducted in two locations (Nilphamari and Rangpur) to find out the suitable varieties and establishment method under potato-rice-rice cropping systems. In the Boro season, transplanted rice performed better than the direct-seeded rice in most cases, while in Aman season, the establishment methods showed no significant difference in grain yield. Among the tested varieties, BRRI dhan98 in Boro and BRRI dhan75 in Aman season gave higher grain yield in both sites.
- A study was conducted in the Nilphamari district to intensify the Rice-Rice cropping pattern through the introduction of Mustard (BARI Sarisha-14) and Field pea (BARI Motor-1) in between the Boro and Aman seasons. Field pea performed better than Mustard as a transitional crop and cropping pattern with Field pea showed 118-130% higher REY than the existing two rice cropping system.
- 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 dhan67-Fallow-BRRI dhan87 turned out the highest grain yield (10.29 t/ha) among the tested sequences. This varietal combination resulted in a gross margin of Tk 83,000/ha with a MBCR of 1.57.
- An experiment was conducted at Dacope, Khulna to maximize the productivity of Watermelon-Fallow-T. Aman cropping pattern through inclusion of Aus rice. Inclusion of Aus rice (BRRI dhan98) and replacement of local T. Aman rice with BRRI dhan87 significantly increased the productivity (30% higher REY) of the existing cropping pattern (33.40 t/ha). The improved cropping pattern resulted in a gross margin of Tk 7,93,300/ ha, with a MBCR of 3.72.
- The study was conducted involving fifteen trials in Nabiganj upazilla of Habiganj district. Fallow-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan87) gave the highest grain yield of 11.09 t/ha with maximum gross margin (1,87,165 Tk/ha), from the cost and return analysis MBCR 2.01 was recorded. The existing farmer's pattern Fallow-Fallow-T. Aman (BRRI dhan49) gave the lowest grain yield (4.67 t/ha) with the lowest gross margin (72,483 Tk/ha).
- An experiment was conducted at BRRI, Gazipur to explore best adaptation practices in water logged wetland ecosystem. The highest gross margin (Tk 3284/dec) obtained from Coriander leaf-Stem amaranth grown on the dyke under dragon and mango fruit tree. Whereas, Bottle gourd-Ash gourd on trellis generated the highest gross margins of Tk 1477 per decimal. The Guava, Jujube, and Mango trees produced 4.03, 2.14 and 3.48 kg of fruit per tree, respectively.
- The activity was conducted at BRRI, Gazipur to increase the productivity of waterlogged wet land through three-tiar production system. On an average 3193 Tk/decimal gross margin was earned by growing vegetables in the dyke. From rice-fish farming, BRRI dhan89-Fallow- BR22 gave the highest grain yield (11.69 t/ha) with the maximum gross margin (2,14,174 Tk/ha) and a total 20.41 kg fish were harvested with gross margin 920 Tk/decimal.
- A total of 50 trials in fringe land were conducted in Rangamati district to find out the suitable Boro rice varieties. Among the tested varieties, BRRI dhan92 gave significantly higher yield (6.4-

7.9 t/ha) in Borkol, Longodu, and Naniarchor; whereas, BRRI dhan74 performed better (8.3 t/ha) in Baghaichhori upazilla of Rangamati district.

- A total of 30 trials in Jhum cultivation system were conducted in seven upzillas of Bandarban, Rangamati and Khagrachhari districts under Chittagong Hill Tracts. The highest grain yield obtained from BRRI dhan83 (3.73-4.01 t/ha) in the Jhum system.
- Field trials were carried out in Dhanbari, Tangail; and Nandail, Mymensingh to intensify Boro-Fallow-T. Aman cropping pattern by inclusion of mustard. In both sites, Mustard-Boro-T. Aman cropping pattern increased the productivity (23%-66% higher REY) and gross margin (49%-54% higher) of the existing cropping system.
- A trial was conducted at Nandail upazila of Mymensingh district to intensify the Boro-Fallow-T. Aman with Aus rice. The highest grain yield (23.02 t/ha) was obtained from BRRI dhan92-BRRI dhan98-BRRI dhan87 which was 76.80% higher than the existing two-rice system. The inclusion of Aus rice and replacement of existing Boro and T. Aman varieties generated a MBCR of 3.00.
- 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. Farmers' participatory quality seed production activities ensured the use of quality seed in Boro and T. Aman season. 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. Characterization of Charland Agriculture

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Introduction

The total area of Bangladesh is 14.8 million hectares; 6.7% of which consist of rivers and inland water bodies (Ahmed *et al*, 2001). It is one of the most disaster-prone countries in the world. Various natural calamities are general phenomena here. Flood is the most frequent and considered to be the main hazard. Major rivers flowing in the country are in old stage. Heavy rainfall in the monsoon, resulting the higher volume of water flow than the capacities of the rivers, makes a flood (Benson and Clay, 2002).

"Charland'' or riverine islands are areas of new land formed through the continual process of erosion and deposition in the major rivers and coastal areas. In general, the riverine island is unstable and prone to annual flooding (Kabir, 2006). The char dwellers are some of the poorest and most vulnerable people particularly those who live on the island/attached river chars. An estimated 5 to 10 million char dwellers live mostly on agriculture (Ashley *et al*., 2000). The soils are typically deficient of most of the plant nutrients, having very low organic matter contents and minimum moisture holding capacity (SRDI, 2013). For the improvement in livelihood of char dwellers, it is essential to gather in-depth information on existing life style, their resource level and prevailing farming systems. The present study was, therefore, conducted to collect the information on diversity of crops and cropping, and the agricultural problems existing in charland, with the aim to support for making plan for future agricultural development of the larger charland areas.

Objective

To characterize and generate insights into the farming systems of Charlands in Rangpur, Sirajganj, and Chattogram regions, identifying challenges and prospects to explore opportunities for improvement

Methodology

This is a field study which has been made on the basis of a survey during the year 2024. A well-designed pre-tested semi-structured questionnaire was used for data collection. The target population of the study was char dwellers of three different regions of Bangladesh. Three locations were (i) Char Gadai in Kaunia upazila under Rangpur district; (ii) Maizbari in Kazipur upazila under Sirajganj district; and (iii) Urirchar in Sandwip upazila under Chittagong district. These areas are representing accordingly three agroecological zones of Bangladesh viz. Tista Meander Floodplain (AEZ#3), Active Brahmaputra Jamuna Floodplain (AEZ#7) and Chittagong Coastal Plain (AEZ#23). The sample size was 25 farmers consisting male and female in each spot. The samples were selected to satisfy all the objectives of the study that covers all necessary information to examine. So, the grand total number of responding farmers was 75. Both qualitative as well as quantitative methods have been used to carry out this study. In this study, mainly primary data were collected. A few data on geographical location and demographic features were collected through secondary sources available in upazila council.

Collected data were sorted, and summarized for the purpose of tabulation using the Microsoft Excel-2020. General descriptive statistics were used for interpretation and conclusion.

Results and Discussion

Geography and demography

Among the three charlands under the present study, Urirchar is the oldest one in respect of cultivation and settlement of human society (Table 1). Char Gadai and Maizbari are affected by flood every year, where Maizbari is affected several times per year. There is no flood situation in Urirchar, however, it is regularly and sometimes extremely affected by tide. In all locations, lion share of the whole population is absolutely dependent on agriculture for their livelihood.

Table 1. Characteristics of land and human population

Location	Char Gadai, Kaunia, Rangpur	Maizbari, Kazipur, Sirajganj	Urirchar, Sandwip, Chittagong
Land connectivity	Connected with mainland	Separated Island	Separated Island
Time of starting Agric. activity	1990	1990	1970
Starting of human settlement	1995	2000	1982
Flooding depth	4 feet	10 feet	No flood
Population	1,250	1,200	40,000
Profession (%)			
Agriculture	70.0	90.0	93.0
Day labour	17.0	5.0	3.0
Fisherman	3.0	0.0	0.5
Service-holder	9.0	3.0	2.5
Business	1.0	2.0	1.0

Socio-economic background of charland farmers

The socio-economic characteristics and background of a farming community influence their production to a great extent (Hassan *et al*., 2001). In order to get a vivid picture on socio-economic status of char dwelling farmers, this paper includes age, education level, family size, main occupation status, types of farmers based on farm size, farming experience, and status of using communication devices.

Age. The socio–economic characteristics of the respondent farmers surveyed on the selected charland in the study area are in Table 2. The results revealed that among 75 respondents, age of the major (29%) farmers was above 55 years. Twenty-four percent of the respondent farmers were in the age group of 36-45 years. Young generation up to 25 years constituted only 8% of farmers. It therefore indicated that a normal trend is prevalent here. Neither an attraction nor a negative attitude is extremely touching a special age group.

Family size. It is observed from Table 2 that, majority (51%) of respondents have medium family size (4-6 members) followed by 32% of Charland farmers having small family (1-3 members) and the rest 17% family belongs to large family (more than 6 members).

Educational status. Illiteracy is prevalent phenomenon in the farmers charland. Among the respondents, the maximum farmers (73%) are from illiterate and primary education group. Twenty percent farmers had been having secondary education (Table 2). Only 7% farmers got the Higher secondary education level.

Communication efficiency. Charland areas are generally considered as a backward community. However, majority of the charland farmers were found skill in social communication. About 95% of them are habituated to use cell phone for smart communication

in family affairs and market situation (Table 2). Only 5% of the community had no cell phone at all.

Main occupation status. On the issue of main occupation status, only farming is the absolute source of livelihood for the majority (81%) of respondents in the study area. It is also observed that 12% of the charland farmers have an alternative occupation of business. Four percent of the charland dwellers are skilled in some technical know-how like driving, cell phone repairing etc. and only 2% were found as service holders (Table 2).

Types of farmers. In the study area as shown in Table 2, Majority of charland farmers (52%) were from small land size group (farm size 51-250 decimals). The second largest group (21%) came from medium farmers. Landless (0-5 decimals) and marginal farmers (6-50 decimals) are also the significant contributors (19%) in charland farming community. Only 8% of them are large farmers (farm size >500 decimals).

Table 2. Socio-economic characteristics of respondent Charland farmers (N = 75)

Characteristics	Frequency	Percent
Age Level		
Up to 25 years	6	8.00
26-35 years	16	21.33
36-45 years	18	24.00
46-55 years	13	17.33
Above 55 years	22	29.33
Family size distribution		
Small (1-3 members)	24	32.00
Medium (4-6 members)	38	50.67
Large (above 6 members)	13	17.33
Educational Status		
Illiterate	28	37.33
Primary	27	36.00
Secondary	15	20.00
Higher Secondary and above	5	6.67
Usage of cell phone		
Smart phone user	34	45.33
Traditional phone user	37	49.33
Non-user	4	5.33
Occupational status		
Absolute farmer	61	81.33
Business (additional occupation)	9	12.00
Technical (additional occupation)	3	4.00
Service (additional occupation)	2	2.67
Type of farmer (based on farm size)		
Landless (0-5 decimal)	6	8.00
Marginal (6-50 decimal)	8	10.66
Small (51-250 decimal)	39	52.00
Medium (251-500 decimal)	16	21.33
Large (>500 decimal)	6	8.00

Land ownership, tenancy and crop sharing tradition

In all three charlands, lion share of the cropped area is cultivated by the owners themselves (Table 3). The second dominant system in Maizbari and Urirchar is the share cropping system. In this second tradition, there two practices are prevailing. In the first one, all crop production costs are paid by share-cropper, hence, the land owner would get one-third and the two-thirds of production would be for share-cropper. In the second option, input cost (viz. fertilizer, pesticide etc.) for crop production is mutually paid by the both parties, hence, production benefits are equally distributed. Among the tenure systems, mortgage system is the worst one for the land-owner which is scarcely available in Char Gadai only. In this case, one lac taka is paid for one acre land. The cropper would use the land for unlimited time. If and when the land

owner pay-back the whole amount of money to the cropper, the land owner could get back his land.

Table 3. Distribution of crop land (%) under different ownership and rental system

Location	Char Gadai, Kaunia, Rangpur	Maizbari, Kazipur, Sirajganj	Urirchar, Sandwip, Chittagong
Land under own cultivation	80.56	64.87	59.15
Land under share cropping	2.94	26.09	37.31
Land under rental system	12.34	9.04	3.54
Land under mortgage	4.16	0.00	0.00
Average rental (Tk/acre)	18,225	16,850	10,000
Av. Mortgage rate (Tk/acre)	1,00,000	Not Applicable	Not Applicable

Crop production and cropping systems

The highest number of cropping patterns has been identified as 15 in Char Gadai under Kaunia upazila of Rangpur district (Table 4). This number of cropping patterns was 12 for Maizbari and 6 for Urirchar. The same trend was found for crop diversity index and also for cropping intensity. Of all the three locations, Char Gadai is the safest one in respect of flood and other natural calamities. The light textured soil as well as its ground water availability encouraged the farmers for Boro rice production. The Maizbari char is frequently affected by flood and enough siltation is occurred. The fertile soil is quietly suitable for an exhaustive crop like maize. Moreover, the market high price of the crop pushed the community for practicing maize-based cropping patterns. In Urirchar, single T. Aman is the dominant cropping pattern. There is no flood here, however, frequent, usual and also unusual tide is occurred. Scarcity of fresh ground water is extreme. Year-round vegetables are grown only in homestead area. Boro rice is cultivated in some pocket area. Irrigation is done possible through LLP from nearly situated canal or ditches. In fact, two or three irrigations are usually needed. Moreover, in some cases, stagnant water is pumped out from the Boro rice field.

Table 4. Comparison among three charlands for existing cropping patterns (%), diversity and intensity

Location	Char Gadai, Kaunia, Rangpur		Maizbari, Kazipur, Sirajganj		Urirchar, Sandwip, Chittagong	
Pattern 1	Boro−Fallow−T.Aman	=22	Maize−Jute−Fallow	=16	Fallow−Fallow−T.Aman	=71
Pattern 2	Maize−Fallow−T.Aman	=18	Mustard−Boro−Fallow	=12	Grasspea−F−T.Aman	=11
Pattern 3	Chilli−G.nut−T.Aman	=10	Maize−Fallow−Fallow	=11	Vegetab−Vegetab	=8
Pattern 4	Chilli−Fallow−T.Aman	=8	Chilli−Jute−Fallow	=11	Gher system	=4
Pattern 5	Potato−G.nut−Fallow	=6	Boro−Fallow−Fallow	=10	Boro−Fallow−Fallow	=3
Pattern 6	Maize−Jute−T.Aman	=6	Maize−Fallow−T.Aman	=10	Boro−Fallow−T.Aman	=3
Pattern 7	Maize−Jute−Fallow	=5	Boro−Fallow−T.Aman	=9		—
Pattern 8	Chilli−Jute−T.Aman	=5	Wheat−Fallow−Fallow	=7		—
Pattern 9	Potato−G.nut−T.Aman	=4	Maize−Jute−T.Aman	=6		—
Pattern 10	Potato−G.nut−T.Aman	=4	Wheat−Jute−T.Aman	=2		—
Pattern 11	Onion−Jute−Fallow	=4	Chilli−Jute−T.Aman	=2		—
Pattern 12	Garlic−Jute−Fallow	=3	Sugarcane	=2		—
Pattern 13	G.nut−Jute−T.Aman	=1	Others	=2		—
Pattern 14	G.nut−Jute−Fallow	=1		—		—
Pattern 15	Mustard−Boro−T.Aman	=1		—		—
Pattern 16	Others	=2		—		—
Crop diversity index (CDI)		0.94		0.91		0.79
Cropping intensity (CI) (%)		235		180		126

Scope of improvement in cropping system

Water salinity is an unavoidable problem in coastal belt. Therefore, there is a little scope of crop intensification. However, a vast area remains fallow in rabi season, where grasspea could easily be grown. In this season, buffalo and cow move openly as like in grazing field. So,

community of approach of grasspea cultivation as a fodder crop might be an option. In the gher system, integration of rice and fish might be an approach for the boost up of production. In the saline area, only some local varieties are planted for T. Aman rice. Promising modern varieties, tolerant to salinity, might go for trial in this area. In Maizbari char, local Aman varieties (*gainja*) are extensively planted in a post flood situation. Rapid growing, short duration T. Aman varieties might make a positive change in the area.

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 four-cropped cropping pattern for irrigated medium high land ecosystem

N Parvin, BJ Shirazy, MK Quais, A Khatun 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:

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 2023-24 to compare the yield and profitability of four-cropped cropping patterns viz. CP_1: Tomato (BARI Tomato-21)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan75), CP_2: Mustard (BARI Sarisha-14)-Boro (BRRI dhan88)-T. Jute (BJRI Tossa Pat-8)-T. Aman (BRRI dhan71), CP_3: Mustard (BARI Sarisha-14)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan71), CP_4: Potato (Asterix)\Pumpkin (BARI Hybrid Mistikumra-2)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan90), CP_5: Potato (Asterix)+Maize (BARI Hybrid Maize-16)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan75), CP_6: Mustard (BARI Sarisha-14)-Vegetable (BARI Puishak-2)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan71) against the CP_7: Mustard (BARI Sarisha-14)-Boro (BRRI dhan88)-T. Aman (BRRI dhan75) cropping pattern. Seeding date, transplanting date, harvesting date and days of field duration are given in Table 6, 7 and 8. 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. MBCR (Marginal Benefit Cost Ratio) was calculated using following equation:

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

Table 6. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2023-24

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-21	BARI Mung-6	BRRI dhan98	BRRI dhan75	BARI Sarisha-14	BRRI dhan88	BJRI Tossa Pat-8	BRRI dhan71
D/S	19 Oct 2023	20 Feb 2023	18 Apr 2023	21 Jul 2023	11 Nov. 2023	28 Dec 2023	10 Apr 2023	21 Jul 2023
D/T	9 Nov 2023	-	10 May 2023	09 Aug 2023	-	31 Jan 2024	11 May 2023	08 Aug 2023
D/H	19 Feb 2024	20 Apr 2023	31 Jul 2023	04 Nov 2023	29 Jan 2024	02 May 2024	02 Aug 2023	06 Nov 2023
FD (days)	102	59	82	87	79	92	83	90

Table 7. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2023-24

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 dhan98	BRRI dhan71	Asterix	BARI Hybrid Misti Kumra-2	BRRI dhan98	BRRI dhan90
D/S	11 Nov 2023	16 Feb 2023	18 Apr 2023	21 Jul 2023	15 Nov 2023	2 Dec 2023	18 Apr 2023	21 Jul 2023
D/T	-	-	10 May 2023	08 Aug 2023	-	23 Dec 2023	09 May 2023	09 Aug 2023
D/H	29 Jan 2024	08 May 2023	31 Jul 2023	06 Nov 2023	16 Feb 2024	02 May 2024	31 Jul 2023	07 Nov 2023
FD (days)	79	81	82	90	93	131	83	90

Table 8. Management practices followed for different crops under four cropped cropping patterns, BRRI Gazipur, 2023-24

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 dhan75	BARI Sarisha-14	BARI Puishakh-2	BRRI dhan98	BRRI dhan71
D/S	15 Nov 2023	20 Dec 2023	18 Apr 2023	21 Jul 2023	11 Nov 2023	6 Feb 2024	18 Apr 2023	21 Jul 2023
D/T	-	-	09 May 2023	09 Aug 2023	-	-	10 May 2023	8 Aug 2023
D/H	15 Feb 2024	24 Apr 2024	31 Jul 2023	04 Nov 2023	29 Jan 2024	30 Apr 2024	31 Jul 2023	6 Nov 2023
FD (days)	92	126	83	87	79	84	82	90

Factors	CP_7: Mustard-Boro-T. Aman		
	Mustard	Boro	T. Aman
Variety	BARI Sarisha-18	BRRI dhan88	BRRI dhan75
D/S	11 Nov 2023	13 Jan 2024	25 Jun 2023
D/T	-	26 Feb 2024	15 Jul 2023
D/H	19-Feb 2024	28 May 2024	08 Oct 2023
FD (days)	100	92	85

Results

Individual crop yield and REY of respective cropping patterns are presented in Table 9. The yield of tomato was 9.58 t/ha under Tomato-Mungbean-T. Aus-T. Aman cropping pattern (CP_1). The yield was lower due to serious attack of late blight disease. Mustard yielded 1.23, 1.72 and 1.47 t/ha under CP_2, CP_3 and CP_6, respectively. Potato yielded 20.01 and 14.30 t/ha under Potato/Pumpkin-T. Aus-T. Aman (CP_4) and Potato+Maize-T. Aus-T. Aman cropping pattern (CP_5), respectively. The lower yield of potato under CP_5 due to late blight attack infestation. Maize yielded under Maize+Potato-T. Aus-T. Aman (CP_5) was 7.21 t/ha. Mungbean was cultivated in CP_1 and CP_3 which faced serious germination problem and yield was 0.30 and 0.39 t/ha, respectively. Pumpkin yielded 7.6 t/ha which was intercropped with potato under CP_4 cropping pattern. Indian spinach and jute yielded 8.04 and 1.22 t/ha under CP_6 and CP_2 cropping pattern respectively. The yield of Boro rice was 4.87 and 5.42 t/ha under Mustard-Boro-T. Jute-T. Aman (CP_2) and Mustard-Boro-T. Aman (Ck.) cropping pattern, respectively. Aus rice yielded 4.01 to 4.59 t/ha under different cropping patterns. Short duration

T. Aman rice varieties (Table 9) were used in all the patterns which yielded 4.00 to 5.65 t/ha. Among the tested cropping patterns, the highest rice equivalent yield (REY) of 35.92 t/ha and gross margin (GM) of 5,36,000 Tk/ha resulted from Potato\Pumpkin-T. Aus-T. Aman cropping pattern (CP4) with a marginal benefit cost ratio (MBCR) of 3.72 (Table 10).

Table 9. Yield and Rice Equivalent Ratio (REY) of different crop combinations under four crop cropping patterns, BRRI, Gazipur, 2023-24

CPs	Yield (t/ha)											REY (t/ha)
	Tomato	Mustard	Potato	Maize	Mungbean	Pumpkin	Vegetable	Boro	T. Jute	T. Aus	T. Aman	
CP_1	*9.58	-	-	-	**0.30	-	-	-	-	4.01	4.00	20.58 b
CP_2	-	1.23	-	-	-	-	-	4.87	1.22	-	5.14	16.38 cd
CP_3	-	1.72	-	-	**0.39	-	-	-	-	4.59	5.65	17.15 cd
CP_4	-	-	20.01	-	-	7.60	-	-	-	4.37	4.27	35.92 a
CP_5	-	-	*14.30	7.21	-	-	-	-	-	4.54	4.09	34.44 a
CP_6	-	1.47	-	-	-	-	8.04	-	-	4.44	5.25	19.22 bc
CP_7 (Ck..)	-	1.77	-	-	-	-	-	5.42		-	4.05	15.15 d
CV (%)												8.19

*Late blight; **Mungbean = Germination problem; In some cases, yield of Aman was less due to logging effect by cyclone Hamoon (21-25 October 2023). Means with the same letter(s) are not significantly different. CP=Cropping Pattern, Ck.=Check., CV=Coefficient of Variation, REY=Rice Equivalent Yield, Price (Tk/kg): Tomato=30, Mustard=80, Potato=30, Maize=30, Pumpkin=20, Mungbean=90, Jute=50, Vegetable (Indian spinach) =15, Rice=25, Jute stick=10; Stover=6

Varieties: Tomato: BARI Tomato-21, Mungbean: BARI Mung-6, Aus: BBRI dhan98, T. Aman: BRRI dhan75, BRRI dhan71, BRRI dhan90, Mustard: BARI Sarisha-14, Boro: BRRI dhan88, T. Jute: BJRI Tosa Pat-8, Potato: Asterix, Pumpkin: BARI Hybrid Misti Kumra-2, Maize: BARI Hybrid Maize-16, Vegetable: BARI Puishak-2

Table 10. Cost-return analysis of different crops combinations under four cropped cropping patterns, Gazipur, 2023-24

Cropping Pattern	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
CP_1=Tomato-Mungbean-T. Aus-T. Aman	452	94	0.68
CP_2=Mustard-Boro-T. Jute-T. Aman	313	97	0.81
CP_3=Mustard-Mungbean-T. Aus-T. Aman	260	169	1.98
CP_4=Potato\Pumpkin-T. Aus-T. Aman	362	536	3.72
CP_5=Potato+Maize-T. Aus-T. Aman	418	443	2.49
CP_6=Mustard-Vegetable-T. Aus-T. Aman	292	188	1.74
CP_7=Mustard-Boro-T. Aman (Ck)	219	160	-

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

From the nutritional point of view of four cropped cropping pattern, maximum energy (180 GJ/ha) as well as fiber (880 kg/ha), ash (238 kg/ha), carbohydrate (8673 kg/ha) found from Potato+Maize-T. Aus-T. Aman (CP5) and minimum was found from Tomato-Mungbean-T. Aus-T. Aman (CP1) cropping pattern. In the consideration of REY (t/ha) & MBCR, Potato\Pumpkin-T. Aus-T. Aman (CP4) spotted the highest result and it was also statistically similar to CP5 cropping pattern whereas in nutritional aspect, Potato+Maize-T. Aus-T. Aman (CP5) performed better than other cropping pattern (Table 11).

Table 11. Proximate nutrient composition of the evaluated cropping pattern, BRRI, Gazipur, 2023-24

Cropping pattern	Protein (kg/ha)	Fat (kg/ha)	Total dietary fiber (kg/ha)	Ash (kg/ha)	Carbohydrate (kg/ha)	Energy (GJ/ha)
CP_1=Tomato-Mungbean-T. Aus-T. Aman	521 e	44 e	395 e	85 de	4413 d	88 c
CP_2=Mustard-Boro-T. Jute-T. Aman	725 cd	457 c	383 e	71 e	5608 c	126 b
CP_3=Mustard-Mungbean-T. Aus-T. Aman	924 b	634 ab	504 cd	120 c	5855 c	141 b
CP_4=Potato\Pumpkin-T. Aus-T. Aman	667 d	75 e	696 b	222 a	6973 b	135 b
CP_5=Potato+Maize-T. Aus-T. Aman	1235 a	281 d	880 a	238 a	8673 a	180 a
CP_6=Mustard-Vegetable-T. Aus-T. Aman	1354 a	558 b	523 c	163 b	5461 c	131 b
CP_7=Mustard-Boro-T. Aman (Ck)	807 bc	646 a	427 de	106 cd	5254 cd	129 b
CV (%)	8.21	11.58	8.74	9.65	8.43	8.54

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

N Parvin, BJ Shirazy, MK Quais, SM Shahidullah 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.

Objective

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

Materials and Methods

The experiment was conducted at BRRI research farm, Gazipur during 2023-24 to evaluate the agronomic and economic performance of three-cropped cropping patterns viz. CP_1: Boro (BRRI dhan88)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan75), CP_2: Mustard (BARI Sarisha-18)-Boro (BRRI dhan88)-T. Aman (BRRI dhan75), CP_3: Potato (BARI Alu-25, Asterix)-Boro (BRRI dhan88)-T. Aman (BRRI dhan95), CP_4: Wheat (BARI Gom-30)-Mungbean (BARI Mung-6)-T. Aman (BRRI dhan75), CP_5: Sunflower (BARI Surjamukhi-3)-T. Aus (BBRI dhan48)-T. Aman (BRRI dhan75), CP_6: Onion (BARI Piaz-4)-Jute (BJRI Tossa Pat-8)-T. Aman (BRRI dhan87), CP_7: Lentil (BARI Mashur-8)-T. Aus (BRRI dhan48)-T. Aman (BRRI hybrid dhan6) against the CP_8: Boro (BRRI dhan92)-Fallow-T. Aman (BRRI dhan49) (Ck.) were tested. Seeding date, transplanting date, harvesting date and field duration are given below (Table 12, 13, 14, 15). 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. MBCR (Marginal Benefit Cost Ratio) were calculated using following equation:

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

Table 12. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2023-24

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 dhan48	BRRI dhan75	BARI Sarisha-18	BRRI dhan88	BRRI dhan75
D/S	23 Nov 2023	09 April 2023	04 July 2023	11 Nov 2023	13 Jan 2024	25 Jun 2023
D/T	30 Dec 2023	20 April 2023	25 July 2023	-	26 Feb 2024	15 Jul 2023
D/H	22 April 2024	17 July 2023	21 Oct 2023	19-Feb 2024	28 May 2024	08 Oct 2023
FD (days)	114	88	88	100	92	85

Table 13. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2023-24

Factors	CP_3: Potato-Boro-T. Aman			CP_4: Wheat-Mungbean-T. Aman		
	Potato	Boro	T. Aman	Wheat	Mungbean	T. Aman
Variety	Asterix	BRRI dhan88	BRRI dhan95	BARI Gom-30	BARI Mung-6	BRRI dhan75
D/S	15 Nov 2023	28 Dec 2023	25 Jun 2023	15 Nov 2023	15 Mar 2023	25 Jun 2023
D/T	-	13 Feb 2024	15 Jul 2023	-	-	15 Jul 2023
D/H	11 Feb 2024	05 May 2024	08 Oct 2023	29 Feb 2024	04 Jun 2023	08 Oct 2023
FD (days)	98	82	85	106	81	85

Table 14. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2023-24

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	BRRI dhan48	BRRI dhan75	BARI Piaz-4 (winter)	BJRI Tossa Pat-8	BRRI dhan87
D/S	11 Nov 2023	09 Apr 2023	04 Jul 2023	18 Oct 2023	10 Apr 2023	15 Jul 2023
D/T	-	18 Apr 2023	25 Jul 2023	26 Nov 2023	-	08 Aug 2023
D/H	07 Feb 2024	17 Jul 2023	21Oct 2023	10 Mar 2024	02 Aug 2023	20 Oct 2023
FD (days)	88	90	88	105	114	73

Table 15. Management practices followed for different crops under three cropped cropping patterns, BRRI Gazipur, 2023-24

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	BRRI dhan48	BRRI hybrid dhan6	BRRI dhan92	BRRI dhan49
D/S	11 Nov 2023	09 Apr 2023	04 Jul 2023	23 Nov 2023	21 Jun 2023
D/T	-	18 Apr 2023	25 Jul 2023	30 Dec 2023	11 Jul 2023
D/H	Damaged	17 Jul 2023	21 Oct 2023	05 May 2024	28 Oct 2023
FD (days)	-	90	88	127	109

Results

Individual crop yield and REY of respective cropping patterns are presented in Table 16. Yield of mustard and potato 1.77 and 11.86 t/ha under Mustard-Boro-T. Aman (CP_2) and Potato-Boro-T. Aman (CP_3) cropping pattern, respectively. Potato yield was low due to late blight disease of potato. Wheat, sunflower, onion and jute yielded 3.74, 1.54, 20.55, and 1.82 t/ha, respectively under respective cropping patterns. Yield of mungbean was very low due to germination problem. Again, lentil was damaged by cyclone effect. Yield of Boro rice was in the range of 4.33 to 6.62 t/ha. The highest yield (6.62 t/ha) of Boro rice was obtained from CP_1: Boro-T. Aus-T. Aman cropping pattern. Yield of T. Aus was 4.22, 4.04 and 5.06 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_3: Potato-Boro-T. Aman and CP_6: Onion-Jute-T. Aman performed comparatively better yield, 5.07 and 5.05 t/ha respectively. Grain yield of T. Aman under CP_5, CP_7 and CP_8 were lower because of logging effect of cyclone at reproductive stage. Lentil was damaged by cyclone Michaung (7-8 December 2023). Among the tested cropping

patterns, highest rice equivalent yield (50.52 t/ha), gross margin (1009,000 Tk/ha) and MBCR (8.05) were found from Onion-Jute-T. Aman cropping pattern (CP_6) (Table 17).

Table 16. Yield and Rice Equivalent Yield (REY) of different crops combination under three-cropped cropping pattern, BRRI, Gazipur, 2023-24

CPs	Yield (t/ha)											REY (t/ha)
	Mustard	Potato	Wheat	Sunflower	Onion	Lentil	Boro	Mungbean	Jute	T. Aus	T. Aman	
CP_1	-	-	-	-	-	-	6.62	-	-	4.22	4.16	14.99 c
CP_2	1.77	-	-	-	-	-	5.42	-	-	-	4.05	15.15 c
CP_3	-	***11.86	-	-	-	-	4.33	-	-	-	5.07	23.63 b
CP_4	-	-	3.74	-	-	-	-	**0.16	-	-	4.09	10.65 cd
CP_5	-	-	-	1.54	-	-	-	-	-	4.04	*2.81	9.93 cd
CP_6	-	-	-	-	20.55	-	-	-	1.82	-	5.05	50.52 a
CP_7	-	-	-	-	-	damaged	-	-	-	5.06	*2.50	-
CP_8 (Ck..)	-	-	-	-	-	-	5.32	-	-	-	*3.80	9.11 d
CV (%)											18.25	

*Logging effect of cyclone Hamoon (21-25 October 2023); **Mungbean=Germination problem; ***Late blight of potato; Lentil was damaged due to cyclone of Michaung (7-8 December 2023). Means with the same letter(s) are not significantly different. CP=Cropping Pattern, Ck.=Check., CV=Coefficient of Variation, REY=Rice Equivalent Yield, Price (Tk/kg): Mustard=80, Potato=30, Wheat=40, Sunflower=50, Onion=50, Lentil=85, Mungbean=90, Jute=60, Rice=25, Jute stick. (Tk/kg)=10; Stover=6
Varieties: Boro: BRRI dhan88 and BRRI dhan92, T. Aus: BRRI dhan48, T. Aman: BRRI dhan49, BRRI dhan75, BRRI dhan87, BRRI dhan95, BRRI Hybrid dhan6, Mustard: BARI Sarisha-18, Potato: Asterix, Wheat: BARI Gom-30, Mungbean: BARI Mung-6, Sunflower: BARI Surjamukhi-3, Onion: BARI Piaz-4, Jute: BJRI Tossa Pat-8, Lentil: BARI Mashur-8

Table 17. Cost-return analysis of different crops combinations under three cropped cropping patterns, Gazipur, 2023-24

CPs	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
CP_1	239	177	2.36
CP_2	220	205	3.45
CP_3	300	312	2.76
CP_4	220	59	0.61
CP_5	227	42	0.38
CP_6	299	1009	8.05
CP_8 (Ck..)	167	79	-

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

From the nutritional point of view, maximum protein (1028 kg/ha), total dietary fiber (1001 kg/ha), ash (135 kg/ha) and energy (146 GJ/ha) found from Wheat-Mungbean-T. Aman (CP_4) cropping pattern except fat and carbohydrate. In the consideration of REY (t/ha) & MBCR, Onion-Jute-T. Aman (CP_6) obtained the highest result but non edible crop jute was included in this pattern that's why, Onion-Jute-T. Aman (CP_6) contained lower nutritional value (Table 18).

Table 18. Proximate nutrient composition of the evaluated cropping pattern, BRRI, Gazipur, 2023-24

Cropping pattern	Protein (kg/ha)	Fat (kg/ha)	Total dietary fiber (kg/ha)	Ash (kg/ha)	Carbohydrate (kg/ha)	Energy (GJ/ha)
CP_1=Boro-T. Aus-T. Aman	693 c	42 d	362 c	53 c	8194 a	153 a
CP_2=Mustard-Boro-T. Aman	806 b	646 a	426 bc	106 b	5245 c	129 b
CP_3=Potato-Boro-T. Aman	546 d	46 d	432 bc	122 ab	6455 b	121 b
CP_4=Wheat-Mungbean-T. Aman	1028 a	222 c	1001 a	135 a	6711 b	146 a
CP_5=Sunflower-T. Aus-T. Aman	457 de	353 b	236 d	49 cd	3941 d	88 cd
CP_6=Onion-Jute-T. Aman	483 de	32 d	461 b	142 a	2632 e	95 c
CP_7=Lentil-T. Aus-T. Aman	350 f	21 d	183 d	26 d	4143 d	77 d
CP_8=Boro-Fallow-T. Aman (Ck)	424 ef	26 d	221 d	32 cd	5011 c	93 c
CV (%)	8.91	21.92	12.78	16.67	7.54	7.62

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

Expt. 2.3. Determination of optimum planting window of newly released rice varieties in Mustard-Boro-T. Aman cropping system

MK Quais, BJ Shirazy and M Ibrahim

Introduction

The cropping system of Bangladesh is usually rice-based as well as diversified, includes tuber crops, pulses, oilseed, Vegetables, and other winter cereals like maize and wheat. In self-sufficiency of rice, the dominant cropping pattern Boro-Fallow-T. Aman plays an important role which covers about 2.3 million hectares (about 27% of the net cropped area) of land (Nasim *et al.*, 2017). Bangladesh Rice Research Institute (BRRI) has recommended the inclusion of short duration Rabi crops in the transition period between T. Aman and Boro rice for the irrigated ecosystem. However, late arrival of monsoon rain, traditional long duration T. Aman varieties and unusual rainfall during and/or after T. Aman harvesting period often hamper the timely sowing of Rabi crops with subsequent delay in Boro rice transplanting. The delayed transplanting shortens the vegetative phase of Boro rice in response to temperature increase. In addition, delayed Boro transplanting often causes reduced grain yields and quality as the reproductive phase coincides with the increase of the temperature. Therefore, the reduction of grain yields of Boro rice in the Rabi crops-Boro-T. Aman cropping system is inevitable. Since pre-monsoon (Aus) rice varieties are well adapted in high temperature condition, it was hypothesized that Aus varieties will perform better than Boro varieties in late Boro situation. In addition, the variable response of rice varieties to high temperature demands the evaluation of newly released rice varieties under this cropping system. Recognizing the magnitude of the above-mentioned issues as well as the importance of Rabi crops and Boro rice in the cropping system, the present study was undertaken with the following objectives:

i) To find out the suitable rice varieties for Mustard-Boro-T. Aman cropping pattern under different planting time

ii) To find out the optimum sowing or planting window of mustard, Boro and T. Aman rice for Mustard-Boro-T. Aman cropping pattern

Materials and Methods

The experiment was conducted at East byde, BRRI experimental farm, Gazipur during Aman and Rabi 2023-24 season. In Aman season, BRRI dhan71, 75, 87 and 49 were transplanted on 10 July, 20 July, 30 July, 09 August, 19 August and 29 August. After harvesting of T. Aman rice, BARI Sarisha-14 was sown on five different dates viz. 01 November, 08 November, 15 November, 22 November and 29 November. During Boro season, BRRI dhan88, 89, 48 and 98 were transplanted across six planting dates viz. 10 January, 20 January, 30 January, 09 February, 19 February and 29 February. The experiments were laid on a split-plot design with planting dates as the main plot and varieties as subplots. The main plots were not replicated while subplots were completely randomized within the main plots with three replications. BRRI and BARI recommended management practices were followed for cultivating the varieties (Table 19).

Table 19. Crop management practices adopted in Mustard, Boro and T. Aman rice cultivation, BRRI, Gazipur 2023-24

Mgt. factors	Mustard	Boro		T. Aman	
Variety	BARI Sarisha-14	BRRI dhan89	BRRI dhan48, 88, 98	BRRI dhan49, 87	BRRI dhan71, 75
Seed rate (kg/ha)	1	30	30	30	30
Seedling age (day)	-	35	35	20	20
Spacing (cm×cm)	Broadcast	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	138-20-83-18-4.5	121-18-75-18-4.5	76-12-53-11-0-0	69-10-41-10-0-0
Weeding (Times)	1	3	2	2	2
Maturity date	23 Jan-10 Feb 2024	17 May- 08 Jun 2024	27 Apr-29 May 2024	24 Oct-10 Dec 2023	08 Oct-26 Nov 2023
Growth duration (days)	73-83	135-163	118-149	120-140	107-118

All data were verified for normality and homogeneity of variance by Levene's test before performing an analysis of variance (ANOVA). Two-way ANOVA, followed by Tukey's post hoc test for multiple comparisons, were performed for grain yield of tested varieties at different planting dates. Different regression models were fitted (linear, quadratic, cubic, and quartic) for grain yield of each variety for day of the year. The one with the highest R^2 value was selected to predict yield. Yield prediction for BARI Sarisha-14, BRRI dhan48, 71, 75, 87, 89, 88, 98 at different planting dates were estimated by fitting the quadratic polynomial equation for the selected calendar day:

$Y = b_0 + b_1x + b_2x^2$ ..... (1)

Where Y is grain yield, b_0 is the intercept, x is the planting day of the year, b_1 is the linear coefficient, and b_2 is the quadratic co-efficient.

Besides, yield prediction for BRRI dhan48 at different planting dates was estimated by fitting the cubic polynomial equation for the selected calendar day:

$Y = b_0 + b_1x + b_2x^2 + b_3x^3$ ..... (2)

Where Y is grain yield, b_0 is the intercept, x is the planting day of the year, b_1 is the linear coefficient, b_2 is the quadratic co-efficient, and b_3 is the cubic co-efficient.

Results

Effect of transplanting/sowing date on grain yield

The grain yield of mustard varied significantly with different sowing dates ($F_{4, 10} = 69.37$, $P < 0.001$) (Fig. 1). BARI Sarisha-14 demonstrated better performance when sown between 1st and 15th November. Subsequently, the grain yield of mustard experienced a decline as the sowing time advanced. The field duration of BARI Sarisha-14 was ranged from 73-83 days depending upon the sowing dates. The growth duration of mustard decreased as the sowing date was delayed.

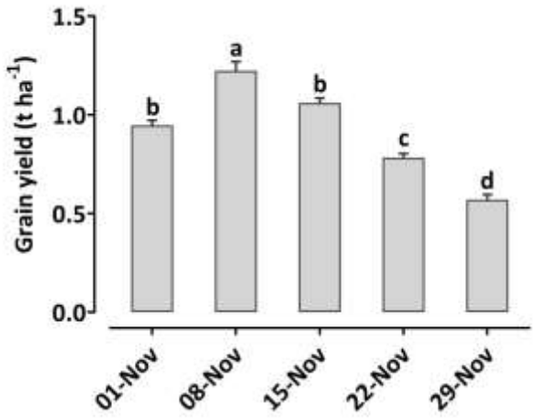

Figure 1. Effects of sowing date on the grain yield of mustard. Different letters indicate significant difference at $P< 0.05$.

The grain yield of Boro rice showed significant variations in response to transplanting dates ($F_{5, 48}= 351.21$, $P< 0.001$), rice varieties ($F_{3, 48}= 118.94$, $P< 0.001$), and the interaction between transplanting date and variety ($F_{15, 48}= 54.94$, $P< 0.001$) (Fig. 2). BRRI dhan89 demonstrated superior performance up to the transplanting date of 09 February, after which there was a sharp decline in grain yield as time progressed. Conversely, BRRI dhan88 performed better up to 20 January transplanting, with a subsequent decrease in grain yield over time. Interestingly, there was no significant difference in the yield of BRRI dhan48 up to 09 February planting. Whereas, BRRI dhan98 turned out higher grain yield on 30 January and 09 February transplanting. BRRI dhan89 gave higher grain yield compared to other tested varieties when transplanted on 10 January, 20 January, 30 January and 09 February. Whereas, BRRI dhan98 gave higher grain yield than other varieties in late planting condition.

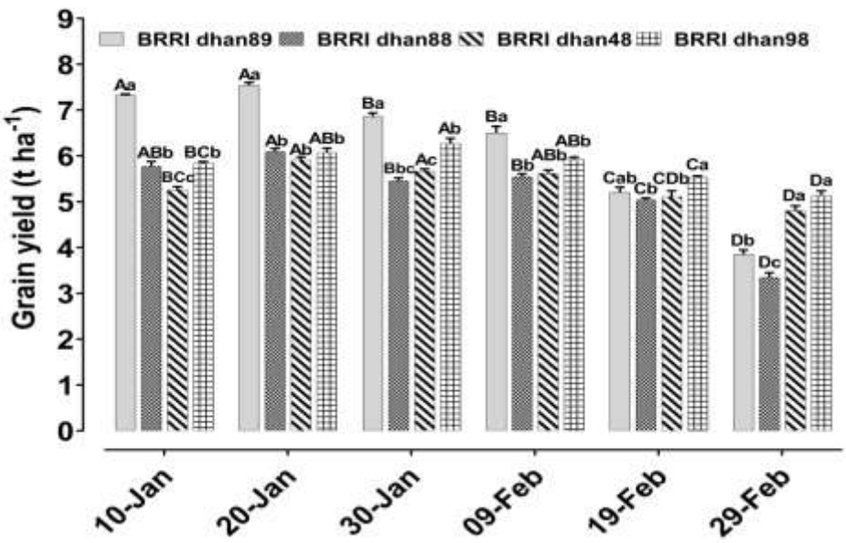

Figure 2. Effects of planting date and variety on the grain yield of Boro rice. Capital letters indicated the comparison among different planting dates of a given variety. Lower case letters indicated the comparison among different varieties within a given planting date. Different letters indicate significant difference at $P< 0.05$.

The grain yield of T. Aman rice, as depicted in Figure 3, exhibited statistically significant variations across transplanting dates ($F_{5, 48} = 64.67$, $P< 0.001$), rice varieties ($F_{3, 48} = 77.94$, $P<0.001$), and transplanting date × variety interaction ($F_{15, 48} = 2.55$, $P= 0.007$). BRRI dhan71 and BRRI dhan49 gave higher grain yield up to the transplanting date of 09 August, after which a decline in grain yield was evident as time advanced. Meanwhile, BRRI dhan49 and BRRI

dhan75 performed best when transplanted between 20 July and 09 August, followed by a decrease in grain yield. Across the planting dates, BRRI dhan71 and BRRI dhan87 consistently outperformed other tested varieties in terms of grain yield.

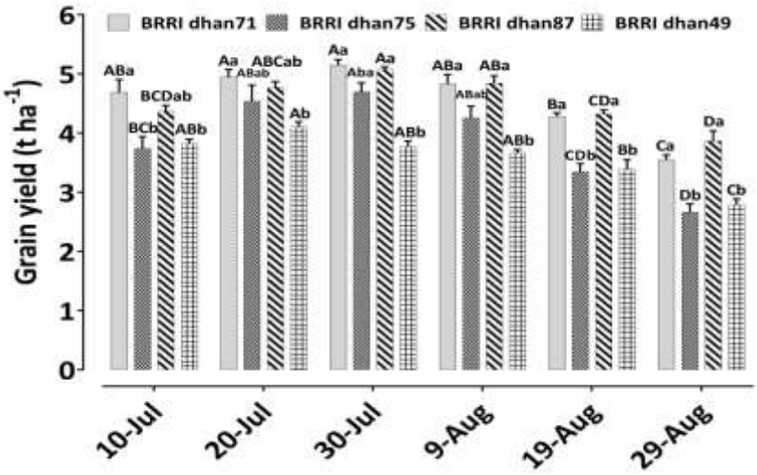

Figure 3. Effects of planting date and variety on the grain yield of T. Aman rice. Capital letters indicated the comparison among different planting dates of a given variety. Lower case letters indicated the comparison among different varieties within a given planting date. Different letters indicate significant difference at $P< 0.05$.

Relationship between planting date and grain yield

The choice of planting date is critical in determining grain yield potential; therefore, a model was fitted to predict the average yield for each calendar day and define the potential yield loss for delayed plantings (Fig. 4). The polynomial quadratic regression showed the best fit with a R^2 of 0.865 for BARI Sarisha-14. According to the model, the grain yield of mustard was negatively affected with the progress of sowing time after 09 November.

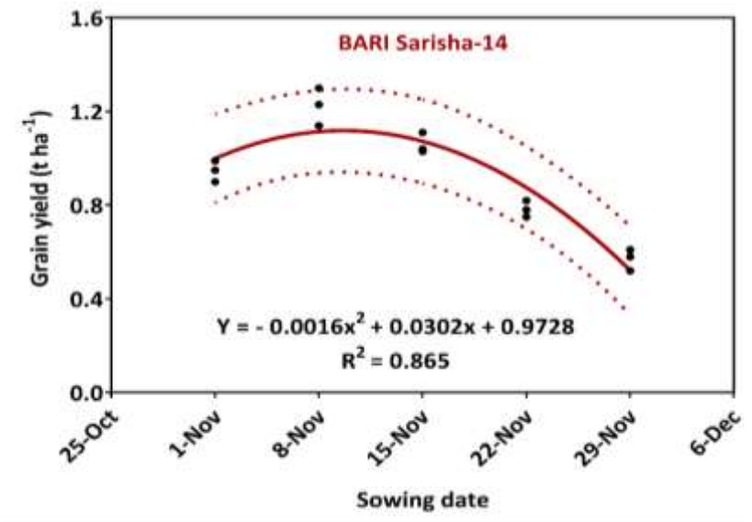

Figure 4. Predicted grain yield of mustard at different sowing dates in Gazipur. The lines show the fitted quadratic regression and the area within the dotted lines represents the 95% confidence interval for the line.

A predictive model was meticulously developed to ascertain the anticipated average yield of Boro rice varieties for each specific day within the calendar (Fig. 5). The polynomial quadratic regression model exhibited the most optimal fit, as evidenced by the coefficients of determination (R^2) of 0.785 for BRRI dhan48, 0.8813 for BRRI dhan98, 0.975 for BRRI dhan89 and 0.9063 for BRRI dhan88. In accordance with the model, the grain yield of all tested varieties exhibited a decline as the transplanting time advanced beyond their respective peak in grain yield. BRRI dhan89 and BRRI dhan88 exhibited a pronounced sensitivity to variations in

transplanting date, experiencing a substantial reduction in grain yield. In contrast, BRRI dhan48 and BRRI dhan98 displayed a relatively milder response to changes in transplanting time, resulting in lower impacts on their grain yields.

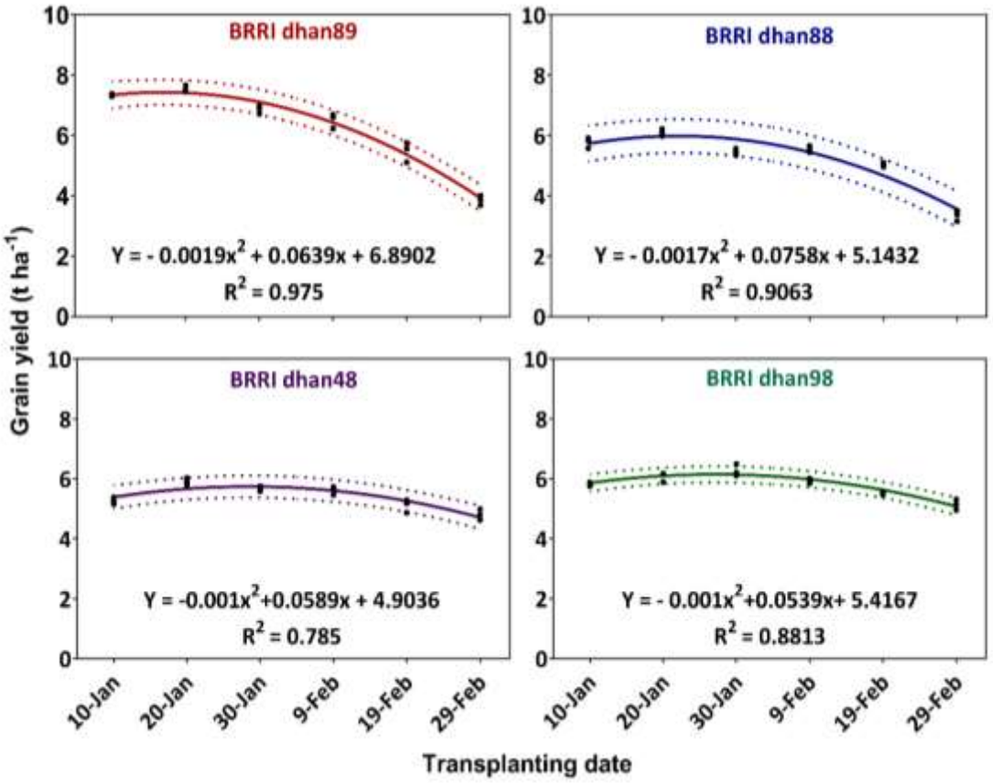

Figure 5. Predicted grain yield of tested Boro rice varieties at different planting dates in Gazipur. The lines show the fitted quadratic regression and the area within the dotted lines represents the 95% confidence interval for the line.

The graphical representation of the predictive model, delineating the projected average yield of T. Aman rice varieties at various transplanting times, is elucidated in Figure 6. The polynomial quadratic regression showed the best fit with a R^2 of 0.8835 for BRRI dhan71, 0.8353 for BRRI dhan75 and 0.8382 for BRRI dhan87; whereas polynomial cubic regression showed the best fit for BRRI dhan49 which had a R^2 of 0.8587. The model's outcomes revealed discernible disparities among the rice varieties concerning their sensitivity to changes in transplanting dates. BRRI dhan49 and BRRI dhan87 exhibited a milder sensitivity to variations in transplanting dates, whereas BRRI dhan71 and BRRI dhan75 displayed a relatively higher impact on their grain yield in response to changes in transplanting time.

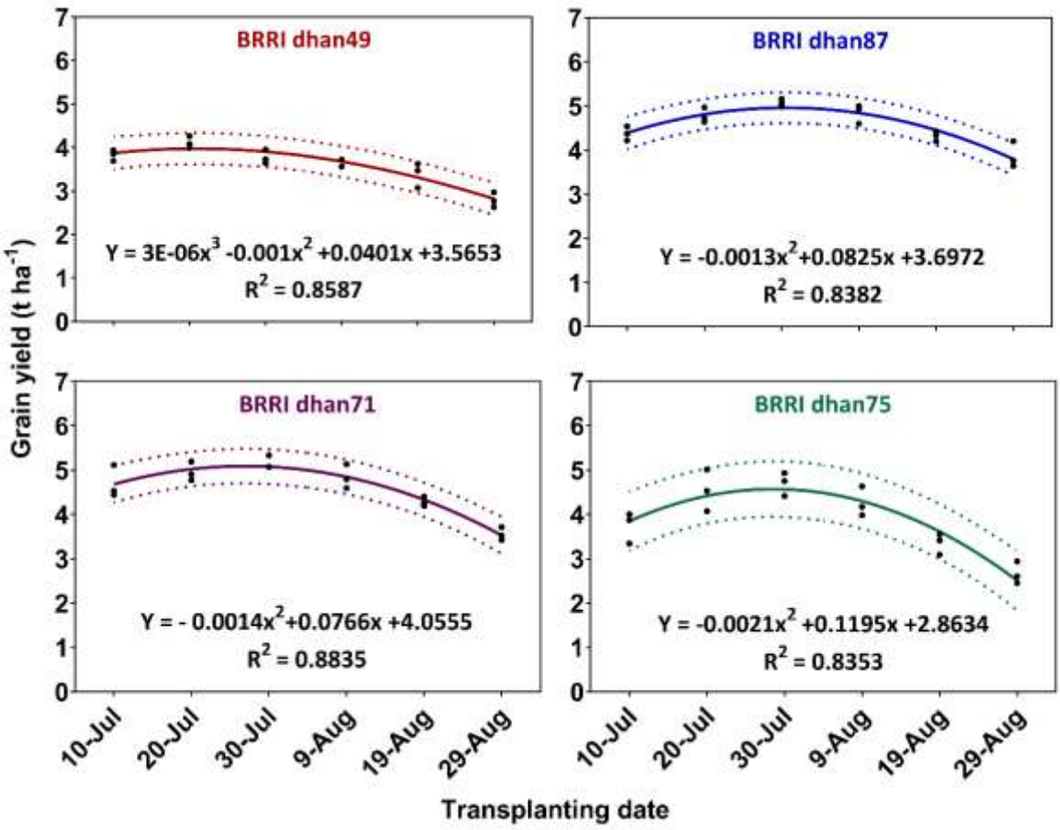

Figure 6. Predicted grain yield of tested T. Aman rice varieties at different planting dates in Gazipur. The lines show the fitted quadratic (BRRI dhan71, BRRI dhan75, BRRI dhan87) cubic regression (BRRI dhan49) and the area within the dotted lines represents the 95% confidence interval for the line.

Optimum planting window of Mustard, Boro and T. Aman rice

As planting date significantly affects the key traits in grain production, it is critical to choose the optimal planting time to maximize yield and mitigate risk. It is not possible to plant on the same calendar day every year; therefore, the different planting dates were grouped into planting windows to determine with confidence the optimum planting window of different mustard/rice varieties (Table 20). BARI Sarisha-14 exhibited its highest grain yield potentiality when sown in the planting window PW_2 (08-15 November). Although the projected grain yield of BARI Sarisha-14 was 01-11% lower at PW_1 (01-07 November) in comparison to PW_2, this planting window (PW_1) also merits consideration as an optimal planting window due to its alignment with the optimal timing for subsequent Boro rice transplanting.

Table 20. Predicted grain yield of mustard varieties at different planting windows fitted with quadratic model, BRRI Gazipur, 2023-24

Variety	Planting window	Potential yield (%)	Predicted yields (t/ha)
BARI Sarisha-14	PW_1 (01-07 Nov)	89-99	1.00-1.11
	PW_2 (08-15 Nov)	95-100	1.07-1.12
	PW_3 (16-22 Nov)	77-93	0.86-1.05
	PW_4 (23-30 Nov)	39-73	0.44-0.82

The anticipated grain yield of Boro varieties across different planting windows, as fitted with quadratic/cubic models, is presented in Table 21. BRRI dhan89 exhibited its highest grain yield potential when sown within planting window, PW_1 (10-20 Jan) and PW_2 (21-31 January). Despite a marginal decrease (1-11%) in predicted grain yield of BRRI dhan89 during PW_3 (01-

07 February) in comparison to PW_2, this planting window (PW_3) is a feasible option for Boro rice cultivation following mustard because of better grain yield potentiality of BRRI dhan89 relative to other varieties during PW_3. Moving to PW_4 (08-15 February), BRRI dhan89 appears as the superior choice among varieties. While the predicted yields of BRRI dhan89 and BRRI dhan98 are similar at the planting window PW_5 (16-23 February), we recommend BRRI dhan98 for this timeframe due to potential high temperature-related risks associated with BRRI dhan89 and the advantage of earlier harvesting with BRRI dhan98, which reduces exposure to rainy weather during harvest. BRRI dhan98 is the best option when planted in the planting window, PW_6 (24 February-01 March).

Table 21. Predicted grain yield of Boro varieties at different planting windows fitted with quadratic model, BRRI Gazipur, 2023-24

Variety	Planting window	Potential yield (%)	Predicted yields (t/ha)
BRRI dhan89	PW_1 (10-20 Jan)	99-100	7.34-7.43
	PW_2 (21-31 Jan)	95-100	7.05-7.39
	PW_3 (01-07 Feb)	89-94	6.57-6.99
	PW_4 (08-15 Feb)	78-87	5.81-6.49
	PW_5 (16-23 Feb)	65-77	4.80-5.70
	PW_6 (24 Feb-01 Mar)	52-63	3.88-4.66
BRRI dhan88	PW_1 (10-20 Jan)	96-100	5.73-5.98
	PW_2 (21-31 Jan)	98-100	5.86-5.99
	PW_3 (01-07 Feb)	93-97	5.57-5.83
	PW_4 (08-15 Feb)	84-92	5.03-5.51
	PW_5 (16-23 Feb)	71-83	4.28-4.95
	PW_6 (24 Feb-01 Mar)	60-70	3.57-4.17
BRRI dhan48	PW_1 (10-20 Jan)	93-98	5.39-5.68
	PW_2 (21-31 Jan)	99-100	5.70-5.77
	PW_3 (01-07 Feb)	99-100	5.70-5.76
	PW_4 (08-15 Feb)	95-98	5.50-5.68
	PW_5 (16-23 Feb)	90-95	5.17-5.46
	PW_6 (24 Feb-01 Mar)	84-89	4.84-5.12
BRRI dhan98	PW_1 (10-20 Jan)	95-99	5.86-6.09
	PW_2 (21-31 Jan)	99-100	6.11-6.14
	PW_3 (01-07 Feb)	98-100	6.02-6.12
	PW_4 (08-15 Feb)	94-98	5.78-6.00
	PW_5 (16-23 Feb)	88-93	5.41-5.74
	PW_6 (24 Feb-01 Mar)	82-87	5.05-5.36

The projected grain yield of T. Aman varieties across varying planting windows, analyzed using cubic models, is summarized in Table 22. BRRI dhan49 showed better performance when transplanted during the planting window, PW_2 (18-26 July), with subsequent yield declines beyond this window. Whereas, superior performance of BRRI dhan71, BRRI dhan75 and BRRI dhan87 in both PW_2 (18-26 July) and PW_3 (27 Jul-05 Aug), indicating their adaptability to these time frames. In PW_1 (10-17 July) and PW_4 (06-13 Aug), BRRI dhan71 outperformed other varieties, while BRRI dhan87 demonstrated its superiority over other varieties during PW_4 (06-13 Aug), PW_5 (14-21 Aug) and PW_6 (22-29 Aug).

Table 22. Predicted grain yield of T. Aman varieties at different planting windows fitted with quadratic/cubic model, BRRI Gazipur, 2023

Variety	Planting window	Potential yield (%)	Predicted yields (t/ha)
BRRI dhan49	PW_1 (10-17 July)	97-99	3.87-3.97
	PW_2 (18-26 July)	100	3.98-4.00
	PW_3 (27 Jul-05 Aug)	96-99	3.85-3.97
	PW_4 (06-13 Aug)	91-95	3.65-3.83
	PW_5 (14-21 Aug)	84-90	3.37-3.62
	PW_6 (22-29 Aug)	76-83	3.02-3.33
BRRI dhan87	PW_1 (10-17 July)	88-94	4.39-4.72
	PW_2 (18-26 July)	95-99	4.76-4.96
	PW_3 (27 Jul-05 Aug)	100	4.98-5.01
	PW_4 (06-13 Aug)	96-99	4.81-4.96
	PW_5 (14-21 Aug)	89-95	4.47-4.78
	PW_6 (22-29 Aug)	79-88	3.97-4.42
BRRI dhan71	PW_1 (10-17 July)	92-97	4.68-4.95
	PW_2 (18-26 July)	98-100	4.98-5.10
	PW_3 (27 Jul-05 Aug)	98-100	5.00-5.10
	PW_4 (06-13 Aug)	92-97	4.72-4.97
	PW_5 (14-21 Aug)	83-91	4.25-4.67
	PW_6 (22-29 Aug)	71-82	3.61-4.18
BRRI dhan75	PW_1 (10-17 July)	84-94	3.85-4.29
	PW_2 (18-26 July)	95-100	4.33-4.55
	PW_3 (27 Jul-05 Aug)	97-100	4.44-4.56
	PW_4 (06-13 Aug)	89-97	4.06-4.41
	PW_5 (14-21 Aug)	74-87	3.40-3.99
	PW_6 (22-29 Aug)	54-72	2.47-3.30

Impact of mustard adoption on Boro rice yield reduction

The reduction in Boro rice yield resulting from the integration of mustard in Boro-Fallow-T. Aman cropping pattern is summarized in Table 23. Mustard is typically sown by farmers throughout the month of November. To evaluate the effect of delayed Boro rice transplanting, the mustard sowing period was divided into four windows, and the yield losses of various Boro rice varieties were calculated for each window. The data demonstrate that delayed mustard sowing exacerbates yield loss in subsequent Boro rice. Additionally, the yield reduction in Boro varieties is higher than that observed in Aus varieties.

Table 23. Yield loss of Boro rice at different sowing windows of mustard due to inclusion of mustard in Mustard-Boro-T. Aman cropping pattern, BRRI Gazipur, 2023-24

Mustard sowing time	BRRI dhan89		BRRI dhan88		BRRI dhan48		BRRI dhan98	
	Yield loss (t/ha)	Loss in %	Yield loss (t/ha)	Loss in %	Yield loss (t/ha)	Loss in %	Yield loss (t/ha)	Loss in %
01-07 Nov	0.20-0.38	3-5	0.04-0.13	0.6-2	0.00-0.01	0-0.1	0.00-0.02	0-0.3
08-15 Nov	0.28-0.70	5-9	0.13-0.32	2-5	0.00-0.04	0-0.7	0.02-0.08	0.3-1
16-22 Nov	0.77-1.11	10-15	0.37-0.59	6-10	0.06-0.13	1-2	0.10-0.20	2-3
23-30 Nov	1.11-1.62	15-22	0.59-0.95	10-16	0.13-0.27	2-5	0.20-0.36	3-6

Optimum planting window of Mustard-Boro-T. Aman cropping pattern

The rice equivalent yield (REY) from the combinations of long- and short-duration T. Aman varieties, along with the best Boro variety in the specific combination, is presented in Table 24. For the combination involving a long-duration T. Aman variety and a short-duration mustard variety, BRRI dhan49 transplanted between 10-17 July followed by BARI Sarisha-14 sown on 11-16 November and BRRI dhan89 transplanted between 03-08 February, resulted in the highest REY (13.16-13.80 t ha^{-1}). However, this combination did not fully exploit the maximum yield potential of mustard, T. Aman or Boro rice.

In the context of medium duration T. Aman and short duration mustard variety, BRRI dhan87 transplanted on 18-25 July and BARI Sarisha-14 sown on 07-12 November followed by BRRI dhan89 transplanted on 31 January-05 February yielded the highest REY (14.42-14.99 t/ha). Despite the high REY, this combination also did not fully capitalize on the maximum yield potential of T. Aman and Boro rice.

In case of a short duration T. Aman and short duration mustard variety, BRRI dhan71/75 transplanted on 26 July-02 August, BARI Sarisha-14 sown on 01-06 November and BRRI dhan89 transplanted on 27 January-01 February resulted the highest REY (14.18-15.26 t/ha). Although the yield potential of mustard was not fully exploited, this combination enabled the full exploitation of T. Aman yield potential and the harvest of the maximum possible yield potential of Boro rice, leading to a high REY.

Table 24. Predicted yield of components crops and REY of Mustard-Boro-T. Aman cropping pattern at different planting/sowing windows, BRRI, Gazipur, 2023-24

T. Aman			Mustard			Boro			REY (t/ha)
Variety	**Planting window**	**Predicted yield (t/ha)**	**Variety**	**Sowing window**	**Predicted yield (t/ha)**	**Variety**	**Planting window**	**Predicted yield (t/ha)**	
Combination-1: Long duration Aman (GD=135-140 d)-Short duration Mustard (GD= 75-80 d)-Suitable Boro variety									
BRRI dhan49	10-17 July	3.87-3.97	BARI Sarisha-14	11-16 Nov	1.05-1.11	BRRI dhan89	03-08 Feb	6.49-6.87	13.16-13.80
	18-25 July	3.98-3.99		13-18 Nov	1.00-1.10	BRRI dhan89	04-09 Feb	6.41-6.80	13.06-13.72
	26 July-02 Aug	3.91-3.98		17-22 Nov	0.86-1.02	BRRI dhan89	07-12 Feb	6.12-6.57	12.32-13.27
	03-10 Aug	3.74-3.89		21-26 Nov	0.68-0.90	BRRI dhan89	10-15 Feb	5.81-6.32	11.36-12.61
	11-16 Aug	3.55-3.71		26-30 Nov	0.44-0.68	BRRI dhan89	13-18 Feb	5.46-6.02	10.18-11.54
						BRRI dhan98	13-18 Feb	5.66-5.85	10.38-11.37
Combination-2: Medium duration Aman (GD=127-130 d)-Short duration Mustard (GD= 75-80 d)-Suitable Boro variety									
BRRI dhan87	10-17 July	4.39-4.72	BARI Sarisha-14	01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	14.05-14.88
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.05-14.76
	18-25 July	4.76-4.95		07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.42-14.99
	26 July-02 Aug	4.96-5.00		13-18 Nov	1.00-1.10	BRRI dhan89	04-09 Feb	6.41-6.80	14.04-14.73
	03-10 Aug	4.89-5.00		18-23 Nov	0.82-1.00	BRRI dhan89	08-13 Feb	6.02-6.49	13.1-14.16
	11-17 Aug	4.66-4.87		24-29 Nov	0.50-0.78	BRRI dhan89	12-17 Feb	5.58-6.12	11.57-13.07
						BRRI dhan89	12-17 Feb	5.70-5.89	11.69-12.84

T. Aman			Mustard			Boro			REY (t/ha)
Variety	**Planting window**	**Predicted yield (t/ha)**	**Variety**	**Sowing window**	**Predicted yield (t/ha)**	**Variety**	**Planting window**	**Predicted yield (t/ha)**	
Combination-3: Short duration Aman (GD=115-120 d)-Short duration Mustard (GD= 75-80 d)-Suitable Boro variety									
BRRI dhan71	10-17 July	4.68-4.95	BARI Sarisha-14	01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	14.34-15.11
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.34-14.99
	18-25 July	4.98-5.10		01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	14.64-15.26
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.64-15.14
	26 July-02 Aug	5.06-5.10		01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	14.72-15.26
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.72-15.14
	03-10 Aug	4.84-5.04		07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.50-15.08
	11-18 Aug	4.45-4.80		13-18 Nov	1.00-1.10	BRRI dhan89	04-09 Feb	6.41-6.80	13.53-14.53
	19-23 Aug	4.11-4.39		20-25 Nov	0.73-0.94	BRRI dhan89	09-14 Feb	5.92-6.41	11.98-13.31
	24-27 Aug	3.79-4.03		25-30 Nov	0.44-0.73	BRRI dhan89	12-17 Feb	5.58-6.12	10.54-12.10
						BRRI dhan98	12-17 Feb	5.70-5.89	10.66-11.87
Combination-4: Short duration Aman (GD=115-120 d)-Short duration Mustard (GD= 75-80 d)-Suitable Boro variety									
BRRI dhan75	10-17 July	3.85-4.29	BARI Sarisha-14	01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	13.51-14.45
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	13.51-14.33
	18-25 July	4.33-4.54		01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	13.99-14.70
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	13.99-14.58
	26 July-02 Aug	4.52-4.55		01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	14.18-14.71
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	14.18-14.59
	03-10 Aug	4.23-4.50		01-06 Nov	1.00-1.10	BRRI dhan89	27 Jan-01 Feb	6.99-7.23	13.89-14.66
				07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	13.89-14.54
	11-18 Aug	3.68-4.18		07-12 Nov	1.10-1.12	BRRI dhan89	31 Jan-05 Feb	6.73-7.05	13.34-14.22
	19-24 Aug	3.08-3.59		15-20 Nov	0.94-1.07	BRRI dhan89	05-10 Feb	6.32-6.73	11.91-13.17
	25-29 Aug	2.47-2.97		20-25 Nov	0.73-0.94	BRRI dhan89	09-14 Feb	5.92-6.41	10.34-11.89

Price (Tk/Kg)- Rice: 30, Mustard: 80

Summary

Based on the aforementioned results, it is evident that the combination of a short-duration T. Aman variety, a short-duration mustard variety, and a long-duration Boro rice variety yields the highest Rice Equivalent Yield (REY) under Mustard-Boro-T. Aman cropping pattern. The recommended planting windows for T. Aman, mustard and Boro rice are identified as 22 July-02 August, 01-06 November and 27 January- 01 February, respectively.

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

S Pramanik, ABMJ Islam, N Parvin, MK Quais and M Ibrahim

Introduction

Sustainable crop production in Bangladesh through improvement of cropping pattern in rice-based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation, land degradation and pollution control. The main challenge of the new millennium is to increase per unit yield by at least 50% through manipulating the limited land resources. In this regard, the challenges for the agronomist are to understand crop production problems and process to develop the best ways of production technologies for the management of problems and sustain production. Boro season of rice starts in November and ends in March (Chowhan *et al*., 2019). Inclusion of Rabi crops causes a delay in the transplanting of Boro rice. Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield because high temperature is one of the major environmental stresses that affect plant growth and development (Boyer, 1982). The present system of fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carryover effect of the fertilizers applied to the preceding crop. Some previous studies tried to fit potato as an additional crop in between Boro and T. Aman cropping system but they did not focus on fertilizer management of Boro rice in late situation after potato cultivation. Considering this situation, the present study was set to compare the yield performance of late Boro rice under different fertilizer management in Potato - Boro -T. Aman cropping pattern.

Materials and Methods

The experiment was conducted at East Byde in Boro season, 2024 at Bangladesh Rice Research Institute (BRRI) farm, Gazipur. After harvesting of Potato, thirty-one-day-old seedlings of BRRI dhan74 and BRRI dhan98 were transplanted on 17 February 2024 at a spacing of 20 cm × 20 cm using 2-3 seedlings per hill. The full dose of P-K-S-Zn was applied as per treatments during final land preparation. The experiment was laid out in a split plot design with three replications. The experiments were laid on a split-plot design with fertilizer management options as the main plot and nitrogen fertilizer application schedule as subplots. The main plots were not replicated while subplots were completely randomized within the main plots with three replications. BRRI recommended management practices were followed for cultivating the varieties (Table 25).

Treatments

Factor A: Fertilizer management options (main plot)	Factor B: Nitrogen fertilizer application schedule (sub plot)
F_1 = Recommended dose	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
F_2 = Pattern based dose	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
	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

Table 25. Crop management practices adopted in late Boro rice, BRRI, Gazipur, 2024

Treatments	Boro	
Variety	BRRI dhan74	BRRI dhan98
Date of sowing	17 Jan. 2024	17 Jan. 2024
Date of transplanting	17 Feb. 2024	17 Feb. 2024
Date of maturity	25 May 2024	20 May 2024
Field duration (days)	98	93
Fertilizer (kg/ha): N, P, K, S Zn		
F_1=Recommended doses	138-20-83-18-4.5	121-18-75-18-4.5
F_2=Pattern based doses	144-8-60-4-2	144-8-60-4-2

Result and Discussion

The interaction effect of fertilizer management options and nitrogen fertilizer application schedule for grain yield was no significant in both BRRI dhan74 and BRRI dhan98. The individual effect of fertilizer management options for grain yield in both BRRI dhan74 and BRRI dhan98 was not significant. The individual effect of nitrogen fertilizer application schedule for grain yield was significant in both BRRI dhan74 and BRRI dhan98.

Table 26. Effect of fertilizer managements on grain yield of late Boro rice, BRRI, Gazipur, 2024

Treatments	Grain yield (t/ha)	
	BRRI dhan74	BRRI dhan98
N_1	6.08a	6.47a
N_2	5.61ab	6.36a
N_3	4.89b	5.86b
CV(%)	10.46	5.92

Means with the same letter are not significantly different

N_1=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

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

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

The results showed that for BRRI dhan74 and BRRI dhan98, there was no statistical variation in the recommended doses and pattern-based doses of fertilizer on grain yield. In case of BRRI dhan74, total cost of fertilizer in recommended doses (F_1) and pattern-based doses (F_2) were 24283 Tk/ha and 15039 Tk/ha respectively. In the case of BRRI dhan98, total cost of fertilizer in recommended doses (F_1) and pattern-based doses (F_2) were 22697 Tk/ha and 15039 Tk/ha. So, use of pattern-based doses for both varieties (BRRI dhan74 and BRRI dhan98) is more appropriate. In case of nitrogen fertilizer application schedule, for both variety grain yield significantly increases in N_1. For BRRI dhan74 there is significant variation among N_1, N_2 and N_3 in grain yield, for BRRI dhan98 there is no significant variation between N_1 and N_2 in grain yield. Applying nitrogen fertilizer in the following schedule appears to be useful for late Boro yield performance: ($\frac{1}{4}$ 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). This study will be repeated for a valid conclusion.

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

S Pramanik, ABMJ Islam, 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 compare the yield performance of aged seedling of T. Aman rice through nitrogen fertilizer and crop management techniques

Materials and Methods

The experiment was conducted at East Byde in T. Aman season, 2023 at Bangladesh Rice Research Institute (BRRI) farm, Gazipur. In transplanting, twenty, thirty and forty-day-old seedlings of BRRI dhan71 were transplanted on 26 July, 06 August and 16 August 2023 respectively at a spacing of 20 cm × 20 cm using 3-4 seedlings per hill. The full dose of P-K-S-Zn was applied as per treatments during final land preparation. The experiment was set up using a split plot design with three replications, with the main plot's fertilizer management and the subplot's seedling age.

Treatments

Factor A: Fertilizer (Main plot)
F_1= Recommended dose
F_2= Recommended dose + 20% Nitrogen
F_3= Recommended dose + 40% Nitrogen

Factor B: Seedling age (Sub plot)
S_1 = 20-day-old seedling
S_2 = 30-day-old seedling
S_3 = 40-day-old seedling
S_4 = 30-day-old seedling + laddering at 14 DAT
S_5 = 40-day-old seedling + laddering at 14 DAT

Result and Discussion

The grain yield of BRRI dhan71 was shown to be significantly impacted by seedling age treatments, and their interactions in T. Aman 2023. In combination with the appropriate fertilizer dose and an additional 20% nitrogen fertilizer (urea), the treatment S_5 produced a greater yield (5.4 t/ha). In all three fertilizer treatments, the yield from seedlings that were thirty days old was reduced. In the case of fertilizer, recommended dose of urea and additional 20%

urea are not statistically comparable on grain yield and showed greater grain yield than recommended dose with 40% urea. The grain yield of S_2 and S_4 are comparable. Thirty-day-old seedlings with laddering at 14 DAT showed greater yield (5.1 t/ha) than with no laddering (3.9 t/ha). In all three fertilizer management scenarios, the grain yields of S_3, S_4, and S_5 were not comparable. This study will be repeated for a valid conclusion.

Table 27. The yield performance of BRRI dhan71 aged seedlings using crop management techniques and nitrogen fertilizer, BRRI, Gazipur, 2023

Treatments	Grain yield (t/ha) Seedling age				
Fertilizer Management	S_1	S_2	S_3	S_4	S_5
F_1=Recommended dose	4.0B	3.5B	5.3A	5.1A	5.4A
F_2= Recommended dose +20% urea	3.9B	3.9B	5.1A	5.0A	5.4A
F_3= Recommended dose +40% urea	4.0B	3.7B	5.0A	4.8A	5.0A
CV%			9.35		

Means with the same letter are not significantly different.
S_1 = 20-day-old seedling, S_2 = 30-day-old seedling, S_3 = 40-day-old seedling, S_4 = 30-day-old seedling + laddering at 14 DAT, S_5 = 40-day-old seedling + laddering at 14 DAT

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

ABMJ Islam, S Pramanik, A Khatun and M Ibrahim

Introduction

Agriculture, dominated by crop, is one of the major sectors for food security of Bangladesh. Among the crops, cereals occupy about 75% of total cropped area, of which about 96% belongs to rice (Sarwar and Biswas, 2021). About 70% of the agricultural GDP and one-sixth of the nation's total revenue come from the rice trade (Sayeed and Yunus, 2018). Rice is the staple food of Bangladesh. In addition, it is a dominant driver of social and political stability (Nath, 2015). Boro-Fallow-T. Aman cropping pattern has been a traditional practice in Bangladesh, ensuring the effective utilization of water resources and the adaptation to the country's agro-climatic conditions. About 2.3 million hectares of land are cultivated under this cropping pattern which covers 27% net cropped area of Bangladesh (Nasim *et al., 2*017). Total rice production of this pattern could be increased by introducing newly released BRRI rice varieties in both Boro and Aman seasons.

Objective: To find out the best performances of newly released BRRI rice varieties in Boro - Fallow-T. Aman cropping pattern.

Materials and Methods

An activity was started from the T. Aman season of 2023 at research station of BRRI head quarter, Gazipur. The soil of the experimental field is Chhiata clay loam, a member of the fine, hyperthermic Vertic Endoaquept (Saleque *et al.*, 2004). Promising modern rice varieties like BRRI dhan87 and BRRI dhan103 were grown in T. Aman season. In Boro season, BRRI dhan92, BRRI dhan100, BRRI dhan102, BRRI dhan104, BRRI dhan105 and BRRI dhan107 were cultivated under Boro-Fallow-T. Aman cropping pattern. BRRI dhan49-Fallow-BRRI dhan29 was considered as control pattern. A total number of 13 combinations for Boro-Fallow-T. Aman cropping pattern were evaluated during 2023-24 (Table 28).

Treatments

CP_1=BRRI dhan92-Fallow-BRRI dhan87

CP_2=BRRI dhan92-Fallow-BRRI dhan103

CP_3=BRRI dhan100-Fallow-BRRI dhan87

CP_4=BRRI dhan100-Fallow-BRRI dhan103

CP_5=BRRI dhan102-Fallow-BRRI dhan87

CP_6=BRRI dhan102-Fallow-BRRI dhan103

CP_7=BRRI dhan104-Fallow-BRRI dhan87

CP_8=BRRI dhan104-Fallow-BRRI dhan103

CP_9=BRRI dhan105-Fallow-BRRI dhan87

CP_{10}=BRRI dhan105-Fallow-BRRI dhan103

CP_{11}=BRRI dhan107-Fallow-BRRI dhan87

CP_{12}=BRRI dhan107-Fallow-BRRI dhan103

CP_{13}=BRRI dhan29-Fallow-BRRI dhan49 (Check)

Table 28. Crop management adopted for Boro-Fallow-T. Aman cropping pattern, BRRI, Gazipur 2023-24

Factors	Boro	T. Aman
Seeding date	28 Nov. 2023	BRRI dhan87: 26 Jun. 2023 BRRI dhan103: 28 Jun. 2023
Transplanting date	08 Jan. 2024	BRRI dhan87: 18 Jul. 2023 BRRI dhan103: 24 Jul. 2023
Spacing (cm×cm)	20×15	20×15
Seedling/hill	2-3	2-3
Fertilizer (kg/ha): N, P, K, S & Zn	(120-19-60-18 & 3) * (137-19-82-18 & 4) **	76-12-52-12 & 0
Basal (kg/ha): N, P, K, S & Zn	(0-19-60-18 & 3) * (0-19-82-18-4) **	26-12-52-12 & 0
N top dress (Amount & DAT)	$^1/_3$ rd each at 15, 25 & 40 DAT	$^1/_3$ rd each at 15 & 30 DAT
Weeding	3 times at urea top dressing	2 times at urea top dressing
Maturity date	BRRI dhan29, 92, 102=06-08 May 2024 BRRI dhan100=24-26 Apr 2024 BRRI dhan104, 105=30 Apr.-02 May 2024	BRRI dhan87: 01 Nov. 2023 BRRI dhan103: 06 Nov.2023

*For BRRI dhan100, ** For BRRI dhan29, 92, 102, 104, 105 & 107

Results

During T. Aman season, BRRI dhan103 produced significantly higher yield (4.85 to 4.96 t/ha), whereas BRRI dhan87 yield ranged from 4.33 to 4.59 t/ha. The highest yield was obtained from CP_2 pattern, where BRRI dhan103 produced 4.96 t/ha of grain. And BRRI dhan87 gave the lowest yield in CP_3 (4.33 t/ha). During Boro season, BRRI dhan92 produced the highest grain yield (7.36 t/ha in CP_2 followed by CP_1 (7.19 t/ha). Statistically similar yield (7.08 t/ha) was found from BRRI dhan102 in CP_5. In CP_6, BRRI dhan102 was produced 7.06 t/ha grain yield which was statically similar with BRRI dhan102 of CP_5 (7.08 t/ha). The lowest grain yield (6.27 t/ha) was obtained from BRRI dhan104 in CP_8. BRRI dhan100, BRRI dhan104 and BRRI dhan107 gave statistically similar yield. Among the thirteen combinations of Boro and T. Aman rice varieties, the highest total grain yield (12.32 t/ha) was attained from BRRI dhan92-Fallow-BRRI dhan103 (CP_2), which was statistically similar (12.00 t/ha) to BRRI dhan102-Fallow-BRRI dhan103 (CP_6). In contrast, CP_{13} (BRRI dhan29-Fallow-BRRI dhan49) gave the lowest grain yield (10.81 t/ha) followed by CP_3 (10.84 t/ha) (Table 29).

Table 29. Yield performances of Boro-Fallow-T. Aman cropping patterns with newly released BRRI varieties, BRRI, Gazipur, 2023-24

Cropping pattern	Yield (t/ha)		
	Boro	T. Aman	Total grain yield
CP_1=BRRI dhan92-Fallow-BRRI dhan87	7.19 ab	4.45 bc	11.65 b
CP_2=BRRI dhan92-Fallow-BRRI dhan103	7.36 a	4.96 a	12.32 a
CP_3=BRRI dhan100-Fallow-BRRI dhan87	6.51 cde	4.33 c	10.84 g
CP_4=BRRI dhan100-Fallow-BRRI dhan103	6.34 de	4.86 a	11.20 cf
CP_5=BRRI dhan102-Fallow-BRRI dhan87	7.08 ab	4.37 bc	11.45 bcd
CP_6=BRRI dhan102-Fallow-BRRI dhan103	7.06 b	4.94 a	12.00 a
CP_7=BRRI dhan104-Fallow-BRRI dhan87	6.36 de	4.59 b	10.95 fg
CP_8=BRRI dhan104-Fallow-BRRI dhan103	6.27 e	4.87 a	11.14 d-g
CP_9=BRRI dhan105-Fallow-BRRI dhan87	6.59 cd	4.50 bc	11.09 efg
CP_{10}=BRRI dhan105-Fallow-BRRI dhan103	6.68 c	4.85 a	11.53 bc
CP_{11}=BRRI dhan107-Fallow-BRRI dhan87	6.58 cd	4.55 bc	11.13 dg
CP_{12}=BRRI dhan107-Fallow-BRRI dhan103	6.55 cde	4.85 a	11.40 be
CP_{13}=BRRI dhan29-Fallow-BRRI dhan49 (Control)	6.30 de	4.52 bc	10.81 g
CV (%)	2.69	3.13	1.82

Means with the same letter(s) are not significantly different. Price (Tk/kg): Rice=35, Straw: Boro=2.5, T. Aman=6.5

Cost and return analysis showed that CP_2 had maximum GM (2,49,109 Tk/ha) with the highest MBCR (18.80) followed by CP_6 (14.09). And the lowest MBCR (-0.04) was recorded in CP_3 with the minimum gross margin (1,94,716 Tk/ha) followed by CP_{13} (1,95,873 Tk/ha) (Table 30).

Table 30. Cost and return analysis of Boro-Fallow-T. Aman cropping patterns with newly released BRRI varieties, BRRI, Gazipur, 2023-24

Cropping pattern	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
CP_1=BRRI dhan92-Fallow-BRRI dhan87	234	224	11.54
CP_2=BRRI dhan92-Fallow-BRRI dhan103	235	249	18.80
CP_3=BRRI dhan100-Fallow-BRRI dhan87	233	195	-0.04
CP_4=BRRI dhan100-Fallow-BRRI dhan103	233	208	9.61
CP_5=BRRI dhan102-Fallow-BRRI dhan87	235	216	8.30
CP_6=BRRI dhan102-Fallow-BRRI dhan103	235	237	14.09
CP_7=BRRI dhan104-Fallow-BRRI dhan87	235	199	1.98
CP_8=BRRI dhan104-Fallow-BRRI dhan103	235	204	3.67
CP_9=BRRI dhan105-Fallow-BRRI dhan87	235	203	3.70
CP_{10}=BRRI dhan105-Fallow-BRRI dhan103	235	219	8.33
CP_{11}=BRRI dhan107-Fallow-BRRI dhan87	235	205	4.33
CP_{12}=BRRI dhan107-Fallow-BRRI dhan103	235	214	6.77
CP_{13}=BRRI dhan29-Fallow-BRRI dhan49 (Control)	232	196	-

TVC-Total variable cost, GM-Gross margin, MBCR-Marginal benefit-cost ratio

Expt. 2.7. Effect of establishment methods and varieties on productivity, profitability and heat stress of late planted Boro rice in Potato-Rice-Rice cropping systems in Northern Bangladesh

A Khatun, ABMJ Islam, MK Quais and M Ibrahim

Introduction

In South Asia, researchers have encouraged a shift from the most dominant agronomic method of rice crop establishment, widely referred to puddled transplanted rice, to dry seeded rice (DSR). DSR can dramatically reduce production costs as well as improve and reduce the

environmental impact of rice production. For farmers that transition from transplanted rice to DSR, however, significant changes in management practices and often the use of agricultural machinery are needed. DSR is established without standing water in the field and this saves labour and water, cultivation costs, and can lower greenhouse gas emissions. Although DSR has benefits, farmers tend to emphasize that it also has risks that limit its adoption in South Asia, including Bangladesh. Examples of these concerns include poor and uneven crop establishment, weed management challenges, and lack of Suitable cultivars for DSR. In addition, soil needs to be of the right texture, and farmers need to be able to carefully manage irrigation and flood water depths.

Objectives

i) To increase the profitability and sustainability of late-planted Boro rice.

ii) To increase the system productivity and resource use efficiency of potato-rice-rice cropping systems.

iii) To find the more heat-tolerant variety for the late Boro.

Materials and Methods

The trials were established in two locations (Nilphamari and Rangpur) in split-plot design and in each location, there were six farmer's fields (6 replications) during 2023-24. The two establishment methods were (i) dry direct-seeded rice (DSR) and (ii) manual transplanting in puddled soil (TPR). The rice varieties BRRI dhan74, BRRI dhan75, BRRI dhan96, BRRI dhan98, BRRI dhan100 and BRRI dhan102 in Boro season and BRRI dhan71, BRRI dhan75, BRRI dhan93, BRRI dhan95 and BRRI dhan103 in Aman season were used in the trials. In the trial area farmers adopted Swarna in Aman season and BRRI dhan28 in Boro season. In Aman season, DSR was established during 10th to 12th July both in Nilphamari and Rangpur at different farmers' fields. TPR was done during 27th to 29th July with 23–25 day-old seedlings both in Nilphamari and Rangpur. Harvesting of Aman rice was done during the 3rd week of October to 2nd week of November in both sites. The potato variety Lady Gold and Courage were grown during the transition period. In Boro season, DSR was established during 11th to 13th February in Nilphamari and 15th to 17th March in Rangpur at different farmers' fields. TPR was done during 12th to 13th March in Nilphamari with 33 day-old seedlings and 14th to 15th March in Rangpur with 40 day-old seedlings at selected farmers' fields. DSR was harvested during the 2nd to 4th week of June in Nilphamari. But in Rangpur, its harvesting date was during the 2nd to 3rd week of July. TPR was harvested during the 3rd to 4th week of June in both the sites. Cropping pattern based recommended fertilizer management and other agronomic, pest management, water management practices were performed accordingly to individual crop requirements.

Results

On average the potato yield was 22.4 t/ha. Between the two locations, the potato yield in Nilphamari was greater (23.2 t/ha) than in Rangpur (21.5 t/ha) (Table 31).

Table 31. Yield of Potato under Potato–Rice–Rice cropping pattern, 2023-24

Location/District	Potato yield (t/ha)		
	B_1	B_2	Avg.
Nilphamari	24.6	21.8	23.2

Rangpur	22.3	20.7	21.5
Grand Mean			22.4

B=Block; Each block consists of 6 bighas of land.

In Boro season, irrespective of varieties, in most of the cases TPR performed better than the DSR in Nilphamari. Irrespective of establishment method, BRRI dhan98, BRRI dhan96 and BRRI dhan75 produced the higher yield. BRRI dhan102 gave the lower yield under both the establishment methods in Nilphamari site (Table 32). In Rangpur site, irrespective of varieties, the yield performance of TPR showed significantly higher compared to DSR. BRRI dhan98, BRRI dhan96, BRRI dhan75 and BRRI dhan74 gave the higher yield among the varieties (Table 32). In both sites, the DSR had a 7-20% lower yield than the transplanted rice. The lower yield of DSR was mainly due to once the DSR crop reached the maturity stage there were no other crops in the field. Therefore, the rate of damage of crops by birds and insects was higher than the transplanted rice specially in Rangpur. It is noted that transplanted rice was harvested two weeks earlier than the DSR due to transplanting seedlings being raised in separate places. In both locations, BRRI dhan98 produced a higher yield followed by BRRI dhan96 (Table 32).

Table 32. Site-wise **g**rain yield of Boro varieties under different establishment methods, 2023-24

Variety	Nilphamari		Rangpur	
	Grain yield (t/ha)			
	DSR	TPR	DSR	TPR
BRRI dhan74	7.22	7.55	4.34	7.07
BRRI dhan 75	7.42	7.59	4.35	7.63
BRRI dhan 96	7.44	7.70	4.39	7.67
BRRI dhan 98	7.69	7.74	4.69	7.75
BRRI dhan100	6.83	6.95	3.41	6.38
BRRI dhan102	5.53	6.41	3.16	6.90
CV (%)	6.9		8.2	
LSD $_{0.05}$ for Var	0.21		0.27	
LSD $_{0.05}$ for EM	0.17		0.39	
LSD$_{0.05}$ for Var x EM	0.34		0.47	

In Aman season, the individual effect of establishment method and the interaction effect of variety and establishment method showed insignificant in Nilphamari site. The grain yield of the tested varieties showed similar under two establishment methods (Table 33). Among the varieties, BRRI dhan75 gave the higher yield followed by BRRI dhan103 and BRRI dhan93. A similar scenario was observed in Rangpur site. BRRI dhan71 gave the lower yield in both the sites (Table 33).

Table 33. Site-wise grain yield of Aman varieties under different establishment methods, 2023

Variety	Nilphamari		Rangpur	
	Grain yield (t/ha)			
	DSR	TPR	DSR	TPR
BRRI dhan71	5.24	5.74	5.22	5.53
BRRI dhan75	6.72	6.85	6.31	6.44
BRRI dhan 93	6.38	6.24	5.91	6.25
BRRI dhan 95	6.26	6.11	6.37	6.19
BRRI dhan 103	6.56	6.71	6.16	6.32
CV (%)	7.2		6.5	
LSD $_{0.05}$ for Var	0.43		0.36	
LSD $_{0.05}$ for EM	NS		NS	

$LSD_{0.05}$ for Var x EM	NS	0.47

Farmer's reaction

The DSR system eliminates the need of puddling and reduces the irrigation water and labor requirement although in some cases yield declined. The yield of DSR is mostly related to the use of proper management practices. Farmers are so happy with this technology, but they gave the opinion that policy formulation for development of appropriate irrigation strategy and seeding machinery would help rapid adoption of the technology.

Expt. 2.8. Cropping systems intensification through introduction of diversified crops under Rice-Rice Cropping Systems

A Khatun, ABMJ Islam, MK Quais and M Ibrahim

Introduction

Bangladesh is a land-scarce rice-based country. About 75% of the crop land is devoted to rice and there is little scope for the diversion of land from cereal to non-cereal crops. Double rice that is Boro-Fallow-T. Aman rice is the widely practiced cropping pattern in the high to medium high land of irrigated environment covering 1.8 million hectares of land which is about 22% of the total land area. Harvesting of T. Aman rice begins from the middle of November and continues up to middle of December depending on growth duration, transplanting time and photosensitivity of varieties. 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 high valued rabi crops, which may increase the total productivity of the system.

Objectives

i) To intensify the existing cropping systems through the inclusion of diversified crops

ii) To increase the system productivity, profitability and sustainability of the existing Rice-Rice cropping systems

Material and methods

This activity is continuing in 45 farmers' fields in Nilphamari. BRRI provided BRRI dhan100 and BRRI dhan102 seeds among 45 farmers (15 farmers for each variety) in Boro season, short duration premium quality rice varieties BRRI dhan71 and BRRI dhan75 in Aman season. Farmers of that locality normally use BRRI dhan28 in Boro season and Swarna in Aman season. After Aman harvest, mustard and field pea cultivated as transition period crops to bring intensification and diversification. The variety BARI Sarisha-14 and BARI Motor-1 for mustard and field pea, respectively, were used in the experiment.

Results

The mustard yield ranged from 0.85 to 1.21 t/ha and the field pea yield ranged from 3.68 to 4.15 t/ha in different locations, respectively. In Boro season, BRRI dhan102 gave the greater yield (8.19 t/ha) compared to BRRI dhan100 (6.59 t/ha) (Fig 7). In Aman season, BRRI dhan71 and BRRI dhan75 yielded 5.45 t/ha and 6.05 t/ha, respectively, averaging over different farmers' fields (Fig 8). In this study two interventions were made. Firstly, rabi crops were included in the existing cropping patterns and at the same time traditional variety was replaced with the recently released BRRI varieties. Due to this intervention all the combinations

performed better than the existing cropping pattern. In terms of rice equivalent yield (REY), introduction of field pea was found to be more productive compared to all other combinations (Table 34).

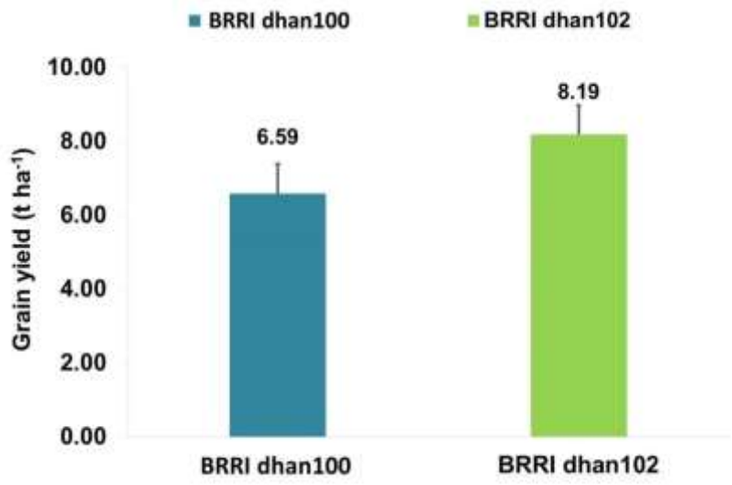

Figure 7. Grain yield of Boro rice in Nilphamari district

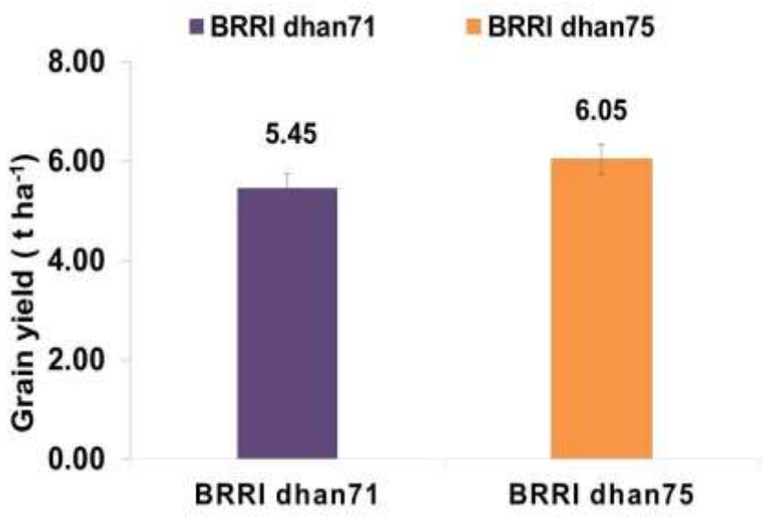

Figure 8. Grain yield of Aman rice in Nilphamari district

Table 34. Yield performance of Rabi crops-Boro-T. Aman cropping pattern in Nilphamari district, 2023-24

Cropping system	Grain/Pod yield (t/ha)				REY (t/ha)
	Mustard	Field pea	Boro	T. Aman	
Mustard – BRRI dhan100 – BRRI dhan71	1.13	--	6.91	5.52	15.57c
Field pea – BRRI dhan100 – BRRI dhan71	--	4.03	6.87	5.21	24.39a
Mustard – BRRI dhan102 – BRRI dhan71	1.21	--	8.84	5.44	17.64b
Field pea – BRRI dhan102 – BRRI dhan71	--	3.78	8.57	5.63	25.75a
Mustard – BRRI dhan100 – BRRI dhan75	0.85	--	6.10	6.33	14.79c
Field pea – BRRI dhan100 – BRRI dhan75	--	4.15	6.48	6.12	25.28a
Mustard – BRRI dhan102 – BRRI dhan75	0.97	--	7.38	5.89	15.96c
Field pea – BRRI dhan102 – BRRI dhan75	--	3.68	7.96	5.84	25.04a
Fallow – BRRI dhan28 – Swarna (Check)	--	--	5.63	5.55	11.18d

Price (Tk/kg): Mustard=50, Field pea=55, Rice=18.

Farmer's reaction

Most of the farmers did not know that any high-value crops like mustard and field pea could be cultivated successfully during the transition period of Aman and Boro cultivation. Rice is their main crop, and they are not interested in sacrificing rice yield. Through this study, they got extra benefit from mustard and field pea which helped them to curtail their household costs for edible oil and nutritious Vegetables. Moreover, they enjoyed high market prices from the early harvest of field pea as winter vegetable.

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

Expt. 3.1. Improvement of Boro-Fallow-T. Aman cropping pattern with BRRI newly released rice varieties

N Parvin, MA Razu, BJ Shirazy

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. Fallow-Fallow-T. Aman is the dominant cropping pattern in the Khulna region where it is distributed to 17 upazilas which is 26.76% of NCA (Nasim *at al.,* 2017). In this area, farmers cultivated only single T. Aman local variety named Morichshail, Chapshail etc. at Aman season. Though there is unavailability of irrigation in that areas but there were some pocket areas where minimum irrigation facilities were remaining. That is why there was a scope of cultivating saline tolerant Boro rice during Rabi season in Fallow-Fallow-T. Aman cropping system. Therefore, this study was designed to increase the productivity and cropping intensity of the coastal saline environment of Bangladesh by including salt tolerant Boro rice varieties in Boro season and modern T. Aman variety against local Aman variety in the Fallow-Fallow-T. Aman cropping pattern.

Objectives

i) To find out the Suitable BRRI released Boro rice varieties for Fallow-Fallow-T. Aman cropping pattern

ii) To maximize the productivity and income

Materials and Methods

The study was conducted in the farmers' field of Batiaghata upazila of Khulna district during 2023-2024. 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. Two salt tolerant modern Boro varieties were included to construct the cropping pattern treatments as follows:

i) BRRI dhan67-Fallow-BRRI dhan87

ii) BRRI dhan99-Fallow-BRRI dhan23

iii) BRRI dhan28 -Fallow-T. Aman (local) (Check)

Ten different farmers' fields were used in the trial where each field was considered as one replication. BRRI dhan99 and BRRI dhan67 were transplanted on 30 January, 2024 with 30 days old seedling. BRRI dhan87 and BR23 were transplanted on 12 and 15 August respectively, with 25 to 28 days old seedling. 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

The average grain yield of salt tolerant Boro variety BRRI dhan99 and BRRI dhan67 was 5.60 t/ha and 5.86 t/ha against BRRI dhan28 (5.37 t/ha). On the other hand, the average grain yield of BRRI dhan87 was 4.43 t/ha and BR23 was 4.39 t/ha against the local variety Ranisalute (2.1 t/ha) (Table 35). The results showed that maximum total rice production (10.2 t/ha), gross margin (83,000 Tk/ha)) and MBCR (1.57) obtained from the cropping pattern BRRI dhan67-Fallow-BRRI dhan87 followed by BRRI dhan99-Fallow-BR23 against the existing BRRI dhan28-Fallow-local T. Aman cropping pattern (Table 35).

Table 35. Yield and economics of Boro-Fallow-T. Aman cropping pattern, Batiaghata, Khulna, 2023-2024

Cropping pattern	Yield (t/ha)		Total rice production (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Boro	T. Aman				
Boro (BRRI dhan67)-Fallow-T. Aman BRRI dhan87)	5.86	4.43	10.2	181	83	1.57
Boro (BRRI dhan99)-Fallow-T. Aman BR23)	5.60	4.39	9.8	174	79	1.55
Boro (BRRI dhan28)-Fallow-T. Aman (local) (Check)	5.37	2.1	7.47	155	69	-

Rice Price:26 Tk/kg; local Ranisalute: 30 Tk/kg; TVC=Total Variable Cost, GM=Gross Margin, MBCR= Marginal Benefit Cost Ratio

Expt. 3.2. Intensification of Watermelon-Fallow-T. Aman cropping pattern by inclusion of Aus rice

N Parvin, MA Razu, BJ Shirazy

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 and to increase the production efficiency of the individual crop by using optimum management practices. Watermelon-Fallow-T. Aman cropping pattern occupies 2100 ha out of 18,770 ha NCA of Dacope upazila under Khulna region (Nasim *et al.,* 2017). There is a fallow period of about 3.5 to 4.0 months after watermelon and before Aman in the existing system. Therefore, it is possible to grow short duration Aus rice variety 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.

Objectives

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

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

Materials and methods

The study was conducted in the farmers' field of Dacope upazila in Khulna district during 2023-24. This activity was executed in collaboration with Department of Agricultural Extension at Dacope, Khulna. Modern T. Aus rice variety was included to intensify the existing cropping pattern treatments as follows:

i) Watermelon (Hybrid) -T. Aus (BRRI dhan98)-T. Aman (BRRI dhan87)

ii) Watermelon (Hybrid)-Fallow-T. Aman (Morichshail)

Ten different farmers' fields were used in the trial where each field was considered as one replication. Aus variety BRRI dhan98 was transplanted after watermelon harvest which remains fallow up to T. Aman transplant. Aman variety BRRI dhan87 was evaluated instead of farmers' existing T. Aman local variety (Morichshail) which was transplanted on 14 August, 2024. 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:

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

Results

In T. Aman season, the average yield of BRRI dhan87 was 4.3 t/ha against the local variety (Morichshail) (1.8 t/ha). This yield was slightly lower due to rat attacks in early mature stage than local variety and tide water was entering during the reproductive stage. The average yield of watermelon was 44.8 t/ha. After watermelon, T. Aus was cultivated in fallow period which yielded 5.9 t/ha in Watermelon-T. Aus-T. Aman cropping pattern. For this new inclusion of T. Aus, the total rice productivity (TRP) increased 467%. The maximum rice equivalent yield (REY) (43.24 t/ha), Total rice productivity (TRP) (10.2 t/ha), Gross Margin (7,93,330 Tk/ha) and MBCR (3.72) was obtained from the Watermelon-T. Aus-T. Aman cropping pattern against the existing cropping pattern Watermelon-Fallow-T. Aman. (Table 36).

Table 36. Yields and economic analysis of different crops under Watermelon-T. Aus-T. Aman cropping pattern, Dacope, Khulna, 2023-2024

Cropping pattern	Yield (t/ha)				REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MB CR
	Watermelon	T. Aus	T. Aman	TRP (t/ha)				
ICP:Watermelon (Hybrid) -T. Aus (BRRI dhan98)-T. Aman (BRRI dhan87)	44.80	5.9	4.3	10.2	43.24	330.92	793.3	3.72
ECP:Watermelon (Hybrid)-Fallow-T. Aman (Morichshail)	41.30	-	1.8	1.8	33.40	262.20	606.3	-

ICP=Improved Cropping Pattern, ECP=Existing Cropping Pattern, TRP=Total Rice Productivity, REY=Rice Equivalent Yield, TVC=Total Variable Cost, GM=Gross Margin, MBCR=Marginal Benefit Cost Ratio
Price (Tk/kg): Rice = 26; watermelon = 19.2

Expt. 3.3. Utilization of fallow land to intensify the single T. Aman area and boost up the productivity in the Sylhet region

ABMJ Islam, MK Quais, A Khatun and M Ibrahim

Introduction

Rice is the dominant crop in Nabiganj upazila of Habiganj district. Cropping intensity in the Sylhet agricultural region has been almost constant for the past twenty years (BBS 2011, 2014, 2015). After all, agriculture is the primary source of income for farmers (Banglapedia, 2004). The rapid increase in human population creates additional pressure on natural resources at above optimal levels of their inherent potential, which resulted in the loss of biodiversity, serious soil erosion leading to depletion of plant nutrient, gradual degradation and decline in productivity and carrying capacity, etc. (Borthakur *et al.*, 1998). Government of Bangladesh suggested both the horizontal and vertical extension approach to increase the food production in the country to meet up the demand for the growing population from the shrinking land resources. The net cropped area of Nabiganj upazila is about 25,010 hectares of land. Seventy–five percent cultivable land (18,790 ha.) of this upazila is under single cropping system. Boro-Fallow-Fallow and Fallow-Fallow-T. Aman are two dominant cropping patterns of Nabiganj upazila. About 31% of cultivable land is covered with Fallow-Fallow-T. Aman cropping pattern (Muttaleb *et al.* 2017). In the fallow period of these patterns, there may still be scope of inclusion of other crops. The productivity of the existing cropping pattern could be increased by growing T. Aus rice in the fallow period before T. Aman rice. Keeping this view in mind, the present study was undertaken to intensify the existing Fallow-Fallow-T. Aman cropping pattern through inclusion of modern T. Aus and to increase the productivity of the system.

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

Materials and Methods

A total of fifteen trials were conducted in the farmers' field of Nabiganj, Habiganj district in collaboration with DAE. The study was initiated to improve the single T. Aman Cropping pattern in Sylhet region. There are two ways for this improvement. One is the utilization of fallow period through inclusion of T. Aus in Kharif-I season. The other is the replacement of existing variety by latest released higher yielding variety in T. Aman season. Both approaches were applied in the activity. Promising modern rice variety BRRI dhan98 was grown in Aus season. During T. Aman season BRRI dhan71, BRRI dhan75, BRRI dhan87 and BRRI dhan103

were cultivated under Fallow-T. Aus-T. Aman cropping pattern. Fallow-Fallow-BRRI dhan49 was considered as control pattern. BRRI recommended management practices were followed for cultivating the varieties (Table 37).

Table 37. Crop management adopted for Fallow-T. Aus-T. Aman cropping pattern, Nabiganj, Habiganj, 2023

Factors	**T. Aus**	**T. Aman**
Variety	BRRI dhan98	BRRI dhan71, 75, 87 and 103
Seeding date	06 May 2023	BRRI dhan71, 75: 14 July 23 BRRI dhan87: 12 July 23 BRRI dhan103: 12 Aug 23
Transplanting date	31 May 2023	BRRI dhan71,75: 26 July 23 BRRI dhan87: 29 July 23 BRRI dhan103: 04 Sep. 23
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	2 times at urea top dressing
Maturity date	31 August 2023	BRRI dhan71, 75: 05-11 Nov. 23 BRRI dhan87: 20 Nov. 23 BRRI dhan103: 25 Dec23

*For BRRI dhan71, 75, ** for BRRI dhan87, 103

Results

BRRI dhan98 produced 5.78 to 5.91 t/ha of grain during Aus season. In T. Aman season, BRRI dhan87 yielded the highest grain yield (5.28 t/ha) followed by BRRI dhan103 (4.83 t/ha). Statistically similar yield (4.67 t/ha) was obtained from farmer's adopted variety BRRI dhan49. Among the four improved cropping patterns, CP_3 yielded the maximum total grain yield (11.09 t/ha), with the highest gross margin (1,87,165 Tk/ha), whereas CP_2 harvested the minimum total grain yield (10.13 t/ha). Statistically similar total grain yield was found from CP_1 (10.39 t/ha). The existing cropping pattern, Fallow-Fallow-BRRI dhan49 (CP_5) yielded the lowest grain yield (4.67 t/ha). Maximum MBCR was recorded from CP_3 (2.01) followed by CP_4 (1.86). And the lowest MBCR was found in CP_2 (1.72) followed by CP_1 (1.78) (Table 38).

Table 38. Yield and profitability of Fallow-T. Aus-T. Aman cropping pattern, Nabiganj, Habiganj, 2023

Cropping pattern	Yield (t/ha)			TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	T. Aus	T. Aman	Total grain yield			
CP_1=Fallow-BRRI dhan98-BRRI dhan71	5.91	4.48 cd	10.39 bc	222	161	1.78
CP_2=Fallow-BRRI dhan98-BRRI dhan75	5.78	4.34 d	10.13 c	220	152	1.72
CP_3=Fallow-BRRI dhan98-BRRI dhan87	5.81	5.28 a	11.09 a	224	187	2.01
CP_4=Fallow-BRRI dhan98-BRRI dhan103	5.85	4.83 b	10.68 b	224	171	1.86
CP_5=Fallow-Fallow-BRRI dhan49(CK.)	-	4.67 bc	4.67 d	110	72	-
CV (%)	3.05	3.33	2.02		-	-

Means with the same letter(s) are not significantly different. Price (Tk/kg): Rice; Aus=32.5, Aman=32.5, Straw; Aus=2.5, Aman=6.5

Expt. 3.4. Modification of waterlogged fallow land into integrated agroforestry and fishery production system

MAU Razu, MK Quais, BJ Shirazy and M Ibrahim

Introduction

Waterlogging is a great problem for Bangladesh while it is very much site-specific hazard. Now-a-days due to special geographical location and climate, the water logging is one of the most serious hazards in southwest coastal region of Bangladesh. Besides, in relatively low-lying areas where due to waterlogging it is not possible to cultivate any crop normally except jute, Dhaincha or deep-water Aman. In that situation, a high raised bed and deep sink of different sizes can be constructed to make it suitable for diversified cultivation of crops, fruits, Vegetables, and fish together. In some coastal and char area of Bangladesh farmers generally grow only fish in the sink and Vegetable in raised bed which is known as Sorjan. If it is possible to grow perennial crops in raised bed with intercropping of different vegetables and spices and fish in sink then it will minimize the risks and maximize the benefits for individuals, households, and communities. Therefore, this study was undertaken with the following objectives.

Objectives

i) To bring waterlogged fallow land under year-round integrated production system through efficient utilization of different niches

ii) To identify the suitable agroforestry system for increasing productivity

iii) To explore the best production practices of fish, vegetables, and fruit production for increasing productivity

Materials and Methods

BRRI had some waterlogged marshy land area in east byde where nothing could be grown. This uncultivable fallow land caused environmental pollution, even threats to lives and inhabitants of the surroundings. This experiment was undertaken to convert this land type into a productive system as well as to ensure a pleasant environment. High raised bed (dyke) and deep sink (ditch) of different sizes were constructed during 2023-24 to develop a Suitable diversified cultivation system of vegetables, fruits, and fish. In this experiment, the raised bed (dyke) was planted with different perennial fruit crops where in between the fallow area of trees, different types of summer and winter crops and Vegetables were intercropped, and different creeper vegetables were grown in trellises (Table 39). Besides, in the deep sink (1m water depth), different fishes with six combinations were released with different size and stocking density. Fertilization and other intercultural operations were followed accordingly as per respective components (Table 40).

Table 39. List of crops and fishes used at different niches of integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

System	Niche		Crop/Fish
Agroforestry	Partially shady place	Rabi-Kharif crops at dyke	Red amaranth-Brinjal, Spinach-Jute leaf, Tomato-Kangkong, Coriander leaf-Stem amaranth, Cabbage-Chili and Black gram-Rice
		Rabi-Kharif crops at trellises	Country Bean-Malabar spinach, Pumpkin-Pumpkin, Bottle gourd-Ash gourd, Watermelon-Snake gourd, Yard long bean-Ridge gourd and Cucumber-Bitter gourd
	Open sunny space	Perennial fruit trees at dykes	Dragon fruit, Malta, Guava, Custard apple, Jujube and Mango
Fishery	Partially shady marshy land	Fish combinations at ditches	Shol+Shing, Tengra+Silver carp, Tilapia+Mrigal carp, Gulsha+Magur, Pabda+Shorputi and Rohu+Mirror carp

Table 40. Crop management practices under integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

Season	Crop	Variety	Cultivation method	Seed rate (kg/ha)	Seedling age	Spacing (cm×cm)	Field duration (days)
Rabi	Red amaranth	Altapeti	Broadcasting	2.5	-	-	97
	Spinach	Local	Broadcasting	35	-	-	102
	Tomato	BARI tomato-21	Transplanting	-	30	60×50	98
	Coriander leaf	Morokko Sobuj Shopno	Broadcasting	40	-	-	164
	Cabbage	Atlas 70	Transplanting	-	30	60×40	102
	Black. gram	BARI mash-6	Broadcasting	35	-	-	66
	Country Bean	IPSA 1	Dibbling	-	-	-	129
	Bottle gourd	Moyna	Dibbling	-	-	-	146
	Watermelon*	Zebra king, Kala chand, Manik	Dibbling	-	-	-	-
	Yard long bean	Green long	Dibbling	-	-	-	129
	Cucumber	Alvi	Dibbling	-	-	-	56
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	30	-	-	124
	Rice	BRRI dhan71	Line sowing		-	20×20	105
	Malabar spinach	Madhuri	Dibbling	-	-	-	87
	Ash gourd	Jaliraj	Dibbling	-	-	-	96
	Snake gourd	Suprima	Dibbling	-	-	-	95
	Ridge gourd	Ashim	Dibbling	-	-	-	97
	Bitter gourd	Papia super gold	Dibbling	-	-	-	96
Year-round	Pumpkin	Sweet ball	Dibbling	-	-	-	234

* Due to excessive cold, the seeds of watermelon did not germinate.

Results

A. Agroforestry system

Crops and Vegetables production

Productivity and economic return of year-round crops and vegetables production at dykes and trellises are presented in Table 41 and Table 42, respectively. From the 6 dykes, a total of 451.06 kg/dec (205.31 kg in Rabi season and 245.75 kg in Kharif season) of crops and vegetables were produced, from which gross return of Tk 22654.71 was obtained. The highest production was obtained from Cabbage (57.75 kg/dec) and Kangkong (84.19 kg/dec) during Rabi and Kharif seasons, respectively. Among the six cropping patterns tested on dykes under various fruit trees, the highest production was obtained from Coriander leaf-Stem amaranth (121.01 kg/dec), followed by Tomato-Kangkong (115.82 kg/dec), achieving gross return of Tk 7859.46 and Tk 4528.36, respectively per decimal area (Table 41). From the 6 trellises, a total of 169.71 kg/dec (84.12 kg in Rabi season and 85.59 kg in Kharif season) of crops and vegetables were produced, from which gross return of Tk 6611.32 was obtained. The highest production was obtained from Pumpkin (27.46 and 19.58 kg/dec) during Rabi and Kharif seasons, respectively. Among the six cropping patterns tested on dykes under various fruit trees, the highest production was obtained from Pumpkin-Pumpkin (47.04 kg/dec), followed by Country Bean-Malabar spinach (31.41 kg/dec), achieving gross return of Tk 1411.19 and Tk 1125.50, respectively per decimal area (Table 42).

Table 41. Productivity and profitability scenario of year-round crops and vegetables at dykes under integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

Pattern	Production (Kg/decimal)													
	Rabi						Kharif						Total	GR (Tk/dec)
	Red amaranth	Spinach	Tomato	Coriander leaf	Cabbage	Black gram	Brinjal	Jute leaf	Kangkong	Stem amaranth	Chili	Rice		
Red amaranth-Brinjal	23.64	-	-	-	-	-	10.74	-	-	-	-	-	34.38	1601
Spinach-Jute leaf	-	47.04	-	-	-	-	-	42.38	-	-	-	-	89.42	3789
Tomato-Kangkong	-	-	31.63	-	-	-	-	-	84.19	-	-	-	115.82	4528
Coriander leaf-Stem amaranth	-	-	-	38.67	-	-	-	-	-	82.34	-	-	121.01	7860
Cabbage-Chili	-	-	-	-	57.75	-	-	-	-	-	7.07	-	64.82	2216
Black gram-Rice	-	-	-	-	-	6.58	-	-	-	-	-	19.03	25.60	1133
Total													451.06	21127

Price (Tk/kg): Red amaranth=45, Spinach=40, Tomato=50, Coriander leaf=150, Cabbage=20, Black. gram=100, Brinjal=50, Jute leaf=45, Kangkong=35, Stem amaranth=25, Chili=150, Rice=25

Table 42. Productivity and profitability scenario of year-round crops and Vegetables at trellises under integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

Pattern	Production (Kg/decimal)													
	Rabi						Kharif						Total	GR (Tk/dec)
	Country Bean	Pumpkin	Bottle gourd	Watermelon	Yard long bean	Cucumber	Malabar spinach	Pumpkin	Ash gourd	Snake gourd	Ridge gourd	Bitter gourd		
Country Bean-Malabar spinach	12.20	-	-	-	-	-	19.21	-	-	-	-	-	31.41	1126
Pumpkin-Pumpkin	-	27.46	-	-	-	-	-	19.58	-	-	-	-	47.04	1411
Bottle gourd-Ash gourd	-	-	19.04	-	-	-	-	-	12.27	-	-	-	31.32	1219
Watermelon-Snake gourd	-	-	-	*	-	-	-	-	-	13.91	-	-	13.91	626
Yard long bean-Ridge gourd	-	-	-	-	8.44	-	-	-	-	-	10.79	-	19.23	962
Cucumber-Bitter gourd	-	-	-	-	-	16.97	-	-	-	-	-	9.82	26.79	1268
Total													169.71	6611

Price (Tk/kg): Country Bean=45, Pumpkin=30, Bottle gourd=35, Yard long bean=50, Cucumber=40, Malabar spinach=30, Ash gourd=45, Snake gourd=45, Ridge gourd=50, Bitter gourd=60

* Due to excessive cold, the seeds of watermelon did not germinate.

Fruits production

The fruit trees, being only two years old, have not yet reached significant bearing levels. However, the Guava, Jujube, and Mango trees produced 4.63, 3.36, and 3.69 kg of fruit per tree, respectively (Table 43).

Table 43. Productivity and profitability scenario of fruits production at dykes under integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

Pattern	Fruit	Production (kg)	No. of trees	Production (kg/tree)	GR (Tk)
1	Dragon Fruit	*	30	-	-
2	Malta	*	25	-	-
3	Guava	115.80	25	4.63	5790
4	Custard apple	**	25	-	-
5	Jujube	84.00	25	3.36	5880
6	Mango	92	25	3.69	9230

*Fruit bearing has not started. **Fruit was not harvested during the reporting period. Planting date: 12-20 June 2022, Price (Tk/kg): Guava=50, Jujube=70, Mango=100

B. Fishery system

Fish fingerlings were released with different combination due to utilization of the highest resources and optimum growth of the fry following recommendation of Bangladesh Fisheries Research Institute. In six ditches, six combinations were applied with different stocking density, initial weight and length. Maximum number of fingerlings (1200) were released in combination-4 and the lowest number (920) was for combination-6. The lowest initial length and weight of the fingerlings was for combination-2 whereas the highest was for combination-1 (Table 44). Fish were not harvested during this reporting period.

Table 44. Different fish combination released in the ditch under integrated agroforestry and fishery production system, BRRI, Gazipur, 2023-24

Combination	Fingerlings	Stocking density (pieces/decimal)	Fingerlings (No)	Initial length (cm)	Initial weight (g)
1	Tengra	150	600	5.7	4.5
	Silver carp	100	400	8.2	5.0
2	Shol	75	300	3.3	0.5
	Shing	200	800	3.4	0.6
3	Tilapia	140	560	8.7	4.5
	Mrigel	140	560	9.3	4.1
4	Rui	150	600	7.3	3.8
	Mirror carp	150	600	7.5	3.5
5	Pabda	200	800	6.6	2.0
	Sorputi	100	400	6.8	3.5
6	Gulsha	150	600	6.7	1.2
	Magur	80	320	4.5	0.7

Date of fish release: 11 September 2023

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

ABMJ Islam, MAU Razu, MK Quais, and M Ibrahim

Introduction

Waterlogging is a persistent problem resulting in damage to crops and therefore livelihood of the coastal people in the southwestern region of Bangladesh which is alarming. People of this region are bound to face this problem for 3-4 months every year and agricultural lands are hailed

under losing valuable agricultural yields. Besides the southwestern region, 43 percent of haor area is low lying. Mostly, these lands are only used for Jute, Dhaincha or deep-water Aman cultivation which minimizes the amount of profit. In this case, a sink and its banks can be constructed in such a way which is suitable for diversified cultivation of rice-fish, fruits and vegetables together. If rice is cultivated along with fish in this land and vegetables are grown along the banks, the cost will be reduced on one side and the land will be used properly on the other side. The inclusion of fruit trees can highly increase the nutritional value from these wetlands. This pattern of waterlogged wetland will minimize the risks and maximize the benefits for individuals, households, and communities.

Objectives

i) To maximize productivity and production diversity through integrating rice-fish, Vegetables, and fruits

ii) To meet up the nutritional requirements of the farm family and increase income

Materials and methods

A waterlogged uncultivable marshy fallow land (12.02 decimal) was situated in 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 and T. Aman rice were cultivated. Different kharif vegetables were cultivated in the south and west dyke. In north and east dyke, year-round papaya was planted for vegetable and fruit purposes. Brinjal and okra were planted in the equal area of the west dyke. Some leafy Vegetables, i.e., red amaranth, jute and kangkong were cultivated equally in the south dyke. Each dyke consists of 0.91 decimal of land. In the shallow pond, BRRI dhan30 and BR22 were transplanted in Aman season. During Boro season, BRRI dhan89 was transplanted. Thirty fingerlings of monosex tilapia, sorputi and common carp were released in per decimal area. In the dry season, fishes took shelter in the canal.

Results

From the shallow pond, the CP_1 and CP_2 cropping patterns yielded 11.09 to 10.68 t/ha of grain with a gross margin of 1,98,464 Tk/ha and 2,14,174 Tk/ha, respectively. From cost and return analysis, BCR 1.29 was found from CP_2, whereas CP_1 showed 1.19 (Table 45).

Table 45. Yield and profitability of Boro-Fallow-T. Aman cropping patterns in waterlogged wetland ecosystem, BRRI, Gazipur, 2023-24

Treatment	T. Aman	Boro	Total grain yield (t/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	BCR
CP_1: BRRI dhan30-Fallow-BRRI dhan89	3.77 b	6.91	10.68	167	198	1.19
CP_2: BR22-Fallow-BRRI dhan89	4.26 a	6.83	11.09	166	214	1.29
CV (%)	2.44	3.05	2.56	-	-	-
Level of significance	*	NS	NS	-	-	-

Means with the same letter(s) are not significantly different.
Price (Tk/kg): Rice; Boro=30, Aman=30-32.5, Straw; Boro=2.5, Aman=6.5

On an average, 228 kg of green papaya were harvested from per decimal area of north and east dyke with the gross margin of 6227 and 5403 Tk/decimal, respectively. In south dyke; red amaranth, jute and kangkong yielded 51 kg, 51 kg and 120 kg leafy vegetables, respectively. In

the west dyke the yield of brinjal and okra were 57 kg and 77 kg, respectively. BCR of papaya, red amaranth, jute, kangkong, brinjal and okra were 5.67, 1.57, 2.65, 5.60, 1.00 and 0.20, respectively (Table 46). From each decimal of shallow pond, 4.23 kg fish were harvested with the gross margin of 920 Tk (Table 47).

Table 46. Yield and profitability of different vegetables cultivated in dyke of a three-tier production system, BRRI, Gazipur, 2024

Dyke	Vegetable	Yield (Kg decimal^{-1})	TVC (Tk decimal^{-1})	GM (Tk decimal^{-1})	BCR
North dyke	Papaya	242	1026	6227	6.07
East dyke	Papaya	214	1026	5403	5.27
South dyke	Red amaranth	51	792	1244	1.57
	Jute (Leaf)	51	842	2228	2.65
	Kangkong	120	726	4066	5.60
West dyke	Brinjal	57	2301	2297	1.00
	Okra	77	4499	886	0.20

Price (Tk/kg): Papaya (Green)=30, Red amaranth=40, Jute (leaf)=60, Kangkong=40, Brinjal=80, Okra=70

Table 47. Yield and cost return of fish released in the canal of transformed waterlogged wetland production system at BRRI, Gazipur, 2023-24

Initial weight of each fingerling (gm)	Yield (Kg decimal^{-1})	TVC (Tk decimal^{-1})	GM (Tk decimal^{-1})	BCR
3.50-4.50	*4.23	93.17	920	9.87

Price (Tk kg^{-1}): fish=190-400

*Some exotic fish got into the pond since the entire field overflowed with a heavy shower on 6th October 2023.

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

A Khatun, ABMJ Islam, MK Quais, SM Shahidullah 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 HYV Boro coverage across the fringe land

Materials and Methods

A total of 50 trials in fringe land cultivation system were conducted in four upazilas (Borkol, Longodu, Baghaichhori and Naniarchor) of Rangamati district in Boro 2023-24. Promising modern rice varieties like BRRI dhan74, BRRI dhan89, BRRI dhan92 and BRRI dhan100 were evaluated in culturable waste of fringe land of Kaptai Lake. 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

The individual effect of location (L) and variety (V) on grain yield was highly significant (Pδ0.01). The interaction effects of (L) × (V) on grain yield were also highly significant (P<0.01) (Table 48). Among the tested varieties, BRRI dhan92 gave a significantly higher yield in all the locations (Borkol, Longodu, and Naniarchor) except Baghaichhori upazilla. BRRI dhan74 gave a greater yield compared to other cultivated varieties in Baghaichhori upazila in Rangamati district (Table 48).

Table 48. Performance of Boro varieties across different upazilas of fringe land, Rangamati, 2023-24

Variety	Grain yield (t/ha)			
	Borkol	Longodu	Baghaichhori	Naniarchor
BRRI dhan74	7.3	6.8	8.3	5.4
BRRI dhan89	6.9	6.1	7.3	5.7
BRRI dhan92	7.8	7.6	7.9	6.4
BRRI dhan100	6.3	6.4	5.8	5.3
CV (%)	6.2			
F for location (L)	*** (0.34)			
F for variety (V)	*** (0.35)			
F for L × V	*** (0.69)			

Farmer's reaction

Farmers are highly impressed and they are being encouraged to grow more rice in the dry season.

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, zinger, 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 Jhum rice productivity by replacing local varieties with modern varieties.

Materials and Methods

A total of 30 trials in Jhum cultivation system were conducted in different upazilas of Khagrachhari (Sadar and Panchhari), Rangamati (Baghaichhari and Naniarchor) and Bandarban (Ruma and Thanchi) districts in Aus 2023. Promising modern rice varieties like BRRI dhan43, BRRI dhan48, BRRI dhan65 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

The grain yield of BRRI dhan43 ranged from 3.19 to 3.51 t/ha in Jhum system of different upazilas under Khagrachhari, Rangamati and Bandarban districts (Table 49). A higher yield of 3.51 t/ha was observed in Panchhari upazila of Khagrachhari district where the farmer's variety Surjomani yielded 2.13 t/ha. The grain yield of BRRI dhan48 ranged from 3.62 to 3.84 t/ha under different upazilas of Khagrachhari, Rangamati and Bandarban districts. The higher yield (3.84 t/ha) was observed at Thanchi upazila under Bandarban district where the farmer's local variety Bordhan gave 2.28 t/ha yield. BRRI dhan65 yielded 3.28 to 3.46 t/ha. The higher yield

of 3.46 t/ha was observed at Ruma 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 3.73 to 4.01 t/ha. The higher yield (4.01 t/ha) was observed at Baghaichhari upazila under Rangamati district where the farmer's local variety Khoborok gave 1.94 t/ha yield. Irrespective of locations and varieties, BRRI dhan83 gave higher grain yield at Baghaichhari (4.01 t/ha) where the locally adopted Khoborok produced 1.94 t/ha under Jhum cultivation system. Among the local varieties, higher grain yield of 3.38 t/ha was obtained from Mongthongno followed by Ranqui (3.19 t/ha) and Kanbui (3.17 t/ha) irrespective of different locations (Table 49).

Table 49. Yield of Aus rice under Jhum cultivation, Chittagong Hill Tract, Aus 2023

Location	MV	Grain yield (t/ha)	Local variety	Grain yield (t/ha)
Sadar, Khagrachhari	BRRI dhan43	3.23	Binni	2.19
Panchhari, Khagrachhari	BRRI dhan43	3.51	Surjomani	2.13
Baghaichhari, Rangamati	BRRI dhan43	3.19	Khamarang	1.83
Naniarchor, Rangamati	BRRI dhan43	3.37	Badui	2.18
Ruma, Bandarban	BRRI dhan43	3.44	Pidi	2.22
Thanchi, Bandarban	BRRI dhan43	3.27	Mongthongno	3.38
Sadar, Khagrachhari	BRRI dhan48	3.73	Shonamukhi	2.07
Panchhari, Khagrachhari	BRRI dhan48	3.65	Churoi	2.11
Baghaichhari, Rangamati	BRRI dhan48	3.81	Khalabadia	1.89
Naniarchor, Rangamati	BRRI dhan48	3.62	Longur	2.22
Ruma, Bandarban	BRRI dhan48	3.79	Kanbui	3.17
Thanchi, Bandarban	BRRI dhan48	3.84	Bordhan	2.28
Sadar, Khagrachhari	BRRI dhan65	3.28	Gallon	2.23
Panchhari, Khagrachhari	BRRI dhan65	3.42	Company	2.33
Baghaichhari, Rangamati	BRRI dhan65	3.31	Lankapora	1.94
Naniarchor, Rangamati	BRRI dhan65	3.37	Ranqui	3.19
Ruma, Bandarban	BRRI dhan65	3.46	Mongthongno	3.35
Thanchi, Bandarban	BRRI dhan65	3.41	Kokro	2.89
Sadar, Khagrachhari	BRRI dhan83	3.84	Amedhan	2.21
Panchhari, Khagrachhari	BRRI dhan83	3.73	Kapali	2.15
Baghaichhari, Rangamati	BRRI dhan83	4.01	Khoborok	1.94
Naniarchor, Rangamati	BRRI dhan83	3.86	Gunda	2.32
Ruma, Bandarban	BRRI dhan83	3.76	Binni	2.27
Thanchi, Bandarban	BRRI dhan83	3.91	Kanbui	3.11

Table 50. Yield of Aus rice under Jhum cultivation, Chittagong Hill Tract, Aus 2023

Aus rice variety	Grain yield (t/ha)	Local variety	Grain yield (t/ha)
BRRI dhan43	3.34	Local	2.32
BRRI dhan48	3.74	Local	2.29
BRRI dhan65	3.38	Local	2.66
BRRI dhan83	3.85	Local	2.33

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. 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: Jhupna, Mushuddi and Kamarpara 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 seventy farmers' fields during 2023-24. Based on farmers' interest and field visits, farmers and their plots were selected. BRRI dhan75, BRRI dhan95 and BRRI dhan103 were tested during the T. Aman season. Mustard (BARI Sarisha-14) was a crop grown during the transition period. BRRI dhan100, BRRI dhan102, BRRI dhan104 and BRRI dhan105 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 dhan100

CP_2= BRRI dhan75-Mustard-BRRI dhan102

CP_3= BRRI dhan95-Mustard-BRRI dhan100

CP_4= BRRI dhan103-Mustard-BRRI dhan102

CP_5= BRRI dhan95-Mustard-BRRI dhan104

CP_6= BRRI dhan75-Mustard-BRRI dhan105

CP_7= BRRI dhan103-Mustard-BRRI dhan104

CP_8= BRRI dhan103-Mustard-BRRI dhan105

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

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 51. In T. Aman season, grain yields of BRRI dhan75 ranged from 6.05 to 6.33 t/ha. Under the tested cropping pattern, grain yields of BRRI dhan95 ranged from 5.88 to 5.96 t/ha, while grain yields of BRRI dhan103 ranged from 6.22 to 6.45 t/ha in different farmers' fields. The average grain yield of BRRI dhan49 was 5.47 t/ha as a check. The yield of mustard ranged from 1.48 to 1.68 t/ha. Under the T. Aman–Mustard–Boro cropping pattern, grain yield of BRRI dhan100 ranged from 6.73 to 6.91 t/ha, whereas grain yields of BRRI dhan102 ranged from 7.69 to 7.84 t/ha and grain yields of BRRI dhan104 and BRRI dhan105 ranged from 6.53 to 6.66 t/ha and 7.22 to 7.37 t/ha, respectively, in different farmers' fields during Boro season. BRRI dhan28 yielded

6.14 t/ha as a check (Table 51). The effect of the cropping pattern on rice equivalent yield (REY) was significant (Pδ0.01). The higher REY (19.23 t/ha) was observed in CP_4 followed by the pattern CP_2 (19.04 t/ha), CP_8 (18.82 t/ha) and CP_6 (18.72 t/ha). The lowest REY was observed in CP_9 (11.61 t/ha). The REY was statistically similar for the patterns CP_1, CP_3, CP_5 and CP_7.

Table 51. Yield of T. Aman, Mustard, and Boro under Madhupur Tract, Dhanbari, Tangail, 2023-24

Cropping pattern	Yield (t/ha)			REY
	T. Aman	Mustard	Boro	(t/ha)
CP_1= BRRI dhan75-Mustard-BRRI dhan100	6.21	1.54	6.73	17.87
CP_2= BRRI dhan75-Mustard-BRRI dhan102	6.05	1.61	7.84	19.04
CP_3= BRRI dhan95-Mustard-BRRI dhan100	5.88	1.66	6.91	18.10
CP_4= BRRI dhan103-Mustard-BRRI dhan102	6.45	1.59	7.69	19.23
CP_5= BRRI dhan95-Mustard-BRRI dhan104	5.96	1.48	6.66	17.36
CP_6= BRRI dhan75-Mustard-BRRI dhan105	6.33	1.57	7.37	18.72
CP_7= BRRI dhan103-Mustard-BRRI dhan104	6.35	1.52	6.53	17.74
CP_8= BRRI dhan103-Mustard-BRRI dhan105	6.22	1.68	7.22	18.82
CP_9= BRRI dhan49-Fallow-BRRI dhan28 (Ck.)	5.47	-	6.14	11.61
CV (%)		5.64		
LSD at 0.05%		0.61		

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 (2,04,500 Tk/ha) followed by CP_2 (1,99,700 Tk/ha), CP_8 (1,94,200 Tk/ha) and CP_6 (1,91,800 Tk/ha). The lowest GM was observed in CP_9 (1,33,100 Tk/ha). The pattern CP_4, CP_2, CP_8 and CP_6 gave 54%, 50%, 46% and 44% higher GM compared to the existing pattern CP_9 (Table 52). The patterns CP_1, CP_3, CP_5 and CP_7 also performed higher GM in comparison to the existing pattern CP_9. BRRI dhan75, BRRI dhan95 and BRRI dhan103 in T. Aman season, and BRRI dhan100, BRRI dhan102, BRRI dhan104 and BRRI dhan105 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 52. Economic performance of different Mustard-Boro-T. Aman cropping pattern under Madhupur Tract, Dhanbari, Tangail, 2023-24

Cropping Pattern	GR (’000 Tk/ha)	TVC (’000 Tk/ha)	GM (’000 Tk/ha)
CP_1= BRRI dhan75-Mustard-BRRI dhan100	446.8	276.3	170.5
CP_2= BRRI dhan75-Mustard-BRRI dhan102	476.0	276.3	199.7
CP_3= BRRI dhan95-Mustard-BRRI dhan100	452.5	276.3	176.2
CP_4= BRRI dhan103-Mustard-BRRI dhan102	480.8	276.3	204.5
CP_5= BRRI dhan95-Mustard-BRRI dhan104	434.0	276.3	157.7
CP_6= BRRI dhan75-Mustard-BRRI dhan105	468.1	276.3	191.8
CP_7= BRRI dhan103-Mustard-BRRI dhan104	443.5	276.3	167.2
CP_8= BRRI dhan103-Mustard-BRRI dhan105	470.5	276.3	194.2
CP_9=BRRI dhan49-Fallow-BRRI dhan28 (Ck.)	290.3	157.2	133.1

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 53). 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 (Table 53). 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 53. Cropping pattern scenario of the study site after intervention of improved cropping pattern of Mustard-Boro-T. Aman, Dhanbari, Tangail, 2023-24

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. 5.2. Increasing productivity of Boro-Fallow-T. Aman cropping pattern through inclusion of Mustard in Mymensingh region

BJ Shirazy, S Pramanik, MK Quais and M Ibrahim

Introduction

Bangladesh has achieved remarkable progress in increasing food production though it is not sufficient for the over growing population. Agricultural land is decreasing @ 0.73% each year owing to the development of houses, roads, and industrial infrastructure (BBS, 2020). At present cropping intensity of Bangladesh is around 200% where there are some scopes of increasing cropping intensity by the inclusion of short-duration crops viz., mustard, potato, mungbean and T. Aus rice in the rice-based cropping system (Nasim *et al.,* 2017). Mymensingh district is located under Agro-Ecological Zone (AEZ) 8, 9 and 16 where soil fertility level is low with medium phosphorus and cation exchange capacity status. The cropping intensity of this area is 187% which is lower compared to the national average. Boro-Fallow-T. Aman is the dominant cropping pattern of this region which occupies half of its net cropped area (735740 ha). About 93% of lands are under irrigation facilities and 76% of lands are under high and medium-high land in which 20% of lands remain fallow after harvesting T. Aman rice (DAE, 2016). Bangladesh Agricultural Research Institute (BARI) has developed high yielding short duration mustard varieties which take only 75-80 days, whereas BRRI has developed

short/medium duration rice varieties. Therefore, the present study was undertaken with the following objectives:

Objective

To develop Mustard-Boro-T. Aman rice cropping pattern and to compare its productivity and profitability against farmer's existing cropping pattern Boro-Fallow-T. Aman rice.

Materials and Methods

The experiment was conducted at Zahangirpur village of Nandail upazila of Mymensingh district from July 2023 to May 2024 in farmers' field conditions. The experiment was laid out in RCB design where the unit plot size was about one bigha of land. There were fifteen dispersed replications with two treatments i.e., improved cropping pattern (Mustard-Boro-T. Aman) and farmers' existing cropping pattern (Boro-Fallow-T. Aman). In the improved cropping pattern (ICP), the variety BARI Sarisha-14 for mustard, BRRI dhan100 for Boro rice and BRRI dhan71 for T. Aman rice was cultivated. While, in the existing cropping pattern (ECP), the variety BRRI dhan28 for Boro rice and in T. Aman rice BRRI dhan49 was used. Fertilizer management and intercultural operations were done according to BRRI and BARI recommendation (Table 54).

Table 54. Crop management adopted for Mustard-Boro-T. Aman cropping pattern, Nandail, Mymensingh, 2023-24

Factors	Existing pattern		Improved pattern		
	Boro	T. Aman	Mustard	Boro	T. Aman
Variety	BRRI dhan28	BRRI dhan49	BARI Sarisha-14	BRRI dhan100	BRRI dhan71
Seeding date	20 Nov 23	01 July 23	15-18 Nov 23	23-26 Dec 23	04-08 Jul 23
Transplanting date	01 Jan 24	25 July 23	-	8-10 Feb 23	26-30 July 23
Spacing (cm×cm)	20×15	25×15	Broadcasting	25×15	20×15
Seedling/hill	2-3	2-3	-	2-3	2-3
Fertilizer (kg/ha): N, P, K, S, Zn & B	138-15-60-13-3-0	69-19-34-10-3-0	115-34-43-24-2-2	138-18-56-17-3-0	83-12-52-11-0-0
Irrigation	5-7 times	2 times	1 time	5-6 times	2 times
Weeding	3 times, at urea top dressing	3 times, at urea top dressing	1 time at flowering	3 times, at urea top dressing	3 times at 7, 25 & 40 DAT
Maturity date	10 April 24	25 Nov 23	3-8 Feb 24	12-15 May 24	3-9 Nov 23
Field duration (day)	99	123	80-82	94-95	100-102

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

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

Marginal Benefit Cost Ratio (MBCR)

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

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

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

crops was calculated based on taka per hectare of different operations performed and materials used for raising the crops.

Results and Discussion

Individual crop yield and REY, GR, TVC, GM and MBCR of respective cropping patterns are presented in Table 55. The yields of Mustard, Boro and T. Aman were 1.45, 6.72 and 5.40 t/ha, respectively in the improved cropping pattern while in existing cropping pattern Boro and T. Aman rice grain yields were 6.2 and 4.7 t/ha, respectively. The rice equivalent yield (17.34 t/ha) of ICP was 23% higher than the REY of ECP (14.1 t/ha). From the economic analysis, it was observed that the gross margin of ICP was 49% higher than that of ECP.

Table 55. Yield and cost return analysis of improved (Mustard-Boro-T. Aman) and existing (Boro-Fallow-T. Aman) cropping pattern, Nandail, 2023-24

Treatment	Yield (t/ha)			REY (t/ha)	GR ('000 Tk/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Mustard	Boro	T. Aman					
Mustard-Boro-T. Aman	1.45	6.72	5.40	17.34a	487	268	219	1.35
Boro-Fallow-T. Aman	-	6.2	4.70	14.1b	327	199	128	-

Price (Tk/kg): Rice = 25, Mustard = 90, Boro straw=5, Aman Straw=12, Mustard straw=6

Expt. 5.3. Improvement of Boro-Fallow-T. Aman cropping system through Aus inclusion and varietal replacement in irrigated ecosystem in Mymensingh region

BJ Shirazy, S Pramanik, 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 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 variety in Boro-Aus-T. Aman cropping pattern

Materials and Methods

The study was conducted in farmers' fields at Savar, Nandail, Mymensingh during 2023-24. 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 Boro season BRRI dhan89 and BRRI dhan92; during T. Aman season BRRI dhan87 and BRRI

dhan103 and in Aus season BRRI dhan98 were tested. Aus rice was cultivated following farmers' practice with their existing varieties (Boro: BRRI dhan28 and T. Aman: Swarna). The tested cropping patterns were as follows:

CP_1: BRRI dhan89-BRRI dhan98-BRRI dhan87

CP_2: BRRI dhan89-BRRI dhan98-BRRI dhan103

CP_3: BRRI dhan92-BRRI dhan98-BRRI dhan87

CP_4: BRRI dhan92-BRRI dhan98-BRRI dhan103

CP_5: BRRI dhan28-Fallow-Swarna (Control)

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 56).

Table 56. Management practices followed for different crops under Boro-T. Aus-T. Aman and Boro-Fallow-T. Aman cropping pattern, Nandail, Mymensingh 2023-24

Factors	Existing pattern		Improved pattern		
	Boro	T. Aman	Boro	T. Aus	T. Aman
Variety	BRRI dhan28	Swarna	BRRI dhan89,92	BRRI dhan98	BRRI dhan87,103
Seeding date	20 Nov 23	01 July 23	25-31 Dec 23	01-05 May 23	05-25 Jul 23
Transplanting date	1-5 Jan 24	25-30 July 23	5-12 Feb 24	20-25 May 23	10-15 Aug 23
Spacing (cm×cm)	20×15	25×15	25×15	20×15	20×15
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	10-15 April 24	25-30 Nov 23	15-20 May 24	1-05 Aug 23	25-30 Nov 23
Field duration (days)	99-103	123	97-99	73-77	107-112

Result and Discussion

Individual crop yield and total grain yield (t/ha) of the cropping patterns are presented in Table 57. In Boro season, the highest grain yield was obtained from BRRI dhan92 (8.91 t/ha) in CP_4 cropping pattern while the lowest yield was found from the variety BRRI dhan28 (6.20 t/ha) in control treatment. In T. Aman season, the highest yield was obtained from BRRI dhan87 under CP_3 followed by BRRI dhan103 under CP_2 and CP_4. The yield of BRRI dhan103 was notably poor due to lodging at flowering stage. The lowest yield was obtained from BRRI dhan49 (5.07 t/ha) which is usually used by farmers under Boro-Fallow-T. Aman cropping pattern in the study area (Table 52). In consideration of the productivity, the highest REY (23.02 t/ha) was observed in CP_3 (BRRI dhan92-BRRI dhan98-BRRI dhan87) which is statistically similar with CP_4 (22.82 t/ha) and CP_2 (22.45 t/ha). Significantly the lowest total productivity (13.02 t/ha) was found from CP_5 (Check). BBRI dhan98 gave statistically similar yield (5.21-5.84 t/ha) in all four cropping patterns.

Table 57. Yield of different rice varieties under specific cropping system, Nandail, Mymensingh, 2023-24

Cropping pattern	Boro (t/ha)	T. Aus (t/ha)	T. Aman (t/ha)	Total grain yield (t/ha)
CP_1: BRRI dhan89-BRRI dhan98-BRRI dhan87	7.33 b	5.21 a	5.50 bc	20.33 b
CP_2: BRRI dhan89-BRRI dhan98-BRRI dhan103	8.58 a	5.54 a	6.00 ab	22.45 a
CP_3: BRRI dhan92-BRRI dhan98-BRRI dhan87	8.66 a	5.84 a	6.23 a	23.02 a
CP_4: BRRI dhan92-BRRI dhan98-BRRI dhan103	8.91 a	5.70 a	5.83 ab	22.82 a
CP_5: BRRI dhan28-Fallow-Swarna (Check)	6.20 c	-	5.07 c	13.02 c
CV (%)	7.94	7.81	5.27	3.64

*Means with the same letter are not significantly different, REY=Rice Equivalent Yield

From the cost and return analysis it was observed that the highest gross margin (GM) was obtained from CP_3 (2,59,000 Tk/ha) followed by CP_4 (2,48,000 Tk/ha) and CP_2 (2,42,000 Tk/ha) (Table 58). The lowest GM was observed in CP_5 (92,000 Tk/ha). The highest MBCR was obtained from CP_3 (3.0) followed by CP_4 and CP_2 (2.8). BRRI dhan71 in T. Aman season, BRRI dhan92 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 58. Cost-return analysis of different crops combinations under improved and existing cropping pattern, Nandail, Mymensingh, 2023-24

Cropping Pattern	GR (‘000 Tk/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
CP1: BRRI dhan89-BRRI dhan98-BRRI dhan87	508	321	187	2.1
CP2: BRRI dhan89-BRRI dhan98-BRRI dhan103	561	319	242	2.8
CP3: BRRI dhan92-BRRI dhan98-BRRI dhan87	575	317	259	3.0
CP4: BRRI dhan92-BRRI dhan98-BRRI dhan103	571	323	248	2.8
CP5: BRRI dhan28-Fallow-Swarna (Check)	327	235	92	0

*Price (Tk/kg): Rice = 25, Boro straw=5, Aus straw=5, Aman straw=8

Activity 5.4. Farmers’ training and field days

There are 8 training programs that have been conducted in Khulna, Habiganj, Gazipur and Tangail districts by the Rice Farming Systems division during 2023-2024. Through these trainings, a total of 320 participants were trained (male 239, female 81) 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 59).

Table 59. Training conducted by Rice Farming Systems division, 2023-24

Name of the training	No. of training	Participants number		Total	Location
		Male	Female		
Farmer’s training on Aman rice production and management	2	46	34	80	Dhanbari, Tangail; Kaliganj, Gazipur
Farmer’s training on Mustard production and management	1	36	04	40	Dhanbari, Tangail
Farmer’s training on Boro rice production and management	2	64	16	80	Dhanbari, Tangail; Kaliganj, Gazipur
Farmer’s training on modern rice production technology in an advanced manner	2	65	15	80	Batiaghata, Khulna
Farmer’s training on Aus rice production and management	1	28	12	40	Nabiganj, Habiganj
Total	8	239	81	320	

The rice Farming Systems division conducted 6 field days at different locations of Bangladesh (Gazipur, Khulna, Rangamati and Tangail) during 2023-2024 where total number of participants was 1232 (male 923, female 309). 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 of Gazipur, Khulna, Rangamati and Tangail districts (Table 60).

Table 60. Field day conducted by Rice Farming Systems division, 2023-24

Title	No. of field day	Participants (no.)		Total	Location
		Male	Female		
Crop cut and field day on BRRI dhan71 in Mustard-Boro-T. Aman cropping pattern	1	180	20	200	Kaliganj, Gazipur
Crop cut and field day on Sunflower in Sunflower-Boro-T. Aman cropping pattern	1	185	15	200	Kaliganj, Gazipur
Crop cut and field day on BRRI dhan87 in Watermelon-Fallow-T. Aman cropping pattern	1	105	15	120	Botiahata, Khulna
Crop cut and field day on salt tolerant Boro (BRRI dhan67) to improve productivity in Boro-Fallow-T. Aman cropping pattern	1	139	61	200	Botiahata, Khulna
Crop cut and field day on high yielding Boro rice variety of BRRI dhan74, BRRI dhan89, BRRI dhan92 and BRRI dhan100	1	118	82	200	Borkol, Rangamati
Crop cut and field day on BRRI dhan100, BRRI dhan102, BRRI dhan104 and BRRI dhan105 in Mustard-Boro-T. Aman cropping pattern	1	196	116	312	Dhanbari, Tangail
Total	6	923	309	1232	

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, BJ Shirazy 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 2023-24 to intensify Boro-Fallow-T. Aman cropping pattern through the 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 dhan100 and BRRI dhan102 in Boro season and BRRI dhan71 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, suflower and mustard were followed while conducting the trial (Table 61, 62).

Table 61. Crop management practices adopted to evaluate the Mustard-Boro-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2023-24

Mgt. factors	Improved pattern			Farmer's practice	
	Mustard	Boro	T. Aman	Boro	T. Aman
Variety	BARI Sarisha-14	BRRI dhan100, 102	BRRI dhan71	BRRI dhan29	BRRI dhan49
Seeding date	20-23 Nov 23	27 Dec 23-01 Jan 24	25 Jun-01 Jul 23	28 Nov-05 Dec 23	25 Jun-19 Jul 23
Seed rate (kg/ha)	7	30	30	50-70	40-60
TP date	-	10-15 Feb 24	15-23 July 2023	10-18 Jan 24	26 Jul-23 Aug 23
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	116-16-69-15-3.5-0	85-16-37-12-0-0
Weeding (Times)	0	2	2	2	1
Maturity/ harvesting date	05-07 Feb 24	BR100: 10-20 May 24 BR102: 15-25 May 24	20-25 Oct 23	05-15 May 24	10-30 Nov 23
Field duration (days)	76-77	BR100: 90-95 BR102: 95-100	94-97	116-118	99-107

Table 62. Crop management practices adopted to evaluate the Sunflower-Boro-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2023-24

Mgt. factors	Improved pattern			Farmer's practice	
	Sunflower	Boro	T. Aman	Boro	T. Aman
Variety	BARI Surjomukhi-3	BRRI dhan102	BRRI dhan71	BRRI dhan29	BRRI dhan49
Seeding date	07-09 Nov 2023	27 Dec 23-02 Jan 2024	25-26 Jun 2023	28 Nov-05 Dec 2023	25 Jun-19 Jul 2023
Seed rate (kg/ha)	15	30	30	50-70	40-60
TP date	-	18-20 Feb 2024	17-22 July 2023	10-18 Jan 2024	26 Jul-23 Aug 2023
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	116-16-69-15-3.5-0	85-16-37-12-0-0
Weeding (Times)	3	2	2	2	1
Maturity/ harvesting date	07-13 Feb 2024	14-21 May 2024	17-20 Oct 2023	05-15 May 2024	10-30 Nov 2023
Field duration (days)	92-96	86-91	90-92	116-118	99-107

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 were determined and quantified. Energy equivalents derived from the published literature given in Table 63 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 63. 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
Outputs			
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's efficiency in using the energy supplied by crop husbandry.

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

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

Results

The individual crop yields and rice equivalent yield (REY) for the respective cropping patterns are presented in Table 64. Mustard yield ranged from 1.23 to 1.35 t/ha, while sunflower yielded 3.19 t/ha, sown between November 07 and 09, 2023. Grain yield of Boro rice showed significant variation among the cropping patterns ($F_{3, 22}$ = 5.816, P= 0.004). The introduction of mustard and sunflower into the Boro-Fallow-T. Aman cropping system resulted in a significant reduction in Boro yield, ranging from 7% to 14%. During the T. Aman season, BRRI

dhan71 yielded significantly more than the existing variety ($F_{3, 22}$ = 3.712, P= 0.027), producing approximately 14% to 18% higher grain yield compared to BRRI dhan49. The REY of different cropping pattern combinations also varied significantly ($F_{3, 22}$ = 17.973, P< 0.001) and BARI Surjomukhi-3-BRRI dhan102-BRRI dhan71 turned out the highest REY among the tested combinations.

Table 64. Grain yield of component crops and REY of different cropping pattern combinations, Jamalpur, Kaliganj, Gazipur, 2023-24

Cropping pattern	Mustard/ Sunflower (t/ha)	Boro (t/ha)	T. Aman (t/ha)	REY (t/ha)
BARI Sarisha-14-BRRI dhan100-BRRI dhan71	1.23	6.49 ab	5.32 a	14.62 a
BARI Sarisha-14-BRRI dhan102-BRRI dhan71	1.35	6.02 b	5.51 a	14.63 a
BARI Surjomukhi-3- BRRI dhan102-BRRI dhan71	3.19	6.04 b	5.44 a	16.04 a
BRRI dhan29-BRRI dhan49 (Check)	-	6.99 a	4.66 b	11.45 b
CV (%)	-	9.37	5.31	12.33

Different letters indicate significant difference at P< 0.05.
REY calculation price (Tk/kg): Rice = 35, Mustard = 80, Sunflower = 50

The cost-return analysis revealed significant variation in both total variable cost ($F_{3, 22}$ = 309.822, P< 0.001) and gross margin ($F_{3, 22}$ =11.38, 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, with an MBCR value greater than 2. Among the tested cropping patterns, the BARI Sarisha-14-BRRI dhan100-BRRI dhan71 combination was identified as the most profitable (Table 65).

Table 65. Cost and return analysis of different cropping pattern combinations, Kaliganj, Gazipur, 2023-24

Cropping pattern	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
BARI Sarisha-14-BRRI dhan100-BRRI dhan71	354 b	209 a	2.09
BARI Sarisha-14-BRRI dhan102-BRRI dhan71	353 b	203 a	2.02
BARI Surjomukhi-3- BRRI dhan102-BRRI dhan71	395 a	241 a	1.98
BRRI dhan29-BRRI dhan49 (Check)	282 c	129 b	-
CV (%)	10.67	11.89	

Different letters indicate significant difference at P< 0.05.
Price (Tk/kg): Boro rice= 30 to 35, T. Aman rice= 30 to 32.5, Boro straw= 2-4, T. Aman straw= 6-9, Mustard= 80, Sunflower= 50, Stover (mustard and sunflower) = 02

The energy use efficiency and energy productivity of various cropping patterns are summarized in Table 66. The analysis revealed that the energy efficiency of Mustard-Boro-T. Aman and Sunflower-Boro-T. Aman cropping pattern were 15% and 36% 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 19% and 36% 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 highest energy productivity among the tested cropping systems.

Table 66. Energy use efficiency and energy productivity of different cropping patterns, Kaliganj, Gazipur, 2023-24

Cropping pattern	Energy balance (MJ/ha)			Energy productivity (g/MJ)
	Input	Output	Balance	
Mustard-Boro-T. Aman	89914	371177	281263	163
Sunflower-Boro-T. Aman	87087	421129	334042	184
Boro-Fallow-T.Aman (Check)	71877	316877	245000	159

Farmer's reaction

Farmers expressed high satisfaction with the yields of mustard and sunflower as transitional crops between T. Aman and Boro rice. Although both crops resulted in higher gross margin, farmers expressed concerns regarding the higher labor requirement for sunflower cultivation, specifically in managing axillary flowers and conducting additional intercultural operations such as weeding, thinning and earthing up. Farmers expressed a strong preference for BRRI dhan100 for the Boro season and were particularly satisfied with the yield of BRRI dhan71 during the T. Aman season. Overall, most of the farmers preferred mustard over sunflower as the transitional crop 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, BJ Shirazy 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.

Materials and Methods

The trials were conducted in farmers' fields located in Kaliganj, Gazipur to increase the productivity of double rice and single rice ecosystem by introducing recently released BRRI rice varieties. We evaluated the performance of BRRI dhan100-Fallow-BRRI dhan103 cropping pattern in double rice ecosystem. Additionally, the suitability of BRRI dhan92 was assessed in single rice ecosystem. We selected thirteen dispersed farmer's fields, covering an area of 12 bh for the evaluation of BRRI dhan100-Fallow-BRRI dhan103 cropping pattern. In the case of the single rice ecosystem, we chose eight farmer's fields, spanning an area of 07 bh, to determine the suitability of BRRI dhan92. Each farmer's field represents one replication. BRRI recommended fertilizer dose and other management practices were followed while conducting the trials (Table 67 and 68).

Table 67. Crop management practices adopted to evaluate the newly released BRRI rice varieties in Boro-Fallow-T. Aman cropping pattern, Jamalpur, Kaliganj, Gazipur 2023-24

Mgt. factors	Improved pattern		Farmer's practice	
	Boro	T. Aman	Boro	T. Aman
Variety	BRRI dhan100	BRRI dhan103	BRRI dhan28	Ranjit
Seeding date	25 Nov-12 Dec 2023	28 June-5 Jul 2023	20-26 Nov 2023	20 Jun-08 Jul 2023
Seed rate (kg/ha)	30	30	45-60	40-60
TP date	13-20 Jan 2024	15-30 July 2023	10-14 Jan 2024	15 Jul-08 Aug 2023
Spacing (cm×cm)	20×Random	20×Random	20-22×Random	15-20 ×Random
Seedling/hill	3-6	3-6	4-5	4-5
Fertilizer (kg/ha): N, P, K, S & Zn	120-18-75-18-4-0	76-12-52-11-0	101-20-48-17-0	77-13-35-9-0
Weeding (Times)	2-3	2-3	2	1
Maturity/ harvesting date	22 April-2 May 2024	04-12 Nov 2023	10-18 April 2024	18-30 Nov 2023
Field duration (day)	100-103	105-112	91-95	114-126

Table 68. Crop management practices adopted to evaluate the suitability of BRRI dhan92 in single rice ecosystem, Muktarpur, Kaliganj, Gazipur 2023-24

Mgt. factors	Improved variety	Farmer's practice
Variety	BRRI dhan92	BRRI dhan29
Seeding date	25 Nov-05 Dec 2023	25-27 Nov 2023
Seed rate (kg/ha)	30	40-45
TP date	01-26 Jan 2024	12-15 Jan 2024
Spacing (cm×cm)	20×Random	15-22×Random
Seedling/hill	3-5	4-5
Fertilizer (kg/ha): N, P, K, S & Zn	138-19-82-18-4	101-17-67-10-0
Weeding (Times)	2	2
Maturity/ harvesting date	04-11 May 2024	10-16 May 2024
Field duration (days)	106-124	119-122

Results

In double rice ecosystem, BRRI dhan100 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 16%. A comprehensive assessment, considering gross margin and the MBCR, BRRI dhan100-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 exhibited notable performance in single rice ecosystem, generating a gross margin that was 14% higher than the existing variety, BRRI dhan29. These findings underscore the potential for uplifting overall productivity by adopting newly released BRRI rice varieties combined with recommended management practices (Table 69).

Table 69. Grain yield and profitability of double and single rice-based cropping patterns, Kaliganj, Gazipur, 2023-24

Cropping pattern		Yield (t/ha)			TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
		Boro	T. Aman	Total productivity			
Double rice	ICP	7.25	5.28	12.53a	291	173	2.81
	ECP	6.32	4.50	10.82b	274	143	-
Single rice	ICP	7.32a	-	7.32a	154	84	6.99
	ECP	6.90b	-	6.90b	152	74	-

Double-rice based cropping Pattern: ICP=BRRI dhan100-Fallow-BRRI dhan103, ECP=BRRI dhan28-Fallow-Ranjit (Ck); Single rice-based cropping pattern: ICP= BRRI dhan92-Fallow-Fallow, ECP=BRRI dhan29-Fallow-Fallow (Ck), MBCR=Marginal Benefit Cost Ratio; Price (Tk/Kg): Boro rice= 32.5 to 35, T. Aman rice= 30 to 32.5, Boro straw= 2-3, T. Aman straw= 5-9

Farmer's reaction

Farmers have expressed their contentment with the excellent grain quality of BRRI dhan100. However, they noted that tillering ability of this variety is little bit lower and opined that closer spacing could improve its productivity. In the Aman season, BRRI dhan103 was well-received due to its high grain and straw yield, though farmers expressed concerns regarding its susceptibility to stem borer and sheath blight infestations. In single-rice ecosystem, BRRI dhan92 was well-regarded by farmers, primarily for its high grain yield, superior grain quality, and lower susceptibility to disease infestation.

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, BJ Shirazy and M Ibrahim

Introduction

The rice yield of outdated cultivars is decreasing day by day because these cultivars have 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).

Materials 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 2023-24. We distributed five kg of BRRI dhan71, BRRI dhan75, BRRI dhan87, BRRI dhan90, BRRI dhan103 in the T. Aman season and BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan100, BRRI dhan102 in the Boro season to the participatory farmers. Additionally, participatory farmers were trained in 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 evaluated the suitable variety for the location.

Results

In T. Aman season, the grain yield of BRRI dhan71 and 87 outperformed the other tested varieties by a significant margin. Farmers highly appreciated these varieties because of their impressive grain yield. Additionally, BRRI dhan90 garnered favor among farmers for its excellent grain quality and high demand in the market (Table 70).

Table 70. Grain yield and farmer's opinion on the tested T. Aman varieties, Kaliganj, Gazipur, 2023

Variety	Yield (t/ha)	Observations	Farmer's opinion
BRRI dhan71	5.39 ± 0.11a	Strong stature	Farmers are highly satisfied with the yield and growth duration of BRRI dhan71. Although BRRI dhan90 turned out lower grain yield, farmers were interested in cultivating this variety because of its excellent grain quality and high market price.
BRRI dhan75	4.47 ± 0.12bc	Rat infestation high	
BRRI dhan87	5.31 ± 0.09a	● Stem borer infestation high ● Lodged during Hamoon	
BRRI dhan90	4.01 ± 0.06c	Tiller number comparatively lower	
BRRI dhan103	4.56 ± 0.08b	● Severe sheath blight infestation ● Lodged during Hamoon	
Ranjit (Check)	4.06 ± 0.12c	● Stem borer infestation high ● Lodged during Hamoon	

In Boro season, BRRI dhan92, BRRI dhan96, BRRI dhan100 and BRRI dhan102 demonstrated superior performance compared to other tested varieties. However, BRRI dhan92, BRRI dhan100 and BRRI dhan102 garnered the preference of farmers. This preference was largely attributed to their grain quality and yield. However, their preference for BRRI dhan88, BRRI dhan89, and BRRI dhan96 is lower because of high pest infestation. The neighboring farmers also expressed their curiosity about cultivating BRRI dhan92, BRRI dhan100 and BRRI dhan102 over BRRI dhan28 by collecting seeds from the participating farmers (Table 71).

Table 71. Grain yield and farmer's opinion on the tested Boro varieties, Kaliganj, Gazipur, 2023-24

Variety	Yield (t/ha)	Observations	Farmer's opinion
BRRI dhan88	5.88 ± 0.14bc	● High stem borer infestation ● Blast infection high	Farmers express great satisfaction with the performance of BRRI dhan92 and BRRI dhan102. Even though the yield of BRRI dhan100 was little bit lower, they appreciate it for its excellent grain quality.
BRRI dhan89	6.72 ± 0.12ab	● High stem borer infestation ● Blast infection high	
BRRI dhan92	7.47 ± 0.16a	● High stem borer infestation ● Rat infestation high	
BRRI dhan96	6.87 ± 0.19a	● High stem borer infestation ● Rat infestation high ● Blast infection high	
BRRI dhan100	6.98 ± 0.31a	● High stem borer infestation ● Rat infestation high	
BRRI dhan102	7.45 ± 0.11a	● Strong stature ● Low insect and disease infection	
BRRI dhan28 (Check)	5.09 ± 0.12c	● Blast infection high ● High stem borer 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

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 produced 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 aren'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.

Materials and methods

Farmers' participatory quality seed production program was executed in Jamalpur, Kaliganj, Gazipur during the T. Aman and Boro seasons of 2023-24. In the Aman season, 1178 kg of seeds were distributed to 209 farmers, while 10.5 kg of newly released Boro varieties were distributed to 3 farmers (Table 72). At the beginning of the season, a farmer's gathering was organized to impart knowledge on quality seed production and recommend management practices.

Table 72. Variety-wise distributed seed amount and the beneficiary farmer number during T. Aman and Boro season, Jamalpur, Kaliganj, Gazipur, 2023-24

T. Aman variety	Distributed seed (kg)	Beneficiary farmer no.	Boro variety	Distributed seed (kg)	Beneficiary farmer no.
BRRI dhan71	450	83	BRRI dhan102	2.5	1
BRRI dhan75	153	23	BRRI dhan104	4	1
BRRI dhan87	285	41	BRRI dhan105	4	1
BRRI dhan90	90	29	Total	10.5	3
BRRI dhan103	200	33			
Total	1178	209			

Results

The disposal pattern of T. Aman cultivar's seed is displayed in Table 73. Farmers set aside about 2-12% of harvested seed for their own seed requirement and to sell in the upcoming T. Aman season as seed. Additionally, they sold around 4588 kg seed which will be used for seeding purposes. Furthermore, a small quantity of seed (475 kg) was exchanged among 114 farmers. Among the varieties, the largest proportion (71.4%) of BRRI dhan90 seeds were sold immediately after harvesting due to its higher market value. 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 dhan103 seeds were sold in the market, with a small portion being consumed by farmers.

Table 73. Distribution pattern of produced T. Aman seeds, FSRD site, Kaliganj, Gazipur, 2023

Variety	Seed produced (kg/variety)	Store for seed (%)	Consumed as paddy (%)	Sold (%)		Exchanged to the neighboring farmers (%)*
				As seed	As paddy	
BRRI dhan71	22,286	7.4	30.2	17.2	44.5	0.7 (25)
BRRI dhan75	9,875	2.2	75.1	1.3	20.9	0.5 (10)
BRRI dhan87	5,057	5.2	20.2	3.1	70.8	0.7 (12)
BRRI dhan90	3,912	8.1	5.2	10.1	71.4	5.2 (50)
BRRI dhan103	1,363	11.6	30.4	5.5	50.2	2.3 (17)

*Figures in parenthesis indicate no. of farmers

The distribution pattern of Boro cultivar's seed is shown in Table 74. Farmers reserved about 3-4% of harvested seed for their own seed requirement and for selling in the next Boro season as seed. They sold about 922 kg of harvested seed as seed. In addition, a portion of seed (95 kg) was exchanged among 37 farmers. The major portion of BRRI dhan102, 104 and 105 seeds (45-54%) were sold as seed. BRRI dhan104 was sold immediately after harvesting due to its higher market price. Farmers allocated a considerable portion of BRRI dhan102 and 105 for their own consumption.

Table 74. Distribution pattern of produced Boro 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 dhan102	642	3.1	26.9	54.2	11.1	4.7 (10)
BRRI dhan104	702	4.3	11.4	46.4	32.9	5.0 (15)
BRRI dhan105	548	3.6	36.5	45.3	9.1	5.5 (12)

*Figures in parenthesis indicate no. of farmers

Expt. 6.1.5. Evaluation of intercropping under mixed orchard in Madhupur tract

MAU Razu, BJ Shirazy, 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, 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.

Materials and Methods

The experiment was conducted at FSRD site of RFSD at Kaliganj, Gazipur during 2023-24 with the treatments consisted of six combinations where different summer vegetables and winter vegetables with turmeric and ginger were grown under different orchard systems (Table 75). The average size of the orchard was 8.48 decimals for each farmer.

Table 75. Patterns followed for intercropping under mixed orchards, Kaliganj, Gazipur, 2023-24

Orchard pattern	Fruit trees	Vegetables		Spice crops	Orchard area (dec)		
		Rabi	Kharif		Vegetables	Spices	Total
1	Guava, Mango	Tomato, Brinjal, Chili, Pumpkin	Okra, Malabar spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric	10	0.43	10.43
2	Mango, Litchi	Tomato, Cauliflower, Cabbage, Chili, Pumpkin	Okra, Malabar spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric	6	0.30	6.30
3	Mango, Jujube	Pumpkin	Okra, Malabar spinach, Kangkong, Pumpkin	Turmeric, Ginger	10	0.54	10.54
4	Burmese grape	Tomato, Spinach, Red Amaranth, Brinjal, Pumpkin	Okra, Malabar spinach, Stem amaranth, Kangkong, Pumpkin	Turmeric, Ginger	10	0.26	10.26
5	Lemon, Mango	Tomato, Cauliflower, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong	Turmeric, Ginger	9	0.12	9.12
6	Banana	Spinach, Chili	Okra, Malabar spinach, Stem amaranth	Turmeric, Ginger	4	0.21	4.21
Average					8.17	0.31	8.48

Vegetables production

Productivity of year-round vegetables production under mixed orchards is presented in Table 76 and utilization scenario and economic return in Table 77. From the 6 patterns followed at 6 orchards, an average of 138 kg of vegetables were harvested from 10 decimals of orchard, where vegetables and spices were cultivated at 9.5 and 0.5 decimal of land, respectively. Irrespective of orchards, among all the vegetables, the highest production was obtained from Cabbage (60 kg), followed by Cauliflower (56 kg). Among the six orchard patterns, the highest Vegetables production was obtained from orchard-2 (192 kg), where various types of vegetables along with spices were intercropped with Mango and Litchi trees (Table 76). From the 6 orchards, an average gross margin of Tk 4224 was obtained from 10 decimals of orchard. The highest gross

margin was produced from orchard-6 (Tk 8592), where various types of vegetables along with were intercropped with Banana (Table 77).

Table 76. Productivity of year-round vegetable production under mixed orchards, Kaliganj, Gazipur, 2023-24

Orchard pattern	Production (kg/9.5 dec)												
	Rabi							Kharif				Year-round	Total
	Red Amaranth	Tomato	Cauliflower	Cabbage	Spinach	Brinjal	Chili	Okra	Malabar spinach	Stem amaranth	Kangkong	Pumpkin	
1	-	19	-	-	-	23	8	18	12	4	4	57	145
2	-	11	79	60	-	-	3	6	10	17	6	-	192
3	-	-	-	-	-	-	-	21	24	-	17	45	107
4	13	14	-	-	12	15	-	14	12	13	16	29	140
5	-	22	33	-	-	-	13	11	5	3	3	-	90
6	-	-	-	-	17	-	64	34	19	21	-	-	155
Average	13	17	56	60	14	19	22	17	14	12	9	44	138

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

Table 77. Utilization scenario and economic return of year-round vegetables production under mixed orchards, Kaliganj, Gazipur, 2023-24

Orchard pattern	Utilization (kg/9.5 dec)			TVC (Tk/9.5 dec)	GM (Tk/9.5 dec)
	Consumption	Distribution	Sale		
1	130	8	7	2875	3817
2	148	11	34	2626	4459
3	86	5	15	1700	2219
4	106	9	24	2256	3299
5	67	3	20	2574	2958
6	113	7	36	4848	8592
Average	108	7	23	2813	4224

Spices production

Productivity, utilization scenario and economic return of spices production under mixed orchards is presented in Table 78. From the 6 patterns followed at 6 orchards, an average of 57 kg of spices (44 kg Turmeric and 13 kg Zinger) were harvested from 10 decimals of orchard, where spices were cultivated at 0.5 decimal of land. Among the six orchard patterns, the highest spice production was obtained from orchard-1 (92 kg), where various Turmeric along with various types of vegetables were intercropped with Guava and Mango trees. From the 6 orchards, an average gross margin of Tk 3686 was obtained from 10 decimals of orchard. The highest gross margin was produced from orchard-3 (Tk 48526), where spices along with various types of vegetables were intercropped with Mango and Jujube trees (Table 78).

Table 78. Productivity, utilization scenario and economic return of spices production under mixed orchards, Kaliganj, Gazipur, 2023-24

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	92	0	92	7	85	2286	3226
2	42	13	55	8	47	3063	3304
3	51	18	69	6	62	3412	4826
4	38	15	54	8	46	3165	3604
5	21	13	33	8	25	2353	2522
6	19	21	40	10	31	2726	4632
Average	44	13	57	8	49	2834	3686

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

Fruit production

Productivity, utilization scenario and economic return of fruits production under mixed orchards is presented in Table 79. From the 6 patterns followed at 6 orchards, an average of 158 kg of fruit were harvested from 10 decimals of orchard, where various types of vegetables and spices were cultivated at 9.5 and 0.5 decimal of land, respectively. Irrespective of orchards, among all the fruits, the highest production was obtained from Banana (325 kg), followed by Jujube (205 kg). Among the six orchard patterns, the highest fruit production (365 kg) as well as gross margin (Tk 12093) were obtained from orchard-3, where various types of Vegetables along with spices were intercropped with Mango and Jujube trees (Table 79).

Table 79. Productivity, utilization scenario and economic return of fruit production under mixed orchards, Kaliganj, Gazipur, 2023-24

Orchard pattern	Production (kg/10 dec)								Utilization (kg/10 dec)			TVC (Tk/10 dec)	GM (Tk/10 dec)
	Mango	Guava	Litchi*	Jujube	Lemon	Burmese grape	Banana	Total	Consumption	Distribution	Sale		
1	15	5	-	-	-	-	-	20	9	2	10	377	773
2*	-	-	-	-	-	-	-	-	-	-	-	-	-
3	160	-	-	205	-	-	-	365	11	6	348	5707	12093
4	-	-	-	-	-	25	-	25	6	4	15	787	1213
5	10	-	-	-	44	-	-	54	11	4	40	1286	3758
6	-	-	-	-	-	-	325	325	55	10	260	4909	11341
Average	62	5	-	205	44	25	325	158	18	5	135	2613	5836

Price (Tk/kg): Mango=60, Guava=50, Jujube=40, Lemon=100, Burmese grape=80, Banana=50
* Fruit bearing not yet started.

Overall scenario of integrated vegetables, spices and fruit production under mixed orchards

Overall productivity and economic return of vegetables, spice and fruit production under mixed orchards from orchards having an average area of 10 decimals, where vegetables and spices were cultivated at 9.5 and 0.5 decimal of land, respectively is presented in Table 80. From the 6 patterns followed at 6 orchards, an average of 327 kg of output was obtained from 10 decimals of orchard, with vegetables, spices, and fruits contributing 39%, 16% and 45%, respectively. Moreover, each orchard yielded a gross margin of Tk 12773 per 10 decimals on average, with Vegetables, spices, and fruits contributing 42%, 17% and 40%, respectively.

Table 80. Overall productivity and economic return of intercropping under mixed orchards, Kaliganj, Gazipur, 2023-24

Pattern (Farmer)	Production (kg/10 dec/yr)				GM (Tk/10 dec/yr)			
	Vegetables	Spices	Fruits	Total	Vegetables	Spices	Fruits	Total
1	145	92	20	257	3817	3226	773	7816
2	192	55	*	247	4459	3304	-	7764
3	107	69	365	541	2219	4826	12093	19138
4	140	54	25	219	3299	3604	1213	8116
5	90	33	54	178	2958	2522	3758	9239
6	155	40	325	521	8592	4632	11341	24565
Average	138	57	158	353	4224	3686	5836	13746

* Fruit bearing has not yet started. Orchard area: 10 decimal (Vegetables=9.5 decimal, Spices=0.5 decimal)

6.2. Homestead Production System

MAU Razu, BJ Shirazy, 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 the vegetables production round the year at homestead area
ii) To generate additional income for farmers by selling surplus vegetables
iii) To create employment opportunity for rural women

Materials and Methods

The study was conducted during 2023-24 at the FSRD site Muktarpur, Kaliganj, Gazipur. Nine cooperative farmers from marginal (5-50 dec) and small (51-247 dec) farmers were selected for homestead vegetables cultivation. Seeds of different vegetables were supplied to the farmers. For implementing vegetables production model, beds were prepared at open spaces of different sizes according to space availability at the homesteads of different farmers. Trellis, shady place of backyard and all 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 81).

Table 81. Patterns followed for integrated homestead production system, Kaliganj, Gazipur, 2023-24

Farmers category	Garden pattern	Vegetables		Spices	Garden area (dec)		
		Rabi	Kharif		Vegetables	Spices	Total
Marginal	1	Red amaranth, Spinach, Cabbage, Tomato, Coriander leaf, Country bean, Brinjal, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong, Bitter gourd	Turmeric	10.60	0.31	10.91
	2	Red amaranth, Spinach, Cabbage, Tomato, Coriander leaf, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong	Ginger	6.40	0.06	6.46
	3	Spinach, Cabbage, Tomato, Radish leaf, Chili	Okra, Malabar spinach, Kangkong, Bitter gourd, Sponge gourd, Yard-long bean	-	3.98		3.98
	4	Red amaranth, Spinach, Tomato, Brinjal, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong, Sponge gourd	Turmeric, Ginger	13.50	0.39	13.89
	5	Spinach, Cauliflower, Cabbage, Tomato, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong	Turmeric, Ginger	5.30	0.46	5.76
Average					7.96	0.31	8.20
Small	6	Red amaranth, Spinach, Cauliflower, Cabbage, Tomato, Radish leaf, Bottle gourd, Country bean, Brinjal, Chili	Okra, Malabar spinach, Stem amaranth, Jute leaf, Ridge gourd, Kangkong, Snake gourd	Turmeric, Ginger	11.51	0.34	11.85
	7	Spinach, Tomato, Brinjal, Chili	Malabar spinach, Stem amaranth, Kangkong, Bitter gourd	Turmeric, Ginger	6	0.36	6.34
	8	Red amaranth, Tomato, Country bean, Brinjal, Chili	Okra, Malabar spinach, Snake gourd, Sponge gourd	Turmeric, Ginger	6.43	0.43	6.86
	9	Red amaranth, Spinach, Tomato, Country bean, Brinjal, Chili	Okra, Malabar spinach, Stem amaranth, Kangkong, Bitter gourd, Snake gourd	Turmeric, Ginger	4.13	0.34	4.47
Average					7.01	0.37	7.38
Cumulative average					7.537	0.30	7.836

Results

Vegetables production

Productivity of year-round vegetables production under integrated homestead production system is presented in Table 82 and utilization scenario and economic return in Table 83. In case of marginal farmers, an average of 181 kg vegetables (97 kg in Rabi season and 84 kg in Kharif season) and in case of small farmers, an average of 172 kg vegetables (81 kg in Rabi season and 92 kg in Kharif season) were harvested per 10 decimals of garden (vegetables in 9.5 decimals and spices in 0.5 decimal). Irrespective of homestead gardens, among all the Vegetables cultivated by marginal and small farmers, the highest production was obtained from Cauliflower (64 kg) and Cabbage (44 kg) in Rabi season and Malabar spinach (29 kg) and Snake gourd (28 kg) in Kharif season, respectively. Among the 9 garden patterns, the highest vegetables production was obtained from Garden-5 (264 kg), where Spinach, Cauliflower, Cabbage, Tomato and Chili were cultivated in Rabi season and Okra, Malabar spinach, Stem amaranth and Kangkong were cultivated in Kharif season along with spices namely Turmeric and Zinger (Table 82). From the 9 gardens, an average gross margin of Tk 5622 (Tk 5341 for 5 marginal farmers and Tk 5973 for 4 small farmers) was obtained from 10 decimals of garden. The highest gross margin was produced from Garden-6 (Tk 7468), where Red amaranth, Spinach, Cauliflower, Cabbage, Tomato, Radish leaf, Bottle gourd, Country bean, Brinjal and Chili were cultivated in Rabi season and Okra, Malabar spinach, Stem amaranth, Jute leaf, Ridge gourd, Kangkong and Snake gourd were cultivated in Kharif season along with Turmeric and Zinger (Table 83).

Table 82. Productivity of year-round vegetables production under integrated homestead production system, Kaliganj, Gazipur, 2023-24

Farmers category	Garden pattern	Production (kg/9.5 dec)																					
		Rabi											Kharif										
		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	Okra	Malabar spinach	Stem amaranth	Kangkong	Jute leaf	Yard-long bean	Snake gourd	Ridge gourd	Bitter gourd	Sponge gourd	Total
Marginal	1	8	25	-	24	7	-	2	2	24	12	-	13	40	14	10	-	-	-	-	8	-	190
	2	8	12	-	64	9	-	3	3	-	-	-	24	25	12	12	-	-	-	-	-	-	171
	3	-	18	-	43	14	8	-	4	-	-	-	25	38	-	19	-	10	-	-	11	10	199
	4	2	6	-	-	8	-	-	3	3	-	-	11	20	6	4	-	-	-	-	-	19	82
	5	-	8	64	68	25	-	-	11	-	-	-	18	22	34	16	-	-	-	-	-	-	264
	Avg.	6	14	64	50	13	8	2	5	14	12	-	18	29	17	12	-	10	-	-	9	14	181
Small	6	3	13	21	44	11	4	-	15	7	4	27	12	13	16	7	6	-	11	6	-	-	219
	7	-	9	-	-	10	-	-	4	5	-	-	-	21	41	24	-	-	-	-	21	-	133
	8	14	-	-	-	19	-	-	4	13	19	-	22	30	-	-	-	-	46	-	-	22	190
	9	10	5	-	-	14	-	-	18	12	18	-	14	21	16	6	-	-	-	-	13	-	147
	Avg.	9	9	21	44	13	4	-	10	9	14	27	16	21	24	12	6	-	28	6	17	22	172
Cumulative average		8	12	42	49	13	6	2	7	11	13	27	17	25	17	12	6	10	28	6	13	8	177

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, Malabar spinach=25, Stem amaranth=25, Kangkong=35, Jute leaf=43, Yard-long bean=50, Snake gourd=45, Ridge gourd=50, Bitter gourd=60, Sponge gourd=55

Table 83. Utilization scenario and economic return of year-round vegetables production under integrated homestead production system, Kaliganj, Gazipur, 2023-24

Farmers category	Garden pattern	Utilization (kg/9.5 dec)			TVC (Tk/9.5 dec)	GM (Tk/9.5 dec)
		Consumption	Distribution	Sale		
Marginal	1	141	8	42	1864	5867
	2	143	9	20	1366	4908
	3	162	8	29	2086	5991
	4	66	6	10	867	3051
	5	243	18	3	3324	6889
	Average	151	10	21	1901	5341
Small	6	144	6	69	1977	7468
	7	102	5	26	1548	3760
	8	-	9	181	2732	6432
	9	-	6	141	1949	6232
	Average	123	6	104	2052	5973
Cumulative average		111	8	58	1968	5622

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 import of these two spices need to bring more land under cultivation. But this is not possible because of land limitation. One avenue of 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 create awareness among farmers in growing turmeric and ginger in unused and/or shady places of the homestead area

ii) To bring up unused shady places under spices production for income generation

Materials and Methods

The study was conducted at the FSR&D site Muktarpur, Kaliganj, Gazipur during 2023-24. Eight farmers were selected at the FSR&D site for the cultivation of ginger and turmeric in the fallow land under their homestead orchard. After preparing land, sowing was done by maintaining 50 cm × 25 cm and 60 cm × 25 cm spacing for ginger and turmeric, respectively. Before sowing, 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 sowing.

Results

Productivity, utilization scenario and economic return of spices production in shady place of homestead area under integrated homestead production system is presented in Table 84. From the 9 patterns followed at 9 homestead gardens, an average of 101 kg of spices (82 kg Turmeric and 33 kg ginger) were harvested from 10 decimals of garden, where spices were cultivated at 0.5 decimal of land. Among the 9 garden patterns, the highest spice production was obtained from Garden-1 (119 kg), where Turmeric was cultivated along with Red amaranth, Spinach, Cabbage, Tomato, Coriander leaf, Country bean, Brinjal and Chili in Rabi season and Okra, Malabar spinach, Stem amaranth, Kangkong and Bitter gourd in Kharif season. From the 9 orchards, an average gross margin of Tk 9782 was obtained from 10 decimals of garden. The

highest gross margin was produced from Garden-9 (Tk 22499), where Turmeric and ginger were cultivated along with Red amaranth, Spinach, Tomato, Country bean, Brinjal and Chili in Rabi season and Okra, Malabar spinach, Stem amaranth, Kangkong, Bitter gourd and Snake gourd in Kharif season. (Table 84).

Table 84. Productivity, utilization scenario and economic return of spices production under integrated homestead production system, Kaliganj, Gazipur, 2023-24

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	Distribution	Sale		
Marginal	1	119	-	119	10	4	105	1900	5222
	2	-	98	98	62	-	36	8465	20052
	3*	-	-	-	-	-	-	-	-
	4	82	8	91	9	-	82	1394	5966
	5	100	9	109	7	3	99	1615	7064
	Average	100	39	104	22	4	80	3343	9576
Small	6	88	10	99	12	-	86	1898	6381
	7	82	7	88	10	2	77	1638	5267
	8	78	10	88	6	-	82	1703	5804
	9	29	88	117	8	4	105	4801	22499
	Average	69	29	98	9	3	88	2510	9988
Cumulative average		82	33	101	16	3	84	2927	9782

* Did not cultivate any spice. Price (Tk/kg): Turmeric=60, Ginger=290

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

Overall productivity and economic return of vegetables and spice production under homestead production system from homestead gardens having an average area of 10 decimals, where vegetables and spices were cultivated at 9.5 and 0.5 decimal of land, respectively is presented in Table 85. From the 9 patterns followed at 9 gardens, an average of 258 kg of output was obtained from 10 decimals of orchard, with vegetables and spices contributing 64% and 36%, respectively. Moreover, each garden yielded a gross margin of Tk 16489 per 10 decimals on average, with vegetables and spices contributing 36%, and 64%, respectively.

Table 85. Overall average productivity and economic return of integrated homestead production system, Kaliganj, Gazipur, 2023-24

Farmers category	Garden pattern	Production (kg/10 dec/yr)			GM (BDT/10 dec/yr)		
		Vegetables	Spices	Total	Vegetables	Spices	Total
Marginal	1	190	119	309	5867	5222	11090
	2	171	98	269	4908	20052	24960
	3	199	0	199	5991	*	5991
	4	82	91	173	3051	5966	9017
	5	264	109	374	6889	7064	13953
	Average	181	83	265	5341	7661	13002
Small	6	219	99	318	7468	6381	13850
	7	133	88	222	3760	5267	9027
	8	190	88	278	6432	5804	12236
	9	147	117	264	6232	22499	28731
	Average	172	98	270	5973	9988	15961
Cumulative average		177	101	258	5622	9782	16489

* Did not cultivate any spice. Garden area: 10 decimal (Vegetables=9.5 decimal, Spices=0.5 decimal)

Expt. 6.2.3. Fruit tree plantation in homestead area

Introduction

Fruit tree plantation and fruit production under 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 analyze the distribution and diversity of fruit tree species within the homestead production system

ii) To evaluate the impact of integrating fruit trees with agricultural crops on productivity, soil health, and economic stability of local farmers

Methodology

Ten small and marginal farmers were selected in Muktarpur, Kaliganj, Gazipur under the activity. All the saplings were distributed on 21 June 2024 along with recommended management practice. All the farmers followed proper management practices during and after planting the saplings.

Results

Most of the distributed saplings were established in the orchards and fruit bearing not yet started. All the fruit trees are in good condition. The sapling distributions data are given in Table 86. Saplings of three mango varieties namely BARI Aam-4, BARI Aam-11 and BARI Aam-12 and one Litchi variety namely BARI Lichi-3 were distributed to the farmers according to their choice and interest. A total of 232 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 86. Fruit tree distribution under homestead production system, Kaliganj, Gazipur, 2023-24

Fruits sapling	Variety	Distribution (No.)	Mortality (No.)
Mango	BARI Aam-4	60	2
	BARI Aam-11	92	1
	BARI Aam-12	30	1
Lichi	BARI Lichi-3	50	2
Total		232	6

Distribution date: 21 June 2024

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 2023-24.

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 2023-24 by using household wastes, Vegetable waste, cow dung, poultry litter and other living materials. The average size of the compost pit was 4 m^2.

Result

Compost production by individual farmers is presented in Table 87. The annual average amount of compost produced by the farmers was 49 kg/4 m^2. Among the 9 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). The compost was used for Vegetables, spices, rice and fish cultivation.

Table 87. Productivity, utilization scenario and economic return of compost production under integrated homestead production system, Kaliganj, Gazipur, 2023-24

Farmers category	Pattern (Farmer)	Annual production (kg)	Utilization (kg)				GR (Tk)	GM (Tk)
			Vegetables cultivation	Spices cultivation	Rice cultivation	Aquaculture		
Marginal	1	43	36	7	-	-	215	115
	2	46	38	8	-	-	230	130
	3	42	20	10	12	-	210	110
	4	42	37	5	-	-	210	110
	5	58	37	11	10	-	290	190
	Average	46	34	8	11	-	231	131
Small	6	56	25	7	10	14	280	180
	7	53	19	11	23	-	265	165
	8	54	30	9	15	-	270	170
	9	47	27	9	11	-	235	135
	Average	53	25	9	15	14	263	163
Cumulative average		49	30	9	9	2	245	145

Size of compost pit (m^2)=4, Price of compost (Tk/kg)=5, TVC/pit (Tk)=50

6.3. Livestock Production System

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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. 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 the 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 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 2023-24. Twenty Sonali chicks were distributed to each of the 9 selected marginal and small farmers during 2023-24. Chicks were about 30 days old. The male female ratio was about 1:4. The chicks were vaccinated before giving them to the farmers. The routine works of vaccination are being followed regularly. Technical supports (feeding and watering management, vaccination etc.) and advice was provided. Necessary treatment was also given as per requirement.

Results

Productivity of chicken rearing under integrated livestock production system is presented in Table 88. Among the distributed chicken, 87% chicken survived. The mortality was mainly because of sudden outbreak of fowl pox. Irrespective of farmers category, on average 17 chickens survived per household from which 4 were consumed and 13 were sold to market. Marginal farmers obtained 993 eggs per household from which 377 were consumed and 616 were sold, respectively from the chicken left after consumption and selling to market (Table 89). Small farmers obtained 1178 eggs per household from which 471 were consumed and 707 were sold. Irrespective of farmers category, gross margin of Tk 18706 was earned per household from the produced egg and surviving chicken having maximum gross margin from household-2 (Tk 20590).

Table 88. Productivity of chicken rearing under integrated livestock production system, Kaliganj, Gazipur, 2023-24

Farmers category	Pattern (Household)	Survived chick (No.)	Mortality (%)	Chicken utilization (No.)		Egg production (No.)		
				Consumption	Sale	By consumed chicken	By sold chicken	Total
Marginal	1	18	10	4	14	138	840	978
	2	17	15	5	12	237	900	1137
	3	16	20	4	12	135	660	795
	4	19	5	5	14	160	910	1070
	5	18	10	4	14	147	840	987
	Average	18	12	4	13	163	830	993
Small	6	18	10	4	14	132	770	902
	7	17	15	3	14	131	1050	1181
	8	17	15	3	14	113	840	953
	9	16	20	3	13	138	1040	1178
	Average	16	20	3	13	138	1040	1178
	Cumulative average	17	13	4	13	148	872	1020

Date of Chick distribution: 03 June 2023; Egg laying period: December 2023 to April 2024

Table 89. Utilization scenario and economic return of chicken rearing under integrated livestock production system, Kaliganj, Gazipur, 2023-24

Farmers category	Pattern (Household)	Egg utilization (No.)		GR (Tk/household)			TVC (Tk/ household)	GM (Tk/ household)
		Consumption	Sale	Egg	Chicken	Total		
Marginal	1	391	587	12470	9450	21920	3579	18341
	2	398	739	14497	8925	23422	2832	20590
	3	302	493	10135	8400	18535	3738	14797
	4	460	610	13641	9975	23616	3247	20369
	5	335	651	12580	9450	22030	3796	18234
	Average	377	616	12665	9240	21905	3438	18466
Small	6	379	523	11501	9450	20951	3287	17663
	7	437	744	15058	8925	23983	2896	21086
	8	391	562	12148	8925	21073	3430	17644
	9	471	707	15014	8400	23414	3784	19631
	Average	471	707	15014	8400	23414	3784	19631
	Cumulative average	396	624	13005	9100	22105	3399	18706

Price (Tk/piece): Chicken (1.5 kg wt.)=525, Egg=12.75

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. 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 nine 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

Productivity, utilization scenario and economic return of pigeon rearing under integrated livestock production system is presented in Table 90. 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 2 squabs/pigeon for small farmers) having an average body weight/pigeon of 327 g during sell. From the 8 households, an average gross margin of Tk 6604 (Tk 4288 for 4

marginal farmers and Tk 8921 for 4 small farmers) was obtained. Among the 8 households, the highest gross margin was produced from Household-9 (Tk 15545), followed by Household-6 (Tk 10286).

Table 90. Productivity, utilization scenario and economic return of pigeon rearing under integrated livestock production system, Kaliganj, Gazipur, 2023-24

Farmers category	Pattern (Household)	Pigeon and squab production (No.)			Utilization of pigeon and squab (No.)		Remaining pigeon and squab (No.)	Average body weight /pigeon during sell (g)	TVC (Tk/household)	GM (Tk/household)
		Initial	Squab production	Total	Consumption	Sale				
Marginal	1	2	8	10	2	6	2	353	54	1896
	2	8	24	32	9	11	12	306	58	6182
	3*	-	-	-	-	-	-	-	-	-
	4	4	16	20	5	7	8	303	47	3853
	5	7	20	27	7	8	12	329	44	5221
	Average	5	17	22	6	8	9	323	51	4288
Small	6	16	37	53	14	23	16	332	49	10286
	7	6	14	20	5	11	4	330	45	3855
	8	8	23	31	8	15	8	336	47	5998
	9	26	54	80	22	36	22	324	55	15545
	Average	14	32	46	12	21	13	331	49	8921
	Cumulative average	10	25	34	9	14	11	327	50	6604

* Pigeon was not reared. Date of pigeon distribution: 14 September 2022
Price (Tk/piece): Pigeon (>300 g wt.)=225, 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

Methodology

One Black Bengal doeling was distributed to each of nine farmers at Kaliganj, Gazipur. Technical supports (feeding, de-worming, vaccination etc.) and advice were also given regularly. Necessary treatments were also provided as per necessity.

Results

Productivity, utilization scenario and economic return of goat rearing under integrated livestock production system is presented in Table 91. All the goats gave birth to kids except one. On average, in each household, 2 kids were generated per doe (1 kid/doe for marginal farmers and 3 kids/doe for small farmers). From the 9 households, an average gross margin of Tk 7162 (Tk 4431 for 5 marginal farmers and Tk 10576 for 4 small farmers) was obtained. Among the 9

households, the highest gross margin was produced from Household-6 (Tk 21934), followed by Household-9 (Tk 6920).

Table 91. Productivity, utilization scenario and economic return of goat rearing under integrated livestock production system, Kaliganj, Gazipur, 2022-24

Farmers category	Pattern (Household)	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	1	2	1	1	936	6664
	2	1	-	1	-	1	844	2956
	3	1	1	2	-	2	875	6725
	4	1	-	1	-	1	893	2907
	5	1	-	1	-	1	897	2903
	Average	1	1	1	1	1	889	4431
Small	6	1	5	6	4	2	866	21934
	7	1	1	2	2	-	871	6729
	8	1	1	2	1	1	881	6719
	9	1	1	2	1	1	680	6920
	Average	1	2	3	2	1	824	10576
	Cumulative average	1	2	2	2	1	860	7162

Date of doelings distribution: 27 September 2022; Price (Tk/goat): 3800

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 disease in infected animals or limit the frequency of disease

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 fifty cattle, eighty goats, three hundred and fifty chickens, seventy ducks and about one hundred pigeons were vaccinated at FSRD site.

Results

It was found that before vaccination, frequency of different disease was higher. The disease incidence was significantly reduced, and farmers were interested to continue vaccination of livestock and poultry birds (Table 92). If the vaccination service is locally available, farmers will continue vaccination of cattle, goat, chicken, duck and pigeon to reduce mortality.

Table 92. Mortality (%) of livestock and poultry birds before and after vaccination against major diseases, Kaliganj, Gazipur, 2022-24

Animal category	Animal	Name of the disease	Number vaccinated	Percentage of mortality (%)	
				Before vaccination	After vaccination
Livestock	Cattle	Foot and Mouth Disease	50	08-10	00
	Goat	Foot and Mouth Disease	80	10-15	02-03
Poultry bird	Chicken	Ranikhet, Fowl pox	350	30-35	08-10
	Duck	Ranikhet, Fowl pox	70	15-20	04-06
	Pigeon	Ranikhet, Fowl pox	150	15-25	05-08

6.4. Aquaculture System

MAU Razu, BJ Shirazy, 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 initiated at the FSRD site, Muktarpur, Kaliganj, Gazipur during 2022-23 to increase productivity of the existing ponds and to increase farm income. Initially, one farmer's pond among the 9 cooperative farmers was selected for the mixed fish cultivation. The size of the pond was about 30 decimal. 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. Eight species of fish namely, Tilapia, Mrigel carp, Rohu, Thai puti, Katla, Kalbaush, Silver Carp 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 93. After three months of fingerling release, Water taro (BARI Panikachu-3) was planted accordingly. Recommended management practices were followed for fish and Water taro. Growth performance, production and economic return were recorded.

Results

The maximum weight was (435 g) gained by Kalbaush (Table 93). Rohu, Katla and Mirror Carp had the maximum length of the fingerlings at release (13 cm) while had at harvest, that was gained by Rohu and Kalbaush (32 cm). Among the 8 fish species, the average initial weight and size of fingerling at release was 14 g and 11 cm, respectively. The average final weight and

size of fingerling at harvest was 334 g and 30 cm, respectively. The average weight and length of Water taro having at harvest were 3.12 kg and 2.13 m, respectively.

Table 93. List of components of integrated fish and Vegetable production under aquaculture system, Kaliganj, Gazipur, 2022-24

Component	Fish/ Vegetable species	Stocking density (Fingerlings/dec)	Average weight (g)		Average length (cm)		Duration at pond (days)
			At release	At harvest	At release	At harvest	
Fish	Tilapia	24	19	273	11	25	491
	Mrigel carp	13	6	245	9	31	
	Rohu	9	16	422	13	32	
	Thai puti	15	22	286	12	27	
	Katla	11	17	413	13	31	
	Kalbaush	8	9	435	10	32	
	Silver Carp	9	9	290	11	29	
	Mirror Carp	7	11	312	13	30	
	Average	12	14	334	11	30	
Vegetable	Water taro			3117		213	188

Date of fish release=19 October 2022, Last date of fish harvest=22 February 2024, Planting date of Water taro=15 February 2023, Last date of Water taro harvest=24 October 2023

Overall productivity, utilization scenario and economic return of vegetable (Water taro) and fish (mixed carp) under aquaculture system from a pond having 10 decimals area is presented in Table 94. A total of 72 kg fish was produced from 8 fish species having gross margin of Tk 5776 in total. Among the 8 fish species, the highest production was obtained from Silver Carp (22 kg), followed by Tilapia (19 kg). In the case of water taro, 1809 kg corm and stolon were produced from 10 decimals of area. Water taro and fish contribute 89% and 11% to the total gross margin of Tk 53438 and water taro is much more profitable as it produces a gross margin of Tk 476626 which is 8.25 times higher than that of fish.

Table 94. Overall average productivity, utilization scenario and economic return of aquaculture system, Kaliganj, Gazipur, 2022-24

Component	Fish/ Vegetable species		Production (kg/10 dec)	Utilization (kg/10 dec)		TVC (Tk/10 dec)	GM (Tk/10 dec)
				Consumption	Sale		
Fish	Tilapia		19	5	14		
	Mrigel carp		6	2	4		
	Rohu		4	2	3		
	Thai puti		10	3	7		
	Katla		6	2	4		
	Kalbaush		3	1	2		
	Silver Carp		22	5	17		
	Mirror Carp		2	1	1		
	Total		72	21	51	7217	5776
Vegetable	Water taro	Corm with petiole	1753	6	1602		
		Stolon	56	5	48		
		Total	1809	11	1650	7457	47662
Cumulative total			1881	32	1701	14673	53438

Price (Tk/kg): Tilapia=180, Mrigel carp=160, Rohu=200, Thai puti=207, Katla=210, Kalbaush=220, Silver Carp=150, Mirror Carp=350, Corm with petiole of Water taro=30, Stolon of Water taro=45

Overall scenario of household components under integrated farming systems at FSRD site, Kaliganj, Gazipur, 2023-24

Overall scenario of a farmer cultivating various year-round vegetables and spices in 10 decimals of homestead area and rearing livestock (goat) and poultry birds (chicken, pigeon) in household at FSRD site, Kaliganj, Gazipur during 2023-24 is presented in Figure 9. It was observed that, livestock contributes 43% of the overall profitability, followed by vegetables (33%), fish (17%)

and spices make up the remaining 7%. This distribution highlights the significant role of livestock and vegetables in the profitability of integrated farming systems in the region.

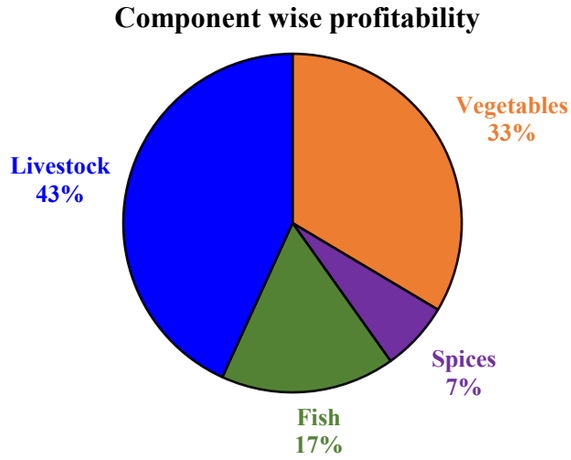

Figure 9. Contribution of household components to annual profit of integrated farming systems at FSRD site, Kaliganj, Gazipur, 2023-24