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PRODUCTIVITY AND PROFITABILITY OF MUSTARD AND BORO RICE PATTERNS IN HAOR AREAS OF NETRAKONA

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Abstract

On-farm trial was conducted at the farmers' field of Madan, Netrakona under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2023-24 and 2024-25 to develop alternate cropping pattern Mustard (var. BARI Sarisha-14)-Boro rice (var. BRRI dhan92)-Fallow and to compare its productivity and profitability against farmers existing cropping pattern, Fallow-Boro (var. BRRI dhan29)-Fallow. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping patterns *viz.*, alternate cropping pattern (Mustard-*Boro* rice-Fallow) and farmers' existing cropping pattern (Fallow-*Boro*-Fallow) were tested as variables of the experiment. The unit plot size was 1000-1200 m^2. The result of the study showed that two crops could be grown successfully in sequence in the tested site. Mean rice equivalent yield of alternate cropping pattern was 13.33 t ha^{-1} which was 111 % higher over existing cropping pattern (6.33 t ha^{-1}). Land utilization index, harvest index and profitability of developed cropping pattern were higher than farmers' existing cropping pattern. The mean gross return (Tk. 2,78,600 ha^{-1}) and gross margin (Tk. 1,27,960 ha^{-1}) were higher in developed cropping pattern compared to farmers' existing cropping pattern. The marginal benefit cost ratio (2.15) also indicated the superiority of the alternate cropping pattern over the farmers' existing cropping pattern.

Keywords: Cropping pattern, Productivity, Profitability, Haor Areas.

Introduction

Bangladesh is almost self-sufficient in rice production but other food production such as oil crops, pulses, and vegetables etc. are still deficient to a large extent. The present cropping intensity of Madan Upazilla of Netrakona district is about 169 % which is lower than the country's cropping intensity 198 %. Mustard (var. BARI Sarisha-14) is a high value cash crop which brings higher economic return. In Fallow-*Boro*-Fallow cropping patterns, mustard may be introduced after receding flood water. Mustard may be grown easily as an alternative of farmers' one. To align with SDG-2 (Zero Hunger), the Bangladesh Agricultural Research Institute

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(BARI) is focused on boosting cropping intensity. The goal is to maximize land productivity by transitioning from single to double, double to triple, and even triple to quadruple cropping systems.

In this context, not only the modern production technology and complementary inputs are essential but also the diversification of crops throughout the country is foremost. In Bangladesh horizontal expansion is very limited, but increase in crop production could be possible with vertical expansion through increasing crop yield per unit area and by reducing production loss. BARI has developed high yielding mustard variety, BARI Sarisha-14 whose yield potential is 40-45 % higher than Tori-7. Inclusion of this mustard variety can create opportunity to fit in the Fallow-*Boro*-Fallow cropping sequence. There are seven major cropping patterns which are practiced by the farmers of Madan, under Netrakona district among which Fallow-*Boro*-Fallow is one of the major cropping patterns under irrigated medium low land. This pattern covers around 40 % of the net cropped area (DAE, 2024). After flood water receded 15-20% land in haor areas is suitable for crop cultivation in last week of September to third week of December. At that time farmers are waiting for cultivating Boro rice by irrigation with deep tube well up to third week of January. As a result, a vast area remains fallow for long time (About 90 to 100 days) before *Boro* rice cultivation. So, there is an opportunity to increase cropping intensity and crop productivity by inclusion of mustard in Fallow-Boro-Fallow cropping pattern. If the farmers will sow mustard by first week of November, then it will be harvested at 3rd week of January. After harvesting of mustard, farmers can easily grow *Boro* rice in proper time which will not be affected by flash flood. Considering the above situation, the present study was carried out to develop two crop-based cropping patterns for haor areas and increase cropping intensity, productivity and income of the farmers.

Materials and Methods

The trial was conducted at the farmers' field of Madan, Netrakona under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Mymensingh during 2023-24 and 2024-25 to increase cropping intensity, productivity and profitability of the farmers by inclusion of mustard (var. BARI Sarisha-14) in the existing cropping system of Fallow -*Boro*-Fallow. The experimental site belongs to Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) of Netrakona. The geographical position of the area in between 24°72$'$N latitude and 90°93$'$ E longitude. The land was medium low and the soil of the study area was clay loam to clay in texture with well drainage system and almost acidic in reaction having pH range of 4.3 to 5.8. The overall soil characteristics are grey clay and silty clay, which are prone to being acidic and organic matter content is medium. In general, fertility level including N, P, K and B was low. Maximum rainfall was received during the months of April to September. The highest temperature (31.8°C) in August and the lowest in January (12.6°C). The relative humidity was the highest (84.5%) in August and the lowest (75.2 %) in March. Monthly mean maximum and minimum air temperature (31.1 and 23.5°C), total rainfall (2195 mm) and relative humidity (82.7 %) were prevailing during the study period.

The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping patterns *viz*., alternate cropping pattern (Mustard-*Boro*-Fallow) and farmers' existing pattern (Fallow-*Boro*-Fallow) were the treatment variables of the experiment. The unit plot size was 1000-1200 m^2. Mustard was grown during *rabi* season and it was the first crop of the sequence. Soil moisture at the time of sowing mustard was prevailing about 65 % at dry weight basis. Major yield contributing characters of mustard are presented in Appendix 1. Fertilizer management was followed by (Ahmmad *et. al*., 2018) and intercultural operations like weeding, irrigation and pest management were done to support the normal growth and development of the crops. Mustard var. BARI Sarisha-14 was seeded as broadcast method @ 7 kg ha^{-1}. The crop was sown during 14 to 19 November 2023 and 12 to 19 November 2024 in two consecutive years. The crop was harvested during 03 to 09 February 2024 and 02 to 10 February 2025. *Boro* rice was the second crop of the sequence. Major yield contributing characters of BRRI dhan92 are presented in Appendix 2. Seedlings of *Boro* rice were grown in adjacent plot and transplanting was done with 35 to 40 days old seedlings of *Boro* rice var. BRRI dhan92 at a spacing of 20 cm × 20 cm during 10 to 15 February 2024 and 08 to 14 February 2025. The Boro rice was harvested during 20 to 27 May 2024 and 19 to 28 May 2025 in two successive years.

Data on yield of different crops in sequences were recorded and converted to ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Agronomic parameters like field duration (FD), turnaround time (TAT), rice equivalent yield (REY), production efficiency (PE), land utilization index (LUI) and harvest index (HI) of cropping patterns were calculated by the following formula.

Rice Equivalent Yield (REY): For comparison between crop sequences, the yield of every crop was converted into rice equivalent yield on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

$$\textbf{Rice Equivalent Yield (t ha}^{-1}\textbf{)} = \frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\text{market price of rice}}$$

Productivity: Production efficiency value in terms of kgha^{-1}day^{-1} was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

Production efficiency (kgha^{-1}day^{-1}) $= \dfrac{\sum Y_i}{\sum d_i}$

Where, Y_i= Yield (kg) of ith crop, d_i= Duration (day) of ith crop of the pattern and i= 1, 2, 3, 4

Land utilization index (LUI): It was worked-out by taking total duration of crops in an individual cropping pattern divided by 365 days (Rahman *et al.,* 1989). It was calculated by the following formula:

$$\textbf{Land Utilization Index (\%)} = \frac{d_1 + d_2}{365} \times 100$$

Where d_1 and d_2 the duration of 1st and 2nd crop of the pattern

Harvest index (HI) was calculated as per following equation (Rahman *et al*., 1989).

$$\text{HI (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economic analysis was done on the basis of prevailing market price of the commodities. The inputs used included seed, fertilizer, labour and insecticides. The MBCR of the farmers' prevalent pattern and any replacement for it can be computed as the marginal value product ((MVP) over the marginal value cost (MVC). The Marginal of prevalent pattern (F) and any potential replacement (E) which was computed as (CIMMYT, 1988).

$$\textbf{Marginal Benefit Cost Ratio (MBCR)} = \frac{\text{Gross return (E) - Gross return (F)}}{\text{TVC (E) - TVC (F)}} = \frac{MVP}{MVC}$$

Results and Discussions

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, fertilizer dose used, field duration and turnaround time etc. of alternate and existing cropping pattern are shown in Table 1. The mean crop field duration of mustard and *Boro* rice under alternate cropping pattern were 83 and 102 days, respectively while, in existing cropping pattern it was 118 days for *Boro* rice. Total field duration of alternate cropping pattern and existing cropping pattern were 183-185 and 117-119 days, respectively in 2023-24 and 2024-25. The crop duration of *Boro* rice under existing cropping pattern was

Table 1. Agronomic practices of alternate cropping pattern and Farmers' existing cropping pattern at Madan, Netrakona MLT site during 2023-24 and 2024-25

Parameters	Years	Improved Pattern (IP)			Farmers' Pattern (FP)		
Crop	2023-24	Mustard	Boro rice	Fallow	Fallow	Boro rice	Fallow
	2024-25	Mustard	Boro rice	Fallow	Fallow	Boro rice	Fallow
Variety	2023-24	BARI Sarisha-14	BRRI dhan92	Fallow	Fallow	BRRI dhan29	Fallow
	2024-25	BARI Sarisha-14	BRRI dhan92	Fallow	Fallow	BRRI dhan29	Fallow
Sowing/	2023-24	14-19 Nov. 23	10-15 Feb.24	Fallow	Fallow	07-12 Jan.24	Fallow
planting time	2024-25	12-19 Nov. 24	08-14 Feb.25	Fallow	Fallow	10-16 Jan.25	Fallow
Seedling age (days)	2023-24	-	35-40	Fallow	Fallow	40-45	Fallow
	2024-25	-	35-40	Fallow	Fallow	40-45	Fallow
Spacing (cm)	2023-24	Broadcasting	20 ^20	Fallow	Fallow	20^15	Fallow
	2024-25	Broadcasting	20^20	Fallow	Fallow	20^15	Fallow
Fertilizer dose	2023-24	115-36-50-32-1-2	138-20-60-20	Fallow	Fallow	140-20-60-20	Fallow
(NPKSZnB kg ha^{-1})	2024-25	115-36-50-32-1-2	138-20-60-20	Fallow	Fallow	140-20-60-20	Fallow
Harvesting time	2023-24	03-09 Feb. 24	20-27 May 24	Fallow	Fallow	03-09 May 24	Fallow
	2024-25	02-10 Feb.25	19-28 May 25	Fallow	Fallow	08-18 May 25	Fallow
Field duration (days)	2023-24	82	101	Fallow	Fallow	117	Fallow
	2024-25	83	102	Fallow	Fallow	119	Fallow
TAT (days)	2023-24	175	07	Fallow	Fallow	248	Fallow
	2024-25	172	08	Fallow	Fallow	246	Fallow

higher (117-118 days) than that of alternate cropping pattern (101-102 days) due to use of long duration rice var. BRRI dhan29 in farmers' pattern. But in alternate cropping pattern *Boro* rice (BRRI dhan92) was cultivated and it was at least 15 days earlier harvested in both years. Turnaround time for mustard and *Boro* rice were 172-175 and 07-08 days, respectively in alternate cropping pattern whereas in existing cropping pattern it was 246-248 days in both the years.

Seed/Grain and by-product yield: Seed/grain and by-product yield of the study have been presented in Table 2. Seed yield of mustard (var. BARI Sarisha-14) was 1.78 and 1.60 tha^{-1} and stover yields were 1.34 and 1.26 tha^{-1} in two successive years, respectively. Two years average seed yield and stover yield of mustard in alternate cropping pattern was 1.69 and 1.30 t ha^{-1}, respectively. Grain yield of *Boro* rice was 7.12 t ha^{-1} in 1st year and 7.40 t ha^{-1} in 2nd year. Two years average grain and straw yields of *Boro* rice were 7.26 and 6.25 t ha^{-1} in alternate cropping pattern, respectively which was 14.69 and 1.46 % higher than existing pattern *Boro* rice (var. BRRI dhan29) due to change of variety along with modern crop production technologies. Similar results were also obtained by Nazrul *et al*. 2013. Farmers' cropping pattern gave lower yield due to imbalance use of fertilizers and poor management practices. It was revealed that the entire component crops of Mustard-*Boro*-Fallow (AP) cropping pattern under improved practices gave higher yield as well as by-product yield in two consecutive years. However, inclusion of mustard (var. BARI Sarisha-14) and *Boro* rice (var. BRRI dhan92) with improved production technologies increased the total yield over the farmers existing practice. Similar results were also obtained by Nazrul *et al*., 2013.

Table 2. Average Seed/grain yield and by-product yield of alternate cropping pattern and farmers' cropping pattern at Madan, Netrakona MLT site during 2023-24 and 2024-25

Parameters	Years	Improved Cropping Pattern (IP)			Farmers' Existing Pattern (FP)		
		Mustard	*Boro*	Fallow	Fallow	*Boro*	Fallow
Seed/Grain yield (t ha^{-1})	2023-24	1.78±0.23	7.12±0.18	-	-	6.46±0.24	
	2024-25	1.60±0.21	7.40±0.22	-	-	6.20±0.27	-
	Average	1.69±0.22	7.26±0.20	-	-	6.33±0.26	
Stover/Straw yield (t ha^{-1})	2023-24	1.34±0.23	6.40±0.28	-	-	6.29±0.21	-
	2024-25	1.26±0.24	6.10±0.24	-	-	6.03±0.27	-
	Average	1.30±0.22	6.25±0.26	-	-	6.16±0.24	-

Rice Equivalent Yield (REY): Total productivity of a cropping system was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Average higher rice equivalent yield (13.33 t ha^{-1})

was recorded with the alternate cropping pattern over farmer's traditional cropping pattern (Table 3). Rice equivalent yield increased by 111% in alternate cropping pattern due to inclusion of mustard (var. BARI Sarisha-14) and new high yielding variety of rice with modern production technologies for the component crops. The lower rice equivalent yield (6.33 t ha^{-1}) was obtained in the farmer's pattern due to single *Boro* rice with traditional management practices. It is evident from the above findings that alternate cropping pattern gave higher yield compared to existing farmers' pattern. Similar results were obtained by Nazrul *et al*. (2017).

Production Efficiency (PE): Mean maximum production efficiency (53.66) in terms of kg ha^{-1} day^{-1} was obtained from farmer's existing cropping pattern which was 10.32 % higher over alternate cropping pattern (Table 3). Production efficiency of alternate cropping pattern was found to be 48.63 and 48.65 kg $ha^{-1}day^{-1}$ in two consecutive years while in existing cropping pattern it was found to be 55.21 and 52.10 kg $ha^{-1}day^{-1}$, respectively. The production efficiency was lower in alternate cropping pattern might be due to inclusion of mustard variety as a result average total duration was (66 days) higher over farmer's existing pattern. The result indicates that the crops remained in the field for longer time leading to lower production per day. On the contrary, crops remain standing in the field for shorter time in farmer's practices, leading to higher production efficiency.

Land utilization index (LUI): Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The average land utilization index indicated that alternate cropping pattern used the land for 50.41 % period of the year whereas farmer's pattern used the land for 32.33 % period of the year (Table 3). Land utilization index was about 55.92 % higher in alternate cropping pattern than farmer's practice due to alternate cropping pattern occupied the land for longer duration (184 days) than farmer's pattern (118 days) in a year. This higher land use efficiency in alternate cropping pattern is due to cultivation of two component crops in the alternate cropping pattern.

Harvest Index: Alternate cropping pattern mustard (var. BARI Sarisha-14)- *Boro* rice (var. BRRI dhan92) recorded the mean harvest index (54.25%) which was 7.02% higher than existing cropping pattern, Fallow-*Boro* (Var. BRRI dhan29) - Fallow). The harvest index of alternate cropping pattern had higher value due to inclusion of mustard and *Boro* rice varieties which contributed the higher economic and biological yield.

Table 3. Average rice equivalent yield, production efficiency, land utilization index and harvest index of alternate cropping pattern and farmers' practices at Madan, Netrakona MLT site during 2023-24 and 2024-25

Year	Cropping patterns	REY (t ha^{-1})	PE (kg ha^{-1} day^{-1})	LUI (%)	HI (%)
2023-24	AP	14.12	48.63	50.14	53.49
	FP	6.46	55.21	32.05	50.67
2024-25	AP	12.54	48.65	50.68	55.01
	FP	6.20	52.10	32.60	50.70
Mean	AP	13.33	48.64	50.41	54.25
	FP	6.33	53.66	32.33	50.69

Note: AP= Alternate Pattern and FP=Farmers' Pattern, REY= Rice equivalent yield, PE= Production efficiency, LUI= Land utilization index and HI= Harvest index

Profitability analysis: The cost and return analysis were done on the basis of prevailing market price during the crop season as shown in Table 4. The study revealed that mean gross return of the alternate and farmers' existing cropping pattern was Tk.2,78,600 and Tk. 1,38,920 ha^{-1}, respectively. The mean gross return of alternate cropping pattern was 101 % higher than farmers' existing cropping pattern and it might be due to inclusion of mustard and high yielding *Boro* rice variety. The mean gross margin of alternate and farmers' existing cropping pattern was Tk. 1,27,960 and Tk. 53,298 ha^{-1}, respectively and it was about 140 % higher over farmer's existing cropping pattern. The mean MBCR was found 2.15 which is also indicated the superiority of alternate cropping pattern over farmer's existing cropping pattern.

Table 4. Cost and return analysis of alternate cropping pattern and farmers' existing cropping pattern at Madan, Netrakona MLT site during 2023-24 and 2024-25

Year	Pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk.ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
2023-24	AP	2,82,480	1,50,570	1,31,910	2.17
	FP	1,41,780	85,620	56,160	
2024-25	AP	2,74,720	1,50,710	1,24,010	2.13
	FP	1,36,060	85,625	50,435	
Mean	AP	2,78,600	1,50,640	1,27,960	2.15
	FP	1,38,920	85,623	53,298	

Note: Unit price (Tk. kg^{-1}): Mustard =70/-, *Boro* rice =20/-, Stover=2/-, and Rice straw=2/-

Farmers' opinion: Farmers opined that cultivation of mustard in a year increased cropping intensity and productivity. Harvesting of short duration BARI Sarisha-14 can easily be grown without hampering Boro rice.

Conclusion:

The total crop productivity, production efficiency and profitability of alternate cropping pattern Mustard (var. BARI Sarisha-14)-*Boro* rice (var. BRRI dhan92) - Fallow were higher than that of existing cropping pattern, Fallow- *Boro* (var. BRRI dhan29)- Fallow due to inclusion of mustard and *Boro* rice varieties. Thus, alternate cropping pattern Mustard-*Boro*-Fallow is economically as well as agronomically suitable technology for haor area of Netrokona. If early flash flood affected the *Boro* rice than at least mustard crop could be harvested but short duration of *Boro* rice should be developed for this pattern in future to avoid flood.

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Appendix1. Characteristics of BARI Sarisha-14 at Madan, Netrakona MLT site during 2023-24 and 2024-25

Year	Plant density /m^2	No. of primary branches /plant	No. of siliqua /plant	No. seed / siliqua	1000-seed weight (g)
2023-24	55	3.40	65.70	22.90	2.41
2024-25	57	3.20	67.30	22.10	2.43
Mean	56	3.30	66.50	22.50	2.42

Appendix2. Characteristics of BRRI dhan92 at Madan, Netrakona MLT site during 2023-24 and 2024-25

Year	Plant density /m^2	No. of effective tillers /hill	No. of filled grain/panicle	1000-grain weight (g)
2023-24	22.14	11.17	170	21.54
2024-25	22.16	11.13	172	21.66
Mean	22.15	11.15	171	21.60