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DEVELOPMENT OF ALTERNATE CROPPING PATTERN BY INCLUSION OF SHORT DURATION POTATO VARIETY AGAINST FARMERS' EXISTING CROPPING PATTERN FALLOW-BORO-FALLOW IN HAOR AREAS OF NETRAKONA

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Abstract

A trial was conducted in farmers' fields in Madan, Netrakona, by the On-Farm Research Division of the Bangladesh Agricultural Research Institute (BARI), Mymensingh, during 2023–24 and 2024–25. The study aimed to develop an alternate cropping pattern, Potato (var. Challisha)-Boro rice (var. BRRI dhan92)-Fallow and compare its productivity and profitability against the existing pattern, Fallow-Boro (var. BRRI dhan29)-Fallow, through the inclusion of potato (var. Challisha) and Boro rice (var. BRRI dhan92) using improved management practices. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping patterns viz., alternate cropping pattern (Potato-*Boro* rice-Fallow) and farmers' existing cropping pattern (Fallow-*Boro*-Fallow) were the treatment 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 26.59 t ha^{-1}which was 271 % higher over existing cropping pattern (7.16 t ha^{-1}). Besides, land utilization index, harvest index and profitability of alternate cropping pattern was higher than farmers' existing cropping pattern. The mean gross return (Tk. 5,49,950 ha^{-1}) and gross margin (Tk. 2,69,148 ha^{-1}) were higher in alternate cropping pattern compared to farmers' existing cropping pattern. The marginal benefit cost ratio (2.01) was also indicated the superiority of the alternate cropping pattern over the farmers' existing cropping pattern

Key words: Rice equivalent yield, harvest index, profitability, efficiency and gross return.

Introduction

Bangladesh is almost self-sufficient in rice production but other food production such as potato, 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 very low than country's cropping intensity (198%). Potato (Challisha) is a high value cash crop with short duration which brings higher

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economic return. In Fallow-Boro-Fallow cropping patterns potato may be introduced after receding flood water. Potato may be grown easily as an alternative of farmers' one. There is no alternative to meet the ever-increasing demand of food for fast growing population except increasing production from the existing available land in the country. In alignment with Sustainable Development Goal 2 (SDG-2), BARI remains committed to developing technologies that increase cropping intensity and ensure food security. Consequently, the institute BARI is working to transition single-cropped areas into double-cropped land, while similarly advancing double-cropped systems into triple or quadruple-cropping patterns

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 losses. A cropping pattern is the yearly sequence, temporal and spatial arrangement of crops in a given land area. Inclusion of potato variety can create opportunity to fit in the Fallow-*Boro* Rice-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 potato in Fallow-*Boro*-Fallow cropping pattern. If the farmers sown potato by first week of November, then it will be harvest at mid-January. After harvesting of potato farmers can easily grow *Boro* rice in proper time which will not be affected by flash flood. The present study was undertaken 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 by the On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2023-24 and 2024-25 to increase cropping intensity, productivity and profitability of the farmers by inclusion of potato (var. Challisha) in the existing cropping system Fallow -*Boro*-Fallow cropping pattern. The experimental site belongs to Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) of Netrakona.The geographical position of the area in between 24º72/N latitude and

90º93/ 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 (31.8ºC) in August and the lowest in January (12.6ºC). 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 23.5ºC), 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 (Potato-*Boro*-Fallow) and farmers' existing pattern (Fallow-*Boro*-Fallow) were the treatment variables of the experiment. The unit plot size was 1000-1200 Sq.m. Potato was grown during *Rabi* season and it was the first crop of the sequence. Major yield contributing characters of potato has been cited in appendix 1. Soil moisture at the time of planting potato was prevailing about 60 % at dry weight basis. Potato seed was sown @ 1500 kg ha^{-1} with 40 cm × 20 cm during 22 to 25 November 2023 and 21 to 25 November 2024 in two consecutive years. 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. Potato was harvested during 25 to 31 January, 2024 and 26 to30 January, 2025 in two successive years. *Boro* rice was the second crop of the sequence. Major yield contributing characters of BRRI dhan-92 has been given in appendix 2. Seedlings of rice were grown in adjacent plot and transplanting was done with 40 to 45 days old seedlings of rice var. BRRI dhan92 at a spacing of 20 cm × 20 cm during 08 to 16 February 2024 and 08 to 12 February 2025. Boro rice was harvested during 23 to 30 May 2024 and 20 to 28 May 2025 in two consecutive years.

Data on the yield of different crops in sequences were recorded and converted into ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Agronomic performance 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).

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

Where, Y_i= Yield (kg) of i^{th} crop, d_i= Duration (day) of i^{th} 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 1^{st} and 2^{nd} 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).

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

Results and Discussions

Crop management: Crop management practices include date of planting/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 potato and *Boro* rice under improved cropping pattern Potato (var. Challisha)- *Boro* rice (var. BRRI dhan92)-Fallow were 66 and

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	Alternate Pattern (AP)			Farmers' Pattern (FP)		
Crop	2023-24	Potato	*Boro* rice	Fallow	Fallow	*Boro* rice	Fallow
	2024-25	Potato	*Boro* rice	Fallow	Fallow	*Boro* rice	Fallow
Variety	2023-24	Challisha	BRRI dhan92	Fallow	Fallow	BARI dhan29	Fallow
	2024-25	Challisha	BRRI dhan92	Fallow	Fallow	BARI dhan29	Fallow
Planting time	2023-24	22-25 Nov. 23	08-16 Feb.24	Fallow	Fallow	11-15 Jan.24	Fallow
	2024-25	21-25 Nov. 24	08-12 Feb.25	Fallow	Fallow	10-14 Jan.25	Fallow
Seedling age (days)	2023-24	-	40-45	Fallow	Fallow	40-45	Fallow
	2024-25	-	40-45	Fallow	Fallow	40-45	Fallow
Spacing (cm)	2023-24	40 ×20	20 ×20	Fallow	Fallow	20×15	Fallow
	2024-25	40 ×20	20 ×20	Fallow	Fallow	20×15	Fallow
Fertilizer dose	2023-24	160-44-150-21-2-1	138-20-60-20	Fallow	Fallow	140-20-60-20	Fallow
(NPKSZnB kg ha^{-1})	2024-25	160-44-150-21-2-1	138-20-60-20	Fallow	Fallow	140-20-60-20	Fallow
Harvesting time	2023-24	25-31 Jan.24	22-30 May 24	Fallow	Fallow	06-14 May 24	Fallow
	2024-25	26-30 Jan.25	20-28 May 25	Fallow	Fallow	06-12 May 25	Fallow
Field duration (days)	2023-24	65	103	Fallow	Fallow	118	Fallow
	2024-25	66	105	Fallow	Fallow	117	Fallow
TAT (days)	2023-24	183	14	Fallow	Fallow	247	Fallow
	2024-25	184	13	Fallow	Fallow	248	Fallow

104 days, respectively while, in existing cropping pattern Fallow- *Boro* (BRRI dhan29)- was 118 days for *Boro* rice. Total field duration of alternate cropping pattern and existing cropping pattern were 168-170 and 117-118 days, respectively in 2023-24 and 2024-25. The crop duration of *Boro* rice under existing cropping pattern was higher (117-118 days) than that of alternate cropping pattern (103-104 days) due to use of long duration BRRI dhan29 variety in farmers' pattern. But in alternate cropping pattern *Boro* rice (var. BRRI dhan92) was cultivated and it was at least 15 days earlier harvested in both years. Turnaround time for Potato and *Boro* rice were 182-183 and 13-14 days, respectively in alternate cropping pattern whereas in existing cropping pattern it was 247-248 days in both the years.

Tuber/grain and straw yield: Tuber/grain and foliage/straw yield of the study have been presented in Table 2. Tuber yield of Potato (Challisha) was 12.8 and 12.93 tha^{-1} and sundry foliage yields were 3.49 and 3.59 tha^{-1} in two successive years, respectively. Two years average, tuber yield and foliage yield of potato in alternate cropping pattern was 12.87 and 3.54 t ha^{-1}, respectively. Grain yield of *Boro* rice was 7.43 t ha^{-1} in 1st year and 7.53 t ha^{-1} in 2nd year. Two years average, grain and straw yields of *Boro* rice were 7.48 and 7.13 t ha^{-1} in alternate cropping pattern, respectively which was 4.47 and 1.0 % higher than existing pattern *Boro* rice (var. BRRI dhan29) due to change of variety with improved 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 Potato-*Boro*-Fallow cropping pattern under alternate practices (AP) gave higher yield as well as by-product yield in two consecutive years. Inclusion of Potato (Challisha) and BRRI dhan92 with modern production technologies increased the total yield over the farmers existing practice. Similar results were also obtained by Nazrul *et al*., 2013.

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

Parameters	Years	Alternate Cropping Pattern (AP)			Farmers' Existing Pattern (FP)		
		Potato	*Boro*	Fallow	Fallow	*Boro*	Fallow
Tuber/Grain yield (t ha^{-1})	2023-24	12.81±0.22	7.43±0.16	-	-	7.20±0.25	-
	2024-25	12.93±0.23	7.53±0.17	-	-	7.12±0.27	-
	Average	12.87±0.21	7.48±0.17	-	-	7.16±0.26	-
Foliage/Straw yield (t ha^{-1})	2023-24	3.49±0.19	7.16±0.16	-	-	7.13±0.21	-
	2024-25	3.59±0.20	7.10±0.18	-	-	7.03±0.19	-
	Average	3.54±0.18	7.13±0.17	-	-	7.08±0.20	-

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 (26. 59 t ha^{-1}) was recorded with the alternate cropping system over farmer's traditional cropping system (Table 3). Rice equivalent yield increased by 271% in alternate cropping pattern due to inclusion of potato (Challisha) and a new high yielding variety of rice with improved production technologies for the component crops. The lower rice equivalent yield (7.16 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 120.42 in terms of kg $ha^{-1}day^{-1}$ was obtained from alternate cropping pattern which was 97.93 % higher over farmer's existing cropping pattern (Table 3). Production efficiency of alternate cropping pattern was found 120.48 and 120.35 kg $ha^{-1}day^{-1}$ in two consecutive years while in existing cropping pattern it was found 61.02 and 60.85 kg $ha^{-1}day^{-1}$, respectively. The production efficiency was lower in farmers' existing cropping pattern might be due to only single *Boro* rice in farmer's existing cropping pattern. The lower production efficiency was observed in farmer's existing cropping pattern (Tables 3). The result indicates that crops remain standing in the field for shorter time in 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 46.30 % period of the year whereas farmer's pattern used the land for 32.14% period of the year (Table 3). Land utilization index was about 44 % higher in alternate cropping pattern than farmer's practice due to alternate pattern occupied the land for longer duration (170) 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 pattern.

Harvest Index: Alternate cropping pattern Potato (var. Challisha)-*Boro* rice (Var. BRRI dhan92) recorded the higher harvest index (65.26 %) and existing cropping pattern Fallow-*Boro* (var. BRRI dhan29) - Fallow) recorded the lower harvest index (50.28 %). The harvest index of alternate cropping pattern had higher value due to inclusion of potato 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})	LUI (%)	HI (%)
2023-24	AP	26.25	120.48	46.03	65.52
	FP	7.20	61.02	32.23	50.24
2024-25	AP	26.92	120.35	46.57	65.00
	FP	7.12	60.85	32.05	50.31
Mean	AP	26.59	120.42	46.30	65.26
	FP	7.16	60.84	32.14	50.28

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.5,49,950 and Tk. 1,58,260 ha^{-1}, respectively. The mean gross return of alternate cropping pattern was 248 % higher than farmers' existing cropping pattern and it might be due to inclusion of potato and high yielding *Boro* rice variety. The mean total variable cost of the alternate and farmers' existing cropping pattern was Tk. 2,80,802 and Tk. 85,672 ha^{-1}, respectively. About 271 % higher gross margin (Tk. 2,69,148 ha^{-1}) was calculated at alternate cropping pattern over farmer's existing cropping pattern (Tk. 72,588 ha^{-1}). The mean MBCR was found 2.01 which also indicated the superiority of alternate cropping pattern over farmer's existing cropping pattern.

Farmers' opinion: Farmers opined that cultivation of potato in a year increased cropping intensity and productivity. Harvesting of short duration potato (Challisha) can easily be grown without hampering *Boro* rice.

Table 4. Cost -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	5,47,200	2,80,650	2,66,550	2.00
	FP	1,58,260	85,720	72,540	
2024-25	AP	5,52,700	2,80,955	2,71,745	2.02
	FP	1,58,260	85,625	72,635	
Mean	AP	5,49,950	2,80,802	2,69,148	2.01
	FP	1,58,260	85,672	72,588	

Note: Unit price (Tk. kg^{-1}): Potato =30/-, Boro rice =20/- and Rice straw=2/-

Conclusion

The total crop productivity, production efficiency, and profitability of the alternate cropping pattern, Potato (var. Challisha)-Boro rice (var. BRRI dhan92)-Fallow, were significantly higher than those of the existing pattern, Fallow-Boro (var. BRRI dhan29)-Fallow, due to the inclusion of potato and the improved Boro rice variety. Thus, the Potato-Boro-Fallow sequence is an economically and agronomically suitable technology for the haor areas of Netrakona. While the potato crop provides a harvested yield even if early flash floods affect the Boro rice, short-duration Boro varieties should be developed for this pattern in the future to further mitigate flood risks

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Appendix 1. Characteristics of Potato (Challisha) at Madan, Netrakona MLT site during 2023-24 and 2024-25

Year	Plant density /m^2	No. of stem /plant	No. of tubers /plant	Average wt. of tubers/plant (g)
2023-24	12.50	3.40	65.70	2.41
2024-25	11.80	3.20	67.30	2.43
Mean	12.15	3.30	66.50	2.42

Appendix 2. 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	22.23	11.28	173	21.19
2024-25	22.26	11.34	170	21.24
Mean	22.25	11.31	172	21.22