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PRODUCTION POTENTIAL AND ECONOMICS OF BLACK GRAM-BORO RICE-FALLOW CROPPING SYSTEM IN OLD MEGHNA ESTUARINE FLOODPLAIN

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Abstract

An experiment was conducted at the farmers' field of Old Meghna Estuarine Floodplain Soils under the Agro-Ecological Zone (AEZ) 19 at Nikli, Kishoreganj, for two consecutive years 2019-20 and 2020-21 to evaluate the performance of Black gram-Boro rice-Fallow improved cropping pattern against a farmer's cropping pattern of Fallow- Boro rice-Fallow. Findings revealed that the mean crop durations of 185-189 days were required for one cycle in a year in an improved cropping pattern which implied that two crops based cropping pattern was agronomically feasible to replace the existing cropping pattern. Total grain yield in terms of rice equivalent yield (REY) of the improved cropping pattern was 9.742 t/ha/year which was 29.38% higher than that of the existing pattern (7.53 t/ha/year). The mean production efficiency of the improved cropping pattern (52.09 kg/ha/day) was 39% less than that of the existing pattern due to more time involved in the improved pattern and land-use efficiency of the improved cropping pattern (51.23%) which was 80% higher than that of existing cropping pattern due to less time involvement in existing cropping pattern. The gross return and gross margin were higher in the improved cropping pattern compared to the existing cropping pattern due to an additional yield of black gram and boro rice. Therefore, farmers in the Old Meghna Estuarine Floodplain region of Bangladesh could follow an alternate cropping pattern where lands remain fallow for 81-86 days after the floodwater receded for higher crop productivity and profitability.

Keywords: Production potential, Economics, Cropping system, AEZ-19

1. Introduction

Kishoreganj is quite different from other districts of Bangladesh for its unique natural beauty characterized by haors, rivers, plain land, and char areas. The total cultivated area of Kishoreganj is 386121 ha of which about 102057 ha of cultivated land are single-cropped, 50874 ha are double-cropped, and 55100 ha are tripled-cropped areas with a cropping intensity of 182% (DAE, 2020). The average cropping intensity in haor areas of Kishoreganj is about 104% (DAE, 2019) and the country is losing 0.49% of cultivable land every year for high population pressure and other purposes (Hasan *et al.*, 2013).

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Cultivable land is declining day by day so escalating cropping intensity with more production and bringing the barren land under cultivation is the pre-requisite for sustainable food security in Bangladesh. Thus, the increase of cropping intensity in the rice-based cropping system is becoming important for food security and poverty alleviation. For producing more food within a limited area, the most important options are to increase the cropping intensity and to increase the production efficiency of the individual crop by using optimum management practices (Mondal *et al.*, 2015). Flash flood comes late in the upper catena part of the haor which is under old Meghna estuarine floodplain areas but wakes up quickly and 10-15% of these areas become suitable for crop cultivation in the last week of September to the second week of October (Mohiuddin and Sarker, 2019). At that time, farmers are waiting for cultivating boro rice with irrigation by deep tube well up to December the second week to the first week of January. As a result, the vast area remains fallow for a long time about 80-90 days after flood water receded.

Black gram fits well in old Meghna estuarine floodplain areas during the fallow period to increase cropping intensity as well as crop productivity due to its short duration, drought tolerance, less care, and minimum input requirement (Mohiuddin *et al.,* 2018). Total cultivated area in Bangladesh is 9805360 ha of which 45%, 18%, and 10% are suitable, moderately suitable, and marginally suitable for black gram production (BARC, 2016). The potential adoption of black gram in the *fallow-boro rice-fallow* cropping system would generate employment and additional income for the farmers by utilizing fallow lands in old Meghna estuarine floodplain areas. Rapid population growth led to acute shortage of pulses in Bangladesh and importing pulses at huge foreign exchange to meet local demand is a major concern to the government but received little attention from farmers and policy makers (Hamjah, 2014; Mohiuddin *et al.,* 2018). On the other hand, pulse crops are the source of nitrogen and reduce nitrogen fertilizer requirement (McDonagh *et al.,* 1995). Inclusion of grain legumes plays an important role in increasing cropping intensity or even sustaining crop productivity along with improving the nutritional status of the people and maintaining soil health (Becker *et al*., 1995; Norman *et al*., 1984). Considering the above facts, pulse production should be increased rapidly to improve the national nutritional status along with less outflow of precious foreign currency.

Many studies on different cropping patterns are available in Bangladesh and India that an additional crop could be introduced without many changes or replacing the existing ones for considerable increases in productivity as well as the profitability of the farmers (Malavia *et al*., 1986; Khan *et al.,* 2005; Nazrul *et al*., 2013; Kamrozzaman *et al.,* 2015) while no work has been done to understand the inclusion of black gram in rice-based cropping systems with specific locations or districts of Bangladesh. The present study was undertaken to know the productivity and profitability of two crops based improved cropping pattern *Black gram-Boro rice-Fallow* in old Meghna estuarine floodplain areas.

Objectives:

i) to study the agronomic practices of *black gram-boro rice-fallow* cropping pattern;

ii) to examine the feasibility of *black gram-boro rice-fallow* cropping pattern in farmers' field condition;

iii) to estimate the productivity and profitability of the above improved cropping pattern against farmer's existing cropping pattern.

2. Materials and Methods

The study was carried out for two consecutive years 2019-20 and 2020-21 at a farmer's field, Kishoreganj (Latitude- 24° 16' 47.028″ N and Longitude-90° 56' 10.902″ E) located in Agro- Ecological Zone (AEZ)-19; under Old Meghna Estuarine Floodplain Soils. This trial was conducted to derive the economic consequences of two cropping patterns viz. IP: improved pattern (Black gram -Boro rice-Fallow) and FP: farmer's pattern (Fallow-Boro rice-Fallow) through the incorporation of high yielding varieties with improved management practices.

In the improved pattern, Black gram var. BARI Mas-3 was introduced against fallow period. Boro rice var. BRRI dhan29 was used in both farmers' patterns and improved patterns, respectively. The agronomic parameters and cultural operations for crop production under improved and farmer's practices are presented in Table 1. All field operations and management practices of both farmers and improved patterns were closely monitored and the data were recorded for agro-economic performance.

Agronomic performance viz. land-use efficiency, production efficiency, rice equivalent yield, and the benefit-cost ratio of cropping patterns were calculated. Land use efficiency is worked out by taking the total duration of an individual crop in a sequence divided by 365 days (Tomer and Tiwari, 1990). It is calculated by the following formula:

$$\text{Land use efficiency} = \frac{d_1 + d_2}{365} \times 100$$

Where d_1 and d_2 the duration of first and second crop of the pattern

Production efficiency: Production efficiency values in terms of Kg./ha/day were calculated by total production in a cropping sequence divided by total duration of crops in that sequence (Lal et al., 2017; Tomer and Tiwari. 1990).

$$\text{Production Efficiency} = \frac{Y_1 + Y_2}{d_1 + d_2} \quad kg/ha/day$$

Where, Y_1= Yield of first crop and d_1= Duration of first crop of the pattern; and Y_2= Yield of second crop and d_2= Duration of second crop of the pattern

Rice equivalent yield: For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield (REY) on the basis of prevailing market price of individual crop.

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

The economic indices like gross return, gross margin, and marginal benefit-cost ratio were also calculated based on the prevailing market price of the product. The economic analysis involved the collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour, and insecticides. The MBCR of the farmer's 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 the prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

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

3. Results and Discussion

Results of the two years study of improved cropping pattern (Black gram -Boro rice- Fallow) and farmer's existing pattern (Fallow-Boro rice-Fallow) are presented in Table 1-5.

Grain and by-product Yield: The improved pattern took 185-189 days against 102-106 days due to the inclusion of black gram in the pattern. This indicates that black gram could easily be grown or fitted before boro rice. After two consecutive years of the study, the result revealed that the seed yields of BARI Mas-3 were 0.93 t/ha and 0.98 t/ha and that of stover yields were 1.4t/ha and 1.39 t/ha, respectively. The mean yield of black gram was observed at 0.96 t/ha. Although a 5.37% yield increase was observed in the second year might be due to less infestation of spodoptera litura than the previous year during the growing season. The grain yield of boro rice in the improved pattern was 7.40 t/ha in 1st year and whilst it was 7.25 t/ha in 2nd year. Mean grain and straw yields of boro rice were 7.33 and 3.68 t/ha. The yields of boro rice in farmer's practice were 7.2 and 7.1 t/ha, in 1st and 2nd year and mean grain and straw yield of boro rice were 7.15 and 3.8 t/ha respectively. It was observed that the improved pattern under the black gram-boro rice -fallow cropping pattern gave higher grain and by-product yield (Table 1). The average yield of Boro rice in the improved pattern increased by 3 and 2% over farmers' practice (FP) in the first and second year, respectively. The yield of the improved pattern was higher presumably due to the change of variety with improved production technologies and timely sowing of the component crops. The lower yield of grain and straw of boro rice in farmers' practice was due to the use of imbalanced fertilizer and poor management practice. Similar results in higher productivity were obtained by Nazrul et al. (2013), Khan et al. (2018), Khan et al. (2005) and Hossain and Wahhab (1992).

Farmers' cropping pattern Fallow-Boro rice-Fallow required 106 and 102 days field duration in the 1st and 2nd year. Contrary, the total field duration of the improved pattern black gram-boro rice-fallow was 189 and 185 days (excluding seedling age of rice) to complete the cycle in the 1st and 2nd year, respectively (Table 1). Thus, the turn-around period of 259-263 days was utilized in the farmer's existing pattern. The result indicated that black gram could be easily fitted in Fallow-Boro rice cropping pattern with an average of 178 days turn-around time in a year. Similar results were found by Khan et al. (2018).

Table 1. Agronomic practices of improved and farmers' existing pattern during 2019-20 and 2020-21

Parameter	Year	Improved Pattern		Farmers' Pattern
		Black gram	Boro rice	Boro rice
Variety	2019/20-20/21	BARI Mas-3	BRRI dhan29	BRRI dhan29
Sowing/ transplanting	2019-20	16 Oct. 2019	26 Jan. 2020	05-10 Jan. 2020
	2020-21	27 Oct. 2020	23 Jan. 2021	10-12 Jan. 2021
Seedling age (days)	2019/20-20/21	-	35-40	40-45
Seed rate (kg/ha)	2019/20-20/21	40	50	50
Planting method	2019/20-20/21	Broadcast	Line	Line
Spacing (Row×hill)	2019/20-20/21	Continuous	20cm × 15cm	20cm × 15cm
Seedling/hill	2019/20-20/21	-	2-3	3-4
Fertilizer dose (NPKSZnB kg/ha)	2019/20-20/21	20-18-20-10-0-02	140-18-53-08-03-02	115-40-63-14-0-0
Fertilizer application method	-	Entire N, P, K, S & B applied as basal after final land preparation	Full P,K,S & Zn were applied as basal. N was applied in three equal splits, 1st top dress was done after seedling establishment, 2nd one at early tillering stage and 3rd one at 5-7 days prior to panicle initiation stage	Full amount of P,K,S & Zn were applied as basal. N was applied in three equal splits, 1st top dress was done after seedling establishment, 2nd one at early tillering stage and 3rd one at 5-7 days prior to panicle initiation stage
Weeding (no.)	2019/20-20/21	Once	Twice at 15-20 and 35-40 DAT	Twice at 15-20 and 35-40 DAT

Parameter	Year	Improved Pattern		Farmers' Pattern
		Black gram	Boro rice	Boro rice
Irrigation (no.)	2019/20-20/21	Once	Several times	Several times
Insect/pest control	2019/20-20/21	IPM	IPM	Chemical
Harvesting time	2019/20	10 Jan, 2020	08 May, 2020	20-24 April, 2020
	2020/21	16 Jan, 2021	07 May, 2021	22-24 April, 2021
Grain yield (t /ha)	2019/20	0.93	7.40	7.20
	2020/21	0.98	7.25	7.10
Straw yield (t /ha)	2019/20	1.4	4.0	4.10
	2020/21	1.39	3.35	3.50
TAT (days)	2019/20	161	16	259
	2020/21	173	07	263
Field duration (days)	2019/20	86	103	106
	2020/21	81	104	102

Rice equivalent yield: The total productivity of improved and farmer's cropping patterns were evaluated in terms of rice equivalent yield (REY) and it was calculated from the yield of component crops. The mean rice equivalent yield revealed that the improved cropping pattern produced higher rice equivalent yield (9.74 t/ha/yr) over the farmer's (7.53 t/ha/yr) existing pattern (Table 2). Inclusion of black gram in *Rabi* season in improved cropping pattern increased REY of 29% compared to farmer's existing one. It was also due to the higher price of component crops in the improved pattern. These results are in agreement with that of Mondal *et al*. (2015) and Nazrul *et al*. (2017) who reported that total productivity increased by 67% over farmer's practice due to the inclusion of a third crop (mungbean) in the pattern.

Production efficiency: Maximum production efficiency (72.42) in terms of kg/ha/day was obtained from farmers existing cropping patterns (Table 2) because it takes less time. This result was found contradictory to that of Nazrul *et al*. (2013), Khan *et al*. (2006), and Khan *et al*. (2005).

Land utilization index (LUI): The land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. The land utilization index (LUI) indicated that the improved pattern used the land for 51% period of the year, whereas the farmers' pattern used the land for 28% period of the year (Table 2). Land use efficiency was 80% higher in improved patterns than in farmer's practices, mostly because the improved pattern occupied the field for a longer duration (185-189 days) than the farmer's pattern (102-106 days) in a year. As a result, labour utilization could be more in the improved cropping pattern than the existing one.

Table 2. Rice-equivalent yield, production efficiency and land utilization index of improved and farmer's cropping pattern during 2019-20 and 2020-21

Items	Improved pattern			Farmer's pattern		
	2019-20	2020-21	Average	2019-20	2020-21	Average
REY (t/ha/yr)	9.80	9.684	9.742	7.61	7.45	7.53
PE (kg/ha/day)	51.85	52.35	52.10	71.79	73.04	72.42
LUI (%)	51.78	50.68	51.23	29.04	27.95	28.49

REY= Rice equivalent yield, PE= production efficiency, and LUI= land utilization index

Cost and return analysis: The benefit-cost ratio of improved patterns and farmers' existing patterns are presented in Table 3. From the economic point of view, the gross return of the improved cropping pattern (Tk.194840/ha) showed its superiority by 29% over the farmer's existing pattern (Tk.150600/ha). The production cost of the improved pattern (Tk.101775/ha) was higher than the farmer's pattern (Tk.83740/ha) due to the inclusion of black gram and improve management which takes the extra cost of inputs of the production. The gross margin was substantially higher in the improved pattern (Tk.93065/ha) than in the farmer's pattern (Tk.66860/ha). The higher gross margin of the improved pattern (39%) was achieved mainly by higher yield advantages and the price of the component crops. The mean marginal benefit- cost ratio (MBCR) was found 2.5 which indicated the superiority of the improved cropping pattern over the farmer's pattern. The MBCR also showed that the inclusion of black gram in the existing pattern might be profitable and acceptable to the farmers.

Table 3. Cost and return analysis of improved and farmers' cropping pattern

Items	**Improved pattern**			**Farmers' pattern**		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean
Gross return (Tk/ha)	196000	193680	194840	152200	149000	150600
TVC (Tk/ha)	100850	102700	101775	85500	81980	83740
Gross margin (Tk/ha)	95150	90980	93065	66700	67020	66860
MBCR	2.85	2.16	2.50	-	-	-

Price of input (Tk/kg): Urea-16, TSP-22, MOP-16, Gypsum-10, Zinc sulphate-130 and Boric acid-300, Black gram seed-85, rice seed-40; Selling price (Tk/kg)**:** Black gram-40, Boro rice-20 and Straw-2.

Disease and Pest infestations: Black gram crop was infested by spodoptera litura, leaf roller, and flea beetle which was controlled by spraying of tracer twice @ 0.4 ml/L water at 10-15 days interval, karate 2.5 Ec @1 ml/L water at 5-7 days interval. Boro rice was sporadically infested by rice stem borer, rice bug, rice brown plant hopper, and rice hispa. Furadan 5G @ 10 kg/ha was applied during final land preparation and Virtako 40WG @ 1.5 g/10L water was sprayed twice at 10 days intervals for controlling stem borer. Dursban @ 2 ml/L and Marshal 2 ml/L water were sprayed at 55 and 65 DAT for controlling other insects. The farmers are willing to grow black gram after flood water receded with zero tillage and boro rice in the future. A good number of farmers are also willing to produce quality black gram seeds for their own and their areas.

4. Conclusion

The research findings indicated that the *black gram-boro rice-fallow* cropping pattern is applicable in some haor areas of Bangladesh and it can easily be fitted in the existing pattern with higher benefit. The inclusion of black gram in the pattern will increase pulses production in the country as well as increase cropping intensity and productivity in haor areas. The results of the two years trial indicated that the black gram (Var. BARI Mas-3)-Boro rice (Var. BRRI dhan29)-Fallow cropping pattern was more productive and profitable than the farmer's existing pattern Fallow- Boro rice (Var. BRRI dhan29)-Fallow. Thus, black gram can be successfully accommodated in the existing farmer's pattern with total crop duration ranging from 185 to 189 days in Nikli upazilla of Kishoreganj district to increase cropping intensity and system productivity with profitability. Furthermore, through this cropping pattern, the soil health may be improved and the farmers could cultivate year-round crop successfully and create employment opportunity for labour forces.

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