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IMPROVEMENT OF EXISTING CROPPING PATTERN THROUGH SHORT DURATION MUSTARD VARIETY IN THE CHALANBEEL AREA

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Abstract

The experiment was conducted at Dobila, Tarash of Shirajgonj in chalanbeel during the *Rabi* seasons of 2018-2019 and 2019-2020 to improve the existing cropping pattern, increase cropping intensity, yields and economic return through incorporating of modern crop varieties and improved management practices. The treatments were i) Mustard (var. BARISarisha-14)-*Boro*-Fallow cropping pattern, ii) Mustard (var. BARI Sarisha-15)-*Boro*-Fallow cropping pattern, iii) Mustard (var. Tori-7)-*Boro*-Fallow cropping patternandiv) Fallow–*Boro*–Fallow (existing cropping pattern). *Boro* rice (var. BRRI dhan29) was used to improve cropping pattern. The results revealed that the mean crop duration of improved cropping pattern ranged 192-195 days by inclusion of mustard. Rice equivalent yield of improved cropping pattern was 9.51-10.04 t ha^{-1} $year^{-1}$ which was 46% higher than that of existing pattern (5.37 t ha^{-1} $year^{-1}$). Land use efficiency (53%) of improved cropping pattern were 9 and 47% higher, respectively than those of existing cropping pattern. Higher mean gross return (Tk. 2,80,860 ha^{-1}), gross margin (Tk. 169680 ha^{-1}) and BCR (2.53) were recorded in improved cropping pattern: Mustard (var. BARI Sarisha-14)- *Boro* – Fallow} due to inclusion of high yielding variety of mustard than existing cropping pattern (Gross return: Tk. 161010 ha^{-1} and Gross margin: Tk. 86183 ha^{-1}) in chalanbeel area. Therefore, farmers in chalanbeel region of Bangladesh could follow improved cropping pattern for higher crop productivity and profitability where lands remain fallow before transplanting of *Boro* rice.

Introduction

Bangladesh is predominately an agricultural country. It is one of the most densely populated countries of the world with population growth rate of 1.34% (BBS, 2017). Rice occupies about 74% of the total cropped area and is cultivated in three seasons in a year (BBS, 2017). In rice based cropping pattern, T. *Aman*-Fallow-*Boro*-Fallow is dominant where cropping intensity is 200% (Aziz *et al.*, 2011). At present total cultivable land is 8.5 million hectare 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 (BBS, 2019).

A number of reports on different cropping pattern are available in Bangladesh and India that an additional crop could be introduced without much changes or replacing the existing ones for considerable increases of productivity as well as profitability of the farmers (Khan *et al*., 2005; Nazrul *et al*., 2013, Kamrozzaman *et al*., 2015). The cropping pattern in an area depends largely on agro-climatic, technical and institutional factors (Vaidyanathan, 1987). There is very little scope of increasing cultivable land but there are scopes of increasing cropping intensity from the present level of

190% to 250% by improving the present cropping pattern incorporating short duration crops like: lentil, mustard, potato etc. in the existing cropping pattern in different unfavourable ecosystem.

Beel (low land goes under water and remains under water about 4-5 months generally from July to November) areas are under unfavourable ecosystem covering an area of 2.43 million hectares in Bangladesh (Aziz *et al*., 2016). Chalanbeel is an extensive lowland area in the lower Atrai basin and spreads across Singra and Gurudaspur upazilas of Natore district, Chatmohar, Bhangura, Faridpur upazilas of Pabna district and Ullahpara, Rajgonj and Tarash upazilas of Sirajgonj district. Generally unfavourable ecosystem is less productive and remains fallow in most of the part of the year. The existing major cropping pattern under chalanbeel area is: Fallow–*Boro*-Fallow and hence the land remains fallow in the *Rabi* and *Kharif* season in this area. The cropping intensity of this region is therefore remarkably low compared to other regions of this country. Among the rice crop, *Boro* rice receives the most irrigation water of all crops, with an estimated amount of 1,000 mm/cycle. For production one kg rice grain 3000-5000 L water is required (Rahman *et al*., 2013 and Hossain *et al*., 2014). On the contrary, mustard, lentil, wheat, potato, mungbean, maize, vegetables like cabbage, cauliflower, yard long bean, spinach and *Aus* rice receive less irrigation water for successfully cultivation than *Boro* rice. But the crop productivity could be increased by improving existing cropping patterns through by introducing new crops and crop varieties suitable for the region. High yielding short duration variety along with modern cultivation techniques are the prerequisite for developing improved cropping pattern. Only rice production is not profitable and suitable for the farmers of this area due to it requires huge amount of irrigation water for *Boro* cultivation as well as soil native fertility decline for monoculture of rice (Sarker *et al*., 2020). A huge part of land remains fallow 4 to 5 months after harvest of *Boro* rice in this area. Mustard can easily be cultivated in this region after harvest of *Boro* rice and can get high economic return within a short time. Recently, Bangladesh Agricultural Research Institute (BARI) has developed high yielding mustard (*Brassica campestris*) varieties, BARI Sarisha-14 and BARI Sarisha-15 whose yield potential is higher than Tori-7 and can easily be cultivated before *Boro* rice. In chalanbeel area, duration of flood, flooding depth etc. are the most important factor that influence of cropping pattern. At present situation, some farmers of chalanbeel area are interested to cultivate maize, wheat, garlic and oilseeds crops (like mustard) after receding of water from the soil. In most cases, farmers cultivate Tori-7. But the farmers harvest poor yield from local var. Tori-7 that can be increased by introducing high yielding varieties (Alam and Rahman, 2006; Basak *et al*., 2007). Crop duration of BARI developed short duration mustard varieties is 75-85 days, whereas BRRI and BINA has developed short/medium duration rice varieties. Under this situation, the experiment was undertakento introduce mustard in Fallow-*Boro*-Fallow cropping pattern and productivity through rice based cropping pattern.

Materials and Methods

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalanbeel during the *Rabi* season of 2018-2020. The treatments were i) Mustard (BARI Sarisha-14)- *Boro* rice, ii) Mustard (var. BARI Sarisha-15)-*Boro* rice, iii) Mustard (var. Tori-7)-*Boro* rice iv) Fallow-*Boro*- Fallow. The experiment was laid out in RCB design with four dispersed replications (farmers' field). Unit plot size was 20 decimals. The experimental site belongs to AEZ-5 of Sirajgonj. The land type is medium low land (generally water depth 1.4-2.3 m) waterlogged 4-5 months from July to October. The geographical position of the area is between 24.52°N latitude and 89.01°E longitude. The land was low land and the soil of the study area was silt loam in texture. The meteorological data of the experimental site revealed that the highest temperature prevails in August-September and the lowest in December to January. In both years, there was no precipitation in December. Maximum rainfall was received during the months of July. The soil was silty clay loam in texture having pH 7.24. Soil samples were collected from the experimental field from a depth of 0-15cm prior to application of fertilizer. Results of soil analysis of chemical properties are presented in Table 1. Organic matter concentration in soil was low (1.34%) and

deficient in total N (0.088%), available P (33.05 ppm), exchangeable K (0.274meq 100^{-1} g soil), available S (17.08 ppm) and available B (0.235 ppm).

All agronomic activities including sowing/transplanting and harvesting date, seed rate, plant spacing, fertilizer management etc. were mentioned in Table 2. Mustard was the first crop of the sequence. The seeds were sown on broadcast with seed rate of 08 kg /ha on 5-12 November, 2018 and 2019, in two consecutive years. Fertilizer management was done followed by FRG (2012) and intercultural operations like weeding, mulching, irrigation and pest management were done to support the normal growth of the crops. The crop was harvested on 24 January- 5 February, 2019 and 2020 in 1st and 2nd year, respectively. After harvest of mustard then *Boro* rice was the second crop of the sequence. *Boro* rice seedlings were grown in adjacent plot and 35-40 days old seedlings were transplanted with a spacing of 20 cm × 15 cm. *Boro* rice seedlings were transplanted on 02-05 February, 2019 and 2020 and harvested on 05-20 May, 2019 and 2020 in 1st and 2nd year, respectively. Fertilizer management and other intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). Rice plant was harvested at 30 cm height from soil surface and remaining parts of the plants were incorporated in soil.

For comparison among the crop sequences, the yields of all crops were converted into rice equivalent yield on the basis of prevailing market price of individual crops (Verma and Modgal, 1983). The economic indices like gross return, gross margin and benefit cost ratio were also calculated on the basis of prevailing market price of the inputs and outputs (produces).

Land use efficiency

Land use efficiency was calculated by taking total duration of individual crop in a sequence divided by 365 days **(**Tomer and Tiwari, 1990). It was calculated by following formula.

$$\text{Land use efficiency} = \frac{d1 + d2 + d3 + d4}{365} \times 100$$

Where $d_1 + d_2 + d_3$ and d_4, the duration of first, second, third and fourth crop of the pattern.

Production efficiency

Production efficiency values in terms of $kgha^{-1}day^{-1}$were calculated by total production in a cropping sequence divided by total duration of crops in that sequence (Tomer and Tiwari, 1990).

$$\frac{Y1 + Y2 + Y3 + Y4}{d1 + d2 + d3 + d4}$$

Y1: Yield of 1st crop
Y2: Yield of 2nd crop
Y3: Yield of 3rd crop
Y4: Yield of 4th crop
d1= Duration of 1st crop of the pattern
d2= Duration of 2nd crop of the pattern
d3= Duration of 3rd crop of the pattern
d4= Duration of 4th crop of the pattern

Crop cut was done from an area of one square meter at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in Table 2.

Table 1. Chemical properties of experimental soil (initial)

Location	AEZ	pH	OM (%)	Total N (%)	Available P (µg/ml)	Exchange able K (meg/100g)	Available S (µg/g)	Available B (µg/g)
Chalanbeel area, Sirajgonj	05	7.24	1.34	0.088	33.05	0.274	17.08	0.235

Table 2. Crop management of existing and improve cropping patterns in the chalanbeel areas of Sirajganj during the year of 2018-2020

Parameter	**Fallow-*Boro*-Fallow**	**Mustard-*Boro*-Fallow**		**Mustard –*Boro*-Fallow**		**Mustard –*Boro*-Fallow**	
Crop	Rice	Mustard	Rice	Mustard	Rice	Mustard	Rice
Varieties	BRRI dhan29	BARI Sarisha-14	BRRI dhan29	BARI Sarisha-15	BRRI dhan29	Tori-7	BRRI dhan29
Date of sowing/ Transplanting	07.2.19 11.2.20	09.11.18 05.11.19	09.2.19 05.2.20	12.11.18 10.11.19	14.02.19 11.02.20	6.11.18 9.11.19	29.01.19 02.02.20
Seed rate ($g/kg\ ha^{-1}$)	50	8	50	8	50	7	50
Sowing method	Line	Broadcast	Line	Broadcast	Line	Broadcast	Line
Spacing (cm)	25×15	-	25×15	-	20×15	-	20×15
Seedling age (days)	35-40		35-40		35-40		40-45
Fertilizer dose ($kg\ ha^{-1}$) (N, P, K, S, Zn and B)	136-25-20-8-0-0	105-32-40-24-2-1	140-20-65-18-2.6-0	105-32-40-24-2-1	140-20-65-18-2.6-0	115-34-44-36-1-1	140-20-65-18-2.6-0
Irrigation (no.)	Several times	1	Several times	1	Several times	1	Several times
Weeding (no.)	1 weeding at 20-25 DAT	1	2 weeding 1st once at 15-20 DAT and 2nd at 40 DAT	1	2 weeding 1st once at 15-20 DAT and 2nd at 40 DAT	-	1 weeding at 20-25 DAT
Date of harvesting (range)	20.5.19 25.5.20	4.02.19 1.02.20	24.05.19 22.05.20	5.02.20 8.02.19	2.06.20 29.05.19	24.01.19 26.01.20	05.05.19 08.05.20
Field duration (days)	102 103	87 88	105 108	89 90	106 109	80 76	97 95
Turnaround time (days)	-	5 4	-	9 3	-	5 3	

Results and Discussion

Yield and yield components of different mustard varieties differed significantly but had no significant variation in $plants m^{-2}$ (Table 3). Among the variety, variation was found in case of days to maturity and it was 84, 86, and 74 days for BARI Sarisha-14, BARI Sarisha-15 and Tori-7. The tallest plant (95.00 cm) was recorded in BARI Sarisha-15 and the shortest plant in Tori-7. Number of siliquae $plant^{-1}$ varied significantly in different mustard varieties. The maximum number of siliquae $plant^{-1}$ was recorded in BARI Sarisha-14 (90) which was followed by BARI Sarisha-15 (81). Tori-7 produced the lowest number of siliquae $plant^{-1}$ (45). The highest number of siliquae $plant^{-1}$ of BARI Sarisha-14 and BARI Sarisha-15 seemed to be related to the tall statured and more branched canopy. Similar trend was observed in seeds $siliqua^{-1}$. The maximum 1000-seedweight was found in BARI Sarisha-14 (3.57 g) which was followed by BARI Sarisha-15 (3.42 g).

Seed yield also differed significantly among mustard varieties. Mustard var. BARI Sarisha-14 produced the highest seed yield (1787 kgha^{-1}) which was 51% higher than Tori-7. The highest seed yield of BARI Sarisha-14 might be due to cumulative effect of siliquae plant^{-1} and 1000-seeds weight. BARI Sarisha-15 was second yielder (1619 kg ha^{-1}). The yield level of BARI Sarisha-15 was also higher (45%) than that of Tori -7.

Table 3. Performance of short duration Mustard varieties in Chalanbeel area during *Rabi* season of 2018-19 and 2019-20 (Pooled analysis)

Variety	Days to maturity	Plants m^{-2} (no.)	Plant height (cm)	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	1000- seed wt.(g)	Seed yield (kg ha^{-1})	Stover (kg ha^{-1})
BARI Sarisha-14	84	54	85	90	25	3.57	1787	2482.50
BARI Sarisha-15	86	59	95	81	20	3.42	1619	2137.50
Tori -7	74	62	72	45	14	2.73	876	1260.00
Level of significance	4.62	NS	5.87	7.09	13.73	0.095	70.49	169.6
CV (%)	3.29	12.66	4.04	5.71	4.7	3.60	6.36	5.00

Seed yield

Mustard–*Boro*-Fallow cropping pattern gave higher grain yield of *Boro* than Fallow–*Boro*- Fallow cropping pattern (Table 4). The rice equivalent yield revealed that Mustard–*Boro*-Fallow cropping pattern produced higher rice equivalent yield (10.04 and 9.51 t ha^{-1}) over farmer's existing cropping system (5.37 t ha^{-1}). Higher rice equivalent yield was obtained in improved cropping pattern due to inclusion of short duration mustard and high yielding varieties as well as improved management technologies. The rice equivalent yield was higher in mustard (var. BARI Sarisha-14)–*Boro*-Fallow cropping pattern which was gave 46% higher than the sole rice yield (5.37 t ha^{-1}) whereas Mustard (var. BARI Sarisha-15)–*Boro*-fallow pattern was showed 28% increased yield than the sole rice cultivation. The lower rice equivalent yield (5.37 t ha^{-1}and 7.62 t ha^{-1}) was obtained in the farmer's pattern with local variety (Tori -7) in mustard and traditional management practices. It is evident from the above findings that improved cropping pattern gave higher yield compared to existing pattern. This finding was in agreement with that of by Nazrul *et al.* (2017), Rahman *et al.* (2015) and Nazrul *et al.* (2013).

Field duration: In improved pattern mustard var. BARI Sarisha-14 and BARI Sarisha-15 and rice var. BRRI dhan-29 was used in *Boro*. BARI Sarisha-14 needed 7-12 more days to attained maturity than Tori-7. As a result, production efficiency and land use efficiency was higher in improved pattern than farmer's existing cropping pattern. Though turn around time in improved pattern very crucial so all inputs including land preparation should be done in proper time (Table 2).

Cost and return analysis

From the economic point of view, Mustard-*Boro*–Fallow cropping pattern showed its superiority over Fallow–*Boro*-Fallow/Mustard–*Boro*- Fallow cropping pattern. The highest gross margin of the Mustard (BARI Sarisha-14)–*Boro*-Fallow pattern was Tk. 169680 ha^{-1}, which was 42% higher than that of sole *Boro* cultivation (Table 4). Similarly, the gross return of the Mustard–*Boro*-Fallow cropping pattern was Tk. 280860 ha^{-1}, which was 42% higher than sole *Boro* rice. The production cost per hectare in Mustrad–*Boro*-Fallow pattern (Tk. 111180 ha^{-1}) was 33% higher over that of sole rice production cost. The higher gross margin of Mustard–*Boro*-Fallow was achieved mainly due to higher yield advantages of component crops. Higher (2.53) BCR was recorded in Mustrad–*Boro*-Fallow pattern over that of sole rice production and Mustard (Tori-7)-*Boro*-Fallow pattern, respectively (Table 4).

Land use efficiency: Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The land-use efficiency of Mustrad–*Boro*-Fallow pattern was 47% higher (53%) than that of existing pattern (28%) (Table 4). The land use efficiency was higher in Mustrad–*Boro*-Fallow due to cultivation of mustard in the pattern.The similar trend of the findings was cited by Nazrul *et al.* (2017), Rahman *et al.* (2015) and Nazrul *et al.* (2013).

Production efficiency: The production efficiency of Mustrad–*Boro*- Fallow pattern was found to be 74.98kg ha^{-1} cropping pattern while in existing cropping pattern it was found to be 52.0 and 67.90 kg ha^{-1} day^{-1} for Fallow–*Boro*-Fallow pattern and Mustard (Tori-7)-*Boro*-Fallow pattern, respectively (Table 4).

Pest and disease incidence: No disease or pest incidence was observed in the experiment plots.

Farmers' opinion

Farmers are interested to grow BARI released variety of mustard in this area. They opined that the Mustard (BARI Sarisha-14) cultivation before rice gave the higher economic return against the Fallow–*Boro*-Fallow pattern. Training on production technology for Mustard–*Boro*-Fallow pattern is needed.

Table 4. Yield and economic performance of existing and improved cropping patterns in the chalanbeel areas of Sirajganj during the year of 2018-19 and 2019-20 (Pooled analysis)

Parameter	Fallow-*Boro*-Fallow	Mustard-*Boro*-Fallow		Mustard-*Boro*-Fallow		Mustard-*Boro*-Fallow	
Crop	Rice	Mustard	Rice	Mustard	Rice	Mustard	Rice
Varieties	BRRI dhan29	BARI Sarisha-14	BRRI dhan29	BARI Sarisha-15	BRRI dhan29	Tori-7	BRRI dhan29
Yield (t ha^{-1})	5.37	1.79	5.72	1.62	5.65	0.87	5.53
Straw yield (t ha^{-1})	6.69	2.5	6.84	2.14	6.8	1.26	6.58
Rice equivalent yield (t ha^{-1} $year^{-1}$)	5.37	10.04		9.51		7.61	
BCR	2.15	2.53		2.36		2.21	
Gross return (Tk. ha^{-1})	161010	110500	170360	98740	168450	53460	164570
		280860		267190		218030	
Total Cost (Tk. ha^{-1})	74827	40960	70220	39960	73200	33605	65245
Gross margin (Tk. ha^{-1})	86183	169680		154030		119180	
LUE (%)	28	53		53		48	
PE ($kgha^{-1}day^{-1}$)	52	74.98		71.50		67.90	

Unit price (Tk. kg^{-1}): *Boro* rice=25, Rice straw= 4, Mustard=60, Mustard straw = 1

Conclusion

The total crop productivity (in terms of REY), land use efficiency and profitability of improved cropping pattern i.e., Mustard (var: BARI Sarisha-14)- *Boro* rice (var: BRRI dhan29)- Fallow were much higher than that of existing cropping pattern Fallow–(var: BRRI dhan29)-Fallow due to inclusion of HYV short duration mustard. Thus, mustard var. BARI Sarisha-14 can be successfully accommodated in the existing cropping pattern which increased cropping intensity and system productivity with reasonable profitability.

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