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INCREASING OILSEED PRODUCTIVITY THROUGH INCLUSION OF MUSTARD IN T. AMAN- FALLOW-BORO RICE CROPPING PATTERN IN JASHORE

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Abstract

The field experiment was conducted at Mahmudkati, Monirampur under Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jashore for two consecutive years of 2021-22 and 2022-23 through inclusion of mustard var. BARI Sarisha-14 in the fallow period and to study the comparative agronomic performance economic return, increasing cropping intensity, productivity and land use efficiency. The experiment was laid out in a randomized complete block design (RCBD) with ten dispersed replications. Three crops pattern (*T. Aman rice –Mustard - Boro rice*) and farmers' existing pattern (*T.Aman- fallow- Boro*) as control were tested.Two years mean data showed that the improved management practices provided higher yield in improved pattern. Average higher rice equivalent yield (REY), (20.22 t ha-1) production efficiency (59.92 kg ha-1 day-1) and 92.88% land utilization indexwas found in the improved cropping pattern in both years. Gross return of the improved pattern was Tk..711010 ha-1 which was more than 68.24% higher than farmer's pattern of Tk. 422615 ha-1. Gross margin (Tk. 483610 ha-[1]) and MBCR (2.13) were also higher in improved cropping pattern in both years than existing pattern.

Keywords: Oilseed productivity, land use efficiency, cropping intensity, mustard and economic return

Introduction

Bangladesh needs to produce more food on less land to assure future food security for millions of people every year. Horizontal expansion is very limited, but increase in crop production could be possible with vertical expansion through increasing cropping intensity and Land Use Efficiency. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity by producing three or more crops from the same piece of land in a year and ii) to increase the production efficiency of the individual crop by using optimum management practices (Dobermann *et al*., 2013; Ladha *et al*., 2016). The present cropping intensity of the country is 198%. Food requirement is estimated to be doubled in the next 25 years. Under such situation; it is very important to improve the existing cropping pattern. There are some scopes of increasing cropping intensity by improving the existing cropping patterns through inclusion of short duration crops viz., mustard, potato, mungbean and transplant aus rice in the rice based cropping systems following the modern

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variety and improved technologies. The main challenge of the new millennium is to increase yield of per unit area by at least 50 % through manipulating the limited land resource. The major cropping pattern of agriculture in Bangladesh mostly consists of rice based crops (Haque, 1998). More than 60% of the total cropped areas covered by *Boro-Fallow-T. Aman* rice cropping pattern in Bangladesh. As a result, the vast area remains fallow for 75 days after T. *Aman* harvest. About 2.4 mha crop land is occupying by this cropping pattern in Bangladesh (Ladha *et al.,* 2003; Dawe *et al.,* 2004; Bhuiyan *et al.,* 2004). The areas of oilseed and pulse in Rabi season are decreasing because of increasing cultivation of Boro rice. But the farmers harvest poor yield from local var. Tori7 that can be increased manifold by introducing high yielding varieties (Alam and Rahman, 2006; Basak *et al.,* 2007). Recently, BARI has developed high yielding yellow seeded mustard (*Brassica campestris*) varieties viz., BARI Sarisha- 14 and BARI Sarisha-15 whose yield potential is higher than Tori-7 and can easily be cultivated during fallow period. Most areas of Bangladesh at present under two crops based cropping pattern, but there prerequisite to increase crop number to meet up the demand. A number of reports on different cropping pattern are available in Bangladesh (Ahmed *et al*. 2017) where an additional crop could be introduced without much changes or replacing the existing ones for considerable increase of the overall productivity as well as profitability of the farmers. Keeping these views in mind, the present study was designed to evaluate the feasibility of increasing cropping intensity and productivity by growing three crops in a year in a same piece of land by introduce mustard var. BARI Sarisha-14 in the fallow period.

Materials and Methods

The experiment was laid out in a randomized complete block design with ten dispersed replications. The trial was conducted to increase cropping intensity, productivity and land use efficiency by incorporating mustard var. BARI Sarisha-14 in the existing cropping pattern: *T. Aman- fallow- Boro* at the farmers' field condition in Mahmudkati, Monirampur, Jashore (Latitude: 23.163401 N, Longitude: 89.218166 E) during two consecutive years 2021-22 and 2022-23.Two cropping patterns viz., T_1= Existing cropping pattern: *T. Aman rice – Fallow - Boro rice*, and T_2 = Improved cropping pattern: *T. Aman rice – Mustard - Boro rice* were the treatments variables. The unit plot size was 1340 Sq. m. with 10 dispersed replications. T. *Aman* rice was the first crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings. *T. Aman rice* var. BRRI dhan 75 were transplanted with 20 cm × 15 cm during 25July - 05 Aug, 2021 and 2022 in both years. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). *T. Aman* rice was harvested during 22October, 2021 and 2022 in two consecutive years. *T. Aman* rice plant was harvested at 15 cm from soil surface and remaining parts of the plants was incorporated in soil. Mustard was grown during rabi season and it was the second

crop of the sequence. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to FRG, 2018. Mustard var. BARI sarisha-14 was seeded as broadcast method with seed rate of 7 kg ha-^{1}. The crop was sown during 05 November, 2021 and 2022 and harvested during 23 January, 2022 and 2023, respectively. Boro rice was the third crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 35-40 days old seedlings of rice var. BRRI dhan 28 and BRRI dhan63 at a spacing of 20 cm × 15 cm during 26 to 27 January, 2022 and 2023. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). Boro rice was harvested during 26 April to 06 May, 2022 and 2023 in two consecutive years. Rice plant was harvested at 30 cm height from soil surface and remaining parts of the plants was incorporated in soil. Crop nutrient uptake was estimated following the standard value of FRG, 2018. The area mostly falls undermedium-high land and high land areas of High Ganges River Flood Plain of Agro Ecological Zone (AEZ) 11. Organic matter content is low in higher parts, but moderate in lower parts. The general fertility level is low including N, P, S and B although CEC medium and K- bearing minerals are medium to high but the Zn status is low to medium (FRG2018). The area receives an annual rainfall of around 1035 mm with relatively early onset and late cessation and the mean annual high temperature is 32.1ºC (89.78ºF), annual low temperature is 22.95ºC (73.31ºF).The initial soil status of the experimental sites was presented in Table1.

Table 1. Initial status of soils of the experimental plots at Mahmudkati, Monirampur, Jashore

Soil characteristics				Mahmudkati, Monirampur, Jashore				
Land type and soil texture				Medium-high land and high land area and loamy soil				
				Available nutrients				
Soil depth	pH	Organic Matter (%)	Total N (%)	K (meq /100g soil)	P (µg/g soil)	S (µg/g soil)	Zn (µg/g soil)	B (µg/g soil)
0-15 cm	7.7 Slightly alkaline	1.71 low	0.09 Low	009 (High)	14.99 (Low)	16.05 (Optimum)	1.85 (Medium)	0.26 Low
15-30 cm	7.8 Slightly alkaline	0.82 Very low	0.04 Very low	0.04 Medium	7.62 Very low	18.38 Optimum	0.83 low	0.14 Very low

After physiological maturity, yield for each crop was determined plot-wise and converted into yield on an area basis (kg/ha). Data on yield was statistically analyzed using statistics 10. Marginal benefit-cost analysis was done to estimate the economic feasibility of Transplant Aman rice, Mustard and Boro rice crop. The production costs of these crops included the cost of field preparation, seed, planting, irrigation, fertilizers, crop protection measures and harvesting.

Table 2. Crop management practices in farmer's existing and improved cropping pattern at Mahmudkati, Monirampur, Jashore

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	T. aman rice	Fallow	Boro rice	T. aman rice	Mustard	Boro rice
Variety	Swarna	-	BRRI dhan 28	BRRI dhan 75	BARI Sarisha-14	BRRI dhan 63
Spacing	20 cm × 15 cm		20 cm × 15 cm	20 cm× 15 cm	Broadcast	20cm ×15cm
Unit plot size	1340 m^2			1340 m^2		
Fertilizer dose (Urea-TSP-MoP- Gyps.-Zn -B Kg/ha)	102-62-20-08-0-0	-	200-75-92-60-7.5-0	150-90-112.5-90-10-0	262-150-05-160-10 + 1.5	225-112-150-90-10-0
Date of sowing for seed	1July	-	17 December	1July	05 November	18 December
Date of transplanting	29 July-15 Aug	-	26 January	25 July- 05 Aug	-	27 January
Seedling age (days)	25-30	-	35-40	25-30	-	35-40
Harvesting date	15November	-	26 April	22 October	23 January	06 May
Total crop duration (days)	138	-	131	114	79	139

Agronomic performance like field duration, rice equivalent yield (REY), production efficiency and land utilization index of cropping patterns were calculated. The details of crop management practices followed for each crop is provided in Table 2.

Rice equivalent yield (REY): For comparison between crop sequences, the yield of all crops was converted into rice equivalent on the basis of prevailing market prices of individual crop (Lal *et al*., 2017). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

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

Production efficiency

Production efficiency value in terms of kg ha-1day-1 was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern ((Lal *et al*., 2017; Tomar and Tiwari, 1990).

$$\text{Production Efficiency (kg/ha//day)} = \frac{\sum Y_i}{\sum d_i}$$

Where, Yi= Yield (kg) of ith crop, di= 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:

$$\text{Land Utilization Index (\%)} = \frac{d_1 + d_2 + d_3}{365} \times 100$$

Where, d_1, d_2 and d_3 the duration of 1st, 2nd and 3rd crop of the pattern. The gross income was estimated using the prevailing average market prices for the yield of these crops in Bangladesh. Net income was calculated by subtracting total expenditure from the gross income which was computed by dividing the gross income with total expenditure (Mahmood *et al*., 2016). 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 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 prevalent pattern (F) and any potential replacement (E) which was computed as (CIMMYT, 1988).

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

Results and Discussion

Yield of the cropping patterns: Results of three crops pattern (*T. Aman - Mustard - Boro*) and farmer's existing pattern (*T.Aman - fallow Boro*) have been presented in Table 3. It was revealed that the entire component crops of *Transplant Aman rice – Mustard - Boro rice* cropping pattern under improved practices (IP) gave higher grain and seed yield as well as by-product yield in two consecutive years. The yield of improved pattern was higher due to inclusion of mustard with improved production technologies for the component crops. Similar results were also obtained by Anwar *et al*., 2017, Khatun *et al*., (2016), Kamrozzaman *et al.,* (2015) and Nazrul *et al*. (2013). Inclusion of mustard with improved variety in *T. Aman rice - Mustard-Boro* rice cropping pattern practice increased the total yield over the farmers existing cropping pattern practice. Grain yields of T. aman rice in case of improved cropping pattern grain yields were 5.80 and straw yields 7.65 t/ha. Grain yield of 5.90 t ha-1 and straw yield of 7.53 t/ha in 1st and 2nd year and mean grain and straw yields of T. aman rice were 5.85 and 7.59 t/ha, respectively. Seed yield of mustard were 1.75 and 1.80 t ha-1 and stover yields were 3.42 and 3.53 t ha-1 in two successive years, respectively where mean seed yield of mustard was 1.78 t ha-1 .Grain yield of Boro rice were 7.05 t/ha and straw yield of 6.94 t/ha in first year and 7.10 t/ha and straw yields 6.85 t/ha in second year. Mean grain and straw yields of Boro rice were 7.08 and 6.90 t/ha , respectively. T. Aman rice in three crops pattern produced 39.62% higher grain yield over farmers' practice due to change of variety with improved production technologies. Similar results were also obtained by (Nazrul *et al.,* 2013; Khan et al., 2006). Farmers' pattern gave lower yield due to imbalance use of fertilizers and poor management practices. Three crops pattern produced higher by-product yield (17.96 t ha-1) over farmers' practice (13.07 t ha-1). Mean by-product yield of three crops pattern was 37.41 % higher over farmer's pattern due to change of variety with improved technologies and inclusion of one crop in the existing pattern.

Rice equivalent yield: 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 (20.22 t ha-1) was recorded with the improved pattern, *Transplant aman - Mustard- Boro* over farmer's existing cropping pattern (12.07 t/ha.), *Transplant aman - Fallow -Boro* (Table 4). REY increased 8.15 t ha-1 by inclusion of mustard with improved production technologies for the component crops. Inclusion of mustard in rabi season in existing cropping pattern increased total productivity by 67.56 % compared to farmers' practice. These results are in agreement with Mondal *et al*. (2015). They reported that total productivity increased by 67 % over farmers' practice. It is noted that inclusion of additional crop during the fallow period produced higher rice equivalent yield than farmer's practice, Transplant *aman* -Fallow -Boro. Similar results were also obtained by Khatun *et al*.,2016; Kamrozzaman *et al*., 2015; Ferdous *et al*. 2011, Anowar *et al*. 2012, Nazrul *et al*., 2013.

Table 3. Productivity of farmer's existing and improved cropping pattern at Mahmudkati, Monirampur, Jashore

Year	Cropping pattern	Crop	Variety	Field duration (days)	Total field duration (days)	Grain or seed yield (t ha-1)	Straw or stover yield (t ha-1)
2021-22	Existing cropping pattern	T. aman	Swarna	112	250	4.23 ±0.17	7.05 ±0.21
		Fallow	-	-		-	-
		Boro	BRRI dhan 28	138		5.7 ±0.21	6.05±0.24
	Improved cropping pattern	T. aman	BRRI dhan 75	113	338	5.8 ±0.15	7.65±0.29
		Mustard	BARI Sarisha-14	79		1.75 ±0.22	3.42±0.18
		Boro	BRRI dhan 63	146		7.05±0.11	6.94±0.29
2022-23	Existing cropping pattern	T. aman	Swarna	113	250	4.15±0.21	6.38±0.23
		Fallow	-	-		-	-
		Boro	BRRI dhan 28	137		5.59±0.15	6.65±0.18
	Improved cropping pattern	T. aman	BRRI dhan 75	114	340	5.9±0.16	7.53±0.12
		Mustard	BARI Sarisha-14	81		1.8±0.24	3.53±0.19
		Boro	BRRI dhan 63	145		7.1±0.23	6.85±0.27

Price: Mustard = Tk. 85 kg-1, Rice = Tk. 35 kg-1, Rice straw = Tk. 6 kg-1 and Mustard Stover = Tk. 5 kg-1
Price (Tk. kg-1): Urea-22, TSP-22, MoP-15, Gypsum-30, Zinc Sulphate-200, Boric acid-160,
REY: Rice Equivalent Yield, GM: Gross Margin.

Field duration: Field duration of a cropping pattern comprises on the individual crop duration. Farmers' cropping pattern Boro-fallow-T. Aman has needed 250 and 250 days field duration in 1st and 2nd year. The newly introduced one crop in the farmer's existing pattern was mustard var. BARI Sarisha-14. A short duration T. Aman rice var. BRRI dhan 75 was also introduced to minimize the field duration of the crop. Total field duration of three crops pattern, T. Aman-Mustard - Boro has needed 338 and 340 days including seedling age of rice to complete the cycle in 1st and 2nd year (Table 3). Thus, long turn around period of 115 days in the farmer's existing pattern was utilized. Result indicated that mustard could be easily fitted in T. Amon rice- Mustard – Boro rice cropping pattern with an average of 26 days turnaround time in a year. Similar trend was also observed by Mondal *et al.* (2015) who reported that all the tested four crops pattern can be grown successfully one after another in sequence

Production efficiency: Mean maximum production efficiency (59.92) in terms of kg ha-1 day-1 was obtained from three crops improved cropping pattern, *Transplant aman- Mustard –Boro* and minimum (48.30 kg ha-1 day-1) in farmers' existing practice, Transplant *aman* -Fallow - Boro (Table 4). The higher production efficiency in improved cropping pattern Transplant *aman*- Mustard - Boro might be due to inclusion of high yielding mustard varieties and improved management practices. Similar trend was noted by Nazrul *et al*. (2013) and Khan *et al*. (2006).

Land utilization index: Land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. Results of the study have been presented in Table 4.Mean land utilization index (LUI) indicated that improved cropping pattern used the land for 92.88% period of the year, whereas existing cropping pattern used the land for 68.49% period of the year. The improved cropping pattern leads to higher land use efficiency due to longer period field occupied by the crops (339 days), whereas the farmers practice occupied the field for 250 days of the year. Similar results were also obtained by Khatun *et al*., 2016.

Table 4. REY, PE and LUI of farmer's existing and improved cropping pattern at Mahmudkati, Monirampur, Jashore during 2021-22 and 2022-23.

Items	Farmers' existing cropping pattern			Improved cropping pattern		
	2021-22	2022-23	Average	2021-22	2022-23	Average
REY(t ha-1)	12.17	11.97	12.07	20.17	20.26	20.22
PE (kg ha-1day-1)	48.70	47.89	48.30	59.73	60.12	59.92
LUI (%)	68.49	68.49	68.49	92.60	93.15	92.88

REY= Rice Equivalent Yield, PE = Production Efficiency and LUI= Land Utilization Index

Table 5. Cost and return analysis of farmer's existing and improved cropping pattern at Mahmudkati, Monirampur, Jashore during 2021-22 and 2022-23

Parameters	Gross return (Tk. ha-1)			Total variable cost (Tk. ha-1)			Gross margin (Tk. ha-1)			MBCR		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Farmers' existing cropping pattern	426150	419080	422615	191654	190665	191160	234496	228415	231456	1.22	1.20	1.21
Improved cropping pattern	706560	715460	711010	221080	233720	227400	485480	481740	483610	2.20	2.06	2.13

Price: Mustard Tk. 85 kg-1, Rice =Tk. 35 kg-1, Rice straw = Tk. 6 kg-1and Mustard stover = Tk. 5 kg-1

Price (Tk. kg-1): Urea-22, TSP-22, MP-15, Gypsum-30, Zinc Sulphate-200, Boric acid-160,

MBCR= Marginal Benefit Cost Ratio

Cost and return analysis

Cost and return analysis were done based on prevailing market price during the crop season. Improved cropping pattern showed its superiority over farmer's pattern during two consecutive years (Table 5) .From the economic point of view; improved cropping pattern (T. Aman- Mustard- Boro rice) showed its superiority over farmer's existing cropping pattern (T. Aman- Boro rice). Mean gross return of improved cropping pattern *(T. Aman- Mustard- Boro rice*) was found Tk. 711010 ha-1 and farmers' pattern was Tk. 422615 ha-1 which was more than 68.24 % higher over farmers' existing pattern. Two rice crop patterns (Farmers' existing pattern) gave the lower gross return Tk. 422615 ha-1. Mean variable cost was higher in improved cropping pattern (Tk. 227400 ha-1) might be due to inclusion of new component crops (mustard) in the pattern while the farmer's existing pattern (Tk. 191160 ha-1) . The mean gross margin was higher in improved cropping pattern (Tk. 483610 ha-1) than farmer's existing cropping pattern (Tk. 231456 ha-1). Three crops pattern achieved higher gross margin mainly due to higher yield advantages of the new component crops. The mean marginal benefit cost ratio (MBCR) was found 2.13 which indicated the superiority of the improved cropping pattern over the farmer's existing cropping pattern. The marginal benefit cost ratio (MBCR) also showed that inclusion of mustard in the existing pattern might be profitable and acceptable to the farmers. Inclusion of new crop (mustard) as well as improvement of management practices in the improved cropping pattern increased the economic return. These results are supported by Mondal *et al.* (2015) and Khatun *et al*., 2016. They reported that inclusion of T. Aus, potato, mustard and mungbean in the existing pattern were profitable and acceptable to the farmers and grown successfully one after another in sequence of one year cycle.

Conclusion

From the above results it showed that improved cropping pattern was more profitable compared to existing pattern. Considering higher rice- equivalent yield, monetary return and more sustainability of the improved cropping pattern, viz., *T. Aman rice (var. BRRI dhan75) – Mustard (var. BARI Sarisha14) - Boro rice (var. BRRI dhan63) showed* higher over farmer's pattern of T. Aman (var. Sarna)-Fallow-Boro (var. BRRIdhan28). As such change of variety with additional crop mustard could be suggested for cultivation in medium-high land and high land areas of the High Ganges River Floodplain Agro Ecological Zone (AEZ) 11 of Bangladesh.

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