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IMPROVEMENT FROM MUSTARD-*BORO*-T. *AMAN* CROPPING PATTERN TO MUSTARD-*BORO*-JUTE-T. *AMAN*

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Abstract

The experiment was conducted at the farmers field of FSRD site, Elenga and MLT site Modhupur, Tangail during two consecutive years 2011-12 and 2012-13 to study the productivity, production efficiency, land use efficiency and economic return of the improved cropping pattern (Mustard - Boro - Jute -T. Aman) against the existing cropping pattern (Mustard -Boro - T. Aman) through incorporating of modern crop varieties and improved management practices. The experiment was laid out in randomized complete block design with six dispersed replications. The pooled data of improved management practice for the pattern produced significantly higher yield in Mustard and T. Aman rice respectively and also gave additional jute yield. The gross return and gross margin were higher in improved pattern compared to that of existing farmer's pattern with only 149 and 151% extra cost at FSRD site, Elenga and MLT site Modhupur, respectively. The higher benefit cost ratio (1.74 and 1.79), rice equivalent yield (22.41 and 21.82), production efficiency (40.19 and 39.48) and land-use efficiency (95.75 and 96.48) indicated the superiority of the improved pattern over the farmer's existing pattern at both sites. Higher rice equivalent yield indicates that improved cropping pattern (Mustard - Boro - Jute -T. Aman) could be suitable in Tangail region for increasing crop productivity as well as cropping intensity.

Keywords: Improved cropping pattern, rice equivalent yield, land use efficiency and production efficiency.

Introduction

Bangladesh is predominately an agrarian country. Bangladesh has achieved a remarkable progress in increasing food production. Although, there has been a great success in rice production and about to self sufficient in food grain production, but increasing population in future when the natural resources, land and water are shrinking and degrading. 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. The cropping pattern and the changes therein depend

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on a large number of factors like climate, soil type, rainfall, agricultural technology, availability of irrigation facilities and other inputs, marketing and transport facilities and growth of agro-industries (Neena, 1998; Gadge, 2003). The cropping pattern in an area depends largely on agro-climatic, technical and institutional factors (Vaidyanathan, 1987).

Rice is the staple food and the economy mainly depends on rice production in Bangladesh and now occupies the 4th position in the world. In self sufficiency of rice, the dominant cropping pattern T. *Aman* (wet season rice)-Fallow-*Boro* (dry season rice) plays an important role which covers about 1.8 million hectare (about 22% of the total land) of land (Elahi *et al*., 1999).

Bangladesh Rice Research Institute (BRRI) has recommended the T. *Aman*-Mustard-*Boro* cropping pattern for the irrigated ecosystem (BARC, 2001; Khan *et al*., 2004) with the inclusion of 70-75 days local mustard variety (Tori 7) in the transition period between T. *Aman* and *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, Bangladesh Agricultural Research Institute (BARI) has developed high yielding yellow seeded mustard (*Brassica campestris*) varieties, BARI Sarisha-14 and BARI Sarisha-15 whose yield potential is higher than Tori-7 and have been recommended for T. *Aman*-Mustard-*Boro* cropping sequence (BARI, 2011). Inclusion of these new varieties of mustard with growth duration of 80-85 days in between existing medium duration T. *Aman* rice (135-140 days) and *Boro* rice can create opportunity to fit in the T. *Aman* -Fallow-*Boro* cropping sequence. Mustard- *Boro*-T. *Aman* is one of the existing dominant cropping pattern at FSRD site, Elenga and MLT site Modhupur, Tangail. The pattern covers around 16.25 % of the cultivated land of the locality (DAE, 2012). Land remains fallow for more than 80 days after harvest of *Boro* rice. The present cropping intensity is 200%. To boost up crop production, four-crops based cropping pattern need to be developed. Jute may be included after harvest of *Boro* rice. It is only possible, if jute is cultivated early and short duration T. *Aman* and *Boro* rice varieties are included in the pattern. Jute crops can be grown easily under moisture stressed condition in high to medium low land (BJRI, 1990). The crop residue from jute crop contributed to enrich soil fertility and benefit the succeeding rice crop (Singh and Ghosh, 1999).

Therefore, the present study was designed to evaluate the feasibility and profitability of four crops based cropping pattern in Tangail region.

Materials and Method

The improved cropping pattern with Mustard - *Boro* -Jute - T.*Aman* against the existing pattern Mustard-*Boro*- T.*Aman* was initiated under medium high land

situation at the FSRD site, Elenga (AEZ 8) and MLT site Modhupur (AEZ 28), Tangail during 2011-12 and 2012-13. The trial was laid out in RCB design with six dispersed replications in both the locations. Unit plot size was 10 m x 8 m. All agronomic activities including sowing/ transplanting and harvesting dates, seed rate, plant spacing, fertilizer management etc. are shown in Tables 1a and 1b. Recommended fertilizer packages following the application methods were used for all the crops (BARC, 2005). Irrigation, pest managements and other intercultural operations were done as and when necessary. Land use efficiency, production efficiency, sustainable yield index and rice equivalent yield of cropping patterns were calculated by the following formulae:

Land use efficiency

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

$$\text{Land use efficiency} = \frac{d_1 + d_2 + d_3 + d_4}{365} \times 100$$

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 Kg. ha^{-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).**

$$\text{Production efficiency} = \frac{Y_1 + Y_2 + Y_3 + Y_4}{d_1 + d_2 + d_3 + d_4}$$

Where,

Y_1: Yield of 1st crop

Y_2: Yield of 2nd crop

Y_3: Yield of 3rd crop

Y_4: Yield of 4th crop

d_1= Duration of 1st crop of the pattern

d_2= Duration of 2nd crop of the pattern

d_3= Duration of 3rd crop of the pattern

d_4= Duration of 4th crop of the pattern

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 price of individual crop **(Verma and Modgal, 1983).** The economic indices like gross, net returns and benefit cost ratio were also calculated on the basis of prevailing market price of the inputs and outputs (produces).

Crop management practices of improved and existing cropping pattern are shown in Table 1a and 1b. Crop productivity, LUE, production efficiency are also given in 2a, 2b, 3a and 3b.

Results and Discussion

Grain/Seed Yield

The results showed in Table 2-3. Table 2a and 2b reveal that Mustard-*Boro*-Jute-T. *Aman* cropping pattern under improved practices (IP) gave higher grain yield in case of Mustard and T. *Aman* in all the years. On an average, the yield of Mustard and T. *Aman* in improved pattern increased by 88.32 and 51.34%, respectively at the FSRD site, Elenga and 97.16 and 70.28%, respectively at the MLT site, Modhupur, over the crops of the farmer's pattern because of using high yielding varieties and improved management practices. The yield of *Boro* rice in improved pattern decreased by 9.65% at the FSRD site, Elenga and 9.72% at the MLT site, Modhupur over the crops of the farmer's pattern but additional jute crop was introduced with fiber yield 2.59 t ha^{-1} without hampering the turn around time.

Field duration

Field duration of cropping pattern mainly depends on individual duration of component crops. In farmer's existing cropping pattern (FECP), (Mustard- *Boro*-Fallow-T. *Aman*) farmers used Tori-7 as mustard variety, BRRI dhan-29 in *Boro* and Pajam in *Aman* season. On the other hand in improved pattern BARI Sarisha-14 was used as mustard variety, BRRI dhan-28 was used in *Boro*, O- 9897 as jute variety and Binadhan-7 in *Aman* season. BARI Sarisha-14 needs 4-5 more days to attained maturity than Tori-7 but BRRI dhan-28 matured 20-21 days earlier than BRRI Dhan-29 which helped in growing jute as an additional crop between *Boro* and T. *Aman* rice. Binadhan-7 took maturity 18 days earlier than Pajam. As a result, production efficiency and land use efficiency was higher in ICP than FECP. Though turn around time in improved pattern is very crucial so all inputs including land preparation should be done in proper time.

Table 1a. Crop managements of improved cropping pattern Mustard–*Boro*–Jute-T.*Aman* and existing cropping pattern Mustard-*Boro*–T.*Aman* at the FSRD site, Elenga, Tangail during 2011-12 and 2012-13.

Parameters	**Improved cropping pattern**				**Existing cropping pattern**		
Crop	Mustard	*Boro*	Jute	T. *Aman*	Mustard	*Boro*	T. *Aman*
Variety	BARI Sharisa-14	BRRI dhan-28	O-9897	Binadhan-7	Tori-7	BRRI dhan-29	Pajam
Date of sowing/ Transplanting	14-20 Nov. 2011 and 10-15 Nov. 2012	6-11 Feb. 2012 and 5-8 Feb. 2013	7-10 May, 2012 and 6-12 May, 2013	11-15 Aug. 2012 and 9-14 Aug. 2013	14-21 Nov. 2011 and 12-19 Nov. 2013	2-7 Feb. 2012 and 3-8 Feb. 2013	20-28 July, 2012 and 18-25 July, 2013
Seed rate (kg ha^{-1})	6	50	6	50	8	50	50
Spacing	Broadcast	25 cm x 15 cm	Broadcast	25 cm x15cm	Broadcast	25 cm x 15 cm	25 cm x15 cm
Seedling age (Day)	-	30-35	-	25-30	-	30-40	25-30
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	54-15-24-10-0-1.7	95-7-27-9-1.1-0	75-7-26-6-1.1-0	66-5-18-8-2.15-0	92-34-25-9-0-0	72-0-0-0-0-0	135-11-0-0-0-0
No. of irrigation	1 time at 20 DAS	25 times	-	16 times	-	30-35 times	20 times
No. of weeding/ thinning	1 time	2 times	3 times	2 times	1 time	2 times 10-14 and 28-32 DAT	2 times 10-15 and 30 DAT
Date of harvesting	2-8 Feb. 2012 and 1-6 Feb. 2013	3-8 May. 2012 and 4-10 May. 2013	5-8 Aug. 2012 and 4-10 Aug. 2013	7-13 Nov. 2012 and 6-11 Nov. 2013	27 Jan.- 04 Feb. 2012 and 28 Jan.- 04 Feb. 2013	21-30 May, 2012 and 22-29 May, 2013	10- 16 Nov. 2012 and 8-15 Nov. 2013

Crop duration in field (days), 2011-12	81	89	90	88	76	112	110
Crop duration in field (days), 2012-13	83	89	90	89	77	110	112
Turn around time (days), 2011-12	-	3	3	5	-	5	61
Turn around time (days), 2012-13	3	3	4	4	2	5	59

Table 1b. Crop managements of improved cropping pattern Mustard–*Boro*–Jute-T.*Aman* and existing cropping pattern Mustard-*Boro*–T.*Aman* at the MLT site, Modhupur, Tangail during 2011-12 and 2012-13.

Observation	**Improved cropping pattern**				**Existing cropping pattern**		
Crop	Mustard	*Boro*	Jute	T. *Aman*	Mustard	*Boro*	T. *Aman*
Variety	BARI Sharisa-14	BRRI dhan-28	O-9897	Binadhan-7	Tori-7	BRRI dhan-29	Pajam
Date of sowing/ Transplanting	15-18 Nov.2011 and 13-17 Nov.2012	9-14 Feb.2012and 4-10 Feb,2013	11-15 May.2012 and 6-11 May, 2013	12-15 Aug. 2012and 7-12 Aug. 2013	15-19 Nov. 2011and 10-16 Nov, 2012	4-11 Feb.2012 and 06 -12 Feb, 2013	22-30 July, 2012and 25-30 July 2012
Seed rate (kg ha^{-1})	6	50	6	50	8	50	50
Spacing	Broadcast	25 cm x15 cm	Broadcast	25 cm x 15cm	Broadcast	25 cm x 15 cm	25 cm x 15 cm

Seedling age (Day)	-	30-35	-	25-30	-	30-40	25-30
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	115-34-60-31-0-2	101-10-27-10-2-0	83-18-65-20-0-0	91-21-37-12-0-0	22-25-41-15-0-0-	115-24-50-0-0-0	129-0-0-0-0-0
No. of irrigation and date	2 time and 18-22 and 50-56 DAS	20-25 times	-	6 times	-	30-35 times	2 times
No. of weeding and date	-	2 times, 10-15 and 28-32 DAT	3 times	2 times, 10-15 and 30 DAT	-	2 times, 10-14 and 28-32 DAT	2 times, 10-15 and 30 DAT
Date of harvesting (range)	6-10 Feb.2012 and 01-07 Feb. 2013	08-12 May.2012 and 03-08 May, 2013	9-13 Aug. 2012 and 3-7Aug. 2013	10-14 Nov. 2012 and 9-12 Nov, 2013	1-5 Feb. 2012 and 2-5 Feb. 2013	22-29 May. 2012 and 26-30 May 2013	6-11 Nov. 2012. and 12-16 Nov. 2013
Crop duration in field (days), 2011-12	83	90	88	92	79	110	108
Crop duration in field (days), 2012-13	81	88	90	95	82	109	109
Turn around time (days), 2011-12	-	2	2	3	-	2	60
Turn around time (days), 2012-13	2	2	2	3	3	3	59

Table 2a. Productivity of Mustard-*Boro*-Jute- T. *Aman* rice cropping patterns under improved and farmer's practices at the FSRD site, Elenga, Tangail during 2011-12 and 2012-13.

Year	Pattern	Grain/seed/fiber yield (t ha^{-1})				By product yield (t ha^{-1})			
		Mustard	*Boro* Rice	Jute	T. *Aman*	Mustard	*Boro* Rice	Jute	T. *Aman*
2011-12	FP	0.73	6.37	-	2.73	1.58	7.24	-	5.63
	IP	1.41	5.79	2.56	4.29	1.85	6.55	2.83	4.72
2012-13	FP	0.78	6.48	-	2.86	1.38	6.94	-	5.96
	IP	1.44	5.82	2.61	4.17	2.17	6.83	2.93	4.68
Mean	FP	0.76	6.43	-	2.80	1.48	7.09	-	5.80
	IP	1.43	5.81	2.59	4.23	2.01	6.69	2.88	4.70

Table 2b. Productivity of Mustard-*Boro*-Jute- T. *Aman* rice cropping patterns under improved and farmer's practices at the MLT site, Modhupur, Tangail during 2011-12 and 2012-13

Year	Pattern	Grain/seed/fiber yield (t ha^{-1})				By product yield (t ha^{-1})			
		Mustard	*Boro* Rice	Jute	T. *Aman*	Mustard	*Boro* Rice	Jute	T. *Aman*
2011-12	FP	0.79	6.32	-	2.58	1.67	7.16	-	5.28
	IP	1.51	5.61	2.41	4.56	2.21	6.11	2.97	4.81
2012-13	FP	0.76	6.13	-	2.67	1.79	6.57	-	5.28
	IP	1.54	5.63	2.27	4.38	2.46	6.37	2.74	4.68
Mean	FP	0.77	6.23	-	2.63	1.73	6.87	-	5.28
	IP	1.53	5.62	2.34	4.47	2.34	6.24	2.86	4.75

Note- FP: Farmer's pattern, IP: Improved pattern.

Table 3a. Rice equivalent yield, production efficiency, land use efficiency and cost benefit analysis of farmers and improved cropping pattern at the FSRD site, Elenga, Tangail during 2011-12 and 2012-13.

Year	Pattern	Rice equivalent yield (t ha^{-1})	Production efficiency Kg. $ha^{-1}day^{-1}$	Land use efficiency (%)	Gross return (Tk.ha^{-1})	Cost of cultivation (TK.ha^{-1})	Gross margin (Tk.ha^{-1})	BCR
2011-12	FP	11.59	32.99	81.64	196787	130113	66674	1.51
	IP	22.33	40.37	95.34	346582	194492	152090	1.78
2012-13	FP	12.01	33.85	81.92	201290	137362	63928	1.47
	IP	22.49	40.00	96.16	349645	204829	144816	1.71
Mean	FP	11.80	33.42	81.78	199039	133738	65301	1.49
	IP	22.41	40.19	95.75	348114	199661	148453	1.74

Unit price (Tk. kg^{-1}): Mustard= 50, *Boro* rice= 13.75, *Aman* rice= 14.00, Rice straw= 2.00, Jute fibre= 40.00, Jute stick= 4.00.

Table 3b. Rice equivalent yield, production efficiency, land use efficiency and cost benefit analysis of farmers and improved cropping pattern at the MLT site, Modhupur, Tangail during 2011-12 and 2012-13.

Year	Pattern	Rice equivalent yield (t ha^{-1})	Production efficiency Kg. $ha^{-1}day^{-1}$	Land use efficiency (%)	Gross return (Tk.ha^{-1})	Cost of cultivation (TK.ha^{-1})	Gross margin (Tk.ha^{-1})	BCR
2011-12	FP	11.27	33.13	81.37	188860	123506	65354	1.53
	IP	22.05	39.92	96.71	342390	184862	157528	1.85
2012-13	FP	11.07	32.53	82.19	185355	130127	55228	1.42
	IP	21.59	39.04	96.99	339693	196990	142703	1.72
Mean	FP	11.17	32.83	81.78	187108	126817	60291	1.48
	IP	21.82	39.48	96.85	341042	190926	150116	1.79

Unit price (Tk. kg^{-1}): Mustard= 50, *Boro* rice= 13.00, *Aman* rice= 14.00, Rice straw= 2.00, Jute fibre= 40.00, Jute stick = 4.00.

Rice equivalent yield

The mean rice equivalent yield revealed that improved cropping system produced higher rice equivalent yield over farmer's traditional cropping system (Tables 3a and 3b). Inclusion of a four crops with high yielding varieties and improvement management practices in the improved pattern increased the rice equivalent yield (22.41 and 21.82 t ha^{-1}). The lower rice equivalent yield (11.80 and 11.17 t ha^{-1}) was obtained in the farmer's pattern with three crops, local variety in mustard & *Aman* rice and traditional management practices at the FSRD site, Elenga and MLT site Modhupur respectively.

Production efficiency

The lower production efficiency was observed in farmer's pattern (Tables 3a and 3b). The result indicates that the crops remained in the field for shorter time and yields were also lower in farmer's traditional system, leading to lower production per day. On the contrary, crops remain standing in the field for longer time with higher yield in improved practices, leading to higher production efficiency.

Land use efficiency

Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The average land-use efficiency indicated that improved pattern used the land for 95.75% period of the year at the FSRD site, Elenga and 96.85% at the MLT site Modhupur, whereas farmer's pattern used the land for 81.78% period of the year. This higher land use efficiency in improved pattern is due to cultivation of jute as a component crop in fallow period.

Economic analysis

From the economic point of view, the ICP (improved cropping pattern) showed its superiority over FECP (farmer's existing cropping pattern). Gross return of the ICP was Tk.348114, which was about 74.89% higher than that of farmers pattern (Table 3a) at the FSRD site, Elenga. At the MLT site, Modhupur, gross return of the ICP was Tk.341042, which was about 82.27% higher than that of farmers pattern (Table 3b). The production cost per hectare of the improved pattern was higher than that of FECP. Higher cost for improved cropping pattern was due to cultivation of jute as a component crop, labor intensive, cultural operations, cost of fertilizer and other inputs. The gross margin was substantially higher in the improved pattern than that of the farmer's pattern. Though cost of cultivation in ICP was much higher but BCR was also higher due to higher benefit from the pattern.

Farmer's opinion

The yield performances of the BARI Sharisha-14, BARI Sharisha-15, BRRI dhan-28, Falgunitusa (O-9897), Binadhan-7 and BRRI dhan-49 are found almost satisfactory performance. After harvest of T. *Aman* rice, short duration modern mustard variety (BARI Sharisha-14) could easily be grown which doesn't hamper or delay the *Boro* cultivation. Jute crop could easily be grown between *Boro* and T. *Aman* rice by using short duration *Boro* rice variety (BRRI dhan-28). Improved knowledge on production technology for four crops is needed.

Conclusion

Improved cropping pattern mustard (var. BARI Sarisha-14)–*Boro* (var. BRRI dhan-28)-Jute (var. O-9897)-T.*Aman* (var. Binadhan-7) is economically viable and biologically suitable technology. The findings may be used as extension message for large scale production but more training is required for the farmers before disseminated the technology.

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