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ON-FARM ASSESSMENT OF SYSTEM PRODUCTIVITY OF WHEAT-JUTE-T. AMAN RICE CROPPING PATTERN IN SYLHET REGION

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Abstract

The study was conducted to determine the yield and economic performance of two cropping patterns viz. IP: improved pattern (Wheat - Jute - T. aman) + improved management practice and FP: farmer's pattern (Fallow - T. aus - T. aman) + management practice. The experiment was laid out in a randomized complete block design with six dispersed replications at farmer's field in Sylhet region during two consecutive years of 2013-14 and 2014-15. Two years means data showed that the pattern with improved management practices provided 31% higher yield of T. aman rice and also contributed more rice equivalent yield compared to farmers practice. Sustainable yield index, production efficiency, and land use efficiency were the maximum with Wheat-Jute- T. aman cropping system. Similarly, highest mean gross margin and benefit cost ratio were attained in improved pattern. It was concluded that farmers of Sylhet region might follow Wheat (var. BARI Gom-26) - Jute (var. CVL-1) - T. aman (var. Binadhan-7) cropping system in medium high land for higher productivity and profitability.

Introduction

Fallow - T. aus - T. aman rice and Boro - Fallow - T. aman rice etc. are the important and popular cropping pattern in Hobiganj of Sylhet region. Farmers mostly cultivate rice under rainfed condition and thus , transplanting of T. aus depends on the onset of rainfall. The delayed transplantation of T. aus causes late cultivation and harvesting of T. aman rice. Due to late harvesting of T. aman, all rabi crops are not possible to be grown. The soils under cropping pattern of these areas are generally heavy clay loams to clays and the top soil quickly becomes dry and hard after the harvest of T. aman crop. More than 40% land remains fallow for a long time (December-May) after the harvest of T. aman due to moisture stress (up to *kharif-I*) in Eastern Surma-Kushiyara Floodplain (AEZ-20) and Northern and Eastern Piedmont Plain (AEZ-22). Farmers of the mentioned areas wait for cultivating T. aus rice following the existing cropping pattern (Fallow - T. aus - T. aman) under rainfed condition. But the weather data of study areas revealed that rainfall starts here in February and prevails up to November in each year that offers an excellent opportunity for the production of short duration crop.

BARI has been developed more than 27 wheat varieties with high yield potential and good quality. Among the BARI released wheat varieties, BARI Gom-24, BARI Gom-25, BARI Gom-26, BARI Gom-27 and BARI Gom-28 have been popularized in different areas of the country and farmers are adopting the varieties rapidly. In order to increase production, wheat can be cultivated before Jute under Wheat - Jute - T. aman rice based cropping pattern instead of existing Fallow - T. aus - T. aman cropping pattern in AEZ-20 of Bangladesh. A number of reports on different cropping pattern are available in Bangladesh and India that indicate 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 (Wahhab and Azad, 1981; Azad *et al.* 1982; Malavia *et al.* 1986; Soni and Kaur, 1984; Khan *et al.,* 2005 and Nazrul, *et al.* 2013*).* But, little efforts have been made for on-farm evaluation of the improved technologies of Wheat-Jute-T. aman rice cropping pattern in Sylhet area. The present study was therefore, initiated to find out the agro-economic feasibility of an improved package of technologies over the farmers existing practices.

Materials and Methods

On-farm trials were carried with out in farmer's field under Eastern Surma - Kushiyara Floodplain (AEZ-20) which is located in between 23°58' and 24°16' north latitudes and in between 91°16' and 91°25' east longitudes of Bangladesh, during two consecutive years 2013-14 and 2014-15. This trial was conducted to with two cropping patterns viz. IP: improved pattern (Wheat - Jute - T. aman) and FP: farmer's pattern (Fallow - T. aus - T. aman) through inclusion of modern high yielding varieties of Jute, T. aman rice as well as Wheat and improved management practices for crop production.

Annual monthly total rainfall 3821 mm was during the period 2014-15. Average maximum and minimum temperature was 31.34 and was 14.72^{0}C, respectively (Fig.1). The soil was clay loam with low organic matter content (1.30%) and soil pH was ranged 5.3-6.2 acidic in nature. The status of N, P, K, S, B and Zn was very low, low, low, very low and medium, respectively. The experimental design was a randomized complete block with six dispersed replications with plot size of 500 m^2.One plot was under the improved pattern and the other farmer's pattern.

In the improved pattern, wheat var. BARI Gom-26 was introduced against fallow period. The var. CVL-1 of Jute and Binadhan-7 of T. aman rice was introduced instead of BR26 and BRRI dhan33, respectively. The agronomic practices and cultural operation for crop production under improved and farmer's practices are presented in Table 1. All field operation and management practices of both farmer's and improved pattern were closely monitored and the data were recorded for agro-economic performance. The yield differences between the practices were statistically analyzed by't' test. Agronomic performance viz. land use efficiency, production efficiency, rice equivalent yield and sustainable yield index of cropping patterns were calculated by the following formula:

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.

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

Where d_1, d_2 and d_3 the duration of 1^{st}, 2^{nd} and 3^{rd} crops 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).

$$\textbf{Production efficiency} = \frac{Y_1 + Y_2 + Y_3}{d_1 + d_2 + d_3}$$

Where, Y_1= Yield of 1st crop and d_1= Duration of 1st crop of the pattern
Y_2= Yield of 2nd crop and d_2= Duration of 2nd crop of the pattern
Y_3= Yield of 3rd crop and d_3= Duration of 3rd crop of the pattern

Sustainable yield index: Sustainable yield index (SYI) was worked out by the following formula suggest by Krishna and Reddy (1997).

$$\text{Sustainable yield index (SYI)} = \frac{Y_{mean} - SD}{Y_{max}} \times 100$$

Where, Y_{mean}: Estimated mean yield of a practice over years; SD: Estimated standard deviation; Y_{max}: Observed maximum yield in the experiment over the years.

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; Bandyopadhyay, 1984). The economic indices like gross and net returns and benefit cost ration were also calculated on the basis of prevailing market price of the produces.

$$\text{Rice equivalent yield (t ha}^{-1}) = \frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of rice}}$$

For economic evaluation of two different cropping sequences averaged data of two crop cycles were used. The gross cost of cultivation of different crops was calculated on the basis of different operations performed and materials used for raising the crops. Gross margin, gross return and total cost of cultivation of the component crops were calculated as well as benefit cost ratio (BCR) as per following formula.

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return (Tk. ha}^{-1})}{\text{Total variable cost of cultivation (Tk. ha}^{-1})}$$

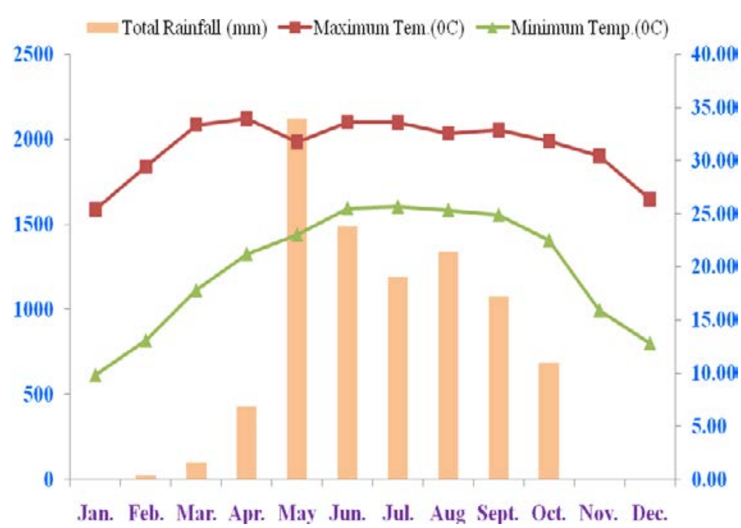

Fig. 1. Month wise total rainfall (mm) and temperature during study period 2013-15 in Srimangal, Moulvibazar.

Results and Discussion

Grain/Fiber Yield of the Cropping Patterns

Improved pattern required 288-309 days against 181-190 days due to inclusion of jute instead of T. aus rice in the pattern, but can be easily fitted before T. aman rice (Table 1). Yield of T. aman rice in the improved pattern was higher due to change of variety with improved production technologies (Table 2). Similar results were also obtained by Nazrul *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005) and Hossain and Wahhab (1992). In both years, farmers' pattern gave lower grain yield of rice due to imbalance use of fertilizers and more plant population. The rice variety, Binadhan-7 in improved pattern performed better than BRRI dhan33 in farmers' practices due to use of balance fertilizer and modern technology.

By-product Yield of the Cropping Patterns

The improved cropping pattern produced higher amount of total by-product yield (12.95 t/ha) than the by-product yield of the crops of the farmers' pattern (9.07 t ha^{-1}). The by-product yield of improved pattern was higher due to introduction and change of variety with improved technologies for the component crops. In both years it was revealed that the component crops wheat and Jute of improved pattern produced valuable by-product. On the contrary, farmers are not able to sale by-product (rice straw) in the local market; whereas, the by-products of Wheat and Jute crops were valuable and high demand in the local market.

Rice equivalent yield also contributed more rice equivalent yield compared to farmers practice. The mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield (13.51 t ha^{-1}) over farmers' traditional (7.29 t ha^{-1}) cropping pattern (Table 3). On an average, the rice equivalent and T. aman rice yield in improved pattern increased by 23.88 and 8.39%, respectively over the crops of the farmers' practices (FP). Inclusion of high yielding new varieties and crops with improved management practices in the improved pattern increased the T. aman rice equivalent yield. It was also due to higher price of components crops in the improved pattern. Lower rice equivalent yield was obtained in the farmer's pattern due to variety and traditional management practices.

Production efficiency

Maximum production efficiency was obtained from improved pattern in each year of 2013-2014 and 2014-15 (Table 3). The higher production efficiency of improved cropping pattern might be due to introduction of new and or modern varieties and management practices. In conversely, the lowest production efficiency was observed in farmers' pattern where modern management practices were absent. Mean production efficiency (44.08) in terms of $kg^{-1}ha^{-1}day$ was higher in improved pattern and lower (38.36) in farmers' pattern. Similar trend were noted by Nazrul *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005) and Krishna and Reddy (1997).

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 81% period of the year, whereas farmer's pattern used the land for 50.69% period of the year. This higher land use efficiency in improved pattern is due to cultivation of wheat as component crop in fallow period.

Table 1. Management practices of improved vsfarmer's existing cropping pattern during 2013-15

Parameters	Cropping pattern index	Farmer's pattern (FP)		Improved pattern (IP)	
		2013-14	2014-15	2013-14	2014-15
Variety	C1	Fallow	Fallow	BARI Gom-26	BARI Gom-26
	C2	BR26	BR26	CVL-1	CVL-1
	C3	BRRI dhan33	BRRI dhan33	Binadhan-7	Binadhan-7
Date of Sowing/ Transplanting	C1	Fallow	Fallow	20-25 Nov	21-24 Nov
	C2	10-15 May	10-15 May	4-7 April	4-8 April
	C3	12-15 August	12-14 August	5-10 August	5-10 August
Seed rate (kg ha^{-1})	C1	Fallow	Fallow	120	120
	C2	30-35	30-35	7	7
	C3	28-30	28-30	20-25	20-25
Planting method	C1	Fallow	Fallow	Line	Line
	C2	Line	Line	Line	Line
	C3	Line	Line	Line	Line
Spacing (cm)	C1	Fallow	Fallow	30 cm in line	30 cm in line
	C2	20 Ч 10	20 Ч 10	20 cm in line	20 cm in line
	C3	20 Ч 15	20 Ч 15	20 Ч 15	20 Ч 15
Fertilizer dose (NPKSZn, kg ha^{-1})	C1	Fallow	Fallow	120-30-60-15-1	120-30-60-15-1
	C2	83-20-40-5-1	83-20-40-5-1	110-15-40-8-0.5	110-15-40-8-0.5
	C3	92-24-60-8-0.5	92-24-60-8-0.5	115-35-40-4-0.5	115-35-40-4-0.5
Fertilizer application method	C1	Fallow	Fallow	All PKSZn & □ N as basal and rest N at 21 and 45DAP	All PKSZn & □ N as basal and rest N at 21 and 45DAP
	C2	All PKS used as basal during final land preparation. N used in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	All PKS used as basal during final land preparation. N_2 used in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	Half of nitrogen and all other fertilizers applied as basal during final land preparation. Remaining nitrogen was top dressed at 40-45 DAS under moist soil condition	Half of nitrogen and all other fertilizers applied as basal during final land preparation. Remaining nitrogen was top dressed at 40-45 DAS under moist soil condition
	C3	All PKS used as basal during final land preparation. N used in 2 equal splits	All PKS used as basal during final land preparation. N_2 used in 2 equal	All PKSZn used as basal and N used in 3 equal splits, the first one after 15DAT,	All PKSZn used as basal and N_2 used in 3 equal splits, the first one after 15 DAT,

Parameters	Cropping pattern index	Farmer's pattern (FP)		Improved pattern (IP)	
		2013-14	2014-15	2013-14	2014-15
		at 15-20 DAT and another one in 35-40 DAT.	splits at 15-20 DAT and another one in 35-40 DAT.	second one at 35-40 DAT and third one at 5-7 days before panicle initiation stage.	second one at 35-40 DAT and third one at 5-7 days before panicle initiation stage.
Weeding (no.)	C1	Fallow	Fallow	1	1
	C2	2	2	2	2
	C3	1	1	2	2
Irrigation/Rainfed	C1	Fallow	Fallow	2-3	2-3
	C2	Rainfed	Rainfed	Rainfed	Rainfed
	C3	Rainfed	Rainfed	Rainfed	Rainfed
Insect-pest control	C1	Fallow	Fallow	IPM	IPM
	C2	Chemical	Chemical	IPM	IPM
	C3	Chemical	Chemical	IPM	IPM
Harvest time (date)	C1	Fallow	Fallow	17-20 March	17-20 March
	C2	10-15 Aug	10-15 Aug	25-28 July	25-23 July
	C3	15-20 Nov	15-20 Nov	10-16 Nov	10-15 Nov
Field duration (days)	C1	-	-	98-105	98-105
	C2	85-90	85-90	100-108	100-108
	C3	96-100	96-100	90-96	90-96

C_1: Fallow/Wheat; C_2: T. aus/Jute, C_3: T. aman; IPM: Integrated pest management

Table 2. Productivity of improved and farmer's existing patterns during 2013-15.

Years	Cropping Patterns	Grain/fiber yield (t ha^{-1})			By product yield (t ha^{-1})		
		Fallow/ Wheat	T.aus/ Jute	T. aman	Wheat	T. aus/ Jute	T. aman
2013-14	IP	3.83	2.31	4.13a	4.74	3.53	4.70
	FP	-	3.92	3.75b	-	4.46	4.80
2014-15	IP	3.61	2.26	3.88a	4.76	3.34	4.85
	FP	-	3.85	3.64a	-	4.38	4.51
Mean	IP	3.72	2.29	4.01a	4.75	3.43	4.77
	FP	-	3.89	3.70b	-	4.42	4.65

FP = Farmer's pattern, IP = Improved pattern. Price of rice seed =26.00 Tk. kg^{-1}; Wheat seed = 35.00 Tk. kg^{-1}; Jute seed = 75.00 Tk. kg^{-1}; Urea = 20.00 Tk. kg^{-1}; TSP =22.00 Tk. kg^{-1}; MoP = 15.00 Tk. kg^{-1}. Among field operations, the cost of plowing was taken as Tk. 10 decimal^{-1}, labour cost of Tk. 300 man^{-1}day^{-1}. Gross returns included income from sale of main and by-products (Tk. ka^{-1}) of all crops; Price of T. aus rice = 19.00 Tk. kg^{-1}; T. aman rice = 20.50 Tk. kg^{-1}; Jute fiber = 40.00 Tk. kg^{-1}; wheat straw/haulm= 1.00 Tk. kg^{-1} and Jute stick =5.00 Tk. kg^{-1}.

Sustainable yield index

The values of sustainable yield index (SYI) as a measure of sustainability of the system which was high in the improved cropping system over farmer's practices (Table 4). It was revealed from the experimental results that between two different cropping systems Wheat-Jute-T. aman rice recorded the highest SYI of 76.41% followed by Fallow-T. aus-T. aman rice (66.10%). It indicates that cropping system involving wheat in fallow period and Jute instead of T. aus rice recorded higher SYI compared to fallow-rice based crop sequences. The results are in agreement with the findings of Nazrul *et al.* (2013) and Ram *et al.,* (2012). This indicated that improved pattern is therefore, more stable than farmer's pattern. Wheat and Jute are providing special advantage regarding utilization of fallow land and improving soil health, respectively.

Cost benefit analysis

Between two crop sequences, the improved cropping pattern showed its superiority over farmers' existing pattern during two consecutive years of cropping. On an average, gross return of the improved pattern was Tk.276955 ha^{-1} which was more than 85% higher than farmers' pattern of TK. 149445 ha^{-1} (Table 4). The production cost of the improved pattern (Tk. 131457 ha^{-1}) was higher than farmers' pattern (Tk. 85261 ha^{-1}) due to introduction of wheat in fallow and cost of fertilizer and other inputs. The gross margin was substantially higher in the improved pattern (Tk.145601 ha^{-1}) than farmers' pattern (Tk. 64184 ha^{-1}). Inclusion of wheat and jute in these cropping systems besides, increasing the system productivity fetched higher market price thereby, increasing the gross margin. As a result, 126% additional gross margin was achieved by adding 54% additional cost in the improved pattern. Returns per Taka invested were highest for wheat-jute-T. aman rice (2.11) over the farmer's pattern (1.75).

Table 3. Rice equivalent yield, production efficiency, land use efficiency and sustainable yield index of improved and farmers patterns during 2013-15

Years	Cropping patterns	Rice equivalent yield (t ha^{-1})	Production efficiency (kg ha^{-1} day^{-1})	Land use efficiency (%)	Sustainable yield index (%)
2013-14	IP	13.83	44.90	84.38	73.69
	FP	7.38	38.84	52.05	67.26
2014-15	IP	13.20	43.27	78.91	79.12
	FP	7.20	37.89	49.32	64.94
Mean	IP	13.51	44.08	81.65	76.41
	FP	7.29	38.36	50.69	66.10

Table 4. Cost benefit analysis of improved and farmer's existing cropping pattern during 2013-15

Years	Cropping patterns	Gross return (Tk. ha^{-1})	Cost of cultivation (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
2013-14	IP	283515	131957	151558	2.15
	FP	1512900	85761	65529	1.76
2014-15	IP	270600	130957	139643	2.07
	FP	147600	84761	62839	1.74
Mean	IP	276955	131457	145601	2.11
	FP	149445	85261	64184	1.75

Conclusion

Wheat - Jute - T. aman rice cropping system was found more productive, sustainable, land-use efficient, and remunerative than the existing farmers cultivated patterns under eastern Surma-Kushiyara Floodplain (AEZ-20) of Bangladesh. . Therefore, farmers of AEZ-20 could follow the Wheat (var. BARI Gom-26) - Jute (var. CVL-1) - T. aman (var. Binadhan-7) rice cropping system for higher system productivity and profitability in medium high land.

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