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IMPROVEMENT OF POTATO-JUTE-T.*AMAN* CROPPING PATTERN THROUGH INCLUSION OF MUNGBEAN

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Abstract

Inclusion of mungbean in a cropping pattern not only increases the cropping intensity but also enriches soil health as well as ensures nutrition for the fast-growing population of Bangladesh. A study was conducted in farmers' field of Domar, Nilphamari, Bangladesh during 2013-14 and 2014-15 to evaluate the performance of four-crop based cropping pattern Potato – Mungbean – Jute - T.Aman rice against the existing farmer's pattern Potato-Jute-T.*Aman* rice. The experiment was laid out in randomized complete block design with six disperse replications. Two-year study revealed that inclusion of mungbean and practice of better management along with use of modern high yielding varieties in the existing cropping pattern increased rice equivalent yield of the whole pattern by 38.7% and economic profit by 73.1%. Moreover, land use efficiency and production efficiency of Potato – Mungbean – Jute -T.*Aman* pattern were higher than the existing pattern by 14.0 and 28.2%, respectively. Thus, the study suggests incorporation of mungbean in the existing Potato-Jute-T.*Aman* pattern could be a agronomically and economically profitable for the farmers as well as cropping intensity can be increased.

Introduction

Agriculture plays a great role in national economy of Bangladesh and more than 70% of rural people are directly or indirectly involved with agriculture (BBS, 2016). This large sector engages nearly 45.6% of total labor force and contributes one sixth of gross national product of the country (BBS, 2016). Now-a-days, agricultural economy of Bangladesh is facing a great challenge to meet the food demand for the fast-growing population with its limit resources. Despite of decreasing the cultivable land by 0.87% per year, presently Bangladesh has achieved a remarkable increase in food production especially in case of rice production (BBS, 2016). The present cropping intensity of the country is 191%, but it needs to be increase significantly as the food requirement of the country people has projected to be doubled in the next 25 years. In Bangladesh, continuous growing of rice is considered as the main reason of declining soil fertility as well as for irrigation water crisis. In addition, rice monoculture also reduces production of non-rice crops, erodes biodiversity and creates nutritional imbalance (Hussain *et al.*, 2001; Rahman, 2010).

Potato – Jute – T. aman rice is a major cropping pattern of greater Rangpur region especially for medium high land (Elahi *et al.*, 1999). This pattern can easily be improved by inclusion of a short duration legume crop like mungbean. The inclusion of mungbean in a cropping system

not only improves production of all crops grown in a rotation compared with monoculture systems (Murray *et al.*, 1987) but also reduces fertilizer requirement by fixing nitrogen in soil, improves soil health, increases potential yield with increased cropping intensity, greater productivity per unit time and space, and higher net returns (Ali *et al.*, 2012; Naresh *et al.*, 2013; Hossain *et al.*, 2015). Therefore, the study had taken to evaluate the performance of the four-crop based cropping pattern and compare with farmers exiting pattern at Domar, Nilphamari.

Materials and Methods

The experiment was conducted at the farmers' field during 2013-14 and 2014-15 to compare the performance of the improved cropping pattern (Potato - Mungbean – Jute - T. aman) against the existing cropping pattern (Potato-Jute-T. aman) in the Domar, Nilphamari (Latitude: $26^0$05.778 N, Longitude: $088^0$50.41 E and Altitude: 34 m). The experimental land was high land with sandy loam textured soil having pH 5.1. Before starting the experiment, the land was neutralized by addition of Dolomite @ 1 t ha^{-1}. Nutrient status of the initial soil and the post-harvest soil at completion of two years study has given in Table 1. The experimental site received 1907.9 mm total rainfall in the year of 2013, 1635.0 mm in 2014 and 2417.0 mm in 2015 (Figure 1a). Monthly averaged maximum temperatures were ranged between 22.5-33.3° C in 2013, 22.2-34.3° C in 2014 and 22.4-32.3° C in 2015. The minimum temperatures were ranged from 9.1-26.8° C in 2013, 12.0-26.8° C in 2014 and 12.0-26.6 C in 2015. The lowest temperature was prevailed in the month of January during all the years of study whereas the temperature was at the peak in the month of June during 2013, in April during 2014 and in October during 2015 (Fig. 1b).

Table 1. Nutrient status of initial and post-harvest soil under Potato-Mungbean-Jute-T.aman rice cropping pattern at Domar, Nilphamari

Nutrient status	Initial soil	Post-harvest soil
pH	5.1	5.7
Organic matter (%)	1.37	1.43
Total N (%)	0.07	0.08
P (µg g^{-1} of soil)	27.2	31.6
S (µg g^{-1} of soil)	15.7	16.1
K (meq. per 100 g of soil)	0.11	0.10
Zn (µg g^{-1} of soil)	0.9	1.04
B (µg g^{-1} of soil)	0.15	0.17

The experiment was laid out in Randomized Complete Block design with 6 dispersed replications (one farmer represents one replication). The unit area for each farmer was 400 m^2. Data of the existing pattern were collected from the neighbor farmer's practiced land of each replication. All agronomic management practices including dates of sowing/ transplanting and harvesting, seed rate, plant spacing, fertilizer management etc. were in Table 2. In the existing pattern, farmers used potato var. BARI Alu-8 , Jute var. Indian Tosa and T. Aman var. Swarna whereas BARI Alu-25, 0-9897 and BRRI dhan56 were used as potato, jute and T.*Aman* rice varieties in the improved pattern (Table 2). Crop-wise recommended fertilizer packages were applied (FRG, 2012). Appropriate application methods of fertilizer were used for all the crops. Irrigation, pest managements and other intercultural operations were done as

and when necessary. All field operations and management practices for both improved and existing patterns were closely monitored and recorded. Aphid infestation was observed in potato field which was controlled by spraying Acephate @ 1.5 g L^{1} of water during 30 days after planting. Dithane M-45 @ 4 g L^{1} of water was applied for 5 times started from 30 DAP and continued up to 70 DAP at 10 days interval to control late blight disease of potato . Mungbean field was sprayed with Dimethoate @ 2ml L^{1} of water at 3 days after emergence to control stem fly and Emamectin Benzoate was sprayed @ 2 ml L^{1} of water to control pod borer. In T. aman rice, Chlorpyrifos was applied @ 80 g ha^{-1} to control stem borer and Tebuconazole (25%) was sprayed @ 2ml per L of water at 65 DAT for controlling leaf blight. Crop yield was recorded from the central 100 m^2 area of each replication and converted into t ha^{-1}.

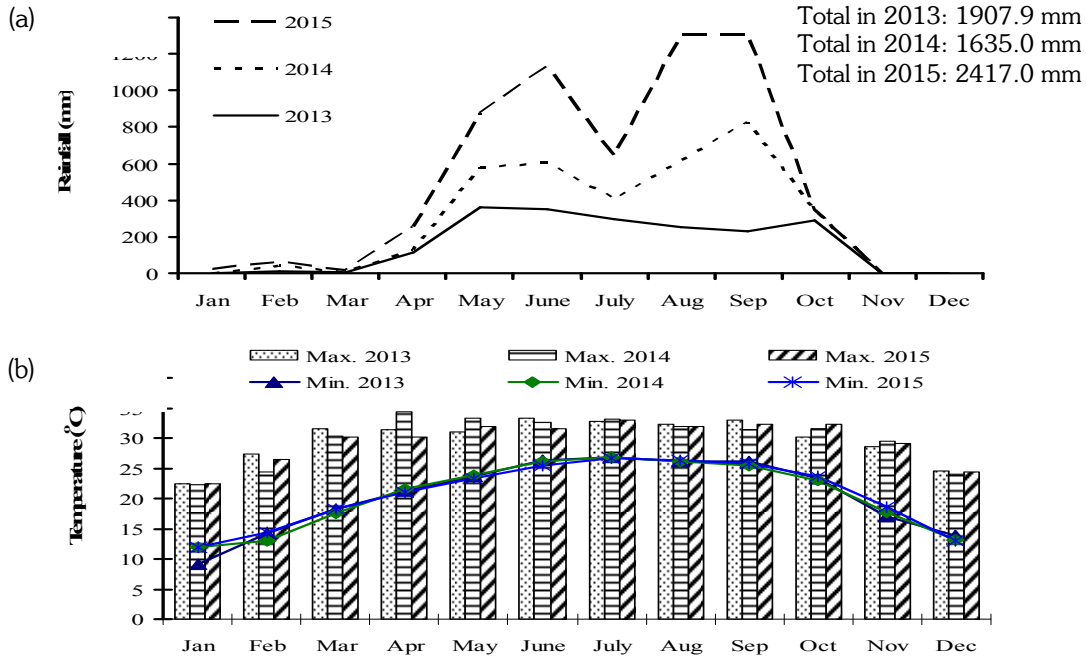

Fig. 1. (a) Monthly and yearly total rainfall and (b) monthly average temperature (maximum and minimum) of the experimental site of Domar, Niphamari during 2013-15

The collected data were analyzed statistically by following 'ANOVA' technique and means were compared by DMRT using statistical package program MSTAT-C. Economic analysis was done on the basis of prevailing local market price of the commodities. Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

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

Land use efficiency (LUE): It is worked-out on total duration of crops in an individual cropping pattern divided by 365 days (Tomer and Tiwari, 1990). It was calculated by the following formula:

$$\text{LUE (\%)} = \frac{d_1+d_2+d_3+d_4}{365} \quad 100$$

Where, d_1= duration of 1st crop of the pattern
d_2 = duration of 2nd crop of the pattern
d_3 = duration of 3rdcrop of the pattern
d_4= duration of 4thcrop of the pattern

Production efficiency (PE): It values in terms of kg ha^{-1} day^{-1} was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomer and Tiwari, 1990). It was calculated by the following formula:

$$\text{PE (\%)} = \frac{y_1+y_2+y_3+y_4}{d_1+d_2+d_3+d_4} \quad 100$$

Where, y_1= Yield of 1stcrop of the pattern
y_2= Yield of 2nd crop of the pattern
y_3= Yield of 3rd crop of the pattern
y_4= Yield of 4th crop of the pattern
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

The cost and return analysis included gross return, gross margin and marginal benefit cost ratio (MBCR). The output and inputs were valued at existing market prices. 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) for it was computed as (CIMMYT, 1988).

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

Results and Discussion

Nutrient status of soil

Soil nutrient analysis results demonstrated that no big change in amount of nutrient elements after completion of two-year cropping cycle (Table 1). The study found a slight positive change in soil pH, OM, N, P, S, Zn and B. This positive change might be related to the supplementary supply of required amount of nutrients as fertilizers that were applied properly to achieve high yield goal. On the other hand, results showed a slight negligible decrease in total K after two years.

Field duration

The study demonstrated that existing farmer's pattern occupies the field for 303 days in 2013-14 and 298 days in 2014-15 leaving 61 days and 64 days as turnaround time, respectively (Table 2). On the other hand, field duration of the improved cropping pattern was longer (341 days in 2013-14 and 344 days in 2014-15) than the existing pattern. However, four-crop base improved pattern reduced the turnaround time by 40 days in 2013-14 and 44 days in 2014-15 because of using short duration BARI Alu-25 and BRRI dhan56 as potato and T.*Aman* rice

varieties. These two varieties helped to save 21-27 days and therefore it was easy to fit a short duration mungbean var.BARI mung-6 within the improved pattern.

Yield performance

Result showed that seed yield of potato in potato-mungbean-jute-T.*Aman* cropping pattern (IP) was higher by 64.3% than that of in the existing farmer's potato-jute-T.*Aman* pattern (FP) (Table 3). The average yield of potato in IP was 24.32 t ha^{-1} whereas it was only 14.80 t ha^{-1} in FP. It might be related to use of high yielding modern potato variety in IP along with improved management practices. On the other hand, the study revealed that fiber yield of jute and grain yield of T.*Aman* rice were little bit lower in IP compared to FP. This might be happened due to use of short duration varieties of jute and T.*Aman* rice. However, total yield of the whole pattern in IP was higher than FP by 42.1% in 2013-14 and 50.4% in 2014-15 as the additional yield of mungbean was obtained from the improved pattern (0.59 and 0/69 t ha^{-1} in 2013-14 and 2014-15).

Rice equivalent yield (REY) of the improved cropping pattern (26.72 t $ha^{-1}yr^{-1}$) was also higher than the existing pattern (19.27 t $ha^{-1}yr^{-1}$) by 39% because high yield of potato and additional yield of mungbean with high market price helped the improve pattern to have higher REY over the existing pattern.

Production efficiency

Higher production efficiency was calculated from four-crop base improved cropping pattern (24.40 kg ha^{-1} day^{-1}) over the farmer's existing three-crop based cropping pattern (19.03 kg ha^{-1} day^{-1}) (Figure 2). Improved management practices and use of modern varieties lead the improved cropping pattern for higher production efficiency over the existing cropping pattern. Production efficiency in farmers' pattern was lower due to lack of modern management practices and local varieties. Similar result was also found in the previous study of potato-rice base improved cropping patter (Nazrul *et al.*, 2013).

Land use efficiency

Land use efficiency depends on crop duration and number of crops cultivated during a cropping season. Therefore, land use efficiency (LUE) of the improved pattern (IP) was 93.84% whereas it was 82.33% in the existing pattern (FP). IP had higher LUE than FP by 28.2% because total field duration of potato – mungbean – jute -T.*Aman* pattern per year was longer (344 days) than potato-jute-T.*Aman* pattern (291 days) (Table 2). Inclusion of mungbean in improved pattern helped to increase land use efficiency as it occupied field for 64-65 days.

Cost and return analysis

Results of the economic analysis showed that total variable cost (Tk.2,96,530 ha^{-1}) was higher in the improved pattern than the existing pattern (Tk.2,22,650 ha^{-1}) because of additional cost involvement of mungbean cultivation. However, gross return (Tk.4,40,805 ha^{-1}) and gross margin (Tk.1,64,975 ha^{-1}) of the improved cropping pattern were higher than the existing pattern (gross return: Tk.3,17,950 ha^{-1} and gross margin: Tk.95,300 ha^{-1}). Moreover, MBCR of the improved pattern was calculated 1.66 indicates that inclusion of mungbean was 66% more economic beneficial than the existing farmer's pattern.

Farmers' opinion

Farmers opined their satisfaction observing overall better performance of this improved pattern over existing cropping pattern but they needs favourable marketing environment.

Table 2. Agronomic management practices of the existing cropping pattern and improved cropping pattern at Domar, Nilphamari during 2013-14 and 2014-15

Pattern	Year	Existing cropping pattern			Improved cropping pattern			
Crop		Potato	Jute	T. aman	Potato	Mungbean	Jute	T. aman
Variety		BARI Alu-8	Indian Tosa	Swarna	BARI Alu-25	BARI Mung-6	O-9897	BRRI dhan56
Spacing		60cm x 25cm	Broadcast	20cm x 15cm	60cm x25cm	30 cm	Broadcast	20cm x 15cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})		120-50-110-22-8-1	120-15-30-10-0-0	114-9.88-12.35-4-4-0	120-50-110-22-8-1	45-90-30-4-1-1.19-0	90-15-30-10-0-0	115-0-40-15-0-2-0
Date of sowing/ transplanting	2013-14	24 Nov. to 08 Dec. 2013	13 to 24 April 2014	21 to 28 July 2014	17 to 19 Nov. 2013	20 to 26 Feb. 2014	02 to 06 May 2014	12 to 16 Aug. 2014
	2014-15	20 Nov. to 05 Dec. 2014	08 to 19 April 2015	26 July to 07 Aug. 2015	16 to 21 Nov. 2014	21 to 27 Feb. 2015	03 to 07 May 2015	10 to 13 Aug. 2015
Field duration	2013-14	94	94	115	87	64	99	91
	2014-15	92	99	107	89	65	98	93
Turnaround time	2013-14	11	45	5	6	8	4	3
	2014-15	10	46	8	3	8	5	4
Harvesting date	2013-14	26 Feb. to 04 Mar. 2014	16 to 25 July 2014	13 to 21 Nov. 2014	12 to 17 Feb. 2014	27 to 29 April 2014	09 to 13 Aug. 2014	11 to 15 Nov. 2014
	2014-15	20 Feb. to 06 Mar. 2015	18 to 23 July 2015	10 to 20 Nov. 2015	13 to 15 Feb. 2015	27 to 30 April 2015	06 to 10 Aug. 2015	11 to 16 Nov. 2015

Table 3. Yield, variable cost, gross margin and marginal benefit cost ratio of the improved pattern and the existing pattern at Domar, Nilphamari during 2013-14 and 2014-15

Pattern		Existing cropping pattern			Improved cropping pattern			
Crop		Potato	Jute	T. aman	Potato	Mungbean	Jute	T. aman
Year								
Grain or seed or fiber yield (t ha^{-1})	2013-14	15.1	2.28	3.68	23.73	0.59	2.21	3.39
	2014-15	14.5	2.36	3.82	24.91	0.69	2.17	3.31
	Mean	14.80	2.32	3.75	24.32	0.64	2.19	3.35
Straw or stick yield (t ha^{-1})	2013-14	-	5.78	4.23	-	-	5.78	4.23
	2014-15	-	5.16	4.05	-	-	5.24	3.97
	Mean	-	5.47	4.14	-	-	5.51	4.10
REY (t $ha^{-1}yr^{-1}$)	2013-14	8.78	5.58	3.87	15.22	2.21	5.89	3.58
	2014-15	9.16	7.02	4.13	14.26	2.45	6.21	3.62
	Mean	8.97	6.30	4.00	14.74	2.33	6.05	3.60
REY of the whole pattern (t $ha^{-1}yr^{-1}$)			19.27			26.72		
Gross return (Tk. ha^{-1})		148000	103950	66000	243210	38400	99820	59375
Total variable cost (Tk. ha^{-1})		120630	57420	44600	146560	36100	62650	51220
Gross margin (Tk. ha^{-1})		27370	46530	21400	96650	23000	37170	8155
Whole pattern GM (Tk. ha^{-1})			95300			164975		
MBCR (Whole pattern)					1.66			

Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-16.50, Rice straw-1, Jute fiber-33, Jute stick-5, mungbean-60 and Potato-10

REY: rice equivalent yield, MBCR: marginal benefit cost ratio, GM: gross margin

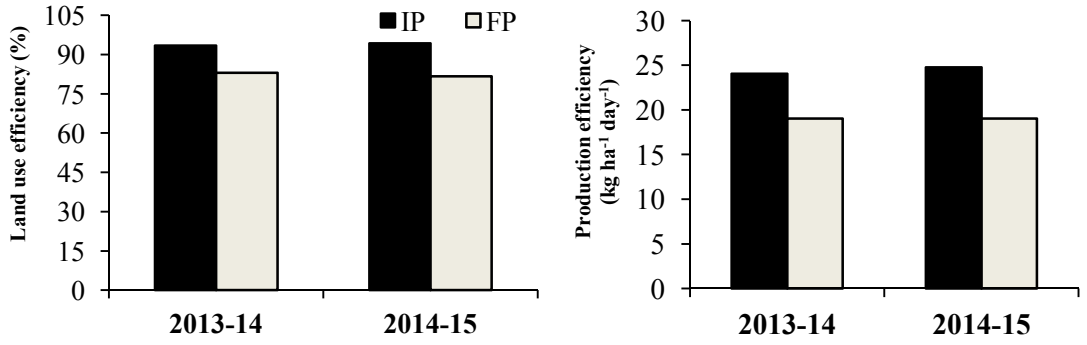

Fig. 2. Land use efficiency and production efficiency of improved cropping pattern and the existing farmer's pattern during 2013-14 and 2014-15 at Domar, Nilphamari

Conclusion

Cultivation of four-crop based potato – mungbean – jute -T.*Aman* pattern is more profitable than the existing potato – jute - T.*Aman* pattern considering yield, financial benefit and also soil health.

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