ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(1): 99-106, March 2021

RELAYING OF MAIZE WITH POTATO UNDER MAIZE-FALLOW-T. AMAN CROPPING PATTERN IN CHARLAND

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Abstract

A field experiment was conducted in the charland of the Jamuna river under Sundargonj upazilla (AEZ 3) of Gaibandha during 2017-18 and 2018-19. Two cropping systems were compared: Potato/Maize-T. Aman (relay cropping of maize with potato) and Maize-Fallow-T. Aman. The experiment was laidout in six dispersed replications maintaining randomized complete block design (RCB) design. The results revealed that the improved cropping pattern (Potato/Maize-T. Aman) produced the higher system rice equivalent yield (21.58 t ha^{-1}) than the existing cropping pattern (11.61 t ha^{-1}), that is almost double than the existing cropping pattern. Similarly, the production efficiency (PE) was 44% higher in the improved cropping pattern with a value of 70 kg ha^{-1} day^{-1} than the existing ones (48.5 kg ha^{-1} day^{-1}). The land use efficiency (LUE) was also 29% more in the same cropping pattern (84.5%) compared to the farmers existing cropping pattern (65.5%). The profitability in terms of gross margin was almost double in the improved cropping pattern (Tk. 1,95,630) than the farmers' existing cropping pattern (Tk. 1,00,750). Inclusion of Potato relay with the existing cropping increase the system productivity and MBCR (1.91) of the farmers in the char areas.

Keyword: Relay cropping, Potato, Maize, Cropping system intensification, Profitability.

Introduction

Charland (Riverine Island) is a mid-channel island that periodically emerges from the riverbed as a result of erosion and deposition of sands . Charland areas irrespective of their geographic attachment to the mainland and distance from the growth centers are particularly vulnerable to flood, drought, and river erosion. There are about 1 Mha (million hectare) of char lands in Bangladesh, of which about 64 to 97% of the char areas are cultivable (Islam *et al.*, 2016). In Gaibandha, the char lands developed by the Brahmaputra and the Tista rivers is about 27,000 ha, mostly extended in Fulchari, Saghata and Sundargonj upazilla (Karim *et al.*, 2017). Generally, farmers in char land cultivate locally adapted crop varieties of different crops with inadequate production systems causes low yield. In recent years char land areas turn into major cash crop growing area such

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as hybrid maize, potato, sweet potato, lentil, mustard, grasspea, field pea, sweet gourd, etc. In this char land, Maize-fallow-T. Aman is the main cropping pattern commonly practices among the farmers.

Now a days, hybrid maize becomes popular in some char areas as monoculture during *rabi* season (November to April) due to its diversified uses and higher productivity. In Poultry feed formulation, producing starch, corn flour, corn oil, inositol, oral glucose high maltose syrup etc are producing from Maize. In addition, Maize plant is a good source of animal feed and source of household fuel.

Potato (*Solanum tuberosum* L.) is the main edible tubers in Bangladesh which are useed as a vegetable throughout the year.

Relay cropping is a multiple cropping system increases system productivity and can solve time contravene among sowing of different crops (Tanveer *et al.,* 2017). It also improve soil quality, farmers income, land equivalent ratio, and control weeds and pest infestation (Jabbar *et al.,* 2011; Bandyopadhyay *et al.,* 2016). Relay cropping is also a beneficial technology that results in better utilization of residual soil moisture of previous crops and reduces cost of production (Jabbar *et al.,* 2005). Potato and Maize can be grown in relay cropping as they have different canopy and growth duration (Zhang *et al.,* 2008). Potato-Maize relay cropping is a system or approach where maize is sown in potato after the reproductive stage but before the maturity of potato. The wider plant spacing of hybrid maize provides facility of other crops for growing as relay cropping. Hence, the study was undertaken with a view to cropping system intensification by relaying of maize with potato in charland of Sundargonj, Gaibandha.

Materials and Methods

A field experiment was conducted during 2017-18 and 2018-19 at Char Zigabari in Sundargonj upazilla of Gaibandha (25°3' N, 89°4' E and 18 m above sea level) with the AEZ-3 (Tista Meander Floodplain) under On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute, Gaibandha. The climate of the site is sub tropical monsoon with high rainfall during May to September. Annual average rainfall is 2086 mm, of which 93% occurs from May to October (Fig. 1). The soil of the experimental site is strongly acidic. Initial soil status was very low in soil organic matter, nitrogen and zinc; low in phosphorus and potassium; medium in sulphur and optimum in boron (Table 1).

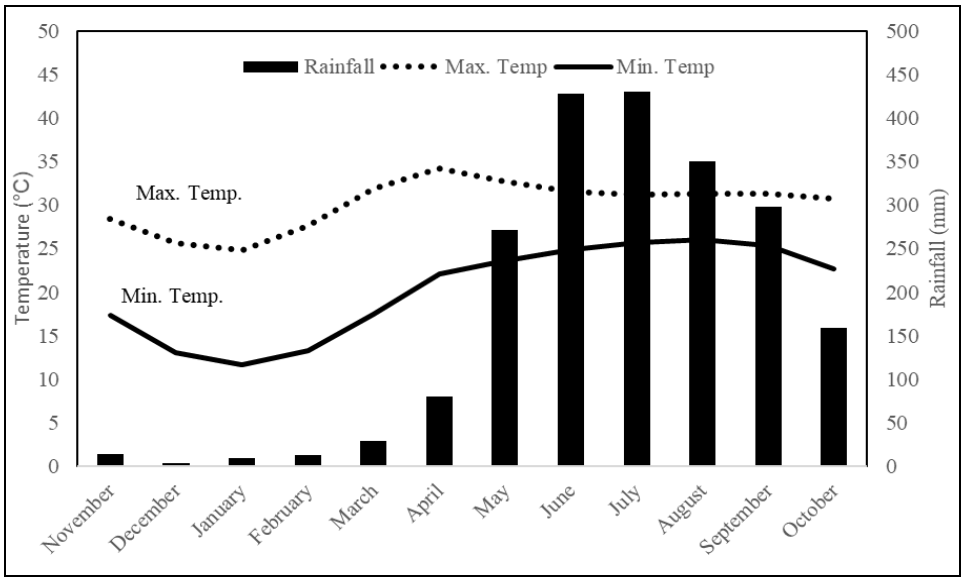

Fig. 1. Monthly rainfall (mm) and monthly mean maximum and minimum temperature of Sundargonj, Gaibandha.

Table 1. Initial soil status of Char Jigabari, Sundargonj, Gaibandha.

	pH	OM (%)	Total N (%)	K	P	S	Zn	B
				meq/100 g	µg/g soil			
Value	5.5	0.61	0.05	0.09	5.98	13.6	0.20	0.48
Interpretation	Strongly acidic	VL	VL	VL	L	L	VL	O

*VL=very low, L=low, O=optimum

The experiment was laid out in a randomized complete block design (RCBD) with 6 dispersed replications. Two cropping patterns were evaluated viz., Potato/Maize-T. Aman (improved pattern) and Maize-Fallow- T. Aman (farmers' existing pattern) for their comparative performance and economic return. The tested crop varieties were BARI Alu-25, BARI Hybrid Maize-9 and locally popular maize variety (NK 40). The unit plot size was 100 sq.m. (10 m x 10 m). Potato seeds were sown @ 1.5 t ha^{-1} and Maize @ 20 kg ha^{-1}. Twenty five-day old rice seedlings were uprooted carefully from the seedbed and transplanted into the main field, with 2-3 seedlings $hill^{-1}$ in both cropping patterns. In existing cropping pattern, fertilizers were applied as per farmer's practice. In improved pattern, Soil Test Based (STB) fertilizer doses were applied in all crops, while relay maize received 50% STB doses of sole maize. In potato, total phosphorous (P), sulphur (S), zinc (Zn) and boron (B) and half of nitrogen (N) and potassium (K) were applied during the final land preparation. Rest of nitrogen and

potassium was applied at 30-35 days after planting during earthing up of soil. In case of maize, one third of N and all P, K, S and Zn were applied in the furrow of the potato field. Remaining N was applied in two equal splits as side dressing in maize rows at 8-10 leaf stage (30-35 DAS) and at taselling stage (50-60 DAS), and mixed thoroughly with the soil as soon as possible for better utilization. In aman rice, all P, K, S and Zn were broadcast on the soil surface immediately before transplanting. Nitrogen was applied into three equal splits at 10 days after transplanting (DAT), 30 DAT and 50 DAT.

Grain yield was determined by harvesting a 20 m^2 (4 m × 5 m) area in each plot. Fresh grain yield of maize and rice was dried to 12% and 14% moisture content. Straw moisture content (%) was determined on a subsample of the fresh straw which was weighed, dried at 70 °C for 3-5 days until a constant weight achieved.

Rice equivalent yield (REY) was calculated to compare pattern performance by converting the yield of each crop into equivalent rice yield on a price basis, using the formula: REY (of $crop_x$) = Y_x *(*P_x */*P_r*)*, where, Y_x is the yield of crop 'x' (tons harvested product ha^{-1}), P_x *is* the price of crop, x and P_r is the price of rice (Biswas *et al*., 2006). The price of rice, potato, maize rice straw and maize straw was Tk. 20, 12, 16.5, 1.0 and 0.5 kg^{-1}, respectively.

The production efficiency (PE) was calculated by dividing the total grain production ha^{-1} in a sequence with total duration of crops in a sequence (Tomar and Tiwari, 1990). Total field duration of a cropping pattern expressed in percentage of 365 days was taken as the land use efficiency (LUE) of the pattern (Tomar and Tiwari, 1990).

The cost and return analysis are included gross return, total variable cost (TVC), gross margin and marginal benefit cost ratio (MBCR). The output and inputs were valued depending on existing market prices. The gross return for each cropping pattern were calculated by multiplying the market price of the produce with crop yield while gross margin for each cropping pattern was calculated by subtracting the TVC from gross return. The MBCR of alternative cropping pattern over farmers existing pattern was computed as the marginal value product (MVP) over the marginal value cost (MVC). The Marginal of farmer's existing pattern (F) and alternative pattern (E) shown as follows:

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

Results and Discussion

System performance of the improved cropping pattern and existing pattern

Grain yields of maize in the existing cropping pattern were 11.00 and 9.85 t ha^{-1} in two years, respectively with an average of 10.4 t ha^{-1} and straw yields were

5.93 and 5.65 t ha^{-1} with an average of 5.80 t ha^{-1}. Grain yield of T. Aman rice was 2.82 and 2.48 t ha^{-1} with an average of 2.65 t ha^{-1} and straw yield was average 4.20 t ha^{-1} (4.38 t ha^{-1} in the first year and 4.02 t ha^{-1} in the second year). In the improved cropping pattern, potato tuber yields were 21.2 and 19.8 t ha^{-1} in 2017-18 and 2018-19, respectively with an average yield of 20.5 t ha^{-1} (Table 2). The grain yields of maize were 7.95 and 7.25 t ha^{-1} with an average of 7.60 t ha^{-1} and mean stover yield was 5.95 t ha^{-1} (6.15 t ha^{-1} in 2017-18 and 5.60 t ha^{-1}in 2018-19). In the improved cropping pattern, the grain yield of maize was 27% lower than the existing cropping pattern that compensate the higher tuber yield of potato. Grain yields of T. Aman rice were 2.80 and 2.50 t ha^{-1} with an average of 2.65 t ha^{-1}, like the existing cropping pattern and straw yields were 4.35 and 4.05 t ha^{-1} in two years, respectively.

The total field duration was 310 days in the improved cropping pattern, that was 29% more than the existing cropping pattern (total field duration 240 days). On the other hand, the turn around time was 125 day in the existing cropping pattern and 55 days in the improved cropping pattern, means 70 more days were required in the improved cropping pattern. The turn around time reduced by 56% (70 days) due to the introduction of an additional crop (relaying of maize with potato).

There was a trend for higher rice equivalent yield (REY) from Maize-Fallow-T. Aman cropping pattern than Potato/Maize- T. Aman cropping pattern on pooled data (Table 2). The average rice equivalent yield of the existing cropping pattern was 11.61 t ha^{-1}, whereas it was almost double in the improved cropping pattern (21.58 t ha^{-1}). The higher REY of the Potato/Maize -T. Aman cropping pattern than the Maize-Fallow -T. Aman cropping pattern might be due to the higher production of potato (average 20.5 t ha^{-1}) and good market price. Alam *et al.* (2017) similarly reported that cropping intensification increase rice equivalent yield (REY).

Production efficiency and land use efficiency

The average highest (PE) production efficiency (70 kg) was recorded in the improved cropping pattern, that was 44% higher than the existing cropping pattern. The lowest PE was recorded in the existing cropping pattern (48.5 kg). Similarly, Potato/Maize-T. Aman expressed maximum land-use efficiency (LUE) during both the years with an average of 84.5% (86% in 2017-18 and 83% in 2018-19) (Table 3). This pattern occupied land for more time in a year, thereby achieved higher LUE. Maize–Fallow–T. Aman expressed the lowest LUE (65 to 66% in both the year), as no summer crop was grown in this pattern. The results revealed that the improved cropping pattern increased land use efficience by 29% than that of exixting cropping pattern.

Table 3. Production efficiency, Land use efficiency of the cropping pattern

Cropping pattern	Production efficiency (kg $ha^{-1}day^{-1}$)			Land use efficiency (%)		
	2017-18	2018-19	Average	2017-18	2018-19	Average
Maize-Fallow-T. Aman (Existing pattern)	50	47	48.5	66	65	65.5
Potato/Maize-T. Aman (Improved pattern)	71	69	70	86	83	84.5

Crop and system economic performance

The highest gross return was calculated from the improved cropping pattern, Potato/Maize-T. Aman (Tk. 4,31,600), almost double than the existing cropping pattern (Tk. 2,32,200) (Table 4). The reason might be due to the higher tuber yield (20.5 t ha^{-1}) of potato as well as more price received in the improved cropping pattern. The total variable cost was Tk. 2,35,970 in the improved pattern and Tk. 1,31,450 in the existing pattern. Finally, the gross margin was almost double in the improved cropping pattern (Tk. 1,95,630) compared to existing pattern (Tk. 1,00,750). The MBCR was calculated 1.91 in improved cropping pattern over existing cropping pattern. Alam *et al.* (2017) reported that cropping system intensification increase the system profitability. Hoque *et al*. (2015) reported that potato hybrid maize relay cropping pattern is suitable for getting higher economic return at Comilla region.

Table 4. Cost benefit analysis of the two cropping patterns evaluated at Sundargonj, Gaibandha, 2017-18 and 2018-19 (average of two years)

Cropping pattern	REY (t $yr^{-1}ha^{-1}$)	Gross return (Tk. $yr^{-1}ha^{-1}$)	Total variable cost (Tk. $yr^{-1}ha^{-1}$)	Gross margin (Tk. $yr^{-1}ha^{-1}$)	MBCR (Whole pattern)
Maize-Fallow-T. Aman (Existing cropping pattern)	11.61	2,32,200	1,31,450	1,00,750	-
Potato/Maize-T. Aman (Improved cropping pattern)	21.58	4,31,600	2,35,970	1,95,630	1.91

** Price (Tk. kg^{-1}): Urea- 16, TSP- 25, MP- 15, Gypsum- 9, Zinc Sulphate- 130, Boric acid- 140*

** Rice grain- 20, Rice straw- 1.0, Maize grain-16.5, Maize straw=0.5 and Potato tuber-12*

** REY: rice equivalent yield, MBCR: marginal benefit cost ratio.*

Conclusion

This study revealed that, Potato/Maize-T. Aman cropping pattern showed better performances in terms of pattern rice eqilevalent yield, production efficiency, land use efficiency and economics compared to the existing cropping pattern. Farmers' are keen interested to know about the relay cropping of maize with potato and convienced that this technology could increase their productivity as well as farm income. Due to practicing relay cropping of maize with potato in a land in a year, system productivity could be increased, and food security will be ascertained for the farmers. So, potato/maize-T. Aman cropping pattern should be disseminated on land suited to this cropping pattern in char areas of Gaibandha and other similar areas.

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