

IMPROVEMENT OF BRINJAL-T. AMAN -CABBAGE CROPPING PATTERN IN TANGAIL REGION

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Abstract

The experiment was conducted at the farmers' field of FSRD site Deldwar, Tangail to evaluate the agro-economic performance of Okra-T.Aman-Cabbage cropping pattern against farmers' existing pattern Brinjal-T.Aman rice-Cabbage through incorporation of high yielding varieties and improved management practices during 2018 to 2020. Two cropping pattern viz., Okra-T.Aman rice-Cabbage improved pattern and Brinjal-T.Aman rice-Cabbage farmers' existing pattern were the treatments variables. The experiment was laid out in randomized complete block design with five dispersed replications. Mean data showed that the improved management practices for Okra-T.Aman rice-Cabbage cropping pattern provided higher rice equivalent yield (41.42 t ha⁻¹), production efficiency (368 kg ha⁻¹ day⁻¹) and land utilization index (78 %) over farmers existing pattern Brinjal-T.Aman rice-Cabbage. Average gross return Tk. 667945 ha⁻¹ and gross margin Tk. 452105 ha⁻¹ of improved pattern were 24 and 33 % higher, respectively compared to that of farmers' pattern with only 8 % extra cost. The marginal benefit cost ratio, land utilization index and production efficiency indicated the superiority of the improved pattern over the farmers' practices.

Keywords: Cropping pattern, Rice equivalent yield, land utilization index, production efficiency and economic return.

Introduction

Bangladesh is almost self-sufficient in rice production but other food production such as vegetables, pulses, oil crops and other are still deficient to a large extent. Cabbage is one of the most important vegetables crop of Bangladesh grown in *rabi* season. The largest area is still under transplanted aman rice (T.Aman rice) cultivation during monsoon season where covered with long durated T. Aman rice varieties which cause a delay in cabbage transplanting, resulted reduce the yield. November 15 to 30 is the best time for cabbage transplanting. There are 15 major cropping patterns which are practiced by the farmers' of Tangail region among which Vegetable-Vegetable-T.Aman rice is one of the major cropping patterns under irrigated Medium High Land of Delduar, Tangail. This pattern covers around 7-8% of the cultivated land area (DAE, 2020). On-Farm trials with Lady's finger var. BARI Dherosh-2 performed better in Tangail region.

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After harvest of cabbage early sowing of okra instead of brinjal may be higher remunerative. Besides, production cost of brinjal is comparatively higher than okra due to disease and insect management though brings higher economic return. However, the productivity of existing farmers' pattern is low due to use of local varieties and traditional management practices. Alam *et al.*, (1998) reported that more than 95% of 8.5 million hectares of net cultivable area is now under cultivation and there is no alternative to meet the ever increasing demand of food for fast growing population except increasing production from the existing available land in the country. In this context, not only the modern production technology and complementary inputs are essential but also the diversification of crops throughout the country is urgently needed. The important aspects in this regard are to explore the possibility to fit a new crop without disturbing the existing ones. Overall productivity as well as profitability of the farmers could be increased considerably by introducing modern varieties and improved management practices. A number of reports on different cropping patterns are available in Bangladesh (Khan *et al.*, 2006 and Nazrul *et al.*, 2013) but little efforts have been made for on-farm evaluation of the improved technologies of Okra-T.Aman rice-Cabbage cropping pattern. The experiment was therefore, initiated with a view to find out the agro-economic performance of improved package of technologies over the existing farmers' practices.

Materials and Methods

The experiment was conducted at the farmers' field of Farming System Research and Development site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail during 2018 to 2020. The experimental site belongs to Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) of Tangail. The geographical position of the area is between 24⁰17' N latitude and 89⁰90' E longitude. The land type of the site was medium high and general soil type predominantly includes Dark Grey Floodplain soil. Organic matter content is low on the ridges and moderate in the basins, top soils are very strongly acidic to neutral and sub-soils are neutral in reaction. There is lowering of soil pH in high land. Status of N, P, K, S and B is low (FRG, 2018).

The meteorological data of the experimental site showed that the higher average temperature prevails in May to August and the lower in December and January. There is minimum precipitation in December and January. In July, the precipitation reaches its peak with an average of 558.3 mm. Maximum rainfall was received during the months of April to September. The meteorological data in 2018-19, monthly mean maximum 31.3⁰C and minimum 20.9⁰C air temperature and annual total rainfall 2439 mm and in 2019-20, monthly mean maximum 30.6⁰C and minimum 20.6⁰C air temperature and annual total rainfall 2240 mm were prevailing in the study area (Appendix 1.)

The experiment was laid out in a randomized complete block design with five dispersed replications. Two cropping pattern viz., improved pattern and farmers' existing pattern were the treatments variables of the experiment. The improved cropping pattern (IP) was tested and compared against the farmers' pattern (FP). Two plots of 600 m² were selected for each dispersed replication. Fertilizer management was followed by FRG (2018) and intercultural operations like weeding, mulching, and pest management were done according to recommended practices to support the normal growth of the crops. In the improved cropping pattern, okra (var. BARI Dherosh-2) and T.Aman (var. BRRI dhan72) were introduced against brinjal (var. Purple King) and T.Aman (var. BR11). The cabbage var. Autumn queen was used in both patterns. Okra was the first crop of the sequence. In improved pattern, BARI Dherosh-2 was seeded as broadcast at @ 5.0 kg ha⁻¹ during 09-12 March, 2018 and 07-12 March, 2019 and harvested during 20 April to 25 June 2018 and 18 April to 25 June, 2019. In the farmers' pattern, brinjal var. Purple King was transplanted during 20-25 January, 2018 and 19-26 January 2019 and harvested during 10 March to 30 June, 2018 and 12 March to 29 June 2019. The second crop T.Aman rice was transplanted, 30 days old seedlings with 20 cm × 15 cm spacing during 25-31 July, 2018 and 21-25 July 2019, respectively. The crop was harvested during 25-30 October 2018 and 18-28 October 2019. In farmers' pattern, 35 days old seedlings of T.Aman rice were transplanted with a 20 cm × 15 cm spacing during 08-14 July, 2018 and 09-13 July 2019 and harvested during 24-31 October, 2018 and 22-26 October 2019, respectively. Cabbage was the third crop of the sequence both in improved and farmers, pattern which was planted in line with 60 cm × 45 cm spacing. In improved pattern cabbage was transplanted during 10-16 November 2018 and 12-16 November, 2019 and harvested during 07-17 February, 2019 and 08-17 February, 2020, respectively. In farmers' pattern, cabbage was transplanted on 15-19 November 2018 and 14-18 November on 2019 and harvested on 10-20 February 2019 and 10-19 February 2020, respectively (Table 1).

Yield data were collected from 4m × 3m area of each plot. Grains and straw were sun dried and weighed adjusting at 12 % moisture content for T.Aman rice. Agronomic performance like field duration, rice equivalent yield (REY), production efficiency and land utilization index of cropping patterns were calculated as follows.

Rice equivalent yield (REY): For comparison between crop sequences, the yields of all crops were converted into rice equivalent on the basis of prevailing market prices of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by prevailing market price of that crop divided by market price of rice.

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

Production Efficiency (PE): Production efficiency value in terms of $\text{kg ha}^{-1}\text{day}^{-1}$ was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

$$\text{Production Efficiency} = \left(\frac{Y_1 + Y_2 + Y_3}{d_1 + d_2 + d_3} \right) \text{kg ha}^{-1}\text{day}^{-1}$$

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 and Y_3 = Yield of 3rd crop and d_3 = Duration of 3rd crop of the pattern

Land utilization index (LUI): It was worked-out by taking total duration (days) of crops in an individual cropping pattern divided by 365 (Rahman *et al.* 1989). It was calculated by the following formula:

$$\text{Land utilization index (LUI)} = \frac{d_1 + d_2 + d_3}{365} \times 100$$

Where d_1 , d_2 and d_3 the duration of 1st, 2nd and 3rd crop of the pattern

The economic analysis was done for gross return, gross margin and marginal benefit cost ratio and it was calculated on the basis of prevailing market price of the produces. Cost and return analysis involved collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour and insecticides. The output and inputs were valued at 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).

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

Results and Discussion

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, seedling age, spacing, fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern are shown in Table 1. The mean crop field duration of Okra, T. *Aman* rice and Cabbage under improved cropping pattern Okra (var. BARI Dherosh-2)-T. *Aman* rice (var. BRRI dhan72)-Cabbage (var. Autumn queen) were 106-108, 85-86 and 90-92 days, respectively while, in existing cropping pattern Brinjal (var. Purple King)-T. *Aman* rice (var. BR11) - Cabbage (var. Autumn queen) were 108-110, 110-112 and 88-90 days for Brinjal, T. *Aman* and Cabbage, respectively. Total field duration of improved cropping pattern and existing cropping pattern were 283-284 and 308-310 days, respectively. The crop

duration of *T. Aman* rice under existing cropping pattern was higher (110-112 days) than that of improved cropping pattern (85-86 days) due to use of long duration BR11 variety in *T. Aman* rice. But in improved cropping pattern, short duration *T. Aman* rice (var. BRRI dhan72) was cultivated and it was harvested during 18-30 October in both years. After harvesting of *T. Aman* rice, okra was easily sown in optimum period. Turnaround times for improved and existing cropping pattern were 81-82 and 55-57 days, respectively.

Yield Performance: Results of the two years experimentation of improved cropping pattern (Okra-T.Aman-Cabbage) and farmer's existing pattern (Brinjal-T.Aman rice-Cabbage) are presented in Table 2-4. Fruit yield of okra were 16.15 and 16.56 t ha⁻¹ in two consecutive years, respectively with average fruit yield of okra was 16.36 t ha⁻¹. Grain and straw yields of *T.Aman* rice were 5.34, 5.30, 5.17 and 5.11 t ha⁻¹ in two successive years where mean grain and straw yield of *T.Aman* rice were 5.32 and 5.14 t ha⁻¹. Head yields of cabbage were 80.55 t ha⁻¹ in the 1st year and 85.50 t ha⁻¹ in the 2nd year. Mean head yields of cabbage were 83.03 t ha⁻¹. It was found that all the component crops under improved pattern (Okra-T.Aman rice-Cabbage) gave higher yield (Table 2). Average yield of *T.Aman rice* in improved pattern increased by 21.46 % over farmers' practice (FP). The yield of improved pattern was higher presumably due to change of variety with improved production technologies and timely sowing of the component crops. Similar results were also obtained by Nazrul *et al.* (2013) and Khan *et al.* (2019). In farmers' pattern, *T.Aman* rice gave less grain yield due to use of imbalance fertilizers and poor management practices. Rice var. BRRI dhan72 in improved pattern performed better than BR11 in farmers' practices due to use of balance fertilizer and improved management practices.

Rice equivalent yield (REY):

Total productivity of improved and farmers' cropping patterns were evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Improved cropping pattern produced higher mean rice equivalent yield (41.42 t ha⁻¹) over farmers' (33.50 t ha⁻¹) existing pattern (Table 3). Introduction of high yielding varieties of crop and recommended management practices in the improved pattern increased rice equivalent yield of 23.64 % compared to farmers' existing pattern. Lower rice equivalent yield was obtained in the farmers' pattern due to old variety and traditional management practices. These results are in agreement with that of Khan *et al.* (2019) who reported that total productivity increased by 83.26% over farmers practice due to change of variety and use modern management practices in the pattern.

Table 1. Agronomic parameters of improved pattern and farmers' existing pattern at FSRD site Atia, Tangail during 2018-19 and 2019-20

Parameters	Years	Improved Pattern (IP)				Farmers' Pattern (FP)			
		Okra	T. Aman	Cabbage	Brinjal	T. Aman	Brinjal	T. Aman	Cabbage
Crop	2018-19	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage		
	2019-20	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage		
Variety	2018-19	BARI Dherosh-2	BRII dhan72	Autumn queen	Purple King	BR11	Autumn queen		
	2019-20	BARI Dherosh-2	BRII dhan72	Autumn queen	Purple King	BR11	Autumn queen		
Sowing/	2018-19	09-12 March	25-31 Jul.	10-16 Nov.	20-25 Jan.	08-14 Jul.	15-19 Nov.		
planting time	2019-20	07-12 March	21-25 Jul.	12-16 Nov.	19-26 Jan.	09-13 Jul.	14-18 Nov.		
Seedling age	2018-19	-	25-30	30-35	40-45	30-35	30-35		
(days)	2019-20	-	25-30	30-33	40-45	30-35	30-33		
Spacing (cm)	2018-19	45 × 30	20 × 15	60 × 45	100 × 75	20 × 15	60 × 45		
	2019-20	45 × 30	20 × 15	60 × 45	100 × 75	20 × 15	60 × 45		
Fert. dose (N- P-K-S-Zn-B kg ha ⁻¹)	2018-19	70-20-75-0-0-0	70-10-40-10-2	140-40-125-20-0-1	140-50-100-16-0-2	90-20-40-20	120-40-75-0-0-0		
	2019-20	70-20-75-0-0-0	70-10-40-10-2	140-40-125-20-0-1	140-50-100-16-0-2	90-20-40-20	120-40-75-0-0-0		
Harvesting	2018-19	20 Apr. to 25	25-30 Oct.	07-17 Feb.	10 Mar.-30 Jun.	24-31 Oct.	10-20 Feb.		
time	2019-20	Jun. 18 Apr. to 25 Jun.	18-28 Oct.	08-17 Feb.	12 Mar.-29 Jun.	22-26 Oct.	10-19 Feb.		
Field duration	2018-19	108	86	90	110	112	88		
(days)	2019-20	106	85	92	108	110	90		
Total field	2018-19		284			310			
duration (days)	2019-20		283			308			
TAT (days)	2018-19	25	30	26	15	24	16		
	2019-20	26	28	28	17	22	18		

Note: IP= Improved Pattern and FP=Farmers' Pattern.

Table 2. Fruit/Grain/Head yield and By-product of improved cropping patterns and farmer's existing pattern at the FSRD site Atia, Tangail during 2018-19 and 2019-20.

Year	Fruit/Grain/Head yield (t ha ⁻¹)							
	Improved Pattern				Farmers Pattern			
	Fruit yield	T. Aman		Head yield	Fruit yield	T. Aman		Head yield
	Okra	Grain	Straw	Cabbage	Brinjal	Grain	Straw	Cabbage
2018-19	16.15	5.34	5.17	80.55	12.90	4.23	4.18	78.40
2019-20	16.56	5.30	5.11	85.50	13.30	4.53	4.31	82.40
Mean	16.36	5.32	5.14	83.03	13.10	4.38	4.25	80.40

Production efficiency (PE):

Average maximum production efficiency (368) in terms of kg ha⁻¹day⁻¹ was obtained from improved cropping pattern and 317 in the farmers' existing pattern (Table 3). The higher production efficiency of improved cropping pattern might be due to the new crop varieties and recommended management practices. Production efficiency in improved cropping pattern increased by 16 kg ha⁻¹day⁻¹ over farmers' practice. Similar trend were reported by Nazrul *et al.* (2013) and Khan *et al.* (2019).

Land utilization index (LUI):

Land utilization index (LUI) is the effective use of land in a cropping year, which depends on individual crop duration. Mean land utilization index indicated that improved pattern used the land for 78 % period of the year, whereas farmers' pattern used the land for 84 % period of the year (Table 3). Land use efficiency was 8 % higher in farmers' practice than improved pattern because this pattern occupied the field for longer duration (309 days), whereas improved pattern occupied the field for 284 days of the year. As a result labour utilization could be more in the farmers' pattern than improved cropping pattern.

Harvest Index

Improved cropping pattern Okra (Var. BARI Dherosh-2)- T. Aman rice (Var. BRRI dhan72)- Cabbage (var. Autumn queen) recorded the higher harvest index (48%) over existing cropping pattern Brinjal (Var. Purple King) - T. Aman rice (Var. BR 11) - Cabbage (var. Autumn queen). The harvest index of improved cropping pattern had higher value due to replacing crop and varieties which contributed the higher economic and biological yield (Table 3).

Table 3. Rice equivalent yield, production efficiency, land utilization index and harvest index of improved pattern and farmers' practices at the FSRD site Atia, Tangail during 2018-19 and 2019-20.

Year	Cropping Pattern	Rice equivalent yield (t ha ⁻¹)	Production efficiency (kg ha ⁻¹ day ⁻¹)	Land utilization index (%)	Harvest Index (%)
2018-19	IP	40.62	357	78	48
	FP	31.89	308	84	46
2019-20	IP	42.21	379	78	48
	FP	35.11	325	84	46
Mean	IP	41.42	368	78	48
	FP	33.50	317	84	46

REY = Rice equivalent yield, PE = production efficiency and LUI = land utilization index

Cost benefit analysis

The cost and return analysis indicated the higher return of the improved cropping pattern (Okra-T. Aman rice-Cabbage) over the farmers' pattern (Brinjal-T.Aman rice-Cabbage). Average gross return of the improved cropping pattern was Tk. 667945 ha⁻¹ which was 24 % higher than farmers' pattern (Table 4). Average gross margin was substantially higher in the improved pattern (Tk. 452105 ha⁻¹) than farmers' pattern (Tk. 340165 ha⁻¹). The higher gross margin of the improved pattern was achieved mainly due to higher yield advantages of the component crops. Additional gross margin (33%) was achieved by adding 8 % extra cost in the improved pattern through slightly higher cost was involved in this pattern. Mean marginal benefit cost ratio (MBCR) was found 6.66 which further indicated the profitability of the improved pattern over the farmers' one. Thus, changing variety, crops and use modern technology in the existing pattern might be agronomically suitable and economically profitable for the farmers' in the study area.

Table 4. Cost and return analysis of improved cropping pattern and farmers' cropping pattern at FSRD site Atia, Tangail during 2018-19 and 2019-20

Year	Pattern	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	MBCR
2018-19	IP	649890	210730	439160	6.34
	FP	510280	196710	313570	
2019-20	IP	686000	220950	465050	6.98
	FP	571280	204520	366760	
Mean	IP	667945	215840	452105	6.66
	FP	540780	200615	340165	

Price (Tk. kg⁻¹): Okra-15.0, T.aman-16.0, Cabbage: 4.00, Brinjal-10.0, Stover-1.0 and Straw-2.0

Conclusion

The total crop productivity (in terms of REY), production efficiency and profitability of improved cropping pattern okra (var. BARI Dherosh-2) -T. *Aman* (var. BRRI dhan72)- Cabbage (var. Autumn queen) were higher than existing cropping pattern Brinjal (var. Purple King)-T. *Aman* rice (var. BR 11)-Cabbage (var. Autumn queen) due to replacing variety, crops and use modern technology. The improved cropping pattern okra (var. BARI Dherosh-2) - T. *Aman* (var. BRRI dhan72) - Cabbage (var. Autumn queen) was found agronomically and economically suitable. So, the farmers' could be suggested to practice this pattern for higher profit.

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Appendix 1. Monthly air temperature, relative humidity and total rainfall in the experimental area of Tangail, during 2018 to 2020

Month	Temperature (°C)				Average RH (%)		Total rainfall (mm)	
	Avr. Max		Avr. Min		2018-19	2019-20	2018-19	2019-20
	2018-19	2019-20	2018-19	2019-20				
July	33.99	33.38	27.36	25.74	80.61	82.74	540.50	576.10
August	33.44	34.13	26.85	26.68	82.68	79.00	356.50	200.10
September	33.54	33.07	25.99	25.71	81.69	82.90	270.50	254.30
October	31.45	31.99	22.80	23.10	80.68	82.00	75.80	163.60
November	29.84	29.92	17.89	19.22	76.83	82.00	46.00	19.50
December	25.63	24.31	13.29	13.51	78.35	85.30	22.80	10.00
January	26.31	23.15	11.57	11.87	74.71	83.58	00.00	44.30
February	28.09	26.26	14.73	13.29	71.71	74.25	73.60	01.00
March	31.26	31.51	19.10	18.47	67.52	66.80	99.70	44.60
April	33.18	33.13	22.37	21.48	74.70	74.77	281.20	273.30
May	34.79	32.93	24.36	23.09	77.13	79.00	360.30	350.40
June	34.13	33.57	25.32	25.45	80.80	82.73	312.40	303.40
Yearly average	31.30	30.61	20.97	20.63	77.28	79.59	2439.30	2240.60