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Research Article

Cropping Intensity and Productivity Increasing Through Cucumber Inclusion in Jute -T. Aman-Fallow Cropping System

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Abstract: The study was conducted at the farmers' field of Bhaluka, Mymensingh to evaluate the agro-economic performance of Jute-T.aman-Cucumber cropping pattern against farmers' existing pattern Jute-*T.aman*-Fallow through incorporation of modern high yielding varieties and improved management practices for crop production during 2016 and 2017. Two cropping pattern viz., Jute-T.aman-Cucumber improved pattern and Jute-*T.aman*-Fallow farmers' existing pattern were the treatments variables of the experiment. The experiment was laid out in randomized complete block design with five dispersed replications in farmers' condition. Mean data showed that the improved management practices for Jute-*T.aman*-Cucumber cropping pattern provided higher rice equivalent yield (16.86 t $ha^{-1}yr.^{-1}$), production efficiency (76.07 kg ha^{-1} day^{-1}) and land utilization index (77.81 %) over farmers existing pattern Jute-T.*aman* rice-Fallow. Average gross return Tk. 291105 ha^{-1} and gross margin Tk. 118355 ha^{-1}) of improved pattern were 72% and 130 % higher, respectively compared to that of farmers' pattern with only 47 % 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: Rice equivalent yield, management, cucumber, production efficiency and return.

INTRODUCTION

Bangladesh is almost self-sufficient in rice production, other food production such as cucumber, wheat, pulses, oil crops and vegetables etc. are still deficient to a large extent. Cucumber is one of the *rabi* season crop in the central and northwestern part of Bangladesh, though the largest area is still under transplanted aman rice cultivation during monsoon season. However, most of the aman rice area is covered with long duration T.*aman* varieties which cause a delay in wheat sowing, resulted reduce the yield. November 15 to 30 is the best time for cucumber sowing, which can avoid drought and diseases at the terminal stage of growth of the crop. There are 16 major cropping patterns which are practiced by the farmers' of Mymensingh region among which Jute-*T.aman*-Fallow is one of the major cropping patterns under rainfed Medium High

Land of Bhaluka, Mymensingh. This pattern covers around 7-8% of the cultivated land area (DAE, 2018). On-Farm trials with CVL-1 Jute variety performed better in Mymensingh region. After harvest of *T.aman* and before sowing of Jute the land remain fallow around 120-130 days. Cucumber is a high value cash crop which brings higher economic return. In Jute based cropping patterns cucumber may be introduced in between *T.aman* and Jute without hampering the existing crops and BRRI dhan49 as an alternative of farmers' one. However, the productivity of this pattern is low due to use of local varieties and traditional management practices. Farmers' practices Jute-*T.aman*-Fallow cropping pattern is greatly influenced by the distribution pattern of annual rainfall. But the nature of distribution and frequency of rainfall as recorded at the research site offers opportunity to introduce modern varieties of Jute and *T.aman* rice in the cropping pattern. More than 95% of 9.11 million hectares of net cultivable area is now under cultivation (Alam *et al*., 1998). 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 foremost. 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 pattern are available in Bangladesh and abroad (Azad *et al*., 1982, Soni and Kaur, 1984, Malavia *et al*., 1986, Khan *et al*., 2005, Khan *et al*., 2006 and Nazrul *et al*., 2013) but little efforts have been made for on-farm evaluation of the improved technologies of Jute-T.aman-Fallow cropping pattern. The study was therefore, initiated with a view to finding out the agro-economic performance of an improved package of technologies over the existing farmers' practices.

MATERIALS AND METHODS

The experiment was conducted at the farmers' field of Bhaluka, Mymensingh under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2016 and 2017.The geographical position of the area is between 24°38/N latitude and 90°33/E longitude. The meteorological data of the experimental site revealed that the highest temperature prevails in July and the lowest in December. There is no precipitation in December. In June, the precipitation reaches its peak with an average of 436.45 mm. Maximum rainfall was received during the months of April to September. The precipitation varies 436.45 mm between the driest month and wettest month. In 2016, monthly mean maximum 33.4 (^{0}C) and minimum 17.7(^{0}C) air temperature and annual total rainfall 2070.70 (mm) and in 2017, monthly mean maximum 30.3 (^{0}C) and minimum 20.9 (^{0}C) air temperature and annual total rainfall 1965.50 (mm) were prevailing in the study area (Appendix I). However, a analysis of 10 years (2006-2015) daily climatic data indicates the average maximum temperature (0.35^{0}C), average minimum temperature (0.11^{0}C) and average temperature (0.24^{0}C) increase over 2006. (Appendix II).

The experimental site belongs to Madhupur Tracts Agro-ecological Zone (AEZ-28) of Mymensingh. The land type was medium high and general soil types exist in the area of which deep red brown terrace, shallow red brown terrace and acid basin clays. The top soil are mainly strongly acidic to slightly acidic with low to medium status of organic matter, low moisture holding capacity and low fertility level. A description of nutrient status of initial soil is presented in Table 1.

Table 1. Initial soil test values of the farmers' field at Bhaluka upazilla, Mymensingh

Sample	pH	OM (%)	Total N (%)	K (meq/100 g)	P (Bray)	S	Zn	B
					(µ/g)			
Initial	5.85	1.59	0.088	0.15	10.30	13.42	0.75	0.18
Critical level	-	-	0.12	0.12	7.00	10.00	0.60	0.20

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) with five dispersed replications under rainfed condition. Two plots of 600 m^2 were selected for each replication. Fertilizer management was followed by FRG (2012) and intercultural operations like weeding, mulching, and pest management were done to support the normal growth of the crops. In the improved pattern, cucumber and BRRI dhan49 were introduced against fallow period and T.aman variety. The jute variety CVL-1 was used in both patterns. Jute var. CVL-1, Cucumber var. Naoga Green, and T.aman rice var. BRRI dhan49 were used in improved pattern and Jute var. CVL-1 and T.aman rice var. BRRI dhan32 were used in the farmers' pattern. Jute was the first crop of the sequence. In improved pattern, CVL-1 was seeded as broadcast at @ 7.0 kg ha^{-1} during 08-15 April, 2016 and 15-20 April, 2017 and harvested during 25-31 July, 2016 and 24-28 July, 2017. In the farmers' pattern, jute var. CVL-1 seeded as broadcast at @ 7.0 kg ha^{-1} during 10-15 April, 2016 and 04-10 April, 2017 and harvested during 01-10 August, 2016 and 23-30 July, 2017. The second crop T.*aman* rice was transplanted, 25-30 days old seedlings with 20 cm × 15 cm spacing during 10-15 August, 2016 and 11-14 August 2017. The crop was harvested during 04-14 November, 2016 and 10-16 November 2017. In farmers' pattern, 30-35 days old seedlings of T.aman rice were transplanted with a 20 cm × 15 cm spacing during 15-20 August, 2016 and 12-18 August 2017 and harvested during 15-20 November, 2016 and 14-18 November 2016. Cucumber was the third crop of the sequence which was planted as line with 75 cm × 75 cm spacing @ 0.6 kg ha^{-1}during 01-05 January 2016 and 03-07 January, 2017 and harvested during 02-31 March, 2016 and 05-31 March, 2017, respectively.

Yield data were collected from 4m × 3m area of each plot. Grains and straw were sun dried and weighed adjusting at 14, 12 and 10 % 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.

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

Production Efficiency

Production efficiency value in terms of kgha^{-1}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).

$$\text{Production Efficiency} = \frac{Y_1 + Y_2 + Y_3}{d_1 + d_2 + d_3}$$

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 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 of crops in an individual cropping pattern divided by 365 days (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. Economic 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).

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

RESULTS AND DISCUSSION

Results of the two years study of improved cropping pattern (Jute-T.aman-Cucumber) and farmer's existing pattern (Jute-T.aman-Fallow) are presented in Table 2-4.

Main Yield and By-Product Yield

Fibre yields of jute were 2.92 and 2.85 t ha^{-1} and stick yields were 4.37 and 4.30 t ha^{-1} in two consecutive years, respectively. Jute fibre yield decreased by 2.40 % in the 2nd year probably due to late sown (7 days) than that in the 1st year. Two years average fibre and stick yields of jute were 2.89 and 4.34 t ha^{-1}. Grain yields of T.*aman* rice were 3.96 and 4.20 t ha^{-1} in two successive years. Mean grain and straw yields of *T.aman* rice were 4.08 and 4.83 t ha^{-1}. Fruit yields of cucumber were 14.33 t ha^{-1} in the 1st year and 14.95 t ha^{-1} in the 2nd year. Mean fruit yields of cucumber was 1464 t ha^{-1}. It was revealed that all the component crops under improved pattern (Jute-T.aman-Cucumber) gave higher grain yield as well as by-product yield (Table 2). Average yield of *T.aman* rice in improved pattern increased by 8.0% 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 crop. Similar results were also obtained by Nazrul *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005) and Hossain and Wahhab (1992). In farmers' pattern gave lower grain yield of *T.aman* rice due to imbalance use of fertilizers and poor management. BRRI dhan49 in improved pattern performed better than BRRI dhan32 in farmers' practices due to use of balance fertilizer and modern technology. Improved pattern produced higher by-product yield (9.17 t ha^{-1}) over farmers' practice (8.72 t ha^{-1}) which was more than 5 % higher due to change of variety with improved management practices. Farmers' pattern produced less yields than the improved one mostly due to use of imbalance fertilizers and poor management practices.

Farmers' cropping pattern Jute-T.aman-Fallow needed 204 days field duration in both year. Contrary, total field duration of the improved pattern Jute-T.aman-Cucumber was 283 and 285 days (excluding seedling age of rice) to complete the cycle in the 1st and 2nd year, respectively (Table 2). Thus, the turn-around period of 160 days was utilized in the farmers existing pattern. Result indicated that cucumber could be easily fitted in Jute-Rice cropping pattern with an average of 81 days turn-around time in a year.

Table 2. Yield of different crops under improved cropping pattern (IP) and farmers' existing cropping pattern (FP) at Bhaluka upazilla, Mymensingh during 2016 and 2017

Parameters	Years	Improved Cropping Pattern (IP)			Farmers' Cropping Pattern (FP)	
		Jute	T.aman	Cucumber	Jute	T.aman
Fibre/grain/fruit yield (t ha^{-1})	2016	2.92	3.96	14.33	2.80	3.60
	2017	2.85	4.20	14.95	2.98	3.95
	Average	2.89	4.08	14.64	2.89	3.78
By-product (t ha^{-1})	2016	4.37	4.48	-	4.12	4.00
	2017	4.30	4.78	-	4.45	4.85
	Average	4.34	4.83	-	4.29	4.43
Duration (days)	2016	108	86	89	112	92
	2017	103	90	92	110	94
	Average	105	88	91	111	93
Turnaround time (days)	2016	07	17	58	146	14
	2017	07	19	54	140	20
	Average	07	18	56	143	17

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 (16.86 tha^{-1}yr^{-1}) over farmers' (9.20 tha^{-1}yr^{-1}) existing pattern (Table 3). Inclusion of cucumber, high yielding varieties and modern management practices in the improved pattern increased rice equivalent yield of 83.26 % compared to farmers' one. Lower rice equivalent yield was obtained in the farmers' pattern due to variety and traditional management practices. These results are in agreement with that of Mondal *et al.* (2015) who reported that total productivity increased by 67 % over farmers, practice due to inclusion of a third crop in the pattern.

Production Efficiency

Average maximum production efficiency (76.07) in terms of kg ha^{-1}day^{-1} was obtained from improved cropping pattern and lower (32.51) in the farmers' existing pattern (Table 3). The higher production efficiency of improved cropping pattern might be due to the modern varieties and management practices. Production efficiency in improved cropping pattern increased by 133.99 kg ha^{-1}day^{-1} over farmers' practice which might be due to inclusion of an additional cucumber crop with modern varieties and improved management practices. Similar trend were noted by Nazrul *et al.* (2013), Khan *et al.* (2006), Khan *et al.* (2005) and Krrishna and Reddy (1997).

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 77.81 % period of the year, whereas farmers' pattern used the land for 38.55 % period of the year (Table 3). Land use efficiency was 38.55 % higher in improved pattern than farmers' practice because this pattern occupied the field for longest duration (284 days), whereas farmers' pattern occupied the field for 205 days of the year. As a result labour utilization could be more in the improved cropping pattern than existing one.

Table 3. Rice equivalent yield, production efficiency and land utilization index of improved cropping pattern and farmers' existing pattern at Bhaluka, Mymensingh during 2016 and 2017

Cropping Pattern	REY ($t\ ha^{-1}yr^{-1}$)	PE ($kg\ ha^{-1}day^{-1}$)	LUI (%)
Jute--T.aman-Cucumber (IP)	16.86	76.07	77.81
Jute- T.aman -Fallow (FP)	9.20	32.51	56.16
Increased (%)	83.26	133.99	38.55

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

Cost Benefit Analysis

The economic analysis indicated the higher return of the improved cropping pattern (Jute-T.aman-Cucumber) than the farmers' pattern (Jute-T.aman-Fallow). Average gross return of the improved pattern was Tk. 291105 ha^{-1} which was 72 % higher over farmers' pattern (Table 4). Mean variable cost was lower in farmers' pattern (Tk. 117343 ha^{-1}) than that in the improved pattern (Tk. 172750 ha^{-1}) which was probably due to inclusion of cucumber in the pattern as well as management practices. Average gross margin was substantially higher in the improved pattern (Tk. 118355ha^{-1}) than farmers' pattern (Tk. 51462ha^{-1}). The higher gross margin of the improved pattern was achieved mainly due to higher yield advantages of the component crops. Additional gross margin (130%) was achieved by adding 47 % extra cost in the improved pattern. These findings are supported by Sarker *et al*. (2014) who reported that among the six patterns, Wheat-Mungbean-*T.aman* rice produced the higher economic benefit in terms of BCR. Mean marginal benefit cost ratio (MBCR) was found 2.21 which further indicated the superiority of the improved pattern over the farmers' one. Thus, inclusion of cucumber in the existing pattern might be agronomically suitable and economically profitable for the farmers' in the study site.

Table 4. Cost and return analysis of improved cropping pattern and farmer's existing pattern at Bhaluka, Mymensingh (average of 2016 and 2017)

Cropping pattern	Gross return ($Tk\ ha^{-1}$)	Total variable cost ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	MBCR
Jute-T.aman-Cucumber (IP)	291105	172750	118355	2.21
Jute -T.aman- Fallow (FP)	168805	117343	51462	
Increased over FP (%)	72	47	130	

Note: Urea: 16.00 Tk kg^{-1}, TSP: 23.00 Tk kg^{-1}, MoP: 16.00 Tk kg^{-1}, Gypsum: 10.00 Tk kg^{-1}, Zinc sulphate: 180.00 Tk kg^{-1}, Boric acid: 220.00 Tk kg^{-1},Labour= Tk.400 day^{-1}, Land preparation for cucumber and jute (3 times ploughing and laddering)= Tk 700 $bigha^{-1}$, Land preparation for rice (3 times ploughing and laddering)= Tk 800 $bigha^{-1}$, Cucumber seed= Tk. 1500 kg^{-1}, Jure=Tk. 145 kg^{-1}, Taman rice seed=Tk. 32 kg^{-1}, Irrigation for T.aman= Tk. 500 $bigha^{-1}$ (Tk.100 $katha^{-1}$)

Conclusion

Results of the two years trial clearly indicated that Jute (Var. CVL-1)-T.aman (Var. BRRI dhan49)-Cucumber (Var. Naoga Green) cropping pattern was more productive and profitable than the farmers existing pattern Jute (Var. CVL-1)-T.*aman* (Var. BRRI dhan32)-Fallow. Thus, cucumber can successfully be accommodated in the existing farmers' pattern with total crop duration (284 days) in Bhaluka upazilla of Mymensingh district to increase cropping intensity and system productivity with profitability. So, the farmers' of the Jute-*T.aman*-Cucumber growing areas could be suggested to practice this pattern for maximum profit.

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