ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 43(2): 333-343, June 2018

INCREASING CROPPING INTENSITY AND PRODUCTIVITY THROUGH MUNGBEAN INCLUSION IN WHEAT-FALLOW-T. *AMAN* RICE CROPPING PATTERN

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Abstract

The experiment was conducted at the farmers' field of Bhaluka Upazilla under On-Farm Research division, Bangladesh Agricultural Research Institute, Mymensingh during 2014-15 and 2015-16 to evaluate the performance of Wheat-Mungbean-T.aman rice improved cropping pattern against a farmers cropping pattern of Wheat-Fallow-T.aman rice. The findings of the study indicated that three crops could be grown successfully in sequence in the tested site. The higher rice equivalent yield (15.33 t hd^{-1} $yr.^{-1}$), production efficiency (34.74 kg ha^{-1} day^{-1}) and land utilization index (70.69 %) were obtained from the improved cropping pattern than the farmer's one. Average gross return (Tk. 262750 ha^{-1}), gross margin (Tk 126204 ha^{-1}) and marginal benefit cost ratio (MBCR) 2.23 of the improved pattern indicate it's superiority over farmers' existing pattern. The fertility status of soil i.e. pH, organic matter, total N, available P, S, Zn and B content in soil were increased over the initial soil due to addition of mungbean biomass.Thus, inclusion of mungbean in the existing farmer's cropping pattern will improve soil health and the system productivity as a whole.

Keywords: Cropping intensity, cropping pattern, mungbean, productivity and gross return.

Introduction

Bangladesh is almost self-sufficient in rice production, other food production such as wheat, pulses, oil crops and vegetables etc. are still deficient to a large extent. Wheat is one of the major cereals in *rabi* season 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 wheat sowing, which can avoid drought and diseases at the terminal stage of growth of the crop. If short duration T.aman rice varieties mainly BRRI dhan56, BRRI dhan57 and Binadhan-16 can be transplanted instead of long duration ones then timely (November) sowing of wheat could be ensured. Most

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of the farmers of Mymensingh area follow Wheat-Fallow-T.aman rice and Wheat-Jute-T.aman rice cropping pattern in 1 % of the cultivated land (Kabir and Islam, 2012). Many farmers are cultivating wheat followed by T.*aman* rice with keep their fallow land for at least 120-130 days. There is an ample scope of introducing a short duration crop like mungbean in *kharif 1* during fallow period after wheat. Mungbean is a short duration (60-70 days) leguminous high value pulse crop, which may easily be fitted in between wheat and T.*aman* rice in the existing cropping pattern. Mungbean contains 60 % carbohydrates, 25 % protein, 4 % mineral and 3 % vitamins (Kaul, 1982). Moreover, as a leguminous crop, it adds nitrogen in soil and improves soil health. Wheat-Mungbean-T.*aman* rice cropping pattern is presumably suitable for the Bhaluka soils, which requires relatively limited amount of irrigation water for wheat, mungbean and T.*aman* rice cultivation. However, incorporation of green manure and grain legume crops in the pattern might improve soil health (BARC, 2001). It is well known that biomass of legumes and arable crops improve soil fertility with little or no reduction in crop yields. Therefore, the experiment was undertaken to assess the feasibility of growing mungbean into Wheat-fallow-T.*aman* rice cropping pattern to improve soil fertility and the system productivity.

Materials Methods

The experiment was conducted at the farmers' field of Bhaluka, Mymensingh under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2014-15 and 2015-16.The geographical position of the area is between 24º38/N latitude and 90º33/E longitude. The meteorological data of the experimental site revealed that the highest temperature prevails in July and the lowest in December (Table 1). 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 2014-15, monthly mean maximum 32.93 (^{0}C) and minimum 17.51(^{0}C) air temperature and annual total rainfall 2110.70 (mm) and in 2015-16, monthly mean maximum 32.95 (^{0}C) and minimum 19.99 (^{0}C) air temperature and annual total rainfall 1895.00 (mm) were prevailing in the study area (Appendix I). However, a analysis of 10 years (2004-2013) 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 2004 (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 six dispersed replications. Two cropping pattern *viz*., improved pattern and farmers' existing pattern were the treatments variables of the experiment. The unit plot size was 1000-1200 m^2. Fertilizer management was followed by FRG (2012) and intercultural operations like weeding, mulching, irrigation and pest management were done to support the normal growth of the crops. Wheat var. BARI Gom-26, mungbean var. BARI Mung-6 and rice var. BRRI dhan57 were used in improved pattern and wheat var. BARI Gom-26 and rice var. Horidhan were used in the farmers' pattern. Wheat was the first crop of the sequence. In improved pattern, BARI Gom-26 was seeded as broadcast at @ 120 kg ha^{-1} during 26-29 November, 2014 and 20-26 November 2015 and harvested during 15-17 March 2015 and 10-15 March 2016. In the farmers' pattern, BARI Gom-26 was seeded as broadcast at @ 120 kg ha^{-1} during 04-07 December 2014 and 24-27 November 2015, and harvested during 21-24 March 2015 and 14-18 March 2016. Mungbean was the second crop of the sequence which was seeded as broadcast @ 30 kg ha^{-1}during 5-10 April 2015 and 26-30 March 2016, and harvested during 15-20 June 2015 and 10-16 June 2016, respectively. After harvest of mungbean pods, the plants were incorporated into soil. The third crop was T.*aman* rice was transplanted, 25-30 days old seedlings with 20 cm × 15 cm spacing during 8-10 August, 2015 and 12-16 August 2016. The crop was harvested during 24-27 October, 2015 and 26-29 October 2016. In farmers'pattern, 30-35 days old seedlings of T.aman rice were transplanted with a 20 cm × 15 cm spacing during 10-15 August, 2015 and 08-13 August 2016, and harvested during 25-28 November, 2015 and 15-20 November 2016. In *T.aman* rice, fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). 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, wheat and mungbean, respectively. 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 yield of every crop was converted into rice equivalent yield. Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice (Verma and Modgal, 1983).

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

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).

Production Efficiency ($kgha^{-1}day^{-1}$) = $\frac{\sum Y_i}{\sum d_i}$

Where, Y_i= Yield (kg) of i^{th} crop, d_i= Duration (day) of i^{th} crop of the pattern and i= 1, 2, 3

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:

Land Utilization Index (%) = $\frac{d_1 + d_2 + d_3}{365} \times 100$

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

Economic analysis was done on the basis of prevailing market price of the commodities. The marginal benefit cost ratio (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) which was computed following CIMMYT (1988).

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

Where TVC= Total Variable Cost

Results and Discussion

Results of the two years study of improved cropping pattern (Wheat-Mungbean-*T.aman* rice) and farmer's existing pattern (Wheat-Fallow-*T.aman* rice) are presented in Table 2-5.

Grain and By-Product Yield

Grain yields of wheat were 3.50 and 3.65 t ha^{-1} and straw yields were 3.65 and 3.90 t ha^{-1} in two consecutive years, respectively. Wheat grain yield decreased by 4 % in the 1^{st} year probably due to late sown (6 days) than that in the 2^{nd}year. Two years average grain and straw yields of wheat were 3.58 and 3.78 t ha^{-1}. Seed yield of mungbean was 1.16 t ha^{-1} in the 1^{st} year and 1.29 t ha^{-1} in the 2^{nd} year. Mean seed and biomass yields of mungbean were 1.23 and 2.31 t ha-^{1}, respectively. The yield of mungbean was also satisfactory in the 1st year but produced 10 % less yield than the 2nd year due to late sown mungbean (10 days earlier in the 2nd year). These results are in agreement with Sarker *et. al*. (2014) who reported that late sown mungbean produced lower yield than that of sown only 5-7 days earlier. Grain yields of T.*aman* rice were 4.10 and 4.23 t ha^{-1} in the two successive years. Mean grain and straw yields of *T.aman* rice were 4.17 and 4.48 t ha^{-1}. It was revealed that all the component crops under improved pattern (Wheat-Mungbean-*T.aman* rice) gave higher grain yield as well as by-product yield (Table 2). Average yield of wheat and *T.aman* rice in improved pattern increased by 9 and 15 % 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. Improved pattern produced higher by-product yield (10.56 t ha^{-1}) over farmers' practice (7.80 t ha^{-1}) which was 35 % higher due to change of variety with improved management practices and inclusion of mungbean. Farmers' pattern produced less yields than the improved one mostly due to use of imbalance fertilizers and poor management practices.

Farmers' cropping pattern Wheat-Fallow-*T.aman* needed 205 and 207 days field duration in the 1st and 2nd year. Contrary, total field duration of the improved pattern Wheat-Mungbean-*T.aman*was 256 and 260 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 158-160 days was utilized in the farmers existing pattern. Result indicated that mungbean could be easily fitted in Wheat-Rice cropping pattern with an average of 108 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 2014-15 and 2015-16

Parameters	Years	Improved Cropping Pattern (IP)			Farmers' Cropping Pattern (FP)	
		Wheat	Mungbean	T.aman	Wheat	T.aman
Grain yield (t ha^{-1})	2014-15	3.50	1.16	4.10	3.10	3.52
	2015-16	3.65	1.29	4.23	3.45	3.75
	Average	3.58	1.23	4.17	3.28	3.64
Straw yield (t ha^{-1})	2014-15	3.65	2.23	4.40	3.29	4.20
	2015-16	3.90	2.38	4.56	3.48	4.62
	Average	3.78	2.31	4.48	3.39	4.41
Duration (days)	2014-15	108	70	78	109	96
	2015-16	109	76	75	109	98
	Average	109	73	77	109	97
Turnaround time (days)	2014-15	32	22	55	20	140
	2015-16	25	17	63	17	141
	Average	29	20	59	19	141

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 (15.33 $tha^{-1}yr^{-1}$) over farmers' (8.75 $tha^{-1}yr^{-1}$) existing pattern (Table 3). Inclusion of mungbean in *kharif-1* season in improved cropping pattern increased REY of 75 % compared to farmers' one. 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 (mungbean) in the pattern.

Production Efficiency (PE)

Maximum production efficiency (34.74) in terms of $kgha^{-1}day^{-1}$ was obtained from improved pattern and slightly lower (33.54) in the farmers' existing pattern (Table 3). Production efficiency in improved cropping pattern increased by 3.57 $kgha^{-1}day^{-1}$ over farmers' practice which might be due to inclusion of an additional mungbean crop with modern varieties and improved management practices.

Land Utilization Index (LUI)

Land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. Land utilization index (LUI) indicated that improved pattern used the land for 70.69 % period of the year, whereas farmers' pattern used the land for 56.44 % period of the year (Table 3). Land use efficiency was 25.25 % higher in improved pattern than farmers' practice, mostly because the improved pattern occupied the field for longer duration (259 days), than the farmers' pattern (206 days) in a 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 pattern and farmers' existing pattern at Bhaluka, Mymensingh (average of 2014-15 and 2015-16)

Cropping Pattern	REY ($t\ ha^{-1}yr^{-1}$)	PE ($kg\ ha^{-1}day^{-1}$)	LUI (%)
Wheat-Mungbean-T.*aman* (IP)	15.33	34.74	70.69
Wheat –Fallow-T.*aman* (FP)	8.75	33.54	56.44
Increased (%)	75.20	3.57	25.25

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

Soil fertility status

The status of soil pH, organic matter, total N, available P, K, S, Zn and B in initial soil as well as after completion of two cropping cycle of Wheat-Mungbean-T.*aman* cropping pattern is shown in Table 4. Initially the pH of the soil was 5.85 but after completion of two cropping cycle the soil pH slightly increased to near 5.88. It was also found that the fertility status of soil i.e. organic matter, total N, available P, S, Zn and B contents in soil were increased slightly over the initial soil due to addition of mungbean biomass. However, K in the improve pattern tended to be lower than the farmers one, which indicated to add more K to the soil to improve K content. Rao and Bhardwaj (1980) conclusively proved that pulses receiving optimum fertilizer, especially P, had more pronounced residual effect both in terms of N and P on the succeeding cereals.

Table 4. Effect of mungbean inclusion in Wheat-Fallow-T.*aman* rice cropping pattern on soil fertility status of the farmers' field of Bhaluka upazilla, Mymensingh during 2014-15 and 2015-16

Sample	Land type	Rainfed/ Irrigated	pH	OM (%)	Total N (%)	K (meq/ 100 g)	P (Bray)	S	Zn	B
							(μg/g)			
Initial	MHL	Irrigated	5.85	1.59	0.088 (VL)	0.15 (L)	10.30 (L)	13.42 (L)	0.75 (L)	0.18 (L)
Final	MHL	Irrigated	5.88	1.62	0.091 (L)	0.12 (L)	10.57 (M)	13.51 (L)	0.77 (L)	0.21 (L)

Note: MHL=Medium high land, VL= Very low and L= Low

Cost and return analysis

The economic analysis as shown in Table 5 indicated the higher return of the improved cropping pattern (Wheat-Mungbean-*T.aman*) than the farmers' pattern (Wheat-Fallow-*T.aman*). Average gross return of the improved pattern was Tk.262750 ha^{-1} which was 72 % higher over farmers' pattern. Mean variable cost was lower in farmers' pattern (Tk. 87420 ha^{-1}) than that in the improved pattern (Tk. 136546 ha^{-1}) which was probably due to inclusion of mungbean in the pattern as well as management practices. Average gross margin was substantially higher in the improved pattern (Tk. 1,26,204 ha^{-1}) than farmers' pattern (Tk. 65,780 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 (92%) was achieved by adding 56 % 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 2.23 which further indicated the superiority of the improved pattern over the farmers' one. Thus, inclusion of mungbean in the existing pattern might be agronomically suitable and economically profitable for the farmers' in the study site.

Table 5. Cost and return analysis of improved cropping pattern and farmer's existing pattern at Bhaluka upazilla, Mymensingh (average of 2014-15 and 2015-16)

Cropping pattern	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	MBCR
Wheat-Mungbean-T.aman (IP)	2,62,750	1,36,546	1,26,204	2.23
Wheat-Fallow-T.aman (FP)	1,53,200	87,420	65,780	--
Increased over FP (%)	71.50	56.19	91.86	1.23

Output Price: Wheat=Tk 25.00 kg^{-1}, T.aman=Tk.16 kg^{-1},Mungbean=Tk.70 kg^{-1}, and Straw= Tk.2 kg^{-1}.

Apparent soil nutrient balance

Total N, P, K and S uptake by different crops at the farmer's field are presented in Fig.1. The partial net balance of N was negative in both the patterns and ranged from -93 to -211 $kgha^{-1}$. Nitrogen replenishment through chemical fertilizer and organic matter addition either singly or in combination was not enough to balance N removal by crops presumably due to substantial loss of the applied N from the soil. The P balance was favourable as expected due to individual crop basis fertilization. Excess amount of P accumulated in the soil and positive effect of P was reflected in the improved pattern. In farmers' pattern, P balance was also positive. However, the partial net balance of K was negative and ranged from -65 to -96 $kgha^{-1}$. This may lead to K depletion in the long run. There was a positive balance of S in both the patterns and ranged from 6 to 33 $kgha^{-1}$. These results are supported by the reports of Khan *et al*. (2006).

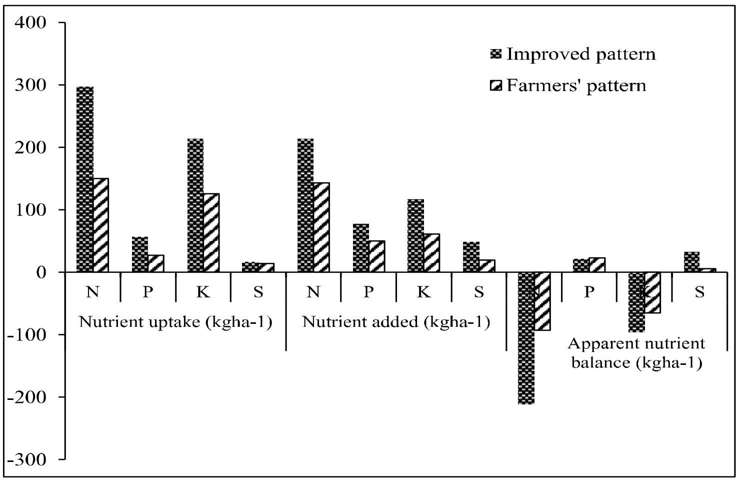

Fig 1. Effect of improved pattern and farmers' pattern on soil nutrient balance at Bhaluka, Mymensingh.

Conclusion

Results of the two years trial clearly indicated that Wheat (Var. BARI Gom-26)-Mungbean (Var. BARI Mung-6)-*T.aman* (Var. BRRI dhan57) cropping pattern was more productive and profitable than the farmers existing pattern Wheat (Var. BARI Gom-26)-Fallow-T.*aman* (Var. Haridhan). Thus, mungbean can be successfully accommodated in the existing farmers' pattern with total crop duration (259 days) in Bhaluka upazilla of Mymensingh district to increase cropping intensity and system productivity with profitability. Furthermore, through this cropping pattern the soil health may be improved and the farmers could cultivated year round crop successfully and creates employment opportunity of labour forces.

Acknowledgement

Authors are grateful to Ministry of Environment and Forest, Peoples Republic of Bangladesh for a research grant through Climate Change Trust Fund to OFRD, BARI for developed sustainable crop management technologies for drought and saline prone areas of Bangladesh.

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Appendix I. Monthly maximum, minimum and mean air temperature (ºC) and monthly total rainfall (mm) of Mymensingh during September 2014 to August 2016

Month/ Year	2014-15			2015-16			Monthly total rainfall (mm)	
	Max.	Mini.	Mean	Max.	Mini.	Mean	2014-15	2015-16
September	35.00	23.00	29.00	35.00	24.00	30.40	394.50	287.50
October	35.00	18.50	26.80	34.00	19.00	27.00	15.30	78.00
November	33.40	13.70	23.60	33.69	15.00	23.60	0.00	4.30
December	28.70	9.80	19.30	28.50	9.00	18.80	0.00	0.00
January	24.70	10.00	18.90	24.90	12.02	17.99	15.20	18.20
February	27.20	11.00	20.60	27.84	16.84	22.34	19.60	8.40
March	35.00	13.50	24.30	34.09	20.16	26.39	0.70	104.80
April	34.70	18.60	26.70	34.69	24.30	28.40	206.50	53.20
May	35.50	20.50	28.00	35.40	22.15	27.90	203.60	331.10
June	35.60	22.50	29.10	35.74	23.94	28.50	484.10	388.80
July	35.70	24.40	30.10	36.70	26.53	29.14	387.90	523.10
August	34.60	24.60	29.60	34.90	26.88	30.04	383.30	97.60
Annual	**32.93**	**17.51**	**25.50**	**32.95**	**19.99**	**25.88**	**2110.70**	**1895.00**

Appendix II. Yearly maximum, minimum and average air temperature (ºC) rainfall (mm) of Mymensingh during 2004 to 2013

Year	Maximum (ºC)	Minimum (ºC)	Average (ºC)	Temperature change (ºC/year) over 2004	Yearly total rainfall (mm)
2004	29.54	20.97	25.25	0.00	2563.50
2005	29.63	21.16	25.39	0.23	2690.40
2006	30.12	21.28	25.70	0.45	2016.20
2007	29.57	20.89	25.23	-0.02	2779.40
2008	29.62	21.17	25.39	0.14	2202.90
2009	30.46	21.28	25.87	0.62	1658.30
2010	30.26	21.40	25.83	0.58	2059.70
2011	29.66	20.82	25.24	-0.01	2144.80
2012	29.94	20.94	25.44	0.19	1521.10
2013	30.10	20.90	25.60	0.35	1660.50
Average	**29.89**	**21.08**	**25.49**	**0.253**	**2129.68**