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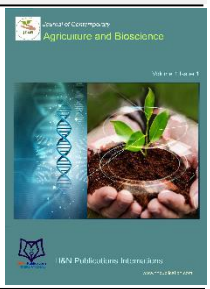

Research Article

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Four Crop-based Cropping Pattern Studies for Increasing Profitability and Productivity in Bogura Region of Bangladesh

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A b s t r a c t

The experiment was conducted at Agricultural Research Station, OFRD, BARI, Bogura (AEZ 3) during 2015-2016 (July 2015 to July 2016) to increase cropping intensity and productivity in rice based cropping system for sustaining food security, poverty reduction, resource management and livelihood improvement of ever increasing populations. Four treatments of cropping sequence were as follows: CP_1 = T. aman–Mustard–Boro–T. aus; CP_2 = T. aman–Potato–Boro–T. aus; CP_3 = T. aman–Mustard–Mungbean–T. aus and CP_4 = T. aman–Fallow–Boro–Fallow (Farmers practice). The highest REY (47.76 t ha^{-1}) was recorded from the cropping sequence T. Aman-Potato-Boro-T. Aus, which was followed by T. Aman-Mustard-Boro-T. Aus (18.90 t ha^{-1}). The lowest REY (11.68 t ha^{-1}) was obtained from the cropping sequence T. Aman-Fallow-Boro-Fallow. Inclusion of mustard during rabi season in CP_1 and CP_3 increased REY 61.62 to 60.79% compared to farmer's pattern CP_4. On the other hand, inclusion of potato in CP_2 increased REY 308.90% during 2015-16.

Key words: *Four crops, cropping intensity, productivity, rice equivalent yield*

Introduction

Bangladesh with an area of 1, 47, 570 sq km is the most densely populated (about 1033 persons per km) country of the world. Its present population is about 152.40 million, which is increasing annually at the rate of about 1.37 percent (BBS, 2016). By the year 2025 AD, the population will increase to about 198 million (en.wikipedia.org/ wiki/world population). Total cultivable land of the country is about 8.44 million hectare. Demographic pressures and increased urbanization have caused cultivated area to decline at a rate of 1 percent per year. Food requirement of the country is estimated to be doubled in the next 25 years (Islam and Haq 1999). The demand has to be met from our limited and shrinking land resources. Bangladesh is predominantly a rice growing country and rice is the staple food. Rice occupies about 80% of the total cropped area and is cultivated in three seasons a year. In rice based cropping system T.aman-Fallow-Boro-Fallow is a dominant cropping pattern of the country. The present cropping intensity of the country is 175.97%. In order to produce more food within a limited area, it is very important to increase cropping intensity and for this reason more suitable crop(s) should be included in the cropping pattern. There is very little scope for increasing cultivated land though there is an ample scope for increasing cropping intensity from the present 180% to 400%, by introducing short duration crops, like mustard, potato, mungbean and aus rice in the rice based cropping patterns. Sustainable crop production in Bangladesh through improvement of cropping pattern in rice based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation and creation of job opportunity (Aziz and Rahman, 2011). The main challenge of the new millennium is to increase per unit yield by at least 50% though manipulating the limited land resource. In this regard, the challenges for the agronomists are to understand crop production problems and processes to develop the best ways of production technologies for the management of problems and sustainable production. In case of production agronomy, targeting high yield through high cropping intensity and productivity is the most logical way to raise the total production. However, in order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity by producing three or more crops over the same piece of land in a year, and ii) to increase the production efficiency of the individual crop by using optimum management practices.

Oil seeds and pulses are the important group of crops which are mostly grown in rabi (winter) season in Bangladesh. The areas of oilseeds and pulses in rabi season are decreasing because of increasing cultivation of irrigated boro rice (Wahhab *et al*., 2002).

Recently with the development of short duration rice, crops like mustard, potato and pulses can be accommodated in four crops based cropping patterns in the same piece of land in a year. Rapeseed-mustard production can be increased by 20-25% only replacing traditional variety by high yielding short duration ones, like BARI Sarisha-14 and BARI Sarisha-15 in the existing rice based cropping system (Elias *et al.,* 1986). Pulses are inherently important grain legume crops in Bangladesh for their importance as food, feed, and soil improvement (Mondal *et al*., 2011). They are generally grown without or little fertilizers since they can meet a major portion of their nitrogen requirement by symbiotic fixation of atmospheric nitrogen in the soil (Islam, 1989). Nevertheless, pulses supply a substantial amount of nitrogen to the succeeding non-legume crops grown in rice based cropping system (Richie and Roberts, 1974; Ahlawat *et al*., 1981; Kurtz *et al.*, 1984; Sharma and Prasad, 1999).

Undoubtedly, potential adoption of mustard, mungbean and potato in T. Aman-Boro-Fallow cropping system would increase crop productivity, generate employment and bring additional income for the rural poor by utilizing fallow and under-used lands of the country. Further, adoption of this alternate cropping pattern Potato-Boro-T. Aus-T. Aman can generate employment and the additional income for the rural poor people (Hossain *et al*., 2017). However, the benefit of incorporation of extra crops in the rice-based cropping pattern will largely depend on selecting suitable crop varities and adopting appropriate agronomic practices (Elias *et al.*, 2014). Therefore, the present study was undertaken to evaluate economic feasibility of growing four crops in a year in a piece of land by incorporating mustard, potato, mungbean and T. aus rice in the existing two or three crops based pattern.

Materials and methods

The experiment was conducted at Agricultural Research Station, OFRD, BARI, Bogura (AEZ 3) during 2015-2016 (July 2015 through July 2016). Four treatments of cropping sequence were as follows:

CP_1 = T. aman–Mustard–Boro–T. aus
CP_2 = T. aman–Potato–Boro–T. aus
CP_3 = T. aman–Mustard–Mungbean–T. aus
CP_4 = T. aman–Fallow–Boro–Fallow (Farmers practice)

Table 1. Initial soil properties of the experimental field of OFRD, BARI, Bogura during 2015-16

Matter	pH	OM (%)	Total N (%)	K (meq 100g^{-1} soil)	P	S	Zn	B
					µg g^{-1} soil			
Value	7.03	1.71	0.07	0.08	6.17	22.20	0.88	0.28
Critical level	-	-	0.12	0.12	8.0	10	0.60	0.20
Interpretation	Slightly Alkaline	Medium	Very Low	Low	Low	Medium	Low	Low

The experiment was laid out in a Randomized Complete Block (RCB) design with 4 replications. The unit plot size was 6 m x 4 m. Transplanted Aman (T.Aman) rice was grown during the Kharif II season and it was the first crop of the sequence. Fertilizers management and intercultural operations like weeding, mulching etc were done according to Rahman *et al.* (2008). Seedlings were grown in seedbed in a separate plot. 24 days old seedling of BINA dhan 7 was transplanted with 20 cm x 15 cm spacing on 20 July, 2015. T. Aman rice was harvested on 23 October, 2015. Rice was harvested at 30 cm height from soil surface and remaining part of the rice plant was incorporated with soil. Grain and straw yields were taken from whole plot. As per treatment potato was grown during Rabi season. Fertilizers management and intercultural operations like weeding, mulching etc. were done according to Kabir and Haque (2012). Potato tubers (cv. Granola) were planted with 60 cm x 25 cm spacing on 30 October, 2015. Potato was harvested on 21 January, 2016. Tuber and foliage (sun dry) weight were taken from the whole plot. Mustard was grown during Rabi season. Fertilizers management and intercultural operations like weeding, mulching etc. were done according to Mondal and Wahab (2001). BARI Sarisha-14 and BARI Sarisha-15 were planted with 30 cm x 5 cm spacing on 26 October, 2015. BARI Sarisha-14 was harvested on 14 January, 2016 while BARI Sarisha-15 was harvested on 18 January, 2016. Seed yield and straw yield were taken from the whole plot. Mungbean was grown during Kharif-I season. Fertilizers management and inter cultural operations were done according to Afzal *et al.,* (2008). Mungbean (cv. BARI Mung-6) was sown on 25 February, 2016. Mungbean was hervested on 25 April, 2016. Seed yield and biomass weight of mungbean were taken from the entire plot. After harvesting of pods, mungbean plants were incorporated into the soil. Boro was the third crop of the sequence. Fertilizers management and intercultural operations were done according to Haque *et al*., (2011). Thirty forty days old seedlings of BRRI dhan28 were transplanted with 20cm x 15cm spacing on 22 January, 2016 in CP_4; 22 January, 2016 in CP_1 and 24 January, 2016 in CP_2. Boro rice was harvested on 10 May, 10 May and 8 May, 2016 in CP_4, CP_1 and CP_2, respectively. Rice was harvested at 30 cm height from soil surface and the remaining part of the rice plant was incorporated with soil. Grain yield and straw yield were taken from the whole plot. Transplanted aus (T. Aus) rice was the fourth crop of the sequence. Fertilizers management and intercultural operations like weeding, mulching, roughing, etc. were done according to Hossain *et al*., (2014). Seventeen days old seedlings of Parija were transplanted with 15cm x 15cm spacing on 12 May both in CP_1 and CP_2 and 25 April in CP_3 in the same year. Transplanted Aus was harvested on 18 July in CP_1; 20 July in CP_2 and 4 July in CP_3. Rice was harvested at 30 cm height from soil surface and remaining part of the rice plant was incorporated with soil. Grain yield and straw yield were taken from whole plot.

Statistical analysis of data

MSTAT-C and Microsoft Excel and DMRT were used to measure the variation of mean data of treatments. Treatment means were compared at P ≤ 0.05. The data were analyzed statistically following computer package MSTATC. All the data were statistically analyzed following the ANOVA technique and the significance of mean differences was adjusted by Duncan's Multiple Range Test.

Results and Discussions

Results from Table 2 revealed that grain and straw yields of T. Aman rice were 5.91 & 6.55 t ha^{-1}, grain and straw yields of mustard (BARI Sarisha-14) were 1.40 & 1.61 t ha^{-1}, grain and straw yields of Boro rice were 6.55 & 6.95 t ha^{-1} and grain and straw yields of T. Aus rice were 2.80 & 3.27 t ha^{-1}, respectively in case of cropping pattern 1. In case of cropping pattern 2, grain and straw yields of T. Aman were 5.99 & 6.17 t ha^{-1}, tuber and straw yields of potato were 25.04 & 2.73 t ha^{-1}, grain and straw yields of Boro rice were 6.70 & 6.89 t ha^{-1}, grain and straw of T. Aus rice were 2.77 & 3.48 t ha^{-1}, respectively. In case of cropping pattern 3, grain and straw yields of T. Aman rice were 5.76 & 6.04 t ha^{-1}, grain and straw yields of mustard (BARI Sarisha-15) were 1.43 & 2.51 t ha^{-1}, seed

Table 2. Performance of different crops under four cropping patterns (1 and 2) during 2015-16 at OFRD, BARI, Bogura

Crop	Cropping pattern 1				Cropping pattern 2			
	T.Aman	Mustard	Boro	T.Aus	T.Aman	Potato	Boro	T.Aus
Variety	Bina dhan 7	BARI Sarisha-14	BRRI dhan 28	Parija	Bina dhan 7	Granola	BRRI dhan 28	Parija
Sowing/ Transplanting date	20/7/15	26/10/15	22/1/16	12/5/16	20/7/15	30/10/15	22/1/16	12/5/16
Crop duration	93	80	108	67	93	84	108	67
Harvesting date	23/10/15	14/1/16	10/5/16	18/7/16	23/10/15	21/1/16	10/5/21	18/7/21
Grain Yield (t ha^{-1})	5.91	1.40	6.55	2.80	5.99	25.04	6.70	2.77
Straw Yield (t ha^{-1})	6.55	1.61	6.95	3.27	6.17	2.73	6.89	3.48
REY	5.91	4.65	6.02	2.32	5.99	33.31	6.16	2.30
$LSD_{(0.05)}$	0.59	0.34	0.63	0.18	0.28	2.48	0.54	0.29
CV (%)	5.54	7.71	5.62	3.67	2.63	7.03	4.75	5.89

Table 3. Performance of different crops under four cropping patterns (3 and 4) during 2015-16 at OFRD, BARI, Bogura

Crop	Cropping pattern 3				Cropping pattern 4			
	T.Aman	Mustard	Mungbean	T.Aus	T.Aman	Fallow	Boro	Fallow
Variety	BINA dhan 7	BARI Sarisha-15	BARI Mung-6	Parija	BINA dhan 7		BRRI dhan 28	
Sowing/ Transplanting date	20/7/15	26/10/15	25/2/16	12/5/16	20/7/15	-	22/1/16	-
Crop duration	93	84	60	67	93	-	108	-
Harvesting date	23/10/15	18/1/16	25/4/16	18/7/16	23/10/15	-	10/5/21	-
Grain Yield (t ha^{-1})	5.76	1.43	1.40	3.19	5.66	-	6.54	-
Straw Yield (t ha^{-1})	6.04	2.51	2.58	3.30	6.04	-	6.97	-
REY	5.76	4.76	5.61	2.65	5.66	-	6.02	-
$LSD_{(0.05)}$	0.49	0.28	0.48	0.21	0.49	-	0.27	-
CV (%)	4.82	5.61	8.74	4.01	4.92	-	2.44	-

and straw yields of mungbean were 1.40 & 2.58 t ha^{-1}, grain and straw yields of T. Aus rice were 3.19 & 3.30 t ha^{-1}, respectively. Whereas, in case of cropping pattern 4 grain and straw yields of T. Aman were 5.66 & 6.04 t ha^{-1}, grain and straw yields of Boro rice were 6.54 & 6.97 t ha^{-1}, respectively (Table 3).

Economic Analysis

Total productivity of different cropping sequences was determined by rice equivalent yield (REY) which was calculated from yield of component crops. Rice equivalent yield was different under different cropping sequence (Table 4).

Table 4. Rice equivalent yield, cost and return of four cropping patterns during 2015-16 at OFRD, Bogura.

Pattern	REY (t ha^{-1})	Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
CP_1	18.90	283500.00	162557.00	120943.00	1.74
CP_2	47.76	716400.00	236306.00	480094.00	3.03
CP_3	18.78	281700.00	107352.00	174348.00	2.62
CP_4	11.68	175200.00	110195.00	65005.00	1.59

Market price of T. aman @ 15 Tk/kg , Mustard @50 Tk/kg, Mungbean @60 Tk/kg, Boro @13.75 Tk/kg, Potato@ 20 Tk/kg, Aus @12.50 Tk/kg

The highest REY (47.76 t ha^{-1}) was recorded from the cropping sequence T. Aman-Potato-Boro-T. Aus, which was followed by T. Aman-Mustard-Boro-T. Aus (18.90 t ha^{-1}). The lowest REY (11.68 t ha^{-1}) was obtained from the cropping sequence T. Aman-Fallow-Boro-Fallow. Inclusion of mustard during rabi season in CP_1 and CP_3 increased REY 61.62 to 60.79% compared to farmer's pattern CP_4. On the other hand, inclusion of potato in CP_2 increased REY 308.90% during 2015-16.

Economics of system productivity of four cropping sequences shown in Table 4 revealed the gross return was different for different cropping patterns. The highest gross return (Tk. 716400.00 ha^{-1}) was recorded from T. Aman –Potato-Boro-T. Aus cropping pattern 2 followed by T. Aman-Mustard-Boro-T. Aus cropping pattern 1(Tk. 283500.00 ha^{-1}), T. Aman-Mustard-Mungbean-T. Aus cropping pattern 3 (Tk. 281700.00 ha^{-1}). T. Aman-Fallow-Boro-Fallow cropping pattern 4 gave the lowest gross return (Tk. 175200.00 ha^{-1}). Total variable cost was lower in cropping pattern 3 (Tk. 107352 ha^{-1}) followed by cropping pattern 4 (Tk. 110195 ha^{-1}). The highest total variable cost (Tk. 236306 ha^{-1}) was recorded from cropping pattern 2 and might be due to higher seed cost of potato. The highest gross margin was obtained from cropping pattern 2 (Tk. 480094.00 ha^{-1}) followed by cropping pattern 3 (Tk. 174348.00 ha^{-1}), cropping pattern 1(Tk. 120943.00 ha^{-1}). Cropping pattern 4 gave the lowest gross margin (Tk 65005.00 ha^{-1}). The highest marginal benefit cost ratio (MBCR) was found in cropping pattern 2 (3.03) followed by cropping pattern 3 (2.62), cropping pattern 1(1.74). Farmer's pattern (control) CP_4 gave the lowest MBCR (1.59) during one year crops period.

Conclusion

From the study, it may be concluded that four crops based on three cropping patterns such as CP_1= Transplanted Aman rice (BINA dhan 7) -Mustard (BARI Sarisha-14)-Boro rice (BRRI dhan28)-

Transplanted Aus rice (Parija); CP_2 = T. Aman rice – Potato (Granola)- Boro rice- T.Aus rice; CP_3 = T. Aman rice-Mustard (BARI Sarisha-15) – Mungbea (BARI Mung-6)-T. Aus rice are agronomically feasible and economically profitable compared to the existing T. Aman – Fallow- Boro –Fallow pattern. However, CP_2 was found the most profitable one. Due to growing of four crops in a year in the same piece of land cropping intensity and productivity will be increased, more employment opportunity for male and female labours will be created and at the same time due to increase production of rice, potato, mustard and mungbean the food and nutritional security will be ascertained for the farmers and the nation as a whole.

Conflict of interest

There is no conflict of interest among the authors.

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