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Rice-based cropping pattern for increasing cropping intensity and productivity in Jamalpur region under AEZ 09

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ABSTRACT

For sustaining food security, poverty reduction, resource management and livelihood improvement of ever increasing populations To increase cropping intensity and productivity in rice based cropping system is necessary to increase. An Experiment was conducted at the Regional Agricultural Research Station, Jamalpur (AEZ 8) during rabi season (October-March, winter) of 2015-2016 in this regard. Six treatments of cropping sequence were as follows: CP_1= Potato – Mungbean – T. Aus – T. Aman, CP_2= Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3= Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4= Garden pea – Boro – T. Aus – T. Aman, CP_5= Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6= Fallow – Boro – Fallow – T. Aman (Farmers practice). The highest REY (34.76 t/ha) was recorded from the cropping sequence Potato – Lalshak- Mungbean – T. Aus – T. Aman followed by Potato – Mungbean – T. Aus – T. Aman (27.44 t/ha). The lowest REY (7.11 t/ha) was obtained from the cropping sequence Fallow – Boro – Fallow – T. Aman (Farmers practice). From one year study it was observed that highest total productivity, gross margin and gross return was obtained from Potato – Lalshak- Mungbean – T. Aus – T. Aman. Garden pea – Lalshak- Mungbean – T. Aus – T. Aman cropping pattern gave the highest profitability in terms of MBCR (Marginal Benefit Cost Ratio). Four crops based patterns can be recommended for higher productivity, soil enrichment & economic benefit besides creating more employment opportunity.

INTRODUCTION

Bangladesh with an area of 1, 47, 570 sq km is the most densely populated (about 1008 persons per km) country of the world. Its present population is about 149 million, which is increasing annually at the rate of about 1.42 per cent (BBS 2011). By the year 2025 AD, the population will increase to about 198 million (en.wikipedia.org/ wiki/world population). On the other hand the cultivable land is decreasing by 1% every year. So, Bangladesh has to produce additional food for millions of people every year.

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 where cropping intensity is 200%. In the pace of per capita land availability decrease and production shortage the existence of fallow land in rice based cropping system is very inconsistent to national perspective. Though it is late, however the recent attention to these lands may open new era to rational development initiative, and can add new dimension to agricultural development. Intensive and diversify use of these lands will help to increase production, ease market pressure on commodities, its availability, farmers income generation, employment opportunity and livelihood improvement.

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,

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poverty alleviation, land degradation and pollution control. The main challenge of the new millennium is to increase per unit yield by at least 50% through manipulating the limited land resource. In this regard, the challenges for the agronomist are to understand crop production problems and process to develop the best ways of production technologies for the management of problems and sustain production. In case of production agronomy, targeting high yield with high cropping intensity and productivity are the most logical way to raise the total production. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing three or more crops over the same piece of land round the year and ii) to increase the productive efficiency of the individual crop.

The government of Bangladesh recently prepared the Country Investment Plan (CIP), which provides guidance on investments in agriculture. The CIP has put strong emphasis on regional issues to address food security. Food security involves food availability, food access and food utilization. Acute shortage of edible oil has been prevailing in Bangladesh during last several decades. This shortage has inherited from the past. Bangladesh is producing about 0.17 million tons of edible oil per year as against the requirement of 1.9 million tons. There has been big gap between supply and demand of edible oils, which has been meeting through imports incurring a big amount of foreign exchange every year. In this context, the increase of production of oilseeds has been given priority from government of Bangladesh. T. Aman-Mustard-Boro is the major cropping pattern in some areas of our country. In this land, farmers are being cultivated traditional mustard variety Tori-7 for a long time due to short duration in spite of low yield, lodging tendency and susceptibility to *Alternaria* disease, aphid, even responding poorly to fertilizers and irrigation. Farmers cultivate short duration variety Tori-7 after T. Aman to fit Boro rice. Yield potentiality of Tori-7 is very low which is only 700-800 kg/ha. For vertical expansion, yield per unit area has to be increased. Rapeseed-mustard production can be increased 20-25% only replacing traditional variety by high yielding short duration varieties like BARI Sarisha-14 and BARI Sarisha-15 in the existing rice based cropping system.

Pulses are important legume crops in Bangladesh because of their importance in food, feed and cropping systems. It contains about twice as much protein as cereals. It also contains amino acid lysine which is generally deficit in food grains (Elias et al., 1986). Pulses are grown in 0.539 million hectares of land producing 0.189 million MT which is 3.25% of the total cropped area of the country (BBS, 2010). Pulses have played an important role in sustaining the productivity soils in Bangladesh for centuries. They are generally grown without fertilizer since they can meet their nitrogen requirement by symbiotic fixation of atmospheric nitrogen in the soil (Islam, 1991; Senanayake et al., 1987; Zapata et al., 1987; Fried and Middleboe, 1977). Nevertheless, pulses supply a substantial amount of nitrogen to the succeeding non-legume crops grown in rice based cropping system (Rachie and Roberts, 1974; Ahlawat et al., 1981; Kurtz et al., 1984; Sharma and Prasad, 1999).

Potential adoption of these improved cropping patterns intensifying mustrd, mungbean and potato in T.aman-Fallow-Boro-Fallow cropping system would generate employment and additional income for the rural poor and save foreign exchange through producing more of these crops utilizing fallow and under used lands in the country. The farm level adoptions of improved oilseeds, pulses and potatoes in rice based cropping system have already been created a wide range of socio-economic impacts that need to be evaluated properly to understand the output of research and development. This information could be useful for both government and donor agencies in investing more on sustainable food production programs in Bangladesh. Considering the above issues, the proposed study was undertaken with the objectives: i) Increase cropping intensity and productivity in rice based cropping system. ii) Sustain food security, poverty reduction, resource management and livelihood improvement of ever increasing populations. iii) Increase farmer's income, access to food and nutrition, employment opportunity and woman's participation in agriculture.

MATERIALS AND METHODS

The experiment was conducted at the research field of RARS, Jamalpur AEZ- 8 (UNDP & FAO, 1988) during 2015-2016 (November 2015 through November 2016). Six treatments of cropping sequence were as follows:

CP_1= Potato – Mungbean – T. Aus – T. Aman
CP_2= Potato – Lalshak- Mungbean – T. Aus – T. Aman
CP_3= Mustard – Lalshak- Mungbean – T. Aus – T. Aman
CP_4= Garden pea – Boro – T. Aus – T. Aman
CP_5= Garden pea – Lalshak- Mungbean – T. Aus – T. Aman
CP_6= Fallow – Boro – Fallow – T. Aman (Farmers practice)

Table 1
Spacing, sowing, harvesting time and duration of different crop varieties in the pattern in the year

Crop	Spacing	Sowing/Trans-planting time	Variety	Harvesting time	Crop duration Tran. to harvest (days)
T. Aman	20 cm × 15 cm	24 July seeding in bed 14 Aug. transplanting	BINA dhan 7	08 November	86
Mustard	30 cm × 5 cm	10 November	BARI Sarisha-14	29 January	80
Potato	60 cm ×25cm	16 November	Diamant	29 January	75
Lalshak	Broadcast	16 December	BARI Lalshak-1	16 January	30
Boro	20 cm × 15 cm	20 Dec. seeding in bed 26 Jan. transplanting	BRRI dhan 28	08 May	103
Mungbean	30 cm × 5 cm	03 February	BARI Mung-6	20 April	77
T. Aus	15 cm × 15 cm	03 April seeding in bed 26 May transplanting	Parija	24 July	97
Garden pea	30 cm × 5 cm	11 November	BARI Motorshuti-3	08 January	58

The experiment was laid out in a RCB design with 4 replications. The unit plot size was 4m × 5m. Recommended doses of fertilizers were used as follows:

Crop	CD (t/ha)	NPKSZnB (kg/ha)
Potato	10	166-43-125-22-5-1
Mustard	5	120-70-50-30-3-1
Lalshak	-	28-7-11-1.6-0-0
Mungbean	-	9-37-36-21-0-0
Garden pea	5	17-9-11-5-0-0
Boro	-	104-12.5-38-20-5-0
T. Aus	-	92-24-60-9-0-0
T. Aman	-	69-12-35-6-3-0

Transplanted Aman (T. Aman) rice was grown during the Kharif II season (July –October,). The full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Thirty-day aged seedling of BINA dhan 7 were transplanted with 20cm × 15cm spacing on 14 August. Nitrogen was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). Intercultural operations were done when necessary. T. Aman rice was harvested on 08 November. Grain yield/ha was taken from whole plot (Table 1).

Potato was grown during rabi season. Half N and full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid respectively. Potato tubers (cv. Diamant) were planted with 60 cm × 25 cm spacing on 16 November. The remaining ½ N was top-dressed at 30 days after planting (DAP) followed by earthing up and irrigation. Other two irrigations were given at 20 and 60 DAP. Intercultural operations were done as and when required. Potato was harvested on 29 January. Tuber and foliage (over dry) weight were taken from whole plot (Table 1).

Mustard was grown during rabi season. Half N and full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. BARI Sarisha-14 was planted with 30 cm × 5 cm spacing on 10 November. The remaining ½ N was top-dressed at 25 days after planting (DAP) followed by irrigation. Other two irrigations were given at 45 and 60 DAP. Intercultural operations were done as and when required. BARI Sarisha-14 was harvested on 29 January. Seed weight was taken from whole plot (Table 1).

Mungbean was grown during Kharif-I season. All fertilizers were applied as basal. Seeds mungbean (cv. BARI mung-6) were sown on 03 February. A pre-sowing irrigation was given for proper emergence of the crop. Other two irrigations were given at 25 and 45 DAP (if necessary). Intercultural operations were done as and when necessary. Grain yield of mungbean were taken from entire plot. After harvesting of pods mungbean plants incorporated into the soil (Table 1).

Boro was the crop of the sequence. The full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Forty day aged seedlings of BRRIdhan28 were transplanted with 20cm × 15cm spacing on 26 January. Nitrogen was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). Intercultural operations were done when necessary. Boro rice was harvested on 08 May. Grain yield/ha was taken from whole plot (Table 1).

Transplanted Aus (T. Aus) rice was the crop of the sequence. The full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Twenty day aged seedlings of Parija were transplanted with 15cm × 15cm spacing on 26 May. Nitrogen was top dressed in two equal splits at 9 and 25 days after transplanting (DAT). Intercultural operations were done when necessary. T. Aman rice was harvested on 02 August. Grain yield/ha was taken from whole plot (Table 1).

Data on yield and yield components of T. aman rice, potato, mustard, mungbean, Boro and T. aus were analyzed statistically and the means were adjudged by Least Significance Difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSION

Rice

Grain yield of T. Aman, Boro and Aus rice differed insignificantly under different cropping sequence. However, yield of T. Aman varied from 3.1 to 5.74 t/ha. Grain yield of Boro varied from 3.4 to 3.4 t/ha. Grain yield of T. Aus varied from 3 to 3.31 t/ha (Table 2).

Mustard

Higher grain yield of mustard (1.12 t/ha) was obtained from BARI Sarisha-14 in CP_3= Mustard – Lalshak- Mungbean – T. Aus – T. Aman cropping sequence (Table 2).

Potato

The crop potato was used in the cropping pattern CP_1= Potato – Mungbean – T. Aus – T. Aman and CP_2= Potato – Lalshak- Mungbean – T. Aus – T. Aman. The yield of potato was 21.2 t/ha and 22.2 in CP_1 and CP_2 (Table 2).

Mungbean

Mungbean was used in the cropping pattern CP_1= Potato – Mungbean – T. Aus – T. Aman, CP_2= Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3= Mustard – Lalshak- Mungbean – T. Aus – T. Aman and CP_5= Garden pea – Lalshak- Mungbean – T. Aus – T. Aman. The yield of mungbean was 0.93, 0.85, 0.79 and 0.98 t/ha CP_1, CP_2, CP_3 and CP_5 (Table 2).

Table 2
Yield of component crops in rice based cropping system.

Cropping pattern	Yield (t/ha)							
	T. Aman	Mustard	Potato	Mung	Boro	T.aus	Lalshak	Garden pea
CP_1	3.34	-	21.2	0.93	-	3.31	-	-
CP_2	3.74	-	22.2	0.85	-	3.2	8.5	-
CP_3	3.1	1.12	-	0.79	-	3.1	8.9	-
CP_4	3.23	-	-	-	3.4	3	-	5.1
CP_5	3.2	-	-	0.98	-	3.3	8.1	5.44
CP_6	3.71	-	-	-	3.4	-	-	-
F-test	**	**	**	**	**	**	**	**
CV%	4.31	32.15	4.5	15.48	4.2	8.1	8.42	19

CP_1=Potato – Mungbean – T. Aus – T. Aman, CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4=Garden pea – Boro – T. Aus – T. Aman, CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)

Table 3
Rice Equivalent Yield (REY) in rice based cropping system.

Treatment	REY (t/ha)								
	T. Aman	Mustard	Potato	Mung	Boro	T. Aus	Lalshak	Garden pea	Total
CP_1	3.34	-	18	2.79	-	3.31	-	-	27.44
CP_2	3.74	-	18.87	2.55	-	3.2	6.4	-	34.76
CP_3	3.1	2.24	-	2.37	-	3.1	6.7	-	17.51
CP_4	3.23	-	-	-	3.4	3	-	10.2	19.83
CP_5	3.2	-	-	2.94	-	3.3	6.1	10.9	26.44
CP_6	3.71	-	-	-	3.4	-	-	-	7.11

CP_1=Potato – Mungbean – T. Aus – T. Aman, CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4=Garden pea – Boro – T. Aus – T. Aman, CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)
T. Aman: 20/-, Mustard: 40/-, Mungbean: 60/-, Boro: 20/-, Potato: 17/-, Aus: 20/- , Lalshak: 15/-, Garden pea: 40/-

Table 4
Gross return in rice based cropping system.

Treatment	Gross return (Tk/ha)								
	T. Aman	Mustard	Potato	Mung	Boro	T. Aus	Lalshak	Garden pea	Total
CP_1	66800	-	360400	55800	-	66200	-	-	549200
CP_2	74800	-	377400	51000	-	64000	127500	-	694700
CP_3	62000	44800	-	47400	-	62000	133500	-	349700
CP_4	64600	-	-	-	68000	60000	-	204000	396600
CP_5	64000	-	-	58800	-	66000	121500	217600	527900
CP_6	74200	-	-	-	68000	-	-	-	142200

CP_1=Potato – Mungbean – T. Aus – T. Aman, CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4=Garden pea – Boro – T. Aus – T. Aman, CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)

Table 5
Total variable cost in rice based cropping system.

Treatment	Total Variable Cost (TK/ha)								
	T. Aman	Mustard	Potato	Mung	Boro	T. Aus	Lalshak	Garden pea	Total
CP_1	41620	-	92677	13370	-	33434	-	-	181101
CP_2	41620	-	92677	13370	-	33434	15750	-	196851
CP_3	41620	18928	-	13370	-	33434	15750	-	123102
CP_4	41620	-	-	-	68575	33434	-	25000	168629
CP_5	41620	-	-	13370	-	33434	15750	25000	129174
CP_6	41620	-	-	-	68575	-	-	-	110195

CP_1=Potato – Mungbean – T. Aus – T. Aman, CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4=Garden pea – Boro – T. Aus – T. Aman, CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)

Table 6
Gross margin and MBCR in rice based cropping system.

Treatment	Gross Return (TK/ha)	MBCR (Tk/Tk)
CP_1=Potato – Mungbean – T. Aus – T. Aman	549200	3.03
CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman	694700	3.53
CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman	349700	2.84
CP_4=Garden pea – Boro – T. Aus – T. Aman	396600	2.35
CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman	527900	4.1
CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)	142200	1.29

CP_1=Potato – Mungbean – T. Aus – T. Aman, CP_2=Potato – Lalshak- Mungbean – T. Aus – T. Aman, CP_3=Mustard – Lalshak- Mungbean – T. Aus – T. Aman, CP_4=Garden pea – Boro – T. Aus – T. Aman, CP_5=Garden pea – Lalshak- Mungbean – T. Aus – T. Aman, CP_6=Fallow – Boro – Fallow – T. Aman (Farmers practice)
T. aman: 20/-, Mustard: 40/-, Mungbean: 60/-, Boro: 20/-, Potato: 17/-, Aus: 20/- , Lalshak: 15/-, Garden pea: 40/-

Rice equivalent yield

Total productivity of different cropping sequence was determined by rice equivalent yield (REY) and it was calculated from yield of component crops. Rice equivalent yield was different under different cropping sequence (Table 3). The highest REY (34.76 t/ha) was recorded from the cropping sequence Potato – Lalshak- Mungbean – T. Aus – T. Aman followed by Potato – Mungbean – T. Aus – T. Aman (27.44 t/ha). The lowest REY (7.11 t/ha) was obtained from the cropping sequence Fallow – Boro – Fallow – T. Aman (Farmers practice).

Economic Analysis

Economics of system productivity of four cropping sequences should that the gross return was different for different cropping sequence (Table 4). The highest gross return (694700 Tk/ha) was recorded from Potato – Lalshak- Mungbean – T. Aus – T. Aman (CP_2) cropping sequence followed by Potato – Mungbean – T. Aus – T. Aman (CP_1) (549200Tk/ha), Garden pea – Lalshak- Mungbean – T. Aus – T. Aman (CP_5) (271089 Tk/ha). Fallow – Boro – Fallow – T. Aman (Farmers practice) (CP_6) cropping sequence gave the lowest gross return (142200 Tk/ha). Total variable cost was lower in CP_6 (110195 Tk/ha) followed by CP_3 (123102 Tk/ha). The highest total variable cost was recorded from CP_2 and might be due to higher seed cost of potato. The highest gross margin was obtained from CP_2 (694700 Tk/ha) followed By CP_1 (549200 Tk/ha), CP_5 (527900 Tk/ha) (Table 5). CP_6 gave the lowest gross margin (142200 Tk/ha). The highest MBCR was found in CP_5 (4.1 Tk/ha) followed by CP_2

(3.53 Tk/ha), CP_1 (3.03 Tk/ha). Farmer's pattern CP_6 gave the lowest MBCR (1.29 Tk/ha) (Table 6).

CONCLUSION

Data showed that Potato (var:Diamont) – Lalshak (Local)- Mungbean (var:BARIMung-6) – T. Aus (var: Parija) – T. Aman (var: Binadhan7). Garden pea (BARI Motorshuti 3) – Lalshak (Local) – Mungbean (var: BARIMung-6) – T. Aus (var: Parija) – T. Aman (var: Binadhan7) cropping pattern gave higher benefit with less cost of production and could be easily fitted in the existing pattern and added higher organic matter than the former one. Short duration of garden pea, red amaranth (lalshak) mungbean, potato, aman and aus rice variety could be easily fitted in the existing pattern without deteriorating soil nutrient system. Due to growing four crops in year in the same piece of land more employment opportunity for male and female laboures could be created and at the same time due to increased production of rice, potato, garden pea, red amaranth and mungbean, the food security and nutritional security could be ascertained for the farmers at same time cropping intensity and productivity could be increased.

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