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Development of four/five crop-based cropping pattern studies for increasing cropping intensity and productivity

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ABSTRACT

A field trial was initiated from 2014-15 cropping years at RARS, BARI, Burirhat, Rangpur with six cropping patterns like CP_1 = Potato - Mungbean - T. Aus rice - T. Aman rice, CP_2 = Potato - Lalshak-Mungbean - T. Aus rice - T. Aman rice, CP_3 = Mustard - Lalshak - Mungbean-T. Aus rice - T. Aman rice, CP_4 = Gardenpea - Boro rice -T. Aus rice -T. Aman rice, CP_5 = Gardenpea - Lalshak -Mungbean-T. Aus rice - T. Aman rice and CP_6 = Fallow - Boro rice - Fallow - T. Aman rice (Farmers practice) to increase cropping intensity, sustain food security, poverty reduction etc.. The highest rice equivalent yield (32.34 t ha^{-1} in 2014-15, 33.44 t ha^{-1} in 2015-16 and 32.26 t ha^{-1} in 2016-17) was found in CP_2 cropping pattern, followed by CP_1 (26.79 t ha^{-1} in 2014-15, 26.32 t ha^{-1} in 2015-16 and 27.10 t ha^{-1} in 2016-17), CP_5 (26.74 t ha^{-1} in 2014-15, 26.21 t ha^{-1} in 2015-16 and 25.60 t ha^{-1} in 2016-17) and others. The highest gross margin Tk. 228025/- ha^{-1} in 2014-15 Tk. and 234355/- ha^{-1} in 2015-16 and Tk. 211495/- *in 2016-17 was obtained from CP_5 and CP_2 cropping patterns, respectively. The highest cost ratio 2.42, 2.38 and 2.32 was recorded from the CP_5 cropping pattern in 2014-15, 2015-16 and 2016-17 cropping years respectively, followed by CP_2. Always the lowest was in CP_6 cropping patterns. So, CP_5* and *CP_2 were compared to better cropping patterns to recommend practice for farmers in this region.*

Key Words: *Cropping pattern, Cropping intensity, Rice, Productivity and Crop*

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I. Introduction

Cropping pattern is yearly sequence and spatial arrangement of crops and fallows in a given area and it means the most efficient use of land and other resources and no cropping pattern can be suitable for all times to come. An efficient cropping pattern must ensure the most outstanding efficiency of land, fertilizer, irrigation water and other inputs (Harwood, 1974). The cropping patterns are the practice of

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integrating farming skills with technology to use available farm resources for production to satisfy farmers' needs (Zandstra et al., 1981). Bangladesh is predominantly a rice-growing country and about 80 % of the total cropped area 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%. However, in the pace per capita, land availability decrease and production shortage, the existence of fallow land in rice based cropping system is very inconsistent with the national perspective. Better pattern production is achieved with crop population density and component species' planting geometry (Myaka, 1995). Potential adoption of these improved cropping patterns intensifying mustard, 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 by producing more of these crops. Greater productivity in cropping pattern systems is commonly achieved by minimizing inter-specific competition and maximizing complimentary use of growth resources (Krishna and Raikhekar, 1997). The farm-level adoptions of improved oilseeds, pulses and potatoes in rice-based cropping systems have already created a wide range of socio-economic impacts that need to be appropriately evaluated to understand research and development output. This information could be useful for government and donor agencies to invest more in sustainable food production programs in Bangladesh. Considering the above issues, the proposed study proposes to undertake a special type of study with the aforesaid objectives i) Increase cropping intensity and productivity through crop intensification in rice-based cropping system; ii) Sustain food security, poverty reduction, resource management and livelihood improvement of ever increasing populations; and iii) Increase farmer's income, access to food and nutrition, employment opportunity and woman's participation in agriculture.

II. Materials and Methods

The field experiment was conducted at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Burirhat farm, Rangpur (AEZ-3) during Rabi season 2014-17. The design followed for the experiment was Randomized Complete Block (RCB) with four replications.

The six treatments were as follows

CP_1 = Potato-Mungbean-T. *Aus* rice-T. *Aman* rice,
CP_2 = Potato-Lalshak-Mungbean-T. *Aus* rice- T. *Aman* rice,
CP_3 = Mustard–Lalshak-Mungbean-T. *Aus* rice-T. *Aman* rice,
CP_4 = Gardenpea-*Boro* rice-T. *Aus* rice -T. *Aman* rice,
CP_5 = Gardenpea-Lalshak-Mungbean-T. *Aus* rice-T. Aman rice and
CP_6 = Fallow-*Boro* rice -Fallow -T. *Aman* rice (Farmers' practice).

The size of the unit plot was 5 m × 4 m and spacing was maintained at 20 cm × 15 cm for T. *Aman* rice, 30 cm × 5 cm for Mustard & Mungbean, 60 cm × 25 cm for potato crop, 30 cm × 5 cm for garden pea, 20 cm × 15 cm for Boro rice, 15 cm × 15 cm for T. *Aus* rice and Lalshak as broadcast. Two ploughs with power tiller were done respectively. All crops were sown and harvested, as shown in Table 01. Seeds of variety were Diamond of potato, BARI Sharisha - 14 of mustard, BARI Matorshoti -3 of Garden pea, BARI Lalshak -1 of Lalshak, BARI Mung - 6 of Mungbean, BRRI dhan 28 of Boro rice, Parija of T. *Aus* rice and BINA dhan-7 of T. *Aman* rice crop by irrigated condition. All pattern crops' fertilizer was used as a recommended dose of BARC (FRG-2012). Weeding, irrigation and spraying were done as required (Haque et al., 2011; Kabir and Haque, 2012; Mondal and Wahhab, 2001). All fertilizers were applied as recommended fertilizer doses for each crop.

Rice Comparable Yield

To compare cropping patterns, the yields of all crops were converted to comparable rice yields using the current market price of the individual crop (Verma and Modgal, 1983).

$$\text{Rice comparable Yield (t ha}^{-1}) = \frac{\text{Yield of each crop x Current price of this crop}}{\text{Current price of T. Aman}}$$

Analysis of the Profitability

Economic guides such as total variable cost and gross return were also computed using product market prices. The financial evaluation of two cropping patterns was carried out using regular data

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from two crop circles. The taka value of the product and by-product per hectare was used to calculate the gross return. For different agricultural production processes and inputs, the total flexible rate of various collects was estimated using taka per hectare. To compare the benefits, fractional budgeting was utilized. The advantage was determined by subtracting the real economic difficulty from the total economic benefit.

Table 01. Sowing date, harvesting date, crop duration and turnaround period for six rice-based cropping patterns during 2014 – 17

CP_1: Cropping pattern	**Potato**	**Mungbean**	**T. *Aus* rice**		**T. *Aman* rice**
Sowing date	7-10 Nov.	7-10 Feb.	2-5 May		20-25 July
Harvest date	5-7 Feb.	12-15 Apr.	15-17 July		25-27 Oct.
Crop duration (days)	85-90	65-67	75-76		90-95
Turn around period	12-15	2-5	17-20		5-10
CP_2: Cropping pattern	**Potato**	**Lalshak**	**Mungbean**	**T. *Aus* rice**	**T. *Aman* rice**
Sowing date	7-10 Nov.	5-7 Feb.	3-5 Mar.	10-15 May	25-28 July
Harvest date	5-7 Feb.	2-5 Mar.	6-8 May	20-25 July	25-30 Oct.
Crop duration (days)	85-90	25-27	64-67	65-70	92-95
Turn around period	12-15	2-5	2-5	7-10	3-5
CP_3 : Cropping pattern	**Mustard**	**Lalshak**	**Mungbean**	**T. *Aus* rice**	**T. *Aman* rice**
Sowing date	25-30 Oct.	18-21 Jan.	23-25 Fab.	5-7 May	22-25 July
Harvest date	18-20 Jan.	20-22 Feb.	1-3 May	20-22 July	20-22 Oct.
Crop duration (days)	80-85	30-32	65-67	70 -75	85-90
Turn around period	5-7	3-5	3-5	5-7	5-7
CP_4: Cropping pattern	**Garden pea**	***Boro***	**T. *Aus* rice**		**T. *Aman* rice**
Sowing date	7-9 Nov.	27-31 Jan.	7-10 May		20-25 July
Harvest date	25-27 Jan.	5-7 May	20-22 July		20-25 Oct.
Crop duration (days)	75-78	95-98	70-75		90-95
Turn around period	12-15	5-7	3-5		5-7
CP_5: Cropping pattern	**Garden pea**	**Lalshak**	**Mungbean**	**T. *Aus* rice**	**T. *Aman* rice**
Sowing date	09 Nov.	28-30 Jan.	2-5 Mar.	7-10 May	25-28 July
Harvest date	25-28 Jan.	25-28 Feb.	5-7 May	20-22 July	25-27 Oct.
Crop duration (days)	75-77	30-35	63-65	70-75	90-95
Turn around period	12-15	3-5	3-5	5-7	5-7
CP_6: Cropping pattern	**Fallow**	**Boro**	**Fallow**	**T. *Aman* rice**	
Sowing date	-	25-29 Jan	-	15-20 July	
Harvest date	-	09/05/15	-	25-30 Oct.	
Crop duration (days)	-	90-120	-	90 -120	

III. Results and Discussion

There was a significant effect of four and five crops pattern total pattern yield and yield where less number crop pattern was used in all patterns. The highest pattern yield (32.34 t ha^{-1} of 2014-15 and 33.44 t ha^{-1} of 2015-16) was given in the C_2 cropping pattern and the second highest yield was obtained from two cropping pattern C_1 (26.79 t ha^{-1} of 2014-15 and 26.32 t ha^{-1} of 2015-16) and C_5 (26.74 t ha^{-1} of 2014-15 and 26.21 t ha^{-1} of 2015-16) and below yield from other cropping patterns (Table 02). The highest gross margin (Tk. 228025 ha^{-1} of 2014-15 and Tk. 234355 ha t ha^{-1} of 2015-16) was obtained from C_2 cropping pattern and the second highest was shown from C_2 cropping pattern Tk. 218405 ha^{-1} (Table 03). The total pattern yield of C_1, C_2 and C_5 cropping pattern were around 26 t ha^{-1} to 32 t ha^{-1} (Table 02). Here, there was significant yield performance in C_1 and C_5 cropping patterns but only Lalshak and garden pea are included in this pattern, then the extra yield came in this pattern. So, this was a good way for these patterns. The lowest yield came from farmer's practices. It was 10.77 t ha^{-1}. The highest result was taken from Potato-Lalshak–Mungbean- T. *Aus* rice-T. *Aman* rice cropping pattern and second highest yield were also shown from Potato–Mungbean-T. *Aus* rice-T. *Aman* rice cropping pattern and similar trend of Garden pea-Lalshak-Mungbean-T. *Aus* rice -T. *Aman* rice cropping pattern. The alternative cropping pattern resulted in a more excellent rice equivalent yield due to adding agricultural technologies and varieties. As demonstrated by the preceding results, changing patterns of cropping resulted in upper yield when linked to the established pattern (Table 03). This argument was maintained by Rahman et al. (2018), Nazrul et al. (2017), Nazrul et al. (2013) and Khan et al. (2005) in the example of alternative crop sequence.

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Table 02. Rice equivalent yield of six cropping patterns (C_1-C_6) at RARS, Burirhat, Rangpur during 2014-17

Patterns	Crop wise yield of six cropping pattern (t ha^{-1})					Rice equivalent yield (t ha^{-1})
CP_1	Potato	Mungbean	T. *Aus* rice	T. *Aman* rice		
2014-15	26.95 (14.46)	1.32 (5.46)	3.25	3.62		26.79b
2015-16	27.25 (14.63)	1.28 (5.29)	2.98	3.42		26.32b
2016-17	28.46 (15.28)	1.25 (5.17)	2.95	3.71		27.10b
CP_2	Potato	Lalshak	Mungbean	T. *Aus* rice	T. *Aman* rice	-
2014-15	30.94 (14.94)	9.26 (6.39)	1.10 (4.55)	2.86	3.60	32.34a
2015-16	32.25 (15.57)	8.48 (5.85)	1.24 (5.13)	2.44	3.45	33.44a
2016-17	30.36 (14.66)	9.44 (6.61)	1.23 (5.12)	2.43	3.44	32.26a
CP_3	Mustard	Lalshak	Mungbean	T. *Aus* rice	T. *Aman* rice	-
2014-15	1.45 (5.00)	10.06 (6.94)	1.25 (5.17)	2.97	3.65	23.73c
2015-16	1.56 (5.38)	9.15 (6.31)	1.14 (4.72)	2.65	3.25	22.31c
2016-17	1.36 (4.68)	8.76 (6.04)	1.16 (4.74)	2.66	3.35	21.47c
CP_4	Garden pea	*Boro* rice	T. *Aus* rice	T. *Aman* rice		-
2014-15	7.12 (7.37)	5.22	3.05	3.70		18.24d
2015-16	7.36 (7.65)	4.86	2.76	3.48		18.75d
2016-17	7.24 (7.53)	4.54	2.74	3.50		18.31d
CP_5	Garden pea	Lalshak	Mungbean	T. *Aus* rice	T. Aman rice	-
2014-15	7.05 (7.29)	11.05 (7.62)	1.25 (5.17)	2.98	3.68	26.74b
2015-16	7.15 (7.36)	10.24 (7.06)	1.34 (5.59)	2.76	3.44	26.21b
2016-17	7.10 (7.31)	9.58 (6.61)	1.32 (5.50)	2.74	3.43	25.60b
CP_6 (FP)	Fallow	*Boro* rice	Fallow	T. *Aman* rice		-
2014-15	-	5.27	-	3.79		9.06e
2015-16	-	5.36	-	3.85		9.21e
2016-17	-	4.85	-	3.78		9.09e
CV (%) of 2014-15		-	-	-		7.94
CV (%) of 2015-16		-	-	-		5.61
CV (%) of 2015-16		-	-	-		6.50
Level of sig.						*

Means followed by the same letter(s) within a column did not differ significantly at 5% level by DMRT. Sig.=significant, *= Crop Standing, *FP = Farmer's Practice; Price (Tk. kg^{-1}): Potato 7, Garden pea 15, Lalshak 10, Mustard 50, Mungbean 60, T. *Aman* rice, T. *Aus* rice and Boro rice 14.50;

On the other hand, the highest benefit-cost ratio 2.42 and 2.38 was recorded from CP_5 cropping year in 2014-15 and 2015-16 cropping year, respectively. Always the lowest was in CP_6 cropping patterns.

Table 03. Rice equivalent yield and economic performance of six cropping pattern (C_1-C_6) at RARS, Burirhat, Rangpur during 2014-17

Treatments	Rice equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio
CP_1 of 2014-15	26.79	388455	233985	150845	1.66
CP_1 of 2015-16	26.32	381640	233985	147655	1.63
CP_1 of 2016-17	27.10	392950	233985	158965	1.68
CP_2 of 2014-15	32.34	468930	250525	218405	1.87
CP_2 of 2015-16	33.44	484880	250525	234355	1.94
CP_2 of 2016-17	32.26	467770	250525	217245	1.87
CP_3 of 2014-15	23.73	344085	162505	181580	2.11
CP_3 of 2015-16	22.31	323495	162505	160990	2.00
CP_3 of 2016-17	21.47	311315	162505	148810	1.91
CP_4 of 2014-15	18.24	264480	172880	91600	1.52
CP_4 of 2015-16	18.75	271875	172880	98995	1.58
CP_4 of 2016-17	18.31	272745	172880	99865	1.57
CP_5 of 2014-15	26.74	387730	159705	228025	2.42
CP_5 of 2015-16	26.21	380045	159705	220340	2.38
CP_5 of 2016-17	25.60	371200	159705	211495	2.32
CP_6 of 2014-15	9.06	131370	123155	8215	1.06
CP_6 of 2015-16	9.21	133545	123155	10390	1.08
CP_6 of 2016-17	9.09	131805	123155	8650	1.07

Crops (Tk. kg^{-1}): Potato 7, Garden pea 15, Lalshak 10, Mustard 50, Mungbean 60, T. *Aman* rice, T. *Aus* rice & *Boro* rice 14.50; Fertilizers (Tk. kg^{-1}): Urea 16.60, TSP 23, MoP 15, Gypsum 6, Zinc sulphate 160, Boron 180

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IV. Conclusion

Considering all, Potato-Lalshak - Mungbean -T. *Aus* rice - T. *Aman* rice cropping pattern produced the highest rice equivalent yield in both the years and the second highest was in Potato- Mungbean- T. *Aus* rice - T. *Aman* rice cropping pattern which was very close to Garden pea -Lalshak - Mungbean - T. *Aus* rice - T. A*m*an rice cropping pattern. Therefore, these patterns are recommended for farmers in this region.

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