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Increasing cropping intensity of Fallow-Boro-T. *Aman* cropping pattern with inclusion of Mustard in Tista Mender Floodplain soil

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Abstract

The field experiment was conducted at MLT site Pirgon, Rangpur and Domar, Nilphamari for two consecutive years 2015-17 to introduce BARI Sarisha-14 in the fallow period and to study the comparative agronomic performance and economic return of two cropping sequences (viz. improved cropping pattern-Mustard-Boro rice-T. aman rice and existing cropping pattern -Fallow-Boro rice-T. aman rice) for increasing cropping intensity, productivity and land use efficiency. The experiment was laid out in randomized complete block design with six dispersed replications. Two years mean data showed that the improved management practices for the pattern provided significantly higher yield in improved pattern. Higher rice equivalent yield (REY) of cropping system (mean value 14.49 t ha^{-1}) was recorded with the improved pattern over existing pattern at MLT site Pirganj. REY increased 4.60 t $ha^{-1}$by inclusion of mustard with improved production technologies for the component crops. Similar results were also found in Domar. The gross return of the improved pattern was BDT.239091 ha^{-1} which was more than 46.44% higher than farmers' pattern of BDT.163267 ha^{-1} at MLT site Pirganj and in Domar gross return of the improved pattern was BDT.241345 ha^{-1} which was more than 44.18% higher than farmers' pattern of BDT.167392 ha^{-1}.The gross margin was higher in improved cropping pattern in both locations than existing pattern due to addition of Mustard.

Key words: Land use efficiency, cropping intensity, mustard inclusion and return

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Introduction

Bangladesh is an agriculture dependent country. Agriculture plays a vital role in Bangladesh economy. More than 70% people in the rural areas directly or indirectly are involved with agriculture (BBS, 2011 and MoEF, 2012). Bangladesh is one of the most densely populated countries of the world. The population will increase to about 200 million (Planning Commission). On the other hand, the cultivable land is decreasing by 1% every year. The total land area of Bangladesh is about 14.84 M ha (million hectares), of which 3.74 M ha (25% of the total) is not available for agriculture due to use for urban areas, industrial buildings, rural homesteads, roads and other infrastructure. The net area of Bangladesh for crop cultivation declined to 7.84 M ha in 2011 from 8.85 M ha in 1985 (BBS, 2012). Bangladesh also suffers regularly from several natural calamities (Haq *et al.*, 2012; Islam *et al.*, 2017; Rahman et al., 2018), which may worsen in the future due to climate change (Hossain *et al*., 2016; Rokonuzzaman *et al*., 2018; Rahman *et al*., 2019). Thus, Bangladesh needs to produce more food on less land to assure future food security for millions of people every year. Horizontal expansion is very limited, but increase in crop production could be possible with vertical expansion through increasing cropping intensity and by increasing Land Use Efficiency. To achieve this, the two techniques that need to be adopted more frequently are an increase in the cropping intensity by producing two or more crops on the same land all-year round, and an increase in the productivity of individual crops, particularly their ability to utilize basic or limiting resources such as water and nutrients (FAOSTAT, 2013; Dobermann *et al*., 2013; Ladha *et al*., 2016).

The present cropping intensity of the country is 192%. The urgent need is to produce more food to feed the teeming populations. Food requirement is estimated to be doubled in the next 25 years. Under such situation; it is very important improving the existing cropping pattern. There are some scopes of increasing cropping intensity from existing level of 192% by improving the existing cropping patterns by incorporating short duration crops viz., mustard, potato, mungbean and aus rice in the rice based cropping system.

Bangladesh is predominantly a rice growing country and rice is the staple food and the economy mainly depends on rice production. Rice occupies about 80 % of the total cropped area and is cultivated in three seasons a year. The major cropping pattern of agriculture in Bangladesh mostly consists of rice based cereal crops (Haque, 1998). More than 60% of the total cropped areas covered by Boro-Fallow-T. aman rice cropping pattern in Bangladesh. About 2.4 mha crop land is occupying by this cropping pattern in Bangladesh (Ladha *et al.,* 2003; Dawe *et al.,* 2004; Bhuiyan *et al.,* 2004). In self-sufficiency of rice, the dominant cropping pattern T. Aman (wet season rice)-Fallow-Boro (dry season rice) plays an important role which covers about 1.8 million hectare (about 22% of the total land) of land (Elahi *et al.,* 1999). Bangladesh Rice Research Institute (BRRI) has recommended the T. Aman- Mustard-Boro cropping pattern for the irrigated ecosystem (BARC, 2001; Khan *et al.,* 2004, Anwar et al. 2012) with the inclusion of 70-75 days local mustard variety (Tori 7) in the transition period between T. Aman and Boro rice. But the farmers harvest poor yield from local var. Tori7 that can be increased manifold by introducing high yielding varieties (Alam and Rahman, 2006; Basak *et al.,* 2007). Recently, Bangladesh Agricultural Research Institute (BARI) has developed high yielding yellow seeded mustard (*Brassica campestris*) varieties, BARI Sarisha-14 and BARI Sarisha-15 whose yield potential is higher than Tori-7 and can easily be cultivated during fallow period.

Most areas of Bangladesh at present under two crops based cropping pattern, but there prerequisite to increase crop number to meet up the demand. A number of reports on different cropping pattern are available in Bangladesh and abroad (Khan *et al*., 2005, Ferdous et al. 2011, Anowar *et al*. 2012, Nazrul *et al*., 2013, Khatun *et al*., 2016 and Anwar et al., 2017, Ahmed et al. 2017) where an additional crop could be introduced without much changes or replacing the existing ones for considerable increase of the overall productivity as well as profitability of the farmers. Keeping these views in mind, the present study was designed to introduce BARI Sarisha-14 in the fallow period.

Materials and Methods

The experiment was conducted at the farmers' field condition in Domar, Nilphamari (Latitude: $26^0$06.766 N, Longitude: $089^0$49.0656 E, Altitude: 48 m) and khalashpir, Pirgonj, Rangpur (Latitude: $25^0$24.249 N, Longitude: $089^0$11.946 E, Altitude: 18 m) *during two consecutive years2015-17*. There were two treatments viz., T_1= Existing cropping pattern Fallow–Boro-T.aman rice, T_2 = Devloped cropping pattern Mustard-Boro-T.aman rice. The area mostly falls under medium-high land and high land areas of the Agro-

Ecological Zone (AEZ) 3 (Tista mender Floodplain). Organic matter content is low in higher parts, but moderate in lower parts. The general fertility level is low to medium, CEC and K status is medium (FRG 2012). The area receives an annual rainfall of around 2,160 mm with relatively early onset and late cessation and the mean annual temperature is about 24.6°C. The maximum land is under double-cropping followed by triple- and mono-cropping (Anwar *et al.*, 2017). The initial soil status of the experimental sites and weather data were presented in Tables 1 and 2.

Table 1. Initial status of soils of the experimental plots at MLT site, Pirganj, Rangpur.

Soil characteristics	MLT site Ulipur, Kurigram
Land type and soil texture	Medium High Land and Loamy
pH	6.2(Slightly acidic)
Organic Matter (%)	0.93(Very low)
N (%)	0.03(Very low)
P (µg/g soil)	43.8(Very high)
K (µg/g soil)	0.45(High)
S (µg/g soil)	5.20(Very low)
Zn (µg/g soil)	0.88(Low)
B (µg/g soil)	0.26(Low)

Table 2. Initial status of soils of the experimental plots at MLT site, Domar, Nilphamari.

Soil characteristics	MLT site Ulipur, Kurigram
Land type and soil texture	Medium High Land and Loamy
pH	5.39 (Slightly acidic)
Organic Matter (%)	2.33 (low)
N (%)	0.12 (Very low)
P (µg/g soil)	72.94 (Very high)
K (µg/g soil)	0.13 (High)
S (µg/g soil)	2.93 (Very low)
Zn (µg/g soil)	0.89 (Low)

Small unreplicated trials on farmers' fields, known as "dispersed experiments", were established under local farm conditions (Ferdous et al. 2016; Ferdous *et al.*, 2017). The land was divided into two equal plots (each of 660 m^2) where one plot was maintained either improved pattern, whereas the other plot was maintained existing pattern in Domar, Nilphamari and khalashpir, Pirgonj, Rangpur. The details of crop management practices followed for each crop at Domar, Nilphamari and khalashpir, Pirgonj, Rangpur location is provided in Tables 3 and 4, respectively.

After physiological maturity, 10 randomly selected plants from each plot were harvested and plant height, yield and yield attributes of Mustard, Boro rice and Transplant aman rice were measured. Yield for each crop was determined plot-wise and converted into yield on an area basis (kg ha^{-1}). Data on yield and yield attributes were statistically analyzed using statistical package IRRISTAT 5.0 (Ferdous et al. 2018) for the data analysis.

Benefit-cost analysis was conducted to estimate the economic feasibility of Mustard, Boro rice and Transplant aman rice crop. The production costs of these crops included the cost of field preparation, seed, planting, irrigation, fertilizers, crop protection measures and harvesting. The gross income was estimated using the prevailing average market prices for the yield of these crops in Bangladesh. Net income was calculated by subtracting total expenditure from the gross income which was computed by dividing the gross income with total expenditure (Mahmood *et al.*, 2016).

Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). Land use efficiency and rice equivalent yield of cropping patterns were calculated. Land use efficiency was worked-out by taking total duration of crops in an individual cropping pattern divided by 365 days. It was calculated by the following formula:

$$\text{Land Use Efficiency (\%)} = \frac{d_1 + d_2 + d_3 + d_4}{365} \times 100$$

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

Production efficiency value in terms of kg ha-1day-1was calculated by total main production a cropping pattern divided by total duration of crops in that pattern (Lal *et al.*, 2017; Tomar and Tiwari, 1990).

Table 3. Crop management practices in improved cropping pattern and existing cropping pattern at MLT site Pirganj.

Observation	**Existing cropping pattern**			**Improved cropping pattern**		
Crop	Fallow	Boro	T.aman	Mustard	Boro	T.aman
Variety	-	BRRI dhan 29	Swarna	BARI Sarisha-14	BRRI dhan 28	BRRI dhan49
Spacing	-	20 cm × 15 cm	20 cm ×15 cm	Broadcast & 30 ×continuous	20 cm × 15 cm	20 cm × 15 cm
Unit plot size	1320 m^2			1320 m^2		
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	-	128-52-23-07-2-0	95-48-22-06-3-0	80.6-26-23.5-10-1.6-0.5	150-20-65-18-1.3-0	90-10-35-12-1-0
Date of sowing/ transplanting	-	10-20Feb	25July-05 Aug	10-19 Nov	13-27Feb	17-25July
Harvesting date	-	05-15June	15-30Nov	31 Jan-10Feb	07-19-June	02-10 Nov

Table 4. Crop management practices in improved cropping pattern and existing cropping pattern at MLTsite, Domar, Nilphamari.

Observation	**Existing cropping pattern**			**Improved cropping pattern**		
Crop	Fallow	Boro	T.aman	Mustard	Boro	T.aman
Variety	-	BRRI dhan 29	Swarna	BARI Sarisha-14	BRRI dhan 28	BRRI dhan49
Spacing	-	20 cm × 15 cm	20 cm ×15 cm	Broadcast & 30 × continuous	20 cm × 15 cm	20 cm × 15 cm
Unit plot size	1320 m^2			1320 m^2		
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	-	136-50-20-08-0-0	102-62-20-08-0-0	80.6-26-23.5-10-1.6-0.5	150-20-65-18-1.3-0	90-10-35-12-1-0
Date of sowing/ transplanting	-	11-18Feb	27 July-12Aug	11-15 Nov	15-24Feb	10-18July
Harvesting date	-	04-10June	15-30Nov	01-06 Feb	07-15 June	25 Oct-02 Nov

Rice equivalent yield (REY): For comparison between crop sequences, the yield of all crops was converted into rice equivalent on the basis of prevailing market prices of individual crop (Lal *et al.*, 2017). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

Rice equivalent yield (t ha^{-1}) =

$$\frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\textit{Market price of rice}}$$

Results and Discussion

Yield of the cropping patterns**:** Results of the study have been presented in Table 5 and 7. It was revealed that the entire component crops of Mustard-Boro-T. Aman rice cropping pattern under improved practices (IP) gave higher yield as well as by-product yield in two consecutive years at both the locations. The yield of improved pattern was higher due to inclusion of mustard with improved production technologies for the component crops. Similar results were also obtained by Anwar *et al.*, 2017, Khatun *et al.*, (2016), Kamrozzaman et al., (2015) and Nazrul *et al.* (2013). BARI Sarisha 14 is a short duration high yielding mustard variety which can easily be grown during the fallow period (Mondal *et al.*, 2015). Inclusion of mustard with improved variety in Mustard-Boro-T.Aman rice cropping pattern practice increased the total yield over the farmers existing cropping pattern practice. Grain yields of T. aman rice in case of improved cropping pattern were 4.35 and 4.40t ha^{-1} at MLT site Pirganj and 4.33 and 4.37 t ha^{-1} at MLT site Domar in two consecutive years respectively.Seed yield of mustard were 1.59 and 1.67 t ha^{-1} at MLT site Pirganj and 1.47 and 1.54 t ha^{-1} at MLT site Domar in two consecutive years respectively. Grain yield of Boro rice were 5.02 and 5.14 t ha^{-1} at MLT site Pirganj and 5.00 and 5.17 t ha^{-1} at MLT site Domar in two consecutive years, respectively.

Table 5. Productivity of farmers' and improved cropping pattern at MLT site, Pirganj, Rangpur.

Year	Cropping pattern	Crop	Variety	Field duration	Grain or seed yield (t ha^{-1})	Straw or stover yield (t ha^{-1})
2015-16	Existing cropping pattern	Fallow	-	-	-	-
		Boro	BRRI dhan 28	112	4.76±0.11	6.05±0.19
		T.aman	Swarna	111	4.24±0.24	5.47±0.28
	Improved cropping pattern	Mustard	BARI Sarisha-14	83	1.59±0.13	2.82±0.15
		Boro	BRRI dhan 28	111	5.02±0.14	6.47±0.22
		T.aman	BRRI dhan49	107	4.35±0.07	5.51±0.25
2016-17	Existing cropping pattern	Fallow	-	-	-	-
		Boro	BRRI dhan 28	113	4.84±0.08	6.15±0.19
		T.aman	Swarna	112	4.27±0.06	5.41±0.21
	Improved cropping pattern	Mustard	BARI Sarisha-14	81	1.67±0.04	2.89±0.09
		Boro	BRRI dhan 28	112	5.14±0.17	6.56±0.11
		T.aman	BRRI dhan49	105	4.40±0.27	5.57±0.14

Rice equivalent yield: Total productivity of a cropping system was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Higher rice equivalent yield (REY) of cropping system (mean value 14.49 t ha^{-1}) was recorded with the improved pattern over existing pattern at MLT site Pirganj (Table 6). REY increased 4.60 t ha^{-1} by inclusion of mustard with improved production technologies for the component crops. Similar results were also found in Domar (Table 8). It is noted that inclusion of additional crop during the fallow period produced higher REY than farmer's practice. Similar results were also obtained by Khatun *et al*.,2016; Kamrozzaman *et al*., 2015; Ferdous *et al*. 2011, Anowar *et al*. 2012, Nazrul *et al*., 2013.

Crop duration: On an average, cropping pattern comprises existing cropping pattern and improved cropping pattern took 224 and 300 days excluding seedling age of T.aman and Boro rice to complete the cycle. It is observed that mustard could be easily fitted in the cropping pattern with turnaround time of 65 days in a year.

Table 6. Rice-equivalent yield and land use efficiency of farmers' and improved cropping pattern at MLT site, Pirganj, Rangpur.

Year	Cropping pattern	REY (t ha^{-1})	Land use efficiency (%)
2015-16	Existing cropping pattern	9.84	61.10
	Improved cropping pattern	14.30	82.47
2016-17	Existing cropping pattern	9.95	61.64
	Improved cropping pattern	14.68	81.64
Mean	Existing cropping pattern	9.90	61.37
	Improved cropping pattern	14.49	82.05

Table 7. Productivity of farmers' and improved cropping pattern at MLT site, Domar, Nilphamari.

Year	Cropping pattern	Crop	Variety	Field duration	Grain or seed yield (t ha^{-1})	Straw or stover yield (t ha^{-1})
2015-16	Existing cropping pattern	Fallow	-	-	-	-
		Boro	BRRI dhan 28	113	4.79±0.1	5.85±0.10
		T.aman	Swarna	111	4.25±0.35	4.97±0.24
	Improved cropping pattern	Mustard	BARI Sarisha-14	81	1.47±0.07	2.53±0.13
		Boro	BRRI dhan 28	112	5.0±0.24	6.21±0.16
		T.aman	BRRI dhan49	107	4.33±0.21	5.22±0.32
2016-17	Existing cropping pattern	Fallow	-	-	-	-
		Boro	BRRI dhan 28	112	4.87±0.22	5.78±0.25
		T.aman	Swarna	110	4.29±0.17	4..97±0.18
	Improved cropping pattern	Mustard	BARI Sarisha-14	82	1.54±0.08	2.49±0.14
		Boro	BRRI dhan 28	111	5.17±0.11	6.19±0.11
		T.aman	BRRI dhan49	106	4.37±0.13	5.22±0.24

***Land use efficiency*:** Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. Results of the study have been presented in Table 6 and 8.

Table 8. Rice-equivalent yield and land use efficiency of farmers' and improved cropping pattern at MLT site, Domar, Nilphamari.

Year	Cropping pattern	REY (t ha^{-1})	Land use efficiency (%)
2015-16	Existing cropping pattern	9.83	61.37
	Improved cropping pattern	13.90	82.19
2016-17	Existing cropping pattern	10.46	60.82
	Improved cropping pattern	15.35	81.92
Mean	Existing cropping pattern	10.15	61.10
	Improved cropping pattern	14.63	82.06

Mean land use efficiency indicated that improved cropping pattern used the land for 82.06% period of the year, whereas ECP used the land for 61% period of the year.The improved cropping pattern leads to higher land use efficiency due to longer period field occupied by the crops (300 days), whereas the farmers practice occupied the field for 224 days of the year. Similar results were also obtained by Khatun *et al.*, 2016.

***Economic analysis*:** Economic analysisdone based on prevailing market price during the crop Season. Improved cropping pattern showed its superiority over farmers' pattern during two consecutive years at both the locations. Results of the study have been presented in Table 9 and 10.

Table 9. Cost benefit analysis of farmers' and improved cropping pattern at MLT site, Pirganj, Rangpur.

Year	Cropping pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Whole pattern GM (Tk. ha^{-1})	Benefit over existing pattern
2015-16	Existing cropping pattern	162360±5820	127375±3938	34985±2021	26452
	Improved cropping pattern	235962±5602	174525±2563	61437±2117	
2016-17	Existing cropping pattern	164175±3800	128250±3517	35925±1650	30908
	Improved cropping pattern	242220±2970	175387±3050	66833±3123	
Mean	Existing cropping pattern	163267±2757	127812±3450	35455±2023	28680
	Improved cropping pattern	239091±3979	174956±3241	64135±1684	

Price: Mustard=BDT.35 kg^{-1}, Rice=BDT.16.50 kg^{-1}, Ricestraw= BDT.9500 ha^{-1}and Mustard stover = BDT.2000 ha^{-1} Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, REY: rice equivalent yield, GM: gross margin.

On an average, gross return of the improved pattern was BDT.239091 ha^{-1} which was more than 46.44% higher than farmers' pattern of BDT.163267 ha^{-1}at MLT site Pirganj (Table 9) and in Domargross return of the improved pattern was BDT.241345 ha^{-1} which was more than 44.18% higher than farmers' pattern of BDT.167392 ha^{-1}. The production cost of the improved pattern (BDT.174956 ha^{-1}) was higher than farmers' pattern (BDT.127812 ha^{-1}) due to labor intensive, cost of fertilizer and other inputs (Table 10).

Table 10. Cost benefit analysis of farmers' and improved cropping pattern at MLT site, Domar, Nilphamari.

Year	Cropping pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Whole pattern GM (Tk. ha^{-1})	Benefit over existing pattern
2015-16	Existing cropping pattern	162195±4631	124815±2109	37380±2215	20324
	Improved cropping pattern	229416±5091	171712±2932	57704±2574	
2016-17	Existing cropping pattern	172590±3938	125735±3297	46855±2390	33788
	Improved cropping pattern	253275±3350	172632±3097	80643±2975	
Mean	Existing cropping pattern	167392±5017	125275±2770	42117±1508	27056
	Improved cropping pattern	241345±2009	172172±3220	69173±2323	

Price: Mustard=BDT.35 kg^{-1}, Rice=BDT.16.50 kg^{-1}, Rice straw= BDT. 9500 ha^{-1}and Mustard stover = BDT.2000 ha^{-1}, Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, REY: rice equivalent yield, GM: gross margin.

Similar results were also found in Domar. The net return was substantially higher in the improved pattern (BDT.64135 ha^{-1}) than farmers' pattern of BDT.35455 ha^{-1} at MLT site Pirganj and in Domar it was also substantially higher in the improved pattern (BDT.69173 ha^{-1}) than farmers' pattern of BDT.42117 ha^{-1}.The higher net return of the improved pattern was achieved mainly higher yield advantages of the component crops. Inclusion of new crop (mustard) as well as improvement of management practices in the improved cropping pattern increased the economic return. Similar results were also obtained by Khatun et al., 2016.

Conclusion

From the above results showed thatimproved cropping pattern was more profitable compared to existing pattern. Considering higher rice-equivalent yield, net monetary return and more sustainability of the improved cropping pattern (Mustard-Boro rice-T. Aman Rice) with additional crop and improved technologies could be suggested for medium high land of the Teesta Meander Floodplain Agro-ecological Zone (AEZ- 3) of Bangladesh.

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