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PRODUCTIVITY AND PROFITABILITY OF IMPROVED VERSUS EXISTING CROPPING PATTERN IN KUSHTIA REGION

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Abstract

The trial was conducted at Multi Location Testing (MLT) site under On-Farm Research Division, BARI, Kushtia during the last week of February, 2015 to second week of February, 2017 at farmers' field condition to cover two cropping cycle of four crops. The main objectives of the trial were to verify the feasibility of growing improved cropping pattern Mustard-Mungbean-T.Aus-T.Aman rice and to compare its productivity and profitability with existing cropping pattern Lentil-Sesame-T.Aman rice. The varieties BARI Sarisha-15, BARI Mung-6, BRRI dhan48 and Binadhan-7 were used for the crop Mustard, Mungbean, T.Aus and T.Aman rice, respectively in the improved cropping pattern, while in case of existing pattern, the varieties were BARI Masur-6, BARI Till-3 and Binadhan-7 for Lentil, Sesame and T.Aman rice, respectively. Findings revealed that the mean crop duration of 340 days were required for one cycle in a year in improved cropping pattern which implied that four crop based cropping pattern was agronomically feasible to replace existing cropping pattern. Total seed/grain yield in terms of REY of improved cropping pattern was 14.85 t ha^{-1} $year^{-1}$ which was 44% higher than that of existing pattern (10.30 t ha^{-1} $year^{-1}$). Mean production efficiency (35.78 kg ha^{-1} day^{-1}), land use efficiency (93.15%) and labour employment (589 mandays ha^{-1} $year^{-1}$) of improved cropping pattern was 51%, 16% and 62%, higher, respectively than that of existing cropping pattern. The mean net economic advangaes of improved cropping pattern was Tk 12677 ha^{-1} $year^{-1}$ which implied that the improved cropping pattern was economically viable. Moreover, the improved cropping pattern increased cropping intensity, farmers knowledge, skill, and income as well as employment. It also maintained soil health by incorporating mungbean stover and T.Aus rice straw in the soil. Therefore, farmers in Kushtia region of Bangladesh could follow the improved cropping pattern in their high and medium high land for higher productivity and profitability as well as employment generation over existing cropping pattern.

Keywords: Four crops, grain yield, production efficiency, rice equvalent yield, profitability

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Introduction

Bangladesh is the most densely populated (about 1033 persons per sq. km) country in the world with a population of 152.40 million, which is increasing annually at the rate of about 1.37 per cent (BBS, 2016). By the year 2030, the population will increase to about 186 million (United Nations, 2017). At present total cultivable land of the country is about 8.44 million hectares and it is shrinking day by day. Demographic pressures and increased urbanization have caused cultivated area to decline at a rate of about 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. There is very little scope of increasing cultivable land but there are some scopes of increasing cropping intensity from existing level of 192% by improving the existing cropping patterns by including short duration crops viz., mustard, potato, mungbean and T.Aus rice in the rice based cropping system (Mondal *et al.,* 2015).

Kushtia district is located under Agro Ecological Zone (AEZ) 11. The soil is calcareous under High Ganges River Floodplain. About 76% lands are under high and medium high land which has a great potential to produce four crops in a year. Total cultivable land of the district is 162125 ha in which 10835 ha were single cropped, 25960 ha was double cropped and 76375 ha was triple cropped land (47% of total cultivable land). The cropping intensity of this area is 263% and about 93% lands are under irrigation (DAE, 2016).It is possible to increase cropping intensity in this area by using short duration crop varieties which is developed by BARI and other research institutes. The lentil production hampers due to foot and root rot and stemphylium blight disease. Besides, the sesame production hampers due to early monsoon at harvesting stag. Moreover, the price of lentil fluctuates every year. So, the farmers in Kushtia face economic loss in the existing lentil and sesame based cropping patterns. Therefore, it is needed a better cropping pattern which is more benefitted to the farmers of Kushtia against.

Recently BARI has developed few four crop based cropping patterns which could give more benefit to the farmers. Mustard-Mungbean-T.Aus-T.Aman is one of them. This cropping pattern is needed to verify in farmers field of Kushtia against existing Lentil-Sesame-T.Aman cropping pattern.

Mondal *et al.* (2015) reported that T.Aman rice (var: Binadhan-7) - Mustard (var: BARI Sarisha-15) -Mungbean (var: BARI Mung-6) -T.Aus rice (var: Parija) cropping pattern gave higher benefit with less cost of production and could be easily fitted in the existing pattern. Hossain *et al.* (2014) also reported that T.Aman rice (var: Binadhan-7) - Mustard (var: BARI Sarisha-15) -Mungbean (var: BARI Mung-6) – T.Aus rice (var: Parija) are agronomically feasible and economically profitable compared to the existing pattern.Due to growing four crops in a year in the same piece of land more employment opportunity could be

created and at the same time due to increased production of crops, food and nutritional security could be ascertained for the farmers and at the same time cropping intensity and productivity could be increased (Mondal *et al.*, 2015; Hossain *et al.*, 2014).

Nazrul *et al.* (2017) found that improved pattern (Mungbean-T.Aus -T.Aman rice) provided higher grain yield, contributed more REY, gave maximum sustainable index, production efficiency, land use efficiency and higher profit compared to farmers pattern (Fallow- T.Aus-T.Aman rice). Moreover, a number of reports on different cropping pattern are available in Bangladesh and India that an additional crop could be introduced without much changes or replacing the existing ones for considerable increases of productivity as well as profitability of the farmers (Azad *et al.*, 1982; Malavia *et al.*, 1986; Soni and Kaur, 1984; Khan *et al.*, 2005; Nazrul *et al.*, 2013; Kamrozzaman *et al.*, 2015).

Farmers in Kushtia have been facing problem in existing patterns, whereas they have a great potential to conduct four crops in a same piece of land in a year because 76% lands are under high and medium high land and 93% lands are under irrigation. But, no attempt has been made for on-farm verification of four crops based improved cropping pattern Mustard-Mungbean-T.Aus-T.Aman rice in Kushtia. With this view in mind, the present study was therefore, undertaken in the following objectives.

Objectives:

i. to document the agronomic practices of growing Mustard-Mungbean-T.Aus-T.Aman rice cropping pattern;

ii. to verify the feasibility of growing Mustard-Mungbean-T.Aus-T.Aman rice cropping pattern in farmers field condition;

iii. to compare its productivity and profitability against farmer's existing cropping pattern Lentil- Sesame-T.Aman rice; and

iv. To determine the land use efficiency, production efficiency and labour employment generation of improved and existing cropping pattern.

Materials and Methods

The trial was conducted at Multi Location Testing (MLT) site under On-Farm Research Division (OFRD), BARI, Kushtia during the last week of February, 2015 to second week of February, 2017 at farmers' field condition to cover two cropping cycle of four crops. Before setting up and end of two cycle of the experiment, soil samples were taken separately over 0-15 cm depth to determine baseline and post soil properties, respectively. Soil samples were air-dried, crushed, and analyzed separately in SRDI laboratory.

The experiment was laid out in block approach for maintaining all activities one after another at a time. There were two blocks consisting of one hectare in each cropping pattern of 8 farmers. One block was under the improved cropping pattern and the other was farmer's existing pattern. In the improved cropping pattern, Mustard (var. BARI Sarisha-15) - Mungbean (var. BARI Mung-6) - T.Aus rice (var. BRRI dhan48) - T.Aman rice (var. Binadhan-7) was cultivated against existing pattern Lentil (var. BARI Masur-6) - Sesame (var. BARI Till-4) - T.Aman rice (var. Binadhan-7). The trial was started by mungbean cultivation in improved cropping pattern. Lentil, sesame, mustard and mungbean seed was sown in broadcasting method and the rice seedling was transplanted 20 x 15 cm. All fertilizers were applied as basal and top dressing by following improved management practices. The agronomic parameters and inter-cultural operation for crop production under improved and farmer's existing practices are presented in Table 2. In T.Aus and T.Aman rice, stem borer and sheath blight was observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @1.5g/10 L for stem borer. In Mustard, Rovral-50 wp @ 2 g/L was sprayed at early stage for controlling alternaria blight disease. In mungbean, Tafgor (2ml/L) and Imitaf 20 SL (0.5ml/L) were sprayed for controlling aphid and thrips. All field operation and management practices of both improved and farmer's pattern were closely monitored and the data were recorded for observing agro-economic performance. The yield data of product and by-product were recorded from 1 m^2 in 3 areas from each block.

Agronomic performance *viz.*, land use efficiency, production efficiency and rice equivalent yield of cropping patterns were calculated.

Land use efficiency: It is worked out by taking total duration of individual crop in a pattern divided by 365 days as Tomer and Tiwari, (1990) as follows:

$$\text{Land use efficiency} = \frac{\sum \text{di}}{365} \times 100$$

Where,

di = duration of the i^{th} crop i = 1, 2, 3 and 4

Production efficiency: Production efficiency in terms of Kg $ha^{-1}day^{-1}$was calculated by total production in a cropping pattern divided by total duration of crops in that pattern (Tomer and Tiwari. 1990).

$$\text{Production efficiency} = \frac{\sum \text{yi}}{\sum \text{di}}$$

Where,

Yi = Yield of the i^{th} crop
di = duration of the i^{th} crop
i = 1, 2, 3 and 4

Rice equivalent yield: For comparison between cropping patterns, the yield of all crops was converted into rice equivalent yield (REY) on the basis of prevailing market price of individual crop (Verma and Modgal, 1983).

$$\text{Rice equivalent yield (t ha}^{-1}) = \frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of rice}}$$

Profitability analysis: The economic indices like total variable cost and gross return were also calculated on the basis of prevailing market price of the produces. For economic evaluation of two tested cropping patterns, average data of two crop cycles were used. Gross return was calculated on the basis of taka per hectare of product and by-product. Total variable cost of different crops was calculated on the basis of taka per hectare of different operations performed and materials used for raising the crops. Partial budgeting was used to compare the advantage in between improved and existing cropping pattern. Net economic advantage was derived by subtracting of total economic disadvantage from total economic advantage.

Results and Discussion

Changes in soil properties: The result of nutrient status of initial and post soil is presented in Table 1. Initially, the soil was slightly alkaline (7.8-8.1), medium in organic matter and K content. The contents of S and B were also in medium level. Total N, P and Zn contents were found low. After completion of two cycles, soil was also tested. Post soil chemical analysis result revealed that the mean pH was slightly lower than initial value whereas OM increased due to incorporation of mungbean in the soil of improved cropping pattern. The contents of K, Zn and B increased in post soil compared to initial soil while the contents of P and S decreased in post soil than initial soil. Total N is same in post and initial soil. This result is supported by the result of Mondal *et al.*(2015).

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern which is shown in Table 2. The crop (field) duration of improved cropping pattern (Mustard-Mungbean-T.Aus-T.Aman rice) took 339 and 341 days for completion of 1st and 2nd cycle, respectively. While, existing cropping pattern (Lentil-Sesame-T.Aman rice) required 290 and 296 days for completion of 1st and 2nd cycle, respectively. Turnaround time in four crops based improved cropping pattern for completion of 1st and 2nd cycle was 26 and 24 days, respectively whereas it was 75 and 69 days, respectively for completion of 1st and 2nd cycle in existing cropping pattern. This indicates that four crops based improved cropping pattern is easily fitted in a piece of land in a year instead of three crops existing pattern.

Table 1. Chemical properties of initial and post soil (0-15 cm depth) of the experimental field at Kushtia sadar, Kushtia during 2014-15 and 2016-17

Replication	pH	Organic matter (%)	K	Total N (%)	P	S	Zn	B
			meq/100 g soil		µg g^{-1}			
Initial:								
R_1	7.8	2.17	0.24	0.11	11.70	20.40	0.87	0.47
R_2	8.1	1.97	0.27	0.10	10.70	18.21	0.87	0.41
R_3	7.9	1.88	0.28	0.09	8.80	18.40	0.72	0.54
R_4	7.8	1.82	0.23	0.09	13.40	22.47	0.97	0.35
R_5	7.9	2.10	0.18	0.10	14.60	26.45	0.72	0.41
Mean/Range	7.8-8.1	1.99	0.24	0.10	11.84	21.19	0.83	0.44
Critical limit	-	-	0.12	0.12	10.00	10.00	0.60	0.20
Interpretation	Slightly Alkaline	Medium	Medium	Low	Low	Medium	Low	Medium
Post:								
R_1	7.7	1.92	0.25	0.09	8.45	15.24	0.75	0.58
R_2	7.2	2.28	0.22	0.11	11.25	22.48	0.92	0.58
R_3	8.0	1.97	0.32	0.10	9.17	14.57	0.85	0.58
R_4	7.2	1.97	0.27	0.10	14.21	20.24	0.95	0.58
Mean/Range	7.2-8.0	2.04	0.27	0.10	10.77	18.13	0.87	0.58
Critical limit	-	-	0.12	0.12	10.00	10.00	0.60	0.20
Interpretation	Slightly Alkaline	Medium	Medium	Low	Low	Medium	Low	Medium

Seed/Grain yield: The mean seed/grain yield of mustard, mungbean, T.Aus and T.Aman were 1.35, 1.14, 5.10 and 4.59 t ha^{-1}, respectively in improved cropping pattern while mean seed/grain yield of lentil, sesame and T.Aman were 0.78, 1.25 and 4.90 t ha^{-1}, respectively in the existing cropping pattern (Table 3). The stover/straw yield of the cited crops is presented in the Table 3. The yield of T.Aus rice was found to be very good which might be occurred due to residual effect of mungbean stover. The yield of lentil in existing cropping pattern was low due to attack of foot and root rot and stemphylium disease. In improved cropping pattern, seed/grain yield of mustard, mungbean, T.Aus and T.Aman were 1.20, 1.15, 4.97 and 4.59 t ha^{-1}, respectively for 1st cycle while seed/grain yield of lentil, sesame and T.Aman were 0.75, 1.20 and 4.70 tha^{-1}, respectively in the existing pattern. In the 2nd cycle of improved cropping pattern, seed/grain yield of mustard, mungbean, T.Aus and T.Aman were 1.49, 1.12, 5.22 and 4.59 tha^{-1}, respectively while in the existing pattern seed/grain yield of lentil, sesame and T.Aman were 0.80, 1.30 and 5.10 tha^{-1}, respectively. Similar findings were found in Mondal *et al.* (2015) and Hossain *et al.* (2014).

Table 2. Crop management practices of existing (Lentil-Sesame-T.Aman) and improved (Mustard-Mungbean-T.Aus-T.Aman) cropping pattern in the 1st and 2nd cycle at Kushtia sadar, Kushtia

Parameters	Existing Cropping Pattern			Improved Cropping Pattern			
Crop	Lentil	Sesame	T.Aman	Mustard	Mungbean	T.Aus	T.Aman
Variety	BARI Masur-6	BARI Til-3	Binadhan-7	BARI Sarisha-15	BARI Mung-6	BRRI dhan48	Binadhan-7
1st cycle:							
Fertilizer dose (CD tha^{-1}, NPKSZnB$kgha^{-1}$)	17.15-18.7-5-0-0	86.5-18-26-9.5-0	103.4-22.5-37.5-9.5-2.6	126-35-46-29.5-2.5-2.12	17-17-18-10-0-1	86-22.5-37.5-9.5-2.15-0.6	86-22.5-37.5-9.5-1.61-0
Date of sowing/ transplanting	18/11/15	18/3/15	2/8/15	14-15 /11/15	27-28 /02/15	13-14 /05/15	10-12 /08/15
Date of harvesting	03/03/16	11/6/15	07/11/15	7-9/2/16	1-10/5/15	6-8/08/15	11-12 /11/15
Irrigation (no.)	-	-	-	1	-	10	-
Weeding (no.)	-	1	2	1	1	1	1
Field duration(day)	106	86	98	86	73	86	94
Turnaround time (day)	10	14	51	18	02	4	2
2nd cycle:							
Fertilizer dose (CD tha^{-1}, NPKSZnB$kgha^{-1}$)	17.15-18.7-5-0-0	86.5-18-26-9.5-0	103.4-22.5-37.5-9.5-2.6	126-35-46-29.5-2.5-2.12	17-17-18-10-0-1	86-22.5-37.5-9.5-2.15-0.6	86-22.5-37.5-9.5-1.61-0
Date of sowing/ transplanting	15/11/16	15/03/16	04/08/16	12-14 /11/16	26-28 /02/16	12-14 /05/16	10-12 /08/16
Date of harvesting	5-7/03/17	14/06/16	04/11/16	08-10/02/17	01-08 /05/16	06-08 /08/16	11-12 /11/16
Irrigation (no.)	-	-	-	1	1	10	-
Weeding (no.)	-	1	2	1	1	1	1
Field duration (days)	111	92	93	89	72	87	93
Turnaround time	10	9	50	17	3	3	2

Table 3. Yield of existing (Lentil-Sesame-T.Aman) and improved (Mustard-Mungbean-T.Aus-T.Aman) cropping pattern at Kushtia sadar, Kushtia

Parameters	Existing Cropping Pattern			Improved Cropping Pattern			
Crop	Lentil	Sesame	T.Aman	Mustard	Mungbean	T.Aus	T.Aman
Variety	BARI Masur-6	BARI Til-3	Binadhan-7	BARI Sarisha-15	BARI Mung-6	BRRI dhan48	Binadhan-7
1st cycle							
Seed/grain yield (t ha^{-1})	0.75	1.20	4.70	1.20	1.15	4.97	4.59
Stover/straw yield (t ha^{-1})	1.10	2.30	4.20	2.00	1.24	4.16	4.12
2nd cycle							
Seed/grain yield (t ha^{-1})	0.80	1.30	5.10	1.49	1.12	5.22	4.59
Stover/straw yield (t ha^{-1})	1.11	2.15	4.03	1.92	1.22	3.54	3.08
Mean							
Seed/grain yield (t ha^{-1})	0.78	1.25	4.90	1.35	1.14	5.10	4.59
Stover/straw yield (t ha^{-1})	1.11	2.23	4.12	1.96	1.23	3.85	3.60

Rice Equivalent Yield: The mean rice equivalent yield (REY) of improved cropping pattern was 14.85 $tha^{-1}year^{-1}$ which was 44% higher over existing cropping pattern (10.30 $tha^{-1}year^{-1}$). The REY of improved cropping pattern was 15.15 $tha^{-1}year^{-1}$ which was 37% higher against existing cropping pattern (11.03 $tha^{-1}year^{-1}$) in 1st cycle. While REY of improved cropping pattern was 14.55 $tha^{-1}year^{-1}$, which was 52% higher over existing cropping pattern (9.57 $tha^{-1}year^{-1}$) in 2nd cycle. Higher rice equivalent yield was obtained in improved cropping pattern due to inclusion of new crops and varieties. It is evident from the above findings that improved cropping pattern gave higher yield compared to existing pattern (Table 4). This finding was supported by Mondal *et al.*,(2015); Hossain *et al.*(2014); Nazrul *et al.* (2017) and Nazrul *et al.* (2013).

Land use efficiency: Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The mean land-use efficiency of improved cropping pattern was higher (93.15%) than that of existing pattern (80.28%). Improved cropping pattern utilized the land by 92.88% and 93.42% for 1st and 2nd cycle, respectively, whereas existing pattern utilized the land by 79.45% and 81.10% for 1st and 2nd cycle, respectively (Table 4). The land use efficiency was higher in improved cropping pattern due to cultivation of more component crops in the pattern. The similar trend of the findings was cited by Nazrul*et al.* (2017) and Nazrul *et al.* (2013).

Production efficiency: Maximum production efficiency was obtained from improved cropping pattern over existing cropping pattern (Table 4). The higher

production efficiency of improved cropping pattern might be due to inclusion of four crops and new modern varieties as well as improved management practices. The mean production efficiency of improved cropping pattern was found to be 35.78 kg ha^{-1} day^{-1}which was 51% higher over existing cropping pattern (23.63 kg ha^{-1} day^{-1}). Production efficiency of improved cropping pattern and existing cropping pattern was found to be 35.13 and 22.93 kg ha^{-1} day^{-1}, respectively in 1st cycle, while it was found to be 36.42 and 24.32kg ha^{-1} day^{-1} for improved cropping pattern and existing cropping pattern, respectively in 2nd cycle (Table 4). Production efficiency of improved cropping pattern was 53% and 50% higher than that of existing pattern in 1st and 2nd cycles, respectively. Finding revealed that maximum production efficiency was found in improved cropping pattern against existing pattern in all the cycles. Similar findings were cited by Nazrul *et al.* (2017), Nazrul *et al.* (2013) and Khan *et al.* (2005) in case of improved cropping patterns.

Labour employment generation: Human labour was employed for land preparation, sowing/transplanting, fertilizing, weeding, pesticide application, harvesting, carrying, threshing, cleaning and drying. It is observed that the mean total number of human labour used for crops cultivation under improved cropping pattern was 589 man-days ha^{-1} $year^{-1}$ (Table 4) which was generated 62% higher labour employment than that of existing cropping pattern (363 man-days ha^{-1} $year^{-1}$). It was also generated employment of women, children and aged people due to inclusion of mungbean.

Table 4. Rice equivalent yield, production efficiency, land use efficiency and labour employment of existing (Lentil-Sesame-T.Aman) and improved (Mustard-Mungbean-T.Aus-T.Aman) cropping pattern at Kushtia sadar, Kushtia

Cycles	Cropping pattern	Rice equivalent yield (tha^{-1})	Land use efficiency (%)	Production efficiency (Kg $ha^{-1}day^{-1}$)	Labour employment (man-days ha^{-1} $year^{-1}$)
1st	Existing	11.03	79.45	22.93	361
	Improved	15.15	92.88	35.13	586
2nd	Existing	9.57	81.10	24.32	364
	Improved	14.55	93.42	36.42	592
Mean	Existing	10.30	80.28	23.63	363
	Improved	14.85	93.15	35.78	589

Profitability analysis: The study revealed that the mean gross return of improved and existing cropping pattern was Tk. 282244 ha^{-1} and Tk. 200966 ha^{-1}, respectively (Table 5). The mean gross return of improved cropping pattern was 40% higher than that of existing cropping pattern. The higher gross return of improved cropping pattern might be due to inclusion of new crops and new high yielding varieties. The mean total variable cost of improved and existing cropping pattern was Tk. 174638 ha^{-1} and Tk. 106037 ha^{-1}, respectively (Table 5). The mean gross margin of alternate cropping pattern was 13% higher (Tk. 107607 ha^{-1}) than that of existing cropping pattern (Tk. 94929 ha^{-1}).

Table 5. Gross return, total variable cost and gross margin of existing (Lentil-Sesame-T.Aman) and alternate (Mustard-Mungbean-T.Aus-T.Aman) cropping pattern at Kushtia sadar, Kushtia

Cycles	Cropping pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk.ha^{-1})
1st	Existing	188197	107478	80719
	Alternate	252619	175175	77444
2nd	Existing	213734	104595	109139
	Alternate	311869	174100	137769
Mean	Existing	200966	106037	94929
	Alternate	282244	174638	107607

Price of produce (1st cycle) (Tk. kg^{-1}): Lentil- 85.00, Stover-2.00, Mustard- 46.50, Straw-1.00, Mungbean- 47.50, T.Aman-15.75, Straw-2.91, T.Aus-11.25, Sesame-30.00.

Price of produce (2nd cycle) (Tk. kg^{-1}): Lentil-65.00, Stover-2.00, Mustard-42.50, Straw-1.00, Mungbean-50.00, T.Aman-20.50, Straw-3.80, T.Aus-16.25, Sesame-30.50.

Table 6. Partial budgeting of existing (Lentil-Sesame-T.Aman) and improved (Mustard-Mungbean-T.Aus-T.Aman) cropping pattern at Kushtia sadar, Kushtia

Cycles	Economic disadvantage	Tk. ha^{-1} $year^{-1}$	Economic Advantage	Tk. ha^{-1} $year^{-1}$
1st	(a) Gross return of existing cropping pattern	188197	(e) Gross return from improved cropping pattern	252619
	(b) Total variable cost of improved cropping pattern	175175	(f) Total variable cost of existing cropping pattern	107478
	(c) Total (a+b)	363372	(g) Total (e+f)	360097
	(d) Net disadvantage (g-c)	-3275		
2nd	(a) Gross return of existing cropping pattern	213734	(e) Gross return from improved cropping pattern	311869
	(b) Total variable cost of improved cropping pattern	174100	(f) Total variable cost of existing cropping pattern	104595
	(c) Total (a+b)	387834	(g) Total (e+f)	416464
	(d) Net disadvantage (g-c)	28630		
Mean	(a) Gross return of existing cropping pattern	200966	(e) Gross return from improved cropping pattern	282244
	(b) Total variable cost of improved cropping pattern	174638	(f) Total variable cost of existing cropping pattern	106037
	(c) Total (a+b)	375604	(g) Total (e+f)	388281
	(d) Net disadvantage (g-c)	12677		

Economic advantage: The mean net economic advantage was Tk. 12677 ha^{-1} $year^{-1}$ which implied that four crop based improved cropping was economically viable than that of existing cropping pattern (Table 6). Similar trend was found in 2^{nd} (Tk. 28630 ha^{-1} $year^{-1}$) cycle. But net economic disadvantage was found in 1^{st} cycle (Tk. 3275 ha^{-1} $year^{-1}$), because farm gate price of lentil in existing cropping pattern was high whereas T.Aus price in improved cropping pattern was lower. In the 2^{nd} cycle, lentil price became lower and T.Aus price became higher which increased net advantage in improved cropping pattern.

Conclusion

The trial was conducted to verify the feasibility of growing improved cropping pattern Mustard-Mungbean-T.Aus-T.Aman rice and to compare its productivity and profitability with existing cropping pattern Lentil-Sesame-T.Aman rice. After completion of two cycles, soil was also tested. Post soil chemical analysis result revealed that the mean pH was slightly lower than initial value whereas organic matter content increased due to incorporation of mungbean in the soil of improved cropping pattern. The contents of K, Zn and B increased in post soil compared to initial soil while the contents of P and S decreased in post soil than initial soil. Total N is same in post and initial soil. The mean crop duration was 340 days for improved cropping pattern which implied that four crop based improved pattern is agronomically feasible to replace existing cropping pattern. Total seed/grain yield in terms of REY of improved cropping pattern was 14.85 t ha^{-1} $year^{-1}$ which was 44% higher than that of existing pattern (10.30 t ha^{-1} $year^{-1}$). Mean production efficiency (35.78 kg ha^{-1} day^{-1}), land use efficiency (93.15%) and labour employment (589 mandays ha^{-1} $year^{-1}$) of improved cropping pattern was 51%, 16% and 62%, higher, respectively than that of existing cropping pattern. The mean net economic advangaes of improved cropping pattern was Tk 12677 ha^{-1} $year^{-1}$ which implied that the improved cropping pattern was economically viable. Moreover, the improved cropping pattern increased cropping intensity, farmers knowledge, skill, and income as well as employment. The food and nutritional security will be ensured for the farmers of Kushtia region due to increase production of crops. It also maintained soil health by incorporating mungbean stover and T.Aus straw in the soil of improved cropping pattern. Farmers in Kushtia region of Bangladesh could follow Mustard (var. BARI Sarisha-15) - Mungbean (var. BARI Mung-6) - T.Aus rice (var. BRRI dhan48) - T.Aman rice (var. Binadhan-7) cropping pattern in their high and medium high land for higher productivity and profitability against existing pattern Lentil (var. BARI Masur-6) – Sesame (var. BARI Till-4) - T.Aman rice (var. Binadhan-7).

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