Feasibility of Introducing Four Crops Based Cropping Patterns in Kushtia Area of Bangladesh

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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 find out the productivity and profitability of three alternate cropping patterns, i.e. ACP_1=Mustard (var: BARI Sarisha-15) - Mungbean (var: BARI Mung-6) - T. Aus rice (var: BRRI dhan48) - T. Aman rice (var: Binadhan-7), ACP_2=Lentil (var: BARI Masur-6) - Mungbean (var: BARI Mung-6) - T. Aus rice (var: BRRI dhan48) - T. Aman rice (var:Binadhan-7), ACP_3=Wheat (var: BARI Gom-28) - Mungbean (var: BARI Mung-6) - T. Aus rice (var: BRRI dhan48) - T. Aman rice (var:Binadhan-7) against the existing cropping pattern, i.e. ECP= Lentil (var: BARI Mashur-6) – Sesame (BARI Teel-3) - T. Aman (var: Binadhan-7). Findings revealed that the required mean crop durations ranged 340-356 days for one cycle in a year in four crops based cropping patterns against 293 days in existing cropping pattern. Total seed/grain yields in terms of REY of ACP_1, ACP_2, and ACP_3 were 14.85, 16.06 and 14.92 t ha^{-1} $year^{-1}$, respectively which were 44%, 56% and 45%, respectively higher than that of existing pattern (10.30 t ha^{-1} $year^{-1}$). Mean production efficiency (32.53-40.43 kg $ha^{-1}day^{-1}$), land use efficiency (93.15-97.53%) and mean gross margin (Tk. 109393 - Tk. 127834 ha^{-1}) of all alternate cropping patterns were higher than that of existing cropping pattern (PE: 23.63 kg $ha^{-1}day^{-1}$, LUE: 80.28% and gross margin Tk. 94929 ha^{-1}). As a result, all alternate cropping patterns were agronomically feasible and economically profitable. Among the alternate cropping patterns, ACP_2=Lentil (var: BARI Masur-6) - Mungbean (var: BARI Mung-6) - T. Aus rice (var: BRRI dhan48) - T. Aman rice (var: Binadhan-7) performed the best. Therefore, farmers in Kushtia area of Bangladesh might follow the alternate cropping patterns in high and medium high land for higher crop productivity and profitability over existing cropping pattern.

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

1. Introduction

Bangladesh is the most densely populated (about 1033 persons per sq. km) country in the world with a population of 161.40 million, which is increasing annually at the rate of about 1.10% (Bangladesh Population, 2018). By the year 2030, the population will increase to about 186 million (United Nations, 2017). At present total cultivable land of the country is 8.44 million hectares and it is shrinking day by day. Demographic pressure and increased

urbanization have caused cultivated area to decline at a rate of 1% per year. There is very little scope of increasing cultivable land but there are some scopes of increasing cropping intensity (192%) by improving the existing cropping patterns through inclusion of short duration crops viz., mustard, potato, mungbean and T. Aus rice in the rice based cropping system (Mondal *et al.,* 2015).

The south western part (Kushtia, Meherpur, Chuadanga, Jhenaidah and Jashore districts) is located under Agro Ecological Zone (AEZ) 11 and 12. 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 piece of land in a year. The cropping intensity of this area ranges 260-264% and about 93% lands are under irrigation (DAE, 2016). Farmers in these areas 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 development of four crops based improved cropping patterns in these areas.

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 reasonable 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 of 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). Four crops based alternate cropping patterns Lentil-Mungbean-T. Aus rice-T. Aman rice in Faridpur region (Ahmed *et al.,* 2019), Lentil-Mungbean-T. Aus rice-T. Aman rice in high barind tract Rajshahi (Hossain *et al.,* 2018), Potato-Boro- T. Aus-T. Aman in Cumilla region (Hossain *et al.,* 2018) and Potato – Mungbean – Jute - T. Aman rice at Domar, Nilphamari (Chowdhury *et al.,* 2017) are agronomically feasible and economically profitable. With this view, the present study was, therefore, undertaken to find out the productivity and profitability of alternate cropping patterns and to compare its productivity, profitability, land use efficiency, and production efficiency against farmer's existing cropping pattern.

2. Materials and Methods

The study was conducted at Multi Location Testing (MLT) site under On-Farm Research Division (OFRD), BARI, Kushtia during the last week of February, 2015 to first week of March, 2017 at farmers' field condition. Soil samples were taken separately over 0-15 cm depth to determine baseline and post soil properties, respectively. Three four-crop based alternate cropping patterns (ACP), i.e., ACP_1= Mustard (var. BARI Sarisha-15) - Mungbean (var. BARI Mung-6) - T. Aus rice (var. BRRI dhan48) - T. Aman rice (var. Binadhan-7), ACP_2= Lentil (var. BARI Masur-6) - Mungbean (var. BARI Mung-6) - T. Aus rice (var. BRRI dhan48) - T. Aman rice (var. Binadhan-7), ACP_3= Wheat (var. BARI Gom-28) - Mungbean (var. BARI Mung-6) - T. Aus rice (var. BRRI dhan48) - T. Aman rice (var. Binadhan-7) and one existing cropping pattern (ECP); Lentil (var. BARI Masur-6) - Sesame (var. BARI Till-3) - T. Aman rice (var. Binadhan-7) as control were tested as per objectives.

The experiment was laid out in block approach where four blocks were separated and each block was consisted in one hectare of land for each cropping pattern including 7-8 farmers. The first block was mustard based ACP, second block lentil based ACP and third block wheat based ACP and fourth block existing cropping pattern based which was considered as control. The trial

was started by mungbean cultivation as first crops in all alternate cropping patterns. Lentil, sesame, mustard, wheat and mungbean seed was sown in broadcasting method due to minimize labour cost of farmers. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to Mondal *et al.* (2011), Azad *et al.,* (2014) and BRRI (2013) for studied crops. The fertilizer dose for studied crops was lentil (Farmers dose: 17.15-18.7-5-0-0-0 for NPKSZnB kgha^{-1} and Experiment dose: 20 - 17 - 17.5 - 9.44 -1-1 for NPKSZnB kgha^{-1}), sesame (86.5-18-26-9.5-0-0 for NPKSZnB kgha^{-1}), mustard (126-35-46-29.5-2.5-2.12 for NPKSZnB kgha^{-1}), wheat (20 - 17 - 17.5 - 9.44 -1-1for NPKSZnB kgha^{-1}), mungbean (17-17-18-10-0-1 for NPKSZnB kgha^{-1}), T. Aman (Farmer dose: 103.4-22.5-37.5-9.5-2.6 for NPKSZnB kgha^{-1} and Experiment dose: 86-22.5-37.5-9.5-1.61-0 for NPKSZnB kgha^{-1}) and T. Aus (86-22.5-37.5-9.5-2.15-0.6 for NPKSZnB kgha^{-1}).

Mugbean (var: BARI Mung-6) seed was sown in broadcasting method during 26 February–7 March and harvested during 01-11May in all ACPs (Table 2).After two picking of the pods, the entire green biomass (1.22-1.40 tha^{-1}) was ploughed down into soil and left for decomposition until the T. Aus was transplanted. In mungbean, Tafgor (2ml/L) and Imitaf 20 SL (0.5ml/L) were sprayed for controlling aphid and thrips, respectively.

T. Aus rice seedlings were grown in adjacent plot and transplanting was done with 24-25 days old seedling of rice var. BRRI dhan48 at a spacing 20 cm X 15 cm during 12-15 May for all ACPs. T. Aus rice was harvested during 06-08 August for all ACPs in two consecutive years. T. Aman rice seedlings were also grown in adjacent plot and transplanting was done with 27-28 days old seedling of rice var. Binadhan-7 for all cropping patterns at a spacing 20 cm X 15 cm during 09-12 August for all ACPs and 02-08 August for ECP. T. Aman rice was harvested during 06-12 November for all ACPs and 04-07 November for ECP in two consecutive years.

Mustard (var: BARI Sarisha-15) seed was sown in broadcasting method during 12-15 November and harvested during 07-10 February in ACP$_1$. In mustard, Rovral-50 WP @ 2 g/L was sprayed at early stage for controlling alternaria blight disease.

Lentil (var: BARI Masur-6) seed was sown in broadcasting method during 09-10 November in ACP$_2$and 15-18 November for ECP. Lentil was harvested on 26 February in ACP$_2$ and 03-07 March for ECP. In lentil, foot and root rot as well as stemphylium blight were observed in some plots. Provex-200 WP@ 3 g/L and Rovral-50 wp @ 2 g/L were sprayed at early stage for controlling these diseases.

Wheat (var: BARI Gom-28) seed was sown in broadcasting method during 16-17 November and harvested on 04 March in ACP$_3$. Sesame (var: BARI Til-3) seed was sown in broadcasting method during 15-18March and harvested during 11-14 June in ECP.

All field operations and management practices of both alternate and existing cropping patterns were closely monitored and the data were recorded for observing agro-economic performance. The yield data of product and by-product were recorded. Grain/seed and straw yields of all rice, mustard, lentil, wheat, sesame and mungbean as well as price data of all inputs and outputs were taken accordingly.

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

2.1 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:

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

Where, d_i = duration of the ith crop
   i = 1, 2, 3 and 4

2.2 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).

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

Where,

Yi = Yield of the ith crop
di = duration of the ith crop
i = 1, 2, 3 and 4

2.3 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).

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

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

2.4 Economic 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 four 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 (TVC) of different crops was calculated on the basis of taka per hectare of different operations performed and materials used for raising the crops. The MBCR of the existing cropping pattern and any replacement for it can be computed as the marginal value product ((MVP) over the marginal value cost (MVC). The Marginal of prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

Marginal Benefit Cost Ratio (MBCR) =

$$\frac{\text{Gross return (E)} - \text{Gross return (F)}}{\text{TVC (E)} - \text{TVC(F)}} = \frac{\text{MVP}}{\text{MVC}}$$

3. Results and Discussion

3.1 Changes in soil properties

The result of nutrient status of initial and post soil was 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 in mustard, lentil and wheat based four crops plot. After completion of two cycles, result revealed that the mean pH was slightly lower than initial value in all plots whereas OM, K, total N, P, S, Zn and B increased in lentil based four crops plot due to incorporation of mungbean in the soil and cultivation of lentil. The contents of K, Zn and B increased while OM, P and S decreased in mustard based four crops based plot. Total N was same in post and initial soil. In wheat based four crops plot, the contents of K, total N, P, Zn and B increased due to incorporation of mungbean in the soil but OM and S decreased in post soil than initial soil. These results were supported by the findings of Mondal *et al.* (2015), Chowdhury *et al.* (2017), Hossain *et al.* (2018) and Ahmed *et al.*(2019).

3.2 Crop management

Crop management practices of the cropping patterns are shown in Table 2. The average crop (field) duration of ACP$_1$, ACP$_2$ and ACP$_3$ took 340, 356 and 352 days, respectively while, existing cropping pattern required 293 days. Turnaround times in four crops based improved cropping patterns of ACP$_1$, ACP$_2$ and ACP$_3$ were 25, 09 and 13 days, respectively whereas it was 72 days in existing cropping pattern. All alternate cropping patterns were successfully accommodated in a year. Similar findings were cited by Ahmed *et al.*(2019), Hossain *et al.* (2018), Hossain *et al.*(2018), Chowdhury *et al.*(2017) and Mondal *et al.*(2015).

Table 1. Chemical properties of soil (0-15 cm depth) of the experimental field at Kushtia Sadar, Kushtia during the experimental period

Cropping pattern based plot	pH	Organic matter (%)	K meq/100 g soil	Total N (%)	P	S	Zn	B
						$\mu g \, g^{-1}$		
Initial (2015)								
Mustard based CP	7.8	2.17	0.24	0.11	11.70	20.40	0.87	0.47
Lentil based CP	8.1	1.97	0.27	0.10	10.70	18.21	0.87	0.41
Wheat based CP	7.9	1.92	0.28	0.09	8.80	18.40	0.72	0.54
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 (2017)								
Mustard based CP	7.7	1.92	0.25	0.11	11.45	18.24	0.95	0.58
Lentil based CP	7.2	2.28	0.29	0.11	11.25	20.48	0.92	0.58
Wheat based CP	7.8	1.87	0.32	0.10	9.17	16.57	0.85	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

3.3. Seed/Grain yield

The mean seed/grain yield of mustard, mungbean, T. Aus and T. Aman for ACP_1 were 1.35, 1.14, 5.10 and 4.59 t ha^{-1}, respectively (Table 2). In case of ACP_2 the mean seed/grain yield of lentil, mungbean, T. Aus and T. Aman were 1.37, 0.81, 4.99 and 4.42 t ha^{-1}, respectively. The mean seed/grain yield of wheat, mungbean, T. Aus and T. Aman for ACP_3 were 3.90, 0.80, 4.97 and 4.57 t ha^{-1}, respectively while in ECP lentil, sesame and T. Aman were 0.78, 1.25 and 4.90 t ha^{-1}, respectively. The yield of T. Aus rice was found satisfactory in all improved pattern, which might be due to residual effect of mungbean stover. The mean straw/stover yield of mustard, mungbean, T. Aus and T. Aman for ACP_1 were 1.96, 1.23, 4.02 and 4.07 t ha^{-1}, respectively while mean straw/stover yield of lentil, mungbean, T. Aus and T. Aman for ACP_2 were 1.51, 1.40, 4.10 and 4.01 t ha^{-1}, respectively. The mean straw/stover yield of wheat, mungbean, T. Aus and T. Aman for ACP_3 were 2.93, 1.31, 3.96 and 4.06 t ha^{-1}, respectively while in ECP lentil, sesame and T. Aman were 1.11, 2.23 and 4.12 t ha^{-1}, respectively. The yield of all crops showed similar trend in two consecutive years. Similar findings were found by Ahmed *et al.* (2019), Hossain *et al.* (2018), Hossain *et al.*(2018), Chowdhury *et al.*(2017), Mondal *et al.* (2015) and Hossain *et al.* (2014).

3.4. Rice equivalent yield

Total productivity of different cropping systems was evaluated in terms of rice equivalent yield (REY) and it was calculated from the yield of component crops. REYs varied due to different cropping systems (Table 3). The mean REY of ACP_1, ACP_2, ACP_3 and ECP were 14.85, 16.06, 14.92 and 10.30 tha^{-1}year^{-1}, respectively. The highest REY (16.06 tha^{-1}year^{-1}) was calculated at ACP_2 and it was followed by ACP_3 (14.92 tha^{-1}year^{-1}) and ACP_1 (14.85 tha^{-1}year^{-1}). Similar trends were found in two consecutive years except ACP_2 2nd cycle. The lowest REY was found in ECP (10.30 tha^{-1}year^{-1}). REY of ACP_1, ACP_2, ACP_3 was 44%, 56% and 45% higher over ECP (10.30 tha^{-1}year^{-1}). Higher rice equivalent yield was obtained in improved cropping pattern due to inclusion of new crops and varieties. It was evident from the above findings that alternate cropping patterns provided higher yield compared to existing pattern. This finding was supported by Ahmed *et al.* (2019), Hossain *et al.* (2018), Hossain *et al.* (2018), Chowdhury *et al.* (2017), Nazrul *et al.* (2017), Mondal *et al.* (2015), Hossain *et al.* (2014); and Nazrul *et al.* (2013).

3.5. 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 ACP_1, ACP_2, ACP_3 and ECP were 93.15, 97.53, 96.44 and 80.28%, respectively (Table 3). The highest land use efficiency (97.53%) was found in ACP_2 and it was followed by ACP_3 (96.44%) and ACP_1 (93.15%). Similar trends were found in two consecutive years. The lowest land use efficiency was found in ECP (80.28%).The land use efficiency was higher in alternate cropping patterns due to cultivation of more component crops in these patterns. The similar trend of the findings was cited by Chowdhury *et al.* (2017), Nazrul *et al.* (2017) and Nazrul *et al.* (2013).

3.6. Production efficiency

Maximum production efficiency was obtained from alternate cropping patterns over existing cropping pattern (Table 3). The higher production efficiency of alternate cropping patterns might be due to inclusion of four crops and new modern varieties as well as improved management practices. The mean production efficiency of ACP_1, ACP_2, ACP_3 and ECP were found to be 35.78, 32.53, 40.43 and 23.63 kg ha^{-1} day^{-1}, respectively which were 51%, 38% and 71% higher over existing cropping pattern (23.63 kg ha^{-1} day^{-1}). Results revealed that maximum production efficiency (40.43%) was found in ACP_3 and it was followed by ACP_1 (35.78%) and ACP_2 (32.53%). The lowest production efficiency was found in ECP (23.63%).

The same trend was observed in two consecutive years. Similar findings were cited by Ahmed *et al.* (2019), Chowdhury *et al.* (2017), Nazrul *et al.* (2017), Nazrul *et al.* (2013) and Khan *et al.* (2005) in case of improved cropping patterns.

3.7. Economic analysis

In terms of economic analysis, gross return, total variable cost and gross margin of system productivity of four cropping sequences differed among the cropping patterns. The mean gross return of ACP_1, ACP_2, ACP_3 and ECP were calculated at Tk. 284030, Tk. 304977, Tk.

288864 and Tk. 200966 ha^{-1}, respectively while the mean total variable cost of ACP_1, ACP_2, ACP_3 and ECP were found to be Tk. 174638, Tk. 177143, Tk. 178263 and Tk. 106037 ha^{-1}, respectively (Table 3). As a result, the mean gross margin of ACP_1, ACP_2, ACP_3 and ECP were calculated at Tk. 109393, Tk. 127834, Tk. 110601 and Tk. 94929 ha^{-1}, respectively which were 15%, 35% and 17% higher over existing cropping pattern.

The higher returns from alternate cropping patterns might be due to inclusion of new crops and high yielding varieties. Results revealed that the highest mean gross margin (Tk. 127834 ha^{-1}) was found in ACP_2 due to inclusion of high value crop lentil and it was followed by ACP_3 (Tk. 110601 ha^{-1}) and ACP_1(Tk. 109393 ha^{-1}). The lowest mean gross margin was found in ECP (Tk. 94929 ha^{-1}). According to cycles, the highest gross margin (Tk. 111855 ha^{-1}) was found in ACP_2 and it was followed by ECP (Tk. 80719 ha^{-1}), ACP_1 (Tk. 77444 ha^{-1}) and ACP_3 (Tk. 58569 ha^{-1}) in 1st cycle while in 2nd cycle, the highest gross margin (Tk. 162634 ha^{-1}) was found in ACP_3 and it was followed by ACP_2 (Tk. 143813 ha^{-1}), ACP_1 (Tk 141341 ha^{-1}) and ECP (Tk. 109139 ha^{-1}). The trend differed due to variation of yield and market prices in two consecutive years. The highest mean MBCR was found in ACP_2 (1.47) and it was followed by ACP_3 (1.24) and ACP_1 (1.21).

Similar findings were cited by Ahmed *et al.* (2019), Hossain *et al.* (2018), Hossain *et al.* (2018), Chowdhury *et al.*(2017), Nazrul *et al.* (2017), Nazrul *et al.* (2013) and Khan *et al.* (2005) in case of improved cropping patterns. The profitability analysis showed that inclusion of mustard, mungbean, lentil, wheat and T. Aus in the existing cropping pattern showed higher benefit. Among the alternate cropping patterns, ACP_2 (Lentil-Mungbean-T. Aus-T. Aman) was found the best for higher benefit. The gross return of 2nd cycle in all cropping patterns was higher due to higher market price of rice compared to 1st cycle. As a result, gross margin and MBCR were higher in 2nd cycle.

Table 2. Performance of different crops under existing and alternate cropping patterns during 2015-2017 at Kushtia Sadar, Kushtia

Parameters	Cycle	Existing Cropping Pattern (ECP)			Alternate Cropping Pattern 1(ACP₁)				Alternate Cropping Pattern 2 (ACP₂)				Alternate Cropping Pattern 3 (ACP₃)			
Crop		Lentil	Sesame	T. Aman	Mustard	Mung-bean	T. Aus	T. Aman	Lentil	Mung-bean	T. Aus	T. Aman	Wheat	Mung-bean	T. Aus	T. Aman
Variety		BARI Masur-6	BARI Til-3	BINA dhan-7	BARI Sarisha-15	BARI Mung-6	BRRI dhan48	BINA dhan-7	BARI Masur-6	BARI Mung-6	BRRI dhan48	BINA dhan-7	BARI Gom-28	BARI Mung-6	BRRI dhan48	BINA dhan-7
Date of transplanting/ sowing	1ˢᵗ	18/11/15	18/3/15	2/8/15	15/11/15	27-28/02/15	13-14/05/15	10-12/08/15	09/11/15	01/03/15	14/05/15	09/08/15	17/11/15	07/03/15	14/05/15	10/08/15
	2ⁿᵈ	15/11/16	15/03/16	04/08/16	12-14/11/16	28/02/16	12-14/05/16	10-12/08/16	10/11/16	01/03/16	14/5/16	09/08/16	16/11/16	07/03/16	15/05/16	11/08/16
Date of harvesting	1ˢᵗ	03/03/16	11/06/15	07/11/15	07-09/02/16	01-10/05/15	06-08/08/15	11-12/11/15	26/02/16	10/05/15	06/08/15	06/11/15	04/03/16	10/05/15	06/08/15	11/11/15
	2ⁿᵈ	06/03/17	14/06/16	04/11/16	08-10/02/17	01-08/05/16	06-08/08/16	11-12/11/16	26/02/17	11/05/16	06/08/16	06/11/16	04/03/17	10/05/16	07/08/16	11/11/16
Field duration (days)	1ˢᵗ	106	86	98	86	73	86	94	110	71	85	90	108	65	85	94
	2ⁿᵈ	111	92	93	89	72	87	93	109	72	85	90	109	65	85	93
	Total		293			340				356				352		
Turn around time	1ˢᵗ	10	14	51	18	2	4	2	02	03	02	02	02	03	03	05
	2ⁿᵈ	10	9	50	17	3	3	2	02	02	02	03	02	04	03	04
	Total		72			25				09				13		
Seed/Grain yield (t ha⁻¹)	1ˢᵗ	0.75	1.20	4.70	1.20	1.15	4.97	4.59	1.21	0.81	4.93	4.49	3.49	0.78	4.88	4.46
	2ⁿᵈ	0.80	1.30	5.10	1.49	1.12	5.22	4.59	1.52	0.81	5.05	4.34	4.31	0.81	5.05	4.68
	Mean	0.78	1.25	4.90	1.35	1.14	5.10	4.59	1.37	0.81	4.99	4.42	3.90	0.80	4.97	4.57
Stover/straw yield (t ha⁻¹)	1ˢᵗ	1.10	2.30	4.20	2.00	1.24	4.16	4.12	1.65	1.40	4.25	4.07	2.86	1.22	3.93	4.10
	2ⁿᵈ	1.11	2.15	4.03	1.92	1.22	3.88	4.02	1.37	1.40	3.95	3.94	2.99	1.40	3.98	4.02
	Mean	1.11	2.23	4.12	1.96	1.23	4.02	4.07	1.51	1.40	4.10	4.01	2.93	1.31	3.96	4.06

Table 3. Economic performance of existing and alternate cropping patterns at Kushtia Sadar, Kushtia during 2015-17

Parameters	Cycle	ECP	ACP$_1$	ACP$_2$	ACP$_3$
Rice equivalent yield (t ha^{-1})	1st	11.03	15.15	16.98	14.45
	2nd	9.57	14.55	15.14	15.39
	Mean	10.30	14.85	16.06	14.92
Land use efficiency (%)	1st	79.45	92.88	97.53	96.44
	2nd	81.10	93.42	97.53	96.44
	Mean	80.28	93.15	97.53	96.44
Production efficiency (kg/ha/day)	1st	22.93	35.13	32.13	38.66
	2nd	24.32	36.42	32.92	42.19
	Mean	23.63	35.78	32.53	40.43
Gross return (Tk. ha^{-1})	1st	188197	252619	282649	240994
	2nd	213734	315441	327305	336734
	Mean	200966	284030	304977	288864
Total variable cost (Tk. ha^{-1})	1st	107478	175175	170794	182425
	2nd	104595	174100	183492	174100
	Mean	106037	174638	177143	178263
Gross margin (Tk.ha^{-1})	1st	80719	77444	111855	58569
	2nd	109139	141341	143813	162634
	Mean	94929	109393	127834	110601
MBCR	1st		0.95	1.49	0.70
	2nd		1.46	1.44	1.77
	Mean		1.21	1.47	1.24

Unit price 2015-2016: lentil: Tk. 85/kg; Sesame: Tk. 30/kg; T. Aman: Tk. 15.75/kg; Mustard: Tk. 46.50/kg; Mungbean: Tk. 47.50/kg; T.Aus: Tk. 11.25/kg; and wheat: Tk. 18.75/kg.
Unit price 2016-17: lentil: Tk. 65/kg; Sesame: Tk. 30.50/kg; T. Aman: Tk. 20.50/kg; Mustard: Tk. 42.50/kg; Mungbean: Tk. 50/kg; T. Aus: Tk. 16.25/kg; and wheat: Tk. 22.50/kg.

4. Conclusions

The above findings showed that all alternate cropping patterns were superior to existing cropping pattern in terms of seed/grain yield, REY, production efficiency, land use efficiency and profitability. It could be easily fitted in the existing cropping pattern within a year. Soil chemical analysis revealed that organic matter, N, Zn and B content increased due to incorporation of mungbean in the soil of alternate cropping pattern. Among the alternate cropping patterns, ACP$_2$=Lentil (var: BARI Masur-6) - Mungbean (var: BARI Mung-6) - T.Aus rice (var: BRRI dhan48) - T. Aman rice (var: Binadhan-7) was the best. The cropping intensity and productivity could be increased by growing four crops in a year in the same piece of land. So, the farmers in Kushtia area of Bangladesh might follow these alternate patterns in their high and medium high land for higher productivity and profitability.

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