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ON-FARM EVALUATION OF IMPROVED PATTERN THROUGH INCLUSION OF MUSTARD IN FALLOW PERIOD PRECEDING T. AUS-T. AMAN RICE CROPPING IN SYLHET REGION

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Abstract

The study was conducted at the farmer's field in Sylhet under AEZ 20 during three consecutive years 2016-17, 2017-18 and 2018-19 to determine the productivity and profitability of cropping patterns viz. IP: improved pattern (Mustard-T. Aus-T. Aman rice) by introducing high yielding varieties and improved management practices and FP: farmer's pattern (Fallow-T. Aus-T. Aman rice). The experiment was laid out in randomized complete block design with six dispersed replications. Results showed that the improved pattern with management practices provided 6.88 and 22.84 % higher grain yield of T. Aus and T. Aman rice, respectively; also contributed higher mean rice equivalent yield (9.44 t ha^{-1}) compared to farmer's pattern.Sustainable yield index (0.36), production efficiency (39.75 kg ha^{-1}day^{-1}), and land use efficiency (75.98 %) were maximum in Mustard-T. Aus- T. Aman rice cropping system on an average. Similarly, the highest mean gross margin (Tk.1,12,425 ha^{-1}) with benefit cost ratio (2.13) was obtained from improved pattern. Three years results revealed that 24% extra cost provides an ample scope of considerable improvement of the productivity with the inclusion of Mustard before T. Aus rice in improved pattern.

Introduction

In Sylhet region, mainly Fallow - T. Aus - T. Aman rice cropping pattern is widely followed by farmers under rainfed condition. Transplantation of Aus rice is being dependent on rainfall, which sown during early monsoon (early May). This delayed transplantation of T. Aus rice that causes late cultivation and harvesting of T. Aman rice, which hampered timely cultivation of rabi crops. The soils under these cropping pattern areas are generally heavy silty clay loams to clays and the top soil quickly becomes dry and hard after the harvest of T. Aman rice. In Eastern Surma Kushiara Floodplain of Sylhet region, a vast area remains fallow for a long time after the harvest of T. Aman rice due to moisture stress up to next season for cultivation of T. Aus rice following the existing cropping pattern (Fallow-T. Aus-T. Aman rice). However, the yields of rice are very low compared to other regions of the country.

Generally, rainfall starts in February and prevails up to November in each year that offers an excellent opportunity for the production of short duration pulse and oilseed crops before T. Aus rice. Shaheb *etal.*(2012) reported that mustard varieties can be grown well in fallow land of Sylhet where var. BARI Sarisha-14 and BARI Sarisha-17 could be more suitable and produced higher seed yield. To enhance the crop production through utilization of fallow land in Sylhet region, the potato-rice and chickpea-rice based cropping patterns have been developed (Nazrul *et al.,* 2013; Nazrul and Shaheb, 2012; Shaheb *et al.,* 2011).

A number of reports on different cropping pattern are available in Bangladesh 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.* 1992; Khan *et al.,* 2005 and Nazrul *et al.,* 2013, Kamrozzaman *et al*., 2015*)*. But, little effort has been made for on-farm evaluation of the improved technologies of Mustard-T. Aus-T. Aman rice cropping pattern in Sylhet area. The present study was therefore, initiated to determine productivity and economic feasibility of an improved package of technologies over the farmer's existing practices.

Materials and Methods

The study was carried out during three consecutive years 2016-17, 2017-18 and 2018-19 at farmer's field, Sylhet (24°54'N latitudes and 91°58' E longitude) located in Agro Ecological Zone (AEZ)-20; under Eastern Surma Kushiyara Floodplain. This trial was conducted to derive the economic consequences of two cropping patterns viz. IP: improved pattern (Mustard-T. Aus rice-T. Aman rice) and FP: farmer's pattern (Fallow-T. Aus rice-T. Aman rice) through incorporation of high yielding varieties with improved management practices.

Annual monthly total rainfalls, along with maximum and minimum average temperatures during the study period are presented in Figure 1. The highest amount of average monthly rainfall occurred in June followed by July and May, whereas lowest amount of rainfall occurred in January followed by November and December. Rainfall increases gradually from the month of January to June and then decreases. The crops received 4295, 5045 and 3575 mm total rainfall during crop season of 2016-17, 2017-18 and 2018-19, respectively.

The monthly maximum air temperature of 35.80, 37.00 and 38.30°C and minimum of 10.30, 10.30 and 8.00°C during the crop season of 2016-17, 2017-18 and 2018-19, respectively. The soil was clay loam with low organic matter content (1.63%) and soil pH was ranged 4.1-5.63 acidic in nature. The initial status of N (0.07%), P (7.59 µg/soil), K (0.18 meq/100g soil), S (10.80 µg/soil), B (0.34 µg/soil) and Zn (1.27 µg/soil) was very low, low, low, low, medium and medium, respectively. The trial was laid out in randomized complete block design with six dispersed replications. Two plots of 500 m^2 were selected for each replication. One plot was under the improved pattern and the other farmer's pattern.

In the improved pattern, mustard var. BARI Sarisha-14 was introduced against fallow period. T. Aus rice var. BRRI dhan65 and T. Aman rice var. BRRI dhan57 was introduced instead of BR-26 and BRRI dhan33, respectively. The agronomic parameters and cultural operation for crop production under improved and farmer's practices are presented in Table 1. All field operation and management practices of both farmer's and improved pattern were closely monitored and the data were recorded for agro-economic performance. The differences between mean was compared by t-test.

Agronomic performance viz. land use efficiency, production efficiency, rice equivalent yield and sustainable yield index of cropping patterns were calculated. Land use efficiency is worked out by taking total duration of individual crop in a sequence divided by 365 days (Tomer and Tiwari, 1990). It is calculated by following formula:

$$\text{Land use efficiency} = \frac{d_1 + d_2 + d_3}{365} \times 100$$

Where d_1, $d_2$and $d_3$the duration of first, secondand third crops of the pattern.

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

$$\text{Production efficiency} = \frac{Y_1 + Y_2 + Y_3}{d_1 + d_2 + d_3} \ (\text{Kg ha}^{-1}\text{day}^{-1})$$

Where, Y_1: Yield of first crop; and d_1: Duration of firstcrop of the pattern; Y_2: Yield of secondcrop and d_2: Duration of second crop of the pattern; Y_3: Yield of third crop and d_3: Duration of third crop of the pattern.

Sustainable Yield index (SYI): The yield data from two different cropping systems was processed and interpreted in terms of SYI. The SYI of individual treatment in each year of experimentation was calculated following the equation suggested by Singh *et al.* (1990).

$$\text{Sustainable yield index} = \frac{(Y_t - \sigma)}{Y_m}$$

Where, Y_t is mean yield of respective treatment, σ is the standard deviation (SD) and Ym is the maximum yield obtained under a set of management practices in any of the treatment and any of year in a given experiment.It indicates that sustainability in production over a period of time even though crop has high yields may or may not give sustainable yield index. Sustainability depends upon variation in the yield during crop period; if during the initial period yield is very low and hereafterit reached very high, as here variation is more from starting period to last, there is more yield but less sustainability and if crop yield variation is less from the beginning to the end there may be higher or lower yield but SYI would be higher.

Rice equivalent yield:

For comparison between crop sequences, 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).

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

The economic indices like gross and net returns and benefit cost ratio were also calculated on the basis of prevailing market price of the produces. For economic evaluation of two different cropping sequences averaged data of two crop cycles were used. The gross cost of cultivation of different crops was calculated on the basis of different operations performed and materials used for raising the crops. Benefit cost ratio (BCR) was also calculated by the following formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return (Tk. ha}^{-1})}{\text{Total (variable) cost of cultivation(Tk. ha}^{-1})}$$

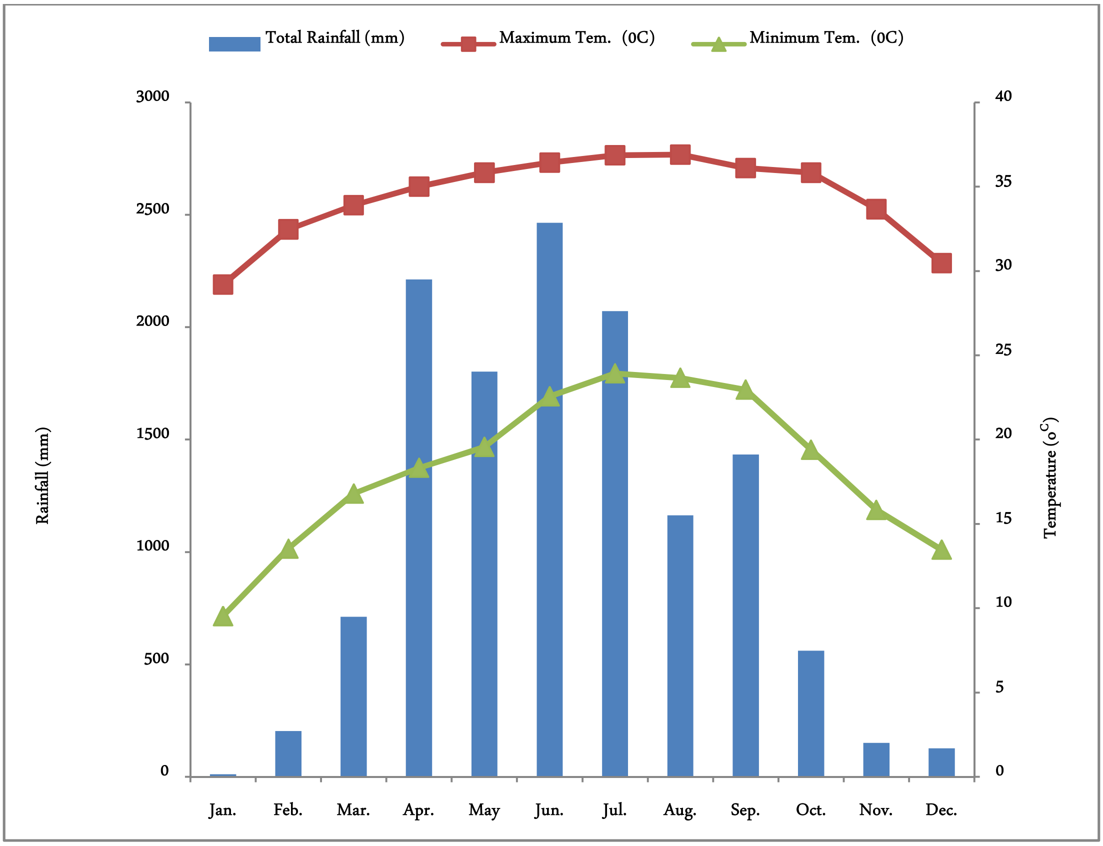

Fig.1. Average of three years monthly total rainfall (mm), maximum and minimum air temperatures during study period (Source: Metrological Department, Sylhet).

Results and Discussion

Yield of rice and mustard: In rice, the average yield of T. Aus and T. Aman was varied from 3.20 - 4.43 t ha^{-1}. In mustard, the variety BARI Sarisha-14 was produced 1.19 t ha^{-1} of seed yield in CP_2 whereas lands remain fallow in CP_1 at that period. The variety of T. Aus and T. Aman rice was given higher grain yields under the pattern CP_2 it might be due to use of improved rice variety. The highest average yield of T. Aus (3.43 tha^{-1}) and T. Aman (4.40 tha^{-1}) rice was provided by CP_2(Table 1).

T. Aman rice equivalent yield: The total productivity of the cropping sequence was ascertained by the rice equivalent yield (REY) it was calculated from the yields of component crops. REY was varied under different cropping sequence. In average of two years revealed that the highest REY (9.37 t ha^{-1}) was recorded from CP_2 as compared to CP_1 (6.46 t ha^{-1}). Inclusion of mustard and modern variety of T. Aus and T. Aman rice in CP_2 increased REY 45.00% as compared to CP_1.

Table 1. Agronomic practices of improved (Mustard T. Aus-T. Aman rice) and farmer's existing (Fallow-T. Aus-T. Aman rice) cropping patterns during 2016-19

Parameters	Cropping pattern index	Farmer's pattern (FP)			Improved pattern (IP)		
		2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Variety	C_1	Fallow	Fallow	Fallow	BARI Sarisha-14	BARI Sarisha-14	BARI Sarisha-14
	C_2	BR-26	BR-26	BR-26	BRRI dhan65	BRRI dhan65	BRRI dhan65
	C_3	BRRI dhan33	BRRI dhan33	BRRI dhan33	BRRI dhan57	BRRI dhan57	BRRI dhan57
Date of Sowing/ Transplant	C_1	Fallow	Fallow	Fallow	20-25 Nov	20-25 Nov	20-25 Nov
	C_2	10-15 May	10-15 May	10-15 May	10-15 May	10-15 May	10-15 May
	C_3	12-15 Aug	12-15 Aug	12-15 Aug	12-15 Aug	12-15 Aug	12-15 Aug
Seed rate (kgha^{-1})	C_1	Fallow	Fallow	Fallow	6-7	6-7	6-7
	C_2	35-40	35-40	35-40	25-30	25-30	25-30
	C_3	30-35	30-35	30-35	25-30	25-30	25-30
Planting method	C_1	Fallow	Fallow	Fallow	Broadcast	Broadcast	Broadcast
	C_2	Line	Line	Line	Line	Line	Line
	C_3	Line	Line	Line	Line	Line	Line
Spacing (cm) (Row×Hill)	C_1	Fallow	Fallow	Fallow	-	-	-
	C_2	20×10	20×10	20×10	25×15	25×15	25×15
	C_3	20×15	20×15	20×15	25×15	25×15	25×15
Fertilizer dose (kgha^{-1}) (NPKSZn)	C_1	Fallow	Fallow	Fallow	92-27-40-12-1.0	23-20-17-15-1.0	23-20-17-15-1.0
	C_2	83-20-40-5-1	83-20-40-5-1	83-20-40-5-1	75-15-30-6-0.6	75-15-30-6-0.6	75-15-30-6-0.6
	C_3	92-24-60-8-0.5	92-24-60-8-0.5	92-24-60-8-0.5	90-10-35-8-1.0	90-10-35-8-1.0	90-10-35-8-1.0
Fertilizer application method	C_1	Fallow	Fallow	Fallow	Half N and all other fertilizer nutrients applied as basal; remaining N top dressed at flowering	Half N and all other fertilizer nutrients applied as basal; remaining N top dressed at flowering	Half N and all other fertilizer nutrients applied as basal; remaining N top dressed at flowering
	C_2	All PKS used as basal during final land preparation. Nused in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	All PKS used as basal during final land preparation. Nused in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	All PKS used as basal during final land preparation. N_2used in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	Half of nitrogen and all other fertilizers applied as basal during final land preparation. Remaining nitrogen was top dressed at 40-45 DAS under moist soil condition	Half of nitrogen and all other fertilizers applied as basal during final land preparation. Remaining nitrogen was top dressed at 40-45 DAS under moist soil condition	Half of nitrogen and all other fertilizers applied as basal during final land preparation. Remaining nitrogen was top dressed at 40-45 DAS under moist soil condition
	C_3	All PKS used as basal	All PKS used as basal	All PKS used as basal	All PKSZn used as basal	All PKSZn used as basal	All PKSZn used as basal

Parameters	Cropping pattern index	Farmer's pattern (FP)			Improved pattern (IP)		
		2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
		during final land preparation. Nused in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	during final land preparation. Nused in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	during final land preparation. Nused in 2 equal splits at 15-20 DAT and another one in 35-40 DAT.	and N used in 3 equal splits, the first one after 15DAT, second one at 35-40 DAT and third one at 5-7 days beforepanicle initiation	and Nused in 3 equal splits, the first one after 15 DAT, second one at 35-40 DAT and third one at 5-7 days before panicle initiation	and N used in 3 equal splits, the first one after 15DAT, second one at 35-40 DAT and third one at 5-7 days before panicle initiation
Weeding (no.)	C_1	Fallow	Fallow	Fallow	0	0	0
	C_2	2	2	2	2	2	2
	C_3	1	1	1	2	2	2
Irrigation/Rainfed	C_1	Fallow	Fallow	Fallow	Rainfed	Rainfed	Rainfed
	C_2	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed
	C_3	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed
Insect-pest control	C_1	Fallow	Fallow	Fallow	IPM	IPM	IPM
	C_2	Chemical	Chemical	Chemical	IPM	IPM	IPM
	C_3	Chemical	Chemical	Chemical	IPM	IPM	IPM
Harvest time (date)	C_1	Fallow	Fallow	Fallow	20-28 Feb.	20-28 Feb.	20-28 Feb.
	C_2	10-15 Aug	10-15 Aug	10-15 Aug	28-30 July	28-30 July	28-30 July
	C_3	10-16 Dec	10-16 Dec	10-15 Dec	15-20 Nov	15-20 Nov	15-20 Nov
Field duration (days)	C_1	Fallow	Fallow	Fallow	75-80	75-80	75-80
	C_2	105-110	105-110	105-110	95-100	95-100	95-100
	C_3	112-115	112-115	105-115	100-105	100-105	100-105
Total duration (days)		217-225	217-225	210-225	270-285	270-285	270-285

C_1: Fallow/Mustard; C_2: T. Aus; C_3: T. Aman rice; IPM: integrated pest management

Grain/Seed Yield of the Cropping Patterns

Improved pattern took 270-285 days against 217-225 days due to inclusion of mustard the pattern. This indicates that mustard could easily be grown or fitted before T. Aus rice. The grain yield of rice was significantly higher in the improved pattern as compared to farmers existing pattern during individual years and mean data (Table 2). Variation in the yield of rice as evident in the improved pattern might be due to change of variety with improved production technologies. Similar results were also obtained by Nazrul *et al*. (2013) and Khan *et al*. (2005) in case of rice based cropping sequences. In all the years, farmers' pattern gave lower grain yield of rice due to imbalance use of fertilizers and traditional management practices. On the contrary, the yield of T. Aus and T. Aman rice was higher in improved pattern due to insertion of high yielding modern rice varieties. During experimentations in year of 2017-18, the rice bug was found in T. Aman rice field at panicle formation to flowering. But it was successfully controlled by applying chlorpyrifos insecticide (Dursban 20 EC @ 20 ml in 10 liters of water for 5 decimal areas). The rice variety, BRRI dhan65 and BRRI dhan57 in improved pattern performed better than BR-26 and BRRI dhan33 in farmers' practices due to higher yield potential of the variety.

By-product yield of the cropping patterns

The improved cropping pattern produced higher amount of total by-product yield (9.06 tha^{-1}) than the by-product yield of the crops (8.74 t ha^{-1}) of the farmers' pattern (Table 2). The by-product yield of improved pattern was higher due to introduction and change of variety with improved technologies for the component crops. In all the years, mustard contributed valuable by-product. On the contrary, farmers are not able to sale by-product (rice straw) in the local market; whereas, the by-product of mustard has been used as fuel by the farmers.

Table 2**.** Productivity of improved (Mustard-T. Aus-T. Aman) and farmer's existing (Fallow-T. Aus-T. Aman) cropping patterns during 2016-19

Years	Cropping patterns	Seed/Grain yield (t ha^{-1})			By product yield (t ha^{-1})		
		Fallow/Mustard	T. Aus	T. Aman	Fallow/Mustard	T. Aus	T. Aman
2016-17	FP	-	3.20	3.64	-	4.25	4.68
	IP	1.19	3.42	4.43	3.19	4.32	4.75
2017-18	FP	-	3.17	3.60	-	4.20	4.56
	IP	0.96	3.43	4.36	3.00	4.35	4.72
2018-19	FP	-	3.22	3.54	-	4.14	4.35
	IP	1.20	3.40	4.44	3.21	4.35	4.70
Mean	FP	-	3.20	3.59	-	4.21	4.53
	IP	1.12	3.42	4.41	3.13	4.34	4.72

Rice equivalent yield

The component crops of Mustard-T. Aus-T. Aman rice cropping pattern under improved practices (IP) gave higher T. Aman rice equivalent yields against grain yield as well as by-product in all the years. The mean rice equivalent yield under improved cropping pattern also produced higher rice equivalent yield over farmers' traditional cropping pattern (Table 3). On an average, the T. Aman rice equivalent yield in improved pattern increased 47% over the crops under farmers' practices. Inclusion of high yielding new crop varieties with improved management practices increased the higher T. Aman rice equivalent yield. It was also due to higher price of components crops in the improved pattern. Lower rice equivalent yield was obtained in the farmers' pattern probably due to variety and traditional management practices.

Production efficiency

Maximum production efficiency was obtained from improved pattern during individual years and also means data (Table 3). The higher production efficiency of improved cropping pattern might be due to inclusion of a new or modern varieties and management practices. In conversely, the lowest production efficiency was observed in farmers' pattern where crop remained in the field for shorter time and yields were also lower, leading to lower production per day. Mean production efficiency (39.75 kg ha^{-1}day^{-1}) was higher in improved pattern and lower (30.18 kg ha^{-1}day^{-1}) in farmers' pattern. Similar trend were noted by Nazrul *et al*. (2013) and Khan *et al*. (2005) in case of improved cropping sequences.

Land use efficiency

Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The average land-use efficiency indicated that improved pattern used the land for 75.98% period of the year, whereas farmer's pattern used the land for 60.55% period of the year (Table 3). The land use efficiency was higher in improved pattern due to cultivation of mustard as additional crop in fallow period.

Sustainable yield index

The sustainable yield index (SYI) of farmer's and improved cropping pattern is presented in Table 3. The values of sustainable yield index as a measure of sustainability of the system which was high in the improved cropping system (0.34-0.37) over farmer's practices (0.18). The results showed that between two different cropping systems Mustard-T. Aus-T. Aman rice recorded the highest mean SYI of 0.36 followed by Fallow-T. Aus-T. Aman rice (0.18). So, cropping system including mustard in fallow period and modern varieties of T. Aus and T. Aman rice recorded higher SYI compared to fallow-rice based crop sequences. The results are in agreement with the findings of Nazrul *et al.* (2017); Nazrul *et* *al*. (2013) and Ram *et al.* (2012). This indicated that improved pattern is therefore, more stable than farmer's pattern. Mustard is providing special advantage regarding utilization of mustard straw as fuel instead of cow dung.

Table 3**.** Rice equivalent yield, production efficiency, land use efficiency and sustainable yield index of improved and farmers patterns at farmer's field during 2016-19

Years	Cropping patterns	Rice (T. Aman) equivalent yield (tha^{-1})	Production efficiency (Kg ha^{-1}day^{-1})	Land use efficiency (%)	Sustainable yield index (SYI)
2016-17	FP	6.48	30.40	59.45	0.18
	IP	9.59	40.18	73.97	0.37
2017-18	FP	6.42	30.09	60.55	0.18
	IP	9.12	38.89	75.90	0.34
2018-19	FP	6.40	30.04	61.64	0.18
	IP	9.59	40.18	78.08	0.37
Mean	FP	6.43	30.18	60.55	0.18
	IP	9.43	39.75	75.98	0.36

Economic

Between two crop sequences, the improved cropping pattern showed its superiority over farmers' existing pattern during three consecutive years of cropping season. On an average, gross return of the improved pattern was Tk. 212175 ha^{-1} which was more than 47% higher than farmers' pattern of Tk. 144675 ha^{-1} (Table 4). The production cost of the improved pattern (Tk. 99750 ha^{-1}) was higher than farmers' pattern (Tk. 80761 ha^{-1}) due to introduction of mustard in fallow period, cost of fertilizer and other inputs. The gross margin was substantially higher in the improved pattern (Tk. 112425 ha^{-1}) than farmers' pattern (Tk. 63914 ha^{-1}). Inclusion of mustard and improved varieties of rice in these cropping systems, increasing the system productivity fetched higher market price; thereby, increasing the gross margin. The 76 % additional gross margin was achieved by adding 24 % additional cost in the improved pattern. Returns per Taka invested were highest for mustard-T. Aus-T. Aman rice (2.13) over the farmers' pattern (1.79).

Table 4. Cost benefit analysis of improved and farmer's existing cropping pattern at farmer's field (average of three years).

Years	Cropping patterns	Gross return (Tk. ha^{-1})	Cost of cultivation (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
2016-17	FP	145800	80761	65039	1.81
	IP	215775	99750	116025	2.16
2017-18	FP	144450	80761	63689	1.79
	IP	205200	99750	105450	2.06
2018-19	FP	144000	80761	63239	1.78
	IP	215775	99750	116025	2.16
Mean	FP	144675	80761	63914	1.79
	IP	212175	99750	112425	2.13

Note- FP: Farmer's pattern, IP: Improved patter; the costs (Tk. kg^{-1}): rice seed (32.00), mustard seed (90.00), and, urea (20.00), TSP (22.00) and MoP (15.00);

Among field operations, the cost of plowing was taken as Tk. 10 decimal^{-1}, labour cost of Tk. 350m^{-1} day^{-1}. Gross returns included income from sale of main and by-products (Tk. ka^{-1}) of all crops; T. aus rice (20.00), T. aman rice (22.50), mustard (40.00), rice straw (0.50), mustard stover (1.00).

Conclusion

Three years study revealed that Mustard-T. Aus-T. Aman rice cropping system is more productive, sustainable and remunerative for medium high land under Eastern Surma Kushiyara Floodplain (AEZ 20). So, farmers of commanding area could follow Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan65)-T. Aman rice (var. BRRI dhan57) cropping pattern for higher productivity and profitability as well as mustard straw can be utilized as fuel instead of cow dung.

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