PRODUCTION POTENTIALS AND ECONOMICS OF CHICKPEA-RICE BASED CROPPING SYSTEM IN SYLHET AREA (AEZ 20)

MD. RAYHAN SHAHEB[1], MAHMUDUL ISLAM NAZRUL[2]
AND M. J. U. SARKER[3]

Abstract

Global food and feed demands have been projected to double in the 21st century, which will further increase the pressure on the use of land, water and nutrients. To increase food productivity, production potential and economic returns, improvement of cropping system may play a vital role in this regards. A study was conducted to determine the economic consequences of two cropping patterns viz., ICP: Improved Cropping Pattern (Chickpea-T.Aus-T.Aman) and FECP: Farmer's Existing Cropping Pattern (Fallow-T. Aus-T. Aman) through incorporation of modern high yielding varieties and improved management practices for crop production at farmers' fields of Sylhet during three consecutive years 2009-10, 2010-11, and 2011-12, respectively. The experiment was laid out in randomized complete block design with six dispersed replications. The pooled data showed that the improved management practices for the pattern provided higher yield in T.Aus and T.Aman rice, respectively. The gross return and gross margin of ICP were higher compared to that of FECP with only 21% extra cost. The higher benefit cost ratio (2.20), rice equivalent yield (10.29 t/ha), production efficiency (27.36 kg/ha/day), land-use efficiency (91.32%) and sustainable yield index (0.41) indicated the superiority of the ICP over the FECP. Higher rice equivalent yield indicate that ICP is suitable in Sylhet region for increasing crop productivity and cropping intensity.

Keywords: Improved cropping pattern, agro-economic performance, land use efficiency, production efficiency, fallow land utilization.

Introduction

In Sylhet, vast areas of lands remain fallow in each year during rabi season due to lack of irrigation facilities. Fallow-Transplanted Aus (T. Aus)-Transplanted Aman (T. Aman) rice is the dominant cropping pattern in this region under rainfed condition in medium highland to lowland areas of Surma-Kushyara Floodplain. Transplantation of T. Aus rice being depended on rainfall, its seeds generally sown during early monsoon (early May). This delayed transplantation of Aus rice hampered the timely cultivation of subsequent T. Aman rice and resulting delay sowing of winter crops. The soils under these cropping pattern areas are generally heavy, clay loams to clays and the top soil quickly becomes dry and hard after the harvest of T.Aman crop. Rainfall prevails from late

[1&2]Senior Scientific Officer, On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Sylhet-3100 and [3]Chief Scientific Officer, OFRD, BARI, Gazipur, 1701, Bangladesh.

October to early November usually in each year that offers the opportunity for the production of short duration crop by utilizing the residual moisture.

On the contrary, soil fertility and productivity status in Sylhet region are not satisfactory due to low organic matter content in soil, imbalance use of inorganic fertilizer, less use of organic manure and use of high yielding modern crop varieties. So, it is urgent to include pulse crops that fixed biological nitrogen by fixation to the soil and plant that ultimately make the soil fertile. Soil organic matter was increased by 26% and total nitrogen content showed an increasing trend, while available phosphorus, and exchangeable K content were also improved in the soil with the incorporation of pulses into the cropping pattern (Islam *et al*., 1993). Results from the on-farm trials with chick pea varieties in several years in Sylhet showed that short duration chickpea variety BARI Chhola-5 grew well in this region (Nazrul and Shaheb, 2011; Shaheb *et al*., 2011). In order to increase production, chickpea based cropping pattern may be introduced instead of farmer's existing Fallow-T.Aus-T.Aman rice cropping pattern. However, the productivity of farmers' pattern is low due to the use of local or low yielding rice varieties and traditional management practices. Moreover, high yielder alternate rice varieties should be selected for T.Aus and T. Aman rice that would boost up the overall production. A number of reports on different cropping patterns are available in Bangladesh and India (Nazrul *et el*., 2013; Azad *et al.,* 1983; Malavia *et al*., 1986; Soni and Kaur, 1984 and Khan *et al*., 2005) 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. Furthermore, the inclusion of chickpea into existing cropping pattern would be a worthwhile alternative to stabilize the crop productivity as well as soil fertility. But little efforts have been made for production potential and economics of Chickpea-T. Aus-T. Aman rice cropping pattern. Keeping these views in mind, the present study was designed to introduce pulse crop (Chickpea) in the fallow period and to cultivate alternate modern rice varieties like BRRI dhan48 and BRRI dhan49 instead of BR-26 and BR-11 for T. Aus and T. Aman rice, respectively.

Materials and Method

The experiments were carried out at farmers' fileds in Sylhet (3 locations, namely Sunamgonj and Moulavibazar & South Surma) belongs to the Surma Kushyara Floodplain under the Agro-Ecological Zone (AEZ)-20 of Bangladesh, during three consecutive years 2009-10, 2010-11, and 2011-12. The study was conducted to determine the economic consequences of two cropping patterns viz., ICP: Improved Cropping Pattern (Chickpea-T. Aus-T. Aman) and FECP: Farmers' Existing Cropping Pattern (Fallow-T. Aus- T. Aman) through incorporation of chickpea crop along with high yielding varieties (HYV) of rice crops and improved management practices for crop production. Initial soil nutrient status, annual profile of monthly total rainfall in Bangladesh (1961-2010) and annual monthly total rainfall in Sylhet (2007-2012) are presented in Table 1, Fig. 1 and

Table 1. Soil nutrient status of the experimental area (AEZ 20) of Sylhet during 2009-12.

Parameters	OM (%)	pH	Total N (%)	K(meq/100g of soil)	P	S	B	Zn
					(µg/g of soil)			
Range	0.8- 2.42	5.2- 6.3	0.03-0.12	0.06- 0.15	3.04-17.42	6.01-9.59	0.28-0.69	0.79-1.83
Average	1.40	-	0.07	0.12	9.55	7.53	0.48	1.04
Critical limit	-	-	0.12	0.12	10.0	10.0	0.2	0.6
Interpretation		-	Very low	Low	Low	Very low	Medium	Medium

Table 2. Agronomic parameters considered in Chickpea-T. Aus-T. Aman rice cropping pattern under farmer's existing cropping pattern and improved practices at farmer's field in Sylhet during 2009-2012.

Parameters	C1=Fallow (-)/ Chickpea C2= T. Aus C3=T. Aman	Farmer's existing cropping pattern (FECP)			Improved cropping pattern (ICP)		
		2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Variety	C1	-	-	-	BARI Chickpea 5	BARI Chickpea 5	BARI Chickpea 5
	C2	BR-26	BR-26	BR-26	BRRI dhan48	BRRI dhan48	BRRI dhan48
	C3	Ranjit (Local)	BR-11	BR-11	BRRI dhan49	BRRI dhan49	BRRI dhan49
Sowing/ transplant	C1	-	-	-	20-25 Nov	18-24 Nov	17-23 Nov
	C2	14-22 May	18-22 May	11-15 May	07-10 May	09-11 May	08-12 May
	C3	20-25 Aug	20-26 Aug	18-22 Aug	13-16 Aug	12-16 Aug	11-15 Aug
Seed rate (kg/ha)	C1	-	-	-	45-50	45-50	45-50
	C2	30-35	30-35	30-35	20-25	20-25	20-25
	C3	28-30	28-30	28-30	20-25	20-25	20-25
Planting method	C1	-	-	-	Line	Line	Line
	C2	Haphazard	Haphazard	Haphazard	Line	Line	Line
	C3	Haphazard	Haphazard	Haphazard	Line	Line	Line

Table 2. Cont'd.

Parameters	C1=Fallow (-)/ Chickpea C2= T. Aus C3=T. Aman	Farmer's existing cropping pattern (FECP)			Improved cropping pattern (ICP)		
		2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Spacing (cm) (Row × Hill)	C1	-	-	-	40 × 10	40 × 10	40 × 10
	C2	Haphazard	Haphazard	Haphazard	20 × 15	20 × 15	20 × 15
	C3	Haphazard	Haphazard	Haphazard	20 × 15	20 × 15	20 × 15
Seedling age (days)	C1	-	-	-	-	-	-
	C2	30-40	30-40	30-40	25-30	25-30	25-30
	C3	40-45	40-45	40-45	30-35	30-35	30-35
Seedling (no./hill)	C1	-	-	-	-	-	-
	C2	4-5	4-5	4-5	2-3	2-3	2-3
	C3	4-5	4-5	4-5	2-3	2-3	2-3
Fert. Dose (kg/ha) (NPKSZn)	C1	-	-	-	23-18-20-2-0	23-18-20-2-0	23-18-20-2-0
	C2	85-28-45-0-0	85-28-45-0-0	85-28-45-0-0	114-70-80-44-3	114-70-80-44-3	114-70-80-44-3
	C3	65-26-36-0-0	65-26-36-0-0	65-26-36-0-0	114-35-80-22-0	114-35-80-22-0	114-35-80-22-0
Fertilizer application	C1	-	-	-	Full doses of NPKSZn as basal.	Full doses of NPKSZn as basal.	Full doses of NPKSZn as basal.
	C2	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45
	C3	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKS basal & N in equal splits at 20 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45	Full doses of PKSZn as basal and N in equal splits at 15, 35 and 45

Table 2. Cont'd.

Parameters	C1=Fallow (-)/ Chickpea C2= T. Aus C3=T. Aman	Farmer's existing cropping pattern (FECP)			Improved cropping pattern (ICP)		
		2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Weeding (no.)	C1	-	-	-	1	1	1
	C2	2	2	2	2	2	2
	C3	1	1	1	2	2	2
Weeding time (after top-dress: ATD)	C1	-	-	-	5-7 Dec.	6-9 Dec.	4-8 Dec.
	C2	ATD	ATD	ATD	ATD	ATD	ATD
	C3	ATD	ATD	ATD	ATD	ATD	ATD
Irrigation	C1	-	-	-	2	2	2
	C2	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed
	C3	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed
Insect-pest Control	C1	-	-	-	IPM	IPM	IPM
	C2	Chemical	Chemical	Chemical	IPM	IPM	IPM
	C3	Chemical	Chemical	Chemical	IPM	IPM	IPM
Harvest time	C1	-	-	-	10-18 March	12-19 March	10-18 March
	C2	18-22 Aug	10-12 Aug	17-22 Aug	07-10 Aug	09-12 Aug	08-11 Aug
	C3	26-30 Nov	25-30 Nov	24-29 Nov	12-20 Nov	13-18 Nov	12-19 Nov
Field duration (days)	C1	-	-	-	111	108	105
	C2	127	125	130	114	115	116
	C3	131	135	132	116	117	115
Turn over period (days)	C1	-	-	-	5-8	6-7	6-7
	C2	169-174	170-173	165-172	50-57	51-58	52-57
	C3	5-7	5-7	5-7	5-7	5-7	5-7

Fig. 2, respectively. The soil was clay loam with low organic matter content (1.40%) and soil pH ranged 5.2-6.3. The status of N, P, K, S, B, and Zn were very low, low, low, very low and medium, respectively.

Bangladesh has tropical monsoon climate with unimodal rainfall pattern throughout the year (Ahasan, *et al.*, 2010). The highest amount of country's average monthly rainfall occurs in July followed by June and August and lowest amount of rainfall occurs in January followed by that of December and February. Rainfall increases gradually from the month of January to July and then decreases (Fig. 1). In Sylhet, the highest amount of average monthly rainfall occurs in June followed by that of August, July, and May, whereas lowest amount of rainfall occurs in January followed by that of December and February. Rainfall increases gradually from the month of January to June and then decreases. Average monthly total rainfall 3720mm was during the period 2007-2012. Average maximum and minimum temperature were 31.32 and 14.71^{0}C, respectively (Fig. 2).
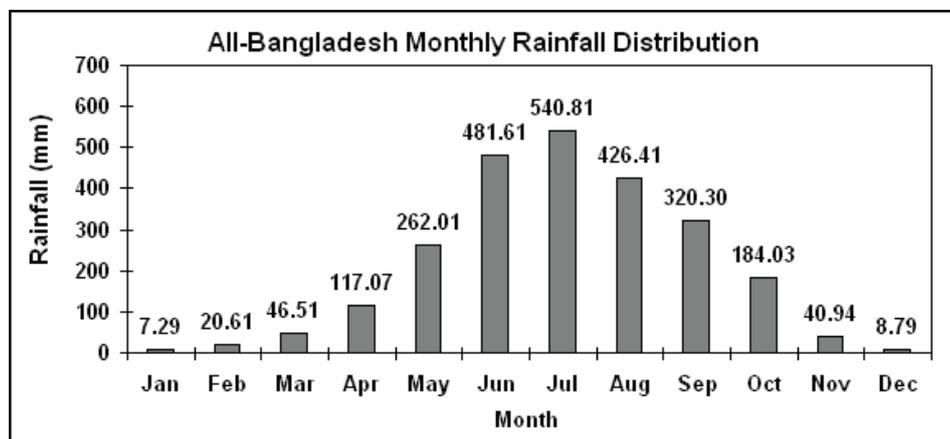
Fig. 1. Bangladesh annual profile of the monthly total rainfall (mm) during the period of 1961-2010.

The experimental design was randomized complete block with six dispersed replications. Two plots of 500 m^2 were selected for each replication. One plot was under the improved cropping pattern and the other was farmer's pattern. In the improved pattern, the chickpea variety BARI Chhola-5 was introduced against fallow period. The alternate modern rice variety BRRI dhan48 and BRRI dhan49 instead of BR-26 and BR-11 for T. Aus and T. Aman rice, respectively, were used in the improved cropping pattern. The agronomic management and cultural practices for crop production under improved and farmer's practices are presented in Table 2. All field operation and management practices of both farmer's and improved pattern were closely monitored and the all necessary data were recorded for agro-economic analysis. The mean data of yield were analyzed by using MS Excel software.
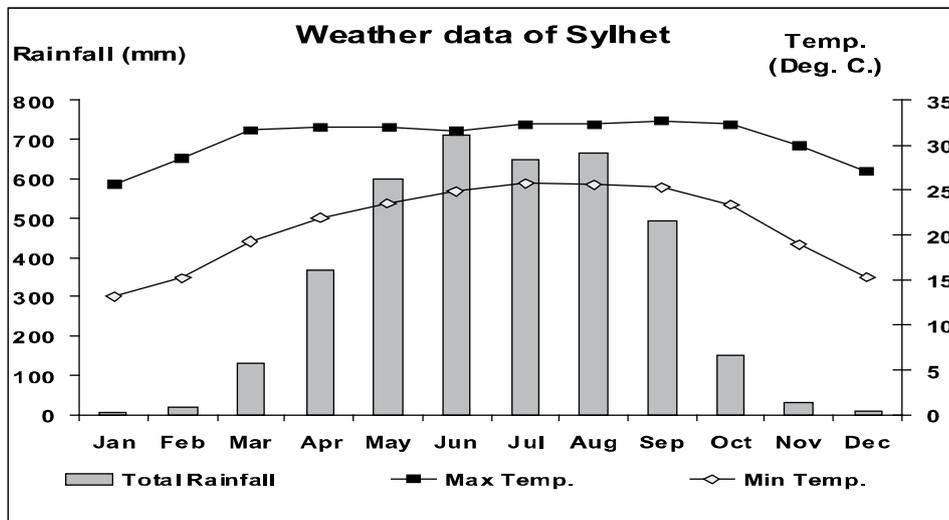
Fig. 2. Annual monthly total rainfall (mm) during the period of 2007-2012 in Sylhet

Agronomic performance like field duration, land use efficiency, production efficiency, sustainable yield index and rice equivalent yield of cropping patterns were calculated by the following formula:

Land use efficiency

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, second, and third crop of the pattern.

Production efficiency

Production efficiency values in terms of kg/ha/day were calculated by total production in a cropping sequence divided by total duration of crops in that sequence (Tomer and Tiwari. 1990).

$$\text{Production efficiency} = \frac{Y_1 + Y_2 + Y_3}{d_1 + d_2 + d_3}$$

Where,

Y_1: Yield of 1st crop
Y_2: Yield of 2nd crop
Y_3: Yield of 3rd crop
d_1 = Duration of 1st crop of the pattern

d_2= Duration of 2nd crop of the pattern
d_3= Duration of 3rd crop of the pattern

Sustainable yield index

Sustainable Yield Index (SYI) was worked out by the following formula suggested by Krishna and Reddy (1997).

$$\text{Sustainable yield index (SYI)} = \frac{Y_{mean} - SD}{Y_{max}}$$

Where, Y_{mean}: Mean yield from a practice over year, SD: Standard deviation and Y_{max}: Maximum yield obtained with any practice.

Rice Equivalent Yield (REY)

For comparison between crop sequences, the yield of all crops was converted into rice equivalent yield on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). The economic indices like gross and net returns and benefit cost ratio were also calculated on the basis of prevailing market price of the inputs and outpus (produces).

Results and Discussion

Field duration

Field duration of cropping pattern mainly depends on individual duration of component crops. The farmer's existing cropping pattern (FECP), Fallow-T. Aus-T. Aman rice had the longer field duration than the improved cropping pattern (ICP), Chickpea-T. Aus-T. Aman rice in all three years (Table 2). In farmers' cropping pattern, BR-26 and BR-11 rice took longer field duration compared to BRRI dhan48 and BRRI dhan49 in improved pattern. As a result, production efficiency and land use efficiency were higher in ICP than FECP.

Grain/seed yield

Results of the present study have been presented in Tables 2-5. Table 3 reveals that all of the component crop' of Chickpea -T. Aus-T. Aman rice cropping pattern under ICP gave higher grain yield as well as by products in all the years. On an average, the yield of T. Aus and T. Aman rice in improved pattern increased by 25.71 and 24.86%, respectively, over the crops of the farmer's pattern. The yield of T. Aus and T. Aman rice in the improved pattern was higher due to change of varieties with improved production technologies for the component crops. Similar results were also obtained by Nazrul *et al.* (2013) and Khan *et al*. (2005). The average yield of chickpea was 1.22 t/ha in improved pattern instead of fallow in farmers' practice. Result showed after the completion of each cycle that in all three years, farmer pattern gave the lower grain yield of rice due to use of traditional variety, imbalance use of fertilizer and sowing methods, etc. The modern variety of T.Aus rice BRRI dhan48 in improved

pattern performed better than BR-26. Moreover, under high rainfall situation during T. Aman rice season, the short duration HYV BRRI dhan49 in improved pattern showed better performance than the local variety of the traditional farming.

By-product yield

The improved cropping pattern produced higher by product yield (8.84 t/ha) than the farmer's pattern (7.45 tha^{-1}). On an average, the by-product yield of T. Aus and T. Aman rice in improved pattern was higher due to replacement of HYV with improved technologies for the component crops. In all three years, BRRI dhan48 and BRRI dhan49 produced higher by-product yield in improved pattern than BR-26 and BR-11 of T. Aus, and T. Aman rice, respectively, in traditional farming. The findings are in agreement with the findings of Nazrul *et al.* (2013) who reported that high yielding varieties of rice in the improved cropping pattern produced higher by product yield than farmers' practiced cropping pattern in Sylhet. However, chickpea in the improved cropping pattern utilized fallow period land and provided 1.07 t/ha by-products which may increase the farmers' extra income.

Table 3. Productivity of Chickpea-T. Aus-T. Aman rice cropping pattern under improved and farmers' practices at farmer's field in Sylhet during 2009-2012.

Year	Pattern	Grain/seed yield (t/ha)			By product yield (t/ha)		
		Fallow/ Chickpea	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
2009-10	FECP	-	2.80	3.35	-	3.45	4.30
	ICP	1.20	3.52	4.50	1.25	4.15	4.92
2010-11	FECP	-	2.70	3.42	-	3.00	4.10
	ICP	1.15	3.60	4.25	1.00	3.70	4.73
2011-12	FECP	-	2.90	3.74	-	3.05	4.45
	ICP	1.32	3.45	4.37	0.95	3.90	5.10
Mean	FECP	-	2.80	3.50	-	3.17	4.28
	ICP	1.22	3.52	4.37	1.07	3.92	4.92

Note- FECP: Farmer's existing cropping pattern, ICP: Improved cropping pattern.

Rice equivalent yield

The mean rice equivalent yield revealed that improved cropping system produced higher rice equivalent yield over farmer's traditional cropping system (Table 4). Inclusion of a new crop and high yielding varieties and improvement of management practices in the improved pattern increased the rice equivalent yield. Lower rice equivalent yield was obtained in the farmer's pattern due to local variety and traditional management practices.

Production efficiency

The production efficiency was higher with improved pattern, where the crop occupied 90-93% of the growing season in all the three years' studies. The lower production efficiency was observed in farmer's pattern (Table 4). The result indicates that the crops remained in the field for shorter time and yields were also lower in farmer's traditional system leading to lower production per day. On the contrary, crops remain standing in the field for longer time with higher yield in improved practices leading to higher production efficiency. Similar trend was noted from India by Krishna and Reddy (1997) 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 average land-use efficiency indicated that improved pattern used the land for 91% period of the year, whereas farmer's pattern used the land for 67% period of the year. This higher land use efficiency in improved pattern is due to cultivation of chickpea as component crop in fallow period. The findings is in full agreement with the findings of Nazrul *et al.* (2013).

Sustainable yield index

The sustainable yield index (SYI) of farmer's and improved cropping pattern are presented in Table 4. The sustainable yield index values as a measure of sustainability of the system which were higher in the improved cropping system (41%) over farmer's practices (35%). The results are in agreement with the findings of Nazrul *et al.* (2013) and Ram *et al.* (2012). This indicated that improved pattern is, therefore, more stable than farmer's pattern.

Table 4. Rice equivalent yield, production efficiency, land use efficiency and sustainable yield index of farmers and improved cropping pattern at farmer's field in Sylhet, 2009-2012.

Year	Pattern	Rice equivalent yield (t/ha)	Production efficiency (kg/ha/day)	Land use efficiency (%)	Sustainable yield index (SYI)
2009-10	FECP	5.15	24.69	67.39	0.37
	ICP	10.42	27.28	92.60	0.43
2010-11	FECP	6.12	24.87	67.94	0.34
	ICP	10.10	27.12	90.95	0.41
2011-12	FECP	6.64	26.99	67.67	0.36
	ICP	10.46	27.69	90.41	0.40
Mean	FECP	5.97	25.52	67.67	0.35
	ICP	10.29	27.36	91.32	0.41

NB: Chickpea price Tk. 50/kg and Rice price- Tk. 25/kg.

Economic analysis

From the economic point of view, the ICP showed its superiority over FECP during three years of cropping. Gross return of the ICP was Tk.2,58,167/ha, which was more than 150% higher than that of farmer's pattern (Table 5). The production cost per hectare of the improved pattern was higher to that of FECP (Tk.1,17,518/ha). Higher cost for improved cropping pattern was due to cultivation of chickpea as component crop, labour intensive, cultural operations, cost of fertilizer and other inputs. The gross margin was substantially higher in the improved pattern (Tk.1,40,648/ha) than that of the farmer's pattern (Tk. 51,882/ha). The higher gross margin of the improved cropping pattern was achieved mainly due to higher yield advantages of component crops. The additional gross margin 72% more was achieved by 21% additional costs in the improved pattern. The higher benefit cost ratio (2.20) further indicated the superiority of the improved pattern over the farmer's practices. Similar trend was followed in three years in all the parameters.

Table 5. Cost benefit analysis of chickpea-rice based cropping pattern under farmers and improved practices at farmer's field in Sylhet during 2009-2012.

Year	Pattern	Gross return (Tk/ha)	Total cost of cultivation (TK/ha)	Gross margin (Tk/ha)	BCR
2009-10	FECP	128750	88375	40375	1.46
	ICP	260500	118345	142155	2.20
2010-11	FECP	153000	90205	62795	1.70
	ICP	252500	120685	131815	2.09
2011-12	FECP	166000	92416	73584	1.80
	ICP	261500	113525	147975	2.30
Mean	FECP	149250	97368	51881.7	1.53
	ICP	258167	117518	140648	2.20

NB: Price of input & output Tk/Kg):

Input price:

Urea-20.00, TSP-22.00, MOP-15.00, **G**ypsum-10.00 and Cowdung-1.00, Labour(m)-Tk.180.00/day, Chickpea (seed) 100 and Rice seed-35, ploughing- Tk.300/bigha, irrigation- Tk.100/hr and pesticides (approx.)- Tk.4500/ha.

Output price:

Chickpea 50 and Rice grain 25, Chickpea by-product 2 and rice by-product 1.5.

Considering, rice-equivalent yield, sustainable yield index, net monetary return and higher BCR of the improved cropping pattern Chickpea (var. BARI Chhola 5)-T. Aus (BRRI dhan48)-T. Aman rice (BRRI dhan49) technology could be suggested for medium high land of the Eastern Surma Kushyara Floodplain in Agro-Ecological Zone (AEZ)-20 of Bangladesh.

Acknowledgements

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