Bangladesh Agron. J. 2020, 23(1): 37-46

ON-FARM EVALUATION AND SYSTEM PRODUCTIVITY OF GARDEN PEA-*BORO*-T. *AMAN* RICE CROPPING PATTERN IN MYMENSINGH

M.A.H. Khan[1], N. Sultana[1], N. Akter[2], S. Akhter[2] and M.R. Ali[3]

[1]SSO, [2]SO, On-Farm Research Division, Mymensingh, BARI, Bangladesh, and [3]PSO, RARS, Jamalpur, Bangladesh.
Corresponding author: helim1367@gmail.com

(**Received:** 30 April, 2020, **Accepted:** 17 August, 2020)

Keywords: Garden pea, management, cropping intensity, profitability, production efficiency

Abstract

The experiment was conducted at Multi Location Testing site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh 2016-17 and 2017-18 to evaluate the agro-economic performance of improved cropping pattern for increasing cropping intensity, system productivity and profitability as compared to farmers' existing cropping pattern. The experiment was laid out randomized complete block design with six dispersed replications. Two cropping pattern viz., improved cropping pattern Garden pea (var. BARI Motorshuti-3) - *Boro* (var. BRRI dhan28) - T. *Aman* rice (var. BRRI dhan32) and farmers' existing pattern Fallow - *Boro* (BRRI dhan28) - T. *Aman* rice (var. BRRI dhan32) as control were tested. Improved cropping pattern produced higher mean rice equivalent yield (30.26 t ha^{-1} $yr.^{-1}$), production efficiency (74 kg ha^{-1} day^{-1}), land utilization index (72 %) and labour employment (382 man-days ha^{-1} $yr.^{-1}$) than farmers' pattern which were 200, 37, 35 and 55% higher over existing pattern. Average gross return (Tk.486430 ha^{-1}), gross margin (Tk. 284787 ha^{-1}) and marginal benefit cost ratio (4.60) of improved pattern indicate it's superiority over farmers' pattern. The fertility status of soil i.e. pH, organic matter, total N, available P, S, Zn and B content in soil were increased over the initial soil due to addition of garden pea biomass. Thus, inclusion of garden pea in the existing pattern would improve soil health and system productivity as a whole. Experimental findings revealed that there is potential for greater adoption of intensified cropping systems with increased productivity and profitability as compared to rice–rice systems in Mymensingh region.

Introduction

Increased population, food scarcity, poverty, starvation and environmental degradation are the primary challenges of the 21st century (Neamatollahi *et al.,* 2017). In the world about 1 billion people keep on hungry every day due to the inadequate food supply and this number will rise up to 2 billion by 2050 (FAOSTAT, 2014). For the developing countries of Asia and Africa, this situation insists on the increasing momentum in agricultural production with more than 70 percent increase in the coming decades (Neamatollahi *et al.,* 2017). To enhance agriculture productivity improved cropping patterns and better management practices are essential.

Land and water resources are becoming very limited due to the rapid change in population and urbanization. Subsequently, to determine the optimal use of the available resources improved cropping pattern has been developed for exploiting the net profit subjected to some limitations (Osama *et al.,* 2017).

Bangladesh covers about 14.84 M ha (million hectares) of total land and among this 3.74 M ha (25% of the total) is not appropriate for cultivation due to deployment for urban areas, commercial buildings, countryside homesteads, roads etc. (Quasem, 2011). Bangladesh also suffers frequently from different normal disasters that may get worse in the long run as a result of climate change (Hossain *et al.,* 2016 and Rokonuzzaman *et al.,* 2018). As such, there is a scope of increasing cropping intensity from existing level of 195% by improving the existing cropping patterns through including short duration crops viz. mustard, potato, mungbean, garden pea and other vegetables in the rice based cropping systems during whole year by augmenting productivity of each crops (Ladha *et al.,* 2016 and Datta *et al.,* 2017).

The existing major cropping pattern of Mymensingh region is Fallow-*Boro*-T. *Aman* rice which covers about 66 % of the total cultivated land (DAE, 2018). Only rice production is not profitable and suitable for the farmers of this area due to it requires huge amount of irrigation water for *Boro* cultivation as well as soil native fertility decline for monoculture of rice (Sarker *et al.*, 2020). So an adaptation of alternative cropping patterns to support the most efficient use of the limited natural resources is a prime need for recent days. A huge part of land remains fallow 2 to 3 months after harvest of T. *Aman* rice in this area. Garden pea can easily be cultivated in this region after harvest of T. *Aman* rice and can get high economic return within a short time. It is also adds nutrient in soil that improves soil health as it is a leguminous crop. Considering the above facts, the present experiment was undertaken for increasing cropping intensity and productivity by incorporating garden pea in rice based cropping system and increasing farmer's income and creating employment opportunity with improved cropping pattern Garden pea - *Boro*-T. *Aman* rice.

Materials and Methods

The experiment was conducted at Multi Location Testing (MLT) site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh at farmers' field under irrigated condition to increase cropping intensity and productivity by incorporating garden pea in the existing cropping system (Fallow – *Boro* - T. *Aman* rice) during 2016-17 and 2017-18. The experimental site belongs to Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) of Mymensingh. The geographical position of the area is between 24°45′ N latitude and 90°24′ E longitude. The land was medium high and the soil of the study area was sandy loam in texture with well drainage system. The meteorological data of the experimental site revealed that the highest temperature prevails in August-September and the lowest in December. In both years, there is no precipitation in December. Maximum rainfall was received during the months of May to September. The meteorological data of the experimental site revealed that the highest temperature prevailed (32.5 and 32.8 °C) in August and the lowest (9.0 and 11.20 °C) in December during two consecutive years. The crop received 213.7 mm and 64.7 mm rain showers from October to March in two successive years. The relative humidity was highest (87.1 & 88.0 %) in July and lowest (75.9 and 74.8%) in March during two consecutive years. Monthly mean maximum and minimum air temperature (32.5 and 20.5 °C), total rainfall (1973 mm) and relative humidity (82.7 %) were prevailing during the study period. Initial soil sample was collected and analyzed (Table 1). General soil types predominantly include Dark Grey Floodplain soils. Organic matter content was low, top soils were acidic to neutral and sub-soils were neutral in reaction. In general, fertility level including N, K and B was very low.

The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping pattern viz., improved cropping pattern Garden pea (var. BARI Motorshuti-3) - *Boro* (var. BRRI dhan28) - T. *Aman* rice (var. BRRI dhan32)) and farmers' existing pattern Fallow - *Boro* (BRRI dhan28) - T. *Aman* rice (var. BRRI dhan32) were the treatments variables of the experiment. The unit plot size was 600-800 sq.m. All field operations and management practiced both improved and farmers' patterns are presented in Table 4. Garden pea was the first crop of the sequence. The seeds were sowing 30 cm × 20 cm a part rows at the rate of 40 kg ha^{-1} on 12-17 November, 2016 and 14-18 November 2017, in two consecutive years. Fertilizer management was done followed by FRG (2012) and intercultural operations like weeding, mulching, irrigation and pest management were done to support the normal growth of the crops. The crop was harvested on 10-27 January, 2017 and 17-31 January 2018 in 1st and 2nd year, respectively. After harvest of garden pea pods, the plants were incorporated into soil. *Boro* rice was the second crop of the sequence. *Boro* rice seedlings were grown in adjacent plot and 35-40 days old seedlings were transplanted with a spacing of 20 cm × 15 cm. *Boro* rice seedlings were transplanted on 14-20 February, 2017 and 17-23 February, 2018 and harvested on 18-26 May, 2017 and 21-31 May, 2018 in 1st and 2nd year, respectively. Fertilizer management and other intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). Rice plant was harvested at 30 cm height from soil surface and remaining parts of the plants were incorporated in soil. T. *Aman* rice was the third crop of the sequence. T. *Aman* rice seedlings were grown in adjacent plot and 25-30 days old seedlings were transplanted with a spacing of 20 cm × 15 cm. on 15-20 July, 2017 and 17-24 July, 2018 and harvested on 16 to 23 October, 2017 and 20-31 October 2018 in two successive years. Fertilizer management and other intercultural operations were done properly to support the normal growth of the crop according to BRRI (2013). T. *Aman* rice plants were harvested at 15 cm height from soil surface and remaining parts of the plants were incorporated in soil.

In farmers' pattern, 40-45 days old seedlings of *Boro* rice and 30-35 days old seedlings of T. *Aman* rice were transplanted with a20 cm × 15 cm spacing. *Boro* rice seedlings were transplanted on 08-12 February, 2017 and 05-11 February, 2018 and harvested on 18-22 May, 2017 and 13-19 May, 2018 in 1st and 2nd years, respectively. T. *Aman* rice seedlings were transplanted on 08-14 August, 2017 and 06-13 August 2018, and harvested on 12-18 November, 2017 and 11-18 November, 2018. Fertilizer management and other intercultural operations like weeding, mulching, irrigation and pest management were done according to farmers' own practices.

Plot-wise yield data were determined on an area basis of each plot. Grains and straw were sun dried and weighed adjusting at 12 % moisture content for rice. Agronomic performance like field duration, rice equivalent yield (REY), production efficiency and land utilization index were calculated as follows.

Rice Equivalent Yield (REY): For comparison between crop sequences, the yield of every crop was converted into rice equivalent on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

$$\textbf{Rice equivalent yield } (\textbf{tha}^{-1}\textbf{yr}^{-1}) = \frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\text{market price of rice}}$$

Production efficiency: Production efficiency value in terms of $kgha^{-1}day^{-1}$ was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

Production Efficiency (kgha^{-1}day^{-1}) $= \dfrac{\sum Y_i}{\sum d_i}$

Where, Y_i = Yield (kg) of i^{th} crop, d_i= Duration (day) of i^{th} crop of the pattern and i = 1, 2, 3, 4

Land utilization index (LUI): It was worked-out by taking total duration of crops in an individual cropping pattern divided by 365 days (Rahman *et al.,* 1989). It was calculated by the following formula:

$$\textbf{Land Utilization Index (\%)} = \frac{d1 + d2 + d3 + d4}{365} \times 100$$

Where d_1, d_2, d_3 and d_4 the duration of 1st, 2nd 3rd and 4th crop of the pattern

Cost and return analysis was done on the basis of prevailing market price of the commodities. The inputs used included seed, fertilizer, labour and insecticides. The MBCR of the farmer's prevalent 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) which was computed as (CIMMYT, 1988).

$$\textbf{Marginal Benefit Cost Ratio (MBCR)} = \frac{\text{Gross return (E) - Gross return (F)}}{\text{TVC (E) - TVC (F)}} = \frac{MVP}{MVC}$$

Results and Discussion

Soil fertility status: The status of soil pH, organic matter content, total N, available P, K, S, Zn and B in initial soil as well as after completion of two cropping cycle of Garden pea-Boro-T. *Aman* rice cropping pattern is shown in Table 1. Soil chemical analysis of improved cropping pattern revealed that on an average, pH and organic matter content of the soil increased slightly. Initially the pH of the soil was 6.07 but after completion of two cropping cycle the soil pH slightly increased to near 6.09. It was also found that the fertility status of soil i.e. organic matter, total N, available P, S, Zn and B contents in soil were increased slightly over the initial soil due to addition of garden pea biomass. However, K in the improve pattern tended to be lower than the farmers one, which indicated to add more K in soil to improve K content. Rao and Bhardwaj (1980) conclusively proved that pulses receiving optimum fertilizer, especially P, had more pronounced residual effect both in terms of N and P on the succeeding cereals.

Table 1. Effect of garden pea inclusion in Fallow – *Boro* - T. *Aman* rice cropping pattern on soil fertility status of the farmers' field in Mymensingh during 2016-17 and 2017-18

Sample	Land type	Rainfed/ Irrigated	pH	OM (%)	Total N (%)	K (meq100^{-1} g)	P (Bray)	S	Zn	B
							(µg g^{-1})			
Initial	MHL	Irrigated	6.07	1.37	0.074 (VL)	0.069 (VL)	18.13 (Opt.)	22.12 (M)	1.27 (M)	0.09 (VL)
Post harvest	MHL	Irrigated	6.09	1.39	0.075 (VL)	0.067 (VL)	21.60 (H)	22.54 (Opt)	1.29 (M)	0.12 (VL)

Note: MHL = Medium high land, VL = Very low and L = Low

Organic matter added to soil through incorporation of non-economic plant parts helped to maintain the quality of soil (Table 2). These results are supported by Mondal *et al.* (2015) and Khan *et al.* (2018) who found that inclusion of mungbean in the existing farmer's cropping pattern improve the soil fertility status.

Table 2. Addition of organic matter from crop residues in soil of improved and farmers' existing cropping pattern at Mymensingh during 2016-17 and 2017-18

Crops	**Improved pattern added residues (t ha^{-1})**			**Farmers' pattern added residues (t ha^{-1})**		
	2016-17	**2017-18**	**Mean**	**2016-17**	**2017-18**	**Mean**
Garden pea	1.36	1.34	1.35	-	-	-
Boro rice (30 cm)	1.35	1.27	1.31	1.25	1.29	1.27
T. *Aman* rice (15 cm)	0.69	0.67	0.68	0.63	0.67	0.65
Total	**3.40**	**3.28**	**3.34**	**1.88**	**1.96**	**1.92**

Crop management: Crop management practices under improved cropping pattern Garden pea- *Boro* - T. A*man* rice and farmers existing cropping pattern Fallow - *Boro* - T. *Aman* rice are shown in Table 3. Average field duration of improved cropping pattern took 261 days for completion of one cycle, while existing cropping pattern required 195 days for completion of one cycle. Average turnaround time for improved cropping was 104 days whereas it was 171 days to complete one cycle of existing cropping pattern.

Table 3. Crop management practices of improved cropping pattern Garden pea – *Boro* - T. *Aman* rice (IP) and farmers' existing cropping pattern Fallow – *Boro* - T. *Aman* rice (FP) in Mymensingh during 2016-17 and 2017-18

Parameters	**Years**	**Improved Cropping Pattern (IP)**			**Farmers' Existing Pattern(FP)**		
Crop		Garden pea	*Boro* rice	T. *Aman* rice	Fallow	*Boro* rice	T.*Aman* rice
Variety	2016-17	BARI Motorshuti-3	BRRI dhan28	BRRI dhan32	-	BRRI dhan28	BRRI dhan32
	2017-18	BARI Motorshuti-3	BRRI dhan28	BRRI dhan32	-	BRRI dhan28	BRRI dhan32
Spacing (cm)	2016-17	30 20	20 15	20 15	-	20 15	20 15
	2017-18	30 20	20 15	20 15	-	20 15	20 15
Fertilizer dose (kg NPKSZnB ha^{-1})	2016-17 2017-18	28-33-60-05-01-01	150-20-65-18-1.3-0	90-10-35-12-1-0	-	160-20-60-20-0-0	100-20-24-0-0-0
Sowing/ planting time	2016-17	12-17 Nov.	14-20 Feb.	15- 20 July	-	08-12 Feb	08-14 Aug
	2017-18	14-18 Nov.	17-23 Feb.	17-24 Jul		05-11 Feb	06-13 Aug
Seedling age (days)	2016-17	-	35-40	25-30	-	40-45	30-35
	2017-18	-	35-40	25-30	-	40-45	30-35
Irrigation (No.)	2016-17	01	15	6	-	17	7
	2017-18	01	14	5	-	18	6
Weeding (No.)	2016-17	01	02	01	-	02	01
	2017-18	01	02	01	-	02	01
Harvesting time	2016-17	10-27 Jan.	18-26 May	16-23 Oct	-	18-22 May	12-18 Nov.
	2017-18	17-31 Jan	21-31 May	20-31 Oct		13-19 May	11-18 Nov.
Field duration (days)	2016-17	66	95	96	-	99	97
	2017-18	70	96	99	-	97	96
Turnaround time (days)	2016-17	25	28	55	-	87	82
	2017-18	22	27	51	-	88	84

The newly introduced crop in the farmers existing pattern was garden pea in the *Rabi* season to use fallow period. Result indicated that garden pea could be easily fitted in the existing cropping pattern.

Yield performance: Green pods/ grain yield of garden pea, *Boro* and T. *Aman* rice of improved and existing cropping pattern have been present in Table 4. Pod yields of garden pea were 8.38 and 8.74 t ha^{-1} and stover yields were 1.36 and 1.34 t ha^{-1} in two consecutive years, respectively. Two years average green pod and stover yields of garden pea were 8.56 and 13.5 t ha^{-1}. Grain yields of *Boro* rice were 5.84 and 5.92 t ha^{-1} and straw yields were 5.94 and 5.98 t ha^{-1} in 1st and 2nd year, respectively. Mean grain and straw yields of *Boro* rice were 5.88 and 5.96 t ha-^{1}, respectively. Grain yields of T. *Aman* rice were 4.40 and 4.42 t ha^{-1} and straw yields were 4.55 and 4.51 t ha^{-1} in the two successive years. Mean grain and straw yields of T. *Aman* rice were 4.41 and 4.53 t ha^{-1}. It was revealed that all the component crops under improved pattern gave higher grain yield as well as by-product yield (Table 5). Average yield of *Boro* and T. *Aman* rice in improved cropping pattern increased by 2 % over farmers' practice (FP). The yield of improved pattern was higher presumably due to improved production technologies and use balanced fertilizers for component crops.

Table 4. Yield of different crops under improved cropping pattern Garden pea - *Boro* - T. *Aman* rice (IP) and farmers' existing cropping pattern (FP) in Mymensingh during 2016-17 and 2017-18

Parameters	Years	Improved Cropping Pattern (IP)			Farmers' Cropping Pattern (FP)		
		Garden pea	*Boro* rice	T. *Aman* rice	Fallow	*Boro* rice	T. *Aman* rice
Pod/Grain yield (t ha^{-1})	2016-17	8.38	5.84	4.40	-	5.74	4.28
	2017-18	8.74	5.92	4.42	-	5.77	4.36
	Mean	8.56	5.88	4.41	-	5.76	4.32
Stover Straw yield (t ha^{-1})	2016-17	1.36	5.94	4.55	-	5.80	4.40
	2017-18	1.34	5.98	4.51	-	5.92	4.46
	Mean	1.35	5.96	4.53	-	5.86	4.43

In farmers' existing cropping pattern, grain and straw yields of *Boro* and T. *Aman* rice have been present in Table 4. In the existing pattern, grain yields of *Boro* rice were 5.74 and 5.77 t ha^{-1} and straw yields were 5.80 and 5.92 t ha^{-1} in two successive years, respectively. Mean grain and straw yields of *Boro* rice were 5.76 and 5.86 t ha-^{1}, respectively. Grain yields of T. *Aman* rice were 4.28 and 4.36 t ha^{-1} and straw yields were 4.40 and 4.46 t ha^{-1} in the two consecutive years. Mean grain and straw yields of T. *Aman* rice were 4.32 and 4.43 t ha^{-1}. Average grain yield of *Boro* rice in Fallow – *Boro* - T. *Aman* rice cropping pattern was obtained 5.86 t ha^{-1}. The result is in conformity with the findings of Sultana *et al.* (2014) for the variety BRRI dhan28 in Mustard – *Boro* - T. *Aman* cropping pattern at Mymensingh region.

System productivity: Total productivity of cropping systems was evaluated in terms of rice equivalent yield (REY) and it was calculated from the yield of component crops. Rice equivalent yields (REY) of improved cropping pattern (Garden pea – *Boro* - T. *Aman* rice) were estimated 29.79 and 30.70 t ha^{-1} yr^{-1} which were 197 and 203 % higher over existing cropping pattern in two successive years. The mean rice equivalent yield of improved cropping pattern was 30.26 t ha^{-1} yr.$^{-1}$ which was 200% higher against existing cropping pattern (10.08 t ha^{-1} yr^{-1}) due to introduction of new crop and improved management practices. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. (Table 5). This findings were supported by Nazrul *et al.* (2017) and Khan *et al.* (2018).

Production efficiency: The higher production efficiency in terms of kg ha^{-1} day^{-1} was calculated from improved cropping pattern than existing cropping pattern (Table 5). Mean production efficiency of improved cropping pattern was found 74 kg ha^{-1}day^{-1} which was 37 % higher over farmers' existing cropping pattern (54 kg ha^{-1} day^{-1}). The higher production efficiency of improved cropping pattern might be due to inclusion of high yielding garden pea as well as improved management practices. Similar trend of findings were noted by Nazrul *et al.* (2017) and Khan *et al.* (2018) in production efficiency of improved cropping pattern.

Land Utilization Index (LUI): Land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. Mean land utilization index (LUI) indicated that improved cropping pattern used the land for 72 % period of the year, whereas farmers' existing pattern used the land for 54 % period of the year. In improved cropping pattern, land use efficiency was 35 % higher than farmers' practice. The higher land use efficiency in improved cropping pattern because this pattern occupied the field for longest period (261 days) whereas the farmers' pattern occupied the field for 195 days of a year (Table 5). As a result labour utilization could be more in the improved cropping pattern than existing one. Analogous trend of findings were cited by Nazrul *et al.* (2017) and Khan *et al.* (2018) in land utilization index of improved cropping pattern.

Labour employment generation: Human labour was employed for land preparation, sowing, and transplanting, fertilizing, weeding, pesticide application, harvesting, carrying, threshing, cleaning and drying. It was observed that mean total number of human labour used for crops production under improved cropping pattern was 382 man-days ha^{-1} year^{-1} which was generated 55% higher labour employment than that of existing cropping pattern (246 man-days ha^{-1} year^{-1}). Improved cropping pattern engaged the field for longest period (261 days) whereas the farmers' pattern occupied the field for 195 days of a year. As a result labour utilization could be more in the improved cropping pattern than existing one. It was also generated employment of women, children and aged people due to inclusion of garden pea (Table 5).

Table 5. Rice equivalent yield, production efficiency, land utilization index and labour employment of improved cropping pattern (IP) and Farmers' existing cropping pattern (FP) in Mymensingh during 2016-17 and 2017-18

Year	**Cropping pattern**	**REY (tha^{-1}yr^{-1})**	**PE (kgha^{-1}day^{-1})**	**LUI (%)**	**Labour employment (man-days ha^{-1} yr^{-1})**
2016-17	IP	29.79	146	70	385
	FP	10.02	51	54	244
2017-18	IP	30.70	76	73	379
	FP	10.13	53	53	248
Mean	IP	30.26	74	72	382
	FP	10.08	54	54	246
% increased/decreased over FP		200	37	35	55

Note: REY = Rice equivalent yield, PE = production efficiency, LUI = land utilization index, IP = Improved Pattern and FP = Farmers' Pattern

Cost and return analysis: The cost and return analysis are presented in Table 6. It indicated that higher return was found in improved cropping pattern (Garden pea – *Boro* - T. *Aman* rice) than farmers' existing pattern (Fallow – *Boro* - T. *Aman* rice). Two years average gross return of the improved pattern was Tk.486430 ha^{-1} which was 183 % higher over farmers' pattern (Tk. 171705 ha^{-1}). Mean total variable cost of improved cropping pattern was Tk. 201643 ha^{-1} which was 51% higher than farmers' pattern (Tk. 133200 ha^{-1}) which was probably due to inclusion of garden pea in the pattern as well as management practices. Average gross margin was substantially higher in the improved pattern (Tk. 284787 ha^{-1}) than farmers' pattern (Tk. 38506 ha^{-1}). The higher gross margin of the improved pattern was achieved mainly due to higher yield advantages of the component crops. Additional gross margin (640%) was achieved by adding 51 % extra cost in the improved pattern. These findings are supported by Sarker *et al.* (2014) who reported that Wheat – Mungbean - *T. Aman* rice produced the higher economic benefit in terms of BCR. Mean marginal benefit cost ratio (MBCR) was found 4.60 which further indicated the superiority of the improved pattern over farmers' one. Thus, inclusion of garden pea in the existing pattern might be agronomically viable, economically profitable and environmentally sustainable for the farmers' in the study site.

Table 6. Gross return, total variable cost, gross margin and marginal benefit cost ratio (MBCR) of garden pea – *Boro* - T. *Aman* rice (IP) and Fallow – *Boro* - T. *Aman* rice (FP) in Mymensingh during 2016-17 and 2017-18

Year	Cropping Pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
2016-17	IP	471670	200640	271030	4.42
	FP	170700	132537	38163	
2017-18	IP	501190	202646	298544	4.78
	FP	172710	133862	38848	
Mean	IP	486430	201643	284787	4.60
	FP	171705	133200	38506	
% increased/decreased over FP		183	51	640	-

Note: Price: Green pod = Tk. 35.00 kg^{-1}, Rice = Tk. 15.00 kg^{-1}, Rice straw = Tk. 2.00 kg^{-1} and stover = Tk. 1.00 kg^{-1}

Apparent soil nutrient balance: Total N, P, K and S uptake by different crops at the farmer's field are presented in Fig.1. The partial net balance of N was negative in both the patterns and ranged from -91 to -214 kg ha^{-1}. Nitrogen replenishment through chemical fertilizer and organic matter addition either singly or in combination was not enough to balance N removal by crops presumably due to substantial loss of the applied N from the soil.

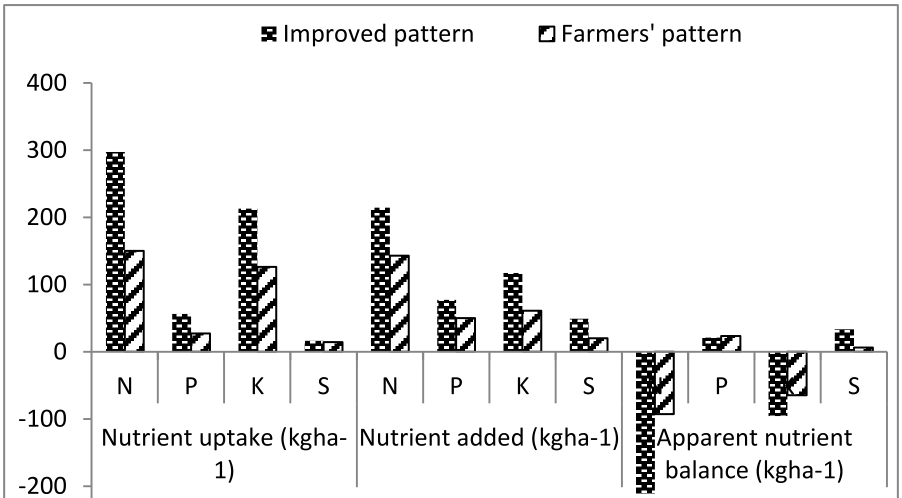

Fig 1. Effect of improved pattern and farmers' pattern on soil nutrient balance in Mymensingh

The P balance was favourable as expected due to individual crop basis fertilization. Excess amount of P accumulated in the soil and positive effect of P was reflected in the improved pattern. In farmers' pattern, P balance was also positive. However, the partial net balance of K was negative and ranged from -63 to -92 kg ha^{-1}. This may lead to K depletion in the long run. There was a positive balance of S in both the patterns and ranged from 7 to 31 kg ha^{-1}. These results are supported by Khan *et al.* (2018) who reported the similar trend of nutrients in Wheat – Mungbean - T. *Ama*n rice cropping pattern.

Conclusion

Results of the two years trial clearly indicated that garden pea (Var. BARI Motorshuti-3) - *Boro* (Var. BRRI dhan28) - T. *Aman* rice (Var. BRRI dhan32) cropping pattern was more productive and profitable than the farmers existing cropping pattern Fallow - *Boro* (Var. BRRI dhan28) -T. *Aman* rice (Var. BRRI dhan32). Thus, garden pea can be successfully accommodated in the existing farmers' pattern with total crop duration (261 days) in Mymensingh region to increase cropping intensity and system productivity with profitability. Furthermore, through this cropping pattern the soil health may be improved and the farmers could cultivate year round crop successfully and creates employment opportunity of labour forces.

References

BRRI (Bangladesh Rice Research Institute). 2013. Modern Rice Cultivation, 17th Edition, Bangladesh Rice Research Institute, Joydebpur, Gazipur-1701.

CIMMYT (International Maize and Wheat Improvement Centre). 1988. Agronomic Data to Farmer Recommendation: An Economic Training Manual. International Maize and Wheat Improvement Centre, Mexico, D. F. 79p.

DAE (Department of Agriculture Extension). 2018. Paper presented in the regional research extension review and program planning workshop at Regional Agricultural Research Station, BARI, Jamalpur.

Datta, A., H. Ullah and Z. Ferdous. 2017. Water Management in Rice. *In*: Chauhan, B.S., K. Jabran, G. Mahajan (Eds.) Rice Production Worldwide. pp.255–277. https://doi.org/10.1007/978-3-319-47516-5_11.

FAOSTAT (Food and Agriculture Organization Corporate Statistical Database). 2014. FAO, Rome, Italy.

FRG (Fertilizer Recommendation Guide). 2012. Bangladesh Agricultural Research Council (BARC), Farmgate, New Airport Road, Dhaka-1215. p.274.

Hossain, M.S., A. Hossain, M.A.R. Sarkar, M. Jahiruddin, J.A. Teixeira da Silva and H.M. Israil. 2016. Productivity and soil fertility of the rice-wheat system in the high Ganges River floodplain of Bangladesh is influenced by the inclusion of legumes and manure. Agric. Ecos. Environ. 218: 40–52. https://doi.org/10.1016/j.agee.2015.11.017.

Khan, M.A.H., N. Sultana, N. Akter, M.S. Zaman and A.K. Choudhury. 2018. Increasing cropping intensity and productivity through mungbean inclusion in Wheat-Fallow-T. *Aman* rice cropping pattern. Bangladesh J. Agril. Res. 43(2): 333-343.

Ladha, J.K., A.N. Rao, A.K. Raman, A.T. Padre, A. Dobermann, M. Gathala and S. Noor. 2016. Agronomic improvements can make future cereal systems in South Asia far more productive and result in a lower environmental footprint. Global Change Biol. 22: 1054–1074. ttps://doi.org/10.1111/gcb.13143.

Mondal, R.I., F. Begum, A. Aziz and S.H. Sharif. 2015. Crop sequences for increasing cropping intensity and productivity. SAARC J. Agri. 13(1): 135-147.

Nazrul, M.I., M.K. Hasan and M.R.I. Mondal. 2017. Production potential and economics of mungbean in rice based cropping pattern in Sylhet region under AEZ 20. Bangladesh J. Agril. Res. 42(3): 413-424.

Neamatollahi, E., J. Vafabakhshi, M.R. Jahansuz and F. Sharifzadeh. 2017. Agricultural optimal Cropping pattern determination based on fuzzy system. Fuzzy Infor. Eng. 9: 479–491. https://doi.org/10.1016/j.fiae.2017.12.004.

Osama, S., M. Elkholy and R.M. Kansoh. 2017. Optimization of the cropping pattern in Egypt. Alexandria Eng. J. 56: 557–566. https://doi.org/10.1016/j.aej.2017.04.015.

Quasem, M.A. 2011. Conversion of Agricultural Land to Non-agricultural Uses in Bangladesh: Extent and Determinants. Bangladesh Dev. Studies, 34: 59-85.

Rahman, M.M., M.H. Khan, R.N. Mallick and R.E. Hudgens. 1989. Guidelines for Farming Systems Research Methodology. Bangladesh Agricultural Research Council, Farmgate, Dhaka-1215.

Rao, J.V. and R.B.L. Bhardwaj. 1980. Influence of residual fertility on green gram in intensive cropping system. Indian J. Agron. 25: 97-101.

Rokonuzzaman, M., M.A. Rahman, M. Yeasmin and M.A. Islam. 2018. Relationship between precipitation and rice production in Rangpur district. Prog. Agri. 29: 10-21. https://doi.org/10.3329/pa.v29i1.37476.

Sarker, M.A.Z., M.A. Alam, A. Hossain and M.A. Mannaf. 2014. Agro-Economic performance of crop diversification in Rice based cropping systems of Northwest Bangladesh. Agric., Forest. Fish. 3(4): 264--270.

Sarker, U.K., S. Monira and M.R. Uddin. 2020. On-farm evaluation and system productivity of Wheat-Jute- T. *Aman* rice cropping pattern in Char area of Bangladesh. Agril. Sci. 2(1): 39-46.

Sultana, S., M.S. Zaman, M. Yasmin and S. Akhter. 2014. Development of Mustard-*Boro*-T. *Aman* rice cropping pattern against Fallow-*Boro*-T. *Aman* rice cropping pattern. Bangladesh J. Agriculturist. 7(1): 95-99.

Tomer, S.S. and A.S. Tiwari. 1990. Production potential and economics of different crop sequences. Indian J. Agron. 35 (1&2): 30-35.

Verma, S.P. and S.C. Modgal. 1983. Production potential and economics of fertilizer application as resources constraints in maize, wheat crop sequence. Himachal J. Agric. Res. 9(2): 89-92.