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Effect of green manuring crops on fertilizer economy and monetary advantages of green manure - T. aman-mustard cropping pattern

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Key words: Green manuring, Soil quality, Fertilizer economy, Monetary advantages, Rice equivalent yield

Abstract

Three experiments were conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Bangladesh, at 2015 to 2016 to increase cropping productivity by inclusion of green manure in existing cropping pattern, monetary advantages and fertilizer economy as well. Total productivity of different cropping pattern was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of rice combined with yield of mustard (rice equivalent yield). The highest REY (9.60 t ha^{-1} in 1^{st} year) and (11.49 t ha^{-1} in 2^{nd} year) was recorded from the cropping pattern; *S. rostrata* – T.aman – Mustard followed by *C. juncea* – T.aman – Mustard and *S. aculeata* – T.aman – Mustard respectively in 2015 and 2016. The lowest REY (6.02 t ha^{-1} in 1^{st} year) and (6.98 t ha^{-1} in 2^{n} year) was obtained from the cropping pattern; Fallow-T. Aman – Mustard. Inclusion of mustard during rabi season in *S. rostrata* (59.47% and 64.61% in 2015 and 2016 respectively) and *C. juncea* (41.47% and 49.14% in 2015 and 2016 respectively) increased REY that followed by *V. unguiculata* (45.70% and 54.15% in 2015 and 2016 respectively) and *S. aculeata* (40.86% and 32.0% for 2015 and 2016 respectively) compared to Fallow-T. Aman-Mustard cropping pattern. It is noted that inclusion of crops likes *S. rostrata, C. juncea, S. aculeata* and *V. unguiculata* showed higher REY than other crops as GM in GM-T. Aman-Mustard cropping pattern. The cost of production in situ green manure was lower than addition of similar quantities from external sources. This would also reduce the N requirement by 50% to obtain similar yields.

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Introduction

The increase of cropping intensity in rice based cropping system is becoming important for food security and poverty reduction. But the continuous use of chemical fertilizers without nutrient recycling has led to an immense loss of soil fertility and productivity (Nand Ram, 2000). It has also been established that cereal-cereal sequences are more nutrient exhaustive and put a heavy demand on soil resources as compared to cereal-legume sequences (Singh *et al.*, 2011). Abrol and Palaniappan (1988) cautioned about the non-sustainability of the rice-wheat or rice-rice system due to occurrence of multi-nutrient deficiencies in intensively cropped soils, an overall decline in soil productivity and escalating prices of inorganic fertilizers. In this aspect, green manures based cropping pattern is the way of hope as an alternative of inorganic fertilizer.

The usefulness of incorporating green manure crops into a monoculture system is widely known. The fixation of nitrogen by legume green manure crops has been extensively reported by Aulakh *et al.* (2000). Becker *et al.* (1995) stated that the maximum amount of nitrogen accumulated by *Sesbania* species. It can entirely substitute the mineral fertilizer N in the subsequent rice crop. However, Green manuring crops is one of the effective techniques for soil quality improvement as it could have benefits for soil N dynamics by recovering residual mineral N in soil. Leguminous green manures also fix atmospheric nitrogen and thereby contributing to subsequent crop N nutrition. Legumes have the potential to enhance yields of subsequent crops through atmospheric nitrogen fixation as well as enhanced mineralization of soil organic N during legume residues decomposition (Jenkinson *et al.*, 1985). Karim (1998) found after two years cropping that soil organic matter content, total N, available P, exchangeable K and available S increased due to green manuring in the legume based rice-rice cropping patterns in both rainfed and irrigated ecosystems. According to Biswas *et al.* (1996), incorporation of green manuring crop to the soil reduced 50 percent of recommended N-levels of subsequent rice. Introducing green manure crops in a cropping pattern are not only improving soil nitrogen quality but also helps to reduce fertilizer cost. After harvesting of Boro rice, farmers can raise green manures without sacrificing main crops as large area remains fallow for about 2-3 month. Some farmers already started growing green manure in Kharif I after wheat. After wheat, farmers are growing maize or mungbean and then transplanted (T) Aman rice. In an intensive cropping sequence, farmers do not set apart 6-8 week exclusively for growing a green manuring crop with no direct benefit.

In this situation, if green manuring crop could be fitted into the turn around period or inter cropped or relay cropped without any adverse effect on yield of main crop, it may help the farmers to grow for increasing organic matter status of the soil and productivity of the subsequent crop (Hossain and Kashem, 1997). Recently with the development of short duration varieties of rice, mustard, potato, pulse and jute, opportunities have been created to fit four crops in same piece of land in a year (BARI, 2017)). The cost of a green manure crop in terms of labour, land and water utilization often out weighed the return, which often was less than the gain from an alternative cash crop (Rerkasem and Rerkasem, 1984). Ramteke *et al.* (1982) reported that economic analysis of cropping systems as a whole brought out the higher monetary returns from the crop sequences involving *Rabi* legumes. Considering the above facts, the present experiment was undertaken to study the feasibility of increasing cropping intensity and productivity by growing four or three crops in a year in a same piece of land by introducing Green manure- T. Aman-Mustard cropping pattern in the existing cropping system with fertilizer economy and monetary advantages as well.

Materials and methods

The field experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University during 2015 to 2016 to fit the suitable green manures in Gm-T.aman-Mustard cropping pattern and find out the monetary advantages and fertilizer economy as well. The initial and after harvesting of crop the soil of experimental field (0-15 cm) was collected for analyzing physical and chemical properties before setting the experiment (Table 1).

Two doses of Nitrogen were used for growing T. Aman crop for finding fertilizer economy. Such as:

i) 100% recommended nitrogen dose in 2015 and NPK in 2016 -F_1

ii) 50% recommended nitrogen dose in 2015 and NPK in 2016 -F_2

First crop sequence was, Green manure crops *viz.* Deshi dhaincha (*Sesbania aculeata*), African dhaincha (*Sesbania rostrata*), Sunnhemp (*Crotolaria juncea* L.), Mungbean (*Vigna radiata*), Blackgram (*Vigna mungo*), Cowpea (*Vigna unguiculata*), Ipil-ipil (*Leucaena leucocephala*) and Mimosa (*Mimosa pudica*) were grown for improving soil fertility along with a control (no green manuring crop). The experiment was laid out in a Randomized Complete Block Design with three replications. There were eight different green manuring crops along with a control as treatments having three replications. The total number of experimental unit was 27 (9 x 3). The experimental plots (except control) were fertilized with the recommended doses of 20-17.6-24.9kg N, P and K ha^{-1}(BARI, 2008) from their sources of Urea, TSP and MOP. Fifty days-old green manuring crops were incorporated after *in situ* cultivation during June.

Transplanted aman (T. Aman) rice was second crop of the sequence and thirty days after green manuring it was transplanted to the field. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2015). Thirty days old seedling of var. BRRI dhan66 were transplanted with 25cm x 15cm spacing during first week of August in the alternate cropping pattern. Grain yield were taken from whole plot in second week of November. The recommended fertilizer used for the T. aman experiments were 95-16-50-16-3kg N,P,K,S and Zn ha^{-1} from their sources of urea, triple super phosphate, murate of potash, gypsum and zinc sulphate respectively. Mustard (BARI Sarisha -14 (1^{st} year) and BARI Sarisha 15 (2^{nd} year) was planted as a third crop during last week of November in the three crop based cropping pattern. The crop was fertilized with 83-30-57-21-2kg N, P, K, S and Zn ha^{-1} from their source of urea, triple super phosphate, murate of potash, gypsum and zinc sulphate respectively. Mustard was planted with 30cm x 30cm spacing in the cropping system field. Mustard was harvested during first week of February and yields were taken.

Table 1. Initial/Mother soil and final organic matter status of GM crop based cropping pattern field at during 2015-16 and 2016-17.

Fertilizer level	Treatments	1^{st} year				2^{nd} year		
		Mother soil	After GM decomposition	After rice harvesting	After mustard harvesting	After GM decomposition (2^{nd})	After rice harvesting (2^{nd})	After mustard harvesting (2^{nd})
F1	T_0	1.01	1.01	1.01	1.01	1.01	1.23	0.74
	T_1		1.02	1.21	1.21	1.1	1.97	1.05
	T_2		1.08	1.02	1.21	1.14	2.01	1.08
	T_3		1.01	1.14	1.08	1.14	1.80	1.03
	T_4		1.00	1.08	0.81	1.14	1.80	0.86
	T_5		0.95	1.75	0.94	1.34	1.56	0.89
	T_6		1.01	0.87	0.94	1.08	1.72	1.01
	T_7		0.94	0.94	0.94	1.61	1.76	1.03
	T_8		1.00	0.87	0.94	1.28	1.23	0.94
F2	T_0		1.01	0.54	1.00	1.00	1.31	0.78
	T_1		1.02	1.41	1.00	1.61	1.72	1.03
	T_2		1.08	1.14	1.01	1.55	1.77	1.04
	T_3		1.01	1.03	0.94	1.28	1.77	0.90
	T_4		1.00	0.81	0.81	1.28	1.72	0.82
	T_5		0.95	0.87	0.67	1.48	1.72	0.90
	T_6		1.01	1.21	0.94	1.34	1.56	0.91
	T_7		0.94	0.94	0.87	1.14	1.77	0.83
	T_8		1.00	0.87	0.81	1.14	1.51	0.84

In above three experiments the labour members and wages were same but the reduction of uses of 100% chemical fertilizer was the main basis of the experiments especially of using the green manuring crops for suplemeting the chemical fertilizers. Data on yield of the crops were recorded carefully and analyzed statistically by a computer program Statistix 10. The mean comparisons of all parameters were done with Tuke"s W- procedure (Gomez and Gomez, 1984). The net income was calculated on the basis of prevailing market price of the commodities. Rice equivalent yield (REY) was determined as follows. REY = [Mustard yield (kg) × Mustard price (Tk. kg-1)] / price of rice grain (Tk. kg-1).

Results and discussion

1000-grain weight Effect of different levels of N and NPK fertilizers In both years, nitrogen levels had no significant effect on 1000–grain weight (Table 02). The maximum 1000–grain weight (23.06 g) was found from 100% Nha^{-1} in 1st year but 2nd year the maximim was found from 50% NPKha^{-1}. The numerically minimum 1000-grain weight was observed from 50% N/NPK application through it was statistically similar with 100% N/NPKha^{-1}.

Grain Yield

Nitrogen levels did not vary significantly the grain yield (Table 02). The maximum yield of grain (4.40 t ha^{-1} and 4.85 tha^{-1}) was obtained from 50% N ha^{-1} and 100% NPKha^{-1} and the minimum yield of grain (4.30 t ha^{-1} and 4.66 t ha^{-1}) was noted in 100% Nha^{-1} and 50% NPKha^{-1} in two consecutive years.

This might be due to the efficient and adequate nutrients supply from dhaincha biomass decomposition and released nutrients for the crop. Again, Bandara and Sangakkara (1993) found that the use of the full complement or 50% of the rate of mineral nitrogen with *Sesbania* produced similar yields. This suggests that the application of in situ mulch with *Sesbania* could reduce the mineral N requirement by 50%, produce rice yields similar to that obtained with the full complement of fertilizers. Beri and Meelu (l98l) also have reported that green manure plus 50% of the recommended fertilizer N resulted in higher rice yields than when recommended N rates were applied.

Table 2. Effect of fertilizer levels on1000-grain weight, grain yield and straw yield of transplant aman rice in two years.

Fertilizer leves	1000 seed wt (g)		Grain yield (t ha^{-1})		Straw yield (tha^{-1})	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
F_1	23.06	23.45	4.30	4.85	6.17	7.00
F_2	22.88	23.47	4.40	4.66	5.99	7.05
SE (±)	NS	NS	NS	NS	NS	NS
CV(%)	3.63	1.96	8.87	8.06	14.91	8.06

Here, F_1= Recommended dose for N in 2015 and NPK in 2016, F_2= Half of recommended dose for N in 2015 and NPK in 2016, NS = Not Significant.

Straw yield

Effect of different levels of N and NPK fertilizers

Straw yield was not significantly influenced by nitrogen levels (Table 02). The maximum straw yield (7.05 t ha^{-1} and 6.17 t ha^{-1}) was produced at 50% NPK ha^{-1} and 100% Nha^{-1} in 2016 and 2015 respectively. The minimum straw yield (5.99 tha^{-1} and 7.00 tha^{-1}) was found in 50% N ha^{-1} in 2015 and 100% NPK ha-^{1} in 2016 respectively. The tallest plant and maximum total tillers may be due to higher straw yield of rice.

Yield and productivity of cropping pattern

Yield and economic performance of alternate and existing cropping pattern during 2015-16 are presented in Table 03. Total productivity of different cropping pattern was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of rice combined with yield of mustard (rice equivalent yield). Rice equivalent yields were varied due to different cropping patterns (Table 03). The highest REY (9.60 t ha^{-1} in 1st year) and (11.49 t ha^{-1} in 2nd year) was recorded from the cropping pattern; *S. rostrata* – T.aman – Mustard followed by *C. juncea* – T.aman – Mustard , *S. aculeata* – T.aman – Mustard, in 2015 but in 2016, *V. unguiculata* based pattern showed second highest rice equivalent yield. The lowest REY (6.02 t ha^{-1} in 1st year) and (6.98 t ha^{-1} in 2nd year) was obtained from the cropping pattern;

Fallow-T. Aman – Mustard. Inclusion of mustard during rabi season in *S. rostrata* (59.47% and 64.61% in 2015 and 2016 respectively) and *C. juncea* (41.47% and 49.14% in 2015 and 2016 respectively) increased REY that followed by *V. unguiculata* (45.70% and 54.15% in 2015 and 2016 respectively) and *S. aculeata* (40.86% and 32.0% for 2015 and 2016 respectively) compared to Fallow-T. Aman-Mustard cropping pattern . It is noted that inclusion of crops likes *S. rostrata, C. juncea, S. aculeata* and *V. unguiculata* showed higher REY than other crops as GM in GM-T. Aman-Mustard cropping pattern. The cost of production in situ green manure was lower than addition of similar quantities from external sources.

This again signifies the usefulness of in situ green manuring, especially for a rice crop, at a time when the fields are idle, rather than importing organic matter. This would also reduce the N requirement by 50% to obtain similar yields.

Table 3. Rice equivalent yield of different cropping patterns in 2015 and 2016.

Cropping patterns	1st year				2nd year				
	Rice yield (t ha^{-1})	Mustard yield (t ha^{-1})	Rice equivalent yield (t ha^{-1})	Net income	Rice yield (t ha^{-1})	Mustard yield (t ha^{-1})	Rice equivalent yield (t ha^{-1})	Net income	Average rice equivelent yield (t ha^{-1})
Fellow-Rice-Mustard	3.42	0.65	6.02	120400	3.70	0.82	6.98	139600	6.50
S.aculeata-Rice-Mustard	5.00	0.87	8.48	169600	5.25	1.23	10.17	203400	9.33
S. rostrata-Rice-Mustard	5.20	1.10	9.60	192000	5.33	1.54	11.49	229800	10.55
C. juncea-Rice-Mustard	4.68	0.96	8.52	170400	5.21	1.30	10.41	208200	9.47
V. radiata-Rice-Mustard	3.73	0.74	6.69	133800	4.59	1.16	9.23	184600	7.96
V. mungo-Rice-Mustard	4.06	0.87	7.54	150800	4.50	1.13	9.02	180400	8.28
V. unguiculata-Rice-Mustard	4.75	0.80	7.95	159000	5.08	1.42	10.76	215200	9.36
L.leucocephala-Rice-Mustard	4.11	0.77	7.19	143800	4.65	1.16	9.29	185800	8.24
M.pudica-Rice-Mustard	4.23	0.82	7.51	150200	4.48	1.21	9.32	186400	8.42

Price: Rice = TK. 20 kg^{-1}, Mustard = TK. 80 kg^{-1}

Economic analysis

Economic analysis was done on the basis of prevailing market price of the product. Productivity of different cropping systems were compared in terms of rice equivalent yield. Economics of system productivity of alternate and existing cropping sequences showed in Table 03 and it was observed that net income was different for different cropping patterns. Higher net income (Tk. 192000 tk) for 1st year and (Tk.229800 tk) for 2nd year were obtained in alternate *Sesbania Rostrata*-T. Aman-Mustard cropping pattern for both the years as compared to Fallow-T. Aman-Mustard cropping pattern.

Conclusion

Inclusion of *S. rostrata* in cropping pattern gave 59% and 64% yield increase over fallow pattern as well as monetary advantages (1,92,000Tk ha^{-1} and 2,29,800Tk ha^{-1} in 1st and 2nd year) in two consecutive years. After two years of study, soil fertility levels i.e., organic matter (7% and 3%) were found increased with 100% fertilizer and 50% fertilizers due to *in situ* application of *S. rostrata* biomass. It was also observed that addition of biomass through *S. rostrata* grown before rice cultivation (succeeding crop) and Mustard (following crop) enriched the organic matter content of the soil very much. *S. rostrata* – T. aman – Mustard cropping pattern gave the highest rice equivalent yield as well as improved soil fertility followed by *C. juncea* – T.aman – Mustard, *S. aculeata* – T. aman – Mustard cropping pattern, so it may recommended for farmers for their betterment of soil as well as crop productivity.

The cost of production in situ green manure was lower than addition of similar quantities from external sources. This again signifies the usefulness of in situ green manuring, especially for a rice crop, at a time when the fields are idle, rather than importing organic matter. This would also reduce the N requirement by 50% to obtain similar yields. The 50% reduction of chemical fertilizer can be recommended for succeeding T. aman rice from followed by growing *Sesbania rostrata, Sesbania aculeata, Crotalaria juncea* or *Vigna unguiculata* as a preceeding green manuring crop. As the recommended cropping patterns needed 207 days, so it can be possible to include another short duration crop like mungbean in existing cropping patterns during the gap between mustard and green manuring crops.

Hence in such case, GM-T. Aman-Mustard-Mungbean may be a more effective cropping pattern in respect of yield and soil quality concern that can be tested in future studies.

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