INTEGRATED NUTRIENT AND CROP MANAGEMENT PRACTICES FOR INCREASED CROP PRODUCTION IN WHEAT-FALLOW-T.AMAN RICE CROPPING PATTERN WITH MUNGBEAN INCLUSION

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Abstract

Integrated use of fertilizers and manures can ensure higher crop yield maintaining soil productivity for sustainable production. An experiment was conducted at Bangladesh Institute of Nuclear Agriculture (BINA) Sub-station Ishwardi, Pabna for consecutive two years (2013-2014 and 2014-2015) with integrated use of organic, inorganic fertilizers and mungbean residue in the Wheat-Mungbean-T.aman rice cropping pattern. The experiment comprised of seven treatments arranged in a randomized complete block design with three replications. Collected soil samples (initial and after completion of two years cropping pattern) were analyzed in the laboratory for different parameters following standard methods. The highest grain yield of wheat was recorded in the treatment T_2 ($N_{120}P_{30}K_{45}S_{20}Zn_4B_2$ kg ha^{-1}) which was statistically identical with T_7 (4.47 t ha^{-1}), T_6 (4.40 t ha^{-1}) and T_4 (4.43 t ha^{-1}). The highest mungbean seed yield 1.45 tha^{-1} was recorded in the treatment T_2 ($N_{10}P_{15}K_{10}S_5$ kg ha^{-1}) along with residual effect of applied fertilizer during rabi season. It was noted that the treatment T_2 (1.45 t ha^{-1}) produced statistically identical yield with the treatment T_4 (1.38 t ha^{-1}), T_5 (1.20 t ha^{-1}) T_6 (1.30 t ha^{-1}) and T_3 (1.17 t ha^{-1}). The results indicated that grain and straw yields of T. Aman rice had positively influenced when inorganic fertilizers were applied along with incorporation of mungbean stovers before transplanting of T. Aman rice. The highest marginal rate of return (MRR) 634% in the treatment T_5 followed by 568% and 410% in the treatments T_6 and T_4. Uptake of different nutrients of the cropping pattern follow the order: N>K>P>S. Incorporation of mungbean stover as brown manuring into the soil before transplanting of Aman rice had significantly increased the yield of rice which minimized 1/3 of recommended N fertilizer and improved soil fertility.

Key wards: Crop management, Mungbean, Brown manure, Nutrient uptake and Soil fertility.

Introduction

Rice is the key staple food for the world's poorest and undernourished people living in Asia and Africa as they cannot afford or do not have access to nutritious foods (Bin *et al*,. 2022) and influences the livelihoods and economies of several billion people. In Bangladesh, Rice-Rice and Rice-Wheat are widely practiced cropping patterns among which Rice-Wheat cropping pattern covers an area of 6,50,000 ha (Bhuiyan *et al.*, 2010). Again, Rice-wheat cropping pattern further has become more popular with the increasing area under high yielding varieties of rice and wheat cultivation. The national average rice yield (3.01 t ha^{-1}) is much lower than that of other rice growing countries (BBS, 2020).

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Modern varieties obviously require higher amount of nutrients to attain higher crop yields. Rice-Wheat cropping system has a capacity to produce more than 8 tons of cereal grain ha^{-1} $year^{-1}$ which removed 400-700 kg ha^{-1} nutrients from soil against the application of 440 kg ha^{-1} nutrients (Bhuiyan *et al.*, 2010). Most of the farmers in Bangladesh do not use balanced doses of fertilizers. Practicing the crop rotations with inadequate and disproportionate amount of fertilizers have created system productivity stagnation, nutrient and water imbalance and soil organic matter depletion (Zia *et al.*, 1992). Rice productivity and total rice production in Bangladesh still have scope to increase if the proper crop management systems are followed (Shelley *et al*., 2015). Grain yield of rice was significantly increased due to application of green manure prior to T aman rice (Irin *et. al.,* 2020). A sustainable agriculture is ecologically sound, economically viable and socially acceptable. These four goals for sustainability can be applied to all aspects of any agricultural system. Basic concepts of sustainable systems are to maintain or improve soil quality and fertility, improve internal nutrient cycles on the farm which will reduce the dependence on external use of chemical fertilizers (Rana and Rana, 2011).

The low organic matter content, higher cropping intensity, improper cropping sequence, and faulty management practices are the major causes of depletion of soil fertility. Proper identification and management of soil fertility problems are pre-requisite for boosting crop production and sustaining higher yields over a long period of time. A suitable combination of organic and inorganic sources of nutrients is necessary for a sustainable agriculture that will provide food with good quality and maintain a sound environment (Mollah *et al.*, 2011). Growing a legume in the cropping sequence has special significance in the maintenance of soil fertility and crop productivity because of its unique ability of fixing and utilizing atmospheric nitrogen (Rahman *et al*., 2013). The rural people has little chance to add organic residues to the soil through farmyard manure, composts or organic residues as a major portion of these materials are being used as fuel. Inclusion of legume crop in between cereals may contribute to maintaining or increasing soil organic matter. Soil N loss may be minimized by using effective legume crops which can supply sufficient BNF (Biological nitrogen fixation) input to enhance soil N by improved recycling of N through plant residues (Cazzato *et al.*, 2012). Growing a legume in the cropping sequence has special significance in the maintenance of soil fertility and crop productivity because of its unique ability of fixing and utilizing atmospheric nitrogen and crop productivity because of its unique ability of fixing and utilizing atmospheric nitrogen (Rahman *et al.*, 2013). Mungbean is the most common grain legume grown in the summer to utilize the gap between winter and rainy season crops (Bhuiyan, 2010). Rice-Wheat cropping systems became important due to consumptions of wheat in many ways like human diets, cattle feed etc. Most of the wheat growing farmers of the country are growing wheat in Wheat-Fallow-T.Aman rice cropping pattern. There is scope of introducing mungbean in fallow period after wheat and a few farmers already started growing mungbean in Kharif-I season. In addition mungbean seed yield added some return for the farmers as well as additional nutrients supply from mungbean brown manuring (Rahman *et al.,* 2013).

The inclusion of leguminous crops into cereal farming system is important for their residues which caused long-term sustainability. In tropical areas like Bangladesh, mungbean can easily be grown as a short duration summer pulse crop between wheat and rice. Mungbean should receive attention for evaluating the sources of organic matter, nutrient supply and to produce certain amount of grains in the cropping system (Sarker *et al.,* 2011). It is used as whole or split seeds as soup (Dal) but in other countries sprouted seeds are widely used as vegetables. It is important source of high quality protein (26%), carbohydrates (51%), moisture (10%), mineral (4%) and vitamins (3%) (Jahan *et al.,* 2014).

The imbalanced use of fertilizers and the traditional cereal-cereal cropping system has not been able to restore the natural fertility of the soils. To increase the crop production and farm income on sustainable basis, these lands require careful handling and land management should scientific manners (Ahmad *et al.,* 2010). Assessment of the nutrient requirement of different crops for desired yield levels in a cropping sequence is the first step in developing sound fertilizer management practices. Inclusion of legumes in crop rotations protect the fragile soil surface and may even counteract erosive forces by restoring the organic matter content and organic fertility of the soils. This would also help to restore the natural fertility of the soils (Ahmad *et al.,* 2010). Therefore, in order to sustain agricultural production it is necessary to introduce mungbean green manuring crops in cropping pattern to maintain and improve soil fertility.

Material and Methods

An experiment was conducted at BINA Sub-station Ishwardi, Pabna for two years (2013-2014 to 2014-2015) with integrated use of organic, inorganic fertilizers and crop residue management using Wheat-Mungbean-T.Aman rice cropping pattern where the existing pattern is Wheat-Fallow-T.Aman rice. The experiment was laid out in a Randomized Complete Block Design (RCBD) having unit plot size of 4m x 5m and replicated thrice. Treatments were T_1 = Control (without fertilizer), T_2 = 100% chemical fertilizers (recommended rate for high yield goal) to each major crop, T_3 = 70% chemical fertilizers in each major crop + cowdung (5 t ha^{-1}), T_4 = 100% chemical fertilizers for the first major crop (only N fertilizer in T. Aman rice), T_5 = 70% chemical fertilizers to each major crop, T_6 = 100% chemical fertilizers for the first crop + 50% chemical fertilizers for T. Aman rice and T_7 = 100% chemical fertilizers for the first crop + 50% chemical fertilizers for T.Aman rice but no mungbean crop in the system. Composite soil samples were collected at 0-15 cm depth from the experimental site. Collected soil samples were analyzed in the laboratory for different parameters following standard methods. The initial soil of experimental field contained pH 8.1, organic matter 1.22%, total N 0.10%, available P, S, Zn and B were 11, 16, 1.05 and 0.35 ppm, respectively. The exchangeable cations were K, Ca Mg 0.20, 4.75 and 1.56 me%. Wheat (cv. Gourav) was sown at the rate of 120 kg seed ha^{-1} with a line to line spacing of 20 cm. The crop cycle was started by sowing of wheat during Rabi season followed by summer mungbean (cv. Binamoog-5) in Kharif-1 season and T.Aman rice (cv. Binadhan-7) in Kharif-II season. Treatment combinations with 100%

and 70% fertilizers used used in the experiment is given in the Table 1. For wheat full dose of cowdung, P, K, S, Zn B and 1/3 of N from urea were applied at the time of final land preparation. Remaining N was applied in two equal splits i.e. at CRI and panicle initiation stages. Irrigation was done as and when necessary. For mungbean, a basal application of recommended dose of N, P, K and S were applied at the time final land preparation. After final harvest seed and stover yields of mungbean were recorded and the stover was incorporated in the respective plots. For T.Aman rice all the fertilizers except urea were applied at the time of final land preparation. Urea was applied in two equal splits at 10 and 45 days after transplanting (DAT). Grain and straw yields were recorded per plot basis at 14% moisture level and the required amount of grain and straw samples were kept for determination of N, P, K and S content. Economic analysis (BCR, MBCR and MRR) of the product was done as described by Perrin *et. al.* (1979). After completion of two cycles soil samples were collected from each plot and analyzed for pH, organic matter, total N and available P, K, S and Zn to monitor the nutritional status of the soils.

Table 1. Treatment combinations with 100% & 70% fertilizers used for Wheat-Fallow-T.Aman rice cropping pattern

Treatment	Nutrient added (kg ha^{-1})										
	Wheat (cv. Gourav)							T. Aman (Binadhan-7) rice			
	N	P	K	S	Zn	B	CD t/ha	N	P	K	S
T_1	-	-	-	-	-	-	-	-	-	-	-
T_2 (100%)	120	30	45	20	04	02	-	80	20	30	08
T_3 (70%)	84	21	32	14	03	01	05	56	14	21	06
T_4 (100%)	120	30	45	20	04	02	-	80	-	-	-
T_5 (70%)	84	21	32	14	03	01	-	56	14	21	06
T_6 (100%)	120	30	45	20	04	02	-	80	10	15	04
T_7 (100%)	120	30	45	20	04	02	-	80	10	15	04

For mungbean (Binamoog-5) a basal recommended dose $N_{20}P_{15}K_{10}S_5$ kg ha^{-1} was used during final land preparation.

Results

Yield of crops

Wheat: Application of different doses of fertilizers treatments increased grain and straw yields of wheat (cv. Gourav) significantly over the absolute control treatment (Table 2). Grain and straw yields of wheat ranged from 0.74-4.55 and 1.52-6.61 t ha^{-1}, respectively. The highest grain yield of 4.55 t $ha^{-1}$was recorded from the treatment T_2 ($N_{120}P_{30}K_{45}S_{20}Zn_4$ and B_2 kg ha^{-1}) which was statistically identical with the treatment T_7 (4.47 t ha^{-1}), T_6 (4.40 t ha^{-1}) and T_4 (4.43 t ha^{-1}). However, treatment T_3 which received 70% chemical fertilizer of T_2 along with cowdung 5 t ha^{-1} produced statistically identical yield (3.87 t ha^{-1}) with treatment T_5 (3.50 t ha^{-1}) (70% chemical fertilizer of T_2 only). Like grain yield the straw yields followed the same trends (Table-2).

Mungbean: Grain and stover yields of mungbean (cv. Binamoog-5) increased significantly due to treatments over control (Table 2). The highest grain yield of 1.45 t ha^{-1} was recorded in treatment T_2 ($N_{10}P_{15}K_{10}$ & S_5 kg ha^{-1}) along with residual effect of fertilizer applied during rabi season. It is noted that treatment T_2 produced statistically identical yield (1.45 t ha^{-1}) with the treatment T_4 (1.38), T_5 (1.20) T_6 (1.30) and T_3 (1.17), t ha^{-1}.

T.Aman: The results indicated that grain and straw yields of T.Aman rice had positive effect when inorganic fertilizers were applied along with incorporation of mungbean stovers before transplanting of aman rice (Table 2). The highest grain yield 4.55 t ha^{-1} was recorded in treatment T_2 ($N_{70}P_{15}K_{30}$ and S_6 kg ha^{-1}) which was statistically identical with treatment T_5 (4.34 t ha^{-1}), T_7 (4.21 t ha^{-1}), T_6 (4.14 t ha^{-1}), and T_3 (4.17 t ha^{-1}). On the other hand, treatment T_4 (3.50 t ha^{-1}) produced 2nd lowest yield compared to others. Like grain yield, the straw yield also followed the same trend (Table 2).

Table 2. Effect of different fertilizer doses on grain/seed and straw/stover yield (t ha^{-1}) of Wheat-Fallow-T.Aman rice

Treatments	Wheat (cv. Gourab)			Mungbean (cv. Binamoog-5)			T.aman rice (cv. Binadhan-7)		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
	Grain/Seed								
T_1	0.75d	0.72c	0.74	1.04c	1.25c	1.15	1.98c	1.60c	1.79
T_2	4.60a	4.50a	4.55	1.34a	1.55a	1.45	4.58a	4.52a	4.55
T_3	3.94b	3.80b	3.87	1.14b	1.20ab	1.17	4.24ab	4.10ab	4.17
T_4	4.39a	4.47a	4.43	1.32a	1.43a	1.38	3.50b	3.50b	3.50
T_5	3.66c	3.33b	3.50	1.10bc	1.30ab	1.20	4.42a	4.25ab	4.34
T_6	4.32a	4.48a	4.40	1.34a	1.25ab	1.30	4.13ab	4.15ab	4.14
T_7	4.38a	4.55a	4.47	*	*	*	4.21ab	4.20ab	4.21
	Straw/Stover								
T_1	1.62a	1.42c	1.52	2.37	2.13c	2.25	3.67d	3.65c	3.66
T_2	6.09ab	6.40a	6.25	3.46	3.21bc	3.34	6.46a	6.40a	6.43
T_3	5.68c	5.15b	5.42	2.69	3.39ab	3.04	6.25ab	6.20a	6.23
T_4	6.84a	6.37a	6.61	3.38	2.86d	3.12	5.13c	5.15ab	5.14
T_5	5.31c	5.95a	5.63	2.42	2.99cd	2.71	5.50bc	5.50ab	5.50
T_6	6.29a	6.58a	6.44	3.31	3.58a	3.45	6.55a	6.35a	6.45
T_7	6.21a	6.40a	6.31	*	*	*	6.77a	6.25a	6.51

* As per treatment plan, there was no green manuring/mungbean crop in T_7 treatment

Economics of Fertilizer Uses

Economics of fertilizer uses have been calculated on the total products of two cropping cycles following partial budget analysis and marginal analysis as described by Perrin *et. al*. (1979). The results of economic analysis for Wheat-Fallow-T.Aman rice cropping pattern (Table 3) indicated that the highest net benefit (Tk. 1,21,458 ha^{-1}) was obtained in treatment T_2 followed by T_6 (Tk. 1,16,149 ha^{-1}), T_4 (Tk. 1,12,501 ha^{-1} and T_3 (Tk. 1,05,982 ha^{-1}). Marginal analysis of undominated fertilizer response data (Table 4) showed the highest marginal rate of return (MRR) in treatment T_5 followed by the treatments T_6 and T_4.

Table 3. Economics of fertilizer use in crop production under Wheat-Fallow-T.Aman rice cropping pattern

Treatments	Economic Yield		Gross Profit			Variable money cost (Fertilizer)	Variable opportunity cost	Total variable cost	Net benefit
	Grain	Straw	Grain	Straw	Total				
	(t ha^{-1})		(Tk. ha^{-1})			(Tk. ha^{-1})			
T_1	3.68	7.43	50,470	7,430	57,900	-	-	-	57,900
T_2	10.55	16.02	1,16,650	16,020	1,32,670	10,612	600	11,212	1,21,458
T_3	9.19	14.69	1,00,400	14,690	1,15,090	9,478	450	9,928	1,05,162
T_4	9.31	14.87	1,06,800	14,870	1,21,670	8,719	450	9,169	1,12,501
T_5	9.04	13.48	99,720	13,840	1,13,560	6,978	600	7,578	1,05,982
T_6	9.84	16.34	1,09,620	16,340	1,25,960	9,211	600	9,811	1,16,149
T_7	8.68	12.82	78,300	12,820	91,120	7,616	450	8,066	83,054

Price of N as urea= Tk. 13.0 kg^{-1}; P as TSP= Tk. 75.0 kg^{-1}; K as MP= Tk. 20.0 kg^{-1}; S as gypsum= Tk. 28 kg^{-1}; Zn as ZnO= Tk. 111 kg^{-1}; B as Borax= Tk. 250 kg^{-1} and CD=Tk. 500 t^{-1}; Price of rice grain=Tk. 8.00 kg^{-1}; straw=Tk. 1000 t^{-1}; Mungbean seed = Tk. 25.0 kg^{-1}; stover = Tk. 1000 t^{-1}; wheat grain = Tk. 10.0 kg^{-1} and straw = Tk. 1.00 kg^{-1}.

Table 4. Marginal analysis of undominated fertilizer response data

Net benefit (Tk. ha^{-1})	Treatments	Variable cost (Tk. ha^{-1})	Changes from next highest		
			Marginal increase in net benefit (Tk. ha^{-1})	Marginal increase in variable cost (Tk. ha^{-1})	MRR (%)
1,21,458	T_2	11,212	5,309	1,401	3.79
1,16,149	T_6	9,811	3,648	642	5.68
1,12,501	T_4	9,169	6,519	1,591	4.10
1,05,982	T_5	7,578	48,082	7,578	6.34
57,900	T_1	-	-	-	-

Nutrient Uptake

The amounts of N, P, K and S absorbed by Wheat-Mungbean-T.Aman cropping pattern as affected by different doses of nutrients, organic matter and crop residue management are presented in Table 5. Total nutrient uptake increased with the increase of yield. Total nutrient uptake ranged from N (71-230), P (11-53), K (84-254) and S (11-36), kg ha^{-1}, respectively. Nutrient uptake of the cropping pattern found to follow the order: K>N>P>S.

Table 5: Nutrient uptake (kg ha^{-1}) of Wheat-Fallow-T.Aman rice cropping pattern as affected by different treatment combinations

Treatments	N	P	K	S
T_1	71	16	84	11
T_2	230	51	240	34
T_3	165	38	206	28
T_4	198	45	213	29
T_5	152	36	174	25
T_6	228	53	254	36
T_7	194	33	193	27
Range	71-230	11-53	84-254	11-36

Soil Fertility Status

The changes in soil pH, organic matter, total N and available P, K and S of initial soil as well as post-harvest soil of Wheat-Mungbean-T.Aman rice cropping pattern are furnished in Table 6. Incorporation of mungbean stover into soil in between two cereal crops has brought no appreciable changes of nutrients in the post-harvest soil during the period of the study. There were considerable decreases in pH and organic matter content appeared in most cases. However, available P and S were slightly increased but there were considerable depressing on exchangeable K in soils resulted from the two years of cropping. On the other hand, the amount of K removal far exceeding that replenished through fertilization.

Table 6: Changes in soil nutrient status due to fertilizer doses under Wheat-Fallow-T.Aman rice cropping pattern after two cropping cycles

Treatment	pH	Organic matter (%)	Total N (%)	Available Nutrients (ppm)				Exchangeable Cations (me%)		
				P	S	Zn	B	K	Ca	Mg
Initial soil										
	8.1	1.22	0.10	11	16	1.05	0.35	0.20	4.75	1.56
Post harvest soil										
T_1	8.0	1.19	0.08	10	14	1.01	0.37	0.16	4.70	1.66
T_2	7.8	1.20	0.09	12	14	1.00	0.36	0.17	4.71	1.60
T_3	8.0	1.16	0.09	11	12	1.04	0.38	0.15	4.80	1.53
T_4	7.9	1.18	0.10	14	13	1.04	0.35	0.18	4.72	1.58
T_5	8.0	1.19	0.08	11	15	1.00	0.37	0.15	4.70	1.58
T_6	7.6	1.17	0.09	12	15	1.06	0.33	0.16	4.70	1.59
T_7	8.0	1.18	0.08	11	16	1.04	0.34	0.17	4.70	1.55

Discussion

Increased crop productivity from the shrinking land resources is the urgent need to meet the increased food demand of the swelling population in Bangladesh (Islam *et al.*, 2002). Application of different doses of fertilizers treatments increased grain and straw yields of wheat (cv. Gourav) significantly over the absolute control treatment. Treatment received 100% chemical fertilizer produced higher yield than treatments received 70% chemical fertilizer. However, treatment T_3 which received (70% chemical fertilizer of T_2 + cowdung 5 t ha^{-1}) produced the statistically identical yield with treatment T_5 (70% chemical fertilizer of T_2 only). That is the treatment received 70% chemical nutrient along with cowdung 5 t ha^{-1} had some positive effect on grain yield over the treatment received 70% chemical fertilizer only. Rahman *et al.* (2013) reported highest grain yield from 100% fertilizer application which was comparable with 75% inorganic fertilizer along with legume residue incorporation. Genetic biofortification coupled with agronomic approach (fertilization) would help to develop of new cultivars of wheat that would have ability to accumulate Zn and Fe in grain (Khan *et al*., 2021).

Grain and stover yields of mungbean (cv. Binamoog-5) increased significantly due to treatments over control. The highest grain yield of 1.45 t ha^{-1} was recorded in the treatment T_2 along with residual effect fertilizer applied during rabi season. It is noted that the treatment T_2 produced the statistically identical yield with the treatments T_4, $T_{5,}$ T_6 and T_3. Soil test based fertilizer recommendation with some additional nutrients would increase the yield in Wheat-Mungbean-T.Aman rice cropping pattern (Das *et al.*, 2018). The lowest grain yield of 1.15 t ha^{-1} was obtained in the control treatment. Considering amount of residue after harvesting legume crops with narrower C:N ratio is left in the soil which upon decomposition improves the physical condition and fertility of soil. Further supply of nitrogen by introducing legume crop in the cropping sequence involves no extra input and risk but may be a better substitute partly for chemical nitrogen (Pokhrel and Pokhrel, 2013).

The results of grain and straw yields of T. Aman rice (cv. Binadhan-7) under Wheat-Fallow-T. Aman cropping pattern are indicated that grain and straw yields of T.aman rice had positive influenced when inorganic fertilizers were applied along with incorporation of mungbean stovers before transplanting of T. Aman rice. The highest grain yield was recorded in the treatment T_2 which was statistically identical with the treatments T_5, T_7, T_6, and T_3. Grain yield of rice was significantly increased due to application of green manure prior to T aman rice (Irin et. al, 2020). According to Haque et al. (2002), nutrient deficiencies have resulted in the decline of yields of rice or/and wheat as well as a reduction in factor productivity at a number of locations where long-term trials have been conducted.

Incorporation of mungbean stover into soil in between two cereal crops has brought no appreciable changes in the post-harvest soil during the period of the study. There were considerable decreases in pH and organic matter content appeared in most cases. However, available P and S were slightly increased but there were considerable depressing on exchangeable K in soils resulted from the two years of cropping. On the other hand, the amount of K removal far exceeding that replenished through fertilization.

Now it is important to pay attention to net benefits rather than yields. Proper fertilization effectively improves quality and yield of crops, reduces cost as well as increase farmers income.

Economic analysis for Wheat-Mungbean-T.aman rice cropping pattern showed highest net benefit of Tk. 1,21,458 ha^{-1} in treatment T_2. All the treatments with mungbean produced higher net benefit than the treatment with no mungbean. The legume base cropping system found appropriate on farm, from the quantitative and qualitative production point of view which is not only ecologically and environmentally sound, but also it is economically viable recommendations and fittest for sustainable soil management (Pokhrel and Pokhrel, 2013). Marginal analysis of undominated fertilizer response data recorded the highest MRR in the treatment T_5 followed by the treatments T_6 and $T_{4,}$ respectively.

Conclusion

For yearly cropping sequences the residual effect of P & S fertilizers applied to the first crop should be evaluated and considered in formulating fertilizer recommendations for the subsequent crop. Incorporation of mungbean stover as brown manuring in soil before transplanting of aman rice may significantly increase the yield of rice as well as minimize 1/3 of recommended N fertilizer. Considering crop yield, economic return and soil fertility, inclusion of mungbean as a green manure could be recommended for the Wheat-Fallow-T. Aman rice cropping pattern.

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