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EFFECT OF INTEGRATED USE OF ORGANIC MANURES WITH CHEMICAL FERTILIZERS IN THE RICE-RICE CROPPING SYSTEM AND ITS IMPACT ON SOIL HEALTH

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Abstract

A field experiment was conducted during 2003-2004 at Bangladesh Agricultural University farm, Mymensingh to evaluate the suitability of different sources of organic materials for integrated use with chemical fertilizers for the Boro-Fallow-T. Aman rice cropping pattern. The experiment was set up in a randomized complete block design (RCBD) with three replications. Eight-treatments, formulated from organic manure and chemical fertilizers have been imposed. The treatment combinations are T_1: control, T_2: 70% NPKS, T_3: 100% NPKS, T_4: 70% NPKS + rice straw (RS) @ 5 t/ha, T_5: 70% NPKS + dhaincha (DH) @ 15 t/ha, T_b: 70% NPKS + mungbean residue (MBR) @ 10 t/ha, T_7: 70% NPKS + cowdung (CD) @ 5 t/ha and T_8: 70% NPKS + poultry manure (PM) @ 3 t/ha. Organic manure or crop residue was applied to T. Aman rice and their residual effects were observed in the following Boro rice. Application of 70% NPKS + PM produced the highest grain yield of T. Aman rice, which was identical to that obtained with 100% NPKS with no manure. In Boro season. application of 100% NPKS produced the highest grain yield of 6.87 t/ha, which was identical with the application of 70% NPKS + PM (6.57 t/ha). The total grain yield in the cropping pattern ranged from 5.14 t/ha in T_1 (control) treatment to 12.29 t/ha in the 100% NPKS. The application of 3 t/ha PM with 70% NPKS (T_8) produced the total yield of 12.09 t/ha followed by 11.59 t/ha in the treatment containing 10 t/ha MBR plus 70% NPKS (T_6). It appears that the application of 3 t/ha PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers. There were negative balances for N and K with the highest mining of K, while the balances for P and S were positive. The economic analysis reveals that most of the treatments produced BCR (benefit-cost ratio) of more than 3.0 showing that they all are economically viable. The integrated use of fertilizers and manure resulted in considerable improvement in soil health by increasing organic matter, available P, and S contents of soils. The overall findings of the study indicate that the integrated use of chemical fertilizer and manure is important for sustainable crop yield in a rice-rice cropping pattern.

Kew Words: Organic manures, chemical fertilizer, soil health.

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Introduction

Soil fertility deterioration is a major constraint for higher crop production in Bangladesh. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic manure have caused severe fertility deterioration of our soils resulting in stagnating or even declining of crop productivity. The farmers of this country use, on an average, 172 kg nutrients/ha annually (132 kg N + 27 kg P + 17 kg K + 4 kg S, and 2 kg Zn), while the crop removal is about 250 kg/ha (Islam, 2002). Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long- term sustainable crop productivity. Soil organic matter is a key factor for sustainable soil fertility and crop productivity. Organic matter undergoes mineralization with the release of substantial quantities of N, P, and S. and smaller amount of micronutrients. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter, while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soils is declining with time due to intensive cropping and use of higher doses of nitrogenous fertilizers with little or no addition of organic manure. Consequently, Zn and B deficiencies are frequently reported on some soils and crops (Jahiruddin *et al.*, 1995 and Mondal *el al.*, 1992). Rice *(Oryza sativa* L.) is intensively cultivated in Bangladesh covering about 80% of arable land. Unfortunately, the yield of rice in this country is low (3.4 t/ha) compared to other rice growing countries like South Korea and Japan where the average yield is 6.00 and 5.6 t/ha, respectively (FAO, 2003). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population.

A suitable combination of organic and inorganic source of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Reganold *et al.*, 1990). Nambiar (1991) viewed that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research of BRRI revealed that the application of cowdung 5 t/ha/yr improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. Based on the soil fertility problem as discussed above, the present study was undertaken to investigate the effect of combined use of chemical fertilizers and organic manures in a rice-rice cropping system.

Materials and Method

A field experiment was conducted during 2003-2004 at Bangladesh Agricultural University farm, Mymensingh to evaluate the suitability of different sources of organic materials for integrated use with chemical fertilizers for the Boro-FalIow-T. Aman rice cropping pattern. The soil was non-Calcareous Dark Grey

Floodplain. The cultivars used were BRRI dhan-29 and BRRI dhan-31 for Boro and T.Aman rice, respectively. The experiment was designed with eight treatments for both the crops. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 5m x 4m. The treatment combinations were: T_1 (control), T_2 (70% NPKS), T_3 (100% NPKS), T_4 (70% NPKS + RS), T_5 (70% NPKS + DH), T_6 (70% NPKS + MBR), T_7 (70% NPKS + CD) and T_8 (70% NPKS + PM). The rates of chemical fertilizers were fixed on soil test basis (STB) with a high yield goal (HYG) target as per Fertilizer Recommendation Guide (BARC, 1997).Thirty-five days old seedlings were used for transplanting in both Boro and T. Aman seasons. T. Aman was transplanted on 5 August and harvested on 29 November 2003. For Boro, the crop was transplanted on 28 January and harvested on 29 May 2004. The initial soil status and the composition of different organic manures are given in Table 1 and 2.

Table 1. General characteristics of initial soil.

Characteristics	Value
% Sand	17.4
% Silt	67.0
%Clay	15.6
Textural class	Silt loam
pH (Soil: Water = 1:2.5)	6.8
Organic carbon (%)	1.15
Organic matter (%)	1.99
CEC (me/I00 g soil)	10.10
Total N (%)	0.077
C:N ratio	9.30
Available P (ppm)	12.0
Available S (ppm)	13.9
Available Zn (ppm)	1.62
Exchangeable K (me/I00 g soil)	0.13

Table 2. Chemical composition of different organic manures.

Organic materials	Nutrient composition (%)					
	H_2O	Organic carbon	N	P	K	S
Rice straw	22	15.4	0.55	0.18	1.47	0.13
Dhaincha	80	18.5	1.55	0.37	1.47	0.12
Mungbean residues	70	16.8	1.12	0.27	1.05	0.12
Cowdung	40	10.5	1.13	0.27	0.68	0.15
Poultrymanure	20	12.6	2.70	0.52	1.58	0.15

The rates of N, P, K, and S for the first crop (T. Aman rice) and second crop (Boro rice) were 100, 15, 45, and 10 kg/ha, and 140, *25*, 60, and 20 kg/ha respectively. Five different sources of organic matters, viz., rice straw (RS), dhaincha (DH), mungbean residues (MBR), cowdung (CD), and poultry manure (PM) were applied @ 5, 15, 10, 5, and 3 t/ha, respectively, during T. Aman season only. Mungbean was grown during April to July and Dhaincha during May to July in the field adjacent to the experimental plots. Sixty and sixty-five days old decomposed dhaincha and mungbean residue were applied 4 days before transplanting of T. Aman rice. Urea was applied in three equal splits. The first split was applied during final land preparation, the second split at active tillering stage and the remaining split at panicle initiation stage of the crop. Organic manure was applied to soil before final land preparation. All the cultural practices like weeding, irrigation, insecticide spray, etc. were done in time. Grain and straw were analyzed separately for determination of N, P, K, and S contents. All the data were analyzed statistically following the F-test and the mean comparisons were made by DMRT at 5% level.

Results and Discussion

1. Grain and straw yield of the crops

Grain and straw yields of T. Aman rice (var. BRRI dhan-3l) responded significantly to the different treatment combinations (Table 3). The highest grain yield (5.52 t/ha was obtained in T_8 (70% NPKS + PM) treatment, which was significantly higher than T_1 (control), T_2 (70% NPKS) and T_4 (70% NPKS + RS) treatments, but statisticaly identical with T_3 (100% NPKS), T_5 (70% NPKS + DH), T_6 (70% NPKS + MBR) and T_7 (70% NPKS + CD) treatments. Treatment T_8 (70% NPKS + PM) resulted in 94% grain yield increase over the control. The lowest grain yield (2.84 t/ha was observed in T_1 (control) treatment. The second highest grain yield (5.42 t/ha) was recorded in T_3 (100% NPKS) treatment. The straw yield of T. Aman rice varied from 4.05 to 6.73 t/ha. The highest straw yield (6.73 t/ha) was observed in T_8 (70% NPKS + PM) treatment, which was statistically higher than all other treatments. The lowest straw yield (4.05 t/ha) was obtained in T_1 (control) treatment. These results agree to that of the earlier workers (Saleque *et al.*, 2004; Haque, 1998 and Ishaque, 1998). Thus, the results indicate that nutrients for high yield goal based on soil analysis without organic manures increased the grain yield and decreased the straw yield. But the nutrients with organic manures increased both straw and grain yields.

Grain and straw yields of Boro rice (var. BRRI dhan-29) were also significantly influenced by the different combinations. Generally, each and every treatment produced significantly higher grain yield over control. Both grain and straw yields of Boro rice varied from 2.30 to 6.87 t/ha and 2.43 to 6.92 t/ha, respectively (Table 3). The highest grain yield was found in T_3 treatment, and gave 199% higher yield over the control, but that was statistically identical with T_8 (6.57 t/ha) treatment. These result was similar to the earlier findings of some workers (Rajni *et al.,* 2001; Rahman, 2001; Channabasavanna and Birandar, 2001). On the other hand, the highest straw yield was obtained in T_3 and gave 185% higher yield over control. The lowest straw yield was observed in T_1 (control) treatment. Above results were also observed by different workers (Ishaque, 1998; Purushotham and Sadashiviab, 1993; Hossain *et al.,* 1997 and Sajjad, 1995). All the organic manures had residual effects on Boro rice. The residual effects of manures may be ranked in order of PM> DH> MBR> CD> RS. Thus, it may be concluded that the treatment of T_3 (100% NPKS) showed the best performance in respect of grain and straw yields of Boro rice. But treatment T_8 (70% NPKS plus residual PM) also showed statistically similar performances.

Table 3. Effects of different treatment on grain and straw yields of cropping pattern and nutrient uptake by the crops.

Treatments	Yield (t/ha)				Nutrient uptake (kg/ha) (T.Aman + Boro and Grain + Straw)			
	T.Aman		Boro		N	P	K	S
	Grain	Straw	Grain	Straw				
T_1: Control	2.84c	4.05g	2.30d	2.43e	69	12	91	6
T_2: 70%NPKS	4.65b	5.56f	6.06c	6.18d	160	32	222	16
T_3: 100%NPKS*	5.42a	6.28d	6.87a	6.92a	212	41	248	21
T_4: 70%NPKS +RS	4.78h	6.l2cd	6.08c	6.30d	168	30	210	16
T_5: 70%NPKS+DH	5.10ab	6.50b	6.27bc	6.37cd	192	34	237	18
T_6: 70%NPKS+MBR	5.27ab	6.39c	6.32bc	6.55bc	194	38	237	20
T_7: 70%NPKS+CD	4.9lab	6.15e	6.l3bc	6.41cd	185	34	233	18
T_8: 70%NPKS +PM	5.52a	6.73a	6.57ab	6.69ab	210	42	260	21
CV (%)	3.78	0.66	3.16	1.57	-	-	-	-
S x	0.11	0.02	0.33	0.06	-	-	-	-

T.Aman = $N_{100}P_{15}K_{45}S_{10}$ kg/ha
Boro = $N_{140}P_{25}K_{60}S_{20}$ kg/ha

2. Nutrient uptake

The result (Table 3) revealed wide variation in nutrient uptake pattern of different treatments. The highest N uptake was recorded in T_3 treatment and the lowest in T_1 (control). The second highest was in treatment T_8. The present observation was similar with earlier findings (Ishaque, 1998). The P uptake varied from 12 to 42 kg/ha. The highest P uptake recorded in T_8 and the lowest was in T_1 (control). The total K uptake ranged from 91 to 260 kg/ha. The highest K uptake in T_8 and the lowest in T_1 (control). The total uptake of S ranged from 6 to 21 kg/ha. Like all nutrients, the highest total S uptake was also observed in T_8 and lowest in T_1 (control). Total nutrient uptake by T. Aman and Boro rice showed wide variation in different treatments (Table 3). The total uptake of nutrients (NPKS) ranged from I 78 kg/ha/yr in T_1 (control) treatment to 533 kg/ha/yr in T_8 (70% NPKS + PM). Total uptake in the treatment T_2 (70% NPKS) was 430 kg/ha/yr, while in T_3 (100% NPKS) was 522 kg/ha/yr The application of DH, MBR, CD or PM with 70% NPKS resulted in considerable higher uptake of nutrients by the crops compared to 70% NPKS application.

3. Changes in soil health

Application of organic manure and crop residue with chemical fertilizer increased the organic matter, total N, available P, available S and exchangeable K contents of soil (Table 4). There were little changes in soil pH due to chemical fertilizers alone or with any source of organic manure. The organic matter status was considerably improved due to the application of organic manure or crop residue. The organic matter varied from 1.75 to 2.22 over the treatments. The increase in total N might be due to the direct addition of N through organic manure added to the soil. Increase in exchangeable K due to the application of organic manure might be attributed to the release of K to the available pool of the soil besides the reduction of K fixation. These results are similar with the findings of some earlier workers (Saleque *et al.*, 1991; Bhardwaj and Omanwar, 1994). The available P and S also increased due to use of organic manures.

Table 4. Effects of different chemical fertilizers and organic manures on soil properties.

Treatments	pH	OM	Total N (%)	Available P (ppm)	Exchange -able	Available S	Available Zn
Initial soil	6.8	1.99	0.077	12.0	0.13	13.9	1.62
Postharvest soil							
T_1:Control	6.95	1.80	0.068	10.84	0.101	1.4	1.37
T_2:70%NPKS	6.79	1.75	0.074	15.52	0.14	14.3	1.27
T_3: 100% NPKS	6.92	1.78	0.078	17.04	0.16	17.6	1 .08
T_4:70%NPKS+RS	7.02	1.90	0.082	13.28	0.14	15.6	1.15
T_5:70%NPKS+DH	6.78	2.15	0.086	20.34	0.15	17.0	1.20
T_6:7ONPKS+MBR	7.02	2.05	0.080	20.30	0.15	17.1	1.32
T_7:70% NPKS +CD	6.83	2.16	0.087	18.00	0.14	13.5	1.34
T_8:70%NPKS+PM	6.72	2.22	0.089	21.30	0.16	20.8	1.37

4. Soil nutrient balance

In the present study, an attempt was also made to find out the apparent nutrient balance as affected by different organic and inorganic fertilizer management packages in Boro-Fallow-T. Aman cropping pattern. In calculating apparent nutrient balance in the pattern, it is assumed that 40% of the applied N from urea was considered effective. In case of organic manure or plant residues, 50% of the N was considered available for plants. The concentration of K in the irrigation water was 3.0 ppm. Assuming that a Boro rice crop requires 100 cm water, the amount of K added through irrigation water was 30 kg/ha. Results demonstrated that the N balance was highly negative (Fig. 1). The P and S balances were slightly positive (Fig. 2 & 3). It was reflected that a large amounts of P and S accumulated in the fertilized plots. But in case of K, it was evident from the data that K uptake by the crops far exceeded than that was replenished from fertilization (Fig. 4). This will lead the K depletion in the long run. Application of cowdung, poultry manure improved the overall nutrient balance in soil. These results are in agreement with the findings of Haque *et al.* (2001) & Ishaque (1998).

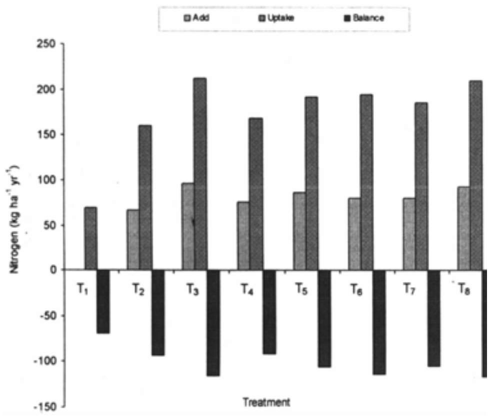

Fig. 1. Apparent N balance in soils as a affected by different treatments.

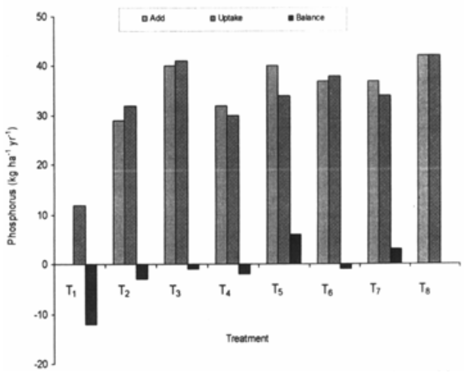

Fig. 2. Apparent P balance in soils as a affected by different treatments.

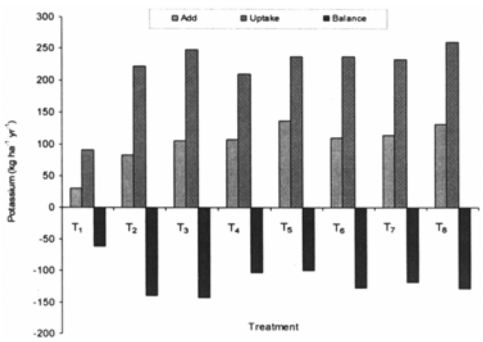

Fig. 3. Apparent K balance in soils as a affected by different treatments.

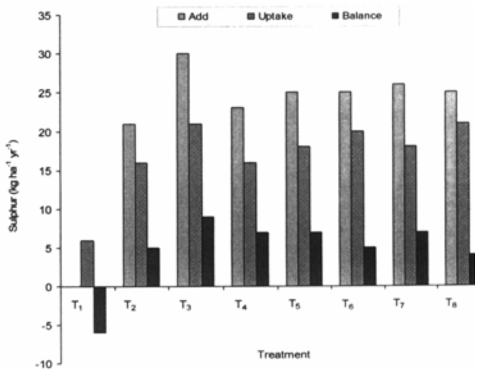

Fig. 4. Apparent S balance in soils as a affected by different treatments.

5. Economic analysis

Economic yields and added benefits as influenced by integrated use of chemical fertilizers and organic materials on rice have been calculated and presented in Table 5. The highest grain and straw yields of 12.29 t/ha, recorded in T_3 (100% NPKS) gave the highest gross return of Tk. 1,11,520 (Table 4). The second highest gross return of Tk. 1,10,140 was found in T_8 (70% NPKS + PM). The results showed that all the treatments have B: C ratios higher than 3.0 (Table 5). The highest B: C ratio of 5.24 was found in T_2 (70% NPKS) followed by 5.14 in T_8 (70% NPKS + PM).

Table 5. Economic analysis as influenced by integrated use of chemical fertilizers and organic materials on rice-rice (Boro-Fallow-T.Aman) cropping pattern.

Treatments	Economic yields (t/ha)		Gross return (Tk./ha/yr)	Net return (Tk./ha/yr)	TVC (Tk./ha)	BCR
	Grain	Straw				
T_1: Control	5.14	6.48	47600	-	-	-
T_2:70% NPKS	10.71	11.74	97420	49820	9513	5.24
F_3:100%NIKS	12.29	13.20	111520	63920	13120	4.87
T_4:70% NPKS +RS	10.86	12.42	99300	51700	14513	3.56
T_5:70% NPKS +DH	11.37	12.87	103360	55760	14943	3.73
T_6:70% NPKS+MBR	11.59	12.94	105660	58060	15963	3.64
T_7:70% NPKS +CD	11.04	12.56	100880	53280	12033	4.43
T_8:70% NPKS +PM	12.09	13.42	110140	62540	12203	5.14

Conclusion

Bangladesh is a rice based country. Only chemical fertilizer is not judicious for producing any crop. Integrated use of chemical fertilizers and organic manure is necessary for crop production as well as maintaining soil fertility. The findings of the experiment revealed that 70% of recommended dose of chemical fertilizers and 3 tons poultry manure per hectare performed better production. Therefore, 30 percent of chemical fertilizer may be replenished by organic manure which is economically viable for the farmers.

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