Effects of different sources of organic materials on nutrient contents and their uptake by T. aman rice

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Abstract: Effects of different sources of organic materials on the nutrient contents and their uptake by T. aman rice were evaluated in a field experiment during July to October 2011 at Bangladesh Agricultural University farm, Mymensingh. Ten treatments formulated from organic manures and chemical fertilizers were T_0 : Control, T_1 : Recommended doses of N, P, K and S (RD-NPKS), T_2 : Green manure @ 10 t ha^{-1} ($GM_{10\ t/ha}$), T_3 : GM @ 5 t ha^{-1} + Rice straw @ 5 t ha^{-1} ($GM_{5t/ha}$ + $RS_{5\ t/ha}$), T_4 : GM @ 5 t ha^{-1} +Farm yard manure @ 5 t ha^{-1} ($GM_{5\ t/ha}$ + $FYM_{5\ t/ha}$), T_5 : Oil cake @ 2.5 t ha^{-1} ($OC_{2.5\ t/ha}$), T_6 : GM @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} + Phosphate solubilizing bacteria ($GM_{5\ t/ha}$ + $FYM_{5\ t/ha}$ + PSB), T_7 : GM @ 5 t ha^{-1} + PSB ($GM_{5\ t/ha}$ + PSB), T_8 : FYM @ 5 t ha^{-1} + PSB ($FYM_{5\ t/ha}$ + PSB) and T_9 : RD-NPKS + PSB. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Among the organic materials used, farm yard manure was better than other organic sources due to its higher nutrient content except green manure which contained higher amount of N. The nutrient contents (N, P, K, S, Ca and Mg) and their uptake by grain and straw were significantly influenced by the application of different treatments except the S content of grain. The highest values of most of the parameters were obtained from RD-NPKS + PSB treatment which was statistically identical with $GM_{5\ t/ha}$ +$FYM_{5\ t/ha}$ + PSB, $GM_{10\ t/ha}$ and $GM_{5\ t/ha}$ + $FYM_{5\ t/ha}$ treatment combinations in many cases. The lowest values for all the parameters were obtained from control. The overall findings of the study indicated that the use organic manure could be important for increasing nutrient contents and their uptake by T. aman rice.

Key words: Organic manure, T. aman rice, nutrient content and uptake.

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 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 our country apply on an average, 172 kg nutrients ha^{-1} 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^{-1} (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. Rice (*Oryza sativa L.*) is intensively cultivated in Bangladesh covering about 80% of arable land. Unfortunately, the yield of rice in our country is low (3.4 t ha^{-1}) compared to other rice growing countries like South Korea and Japan where the average yield is 6.0 and 5.6 t ha^{-1}, 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 use of organic manure 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^{-1} yr^{-1} improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Thus, it is necessary to apply nutrients from organic sources 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 effects of different sources of organic materials on the nutritional status of T. aman rice.

Materials and Methods

The field experiment was carried out during aman season from 11 July to 27 December, 2011 at the central farm of Bangladesh Agricultural University, Mymensingh. Initial soil sample was collected, processed and kept in a polyethylene bag for chemical analysis. The soil was silt loam textured having pH 6.49, organic carbon 0.72%, total N 0.12%, available P 12.1µg g^{-1} soil, exchangeable K 0.5 c mol kg^{-1} available S 9.28 µg g^{-1} . Seeds were collected from Bangladesh Agricultural Development Corporation (BADC). There were 10 treatments combination viz. T_0 : Control, T_1 : Recommended doses of N, P, K and S (RD-NPKS), T_2 : Green manure @ 10 t ha^{-1} ($GM_{10\ t/ha}$), T_3 : GM @ 5 t ha^{-1} + Rice straw @ 5 t ha^{-1} ($GM_{5t/ha}$ + $RS_{5\ t/ha}$), T_4 : GM @ 5 t ha^{-1} +Farm yard manure @ 5 t ha^{-1} ($GM_{5\ t/ha}$ + $FYM_{5\ t/ha}$), T_5 : Oil cake @ 2.5 t ha^{-1} ($OC_{2.5\ t/ha}$), T_6 : GM @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} + Phosphate solubilizing bacteria ($GM_{5\ t/ha}$ + $FYM_{5\ t/ha}$ + PSB), T_7 : GM @ 5 t ha^{-1} + PSB ($GM_{5\ t/ha}$ + PSB), T_8 : FYM @ 5 t ha^{-1} + PSB ($FYM_{5\ t/ha}$ + PSB) and T_9 : RD-NPKS + PSB. The experiment was laid out in randomized complete block design with three replications. The unit plot size was 4 m × 2.5 m. The total number of unit plots were 30. The spaces between the unit plots were 1m and 0.5 m, respectively. Half of N and full doses of P, K, S were applied at the time of puddling and remaining N was applied in early tillering, late tillering and panicle initiation stage. Rice straw was chopped and incorporated into soil 7 days before transplanting. Oil cake and farm yard manure were applied one day before transplanting of rice. Chemical composition of the organic manure used in the experiment were shown in Table 1, which shows that rice straw contained highest amount of organic carbon

(41.14%) which was followed by OC (39.06%) and GM (36.75%) and the lowest C content was found in FYM (35.16%). In contrast, the highest N content (5%) was obtained from GM which was followed by OC (2.46%) and FYM (1.60%) and the lowest N content was from RS (0.65%). High P (1.80%) was contained in FYM followed by GM (.83%) and OC (0.40%). On the other hand, the highest amounts of K, S, Ca and Mg were found in FYM and the lowest amount of all these nutrients except K were obtained from RS.

Table 1. Chemical composition of organic manure used in the experiment

Organic amendments	Organic C (%)	Total N (%)	Total P (%)	Total K (%)	Total S (%)	Total Ca (%)	Total Mg (%)
Farm yard manure	35.16	1.60	1.80	1.70	0.56	0.24	0.31
Rice straw	41.14	0.65	0.15	1.30	0.12	0.17	0.21
Mustard oil cake	39.06	2.46	0.40	1.20	0.38	0.20	0.23
Green manure	36.75	5.00	0.83	0.32	0.20	0.21	0.25

The test crop was T. aman rice var. BRRI dhan49. Seeds were sown on July 11, 2011 and transplanting was done August 7, 2011. Weeding, gap filling, thinning, irrigation and pesticide application were performed as and when necessary throughout the growing period. The plants were harvested on November 27, 2011. N, P, K, S, Ca and Mg contents were determined following standard methods (Page *et al.*, 1982). Nutrient uptake was calculated by multiplication of concentration (%) with dry matter yield and divided by 100. Analysis of variance was done with the help of computer package program MSTAT according to Gomez and Gomez (1984) and the mean differences were adjudged by DMRT.

Results and Discussion

Nutrient content and uptake: Nutrient declining in Bangladesh soils have been increasing day by day. Before 1980, deficiency of N, P and K was a major problem in Bangladesh soil. Now the deficiency of other nutrients (secondary and micro) has been identified across the country. Nutrient content and their uptake are indispensable for the crop production systems of modern agriculture. Among the factors that affect crop production nutrient content and their uptake is the single most important factor that plays a crucial role in yield increase.

Table 2. Effects of organic nutrients management on N, P and K contents of T. aman rice var. BRRI dhan49.

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
CT	0.68cd	0.49c	0.24d	0.099d	0.14c	0.92f
RD-NPKS	0.94abc	0.63bc	0.31a	0.179a	0.24ab	1.32ab
GM $_{10\ t/ha}$	1.15a	0.80a	0.25cd	0.130c	0.23ab	1.31b
GM $_{5\ t/ha}$ + RS $_{5\ t/ha}$	0.58d	0.57bc	0.26bcd	0.158b	0.19bc	1.19cd
GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$	0.91abc	0.59bc	0.27b	0.170ab	0.21ab	1.22bc
OC $_{2.5\ t/ha}$	0.85bcd	0.55bc	0.26bc	0.131c	0.21ab	1.10de
GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB	0.93abc	0.61bc	0.27b	0.170ab	0.23ab	1.31b
GM $_{5\ t/ha}$ + PSB	0.84bcd	0.51c	0.25bcd	0.126c	0.18bc	0.95f
FYM $_{5\ t/ha}$ + PSB	0.82bcd	0.49c	0.25cd	0.104d	0.19bc	1.06e
RD-NPKS + PSB	1.02ab	0.67b	0.32a	0.186a	0.26a	1.41a
S(x)	0.23	0.18	0.10	0.21	0.19	0.14

N content: The N content in rice grain and straw were significantly influenced by the application of different treatments (Table 2). The highest N content (1.15%) was found in the treatment GM $_{10\ t/ha}$ which was identical with the treatment GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB, GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$, RDCF + PSB and RDCF. The lowest N content (0.68%) was observed in control. In rice straw, the highest N content (0.80%) was recorded in GM $_{10\ t/ha}$ which was different from other treatments. The lowest N content (0.49%) in rice straw was recorded in FYM $_{5\ t/ha}$ +PSB and control. Application of green manure and farm yard manure might be responsible for increasing the N content of rice grain and straw (Table 1). Similar result was obtained by Dwivedi *et al.* (2006) who reported that farm yard manure was the excellent source of N and its application increased the grain and straw yield as well as N content of rice.

P content: The data presented in Table 2 showed that significant variation were observed in P content of rice grain and straw. The highest P content (0.32%) in rice grain was found in RD-NPKS + PSB which was identical with the treatment RD-NPKS. The lowest P content (0.24%) in rice grain was observed in control where no fertilizers were applied. Again, the highest P content (0.186%) in rice straw was recorded in RD-NPKS + PSB which was identical with GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB, GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ and RD-NPKS. The lowest P content (0.099%) in straw was obtained from control. Application of green manure and farm yard manure contained higher amount of P, compared to the other organic manure. It might be responsible for increasing the P content in straw. The findings of our study is in agreement with the result of Naher *et al.* (2004) who reported that farm yard manure performed best in respect of yield and P content by rice.

K content: Potassium content of rice grain and straw were significantly influenced by different sources of organic materials (Table 2). The highest K content (0.26%) in rice grain was found in the RD-NPKS + PSB which was identical with the GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB, GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$, OC $_{2.5\ t/ha}$, GM $_{10\ t/ha}$ and RD-NPKS. The lowest K content (0.14%) was observed in the control. Similar trends were also observed in case of rice straw. However the highest K content (1.41%) in rice straw was recorded from RD-NPKS + PSB which was identical with the treatment RD-NPKS. The lowest K content (0.92%) in rice straw was notified in control where no fertilizers were applied. It was interesting to see that the straw K content was almost five times higher than the grain K content

irrespective of treatments. Higher amount of K was obtained from farm yard manure, it might be responsible for increasing the K content (Table 1). A similar result was obtained by Surenda (2006) who reported that application of farm yard manure and green manure increased the K content in both rice grain and straw.

S content: S content in rice grain was not significantly affected with the different treatments but (Table 3) numerically the highest S content (0.29%) in grain was observed in the treatment RD-NPKS + PSB and the lowest S content (0.16%) in grain was observed in the control. Significant variation was found in S content in straw. Again the highest S content (0.21%) in straw was recorded in RD-NPKS + PSB which was identical with the treatment GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB, GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$, GM $_{10\ t/ha}$, GM $_{5\ t/ha}$ +RS $_{5\ t/ha}$, and RD-NPKS. The lowest S content (0.08%) in straw was obtained from control where no fertilizers were applied. Application of farm yard manure contained higher amount of S compared to the other manure, it might be increased S content in straw (Table 1). It was surprising to note that the S content of rice grain was not significantly influenced by different treatment though the effect was significant on straw S. It is difficult to explain why that happened.

Table 3. Effects of organic nutrients management on S, Ca and Mg contents of T. aman rice var. BRRI dhan49

Treatments	S content (%)		Ca content (%)		Mg content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
CT	0.16	0.08d	0.29b	0.37f	0.41b	0.26b
RD-NPKS	0.28	0.19ab	0.43ab	0.67ab	0.58ab	0.40ab
GM $_{10\ t/ha}$	0.24	0.18abc	0.32b	0.56b-e	0.46ab	0.35ab
GM $_{5\ t/ha}$ + RS $_{5\ t/ha}$	0.21	0.14a-d	0.35b	0.60a-d	0.44ab	0.32ab
GM $_{5\ t/ha}$ +FYM $_{5\ t/ha}$	0.23	0.16a-d	0.32b	0.56b-e	0.44ab	0.34ab
OC $_{2.5\ t/ha}$	0.20	0.11bcd	0.32b	0.51cde	0.43ab	0.32ab
GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB	0.26	0.18abc	0.37b	0.61abc	0.53ab	0.36ab
GM $_{5\ t/ha}$ + PSB	0.18	0.09d	0.32b	0.48def	0.43ab	0.29ab
FYM $_{5\ t/\ ha}$ + PSB	0.19	0.10cd	0.29b	0.45ef	0.43ab	0.31ab
RD-NPKS + PSB	0.29	0.21a	0.61a	0.69a	0.59a	0.47a
S(x)	0.29	0.41	0.35	0.20	0.20	0.29

Ca content: From the results it can be seen that Ca content in rice grain and straw were significant due to the application of organic manures, biofertilizers and inorganic fertilizers (Table 3). The highest Ca content (0.61%) in rice grain was found in RD-NPKS + PSB treatment which was identical with RD-NPKS treatment. The lowest Ca content (0.29%) in rice grain was observed from control. Similarly the highest Ca content (0.69%) in rice straw was recorded in RD-NPKS + PSB treatment which was statistically similar with GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB, GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ and RD-NPKS. The lowest Ca content (0.37%) in rice straw was obtained from control. Application of farm yard manure might be responsible for increasing the Ca content of rice straw (Table 1). The results of our study was supported by the findings of Blum *et al.* (2003) who reported that the concentration of Ca increased with the addition of farm yard manure.

Mg content: Significant variation was found on Mg content of rice grain and straw (Table 3). The highest Mg content in rice grain (0.59%) and straw (0.47%) were found in RD-NPKS + PSB treatment which were identical with all other treatments except control. The lowest Mg content in rice grain (0.41%) and straw (0.26%) was observed in control where no fertilizers were applied. Use of chemical fertilizers all the nutrients were present in balanced proportion, it might be responsible for increasing the Mg content of rice grain and straw. A similar result was obtained by Blum *et al.* (2003) who found that application of farm yard manure increased Mg content of squash fruit.

Nutrient uptake

N uptake: Significant variation were found in N uptake by rice grain and straw (Table 4). Maximum N uptake (39.34 kg N ha^{-1}) in rice grain was found in RD-NPKS + PSB treatment which was identical with the treatment GM $_{10\ t/ha}$ and RD-NPKS. The lowest N uptake (14.75 kg N ha^{-1}) was found in control. The highest N uptake (29.19 kg N ha^{-1}) in rice straw was found in GM $_{10\ t/ha}$ treatment which was identical with the treatment RD-NPKS + PSB and RD-NPKS. The lowest N uptake (15.20 kg N ha^{-1}) in rice straw was found in control. Application of green manure might be responsible for increasing the N uptake by rice grain and straw, because green manure contained the highest N compared to the other manure (Table 1). The findings of the present study is in agreement with the result of Surenda (2006) who found that application of green manure in the field, highest N uptake was observed by rice grain.

P uptake: The data presented in table 4 showed that significant variation were found in P uptake by rice grain and straw. The maximum P uptake in rice grain (12.34 kg P ha^{-1}) and straw (7.80 kg P ha^{-1}) were found in RD-NPKS + PSB treatment which was identical with the treatment of RD-NPKS. The minimum P uptake in rice grain (5.20 kg P ha^{-1}) and straw (3.07 kg P ha^{-1}) were observed in control where no fertilizers were applied. Application of PSB might be increased the availability of P, which may ultimately increased the P uptake by rice grain and straw.

K uptake: Application of different organic nutrients showed a significant variation in K uptake by rice grain and straw (Table 4). The maximum K uptake in rice grain (10.02 kg K ha^{-1}) and straw (59.18 kg K ha^{-1}) were found in RD-NPKS + PSB which was identical with the treatment RD-NPKS. The minimum K uptake in rice grain (3.04 kg K ha^{-1}) and straw (28.54 kg K ha^{-1}) were obtained from control where no fertilizers were applied. Use of chemical fertilizers all the nutrients were present in balanced proportion, it might be responsible for increasing the K uptake by rice grain and straw.

S uptake: Organic nutrients management significantly influenced in S uptake by rice grain and straw (Table 5). The maximum S uptake in rice grain (11.18 kg S ha^{-1}) and straw (8.81 kg S ha^{-1}) were found in RD-NPKS + PSB which was identical with the treatment GM $_{5\ t/\ ha}$ + FYM $_{5}$

$_{t/ha}$ + PSB , GM $_{10\ t/ha}$, and RD-NPKS. The lowest S uptake in rice grain (3.47 kg S ha^{-1}) and straw (2.48 kg S ha^{-1}) were observed in control. Green manure and farm yard manure contained the higher amount of S, compared to the other organic manure (Table 1). It might be responsible for increasing the S uptake by rice. The results of our study is well supported by the findings of Basumatari and Talukdar (2007) who found that application of organic manure increased the S uptake in rapseed and rice.

Table 4. Effects of organic nutrients management on N, P and K uptake by T. aman rice var. BRRI dhan49

Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
CT	14.75e	15.20b	5.20cd	3.07f	3.04e	28.54e
RD-NPKS	34.15ab	26.35a	11.26a	7.48a	8.71ab	55.21a
GM $_{10\ t/ha}$	37.29ab	29.19a	8.43bc	4.73de	7.45bc	47.33bc
GM $_{5\ t/ha}$ + RS $_{5\ t/ha}$	23.05cd	20.17b	7.33bcd	5.59bc	5.16cd	42.12cd
GM $_{5\ t/ha}$ + FYM 5 $_{t/ha}$	24.99cd	19.71b	7.41bcd	5.67b	5.76cd	36.74cd
OC $_{2.5\ t/ha}$	21.42cde	18.02b	6.55bcd	5.29cd	5.29cd	39.98bc
GM $_{5t/ha}$ + FYM $_{5\ t/ha}$ + PSB	31.89bc	21.82b	8.57b	6.08b	7.88bc	46.86b
GM $_{5\ t/ha}$ + PSB	20.46cde	17.01b	6.09cd	4.37cd	4.38de	32.98de
FYM $_{5\ t/ha}$ + PSB	17.64de	17.09b	5.37d	3.48ef	4.08de	35.53de
RD-NPKS + PSB	39.34a	28.12a	12.34a	7.80a	10.02a	59.18a
S(x)	0.33	0.25	0.30	0.31	0.36	0.24

Table 5. Effects of organic nutrients management on S, Ca and Mg uptake by T. aman rice var. BRRI dhan49

Treatments	S uptake (kg ha^{-1})		Ca uptake (kg ha^{-1})		Mg uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
CT	3.47c	2.48de	6.22c	11.60d	8.68b	8.06c
RD-NPKS	10.17ab	7.94ab	15.51b	28.06a	21.07a	16.73ab
GM $_{10\ t/ha}$	7.78abc	6.55abc	10.37bc	18.78bc	14.91b	12.74bc
GM $_{5\ t/ha}$ + RS $_{5\ t/ha}$	5.70c	4.95cde	9.42bc	21.16bc	11.67b	11.32bc
GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$	6.31bc	5.34b-e	8.81c	18.74bc	12.08b	11.35bc
OC $_{2.5\ t/ha}$	5.04c	3.60cde	7.83c	16.61bc	10.83b	10.48bc
GM $_{5\ t/ha}$ + FYM $_{5\ t/ha}$ + PSB	8.91abc	6.43a-d	12.82bc	21.96b	18.07b	12.87bc
GM $_{5\ t/ha}$ + PSB	4.38c	3.12e	7.16c	16.70bc	10.08b	10.07bc
FYM $_{5\ t/ha}$ + PSB	4.08c	3.35e	6.29c	15.22cd	9.02b	10.39bc
RD-NPKS + PSB	11.18a	8.81a	23.68a	29.13a	22.87a	19.72a
S(x)	0.37	0.53	0.54	0.30	0.38	0.39

Ca uptake: Ca uptake by rice grain and straw were significantly affected due to the application of organic manure (Table 5). The maximum Ca uptake (23.68 kg Ca ha^{-1}) in rice grain was found in RD-NPKS + PSB which was different with the other treatments. The lowest Ca uptake (6.22 kg Ca ha^{-1}) in rice grain was showed in control. Again the highest Ca uptake (29.13 kg Ca ha^{-1}) in rice straw was found in RD-NPKS + PSB which was identical with RD-NPKS. The lowest Ca uptake (11.60 kg Ca ha^{-1}) in rice straw was notified in control. Use of chemical fertilizers all the nutrients were present in balanced proportion, it might be responsible for increasing the Ca uptake by rice grain and straw.

Mg uptake: The result indicated that significant variation were found in Mg uptake by rice grain and straw (Table 5). The maximum Mg uptake in rice grain (22.87 kg Mg ha^{-1}) and straw (19.72 kg Mg ha^{-1}) were found in RD-NPKS + PSB which was identical with the treatment RD-NPKS. The minimum Mg uptake in rice grain (8.68 kg Mg ha^{-1}) and straw (8.06 kg Mg ha^{-1}) were observed in control where no fertilizers were applied. Use of chemical fertilizers all the nutrients were present in balanced proportion, it might be responsible for increasing the Mg uptake by rice grain and straw.

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