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Yield Dynamics, Nutrient Contents and Soil Properties under T. *aman* (cv. BR 11) Rice as Influenced by Source and Management of Nitrogen

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Abstract:

The experiment was carried out at SAU farm, Dhaka from May to November 2012 to investigate the response of different sources and management of N on the growth and yield of T. aman rice (cv. BR 11). There were nine treatments taking various doses of urea, USG and vermicompost viz. T_0:control, T_1: 120 kg N from urea, T_2: 100 kg N from urea+ 20 kg N from vermicompost, T_3: 80 kg N from urea + 40 kg N from vermicompost, T_4:60 kg N from urea + 60 kg N from vermicompost, T_5: 120 kg N from USG, T_6: 103.5 kg N from USG + 16.5 N from vermicompost, T_7: 69 kg N from USG +51 kg N from vermicompost and T_8: 45 kg N from USG + 75 kg N from

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vermicompost. The experiment was laid out in a randomized complete block design with four replications. The application of urea, USG and vermicompost had a significant positive effect on the plant height, panicle length and grains panicl^{-1}.The highest grain (4.85 t ha^{-1}) and straw yields (6.92 t ha^{-1}) of rice were recorded in the T_1 treatment. The T_0 treatment gave the lowest grain (2.56 t ha^{-1}) and straw yields (3.97 t ha^{-1}). The application of urea, USG and vermicompost significantly increased the N, P, K and S contents as well as their uptake by the crop. From the economic point of view, the application of urea at a recommended rate i.e. 120, kg N ha^{-1} along with recommended rate of P, K, S and Zn is necessary for obtaining higher grain yield as well as straw yield of T. aman rice.

Key words: Yield components, Nutrient contents, Soil properties, Nitrogen source and management

Introduction

Rice is the most important food cereal crop in the developing countries of Asia. In Bangladesh out of total rice production, about 48%, 45% and 7% come from *boro*, *aman* and *aus* rice respectively (BBS, 2000). The average yield of rice is low (3.44 t ha^{-1}) compared to other leading rice producing countries such as China, Korea, Japan and USA where per hectare yield is 6.26, 6.23, 6.58 and 7.37 t ha^{-1} respectively (FAO, 2003). Soil fertility management has significant importance to increase crop productivity. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Bhuiyan *et al*., 199l). The farmers of Bangladesh usually apply only about 172 kg nutrients ha^{-1} annually (l32 kg N, l7 kg P, l7 kg K, 4 kg Sand, 2 kg Zn + B + others), while the crop removal is about 250 kg ha^{-1} (Islam, 2002). In 1975, IFDC proposed use of super granules of urea (USG) in place of mudballs containing urea fertilizer to achieve the same agronomic benefits as achieved through the Japanese concept of deep point placement of N fertilizer in transplanted rice. The utilization of vermicompost decomposed form from earth worm results in several benefits to farmers, industries, environment and overall national economy. The principles objectives under present study are to evaluate the efficiency of nitrogen supplied from different sources on the growth, yield and nutrient uptake by T. *aman* rice.

Material and methods

The experiment was conducted at Sher-e-Bangla Agricultural University (SAU) research farm, Dhaka during May to November 2012. The farm belongs to the Madhupur Tract agro ecological zone (AEZ 28). The checked crop under study was T. aman rice (cv. BR 11). The experiment was laid out at Randomized Complete Block Design (RCBD) with 4 replications. There were nine treatments with various combinations of urea, USG and vermicompost including control viz.,T_0: control, T_1: 120 kg N from urea, T_2: 100 kg N from urea+ 20 kg N from vermicompost, T_3: 80 kg N from urea + 40 kg N from vermicompost, T_4: 60 kg N from urea + 60 kg N from vermicompost, T_5: 120 kg N from USG, T_6: 103.5 kg N from USG + 16.5 N from vermicompost, T_7: 69 kg N from USG +51 N from vermicompost and T_8: 45 kg N from USG + 75 N from vermicompost. Well decomposed vermicompost was incorporated to the plots as per treatment at 6 days before transplantation of rice. The sources of N, P, K, S and Zn were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc oxide respectively. Urea was applied to the plots as per treatments, One-third of which and the entire amount of other fertilizers were applied to the individual plots during final land preparation. Urea super granules were placed into the soil at 5 cm to 8 cm deep at 7 days after transplantation The fertilizers were incorporated into soil by spading. As the amount of ZnO for a unit plot was small, the fertilizer was mixed with ground dry soil before application and then applied to the plot. The second split of urea was applied at 30 days after transplanting i.e. at maximum tillering stage and the remaining split at 55 days after transplanting i.e. at panicle initiation stage. Well emerged rice seedlings were transplanted in the plots on 08 August, 2007. Irrigation, gap filling, weeding and plant protection measures were taken as per when needed. The data on plant height (cm), panicle length (cm), filled grain panicle^{-1}(no), unfilled grain panicle^{-1}, 1000 grain weight (g), grain yield (t ha^{-1}), straw yield (t ha $^{-1}$), nutrient content in rice (nitrogen, phosphorus, potassium, sulphur), nutrient uptake by rice plant (nitrogen, phosphorus, potassium, sulphur), soil properties (soil pH, organic matter content, total nitrogen, available phosphorus, exchangeable potassium, available sulphur) were collected.. The collected data were subjected to statistical analysis (MSTATC) as per the design used and different means were tested by Duncan's Multiple Range Test (DMRT) methods.

Results and discussion

Plant height

Plant height of aman rice was significantly affected due to application of various rates of urea and USG combined with vermicompost (Table 1). The highest plant height was observed in T_1 treatment the recommended dose of N (BARC 2005) which is statistically similar to the treatment T_5. The lowest plant height observed in T_0 (control) treatment. Plant height due to different treatments varied from 91.6 to 120.7 cm.

Filled grains panicle^{-1}

The number of filled grains panicle^{-1} varied significantly with the treatments except the control. The highest number of grains panicle^{-1} was observed in T_1 treatment and the lowest in T_0 (control).

Thousand grain weight

The weight of 1000 grains did not vary significantly with the treatments. Islam (1978) reported a significant increase of 1000 grain weight of rice due to N application).

Table 1: Effects of urea and USG combined with vermicompost on the yield components of T. *aman* rice (cv. BR 11)

Treatments	Plant height (cm)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	1000 grain weight (g)
T_0	91.6c	18.6 be	63.4d	21.9
T_1	120.7 a	25.7 a	120.3 a	22.5
T_2	115.1b	24.4b	112.6b	22.3
T_3	119.4b	24.6b	101.4 be	22.2
T_4	117.0b	23.1b	100.8bc	22.5
T_5	119.7a	24.0a	115.4a	22.1
T_6	117.9 b	23.6 b	99.7 be	22.4
T_7	117.6 b	23.5 b	98.8 be	22.2
T_8	112.3 b	23.0 b	87.9 e	22.3
SE (±)	8.36	5.74	6.77	NS
CV (%)	5.47	4.26	8.78	2.31

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV= Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea +20 kg N supplied by vermicompost, T_3: 80 kg N from urea +40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG +51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

Grain yield

Grain yield was the most important parameter of this study. The grain yield was significantly affected due to application of urea, USG then combination with vermicompost (Table 2). The grain yield varied from 2.56 to 4.85 t ha^{-1}. The highest grain yield was obtained in T_1 (120 kg N ha^{-1} from urea) treatment. Again treatments T_2 (100 kg N from urea + 20 kg N from vermicompost), T_3 (80 kg N from urea +40 kg N from vermicompost) and T_5 (120 kg from USG) producing yields of 4.51, 4.41 and 4.82 t ha^{-1} respectively were not significantly different. The lowest grain yield was observed from treatment T_0 (control). The yields of treatments T_4, T_6 and T_7 were statistically similar. Yield was higher in T_1 treatment and T_5 compared to other treatments due to higher production of effective tillers $hill^{-1}$ and increased number of grains $panicle^{-1}$. Positive impact of N fertilization on rice yield is evidenced by many other scientists (Idris and Jahiruddin, 1982). A number of researchers also reported that S and N application had significantly higher grain yield over control (Choudhury and Hore, 1989; Hoque *et al.*, 1994).

Table 2: Effects of urea and USG and vermicompost on grain and straw yields of T. *aman* rice (cv. BR 11)

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	% yield increase over control	
			Grain	Straw
T_0	2.56d	3.97c	-	-
T_1	4.85 a	6.92 a	89.5	74.3
T_2	4.51 a	5.92 ab	76.2	49.1
T_3	4.4lab	5.32 be	72.3	34.0
T_4	3.59 c	5.25 be	40.2	32.2
T_5	4.82 a	6.84 a	88.3	72.3
T_6	3.55 e	5.27 be	38.7	32.7
T_7	3.52 c	4.92 be	37.5	23.9
T_8	3.87 bc	4.9lbc	51.2	23.7
SE(±)	0.183	133.22	-	-
CV (%)	8.22	761	-	-

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV= Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea +20 kg N supplied by vermicompost, T_3: 80 kg N from urea +40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG +51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

Straw yield

Like grain yield, there was a significant and positive effect of different sources of nitrogen on straw yield of T. aman rice (Table 2). The straw yield varied between 3.97 to 6.92 t ha^{-1} with the highest yield in T_1 treatment (6.92 t ha^{-1}), the second highest in T_5 treatment and the lowest in T_0 treatment. These results are in close agreement with the findings of Choudhury and Hore (1989). Treatments T_3, T_4, T_7 and T_8 were gave the statistically similar yields (viz. 5.32, 5.25, 5.27, 4.92 and 4.91 t ha^{-1}). The highest % yield increase was observed in treatment T_1. The trends of straw yield were $T_1>T_5>T_2>T_3>T_4>T_6>T_7>T_8$.

Nitrogen content

Application of different sources of nitrogen increased the N content in both grain and straw (Table 3). The grain N content ranged from 0.997% to 1.410%. The N content of grain was found maximum in treatment T_5 (1.41%) followed by the second highest value (1.40%) of N content was found in treatment T_1 and the third highest value (1.35%) was in T_2 treatment. In case of N content of straw the result varied from 0.515 to 0.670%, the highest value being obtained in T_1 and the lowest in control treatment. The findings of the present study are in conformity with the report of Mandata *et al.*, (1994) reported that concentration of N in rice plant increased with increasing rates of N application.

Table 3: Effects of urea and USG and vermicompost on nutrient (N, P) contents in grain and straw of T. *aman* rice (cv. BR 11)

Treatments	N concentration (%)		P concentration (%)	
	Gain	Straw	Grain	Straw
T_0	0.997d	0.515	0.245	0.072d
T_1	1.40 a	0.670	0.329	0.112 a
T_2	1.35 b	0.662	0.324	0.107 b
T_3	1.32 b	0.656	0.301	0.103b
T_4	1.33b	0.655	0.272	0.100b
T_5	l.41a	0.661	0.326	0.111 a
T_6	1.18 bc	0.625	0.256	0.094c
T_7	1.13 c	0.65 1	0.254	0.093c
T_8	1.15c	0.622	0.268	0.096c
SE(±)	0.017	NS	NS	0.045
CV (%)	569	4.65	8.96	11.23

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV= Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea +20 kg N supplied by vermicompost, T_3: 80 kg N from urea +40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG +51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

Phosphorus content

Phosphorus concentrations in grain and straw of BR11 have been shown in Table 3. It appeared that the P content in grain varied from 0.245 to 0.329% The highest P content was obtained in T_1 treatment which was closely followed by the treatment T_5 (0.26%) with no significant difference between these two treatments. The lowest value was found in control treatment. All the treatments res1nded to P application compared to control. In case of straw, the P content ranged from

0.072 to 0.112%. Again, the highest P content was observed in T_1 treatment. It also showed that all the treatments responded significantly over control.

Table 4: Effects of urea and USG and vermicompost on nutrient (K, S) contents in grain and straw of T. *aman* rice (cv. BR 11)

Treatments	K concentration (%)		S concentration (%)	
	Gain	Straw	Grain	Straw
T_0	0.194	0.760	0.094	0.120
T_1	0.249	1.42 a	0.130	0.168
T_2	0.241	1.32b	0.116	0.168
T_3	0.240	1.19 bc	0.125	0.162
T_4	0.231	1.27b	0.116	0.150
T_5	0.245	1.51 a	0.133	0.145
T_6	0.214	1.16 bc	0.108	0.142
T_7	0.224	1.19 bc	0.102	0.134
T_8	0.215	1.18 bc	0.110	0.140
SE(±)	NS	0.125	NS	NS
CV (%)	3.65	3.55	4.66	6.54

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV= Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea +20 kg N supplied by vermicompost, T_3: 80 kg N from urea +40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG +51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

Potassium content

Application of N from different sources of fertilizer and manure significantly increased the K content in both grain and straw (Table 4). The K content in grain ranged from 0.194% to 0.249%. The K content in grain was found maximum in treatment T_5 which was more of less similar to the treatment T_1. The second highest value (0.245%) of K content was found in treatment T_1 and the third highest value (0.240%) was in T_3. In case of straw K content, the result varied from 0.760 to 1.51%, the highest value being obtained in T_5 and T_1 treatments and the lowest in control. The findings of the present study are in conformity with the report of Mandata *et al.*, (1994) reported that concentration of K in rice plant increased with increasing rates of K application.

Sulphur content

Sulphur concentrations in grain and straw of BR11 have been shown in (Table 4). It appeared that the S content in grain varied from 0.094 to 0.110%. The highest S content was obtained in T_5 treatment which was closely followed by the treatment T_1 (0.l30%). The lowest value was found in control (T_0) treatment. All the treatments responded to S application compared to control. In case of straw, the S content ranged from 0.120 to 0.168%. Again, the highest S content was observed in T_1 and T_2 treatments. It also showed that all the treatments responded significantly over control. The trend of S content in rice straw were $T_1>T_2>T_3>T_4>T_5>T_6>T_7>T_8>T_0$.

Soil pH

Application of organic manure and chemical fertilizers caused an insignificant decreasing effect on the pH of the post-harvest soil (Table 5). All the treatment slightly decreased the soil pH as compared to initial soil. The pH value of post-harvest soils ranged from 5.75 to 6.150 against pH value of 6.2 of the initial soil sample. The decreasing effect was more where no fertilizer was applied, lowest value of pH (5.75) was observed in the treatment T_0 (Control) and the highest value (6.150) was recorded in T_5: 120 kg N substituted by USG. A decreasing trend in the pH values of the post-harvest soils might be due to the organic acids released from the decomposition of organic manure, crop residue and the acidic effect of sulphur fertilizers. Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM with pressmud.

Organic matter content

Table 5 reveals that the organic matter content of the post-harvest soils ranged from 1.245 to 1.412%. The organic matter of initial soil was 1.187%. It was observed that organic matter content tended to increase in the soils treated with organic manure while the soils treated with chemical fertilizers caused a decreasing effect but the effect was statistically insignificant Application of organic manure resulted in an increased organic matter content of post-harvest soils as compared to the initial soil. Increasing organic matter content might be due to the addition of increasing through manuring. The highest value of 1.412% organic matter content in soil was observed in the treatment T_6: 103.5 kg N from USG + 16.5 N substituted by vermicompost and the lowest value was obtained in the treatment T_0 (Control). Zhang *et al.*, (1996) showed that the combined application of organic manure and chemical fertilizers increased organic matter content in soil.

Total Nitrogen

The total N contents of the post-harvest soils varied considerably by different treatments (Table 5). The total N content of the post-harvest soils ranged from 0.023 to 0.053 % as compared to the value of 0.032% of the initial soil. The highest value (0.053%) was observed in the treatment T_6: 103.5 kg N from USG + 16.5 N substituted by vermicompost and lowest value was found in the treatment T_0 (Control). The result indicates that application of organic manure exerted increasing effect on the total N content of the post-harvest soils although the increase was insignificant. Rice cultivation with chemical fertilizers tended a decreasing effect on the organic matter and total N content of the soil. Gao and Chang (1996) reported that the application of organic manure increased the total N content in soil. Several workers reported that organic manure had a positive influenced on total and available N content of soil.

Available Phosphorous

Available phosphorous contents of the post-harvest soils varied considerably by the application of organic manure and chemical fertilizers (Table 5). Available phosphorous content in soil ranged from 18.92 to 24.14 ppm against the P value of 19.85 ppm in the initial soil. The highest P content (24.14 ppm) was recorded in the treatment T_5: 120 kg N substituted by USG and in the treatment T_0 (Control) having lowest P content (18.92 ppm). There was a little decrease in available P content in the soil treated with chemical fertilizers. Gupta *et al.*, (1996) reported that organic carbon and available P content in the post-harvest soil were increased by poultry manure application.

Table 5: Effect of different treatments by the use of vermicompost and chemical fertilizers on the post-harvest soils in T. *aman* rice (cv. BR 11) field

Treatments	Soil pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (m. eq. per 100g)	Available S (ppm)
T_0	5.75	1.245	0.023 f	18.92 b	0.095 f	11.338 g
T_1	5.857	1.234	0.049ab	19.31 c	0.134e	18.188c
T_2	5.825	1.180	0.036 c	24.35 a	0.135 de	16.650 f
T_3	5.675	1.199	0.046 be	17.60 d	0.140 cd	17.750 d
T_4	5.70	1.190	0.039 dc	17.43 d	0.147 b	17.550 e
T_5	6.150	1.303	0.043cd	24.14 a	0.148b	19.575a
T_6	5.750	1.412	0.053 a	19.95 b	0.141 C	17.775 d
T_7	5.80	1.329	0.050 ab	18.83 c	0.156 a	18.400 b
T_8	5.95	1.372	0.047 ab	20.43 b	0.149 b	18.54 b
SE(*)	NS	NS	17.89	2.01	2.11	0.54
CV(%)	3.13	0.0182	0.0027	0.1436	0.001	0.033
Initial Soil (Composite Sample)	6.2	1.187	0.032	19.85	0.12	14.4

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV= Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea +20 kg N supplied by vermicompost, T_3: 80 kg N from urea +40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG +51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

Exchangeable Potassium

Exchangeable potassium content of the post-harvest soils varied considerably due to the application of organic manure and chemical fertilizers (Table 5). The exchangeable K content in post-harvest soils ranged from 0.095 to 0.156 m. eq. per 100 g against the K value of 0.12 m. eq. per 100g in the initial soil. The highest value of exchangeable K was noted in the treatment T_7: 69 kg N from USG + 51 N substituted by vermicompost and the lowest (0.095 m. eq. per 100 g) was observed in the treatment T_0 (Control). Zhang *et al.,* (1996) reported that the combined application of poultry manure with chemical fertilizer increased exchangeable K content in soil.

Available sulphur

Available sulphur content of the post-harvest soil also varied considerably due to different treatments (Table 5). The available sulphur content of the initial soil was 14.4 ppm and values in the post-harvest soils ranged from 11.338 to 19.575 ppm. The highest available S content (19.575 ppm) was observed in the treatment T_5: 120 kg N substituted by USG and lowest value was observed in the treatment T_0 (Control). The S content of the post-harvest soils was higher in soils treated with organic manure compared to the soils treated with the chemical fertilizers. Hossain (1996) found that the combined use of the organic manure with NPKS improved the S status in soil.

Conclusion

From the present study it may be concluded that, the application of nitrogen (100%) as prilled urea or USG performed better than their combination with vermicompost. Substitution of N by vermicompost had no positive effect on yield of rice or nutrient status of post-harvest soil. So, from the economic point of view, the application of urea at a recommended rate i.e. 120, kg N ha^{-1} along with recommended rate of P, K, S and Zn is necessary for obtaining higher grain yield as well as straw yield of T. *aman* rice and nutrient contents and soil properties as a whole.

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