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Article

Improvement of rice production through combined use of organic manures and bio-slurries with chemical fertilizers

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Abstract: The field experiment was conducted at the Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period of February to May 2015 to evaluate the effect of organic manures and bio-slurries with chemical fertilizers on the improvement of rice production in Old Brahmaputra Floodplain soils. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were eight treatment combinations viz. T_0: Control (no fertilizer or manure), T_1: Farmers' practice, T_2: 100% RFD chemical fertilizers (NPKSZnB), T_3: 75% RFD (NPKSZnB) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZnB) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZnB) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZnB) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZnB) + Compost (10 t ha^{-1}). The rice crop cv. BRRI dhan29 was used as a test crop. Result showed that most of the growth and yield components of rice viz. plant height, effective tillers, panicle length, grains per panicle and 1000-grain weight were significantly influenced due to application of organic manures and bio-slurries with chemical fertilizers. Application of chemical fertilizers alone or in combination with organic manures or bio-slurries resulted in a significant increase in grain and straw yields of rice. Treatments 100% RFD chemical fertilizers (NPKSZnB) as well as 75% RFD (NPKSZnB) + PM slurry (3 t ha^{-1}) showed better performances than other treatments. Nutrient uptake by rice was also significantly affected by different treatments. Therefore, treatment (T_6) 75% RFD (NPKSZnB) + PM slurry (3 t ha^{-1}) could be the best option to increase crop yield in Old Brahmaputra Floodplain soils.

Keywords: crop productivity; bio-slurry; organic manure

1. Introduction

Rice (*Oryza sativa* L.) is the staple food for the people of Bangladesh. Bangladesh ranks 3rd position in rice area and 4th in production among rice growing countries of the world (FAO, 2008). Rice is intensively cultivated in Bangladesh covering about 80% of arable land (BBS, 2011). The application of urea with mustard oil cake produced maximum grain and straw yield (Alim, 2012**)**. 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 (Tilahun *et al*., 2013).

There are good opportunities to improve soil fertility and crop production by application of organic manure and bio-slurry along with chemical fertilizers. Improvement of crop production in intensive cropping systems could be achieved by integrated plant nutrition systems especially using bio-slurries. However, no systematic information is available in Bangladesh about the role of integrated plant nutrient management with bio-slurry in improving soil fertility and crop productivity. Bio-slurry is recently being used as a good source of plant nutrient in soil. The combined application of farmyard manure (FYM) and inorganic N and P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice (Tilahun *et al*., 2013). Organic manure can supply a good amount of plant nutrients, contributing to the improvement of rice yield. Therefore, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without declining soil fertility.

Cowdung, poultry manure, bio-slurry and compost are the good sources of organic matter in soils. Presently a large number of poultry industries have been developed across the country. Poultry excreta are not used as fuel, so poultry excreta can be a potential use in crop production. The slurry effluent produced from biogas plant, which is called bio-slurry or biogas slurry, can also be used as manure for crop production (Mosquera *et al*., 2000; Yu *et al*., 2010; Abu baker, 2012). Cowdung and poultry manure are usually used in biogas plant. Due to the decomposition and breakdown of its organic content, digested slurry provides fast-acting nutrients that easily enter into the soil solution, thus becoming immediately available to plants.

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. The yield of rice and soil productivity can be increased substantially with the judicious application of organic manure with chemical fertilizer (Hossaen *et al*., 2011). The integrated use of chemical fertilizer and manure is important for sustainable crop yield in a rice-rice cropping pattern and soil fertility (Ali *et al*., 2009). Soil organic matter improves the physico-chemical properties of the soil and ultimately promotes crop production. More recently, attention is given on the utilization of organic wastes, FYM, compost and poultry manure as the most effective measure for the improving soil fertility and thereby crop productivity. A suitable combination of organic and inorganic sources of nutrient is necessary for higher crop production. This strategy will ensure sustainable crop production in intensive cropping system through integrated nutrient management with organic manures and bio-slurries.

Farmers need to use chemical fertilizers to increase crop production. If chemical fertilizers are continuously applied to the soil without adding organic manures, productivity of soil will decline. Conversely, if organic manure is only added to the soil, desired crop yield cannot be achieved. Neither organic manure nor chemical fertilizer alone is enough to meet the demand of soil-plant systems (Rahman, 2013). Integrated use of inorganic fertilizers with organic manures not only sustains the crop production but also is effective in improving soil health and enhancing nutrient use efficiency (Verma *et al*., 2005; Ali *et al*., 2009).

Therefore, the present research work was undertaken to investigate the effect of integrated nutrient management with organic manures and bio-slurries in intensive cropping systems for sustaining soil fertility and increasing rice productivity.

2. Materials and Methods

2.1. Experimental site

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh from February to May, 2015.

2.2. Collection and preparation of soil and manures

Soil samples from 0-15 cm depth of the experimental field were collected for determining the characteristics of the soil. The soil samples were mixed to make a composite soil sample. Then soil samples were air-dried, crushed and passed through a 2-mm sieve. The soil samples were kept in plastic containers for analysis of physical and chemical properties. The soil was silt loam having pH 6.15, total N 0.11%, available P 10.10 ppm, available S 11.98 ppm, exchangeable K 13.54 me/100g soil and organic matter 1.90%. Manures viz. cowdung, cowdung slurry, poultry manure, poultry manure slurry and compost were used in this study. Cowdung, poultry manure and compost were collected from BAU farm. Cowdung slurry and poultry manure slurry were collected from biogas plants of Bhaluka, Mymensingh.

2.3. Experimental design, crop and treatment combinations

The experiment was laid out in a randomized complete block design with three replications. Boro rice cv. BRRI dhan29 was used as a test crop. Seedlings of rice were transplanted in the experimental fields.

There were eight (8) treatment combinations with CD, PM, CD slurry, PM slurry, compost and Recommended Fertilizer Dose (RFD) of chemical fertilizers for high yield goal (HYG) as follows- T_0: Control (no fertilizer or manure),T_1: Farmers' practice, T_2: 100% RFD chemical fertilizers (NPKSZnB), T_3: 75% RFD (NPKSZnB) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZnB) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZnB) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZnB) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZnB) + Compost (10 t ha^{-1}). Here, CD-Cowdung; PM-Poultry manure. Manures were added to the soils during final land preparation.

All manures were applied at 15% moisture basis. The rates of chemical nutrients were calculated on the basis of HYG (BARC, 2012).

2.4. Fertilizer application and intercultural operations

Experimental plots received manures and/or fertilizers as per treatments. Triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid were applied during final land preparation. Urea was applied in three equal splits. Weeding and other management practices were performed as and when required. Irrigation was also done whenever required.

2.5. Crop harvesting and data recorded

The crops were harvested at full maturity. Grain and straw yields and plant parameters were recorded.

2.6. Laboratory analysis

Chemical analysis of plant and soil samples was performed in the Department of Soil Science, BAU. The N, P, K and S contents were measured from plant samples following standard methods as described by Khanam *et al*. (2001).

2.7. Statistical analysis

Data were analyzed statistically using analysis of variance (ANOVA) to examine the treatment effects. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) and ranking was indicated by letters.

3. Results and Discussion

3.1. Growth and yield components of rice

3.1.1. Plant height

Plant height responded significantly due to application of manures and fertilizers (Figure 1). Plant height ranged from 73.07 to 90.67 cm. The longest plants were recorded in the treatment where 100% RFD NPKSZnB fertilizers were applied. On the other hand, the shortest plants were found in the control treatment where no manures or fertilizers were applied. Treatments received manures or bio-slurry along with chemical fertilizers also produced taller plants which were significantly similar to 100% RFD fertilizer treatment (Figure 1). Bio-slurry amendment increased leaf area index, root length density and plant height of wheat and rice compared to unamended plots (Garg *et al*., 2005).

3.1.2. Number of effective tillers hill^{-1}

The number of effective tillers of rice was significantly increased by application of manures and fertilizers (Figure 2). The number of effective tillers ranged from 6.93 to 10.8. The maximum tillers were recorded in the treatment T7 where 75% RFD (NPKSZnB) + compost (10 t ha^{-1}) were applied. The lowest number of tillers was observed in the control treatment. Treatments (T2-T6) consisting manures or bio-slurry along with chemical fertilizers produced similar number of effective tillers compared to T7 treatment (Figure 2).

3.1.3. Panicle length

Panicle length of rice also responded significantly due to application of manures and fertilizers (Figure 3). The highest panicle length was found in the treatment where 100% RFD NPKSZnB fertilizers were applied. On the other hand, the lowest panicle length was found in the control treatment. Treatments received manures or bio-slurry along with chemical fertilizers recorded similar results in aspect of panicle length compared to treatment T2 (Figure 3).

3.1.4. Number of grains per panicle

The number of grains per panicle was significantly increased due to application of manures and fertilizers (Figure 4). The highest number of grains was recorded in the treatment where 100% RFD NPKSZnB fertilizers were applied whereas the lowest numbers were found in the control treatment. Manures or bio-slurry along with chemical fertilizers treatments also increased grains per panicle of rice over control (Figure 4).

3.1.5. Thousand grain weight

The 1000-grain weight was also increased by application of manures and fertilizers (Figure 5). The highest 1000-grain weight was recorded in the treatment where 100% RFD NPKSZnB fertilizers were applied. Conversely, the lowest 1000-grain weight was observed in the control treatment. Manures or bioslurry along with chemical fertilizers treatments also increased 1000-grain weight over control (Figure 5).

Table 1. Effects of manures or bioslurry along with chemical fertilizers on nutrient uptake by rice.

Treatments	Total nutrient uptake (kg ha^{-1})			
	N	P	K	S
T0	55.07d	11.36e	66.48d	8.65c
T1	79.03c	17.94d	109.28c	13.57b
T2	105.82b	22.33bc	140.28a	17.44a
T3	103.74b	22.03bc	126.45b	17.64a
T4	102.42b	20.96c	129.18b	17.69a
T5	102.04b	20.29c	128.29b	18.67a
T6	112.41a	24.10a	142.29a	18.75a
T7	105.19b	23.66ab	143.88a	17.87a
SE(±)	2.53	0.84	2.12	1.16

Common letters in a column does not differ significantly at 5% level of significance
T_0: Control (no fertilizer or manure),T_1: Farmers' practice, T_2: 100% RFD chemical fertilizers (NPKSZnB), T_3: 75% RFD (NPKSZnB) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZnB) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZnB) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZnB) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZnB) + Compost (10 t ha^{-1}).

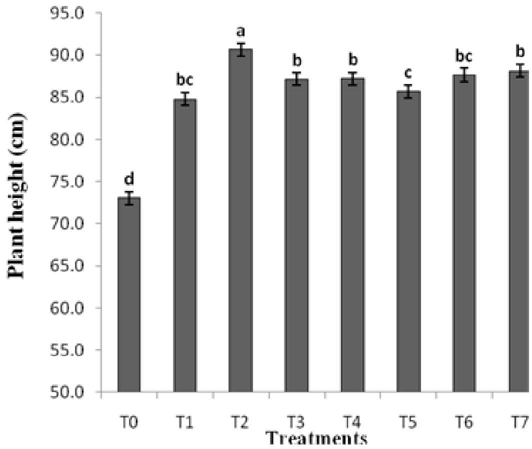

Figure 1. Effects of manures or bioslurry along with chemical fertilizers on plant height of rice.

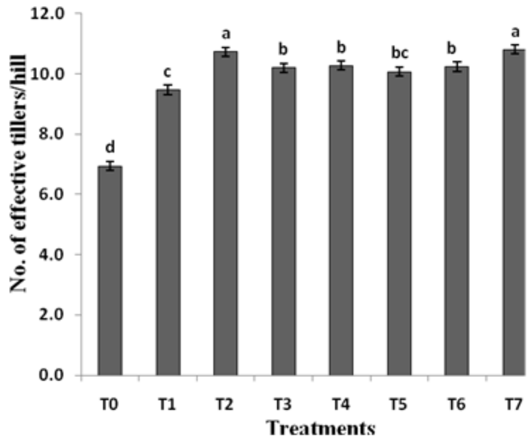

Figure 2. Effects of manures or bioslurry along with chemical fertilizers on No. of effective tillers/hill in rice.

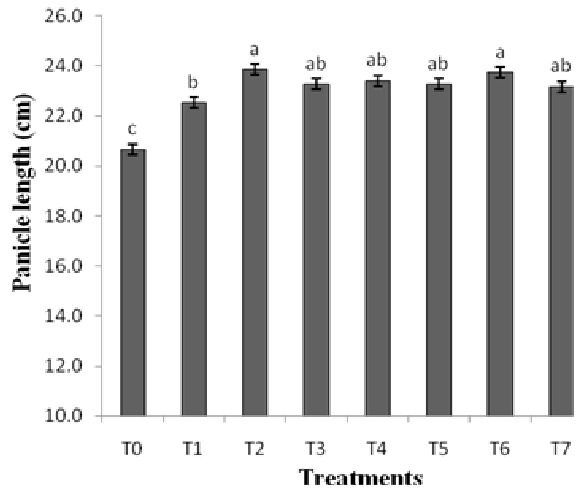

Figure 3. Effects of manures or bioslurry along with chemical fertilizers on panicle length of rice.

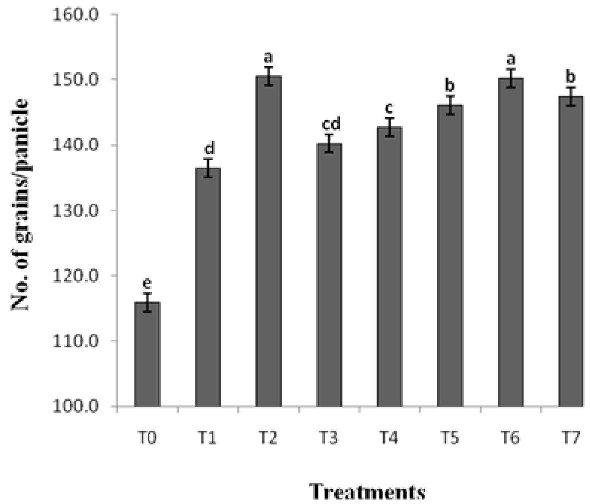

Figure 4. Effects of manures or bioslurry along with chemical fertilizers on number of grains per panicle of rice.

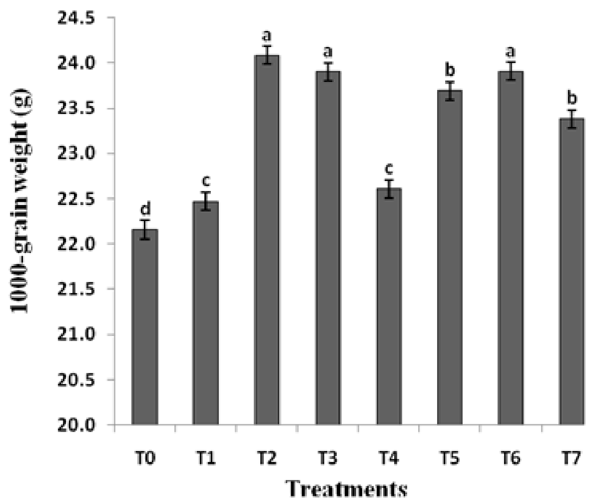

Figure 5. Effects of manures or bioslurry along with chemical fertilizers on 1000-grain weight of rice.

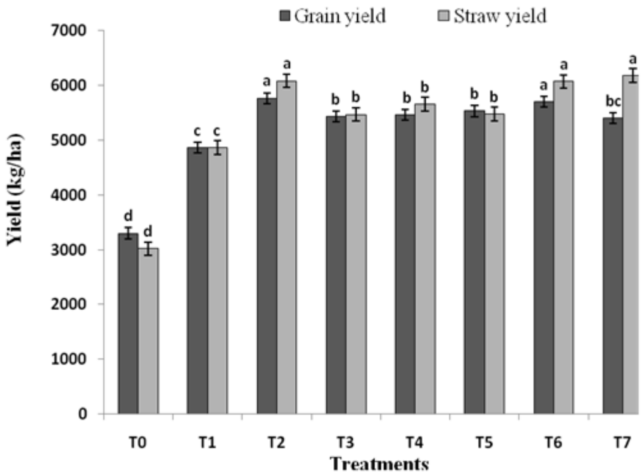

Figure 5. Effects of manures or bioslurry along with chemical fertilizers on grain and straw yield of rice.

There are also some reports showing the similar results. It was found that bio-slurry amendment increased leaf area index, root length density and plant height of wheat and rice compared to unamended plots (Garg *et al*., 2005). Growth of rice plants applied with digested bioslurry simultaneously also increased the yield of rice by increasing the number of effective tillers per hill (Miho *et al*., 2004). Zamil *et al*. (2004) also reported that application of organic manure and bioslurry along with inorganic fertilizers increased the yield contributing characters of rice like panicle length, number of grains per panicle, thousand grain weights etc.

3.1.6. Grain yield

A significant variation in grain yield of rice was observed in response to fertilizers and manures (Figure 1). The grain yield due to various treatments ranged from 3300 to 5767 kg ha^{-1}. All the treatments showed higher grain yield over control. The highest grain yield (5767 kg ha^{-1}) was obtained in the treatment T2 (100% RFD NPKSZnB fertilizers), which was statistically similar to treatment T6 (75% RFD (NPKSZnB) + PM slurry 3 t ha^{-1}. The lowest grain yield (3300 kg ha^{-1}) was obtained in control treatment.

3.1.7. Straw yield

A significant variation in straw yield of rice was also observed due to combined application of fertilizers and manures (Figure 1). The straw yield ranged from 3020 to 6183 kg ha^{-1}. All the treatments showed higher straw yield over control. The highest straw yield was produced in the treatment T7 (100% RFD NPKSZnB fertilizers), which was statistically similar to treatments T2 and T6. The lowest straw yield was obtained in control treatment.

A positive response to slurry was also found on rice yield (Ullah *et al*., 2008) and however, the treatment where poultry slurry was used showed higher grain and straw yield and higher economic performance. Abu Baker (2012) also showed that biogas residues increased crop yield to the same extent or more than conventional mineral fertilizer and compost. Application of bio-slurry generally improved growth, yield and quality of carrots (Jeptoo *et al*., 2013). Similar result was also observed by Miho *et al*. (2004) that growth of rice plants applied with digested bioslurry simultaneously also increased the yield of rice both grain and straw by increasing the number of effective tillers per hill. There are also some reports that the use of compost or other organic amendments in combination with mineral fertilizers enhanced crop yield in many cropping systems over more than 10 years compared with compost and amendments alone (Ros *et al*., 2006; Bi *et al*., 2009).

3.2. Nutrient uptake by rice

3.2.1. Nitrogen uptake

Results in Table 1 show that total N uptake by rice was significantly affected due to different treatments. The N uptake by crop varied from 55.07 to 112.41 kg ha^{-1}. The highest N uptake was recorded in the treatment T6 which was statistically different from other treatments. The minimum N uptake was recorded in the control treatment.

3.2.2. Phosphorus uptake

The phosphorus uptake by rice was significantly influenced due to various treatments used in the experiment (Table 1). The ranges of total P uptake observed were 11.36 to 24.10 kg ha^{-1}. The maximum P uptake was recorded in the treatment T6 which was statistically identical to the treatment T7. The minimum P uptake by crop was observed in the control treatment.

3.2.3. Potassium uptake

The results indicated that total K uptake by rice was significantly influenced by different treatments (Table 1). The total K uptake varied from 66.48 to 143.88 kg ha^{-1}. The highest K uptake was recorded in the treatment T7 which was statistically identical with those found in the treatments T2 and T6. The lowest K uptake was observed in control treatment.

3.2.4. Sulphur uptake

Results in Table 1 demonstrated that total S uptake by rice was significantly affected due to application of manures and fertilizers. The S uptake varied from 8.65 to 18.75 kg ha^{-1}. The highest S uptake was observed in the treatment T6 which was statistically similar to those recorded in the treatments T2, T3, T4, T5 and T7. The lowest S uptake was found in the control treatment.

There are also some reports that integrated use of inorganic fertilizers with organic manures not only sustains the crop production but also is effective in improving soil health and enhancing nutrient use efficiency in rice (Verma *et al*., 2005; Ali *et al*., 2009). Zamil *et al*. (2004) and Islam (2012) also reported that application of organic manures and bioslurry increased as nutrients are slowly released from theses sources. That's why nutrient loss is less and thus creating scope for more plant uptake. Ghuman and Sur (2006) and Adeleye *et al*. (2010) also reported that application of bioslurry and organic manure increased the N, P, S and K uptake by plants.

4. Conclusions

To meet the demand of food as well as nutritional securities for increasing population of Bangladesh, intensive cropping systems must be adopted with maintaining soil fertility. Combined application of manure or bioslurry with fertilizers also significantly increased growth, yield components and grain and straw yields of rice. We measured NPKS contents in rice whether nutrient uptake influenced by different treatments. Nutrient uptake by rice crop was also significantly affected due to application of manure or bioslurry with fertilizers. It was also observed that organic manure or bioslurry improved soil fertility status by increasing organic matter, total N, and available P, K and S contents in soils (data not shown). It can be concluded that application of chemical fertilizers alone or in combination with manure or bioslurry increased growth and yield of rice whereas combined application of manure or bioslurry with fertilizer not only increased crop production but also maintained soil fertility status in intensive cropping system.

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Conflict of interest

None to declare.

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