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EFFECTS OF ORGANIC MANURES AND BIO-SLURRIES WITH CHEMICAL FERTILIZERS ON GROWTH AND YIELD OF RICE (cv. BRRI dhan28)

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ABSTRACT

Rhaman MS, Kibria MG, Hossain M, Hoque MA (2016) Effects of organic manures and bio-slurries with chemical fertilizers on growth and yield of rice (cv. BRRI dhan28). *Int. J. Expt. Agric.* 6(2), 36-42.

The soil fertility of Bangladesh is decreasing every year at an alarming speed. Low organic matter content is one of the most important contributing factors for poor fertility status of soils. Organic manure and bio-slurry along with chemical fertilizer can successfully be used to improve the soil health and productivity. To evaluate the effect of organic manures and bio-slurries along with chemical fertilizers on growth and yield of rice production, an experiment was conducted at the farmers' field of Fulbaria Upazilla, Mymensingh during the period of February to May 2015. The experiment was laid out following randomized complete block design (RCBD) where each treatment was replicated three times. There were eight treatment combinations *viz.* T_0: Control (no fertilizer or manure), T_1: Farmers' practice, T_2: 100% recommend fertilizer dose (RFD) of chemical fertilizers (NPKSZn), T_3: 75% RFD (NPKSZn) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZn) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZn) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZn) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZn) + Compost (10 t ha^{-1}). The rice crop cv. BRRI dhan28 was used as a test crop. Growth and yield of BRRI dhan28 were very low in the control treatment where no manures or fertilizers were applied in the experimental plots. Application of organic manures or bio-slurries with chemical fertilizers significantly influenced growth and yield components of rice *viz*. plant height, effective tillers, panicle length and grains per panicle. Grain and straw yields of rice significantly increased due to application of manures or bio-slurries with chemical fertilizers. Nutrient (NPKS) uptake by crop was also significantly influenced by application of manures or bio-slurries with chemical fertilizers. Therefore, results suggest that combined application of manure or bio-slurry with chemical fertilizers might improve soil fertility, thereby increasing yield of rice.

Key words: *crop productivity, nutrients management, organic amendment*

INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant food crop in Bangladesh. Bangladesh ranks 3rd position in rice growing area and 4th position in production among rice growing countries of the world (FAO 2008). In Bangladesh among cereals, the primary position is occupied by rice with about 80 percent of the total arable land is dedicated to rice cultivation (BBS 2014). 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, very few 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. Bio-slurry is an excellent soil conditioner, adds humus, and enhances the soil's capacity to retain water. 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). FYM is effective in stabilizing rice productivity under low to medium cropping intensity where the nutrient demand is relatively small. Nonetheless, integrated use of organic and mineral fertilizers has been found to be more effective in maintaining higher productivity and stability through correction of deficiencies of secondary and micronutrients in the course of mineralization on one hand and favorable physical and soil ecological conditions on the other. Organic manuring also improves the physical and microbial conditions of soil and enhances fertilizer use efficiency when applied in conjunction with mineral fertilizers. Cowdung, poultry litter, and other biomass wastes are widely used to produce biogas which is potential renewable energy alternative in rural areas of Bangladesh. More than 30,000 biogas plants of varying gas-producing capacities run with cow dung and poultry litter for domestic purposes. These biogas plants generate more than 200,000 tones of bio-slurry on dry weight basis (Islam 2006). 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).

The organic matter content as well as the fertility status of Bangladesh soil is low. Now it is well agreed that depleted soil fertility is a major constraint for higher crop production in Bangladesh and indeed, yield of several crops are declining in some soils (Bhuiyan 1991). Maintenance of soil fertility is a prerequisite for long term sustainable agriculture and it is certain that organic manure (cowdung, poultry manure and their slurry) with chemical fertilizers can play a vital role in the sustainability of soil fertility and crop production. 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).

Cropping patterns in Bangladesh are mainly rice-based. Plant nutrients in soil, whether naturally endowed or artificially maintained, is a major factor of the success or failure of a crop production system. Intensive rice cropping with constant and high fertilizer inputs indicated a declining trend in rice yield (Cassman and Pinagli, 1995), and this decline of grain yield can be attributed to soil nutrient depletion, as evidenced from long term experiments in Asia (Dobermann and Fairhurst, 2000). Available data indicate that the fertility of Bangladesh soils has deteriorated over the years (Ali *et al.* 1997 a, b). It is apparent that sustainability of crop production system in future will mainly depend on integrated nutrient management and balanced supply of nutrients. 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.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the farmers' field of Fulbaria Upazilla (AEZ-9; latitude 24°44′ N and longitude 90°28′E), Mymensingh from February to May, 2015.

Collection and preparation of soil and manures

Soil samples were collected from the experimental field from 0-15cm depth for determining the characteristics of the soil. Collected soil samples were mixed to make a composite soil sample. Then soil samples were air-dried, crushed and passed through a 2-mm sieve. For the analysis of physical and chemical properties of soils, soil samples were kept in plastic containers. The soil was clay loam having pH 5.34, total N 0.07%, available P 5.0 ppm, available S 7.2 ppm, exchangeable K 7.4 me/100g soil and organic matter 1.2%. Manures *viz.* cowdung, cowdung slurry, poultry manure, poultry manure slurry and compost were used in this study (Table 1). Cowdung, poultry manure and compost were collected from farmers' farm. Cowdung slurry and poultry manure slurry were collected from biogas plants of Bhaluka, Mymensingh.

Table 1. Nutrient contents in cowdung, cowdung slurry, compost, poultry manure and poultry manure slurry

Manures	Nutrient contents			
	%N	%P	%K	%S
Cowdung	0.62	0.46	0.589	0.28
Cowdung slurry	1.39	0.62	0.52	0.42
Compost	0.56	0.40	0.69	0.52
Poultry manure	1.15	1.02	0.84	0.44
Poultry manure slurry	1.93	0.75	1.09	0.52

Experimental design, crop and treatment combinations

The experiment was laid out following RCBD where each treatment was replicated three times. Boro rice cv. BRRI dhan28 was used as a test crop. Thirty-days-old seedlings of rice were transplanted in the experimental field. There were eight (8) treatment combinations with cowdung (CD), poultry manure (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 (NPKSZn), T_3: 75% RFD (NPKSZn) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZn) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZn) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZn) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZn) + Compost (10 t ha^{-1}). Manures and bio-slurries 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).

Application of fertilizer and intercultural operation

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

Crop harvesting and data recorded

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

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).

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.

RESULTS AND DISCUSSION

Growth and yield components of rice

Plant height

The mean plant height of rice grown in soil treated with organic manures and fertilizer were found to be significantly different from the control plant (Table 2). Plant height ranged from 66.53 to 92.00 cm. The longest plants were recorded in the treatment where 75% RFD (NPKSZn) + PM (3 t ha^{-1}) 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 75% RFD (NPKSZn) + PM (3 t ha^{-1}) fertilizer treatment (Table 2).

Number of effective tillers hill^{-1}

The number of effective tillers of rice was significantly increased by application of manures and fertilizers (Table 2). The number of effective tillers ranged from 8.20 to 13.33. The maximum tillers were recorded in the treatment T_5 where 75% RFD (NPKSZn) + PM (3 t ha^{-1}) were applied. The lowest number of tillers was observed in the control treatment. Treatments (T_2, T_3, T_4, T_6 and T_7) consisting manures or bio-slurry along with chemical fertilizers produced similar number of effective tillers compared to T_5 treatment (Table 2).

Panicle length

Panicle length of rice was also significantly increased due to application of manures and fertilizers (Table 2). The panicle length of rice ranged from 18.93 to 24.53 cm. The highest panicle length was found in the treatment where 75% RFD (NPKSZn) + PM (3 t ha^{-1}) 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 T_5 (Table 2).

Table 2. Effect of organic manure and bio-slurries with chemical fertilizer on yield and yield contributing characters of rice

Treatments	Plant height (cm)	No. of effective tillers/hill	Panicle length (cm)	No. of filled grains/ panicle	1000-grain weight (g)
T_0	66.53 c	8.20 b	18.93 b	65.070 d	22.30
T_1	84.47 b	12.13 a	21.80 a	102.80 c	22.73
T_2	87.73 ab	13.20 a	22.73 a	123.30 b	22.67
T_3	87.07 ab	12.93 a	22.33 a	125.30 ab	22.27
T_4	87.53 ab	12.93 a	23.40 a	129.30 ab	22.67
T_5	92.00 a	13.33 a	24.53 a	132.90 a	22.67
T_6	88.67 ab	12.67 a	22.87 a	130.20 ab	22.73
T_7	88.93 ab	12.53 a	23.07 a	124.20 ab	22.50
$LSD_{0.05}$	6.71	1.82	2.67	8.37	2.71
Level of significance	**	**	*	**	NS
SE (±)	2.21	0.995	0.884	2.76	0.894
CV (%)	4.49	8.48	6.82	4.10	6.86

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant

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 (NPKSZn), T_3: 75% RFD (NPKSZn) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZn) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZn) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZn) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZn) + Compost (10 t ha^{-1})

Number of grains per panicle

The number of grains per panicle was significantly increased by application of manures and fertilizers (Table 2). The highest number of grains was recorded in the treatment where 75% RFD (NPKSZn) + PM (3 t ha^{-1})

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 (Table 2).

Thousand grain weight

The 1000-grain weight was also increased by application of manures and fertilizers (Table 2). The highest 1000-grain weight was recorded in the treatment T_1 and T_6. Conversely, the lowest 1000-grain weight was observed in the T_3 treatment. Manures or bio-slurry along with chemical fertilizers treatments also increased 1000-grain weight over control (Table 2).

There was a report 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). Basak *et al*. (2016) also reported that improvement of rice production through combined use of organic manures and bio-slurries with chemical fertilizers.

Grain and straw yield

In grain yield of rice, a significant variation was observed in response to fertilizers and manures (Fig. 1). The grain yield ranged from 1843 to 5704 kg ha^{-1}. All of the treatments showed higher grain yield except control. The highest grain yield (5704 kg ha^{-1}) was obtained in the treatment T_5 (75% RFD (NPKSZn) + PM 3 t ha^{-1}), which was statistically similar to treatments T_2, T_3, T_4, T_6 and T_7. The lowest grain yield (1843 kg ha^{-1}) was obtained in control treatment.

A significant variation in straw yield of rice was also observed due to combined application of fertilizers and manures (Fig. 1). The straw yield ranged from 2843 to 7410 kg ha^{-1}. All of the treatments showed higher straw yield except control. The highest straw yield was produced in the treatment T_5(75% RFD NPKSZn + PM 3 t ha^{-1} fertilizers). 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. 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). 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).

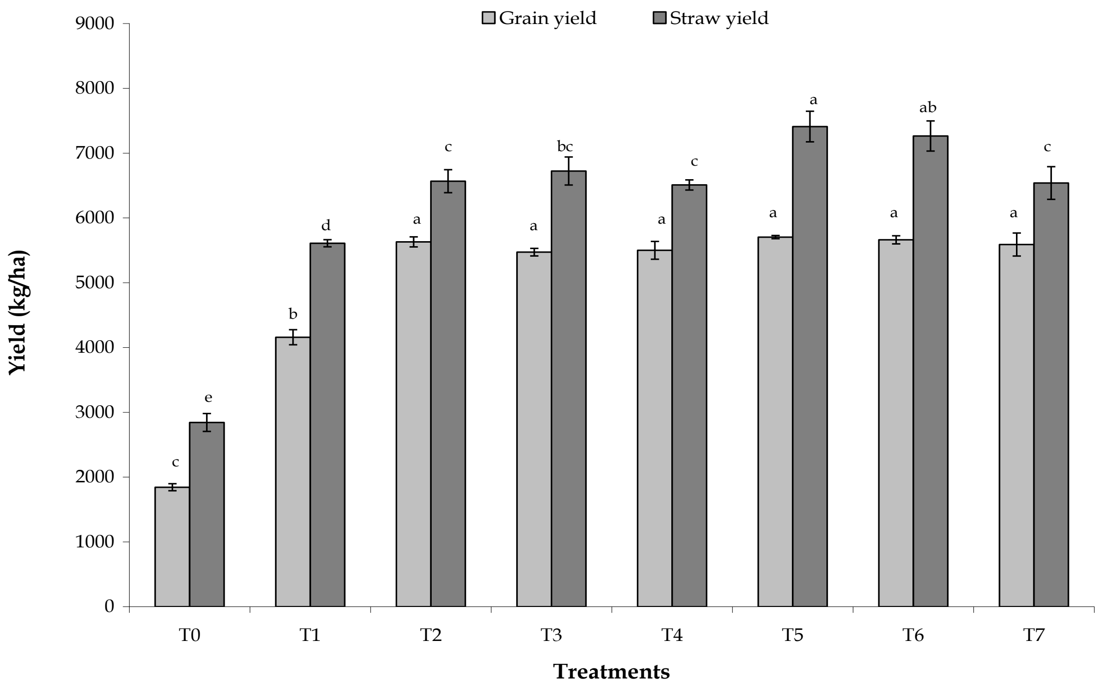

Fig. 1. Effect of organic manure and bio-slurry along with chemical fertilizer on yield

Error bars indicate the standard error of the mean (n = 3, mean ± SE). Bars with different letters differ significantly [Duncan's Multiple Range Test (DMRT) test, P ≤ 0.05]

Nutrient uptake by rice

Nitrogen uptake

Total N uptake by rice was significantly affected due to different treatments (Table 3a). The N uptake by crop varied from 31.08 to 136.4 kg ha^{-1}. The highest N uptake was recorded in the treatment T_6 which was statistically different from other treatments. The minimum N uptake was recorded in the control treatment.

Table 3(a). Effect of organic manure and bio-slurry along with chemical fertilizers on nutrient (N and P) uptake by rice

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_0	16.29 d	14.78 d	31.08 e	1.77 d	0.94 f	2.70 f
T_1	41.62 c	37.92 c	79.54 d	4.32 c	2.18 e	6.51 e
T_2	56.75 b	51.49 b	108.2 c	6.64 b	3.08 cd	9.73 cd
T_3	54.93 b	56.48 b	111.4 c	6.62 b	3.36 bc	9.98 bcd
T_4	56.10 b	53.89 b	110.0 c	6.82 b	3.38 bc	10.20 bc
T_5	58.63 b	65.50 a	124.1 b	6.78 b	3.63 ab	10.42 b
T_6	67.27 a	69.15 a	136.4 a	7.76 a	3.77 a	11.54 a
T_7	56.12 b	50.48 b	106.6 c	6.54 b	2.94 d	9.48 d
$LSD_{0.05}$	4.25	5.63	6.21	0.421	0.287	0.498
Level of significance	**	**	**	**	**	**
SE (±)	1.40	1.86	2.05	0.139	0.095	0.165
CV (%)	4.77	6.44	3.52	4.08	5.64	3.23

** = Significant at 1% level of probability

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 (NPKSZn), T_3: 75% RFD (NPKSZn) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZn) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZn) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZn) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZn) + Compost (10 t ha^{-1})

Phosphorus uptake

The phosphorus uptake by rice was significantly influenced due to various treatments used in the experiment (Table 3a). The ranges of total P uptake observed were 2.70 to 11.54 kg ha^{-1}. The maximum P uptake was recorded in the treatment T_6 which was statistically different from other treatment. The minimum P uptake by crop was observed in the control treatment.

Potassium uptake

The potassium uptake by rice was significantly influenced by different treatments (Table 3b). The total K uptake varied from 53.87 to 172.5 kg ha^{-1}. The highest K uptake was recorded in the treatment T_5 which was statistically identical to treatment T_6. The lowest K uptake was observed in control treatment.

Table 3(b). Effect of organic manure and bio-slurry along with chemical fertilizers on nutrient (K and S) uptake by rice

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_0	6.67 d	57.20 d	53.87 e	1.19 c	1.79 e	2.99 f
T_1	15.88 c	98.72 c	114.60 d	2.99 b	4.09 d	7.08 e
T_2	22.63 ab	122.20 b	144.83 c	4.78 a	4.79 c	9.58 d
T_3	22.00 b	121.70 b	143.70 c	4.76 a	5.11 bc	9.87 cd
T_4	22.00 b	124.30 b	146.3 c	4.73 a	4.81 c	9.547 d
T_5	23.56 a	148.90 a	172.5 a	5.02 a	6.07 a	11.09 a
T_6	23.95 a	144.60 a	168.5 ab	4.75 a	6.03 a	10.79 ab
T_7	23.64 a	134.70 ab	158.3 b	4.75 a	5.49 b	10.24 bc
$LSD_{0.05}$	1.32	16.92	11.88	0.271	0.476	0.578
Level of significance	**	**	**	**	**	**
SE (±)	0.436	5.58	3.92	0.088	0.156	0.190
CV (%)	3.77	8.12	4.92	3.72	5.68	3.71

** = Significant at 1% level of probability

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 (NPKSZn), T_3: 75% RFD (NPKSZn) + CD (5 t ha^{-1}), T_4: 75% RFD (NPKSZn) + CD slurry (5 t ha^{-1}), T_5: 75% RFD (NPKSZn) + PM (3 t ha^{-1}), T_6: 75% RFD (NPKSZn) + PM slurry (3 t ha^{-1}), T_7: 75% RFD (NPKSZn) + Compost (10 t ha^{-1})

Sulphur uptake

The results indicated that total S uptake by rice was significantly affected due to application of manures and fertilizers. The S uptake varied from 2.99 to 11.09 kg ha^{-1}. The highest S uptake was observed in the treatment T_5 which was statistically identical to treatment T_6. 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). Ghuman and Sur (2006) and Adeleye *et al*. (2010) and Basak *et al.* (2016) also reported that application of bio-slurry and organic manure increased the N, P, S and K uptake by plants. Zamil *et al*. (2004); Islam and Nahar (2012) also reported that application of organic manures and bio-slurry increased as nutrients are slowly released from theses sources. That's why nutrient loss is less and thus creating scope for more plant uptake.

CONCLUSION

Combined application of manure or bio-slurry with fertilizers 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 bio-slurry with fertilizers. It can be concluded that application of chemical fertilizers alone or in combination with manure or bio-slurry increased growth and yield of rice whereas combined application of manure or bio-slurry with fertilizer not only increased crop production but also maintained soil fertility status in intensive cropping system.

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