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Effect of different sources of nitrogen on yield and yield attributes of transplanted rice under east and south coastal plains of Odisha

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ABSTRACT

Integrated nutrient management (INM) plays an important role to maintain the soil health and improve crop productivity. A field experiment was conducted to study the effect of integrated nitrogen application on transplanted rice. The present investigation was laid out in randomised block design with 10 treatments. Growth parameters like plant height, dry matter accumulation varied significantly among different treatments and the highest value was recorded under the treatment T_6 (75% N through fertilizer + 25% N through vermicompost with full dose of P and K). All the yield attributing characters like panicles m^{-2}, grains panicle^{-1} significantly varied under different treatments. Significantly, higher tiller m^{-2}, grain panicle^{-1} and panicle length were recorded under T_6. Similarly, significantly highest grain yield (4.93 t ha^{-1}) and straw yield (6.01 t ha^{-1}) were observed under T_6. Thus, substituting a part of nitrogen fertilizer with organic manure improves soil quality and sustains the crop productivity.

Key words: *Transplanted rice, vermicompost, farmyard manure, integrated nutrient management*

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than 50 % of the world's population, including regions of high populationdensity and rapid growth (Fageria, 2007). In India, the importance of organic matter addition was considered so important in rice-based systems that numerous studies with organic manures were conducted. The primary purpose was to determine their nutrient equivalence in comparison to chemical fertilizers. Increasing the use of nitrogen (N) fertilizer in rice production is essential, due partly to the limited cultivated area ofrice paddies (Galloway et al., 2008). Integrated nutrient management (INM) is the concept of using a combination of organic and inorganic amendments to increase nitrogen use efficiency (NUE) and reduce nutrient loss by synchronizing crop yield with nutrient availability in soil (Wu and Baoluo, 2015). Inorganic fertilizer and organic manure are the most common resources applied in agricultural production system to improve soil quality and crop productivity (Shahid et al., 2013). Many studies have concluded that balanced application of inorganic fertilizers with or without application of organic manure can increase SOC and maintain soil productivity (Purakayastha et al., 2008). Moreover, the addition of fertilizer on a regular basis leads to an increase in soil microbial biomass and also alters soil C and N dynamics (Shahid et al., 2017). However, it is difficult to achieve the soil health and nutrient-provisioning benefits of organic N sources. High-quality organic amendments with a low carbon to nitrogen ratio (C:N) decompose quickly and contribute less to stable organic matter in the soil, whereas amendments with a high C:N (low quality) decompose slowly and may not supply sufficient N to meet crop demand, potentially resulting in lower yields (Wortman et al., 2012). By contrast, inorganic N fertilizers easily dissolve in soil solution and are quickly available for plant uptake upon application. Given their contrasting properties, the integrated use of both organic amendments and inorganic fertilizers may contribute to improved soil quality without sacrificing crop nutrition or yield. So, use of organics would be quite promising not only in providing superior stability in production, but also in sustaining better soil fertility.

Application of inorganic fertilizers even in balanced amount cannot sustain the soil fertility and crop productivity under varied continuous cropping or monocropping, as a result agriculture is now facing a lot of strains (Kundu et al., 2010). To make the system productive and profitable, integration of organic sources such as vermicomposting (VC) and application of farm yard manure (FYM) is an excellent example, which may also help in the restoration of soil health (Chowdhury et al., 2015) and the combined use of organic manure with inorganic fertilizers performed better than sole inorganic fertilizer to sustain the soil fertility and rice productivity. Some of the earlier findings have shown a build-up of soil organic matter stock in rice-based cropping system with FYM, rice straw or green manure in tropical or subtropical Asian countries (Ghosh et al., 2012; Nayak et al., 2012). Considering the above facts, objectives of our study was to study the effect of different dose of N fertilizer along with organic fertilizers on rice yield and the nutrient uptake.

MATERIALS AND METHODS

Experimental details

A field experiment was conducted at Instructional Farm-I of Faculty of Agricultural Sciences (Institute of Agricultural Sciences), Siksha 'O' Anusandhan (deemed to be university)Pandakudiya, Bhubaneswar, Odisha during the *kharif* 2018. The experimental site was situated at 20º17'21" N, 85º45'51" E, under East & South Eastern Coastal plains in Odisha, India. The present investigation was laid out in randomised block design with 10 treatments like T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; $T_5 = T_3$ + 25% N through FYM (4.25 t/ha); $T_6 = T_3$ + 25% N through VC (0.8 t/ha); $T_7 = T_4$ + 50% N through FYM (8.5 t/ha); $T_8 = T_4$ + 50% N through VC (1.6 t/ha); $T_9 = T_4$ + 25% N through FYM (4.25 t/ha) + 25% N through VC (0.8 t/ha); T_{10} = 50% N through FYM (8.5 t/ha) + 50% N through VC (1.6 t/ha). All the treatments received a uniform dose of P_2O_5 and K_2O. The soil of the experimental site was neutral in reaction with low in available nitrogen (161.66 kg ha^{-1}), phosphorous and medium in potassium content. The test variety was Naveen.

Nutrient content and uptake

Nitrogen, phosphorus and potassium content (%) and uptake (kg ha^{-1}) were evaluated in laboratory after the harvest of crop. The total nitrogen content in plant was determined by modified Kjel-dahl method (Jackson, 1973). Total phosphorus content of the plant materials was determined by Vanadomolybdo-phosphoric acid yellow color method in HNO_3 system with the help of UV-Vis Spectrophotometer as described by Koening and Jackson, 1972. Potassium content of the plant material was determined by wet digestion method with the help of Flame photometer (Jackson, 1973).

Milling qualities

Whole or a part of the brown layer was removed from the brown rice with Mc Gill Miller No. 3 to produce milled or polished rice. The broken grains of milled rice were then separated from unbroken rice and the weight of head rice was recorded. Milling qualities like hulling, milling and head rice recovery were calculated by following formulae as suggested by Khush et al. (1979):

Weight of brown rice

$$\text{Hulling \%} = \frac{\text{Weight of brown rice}}{\text{Weight of rough rice}} \times 100$$

$$\text{Milling \%} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100$$

$$\text{Head rice recovery \%} = \frac{\text{Weight of head rice}}{\text{Weight of rough rice}} \times 100$$

Yield and yield parameter

After harvesting of rice, grain and straw yield was taken by maintaining the constant moisture. Apart from this, rice growth attributes like plant height, dry matter production, no of panicles, no of grains per panicle and panicle length were also taken after rice harvesting.

RESULTS AND DISCUSSION

Yield and yield attributes

Rice grain and straw yield significantly varied under different treatments. The grain yield was higher under T_6 (4.97 t ha^{-1}) followed by T_2 (4.78 t ha^{-1}) (Fig. 1). Similarly, the straw yield was also more under T_6 (6.01 t ha^{-1}) as compared to all other treatments (Fig. 2). The higher grain and straw yield of rice under combined application of nutrients through inorganic and organic sources might be due to availability of nutrients throughout the rice growth stages (Nayak et al., 2012). Different sources of plant nutrients (*e.g.*, FYM, vermicompost, oil cakes, biofertilizer, crop residues etc) has a favourable role on all the yield attributes vis-à-vis yield of rice grown either as a single sole crop or as a component crop of a cropping sequence of three or four crops. This may be due to the fact that organic manures like FYM, vermicompost, oilcakes maintain the physical condition of soil besides supplying plant nutrients slowly but steadily along with the added advantage of quick, adequate and easy nutrient supplying capacity of chemical fertilizer to the crop in this treatment. These findings were confirmed by Barik et al. (2006) and Chowdhury et al. (2015).

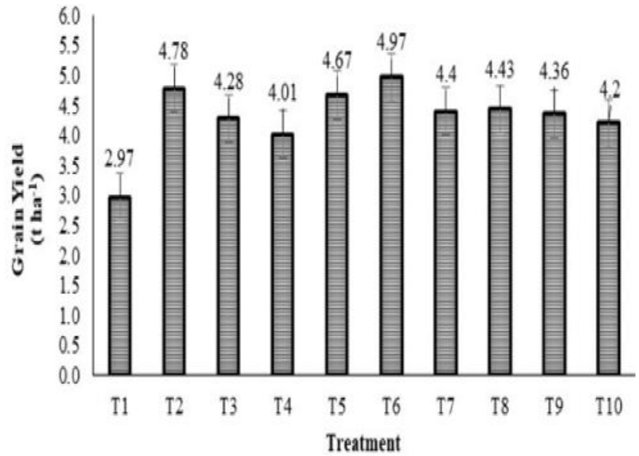

Fig. 1. Grain yield of rice under different treatments.
T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25% N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25% N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50% N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50% N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25% N through FYM (4.25 t ha^{-1}) + 25% N through VC (0.8 t ha^{-1}); T_{10} = 50% N through FYM (8.5 t ha^{-1}) + 50% N through VC (1.6 t ha^{-1}).

Apart from this, all yield attributes like, plant height, dry matter accumulation, number of panicles m^{-2}, number of grains panicle^{-1} and panicle length (cm) were significantly higher under T_6 as compared to all other treatments and least under control treatment (Table 1). Positive change in dry matter accumulation and CGR at all the growth stages is due to modification in NPK levels may be accredited to increase in the amount and efficiency of chlorophyll, which might have influenced the photosynthetic efficiency and construction of additional nitrogenous compounds *viz.*, amino-acids, proteins, alkaloids and protoplasm resulting in upsurge in plant height, numbers of tillers/hill, which donated towards increased dry matter yield and CGR. It is a well-established fact that tillering capacity is one of the most important characteristics of a variety and initiation of tillers primordia remains free

Table 1. Growth parameters and yield attributes of rice

Treatments	Plant height (cm)	Dry matter production (g m^{-2})	No Panicles m^{-2}	No of grains panicle^{-1}	Panicle length (cm)
T_1	65.10	578.12	179.30	129.67	18.83
T_2	92.51	853.32	271.20	182.37	26.37
T_3	82.53	793.06	231.87	150.33	22.72
T_4	75.90	777.16	205.03	135.00	20.98
T_5	90.73	837.18	263.73	179.67	26.22
T_6	91.86	866.68	272.70	187.67	26.48
T_7	79.63	804.56	223.50	136.33	23.15
T_8	79.80	802.33	229.47	139.67	23.47
T_9	80.40	778.38	231.77	136.33	22.96
T_{10}	76.63	771.46	211.43	134.67	21.91
SE m (±)	0.57	12.72	3.20	2.07	0.88
CD ($P \leq 0.05$)	1.69	37.78	6.72	4.35	2.60

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25% N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25% N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50% N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50% N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25% N through FYM (4.25 t ha^{-1}) + 25% N through VC (0.8 t ha^{-1}); T_{10} = 50% N through FYM (8.5 t ha^{-1}) + 50% N through VC (1.6 t ha^{-1}).

Table 2. Effect of different nutritional management practices on nutrient content in grain and straw of rice.

Treatments	Nutrient content in grain			Nutrient content in straw			Nutrient uptake in grain (kg ha^{-1})			Nutrient uptake in straw (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	0.867	0.357	0.303	0.473	0.207	1.063	27.88	11.41	9.75	18.49	8.04	41.34
T_2	1.157	0.523	0.373	0.627	0.270	1.373	55.62	25.05	17.94	35.97	15.41	79.33
T_3	1.143	0.447	0.360	0.607	0.257	1.290	48.80	19.08	15.39	30.86	13.10	65.90
T_4	0.983	0.427	0.343	0.527	0.240	1.207	37.44	14.94	13.74	25.69	11.72	58.88
T_5	1.140	0.507	0.363	0.620	0.267	1.360	53.07	22.79	16.85	36.89	15.83	80.75
T_6	1.160	0.543	0.390	0.667	0.293	1.383	57.01	25.18	19.27	40.00	17.66	82.61
T_7	1.133	0.463	0.345	0.553	0.243	1.260	49.94	20.50	15.16	29.68	13.32	68.88
T_8	1.143	0.430	0.337	0.563	0.253	1.300	50.62	19.06	14.92	30.28	13.60	69.18
T_9	1.127	0.443	0.331	0.560	0.230	1.267	49.18	19.24	14.40	30.11	12.35	67.81
T_{10}	1.137	0.433	0.350	0.537	0.220	1.233	47.73	18.16	14.70	27.92	11.36	63.57
SE m (±)	0.038	0.021	0.008	0.023	0.023	0.011	1.68	0.726	0.538	0.915	0.528	2.682
CD (P = 0.05)	0.113	0.063	0.024	0.069	0.069	0.034	4.98	2.156	1.597	2.69	1.571	7.96

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25 % N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25 % N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50 % N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50 % N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25 % N through FYM (4.25 t ha^{-1}) + 25 % N through VC (0.8 t ha^{-1}); T_{10} = 50 % N through FYM (8.5 t ha^{-1}) + 50 % N through VC (1.6 t ha^{-1}).

from the influence of environment but their emergence and development are greatly influenced by factors i.e. water and nutrient levels (Das, 2002; Barik et al., 2006).

Nitrogen, phosphorous and potassium content by grain and straw varied significantly among the different treatments (Table 2). Maximum nitrogen accumulation (1.160 % and 0.667 % in grain and straw, respectively) and uptake by grain and straw was noticed under T_6. It has been observed that the use of N partially through either FYM or Vermicompost played an important role and has a positive response in nutrient contents both in grain and straw of rice. The nutrient uptake by N, P and K in grain and straw follows the same trend depicting the highest values under T_6 followed by T_5 and T_2. Similar trend was also observed for, P and K content and their uptake.The above results show that integration of organic manures along with chemical fertilizers resulted in better nutrient absorption as compared to the treatments which received nutrients only through chemical fertilizer (Das, 2006; Yawalkaret al., 2008; Chowdhury et al., 2015). The integration of different sources of plant nutrients (FYM and vermicompost) has a favourable role in maintaining proper nutrient status, temperature, water retention capacity, and microbial population etc of the soil.

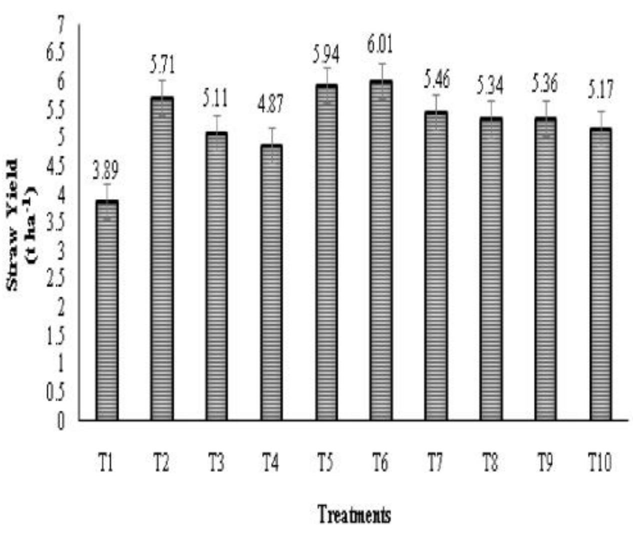

Fig. 2. Straw yield of rice under different treatments.

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25% N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25% N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50% N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50% N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25% N through FYM (4.25 t ha^{-1}) + 25% N through VC (0.8 t ha^{-1}); T_{10} = 50% N through FYM (8.5 t ha^{-1}) + 50% N through VC (1.6 t ha^{-1}).

The Nitrogen balance was calculated and represented in the Fig. 3. It was found that the treatments which received a part of N through organic source *i.e.*, via FYM and Vermicompost showed a positive nitrogen balance after harvesting of rice crop. The treatment supremacy was found in the treatment T_{10} with a value of + 31.74 kg ha^{-1} in respect to Nitrogen balance whereas, the least under control, -11.57 kg ha^{-1} (Fig.

Table 3. Economics of rice under different source of nitrogen combinations.

Treatments	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1	51364.50	10755.50.	1.22
T_2	86757.00	40511.00	1.86
T_3	77682.00	32539.00	1.72
T_4	72781.50	28736.50	1.65
T_5	84760.50	36790.50	1.77
T_6	90205.50	42697.50	1.90
T_7	79860.00	30865.00	1.62
T_8	80404.50	31909.50	1.66
T_9	79134.00	29984.00	1.61
T_{10}	76230.00	24030.00	1.46

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25 % N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25 % N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50 % N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50 % N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25 % N through FYM (4.25 t ha^{-1}) + 25 % N through VC (0.8 t ha^{-1}); T_{10} = 50 % N through FYM (8.5 t ha^{-1}) + 50 % N through VC (1.6 t ha^{-1}).

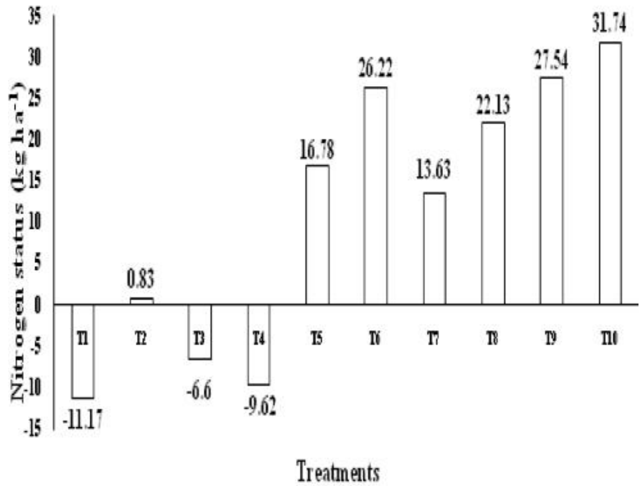

Fig. 3. Nitrogen balance after harvesting of rice under different treatments.

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; T_5 = T_3 + 25% N through FYM (4.25 t ha^{-1}); T_6 = T_3 + 25% N through VC (0.8 t ha^{-1}); T_7 = T_4 + 50% N through FYM (8.5 t ha^{-1}); T_8 = T_4 + 50% N through VC (1.6 t ha^{-1}); T_9 = T_4 + 25% N through FYM (4.25 t ha^{-1}) + 25% N through VC (0.8 t ha^{-1}); T_{10} = 50% N through FYM (8.5 t ha^{-1}) + 50% N through VC (1.6 t ha^{-1}).

3). Similar type of work was carried out by Acharya (2006). The higher positive nitrogen balance recorded under the plots treated with organic sources of nutrients might be due to the fact that organic manures help to reduce the losses of nitrogen from the soil, simultaneously keep the N reserve quite well in the soil.

It has been observed that the use of FYM and vermicompost plays an important role in determining the quality character of rice *viz*., hulling, milling and hear rice recovery of rice (Fig. 4). It was observed that these parameters were significantly superior when a treatment receives a part of N via FYM or VC. The treatment T_2, T_3 and T_4 which receives N, P and K only through fertilizer and T1 which did not receive any nutrient showed lower value of hulling, milling and HRR.

Application of organic manures like farm yard manure and vermicompost increases the total microbial population of nitrogen fixing bacteria and actinomycetes. Specially, vermicompost application increases the symbiotic association of micorrhiza on plant root system. Earthworm casts harbour large number of VAM propagules surviving up to eleven months on it. The increased microbial activity improves the availability of soil phosphorus and nitrogen. A number of plant growth promoters are observed in earthworm casts and presence of earthworms help in aerating the soil. Similar results were also reported by Kundu et al., 2010; Chowdhury et al., 2015.

The highest and the least gross return were recorded under treatment T_6, Rs. 90205.50 and Rs. 51364.50. The highest net return (Rs 42697.50) was found under the treatment that received 75% N through fertilizer + 25% N through vermicompost with full dose of P and K. Highest values of B:C ratio (1.90) recorded in the treatment receives 75% N through fertilizer + 25% N through vermicompost with full dose of P and K. The least B:C ratio of 1.22 was recorded under control (Table 3). So, using a part of N via either FYM or vermicompost almost sustain the yield with the treatments receives all amount of nitrogen through fertilizer. The B:C ratio are almost same with integration of fertilizer + FYM or VC with only 75% nitrogen through fertilizer.

Application of 75% N through fertilizer + 25% N through vermicompost along with full dose of P and K is found to be optimum in terms of growth and productivity of rice. Partial use of N through organic (25%) form provides positive N balance as well as soil

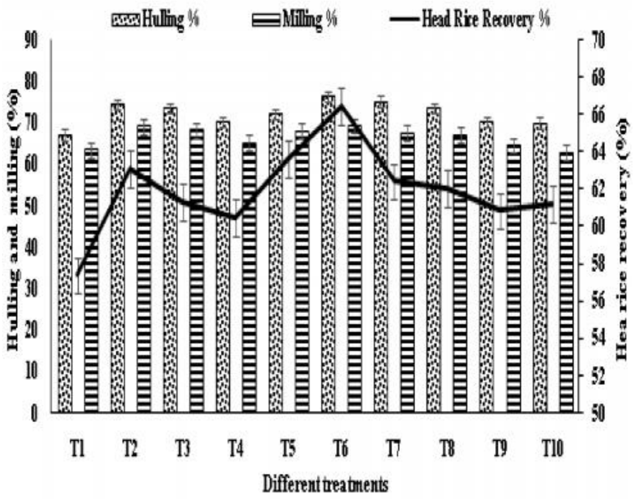

Fig. 4. Quality characteristics of rice under different treatments.

T_1 = Control; T_2 = 100% N through chemical fertilizer; T_3 = 75% N through chemical fertilizer; T_4 = 50% N through chemical fertilizer; $T_5 = T_3$ + 25% N through FYM (4.25 t ha^{-1}); $T_6 = T_3$ + 25% N through VC (0.8 t ha^{-1}); $T_7 = T_4$ + 50% N through FYM (8.5 t ha^{-1}); $T_8 = T_4$ + 50% N through VC (1.6 t ha^{-1}); $T_9 = T_4$ + 25% N through FYM (4.25 t ha^{-1}) + 25% N through VC (0.8 t ha^{-1}); T_{10} = 50% N through FYM (8.5 t ha^{-1}) + 50% N through VC (1.6 t ha^{-1}).

fertility *i.e*., application of 75% N through fertilizer + 25% N through Vermicompost (0.8 t) with full dose of P_2O_5 and K_2O. On the economic considerations (gross return, net return and B:C ratio) using 75% N through fertilizer + 25% N through Vermicompost (0.8 t) with full dose of P_2O_5 and K_2O worked out as suitable.

CONCLUSION

This study indicates that chemical fertilizers either alone or combination with manure (FYM and vermicompost) inputsignificantly increased rice yields and yield attributes as compared to control. Similarly, the nutrient content both in grain and straw as well as nutrient uptake were also influenced by the INM treatments. Hence INM can be considered as good option for maintaining the soil quality as well as improving the rice productivity instead of use of chemical fertilizer alone.

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