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Effect of organic and inorganic sources of N on growth attributes, grain and straw yield of rice (*Oryza sativa*)

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Abstract

The present investigation was carried out at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Kharif* seasons of 2001 and 2002, in agro–ecological zone V of India. The soil of experimental site was sandy clay loam in texture with normal pH, low in nitrogen and phosphorus and medium in organic carbon and potassium contents. The experiment was laid out in Randomised Block Design with nine treatments replicated thrice. The treatments were applied to rice crop during *kharif* season. Application of recommended doses of fertilizer (T_9) brought about maximum improvement in the different growth attributes such as total tillers, dry matter production and LAI in comparision to other sources of organic N carriers. These attributes were also observed to increase significantly over control due to various organic N sources among which the combination of three organics (T_8 – 40 kg N through D.S + 40 kg N through P.M + 40 kg N through C.W) proved to be superior. Application of N through chemical fertilizer (T_9) brought about significant improvement in grain and straw yields of rice crop and established superiority over rest of the treatments. Among organic N sources, supplication of N through combination of D.S + P.M + C.W @ 40 kg N ha^{-1}each (T_8) increased the grain and straw yield significantly as against the application of rest of the organic N sources and the control (T_1) except the straw yield due to incorporation of P.M alone (T_3) which remained at par.

Key-Words: Organic sources, Growth attributes, Yield, Rice

Introduction

Rice (*Oryza sativa*), the prince among cereals is the premier food crop not only in India but world too (Chhabra, 2002). Our national food security system largely depends on the productivity of rice ecosystem. India is the second largest producer of rice only after China and its production in India has increased from 20 million tonnes during 1950-51 to 93.1 million tonnes during 2001-02 (Anonymous, 2003). Considering the heavy demand of rice and the scope of quality rice in international market, interactive research work in almost all aspects of rice is needed.

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Nutrients supplied exclusively through chemical sources, though enhances yield initially, but the yields are not sustainable over the years. Even the introduction of high yielding varieties and intensive cultivation with excess and imbalanced use of chemical fertilizers and irrigation showed reduction in the soil fertility status and yield by 38 per cent of rice crop (Singh *et al.*, 2001). These causes have led to renewed interest in the use of renewable sources (organic manures/wastes) and prompted the scientists to find out an alternative agricultural system which involves the farming i.e. crop and animal husbandry in a way that harmonize rather than conflict with natural processes operating in a natural eco-system (Sharma, 2001).

The locally available industrial wastes in Varanasi region such as digested sludge, woolen carpet wastes and press mud are generated in huge amount from sewage treated plants, carpet industry and sugar mills as bye products and, in long run, pose a threat to environmental pollution.

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It can be hypothesized that the use of proper combination of these locally available organic wastes which are narrow in C:N ratio and safe to apply for agricultural purposes, is as critical as that for integrated use which has an impact on growth attributes, grain and straw yield of rice (*Oryza sativa*).

Material and Methods

The present investigation entitled, "Effect of organic and inorganic sources of N on growth attributes, grain and straw yield of rice(*Oryza sativa*)" was undertaken during 2001 and 2002 at the Agricultural Research Farm, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, in agro-ecological zone V of India with an objective to study the effect of organic and inorganic sources of N on yield attributes and yield of rice grain.

Results and Conclusion

Varanasi enjoys sub-tropical climate and is often subjected to extremes of weather conditions i.e., very hot in summer and very cold in winter. In Indian agro-ecological zone, the area falls under V – eastern plain zone. The soil of Varanasi region formed due to deposition of alluvium by river Ganges have predominance of illite, quartz and feldspar minerals.. Most of the soils of the Varanasi division have been classified in the soil order of Inceptisol (Udic, Ustochrept). However, the soils of the experimental site fall under Inceptisol.

The normal annual rainfall of this region is about 1100 mm. In terms of percentage of total rainfall, about 87.3 per cent is received from June to September (monsoon season), 5.9 per cent from October to December (winter season), 3.9 per cent from January to February and 2.8 per cent from March to May as pre-monsoon rain. The minimum and maximum relative humidity of this area varies in between 38 per cent during April to early June and 81 per cent during July to September with a mean of about 68 per cent. The highest mean temperature recorded was 34.475 and 37.35^0 C in the month of June during both the years of experimentation.

The soil of experimental site was sandy clay loam in texture with normal pH, low in nitrogen and phosphorus and medium in organic carbon and potassium contents. The experiment was laid out in Randomised Block Design with nine treatments replicated thrice. The treatments were applied to rice crop during *kharif* season.

The treatments are T_1- Control (without chemical fertilizers and organics), T_2-120 kg N through digested sludge (D.S, 6936.4 kg), T_3-120 kg N through press mud (P.M, 11428.6 kg), T_4-120 kg N through woolen carpet wastes (C.W, 960 kg), T_5-60 kg N through D.S (3468.2 kg) + 60 kg N through P.M (5714.29 kg), T_6-60 kg N through D.S (3468.2 kg) + 60 kg N through C.W (480 kg), T_7-60 kg N through P.M (5714.29 kg) + 60 kg N through C.W (480 kg), T_8-40 kg N through D.S (2312.1 kg) + 40 kg N through P.M (3809.5 kg) + 40 kg N through C.W (320 kg), T_9- Recommended doses of fertilizers [120 : 60 : 60 :: N (209.8 kg Urea) : P (130.4 kg D.A.P) : K (100 kg M.O.P)].

Nitrogen was applied at the rate of 120 kg ha^{-1} through different organic sources along with two additional treatments which were recommended doses of NPK through chemical fertilizer (120 kg N : 60 kg P_2O_5 : 60 kg K_2O) and without N (control). The organic sources of N were digested sludge, press mud and carpet wastes and inorganic N source was urea. Phosphorus and potassium were applied through diammonium phosphate and muriate of potash, respectively. The half of recommended dose of nitrogen with full doses of phosphorus and potassium were applied as basal at the time of transplanting and rest 50 % N was top dressed in two equal splits (coinciding maximum tillering and panicle initiation stage) at the interval of one month after transplanting of rice seedlings. The total amount of organic manures/wastes viz. digested sludge, press mud and woolen carpet wastes were applied 14 days before transplanting of the rice var. Sarju-52 at a spacing of 20 cm x 10 cm.

The response of rice crop to the various treatments was measured in terms of quantitative expressions. The quantitative indices included observations on total tillers m^{-2}, dry matter accumulation m^{-2}, Leaf Area Index, grain and straw yield.

The five tagged hills from each plot were used for recording leaf area index and the respective numbers of tillers $hill^{-1}$ were counted. The maximum length and width of each leaf on the middle of the tiller measured and the area of each leaf was computed on the basis of following formula (Yoshida et al., 1976).

Leaf Area = K x L x W

Where K is the correction/adjustment factor, L is the length of the leaves (cm) and W is the width of leaves (cm). The value of K was 0.75. Subsequently, leaf area $hill^{-1}$ and LAI were computed in the following manner:

Leaf Area $Hill^{-1}$ = Total leaf area of middle tiller (cm^2) x Total tillers number as per observation.

$$LAI = \frac{\text{Sum of leaf area of five sample hills } (cm^2)}{\text{Area of the land covered by five hills } (cm^2)}$$

The number of total tillers were counted by using quadrate square meter ring randomly from five places of each plot and thereafter average number of effective and total tillers m^{-2} were calculated. The hills from 0.5 m^2 area from the border were cut from each plot and weight was recorded and calculated per m^2 after drying

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in a hot air oven at 65^0 C. Grain yield was recorded (kg $plot^{-1}$) after threshing, winnowing and cleaning. The difference of the bundle weight and grain yield gave the straw yield (kg $plot^{-1}$) of the crop per plot. Thereafter, both the yields were computed to kilogram per hectare for each of the plot.

Total tillers m^{-2}:

Data on total tillers recorded m^2 at harvest stage are presented in Table 1. Perusal of the data revealed significant variation in the number of tillers due to various treatments during both years of experimentation. It is clearly evident that incorporation of recommended doses of fertilizer (T_9) brought about significant improvement in the total tillers as against the application of N through different sources of organic N carriers alone or in combination except the combination of three organics (T_8 – 40 kg N through D.S + 40 kg N through P.M + 40 kg N through C.W). This supports the well established fact that N sufficiency to the growing plants resulted into vigorous growth of the foliage, thereby, increasing total tillers m^{-2}. Increased total tillers due to application of N through chemical fertilizers might also be attributed to easy availability of N as against the organic N sources.

As compared to control (T_1), all the treatments receiving organics alone or in combinations proved much effective in increasing the number of total tillers significantly. Among organics, D.S, P.M and C.W @ 40 kg N ha^{-1} each in combination (T_8) produced significantly higher number of tillers than other treatments receiving organics but remained at par with T_9 (120 kg N through chemical fertilizer). Increasing availability of N from the native sources of soil and organics due to easy and steady release of N along with other plant nutrients through mineralization process might be the reason for the increase in the tiller number.

Hiroki and Fujii (1984) also found that with application of 2.5, 5, 10, or 30 t ha^{-1} limed domestic sewage sludge or NPK fertilizers applied 2 weeks before transplanting of rice, initial growth was slower with sewage sludge than with NPK fertilizer or no fertilizer and the number of panicles per plant were increased due to the treatments receiving NPK fertilizers in comparison to control. Datta *et al.* (1995) reported increased number of tillers per hill due to application of sludge and industrial wastes. Babu *et al.* (2001) showed significant influence on number of tillers per hill due to individual and combined application of organic manures (FYM, green manure and press mud) along with inorganic fertilizer.

Dry matter:

The data pertaining to the dry matter accumulation per m^{-2} as affected by different treatments are summarized in Table 1. Perusal of the data revealed significant variations in the dry matter accumulation due to various treatments during both the years of experiment. An analysis of the pooled data clearly revealed that the sources of N had significant effect on the dry matter accumulation by plant and incorporation of 100 % N of the recommended dose through chemical fertilizer (T_9) followed by application of N through all the three organic wastes @ 40 kg N ha^{-1} each (T_8) significantly increased the dry matter as against the application of 120 kg N through organic sources. Overall the dry matter production was in decreasing order of: $T_9 > T_8 > T_7 > T_3 > T_6 > T_5 > T_4 > T_2 > T_1$.

Favourable vegetative growth may be attributed to strong architecture of the plant adequately fed with N. Nitrogen as a constituent of protein is associated with the activity of every living cell. Thus, there was vigorous growth of aerial organs due to high rate of synthesis of protoplasmic protein. It has been observed that protein synthesis and protoplasmic protein increased cell size within cell wall and was, finally, responsible for greater vertical development of plant (Babe, 1964; Chandler, 1969; Novoa and Loomis, 1981). Increased dry matter accumulation in plant due to N application would also appear to have resulted due to increased chlorophyll formation and its ultimate effect on photosynthesis.

Pandya *et al.* (1988) showed increased dry weight of rice plant in soil containing irradiated sludge. Niwa *et al.* (1999) found that growth of rice plants increased with the increasing application rate of sludge. Increased dry matter of wheat in comparison to control was found due to application of P.M (sulphitation) @ 0.3 % (Narwal *et al.*, 1993).

Abubacker and Rao (1995) opined that press mud application increased rice plant dry weight. Enhanced dry matter production of rice with application of P either alone or in combination with press mud (filter cake) or lime (Biswas and Dravid, 1998). Dry matter production was significantly influenced by individual and combined application of organic manures (FYM, green manure and press mud) along with inorganic fertilizers (Babu *et al.*, 2001).

Leaf Area Index:

Leaf area index (LAI) recorded at 75 days after transplanting (DAT) are presented in Table 1. The scanning of the data showed significant variations on LAI due to various treatments during both the years of experimentation (2001 and 2002). It is evident that application of 120 kg N through chemical fertilizer (T_9) brought about significant improvement in LAI over rest except P.M alone (T_3) and combination of P.M, D.S and C.W (T_8). Babu *et al.* (2001) reported significant influence on LAI due to application of FYM, green

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manure and press mud individually and in combination along with inorganic fertilizers.

Different N sources increased the number of leaves per hill leading to higher LAI. Sufficient availability of N helps in vigorous growth of leaves and foliage since more number of leaves with expanded leaf blades are produced, hence LAI also increase. Among treatments receiving organics alone or in combination, maximum LAI was recorded in the treatment receiving all the organics @ 40 kg N ha^{-1} each (T_8).

Grain yield:

Data on grain yield (kg ha^{-1}) are presented in Table 2. Data on grain yield revealed significant variation due to experimental variables during both the years of field experimentation.

Economic yield is a complex inter-relationships of its components, which are determined from the growth rhythm in vegetative phase and its subsequent reflection in reproductive phase. Grain yield is the manifestation of yield attributing characters in rice (Matsushima, 1976). It is quite obvious from the pooled data that application of N through chemical fertilizer (T_9) brought about significant improvement in grain yield and established superiority over the application of organic N source and the control (T_1). Among organic N sources, supplying N through combination of D.S, P.M and C.W @ 40 kg N ha^{-1}each (T_8) significantly increased the grain yield as against the application of rest of the organic N sources. The addition of N through chemical fertilizers (T_9) and different combination of organic N sources (T_8, T_7, T_6, T_5) produced significantly more grain yield over the incorporation of organic N sources alone (T_2, T_4) with the exception of the addition of P.M alone (T_3) and the control (T_1). However, all the treatments increased the grain yield significantly as against no fertilizer/manure (T_1). The trend observed in increasing order was: $T_1 > T_4 > T_2 > T_6 > T_5 > T_7 > T_8 > T_9$.

It is, by and large, true that dwarf indica rice varieties have high rate of responsiveness towards fertilizer application and more particularly for N because of their conducive genetic make up. The findings of the present investigation revealed profound effect of N on yield and yield attributes of rice. It was noticed that the grain yield due to application of N through chemical fertilizer and various organics was associated with the number of grains per panicle, effective tillers m^{-2} and test weight of 1000 grains. Correlation studies have shown that grain yield is highly correlated with yield attributes (Hernandez, 1956 and Shastri *et al.*, 1967).

In physiological term, yield of most cereals is largely governed by source (photosynthesis) and sink (grain growth) relationship (Evans and Wardlaw, 1976). However, capacity of system transporting the photosynthates and partitioning of assimilates between their sites of utilization i.e., sink, are the major determinants of crop yield (Gifford and Evans, 1981).

The present investigations revealed significant increase in the yield attributes under N application through chemical fertilizer (T_9) followed by N through D.S + P.M + C.W (T_8) due to increased absorption of nutrients and their assimilation. Supply of N in balanced quantity enabled the rice plants to assimilate sufficient photosynthetic products and, thus, increased the dry matter accumulation. With increased dry matter and photosynthetic products, coupled with efficient translocation, plant produced more panicles with more number of fertile grains with increased test weight and ultimately higher grain yield.

Increase in grain yield due to application of D.S, P.M and C.W were observed by various workers (Ram et al., 2000; Singh[1] *et al.*, 2001 and Tiwari, 2002).

Straw yield:

Yield of straw pertaining to the various treatments are summarized in the Table 2. Statistical analysis of straw yield data manifested profound variation due to different treatments during both the years of field trials. Application of N through chemical fertilizer (T_9) enhanced the straw yield significantly as against organic N sources and no N (T_1), which might be attributed due to quicker conversion of urea making N available to rice plants easily as compared to organics which release most of N after mineralization.

Straw yield of a crop is closely related to the vegetative growth viz. plant height, tiller numbers, leaf numbers and final stand of a crop (Singh and Verma, 1971). The beneficial effect of any treatment on one or more of these characters without a corresponding decrease in one or more of them will result in increased straw yield. In the present investigation, the N application through any means enhanced the growth attributes that ultimately led to higher straw yield.

Among organic N sources, incorporation of D.S, P.M and C.W @ 40 kg N ha^{-1} each (T_8) being at par with incorporation of P.M alone (T_3) significantly improved the straw yield over rest of the treatments treated with organics along with control (T_1). The availability of mineralizable N and other nutrients might be more in case of the treatment T_8 followed by the treatment T_3 than the treatments with organics due to differential rate of organic N mineralization in soil (Mukherjee *et al.*, 1995).

Incorporation of organics such as D.S, P.M and C.W increased the straw yield of rice (Ram *et al.*, 2000; and Tiwari, 2002).

Application of recommended doses of fertilizer (T_9) brought about maximum improvement in the different growth attributes such as total tillers, dry matter production and LAI in comparision to other sources of

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organic N carriers. These attributes were also observed to increase significantly over control due to various organic N sources among which the combination of three organics (T_8 – 40 kg N through D.S + 40 kg N through P.M + 40 kg N through C.W) proved to be superior. Application of N through chemical fertilizer (T_9) brought about significant improvement in grain and straw yields of rice crop and established superiority over rest of the treatments. Among organic N sources, supplication of N through combination of D.S + P.M + C.W @ 40 kg N ha^{-1}each (T_8) increased the grain and straw yield significantly as against the application of rest of the organic N sources and the control (T_1) except the straw yield due to incorporation of P.M alone (T_3) which remained at par.

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Table 1: Effect of organics and inorganics on growth attributes of rice

Treatments	2001 Total tillers m^{-2}	2002 Total tillers m^{-2}	Pooled	2001 Dry matter m^{-2} 75 DAT	2002 Dry matter m^{-2} 75 DAT	Pooled	2001 Leaf Area Index 75 DAT	2002 Leaf Area Index 75 DAT	Pooled mean
T_1	209.00	226.33	217.7	532.13	544.23	538.18	4.13	4.38	4.255
T_2	242.33	275.67	259.0	751.40	836.87	794.13	5.67	5.98	5.825
T_3	282.67	308.00	295.3	824.53	895.33	859.93	6.43	6.61	6.52
T_4	246.33	279.33	262.8	759.37	843.17	801.27	5.96	6.47	6.215
T_5	258.33	291.67	275.0	771.60	868.47	820.03	6.09	6.20	6.145
T_6	270.33	290.33	280.3	783.27	857.37	820.32	5.89	6.28	6.085
T_7	280.00	303.00	291.5	836.30	891.23	863.77	6.38	6.52	6.45
T_8	298.00	319.00	308.5	855.23	912.10	883.67	6.51	6.67	6.59
T_9	306.33	326.33	316.3	864.43	921.27	892.85	6.57	6.73	6.65
C.D. (P=0.05)	11.36	11.75	7.85	10.89	10.99	7.43	0.15	0.16	0.11

Table 2: Effect of organics and inorganics on grain and straw yield of rice

Treatments	2001 Grain Yield (kg ha^{-1})	2002 Grain Yield (kg ha^{-1})	Pooled	2001 Straw yield (kg ha^{-1})	2002 Straw yield (kg ha^{-1})	Pooled
T_1	1783.3	1966.7	1875.0	3316.7	3516.7	3416.7
T_2	3266.7	3833.3	3550.0	4883.3	5633.3	5258.3
T_3	3833.3	4433.3	4133.3	5333.3	6166.7	5750.0
T_4	3116.7	3716.7	3416.7	4733.3	5550.0	5141.7
T_5	3516.7	4150.0	3833.3	5016.7	5933.3	5475.0
T_6	3566.7	4083.3	3825.0	5100.0	5916.7	5508.3
T_7	3783.3	4316.7	4050.0	5333.3	5983.3	5658.3
T_8	4233.3	4716.7	4475.0	5716.7	6300.0	6008.3
T_9	4683.3	5283.3	4983.3	6183.3	6850.0	6516.7
C.D. (P=0.05)	198.0	190.0	131.9	363.3	530.0	308.8