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Effect of Organic and Inorganic Sources of N on Yield Attributes, Grain Yield 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 120 kg N ha^{-1} through chemical fertilizer (T_9) and combination of D.S, P.M and C.W (T_8) increased effective tillers m^{-2} as well as HI significantly as against the other N sources along with control (T_1) and remained at par to each other. However, highest number of effective tillers m^{-2}, filled grains per panicle, 1000 grain test weight and HI were observed in the treatment receiving recommended doses of chemical fertilizer (T_9) followed by the treatment T_8 (@ 40 kg N ha^{-1} each source). 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, yield attributes, yield, rice, straw yield, fertilizer

INTRODUCTION

Rice (*Oryza sativa*), the prince among cereals is the premier food crop not only in India but world too (Chhabra, 2002). The 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 ton during 1950-51 to 93.1 million ton during 2001-02. 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.

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% of rice crop (Singh *et al*., 2001a). 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. 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 yield attributes, grain yield and straw yield of rice (*Oryza sativa*).

MATERIALS AND METHODS

The present investigation entitled, effect of organic and inorganic sources of N on yield attributes, grain yield

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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 inor ganic sources of N on yield attributes and yield of rice grain.

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 1 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 20×10 cm.

The response of rice crop to the various treatments was measured in terms of quantitative expressions. The quantitative indices included observations on effective tillers m^{-2}, number of grains $panicle^{-1}$, 1000 grain test weight, harvest index, grain and straw yield.

The number of effective tillers were counted by using quadrate square meter ring randomly from five places of each plot and thereafter average number of effective tillers m^{-2} were calculated. The numbers of filled grains of each of the ten panicles were counted and average number was determined. About 1000 grains were counted randomly from the grain yield of each net plot and weight (g) was recorded. 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. The HI was calculated by using the following Equation:

$$HI = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain + straw yield)}} \times 100$$

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% is received from June-September (monsoon season), 5.9% from October-December (winter season), 3.9% from January-February and 2.8% from March-May as pre-monsoon rain.

The minimum and maximum relative humidity of this area varies in between 38% during April to early June and 81% during July-September with a mean of about 68%. The highest mean temperature recorded was 34.475 and 37.35°C in the month of June during both the years of experimentation.

RESULTS AND DISCUSSION

Yield attributes

Effective tillers m^{-2}: The data regarding effective tillers m^{-2} are shown in Table 1. Perusal of the data showed significant variation in this parameter among the treatments during both 2001 and 2002. It is clearly evident from the pooled data that application of 120 kg N ha^{-1} through chemical fertilizer (T_9) and combination of D.S, P.M and C.W (T_8) produced significantly more effective tillers m^{-2} as against the other N sources along with control (T_1) and remained at par to each other. Tillering is largely related with genetic behaviour of a variety. It is the

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

	Effective tillers m^{-2}			Grains panicle^{-1}			Test weight (g)		
Treatments	2001	2002	Pooled	2001	2002	Pooled	2001	2002	Pooled
T_1	182.67	186.67	62.15	59.07	65.23	184.67	20.98	21.11	21.05
T_2	219.00	224.33	87.15	80.93	93.37	221.67	22.31	22.45	22.38
T_3	224.33	242.67	91.48	86.97	96.00	233.50	23.47	23.66	23.57
T_4	221.67	236.33	81.55	76.83	86.27	229.00	22.13	22.34	22.24
T_5	233.00	231.00	89.62	83.60	95.63	232.00	22.52	22.73	22.63
T_6	228.67	233.67	89.62	84.93	94.30	231.17	22.76	22.59	22.68
T_7	230.67	238.33	91.73	87.63	95.83	234.50	23.03	23.18	23.11
T_8	239.33	251.33	93.42	90.73	96.10	245.33	23.86	23.93	23.90
T_9	245.67	257.67	100.88	97.47	104.30	251.67	23.95	24.08	24.02
C.D. (p = 0.05)	12.68	11.74	3.45	4.23	5.80	8.30	0.08	0.07	0.05

outcome of the expansion of auxillary buds which is closely associated with the nutritional condition of the mother culm and a tiller receives carbohydrates and nutrients from the mother culm during its early growth period which gets improved by the application of N (Tisdale and Nelson, 1975).

Increased effective tillers m^{-2} was also recorded due to application of digested sludge and press mud (Ram *et al*., 2000). Though all the N sources increased effective tillers over the control (T_1), the increase in this yield attribute in the treatments receiving organics may be due to differential rate of N mineralization and in case of all the organics applied @ 40 kg N ha^{-1} each (T_8), the improvement may be attributed to the combined effect of nutrient supply, synergism and improved soil physical and biological properties.

Increase in tiller production might probably be due to the greater supply of N with efficient utilization for cell multiplication and enlargement and formation of nucleic acids and other vitally important organic compounds in the cell sap (Chandravanshi and Singh, 1974; Simons, 1982).

Grains per panicle: The data pertaining to grains per panicle as affected by different treatments are shown in Table 1. An analysis of the data clearly revealed significant variation due to different treatments in both the years of experimentation (2001 and 2002) on this attribute. It is perceptible from the pooled data that incorporation of 120 kg N through chemical fertilizer (T_9) produced significantly higher number of filled grains per panicle over the rest. Application of inorganic fertilizer (T_9) might have brought about better mobilization of nutrients towards panicles producing more number of grains. This was followed by the treatment receiving all the three organics (T_8) but it remained at par with P.M and C.W @ 60 kg N ha^{-1} each (T_7) and 120 kg N through P.M (T_3). Increase in grains per panicle through different organics might be attributed to different rates of mineralization that had the ultimate effect on nutrient uptake and translocation of synthesized food to grains.

Ram *et al.* (2000) reported significant increase in grains per panicle in rice due to integrated use of FYM, press mud, water hyacinth along with fertilizer N.

Test weight (g): The data pertaining to grain test weight as affected by different treatments are shown in Table 1. Data on test weight revealed significant variation due to various treatments in both the years of field trials. An analysis of the pooled data clearly showed that application of chemical fertilizers (T_9) followed by combination of three organics (T_8) significantly increased the test weight over the application of organic N sources and the control (T_1). All the organic N sources applied were also found to improve the test weight significantly as against the control (T_1). Babu *et al.* (2001) also confirmed increased test weight due to application of organic manures (FYM, green manure and press mud) as compared to control. This significant response might be due to better availability and translocation of nutrients as well as photosynthates from source to sink resulting in increased grain test weight.

Harvest Index (HI): Scanning of data pertaining to harvest index (Table 1) showed significant variation on HI due to various treatments in both the years of field trial (2001 and 2002). It is obvious from the pooled data that incorporation of N through chemical fertilizer (T_9) produced significant improvement in HI over the rest except the application of combination of D.S, P.M and C.W @ 40 kg N ha^{-1} each (T_8), P.M and C.W @ 60 kg N ha^{-1} each (T_7) and 120 kg N through P.M (T_3) which were at par among each other. However, all the N sources increased HI significantly over the control (T_1) and application of N through chemical fertilizer (T_9) followed by combination of three organics (T_8) was found to be superior among all the treatments. This might be ascribed to optimum plant vigour which favoured the portioning of the photosynthates to reproductive part that increased grain to straw ratio. HI itself can be improved by increasing the grain ear^{-1} on increasing the ear bearing tillers (Swaminathan, 1977).

Table 2: Effect of organics and inorganics on yield attributes and yields of rice

	Harvest index			Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
Treatments	2001	2002	Pooled	2001	2002	Pooled	2001	2002	Pooled
T_1	0.350	0.359	0.354	1783.3	1966.7	1875.0	3316.7	3516.7	3416.7
T_2	0.392	0.405	0.399	3266.7	3833.3	3550.0	4883.3	5633.3	5258.3
T_3	0.418	0.419	0.419	3833.3	4433.3	4133.3	5333.3	6166.7	5750.0
T_4	0.397	0.401	0.399	3116.7	3716.7	3416.7	4733.3	5550.0	5141.7
T_5	0.412	0.412	0.412	3516.7	4150.0	3833.3	5016.7	5933.3	5475.0
T_6	0.412	0.408	0.410	3566.7	4083.3	3825.0	5100.0	5916.7	5508.3
T_7	0.415	0.419	0.417	3783.3	4316.7	4050.0	5333.3	5983.3	5658.3
T_8	0.425	0.428	0.427	4233.3	4716.7	4475.0	5716.7	6300.0	6008.3
T_9	0.431	0.435	0.433	4683.3	5283.3	4983.3	6183.3	6850.0	6516.7
C.D.(p = 0.05)	0.020	0.030	0.018	198.0	190.0	131.9	363.3	530.0	308.8

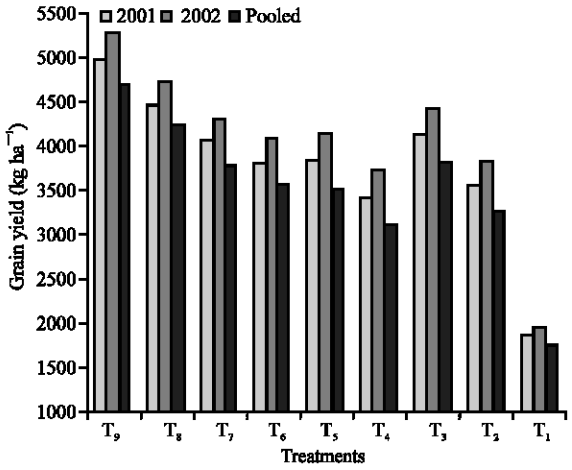

Fig. 1: Effect of organics and inorganics on yield of rice grain

Grain yield: Data on grain yield (kg ha^{-1}) are shown in Table 2 and Fig. 1. 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; 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 researchers (Ram *et al*., 2000; Singh *et al*., 2001a, b; Tiwari, 2002).

Straw yield: Yield of straw pertaining to the various treatments are shown in the Table 2 and Fig. 2. Statistical analysis of straw yield data manifested profound variation

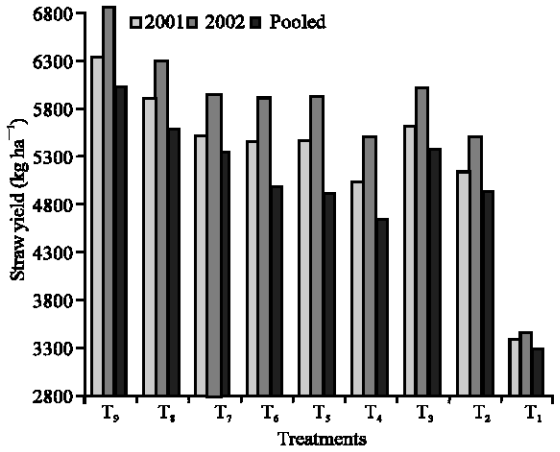

Fig. 2: Effect of organics and inorganics on yield of rice straw

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; Tiwari, 2002).

CONCLUSION

Application of 120 kg N ha^{-1} through chemical fertilizer (T_9) and combination of D.S, P.M and C.W (T_8) increased effective tillers m^{-2} as well as HI significantly as against the other N sources along with control (T_1) and remained at par to each other. However, highest number of effective tillers m^{-2}, filled grains per panicle, 1000 grain test weight and HI were observed in the treatment receiving recommended doses of chemical fertilizer (T_9) followed by the treatment T_8 (@ 40 kg N ha^{-1} each source). 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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