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Assessment of long term fertilization and manuring on rice productivity in *Vertisol*

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Abstract
The present experiment was conducted during *kharif* season 2017 at the Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid out in RBD plot design with 10 treatments. Long-term fertilization experiment with a no fertilizer control, 50% NPK, 100% NPK, 150% NPK, 100% NPK+Zn, 100% NP, 100% N, 100% NPK+FYM, 50% NPK+BGA and 50% NPK+GM. Treatments were replicated thrice. The different integrated nutrient management treatments, application of 150 % NPK showed significantly higher plant height and number of leaves as compared to rest of the treatments at 30, 60 and 90 DAT and at harvest. Panicle length, number of grain, test weight, grain and straw yield significantly higher under 150% NPK treatment and number of tillers and number of effective tillers higher in 100% NPK +FYM treatment, sterility was higher under 100 % alone N treatment.

Keywords: Rice, fertilizer, Nitrogen, Phosphorus and Potassium

Introduction

Rice cultivation is the common practices in tropical and subtropical regions and it is a considered as important staple food for more than three billion peoples in the world, and proximately 90% of the world's rice is produced in Asian regions Rice is the second largest produced cereal in the world. Rice is one of the most important food-grain in the world. India is the second largest rice producer, exporter and consumer after China, with increasing population, the demand for food, feed, fodder, fiber, fuel and shelter is rapidly increasing. To meet out the future requirements, we would need better planning and resource management besides intensification of cropping. By 2025 total food grain demand of the country will reach 291 million tonnes comprising 109 million tonnes of rice and 91 million tonnes of wheat (Kumar and Shivay 2004) [5]. Despite the past gains in rice production through chemical fertilizers, recent observations of stagnant or declining yields have raised concerns about the long-term sustainability of the crop production. Continuous use of imbalanced fertilizers leads to deterioration in soil chemical, physical, biological properties, and soil health. The negative impacts of imbalanced fertilizers, coupled with escalating prices, have led to growing interests in the use of organic materials as a source of nutrients. The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields. Long-term experiment has shown that crop residues incorporation, farm yard manures and green manures increased soil organic carbon and nutrient availability as compared to the nitrogenous fertilizers alone. Balanced use of nutrients is one of the most important factors for sustaining agricultural production and soil health. The results emanating from long-term fertilizer experiments across the country have clearly indicated that imbalance use of chemical fertilizers has resulted in numerous problems *viz.* micronutrient deficiencies, nutrient imbalances in soil and plant system, environmental degradation and deterioration of soil health. It is therefore, appropriate to develop a sustainable crop production technology which is cheaper, locally available, socially acceptable and environmentally sound vis-à-vis maintains soil health. Such a scenario can be retrieved through integration of chemical fertilizers with available organic sources of plant nutrients.

Materials and methods

A field experiment was conducted on Vertisol of Research Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh. Raipur is situated at 210 4'

North Latitude and 810 4' East Longitude with the altitude of 293 meter above mean sea level. The experimental soil (Vertisol) is fine montmorillonite, hyperthermic, udic chromustert, locally called as Kanhar and is identified as Arang II series. It is usually deep, heavy clayey (50%), dark brown to black in colour and neutral to slightly alkaline in reaction due to presence of lime concentrations. The soil was analyzed for its initial characteristics as per the methods mentioned below and some important physicochemical properties of the soil. Treatment details are T1 - Control, T2 - 50% of the recommended optimum NPK dose, T3 - 100% of the rec. optimum NPK dose, T4 - 150% of the rec. optimum NPK dose, T5 - 100% of the rec. optimum NPK + ZnSO4 @ 10 kg ha-1 in kharif crop only, T6 - 100% NP of rec. optimum N and P dose, T7 - 100% N of rec. optimum N dose, T8 - 100% NPK + FYM (5 t ha-1 in kharif crop only), T9 - 50% NPK + BGA (10 kg ha-1 dry culture in kharif crop only), T10 - 50% NPK + GM (sown in site and mixed in soil in kharif season only). Plant height, number of leaves, Panicle length, number of grain, test weight, number of tillers and number of effective tillers, sterility, grain and straw yield. Analysis of variance (ANOVA) was carried out using the randomized block design method and Least Significance Difference (LSD) was calculated on soil data for treatment means at 5 percent probability.

Results & Discussion

1. Plant height (cm)

The data on mean plant height of rice are presented in Table 1. Data reveal that average plant height increased progressively with increase in the age of the crop. The plant gained height at relatively slower rate between 90 to at harvest and accelerated between 30 to 60 DAT. Data showed that plant height varied significantly at 30, 60, 90 DAT and at harvest due to their crop growth period and recorded significantiy higher plant height at all the stages of crop. Among the different integrated nutrient management treatments, application of 150% NPK showed significantly higher plant height as compared to rest of the treatments at 30, 60 and 90 DAT and at harvest. However, it was found to be at par with treatments of T_3, T_5, T_6, and T_{10} at all the stage of crop growth, plant height remained unaffected due to integrated nutrient management treatments. Among the integration of organic and inorganics, the application of nutrient recorded relatively higher plant height over the rest of the other combination of organic and inorganic source of nutrient treatments. Lowest plant height at all the stages of crop growth was recorded under control treatments. The positive role of nitrogen, phosphorus and potassium for cell division and enlargement has been already established. However, when organic sources of nutrients applied and supplemented with inorganic sources of nutrients enhanced the nutrient availability and helped in increasing plant height. The results are in agreement with the findings of Sarawgi and Sarawgi (2004_a) [16] and Sarawgi and Sarawgi (2004_b) [16], Jha *et al.* (2006) [3], Roul *et al*. (2007) [15] and Netam *et al.* (2008) [11]. In case of varieties differences in plant height may be due to their genetic characters. Use of 150% NPK ha^{-1} with blending of N and P through FYM (T_6) recorded significantly highest number of tillers as compared to others at all the stages of growth.

2. Number of tillers (m^{-2}).

Data pertaining to number of tillers m^{-2} are presented in Table 2. In general tillers m^{-2} increased with increasing the crop age up to 90 DAT, but the number of tillers at maturity was slightly reduced. T8 (100% NPK + FYM) recorded significantly higher number of tillers (286) m^{-2} at all the stages of crop growth of all the stages, of integrated nutrient management treatments, followed by T4 treatments (150% NPK kg ha^{-1}) produced significantly number of tillers m^{-2} at all the stages of crop growth, which was found to be at par with the treatments of T_2 and T_7 at all the stage of crop growth periods. Besides blending, the integration of organic and inorganic treatments, the application recorded relatively higher number of tillers m^{-2}, over the rest of the other combination of organic and inorganic source of nutrient treatments. The lowest tillers m^{-2} was recorded under control at all the stages. This might be due to the fact that these treatments led to the greater availability and steady supply of essential plant nutrients during the entire period of crop growth, thus these treatments assisted in increasing tillers m^{-2}. Increased plant height helped in increasing the photosynthetic area for photosynthesis in plant, which in turn helped in formation of new tillers. Similar results were also obtained by Sarawgi and Sarawgi (2004_a) [16], Sarawgi and Sarawgi (2004_b) [16], Jha *et al*. (2006) [3] and Netam *et al.* (2008) [11].

Table 1: Effect of long term fertilization and manuring on plant height (cm) of Rice

Treatments	30DAT (cm)	60DAT (cm)	90DAT (cm)	At harvest (cm)
T1-control	34.60	56.10	76.3	81.38
T2 -50% NPK	54.20	80.88	102.3	101.22
T3 -100% NPK	60.80	87.73	111.1	111.83
T4 -150% NPK	62.35	95.18	112.6	113.10
T5 -100% +Zn	60.08	86.83	108.9	108.55
T6 -100%NP	59.75	86.45	108.1	107.00
T7 -100% N	53.83	81.78	101.3	103.98
T8 -100% NPK +FYM	64.08	95.78	114.5	113.78
T9 -50% NPK +BGA	56.58	82.98	103.9	102.83
T10 50% NPK + GM	57.80	85.18	106.5	106.53
SEM±	2.47	2.1	2	1.7
CD	5.94	5.06	4.8	4.08

Table 2: Effect of long term fertilization and manuring on Number of tiller (m^{-2}) of Rice

Treatments	30DAT (m^{-2})	60DAT (m^{-2})	90DAT (m^{-2})	At harvest (m^{-2})
T1-control	136	171	162	155
T2 -50% NPK	212	253	247	234
T3 -100% NPK	249	290	281	277
T4 -150% NPK	268	305	289	284
T5 -100% +Zn	235	278	264	258
T6 -100%NP	233	274	263	255
T7 -100% N	248	248	240	228
T8 -100% NPK +FYM	277	308	296	286
T9 -50% NPK +BGA	190	246	240	230
T10 50% NPK + GM	243	284	273	263
SEM±	5.35	8.35	7.04	5.81
CD	12.84	20.05	16.9	13.96

3. Number of leaves ($Plant^{-1}$).

Data pertaining to number of leaves ($Plant^{-1}$) are presented in Table 3. In general number of leaves ($Plant^{-1}$) increased with increasing the crop age up to 60 DAT, but the number of leaves ($Plant^{-1}$) at maturity was slightly reduced. T8 (150% NPK) recorded significantly higher number of leaves (72 $Plant^{-1}$) at 60DAT of crop growth of inorganic nutrient management treatments, followed by T8 treatments (100%

NPK+FYM) produced significantly number of leaves ($Plant^{-1}$) at all the stages of crop growth, which was found to be at par with the treatments of $T_{2,}$ T_9 and T_7 at all the stage of crop growth periods. Besides blending, the integration of organic and inorganic treatments, the application recorded relatively higher number of leaves ($Plant^{-1}$), over the rest of the other combination of organic and inorganic source of nutrient treatments. The lowest number of leaves ($Plant^{-1}$) was recorded under control at all the stages. The role of organic manure for addition of nutrients, maintaining soil health, reducing nutrient losses, enhancing availability of nutrients and fulfill crop demand resulting increase in total tillers has been also reported by However, proper nutrient supply has to maintain for the production of tillers and leaves because increased sink size demands sufficient supply of nutrients for growth and development and increases the plants ability to produce numerous tillers and leaves during their vegetative growth stage under above mention treatments as also suggested by.

Table 3: Effect of long term fertilization and manuring on Number of leaves $plant^{-1}$ of Rice

Treatments	30DAT $plant^{-1}$	60DAT $plant^{-1}$	90DAT $plant^{-1}$
T1-control	17.00	26.00	20.00
T2 -50% NPK	34.50	40.50	35.25
T3 -100% NPK	51.75	69.00	53.75
T4 -150% NPK	56.25	72.25	56.25
T5 -100% +Zn	49.75	64.25	50.75
T6 -100%NP	47.50	63.50	43.50
T7 -100% N	28.25	37.00	28.00
T8 -100% NPK +FYM	54.75	71.75	54.00
T9 -50% NPK +BGA	37.25	39.50	32.25
T10 50% NPK + GM	47.00	63.25	50.50
SEM±	1.07	1.4	2.62
CD	2.58	3.36	6.3

4. Panicle length of rice

Data pertaining to panicle length (cm) are presented in table 4 revealed that panicle length were significantly influenced due to organic and inorganic combination of fertilized treatments. Higher panicle length of rice was found under the treatment T4 fallowed by T8, T5, T9 and T10 treatments and minimum was recorded under the T1 treatments. The variation for length of panicle in case of varieties might be due to genetic characters. Paraye *et al*., (2006) [14], Mhaskar *et al*., (2005) [10], Sarawgi and Sarawgi (2004a) [16] were of the same opinion. The variation in length of panicle for nutrient management treatments may be due to the variation in nutrients availability. Treatments where organic sources of nutrients in combination with inorganic sources of nutrients were applied resulted the highest panicle length. This indicated that the supply of nutrients under this treatment were sufficient to meet the demand of the crop. Similar results were found by Sarawgi and Sarawgi (2004a) [16], 2005, Sarawgi and Sarawgi (2004b) [16] and Netam and Sarawgi (2008) [11].

5. Effective tillers (m^{-2})

Data pertaining to effective tillers are presented in table 4 revealed that effective tillers were significantly influenced due to organic and inorganic combination of fertilized treatments. Higher effective tillers of rice were found under the treatment T8 fallowed by T4, T3, and T10 treatments and minimum was recorded under the T1 treatments. The variation for effective tillers in case of varieties might be due to genetic characters. Paraye *et al*., (2006) [14], Mhaskar *et al*., (2005) [10], Sarawgi and Sarawgi (2004a) [16] were of the same opinion. The variation in effective tillers for nutrient management treatments may be due to the variation in nutrients availability. Treatments where organic sources of nutrients in combination with inorganic sources of nutrients were applied resulted the highest effective tillers. This indicated that the supply of nutrients under this treatment were sufficient to meet the demand of the crop. Similar results were found by Sarawgi and Sarawgi (2004a) [16], 2005), Sarawgi and Sarawgi (2004b) [16] and Netam and Sarawgi (2008) [11].

6. Numbers of grains ($Penicle^{-1}$)

Data pertaining to Numbers of grains ($Penicle^{-1}$) are presented in table 4 revealed that Numbers of grains ($Penicle^{-1}$) were significantly influenced due to organic and inorganic combination of fertilized treatments. Higher numbers of grains ($Penicle^{-1}$) of rice were found under the treatment T4 fallowed by T8, T3, T5 and T10 treatments and minimum was recorded under the T1 treatments. The application of organic sources of nutrients alone or in combination with inorganic sources of nutrients might have helped in improving the nutrient availability for a prolonged period during crop growth and development stages, ultimately it influenced the reproductive stage and resulted in more number of spikelets and filled grains $panicle^{-1}$ and test weight. Similar results have also been obtained by Dahiphale *et al.* (2004) [2], Sarawgi and Sarawgi (2004_a) [16], Mandal *et al.* (2004) [9] and Chandrakar *et al.* (2004), Mhaskar *et al.* (2005) [10], Paraye *et al.* (2006) [14] and Lal *et al.* (2009) [7]. Whereas, variation for above characters under varieties may be due to their genetic character. Sarawgi and Sarawgi (2004_b) [16], Singh *et al.* (2004) and Netam *et al.* (2008) [11] have also recorded the similar response.

7. Test weight (g)

Data pertaining to test weight (g) are presented in table 4 revealed that test weight (g) were significantly influenced due to organic and inorganic combination of fertilized treatments. Higher test weight (g) of rice were found under the treatment T4 fallowed by T8, T3,T10 and T2 treatments and minimum was recorded under the T1 treatments. The application of organic sources of nutrients alone or in combination with inorganic sources of nutrients might have helped in improving the nutrient availability for a prolonged period during crop growth and development stages, ultimately it influenced the reproductive stage and resulted in more test weight. Similar results have also been obtained by Dahiphale *et al.* (2004) [2], Sarawgi and Sarawgi (2004_a) [16], Mandal *et al.* (2004) [9] and Chandrakar *et al.* (2004), Mhaskar *et al.* (2005) [10], Paraye *et al.* (2006) [14] and Lal *et al.* (2009) [7]. Whereas, variation for above characters under varieties may be due to their genetic character. Sarawgi and Sarawgi (2004_b) [16], Singh *et al.* (2004) [18] and Netam *et al.* (2008) [11] have also recorded the similar response.

8. Sterility (%)

Data pertaining to sterility (%) are presented in table 4 revealed that sterility (%) were significantly influenced due to organic and inorganic combination of fertilized treatments. sterility (%) percent found significantly lower under the treatment T8 fallowed by T10, T4,T5 and T6 treatments and maximum was recorded under the T7 treatments. The sterility percentage was more in inorganic-treatments it may be due to minimum yield. Similar results have also been reported by Jha *et al.* (2006) [3], Paraye *et al.* (2006) [14], Dahiphale *et al.* (2004) [2], Mahapatra *et al.* (2004), Pandey and Nandeha (2004) [13], Sarawgi and Sarawgi (2004 a) [16], Pandey *et al.* (1999) [12].

9. Grain, Straw and Biological yield of Rice kg ha^{-1}

Grain and straw yield of rice increased significantly with increasing level of fertilizers up to 150% NPK (Table.5) Grain yield of rice varied from 1780 to 5405 kg ha^{-1} amongst different nutrient concentration alone and along with organics. Increase in grain yield over control (1780 kg ha^{-1}) was 4100, 4825 and 5405 kg ha^{-1} with the application of 50, 100 and 150% NPK, respectively. Among the treatments maximum grain (5405 Kg ha^{-1}) and straw yield (6195 Kg ha^{-1}) were obtained with 150% NPK. This may be due to the higher available nutrients and optimum soil properties in the plots receiving higher dose (150% NPK) of inorganic fertilizers. Similar results were also reported by Pandey *et al.* (2009) [12].

The yield of rice increased with increasing the levels of nutrients from 50 to 150% NPK and combination with organic sources. The significantly higher grain yield of rice was found under treatment T_4 (150% NPK) fallowed by T_8, T3, T6, T5, and T10 and consisting of 150% NPK as received from inorganic source of nutrient registered highest grain yield of rice. The minimum grain yield of rice was found lower in control (1780 kg ha^{-1})

On the other hand, incorporation of organic sources with inorganic sources of nutrition, the grain (5390 kg ha^{-1}) and straw yield (6170 kg ha^{-1}) of 100% NPK + FYM higher than 50% NPK + GM and 50% NPK + BGA. The integrated effects of fertilizer and farm yard manure, blue green algae and green manure were noted to be more beneficial than the use of chemical fertilizer alone. Additional increase in grain and straw yield was registered due to the integrated effect of FYM with inorganic fertilizer. 100% NPK + FYM produced the highest Grain yield (5390 kg ha^{-1}) and Straw yield (6170 Kg ha^{-1}) compare to 100% NPK treatment. Grain yield (4690 kg ha^{-1}) with 50% NPK + GM also gives similar results and comparatively higher grain yield was recorded in 100% NPK (4825 Kg ha^{-1}). This indicates that more than half of the nutrients in fertilizer could be substituted with GM to the sustainable yields.

The use of fertilizer N has helped in sustaining the yield of rice as reported by Singh *et al* (2001) [19]. Rice was found to be more responsive than rabi crops to green manuring, which might be due to direct effect of green manure in supplying nutrient to rice crop and beneficial effect on soil health as reported by Kumar and Singh (2010) [6]. studied the comparison of Sesbania and FYM applied at 20 ton ha^{-1} showed that Sesbania remained superior over the farm yard manure for improving the paddy and straw yield. The increased efficiency of NPK fertilizer with green manuring may be due to chemical, enzymatic and metabolic transformation of organic material, as the green manuring is continuously subject to degradation, thus more susceptible to change in metal uptake than inorganic soil fractions.

Biological yield of rice presented in table 5, it revealed that the biological yield (grain + straw) was found significantly higher in Treatment T 4 fallowed by T8, T3 and T5. The minimum biological yield was recorded under the control. Biological yield of rice varied from 3720 to 11600 kg ha^{-1} amongst different nutrient concentration alone and along with organics. Increase in biological yield over control (3720 kg ha^{-1}) was 8405, 10445 and 11600 kg ha^{-1} with the application of 50, 100 and 150% NPK, respectively. Among the treatments maximum biological yield 11600 kg ha^{-1} were obtained with 150% NPK. This may be due to the higher available nutrients and optimum soil properties in the plots receiving higher dose (150% NPK) of inorganic fertilizers. Similar results were also reported by Pandey *et al.* (2009) [12].

Table 4: Effect of long term fertilization and manuring on yield attributing characters of Rice

Treatments	Penicle length (cm)	Effective tiller (m^{-1})	Number of grain	Test Weight (gm)	Sterility (%)
T1-control	19.20	132.1	97.50	27.78	9.4
T2 -50% NPK	21.74	199.5	134.25	29.25	10.0
T3 -100% NPK	21.70	236.1	155.00	30.30	9.1
T4 -150% NPK	22.99	242.7	161.10	31.07	8.7
T5 -100% +Zn	22.10	220.5	155.05	28.83	8.7
T6 -100%NP	21.37	217.7	145.50	28.03	8.8
T7 -100% N	21.41	194.6	125.95	29.02	14.8
T8 -100% NPK +FYM	22.84	244.0	158.30	30.48	7.7
T9 -50% NPK +BGA	22.23	196.4	142.35	29.13	12.6
T10 50% NPK + GM	22.26	224.6	154.05	29.74	7.9
SEM±	0.56	4.96	7.08	0.53	1.62
CD	1.35	11.92	17..01	1.29	3.9

Table 5: Effect of long term fertilization and manuring on grain, straw and biological yield of rice (kg ha^{-1})

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (Grain+Straw)(kg ha^{-1})
T1-control	1780	1940	3720
T2 -50% NPK	4100	4305	8405
T3 -100% NPK	4825	5620	10445
T4 -150% NPK	5405	6195	11600
T5 -100% +Zn	4710	5485	10195
T6 -100%NP	4755	5480	10235
T7 -100% N	2980	3800	6780
T8 -100% NPK +FYM	5390	6170	11560
T9 -50% NPK +BGA	3945	4285	8230
T10 50% NPK + GM	4690	5115	9805
SEM±	308.08	312.71	460.69
CD	739.41	750.52	1105.66

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