Effect of Integrated Nutrient Management on Physico-chemical Soil Properties Under Rice Crop in Hot Sub Humid Ecoregion of Middle Gangetic Plains of India

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A field experiment was conducted during *Kharif* season (2010) to find out the effect of integrated use of urea, zinc, poultry manure and *Azotobacter* on physico-chemical properties, available NPKS content of soil under rice crop (*Oryza sativa* L.). The experiment was laid out in Randomized Block Design (RBD) during kharif seasons with seven treatments and three replications. The details of various treatments applied to rice crop are as follows: T_1 (Control); T_2 (100% RDF); T_3(100% RDF+ Zn); T_4 (50 % RDF + 50 % N through urea); T_5 (50 % N through poultry manure + 50 % N through urea + Zn); T_6 (50 % N through poultry manure + 25 % N through urea+ *Azotobacter*); T_7 (50 % N through poultry manure + 25 % N through urea + *Azotobacter* + Zn). The integrated use of poultry manure along with urea, zinc and *Azotobacter* were found to build up in organic carbon, available N, P, K and S content of soil under rice plants significantly over the sole use of chemical fertilizer. The plots which had received poultry manure and chemical fertilizers with *Azotobacter* showed significant improvement in residual soil fertility. It could also be concluded that the application of poultry manure with *Azotobacter* has good performance over sole application of manure.

Keywords: *Azotobacter*, urea, zinc, physico-chemical properties, available NPKS.

The Green Revolution in India during the late 1960s has no doubt brought about self-sufficiency in food grain production. It is to be pointed out here that the Green Revolution, which started mostly with rice and wheat crops during 1967-68, has now reached a plateau and is sustained with diminishing returns and falling dividends. However, indiscriminate use of inorganic fertilizers and plant protection chemicals for maximizing crop yield has resulted in the deterioration of the physical, chemical and biological health of the rice growing soils due to the imbalanced dose of N:P:K fertilizers. A glance at fertilizer ratio data shows that it has never been found to be used in its ideal proportion, which is 4:2:1. Currently, there is a growing concern about the sustainability of the rice system as the growth rate of rice yields is either stagnant or have declined in a number of states such as Punjab, Haryana, eastern Uttar Pradesh, Madhya Pradesh, Bihar, Himachal Pradesh and Jammu & Kashmir. There is a huge potential of organic resources in Indian farms which could be effectively made use of. As per the estimate made nearly 7.5 million tons of NPK could be saved by using organic components. The challenge before us is to develop a suitable technology package to make full use of organic manures and other sources along with

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inorganic fertilizers to improve food production without impairing soil health. This would ensure sustainability in agricultural production. Rice is the most important crop in India, which played a critical role in food security. It is the important staple food for more than half of the world population and provides 60-70 per cent body calorie intake to the consumers. Rice is specifically important to India as it is grown on more than 44 million hectares, the highest area ever occupied by a single crop. It is a choice crop of the millions of poor and small farmers not only for income but also for household food security. The FAO data shows that while many countries show declining trend in production during past couple of years, India's production remained relatively stable. Keeping these facts in view the present study was conducted to study the effect of integrated use of urea, zinc, poultry manure and biofertilizer on soil properties and growth, yield and nutrient uptake by rice.

MATERIALS AND METHODS

Site description and field experiment

The field experiments were conducted at the research farm of the Department of Agricultural Chemistry and Soil Science, Udai Pratap Autonomous College, Varanasi, during 2010, followed by laboratory analysis of the post harvest soil and plant samples. The Geographical situation of the farm lies of 25^0 8' North latitude and 88^0 03' East longitudes and 128.93 m above the mean sea level.The initial physico-chemical properties viz. bulk density (1.53 g cm^{-3}), particle density (2.61 g cm^{-3}), texture (Sandy clay loam), pH (1:2; 7.82), EC (0.32 dSm^{-1}), organic C (0.44%), available N (189.8 kg ha^{-1}), available P (9.90 kg ha^{-1}), available K (174.7 kg ha^{-1}) and available S (7.3 kg ha^{-1}) of experimental plot has been given in parentheses.

Experiment design and treatment details

The experiment was laid out in Randomized Block Design (RBD) during kharif seasons with seven treatments and three replications. The details of various treatments applied to rice crop are as follows: T_1 (Control); T_2 (100% RDF); T_3(100% RDF+ Zn); T_4 (50 % RDF + 50 % N through urea); T_5 (50 % N through poultry manure + 50 % N through urea + Zn); T_6 (50 % N through poultry manure + 25 % N through urea+ *Azotobacter*); T_7 (50 % N through poultry manure + 25 % N through urea+ *Azotobacter* + Zn). Field was prepared by cross harrowing followed by transplanting of seeding. Full care was taken to levels the plots uniformly and grasses were removed from the plots. 25 days old rice seeding of cultivar HUR-105 were transplanted at spacing of 20 ´ 15 cm in the plots having net plot area of 7 m^2. Recommended doses of nitrogen, phosphorus and potassium i.e. @ 120, 60 and 60 kg ha^{-1} respectively, were applied to rice as 120 kg of nitrogen ha^{-1} was considered as 100 per cent of nitrogen. Nitrogen was applied through urea, uniform based application of phosphorus and potassium was made through single super phosphorus and mureate of potash, respectively to all plots. Poultry manure were obtained from agriculture research farm of Udai Pratap Autonomous College, Varanasi and analyzed for their elemental composition. The elemental composition of poultry manure (4.5% N; 2.5% P_2O_5; 2.1 % K_2O) so obtained had been used to supplement the nitrogen requirement of rice crop. Intercultural operations were done to ensure normal growth of the crop. There was no infestation of insects, pests and diseases in the field, therefore, no control measures were applied for insects, pests and diseases. Plant heights from marked plants were recorded in each plot as different growth stages. Five plants are marked randomly and tagged in each replicate plot and the height was measured from the base of the plant to the upper most fully stretched leaf. The average of all the observation of each plot were worked out and designed as mean plant height. The crop was harvested on 5th Nov 2010. Intercultural operations were done to ensure normal growth of the crop. All the grasses have been removed from the land surface and soil samples have been taken from each plot at 30, 60 and at harvest of rice. The Spade and Tube Auger have been used as sampling tools. The samples were collected in plastic bag. A dried soil samples were crushed and passed through 2mm round hole sieve. The sieved samples were selected in labelled polythene bags plot wise for condition selected laboratory analysis by following standard analytical procedures.

Statistical analysis

Least significant difference (LSD) between the mean values was evaluated statistically by following standard procedure to determine the significance among treatment means using the principle of F-statistics with a probability P=0.05 using SPSS version 10.0.

RESULTS AND DISCUSSIONS

SOIL PH

Data show that soil pH (Table 1) of rice plots under different treatments varied from 7.86 to 7.57, 7.70 to 7.59 and 7.72 to 7.62 at 30, 60 DAT and at harvesting, respectively. The pH of soil water suspension of rice plots increased continuously with days after transplanting and lowest soil pH was recorded under 50% nitrogen through poultry manure + 25% nitrogen through urea + biofertilizers + Zn (T_7) as compared to other treatments at all growth stages. Differences in value of soil pH at 30, 60 DAT and of harvesting was not significant. Soil pH under different treatment was found in the order $T_1>T_2>T_3>T_4>T_5>T_6>T_7$ and values varied from 7.86 to 7.72, 7.66 to 7.86, 7.65 to 7.67, 7.63 to 6.65, 7.60 to 7.64, 7.59 to7.63 and 7.57 to 7.62 under respective treatments. The lowest soil pH of control plot (T_1). The highest soil pH under application of 50% N through poultry manure + Zn treated plots may be due to highest amount of plant residue and organic manure in this plots. The result corroborate with the finding of Singh *et al.* (2008).

Electrical conductivity

The electrical conductivity of experimental soil (Table 1) under different combination of urea, poultry manure and biofertilizers varied from 0.52 to 0.67, dSm^{-1} further, the EC of soil water suspension of rice plots increased continuously with days after transplanting under all treatments. Different in values of EC of 30 and 60 DAT was not significant at harvesting. The effect of different treatment on soil EC could be arranged in order $T_1>T_2>T_3>T_4>T_5>T_6>T_7$. The increased electrical

Table 1. Effect of urea, zinc, poultry manure and biofertilizer on physico-chemical soil properties

Treatments	Bulk Density			pH			EC			Organic C		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1	1.36	1.40	1.46	7.86	7.70	7.72	0.62	0.66	0.67	0.46	0.41	0.38
T_2	1.35	1.38	1.45	7.66	7.67	7.68	0.58	0.62	0.65	0.51	0.45	0.41
T_3	1.32	1.36	1.42	7.65	7.66	7.67	0.56	0.60	0.62	0.53	0.48	0.43
T_4	1.31	1.35	1.41	7.63	7.64	7.65	0.55	0.59	0.60	0.58	0.52	0.48
T_5	1.30	1.34	1.40	7.60	7.63	7.64	0.54	0.56	0.58	0.60	0.54	0.51
T_6	1.28	1.33	1.39	7.59	7.61	7.63	0.53	0.54	0.57	0.63	0.58	0.54
T_7	1.27	1.31	1.36	7.57	7.59	7.62	0.52	0.53	0.56	0.67	0.61	0.56
LSD(0.05)	NS	0.04	0.05	NS	NS	NS	NS	NS	0.07	0.04	0.05	0.04

Table 2. Effect of urea, zinc, poultry manure and biofertilizer on available nutrients at different stages

Treatments	Available N			Available P			Available K			Available S		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1	224.8	216.7	212.0	14.0	12.0	9.3	173.5	168.0	162.0	9.2	7.5	7.0
T_2	230.9	221.1	216.4	15.3	13.0	11.0	181.7	175.0	167.3	11.0	9.0	8.0
T_3	235.7	227.4	221.0	16.6	14.2	12.0	187.3	181.2	173.6	12.0	10.5	9.0
T_4	241.4	232.0	226.8	17.1	16.0	13.5	192.0	185.2	178.6	13.4	12.0	10.5
T_5	245.7	236.5	231.0	20.6	18.6	14.7	198.9	190.6	182.6	15.0	13.3	11.5
T_6	250.9	243.4	237.7	22.3	20.7	16.0	293.3	196.5	190.0	16.6	14.7	13.0
T_7	258.7	249.0	242.6	26.0	23.2	18.7	215.5	297.6	198.0	19.5	17.0	14.7
LSD(0.05)	12.79	8.49	11.80	1.42	5.24	5.38	5.15	4.99	5.17	1.62	1.55	1.74

conductivity under chemical fertilizer alone was probably due to accumulation of soluble salt which might be come from the application of fertilizer and exchange of several cations. This result is conformity with finding of Gaur, (1998) and Santhy *et al.* (1999).

Bulk density

The result showed that the bulk density of soil increased gradually from 30 DAT to harvest under all treatment and values varied from 1.27 to 1.46 Mg m^{-3} (Table 1). The bulk density increased gradually with time on account of natural consolidation of soil particle in all treatment up to harvesting of rice. Significantly lower bulk density was recorded under 50% nitrogen through poultry manure + 25% nitrogen through urea + biofertilizers + Zn (T_7) applied plots as compared to other treatments on bulk density was found in the order $T_1>T_2>T_3>T_4>T_5>T_6>T_7$ and the value varied from 1.36 to 1.46, 1.35 to 1.45, 1.32 to 1.42, 1.31 to 1.41, 1.30 to 1.40, 1.28 to 1.39 and 1.27 to 1.36 Mg m^{-3} under respective treatment. Decreased the bulk density in 50% nitrogen through poultry manure + 25% nitrogen through urea + biofertilizers + Zn applied plots may be due to higher organic matter more pore spaces and better soil aggregation. Singh *et al.* (2000), Sharma *et al.* (2001), also reported that more crop residue, higher organic matter content and better crop growth, might be possible reasons for decrease in bulk density.

Organic carbon

In general, organic carbon content of rice plots showed that continuously decreasing trend from 30 DAT to the harvest of the crop (Table 1). The effect of different treatments on organic carbon content of soil of rice plots was found in the order $T_7>T_6>T_5>T_4>T_3>T_2>T_1$. The value of organic carbon content of soil varied from 0.56 to 0.67, 0.54 to 0.63, 0.51 to 0.60, 0.48 to 0.58, 0.43 to 0.53, 0.41 to 0.51 and 0.38 to 0.46 percent under respective treatment. Significantly higher organic carbon content was recorded under T_7 0.67% as compared to other treatment at all growth stages except with T_6 which was remained at per with T_7 treatment at all growth stages. Addition of organic nutrient sources might have created environment conducive for formation of humic acid, stimulated the activity of soil micro-organism resulting in an increase in organic carbon content in the soil. Bajpai *et al.* (1980) who reported that increase in the organic carbon was due to higher microbial population in biofertilizer treated plots. The increase in the organic carbon content due to use of poultry manure and biofertilizers might be attributed to higher contribution of biomass to the soil in the form of greater root and crop residues and addition of organic material (Sarkar and Singh 1997, Sharma et. al 2005).

Available Nitrogen

The data presented in table 2 indicated that available nitrogen content of soil continuously decreased with advancement in crop growth stages under all treatments. The effect of different treatments of poultry manure, biofertilizers and inorganic fertilizers on available nitrogen content soil was found in the order $T_7>T_6>T_5>T_4>T_3>T_2>T_1$ and value varied from 242.60 to 258.70, 237.70 to 250.90, 231.0 to 245.75, 226.85 to 241.46, 221.00 to 235.70, 216.4 to 230.90 and 212.0 to 224.86 kg ha^{-1} under respective treatment. Decline in nitrogen content with increasing growing could be attributed to higher nitrogen requirement for crop with age (Chand *et al.* 2010). Significantly higher nitrogen content was recorded in 50% nitrogen with poultry manure + 25% nitrogen through urea+ biofertilizers + Zn treated plots (T_7) as compared T_1, T_2, T_3, T_4, T_5 and T_6 treatment. While statically non-significant differences was observed between T_7 and T_6 at all growth stages. Increase in available nitrogen with poultry manure and biofertilizers application might be attributed to the direct addition of nitrogen to the available pool of soil nitrogen through poultry manures and nitrogen fixation by Azotobacter (Singh et. al. 2008). Better response of addition of organic manure in improving the nitrogen status of the soil can be ascribed to its slow decomposition producing humic and amino acids, which in turn increase the nutrient availability. Ramamurthy (2002) also reported that application of FYM improves the N status of the soil.

Available phosphorus

Data revealed that available phosphorus content of soil (Table 2) of rice plots decreased continuously with of crop under all treatments. The value of available phosphorus content of rice plots at harvesting were 9.35, 11.00, 12.00, 13.56, 14.72, and 18.70 kg/ha under T_1, T_2, T_3, T_4, T_5, T_6 and T_7 treatment, respectively. The available phosphorus content of rice plots estimated at 30, 60 DAT and at harvesting was significantly higherwith 50% nitrogen trough poultry manure + 25% nitrogen through urea + biofertilizers + Zn (T_7) as compared to other treatments except T_6, which was at par at 60 DAT and maturity. Incorporation of organic manure with inorganic fertilizers increased the availability of P to crop due to mineralization of organic P by to microbial action and enhanced mobility of P. Beneficial effect of organic manure along with inorganic fertilizers on phosphorus availability was also observed by Tolanur and Badanur (2003). Mishra *et al.* (2008) also reported that phosphorus content of soil increased due to the application of organic sources of nitrogen. Higher amount of available P observed in biofertilizers treated plots might be attributed to solubilizing effect of PSB on mineral and unavailable form of P. Solubilization of P associated with pH drop in PSB treated plots indicated that organic acid production by PSB played a significant role in acidification facilitating P solubilization (Hwangbo *et al.* 2003).

Available potassium

Data revealed that available potassium content (Table 2) of experiment soil decreased continuously with advancement in growth stages up to harvest under all treatments, differences in available potassium content among various treatments were however narrowed down with time. Available K content of soil were 173.56, 181.78, 187.30, 192.00, 198.96, 203.96 and 215.56 kg/ha at 30 DAT and 1668.00, 175.00, 181.26, 185.23, 190.46, 196.35 and 207.63 kg ha^{-1} at 60 DAT and 162.00, 167.13, 173.26, 178.26, 182.63, 190.00 and 198.00 kg ha^{-1} at harvesting under T_1, T_2, T_3, T_4, T_5, T_6 and T_7 treatments, respectively. Significantly higher available potassium content was recorded under 50% nitrogen through poultry manure + 25% nitrogen through urea + biofertilizers + Zn treated plots (T_7) as compared to other treatments at all growth stages except at maturity where non significantly different observed between T_6 and T_5 treatment. Vasanthi and Kumarswami also reported that the available K content of soil increased significantly with the application of organic manure also with chemical fertilizers.

Available sulphur

The data to available sulphur content of soil of rice plots under different treatments measured at. 30, 60 and at harvesting has been presented in table 2. In general, the available sulphur content of soil of rice plots under various treatments varied from 9.26 to 19.50, 7.56 to 17.00 and 7.00 to 14.76 kg ha^{-1} at 30, 60 DAT and harvesting, respectively. Further, the available sulphur content of soil decreased with increasing crop age. At 30 DAT, the differences in available sulphur content of soil under various treatments were significantly higher and highest available sulphur was recorded under T_7 (19.50 kg ha^{-1}) and test under control (9.26 kg ha^{-1}). These differences in available sulphur content however narrowed down with time. Higher biomass added by plant and direct application of sulphur under organic manure treated plots (T_7) responsible for higher available sulphur. Similar results were also reported by Dhillon and Dev (1978).

CONCLUSION

The integrated use of poultry manure along with urea, zinc and *Azotobacter* were found to build up in organic carbon, available N, P, K and S content of soil under rice plants significantly over the sole use of chemical fertilizer. The plots which had received poultry manure and chemical fertilizers with *Azotobacter* showed significant improvement in residual soil fertility. It could also be concluded that the application of poultry manure with *Azotobacter* has good performance over sole application of manure.

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