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Effect of integrated use of NPKZn, FYM and bio-fertilizers on soil properties and performance of rice crop (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during 2016-17 to evaluate the influence of integrated use of NPKZn, FYM and bio-fertilizers on soil properties and performance of rice. The treatments were control (T_1), 50% NPK Zn + FYM (10 t ha^{-1}) (T_2), 100% NPK Zn (T_3), 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) (T_4), 150% NPK Zn (T_5) and FYM (10 t ha^{-1}) + Bio-fertilizer (PSB+BGA) (T_6). Application of 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) i.e. T_4 significantly increased the growth and yield as well as soil fertility status as compared to chemical fertilizers alone. Significantly higher plant height, number of tillers $plant^{-1}$, grain and straw yield of rice and soil properties in terms of organic carbon, available NPK and S were obtained with application of 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) (T_4) in comparison to other treatments. Significantly higher NPKS uptake was also observed with application of 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) (T_4). This experiment proved the superiority of integration between chemical fertilizer and bio-fertilizer over chemical fertilizer alone at all level of fertility.

Keywords: NPKZn, Rice, bio-fertilizers, FYM, soil properties, nutrient uptake, growth, yield

Introduction
Rice (*Oryza sativa* L.) is a popular cereal crop commonly used as human food. It belongs to family Gramineae includes other cereals such as wheat and maize. It is a source of magnesium, thiamin, niacin, phosphorus, vitamin B_6, zinc and copper. In terms of area under rice crop cultivation India having largest area (43. 90 ha), followed by China and Indonesia. But, in terms of production China is on rank 1st (207 million tons), followed by India at rank 2nd (157 million tons) (FAOSTAT, 2016). Rice production in India crossed the mark of 100 million tons in 2015-16 accounting for 21.2% of global production in that year. Rice production in India during 2015-16 was observed as 104.32 million tons. Rice producing states of India are Andhra Pradesh, Bihar, Uttar Pradesh, Madhya Pradesh and West Bengal. Maximum rice production occurs in West Bengal and Uttar Pradesh but, maximum productivity was observed in Punjab (3974 kg ha^{-1}) (Ministry of Agriculture, 2016) [13]. Productivity of rice enhanced after green revolution due to use of fertilizer and irrigation. In 2006-07 rice productivity 1984 kg ha^{-1}, but it was enhanced to 2404 kg ha^{-1} during 2015-16. Micronutrients are as important as macro nutrients in plant nutrition. In case of rice zinc deficiency is prime concern which leads to reduction in crop productivity. Integrating nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007) [9]. The major components of INM system are fertilizers, farmyard manure/compost, green manure, crop residues/recyclable wastes and bio fertilizers. FYM helps to improve the organic carbon (OC) status, availability of primary and secondary nutrients in the soil (Badanur *et al.*, 1990) [1], and also supplies sufficient amount of micronutrients in available forms. However, due to its low nutrient and slow acting nature, FYM alone may not be able to meet the high nutrient requirements of crops. Likewise, the use of NPK fertilizers alone under modern intensive farming may not be sufficient. Large number of experiments has demonstrated the importance of FYM and bio-fertilizers in supplementing the nutrient requirements of crops and providing yield stability (Venkateswarlu and Wani, 1999) [24]. FYM application has been reported to improve crop growth by supplying plant nutrients including micronutrients as well as improving soil physical, chemical, and biological properties (Dejene and Lemlem, 2012) [4]. Ibrahim *et al.* (2010) [8] reported a significant increase in rice root length and root volume with FYM application which indicates that the better root development would allow the plant to exploit more water under water stress conditions.

With this background the present experiment was undertaken to evaluate the effect of integrated use of NPKZn, FYM and bio-fertilizers on soil properties and crop performance of rice crop *(Oryza sativa* L.).

Materials and Methods

A field experiment was conducted in *kharif* season (2016-2017) at agricultural form of Udai Pratap Autonomous College, Varanasi developed due alluvium deposition. The soil of experimental site was sandy loam in texture, slightly saline and non-alkaline in reaction. The initial physico-chemical properties of experimental soil were bulk density 1.49 g cm^{-3}, particle density 2.65 g cm^{-3}, pH (1:2.5) 7.72, EC 2.65 dSm^{-1}, organic carbon 0.53 %, available nitrogen 230.65 kg ha^{-1}, available phosphorus 10.00 kg ha^{-1}, available potassium 236.68 kg ha^{-1} and available sulphur 8.00 kg ha^{-1}. The various treatments applied to rice were control (T_1), 50% NPK Zn + FYM (10 t ha^{-1}) (T_2), 100% NPK Zn (T_3), 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) (T_4), 150% NPK Zn (T_5) and FYM (10 t ha^{-1}) + Bio-fertilizer (PSB+BGA) (T_6). The treatments were triplicated in randomized block design (RBD). The recommended dose for rice was 120 kg N ha^{-1}, 60 kg P_2O_5 ha $^{-1}$, 60 kg K_2O ha^{-1}. Nitrogen, phosphorus, potash and zinc were applied by chemical fertilizers as per treatments. Half dose of nitrogen (60 kg ha^{-1}) and full dose of phosphorus and potassium were applied as basal application at the time of sowing. Rest half dose of nitrogen (60 kg ha^{-1}) applied at ear head initiation stage as top dressing. PSB and BGA were applied as per treatments at the time of transplanting (seedling treatments). Soil samples from 0-15 cm depth were collected in plastic bag from individual plots at 30 and 60 DAT and after harvest of the crop. Soil sample of each plot was air- dried, processed to pass through 2 mm round hole sieve and analyzed for oxidizable organic carbon (1*N* $K_2Cr_2O_7$), available N (0.32% alkaline $KMnO_4$ oxidizable), P (0.5 M $NaHCO_3$ extractable), K (1 *N* neutral ammonium acetate extractable) and S (0.15% $CaCl_2$) following the methods described by Walkley and Black method (1934) [25], Subbiah and Asija (1956) [22], Olsen's *et al.* (1954) [15], Hanway and Heidel (1952) [7] and Williams and Steinbergs (1959) [26], respectively. Soil pH was determined in 2:1 soil: water suspension with the help of glass electrode in digital pH meter and electrical conductivity of soil was measured in the supernatant liquid of soil water suspension (1:2) by conductivity bridge (Jackson, 1973) [10]. Bulk density in undisturbed samples collected with metal cores of 4.2 cm diameter and 5.8 cm height was measured (Blake, 1965) [2]. Five plants were marked randomly in each replicated plot and height was measured from base of plant to the tip of the upper most latest leaf for calculating mean plant height at 30, 60 and at harvest after transplanting. Number of tillers $plant^{-1}$ at different growth stages (30, 60 DAT and at harvest) were recorded from the marked plants in each plot. After harvesting and threshing the weight of grain was recorded. Straw yield was calculated by subtracting grain yield from biological yield. The data collected from field and laboratory were analyzed statistically using standard procedure of randomized block design (Cochran and Cox, 1957). Critical difference (C.D.) and standard error of mean (SEM) were calculated to determine the significance among treatment means.

Results and Discussion

Effect of integrated use of chemical fertilizers, FYM and bio-fertilizers on physico-chemical properties of soil under rice

Organic Carbon

Results indicated that in all treatments organic carbon content of soil decreased significantly with advancement in growth stage (Table-1). Significantly higher soil organic carbon content was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. The effect of different treatments on soil organic carbon content under rice crop was found in the order $T_4>T_2>T_5>T_3>T_6>T_1$, with advancement of crop organic carbon content was reduced from 0. 71 to 0.66, 0.70 to 0.64, 0.68 to 0.61, 0.65 to 0.58, 0.64 to 0.56 and 0.62 to 0.53%, under respective treatments. This decline in organic carbon content with advancement of crop was in accordance with (Singh *et al.* 2011) [20]. Addition of farm yard manure and BGA showed positive changes in organic carbon and nitrogen content of the soil (Dixit *et al.* 2000) [5]. Improvement in soil organic carbon content in FYM treated plots might be attributed to better root growth, while high organic carbon content along with combined use of NPK and Zn +bio-fertilizer (PSB+BGA) may be attributed to plant exudates released by plant root. The increase in organic carbon content due to use of chemical fertilizers as compared to control can be attributed to higher contribution of biomass through crop stable and residues (Singh *et al.* 2007) [19].

Available Nitrogen

Available N content of soil continuously decreased with advancement in crop growth stage under all treatment (Table-1). Significantly higher available nitrogen content was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. Available N content of soil under different treatments was found in the order $T_4>T_2>T_5>T_3>T_6>T_1$, with advancement of crop the values of available N content of soil varied from 298.58 to 262.53, 272.08 to 258.38, 268.45 to 252.65, 263.90 to 249.65, 260.36 to 245.38 and 254.62 to 239.75 kg ha^{-1}, under respective treatments. Decline in nitrogen content with advancement of crop age could be attributed to higher N requirement. The Soil availability of nitrogen increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizers alone **(**Tolanur *et.al.* 2003) [23]. Singh *et al.* (2006) [18] also observed that application of chemical fertilizers along with bio-fertilizers and FYM increases nitrogen availability in soil might be due to fast mineralization of nitrogen from organic manures in soil. Sharma *et al.* (2015) [21] also reported a build-up of available nitrogen in soil in all integrated nutrient management practices conjunctive use of organic manure and bio-fertilizers.

Available Phosphorus

Data showed the available phosphorus content of rice plots decreased continuously with age of crop under all treatment (Table-1). Significantly higher available phosphorus content was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. In respect of available phosphorus content of soil, the treatments could be arranged in the order $T_4>T_2>T_5>T_3>T_6>T_1$, with advancement of crop age the values of soil available phosphorus declined from 26.75 to 21.48, 23.84 to 18.38, 21.74 to 16.69, 20.07 to 14.57, 18.51 to 12.79 and 15.28 to 10.09 kg ha^{-1} under respective treatments. The Increase in available phosphorus content of soil due to the incorporation of organic manure may be attributed to the direct addition of phosphorus as well as solubilization of native phosphorus through release of various organic acids during decomposition. The soil available nutrients like phosphorus increased significantly with the application of various organic sources of nutrients in combination with fertilizers are the fertilizers alone (Tolanur *et al.* 2003) [23]. Sharma *et al.* (2015) [21] observed that the conjunctive use of organic manure and fertilizers along with bio-fertilizers and micronutrients gave highest availability of phosphorus in post- harvest soil of rice as compared to other treatment combination.

Available Potassium

Data revealed that available potassium content of soil of rice plots decreased continuously with advancement of crop (Table-1). Significantly higher available potassium content was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. In respect of available potassium content of soil, the treatments could be arranged in the order $T_4>T_2>T_5>T_3>T_6>T_1$, with advancement of crop age the values of soil available potassium declined from 293.45 to 272.69, 287.38 to 267.45, 282.62 to 261.38, 277.08 to 257.79, 273.58 to 253.49 and 265.39 to 244.89 kg ha^{-1}, under the respective treatments. The soil available potassium content increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizer alone (Tolanur *et al.* 2003) [23]. Application of organic manures along with inorganic fertilizers significantly increased available potassium over chemical fertilizers and bio-fertilizers alone. This increase in available potassium might be direct addition of potassium to available pool of the soil. Beneficial effect of organic manure on potassium availability may be attributed to the reduction of fixation and release of potassium.

Available Sulphur

Available S content in rice plots decreased continuously with the advancement of the age of crop under all treatments (Table-1). Significantly higher available sulphur content was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. In respect to availability of soil sulphur content treatments could be arranged in the order $T_4>T_2>T_5>T_3>T_6>T_1$ and the values varied from 23.65 to 18.39, 21.71 to 16.81, 20.00 to 15.06, 18.31 to 13.73, 15.65 to 11.83 and 12.08 to 8.76 kg ha^{-1}, under the respective treatments. These results are in accordance with Sharma *et al.* (2015) [21] where, conjunctive use of organic manure and fertilizers along with bio-fertilizers and micronutrients gave highest availability of sulphur under rice crop in compared to other treatments. Higher sulphur availability observed in FYM application as compared to bio-fertilizers (BGA+PSB), might be due to incorporation of direct source of sulphur.

Effect of chemical fertilizers, FYM and bio-fertilizers on growth and yield of rice

Plant height

It is evident from results that the plant height of rice crop increased continuously with advancement in growth stage up to the harvesting under all treatments (Table-2). Significantly higher plant height at all the growth stages was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. Order of the plant height under all the treatments was observed as $T_4>T_2>T_5>T_3>T_6>T_1$.The average plant height was increased from 99.29 to 135.32, 94.97 to 129.84,93.15 to 126.94, 88.77 to 121.59, 85.59 to 117.00 and 78.44 to 103.67 cm under respective treatments at 30 DAT and harvest stage respectively. These results are in conformity Kumar *et al.* (2012) [11] where, significantly higher plant height was observed under integrated use of organic manure, and chemical fertilizer, bio-fertilizers over the sole use of chemical fertilizers. Integrated nutrient management proved more beneficial than alone application of chemical fertilizers or bio-fertilizers and manures due to more availability of nutrients when crop is in need. Addition of organic manure along with blue green algae and phosphorus solublising bacteria increases plant height due to more availability of nutrients influenced by solublization effect and microbial decomposition.

Number of tillers plant^{-1}

Number of tillers increased continuously with advancement of age of crop (Table-2). Significantly higher number of tillers at all the growth stages was found in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments. Order of the number of tillers per plant under all the treatments was observed as $T_4>T_2>T_5>T_3>T_6>T_1$.Values of number of tillers per plant was increased from 10.00 to 13.25, 9.00 to 12.75, 8.75 to 12.00, 7.50 to 11.50, 6.41 to 10.41 and 5.50 to 9.50 under respective treatments at 30DAT and harvest stage respectively. Significantly higher number of tillers with FYM and bio-fertilizers as compared to chemical fertilizers alone might be due to more supply of nutrients during growth stages (Satyanarayana *et al.* 2002) [17]. Similar results was observed by Kumar *et al.* (2012) [11], where application of N, P and organic sources significantly increased the number of tillers of rice over control.

Straw and grain yield

Significantly higher straw and grain yield was recorded in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments (Table-2). Order of straw and grain yield under all the treatments was observed as $T_4>T_2>T_5>T_3>T_6>T_1$. Amount of straw yield under respective treatments was observed as 89.98, 86.99, 85.33, 82.34, 76.36 and 75.04 q ha^{-1}, whereas amount of grain yield under respective treatments was observed as 32.87, 30.22, 29.22, 27.40, 25.40 and 12.12 q ha^{-1}. The beneficial effect of organic manure on straw and grain yield might be due to additional supply of plant nutrients as well as improvement in the physical and chemical properties of soil. These results are in accordance with Nath *et al.* (2015) [14], where significant increase in grain and straw yield of rice was observed with 100% NPK and bio-fertilizers in comparison to other treatments. Further, the yield was significantly Superior under the conjoint use of chemical fertilizers and bio-fertilizers over the sole of use bio-fertilizers emphasized on the essentiality of integration of chemical fertilizers with bio-fertilizers to obtained higher productivity. In terms of grain and straw yield integrated nutrient management proved more superior than alone application of chemical fertilizers or bio-fertilizes and manure. Higher yield in treatments having INM was observed due to more uptake of nutrients under the influence of improved physical and chemical characteristics of soil (Satyanarayana *et al.* 2002) [17].

Nutrient uptake in rice influenced by integrated use of chemical fertilizers, FYM and bio-fertilizer

Nutrients (NPKZn) uptake by the rice increased significantly and consistently with the addition of organic manure and biofertilizers over control. Significantly higher nutrients uptake was recorded in the treatment T_4 [50% NPK Zn + bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1})] in comparison to other treatments (Table-1). Order of nutrients (NPKZn) uptake under all the treatments was observed as $T_4>T_2>T_5>T_3>T_6>T_1$. Among various treatments the uptake of nitrogen varied from 64.38 to 101.6 kg ha^{-1}, Phosphorus uptake varied from 13.35 to 20.80 kg ha^{-1} whereas, Potassium uptake was varied from 100.56 to 120.75 kg ha^{-1}. Combined application of chemical fertilizers, bio-fertilizers and FYM proved its superiority with respect to nutrients uptake in comparison to other treatments due to more availability of nutrients caused solublization of nutrients from insoluble sources by bio-fertilizers due to release of organic acids and improvement in soil physico-chemical properties and biological environment. These results are in accordance with the finding of Lakshmi *et al.* (2015) [12].

Table 1: Effect of integrated use of NPKZn, FYM and bio-fertilizers on soil organic carbon, available N.P.K.S and nutrients uptake pattern of rice crop (*Oryza sativa* L.)

Treatments	Organic carbon (%)		Available nutrients (kg ha^{-1})								Nutrients uptake (kg ha^{-1})		
			N		P		K		S				
	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	N	P	K
T_1	0.62	0.53	254.62	239.75	15.28	10.09	265.39	244.89	12.08	8.76	64.38	13.35	100.56
T_2	0.70	0.64	272. 08	258. 38	23.84	18.38	287. 38	267. 45	21.71	16.81	93.68	19.91	117.73
T_3	0.65	0.58	263.90	249.65	20.07	14.57	277.08	257.79	18.31	13.73	76.43	17.68	115.09
T_4	0. 71	0.66	298.58	262. 53	26.75	21.48	293. 45	272.69	23.65	18.39	101.60	20.80	120.75
T_5	0.68	0.61	268.45	252. 65	21.74	16.69	282.62	261.38	20.00	15.06	83.70	18.30	112.65
T_6	0.64	0.56	260.36	245.38	18.51	12.79	273.58	253.49	15.65	11.83	70.15	15.56	105.65
SEm(±)	0.013	0.012	0.782	1.213	0.318	0.443	0.579	1.039	0.234	0.156	0.020	0.035	0.019
CD (P=0.05)	0.040	0.039	2.464	3.821	1.001	1.395	1.825	3.275	0.739	0.492	0.065	0.05	0.067

DAT=Days after Transplanting

Table 2: Effect of integrated use of NPKZn, FYM and bio-fertilizers on crop productivity and growth performance of rice crop (*Oryza sativa* L.)

Treatments	Plant height (cm)			Number of tillers $plant^{-1}$			Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest		
T_1	78.44	99.00	103.67	5.50	8.58	9.50	12.12	75. 04
T_2	94. 97	114.01	129.84	9.00	12.00	12. 75	30. 22	86.99
T_3	88.77	108. 49	121.59	7.50	9.83	11.50	27.40	82. 34
T_4	99. 29	118.10	135. 32	10. 00	12. 75	13. 25	32.87	89.98
T_5	93. 15	111.52	126.94	8.75	11. 00	12. 00	29.22	85. 33
T_6	85.59	101.54	117.00	6.41	9.30	10.41	25.40	76.36
SEm(±)	0.942	1.022	1.14	0.283	0.404	0.31	0.085	0.101
CD (P=0.05)	2.968	3.221	3.591	0.892	1.272	0.976	0.267	0.318

DAT=Days after Transplanting

Conclusion

From the present study it is concluded that under rice crop combined application of organic manure, chemical fertilizers and bio-fertilizers is more superior in increasing crop productivity as well as improving soil fertility as compared to sole application of chemical fertilizers.

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