International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 2520-2526

Received: 22-11-2018
Accepted: 25-12-2018

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Effect of enriched FYM and P_2O_5 levels on physio-chemical properties of soil after harvesting of rice

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Abstract
A field study was established during *Kharif* season of 2013 and 2014 at the Agricultural Research Farm, BHU, Varanasi to find out the effect of PGPR and zinc enriched FYM on physio-chemical properties of soil after harvesting of rice crop at different levels of phosphorus in an Inceptisol. The treatment combinations consisted five levels of enriched FYM (M_0= control, M_1= without enriched FYM, M_2= PGPR enriched FYM, M_3= PGPR and Zn @ 2.5 kg ha^{-1} enriched FYM and M_4= PGPR and Zn @ 5.0 kg ha^{-1} enriched FYM) and four levels of phosphors ($P_0 = 0$, $P_1 = 20$, $P_2 = 40$ and $P_3 = 60$ kg P_2O_5 ha^{-1}). The results of experiment revealed that application of different enriched FYM and P_2O_5 levels did not showed significant effect on bulk density (Mg m^{-3}), pH and EC (dS m^{-1}) of the soil. Organic carbon was increased significantly due to application of enriched FYM but it was not affected significantly by different levels of phosphorus. Different kinds of enriched FYM significantly increased available nitrogen, phosphorus and potassium in the soil after harvesting of rice during both years. Available nitrogen (224.59 and 227.73 kg N ha^{-1}), phosphorus (20.33 and 22.05 kg P_2O_5 ha^{-1}) were found highest in the treatment of PGPR and Zn @ 5.0 kg ha^{-1} enriched FYM (M_4) but they were remaining at par with treatment PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) during both the years. Available potassium (203.28 and 205.46 kg K_2O ha^{-1}) was found highest but it was significant over control (M_0) and without enriched FYM (M_1) during 2013 and 2014, respectively. The treatment P_3 (60 kg P_2O_5 ha^{-1}) significantly increased the highest available N and P_2O_5 (kg ha^{-1}) over control but available nitrogen was found at par with the treatment of P_2 (40 kg P_2O_5 ha^{-1}) and available potassium did not show significant effect with different levels of phosphorus. Interaction effect of enriched FYM and P_2O_5 levels was found significant and obtained PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM + 40 kg P_2O_5 ha^{-1} most effective treatment combination at farmers level due to reduction in 20 kg P_2O_5 ha^{-1} and 2.5 kg Zn ha^{-1} in the recommended dose of P and Zn for optimum yield along with maintenance of soil health. PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM increased significantly available Zn (0.70 and 0.75 ppm) in soil over control but found statistically at par with PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM during both years. Higher available Zn was found significant with application of 60 kg P_2O_5 ha^{-1} over control and showed at par result with 40 kg P_2O_5 ha^{-1}.

Keywords: PGPR, Zn, enriched FYM, physio-chemical properties of soil

Introduction

There was a phenomenal increase in production of rice after mid-1960s with the introduction of high yielding varieties. However, due to inadequate and imbalanced fertilizer application, farmers are not able to harness the full potential yield of rice crop. The organic matter being the storehouse of nutrients, combined application of organic and inorganic fertilizer can be increase in yield, improve the fertility status of soil, improve the input use efficiency by the crop and certainly cut down the expenditure on costly fertilizers (Laxminarayana and Patiram, 2006) [12].

Besides major nutrients, deficiency of micronutrients is also emerging. About 47% soils of India are deficient in zinc (Zn). Zinc has generally been reported deficient in rice growing areas of India; therefore, to have a good harvest of rice, it is necessary to provide Zn in sufficient quantities as per requirement of the soil and crop. Regar and Yadav (2017) [22] suggested that Application of enriched FYM @ 5 tonnes ha^{-1} (PGPR and Zinc @ 2.5 kg ha^{-1}) at 40 kg P_2O_5 ha^{-1} was provided optimum yield and profitability for growing of rice without endangering the soil health through the supply of sufficient amount of N and P_2O_5 due to biological N_2 fixation and P solubilisation by PGPR and zinc use efficiency also increased by chelating of Zn with FYM.

The process of enrichment of organic manures with micronutrients like zinc not only improve the nutrient use efficiency but also helps in reducing the load of inorganic chemicals as well as quantity of organics to a considerable extent (Meena *et al*., 2006) [16] PGPR and zinc enriched FYM increases P solubilisation through secretion of organic acids by PGPR, N through biological nitrogen fixation and also enhance zinc use efficiency by the enrichment of FYM with zinc. Enriched FYM also improve other physio-chemical properties of soil by application of PGPR and zinc enriched FYM at different levels of phosphorus. Hence, a field experiment was undertaken to study the effect of PGPR and zinc enriched FYM on Physio- chemical properties of soil at Varanasi, Uttar Pradesh.

Materials and Methods

The field experiments were conducted during *kharif, 2013* and 2014 at the Agriculture Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to study the effect of enriched FYM on physio-chemical properties of soil at different levels of Phosphorus in an Inceptisol. The soil under investigation was sandy loam in texture (51.06% sand, 29.59% silt and 19.35% clay) & bulk density ranging from 1.41 to 1.40 Mg m^{-3} during both the years. Likewise the values of the chemical properties, pH (8.06 to 8.04), EC (0.209 to 0.210 dSm^{-1}), organic carbon (0.37 to 0.38%) and available N, P, K and Zn of soil were ranging from 180.43 to 183.20, 18.15 to 18.40 and 193.50 to 196.70 kg ha^{-1} and 0.55 to 0.57 g ha^{-1}, respectively in both the years. The experiment was laid out in a randomized block design in factorial experiment with 20 treatments comprised of five types of enriched FYM and four P_2O_5 levels with three replications. There were twenty treatment combinations consisted five levels of PGPR and Zinc enriched FYM (M_0= control, M_1= without enriched FYM, M_2= PGPR enriched FYM, M_3= PGPR and Zn @ 2.5 kg ha^{-1} enriched FYM and M_4= PGPR and Zn @ 5.0 kg ha^{-1} enriched FYM) and four levels of phosphors (P_0 = 0, P_1 = 20, P_2 = 40 and P_3 = 60 kg P_2O_5 ha^{-1}). Enriched FYM @ 5 tonnes ha^{-1} along with half of recommend dose of nitrogen, treatment wise full doses of phosphorus and full dose of potassium at the time field preparation and rest dose of nitrogen were applied in two splits at the time of tillering and before flowering of rice. The fertilizers were used: urea (46% N), DAP (18% N and 46% P_2O_5), muriate of potash (60% K_2O) and zinc sulphate (21% Zn). PGPR and zinc were applied in form of enrichment with FYM and applied before the transplanting of rice. Soil samples from 0- 15 cm depth were collected from individual plots after harvest of the rice crop. Soil sample of each plot was air-dried, processed to pass through 2 mm sieve and analysed for Bulk density, pH, EC, 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 DTPA extractable Zn following the methods described by Baruah and Barthakur (1997) [2], Jackson, 1973 [9] (pH and EC), Walkley and Black (1934) [30], Subbiah and Asija **(**1956) [27], Olsen *et al.* (1954) [17], Hanway and Heidel (1952) [8] and Lindsay and Norvell (1978) [13] respectively and results were expressed on oven-dry weight basis.

Results and Discussion

Effect on bulk density

The bulk density tends to slightly decreased with different enriched FYM but statistically was not achieved significant effect during both the years (Table 1). Addition of enriched FYM however, decreased the bulk density from 1.39 Mg m^{-3} (No enriched FYM) to 1.35 Mg m^{-3} during 2013 and from 1.39 Mg m^{-3} (No enriched FYM) to 1.34 Mg m^{-3} in 2014. The decrease in bulk density was might be due to increase in organic carbon content of the soil. The similar results were also reported by Dadhich *et al*. (2011) [7] and Singh *et al.* (2012) [25] who observed a decrease in bulk density with increase in organic matter content in the soil.

The lowering in bulk density but statistically not significant with increasing levels of P_2O_5 application was noticed during both the years of experiments. The lowering in bulk density with application of increasing levels of fertilizer has also been reported by Thakur *et al*. (2011) [29]; Dadhich *et al.* (2011) [7] and Jat *et al.* (2012) [10].

Effect on soil pH and EC

An examination of data presented in Table 2 on pH and EC as affected by various treatments under study, indicated that application of PGPR and Zinc enriched FYM (M) and P_2O_5 levels (P) have no significant effect on pH and EC during both the years. However slightly decreased in soil pH might be due to the fact that formation of organic acids during the decomposition of organic manure and crop residues (Yaduvanshi, 2001 and Sharma *et al*., 2013) [31, 23].

Data pertaining to electrical conductivity of soil after harvesting of rice as affected by application of enriched organic manure and P_2O_5 have been presented in Table 2. As the data showed that there was no significant change in electrical conductivity of soil at harvest by the application of PGPR and zinc enriched organic manure and P_2O_5 in both years of experimentation. The electrical conductivity was gradually increased as from 0.209 to 0.214 dS m^{-1} and from 0.210 to 0.216 dS m^{-1} with application of PGPR and Zn @ 5.0 kg ha^{-1} enriched FYM during 2013 and 2014, respectively. Increasing dose of P_2O_5 was also increase the electrical conductivity of soil *viz.* 0.210 to 0.213 dS m^{-1} and 0.211 to 0.215 dS m^{-1} in 2013 and 2014, respectively.

Effect on Organic carbon

Data on organic carbon content recorded after harvest of rice during subsequent two years as affected by application of enriched FYM and P_2O_5 levels has been presented in Table 2. Organic carbon of soil after harvest of rice was increased significantly with application of PGPR and zinc enriched FYM during both the years. Application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM resulted 19.44 and 21.62% increased in organic carbon content of soil over no FYM application during both the years, respectively. Organic carbon ranged from 0.36 to 0.43% and 0.37 to 0.45% which increased from control to application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM during both years, respectively. The increased organic carbon content due to use of enriched FYM can be attributed to higher contribution of biomass to the soil in the form of root, crop stubbles and residues. This could be attributed not only to addition of organic materials but also to better root growth and plant residue addition by the growing crop at harvesting. It is an important source of soil organic matter and nutrients which after decomposition by the microorganisms becomes available to the plants. These results are in line with findings of Abraham and Lal (2004) [1], Thakur *et al*. (2011) [29] and Singh *et al*. (2012) [25].

Organic carbon content non-significantly increased with increasing dose of P_2O_5 during both the years. The higher organic carbon content 0.41 and 0.44% during subsequently years, was observed at 60 kg P_2O_5 ha^{-1} (RDP) application while, at 0 kg P_2O_5 ha^{-1} (control) the Organic Carbon content was 0.39 and 0.40% in 2013 and 2014, respectively. Increasing organic carbon with increasing rates of fertilizer application have been also reported by Manna *et al*. (2005) [15]; Bhardwaj *et al*. (2010) [4]; Thakur *et al*. (2011) [29] and Sharma *et al*. (2013) [23].

Effect on available nitrogen

Data pertaining to the available N content in soil after harvesting of rice crop presented in Table 3 and would make it clear that treatments had significant effect on available N content of soil samples during both the years of experiments. Application of enriched FYM with P_2O_5 significantly affected the available N content of soil after harvesting of rice crop but treatment M_3 with M_4 and M_1 with M_2 were at par during both years. The post harvest available nitrogen content of soil significantly increased from 199.74 kg ha^{-1} without FYM (M_0) to 224.59 kg ha^{-1} with application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) resulting in an increase of 12.44% in 2013. It was increased during 2014 from 201.06 kg ha^{-1} without FYM (M_0) to 227.73 kg ha^{-1} with application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) resulting in an increase of 13.26% over the control. The increase in available N after FYM application might be due to the direct addition of nitrogen through decomposition of the FYM to the soil or the increase in available nitrogen due to application of FYM could also be attributed to the greater multiplication of soil microbes, which could convert organically bound nitrogen to inorganic form of nitrogen (Bharadwaj and Omanwar, 1994) [3]. The beneficial effect of various Zn-enriched organics in improving soil properties and enhancing the N availability has been reported by Latha *et al.* (2001) [11]. Parmar *et al*. (1998) [18] also suggested that significant build up of the soil available N could be attributed to increased activity of nitrogen fixing rhizobia thereby resulting in higher accumulation of nitrogen in the soil.

The available nitrogen content in soil increased significantly with increasing levels of P_2O_5 application but application of 40 and 60 kg P_2O_5 ha^{-1} were achieved at par effect during both the years. The available nitrogen content of soil increased with 20, 40 and 60 kg P_2O_5 ha^{-1} to the extent of 3.45, 6.11 and 7.42%; and 3.59, 6.32 and 7.62% over control during 2013 and 2014, respectively. According to Dadhich *et al*. (2011) [7], Application of P levels significantly improved available nitrogen content in soil. An increment in available nitrogen with increasing levels of fertilizer was also reported by Shivakumar and Ahlawat (2008) [24]; and Bhardwaj *et al*. (2010) [4].

Effect on available phosphorus

Data on available soil P recorded after harvest of rice as influenced by PGPR and zinc enriched FYM with P_2O_5 levels are presented in Table 3. Data presented in Table 3 had shown that addition of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) increased significantly available P content in experimental soil over control which found at par with PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_4) and remaining treatments were significant to each other. Application of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) resulted 20.07 and 21.65 kg P_2O_5 ha^{-1} which were significantly higher by 39.47 and 41.50% in soil. The improvement in the soil available phosphorus due to FYM addition could be attributed to many factors, such as the addition of phosphorus through FYM and retardation of soil P fixation by organic anions formed during FYM decomposition. Similar views were also expressed by Chand (2007) [6]; Dadhich *et al.* (2011) [7] and Singh *et al*. (2012) [25]. However, it might be due to solubilisation of fixed form of native soil phosphorus and make available to the plants through secreting organic acids by PGPR strains.

Examination of the data indicated that available P content in the soil significantly increased with increasing level of the P_2O_5 after harvest of the rice during both the years. The available soil P content at 0 kg P_2O_5 ha^{-1} achieved 15.44 and 16.28 kg ha^{-1} during 2013 and 2014, respectively, increased to maximum 19.76 and 21.77 kg ha^{-1} due to application of 60 kg P_2O_5 ha^{-1} in 2013 and 2014, respectively. Bhat *et al*. (2013) [5] resulted that increased in soil available N, P and K could be attributed to greater biological nitrogen fixation with adequate P supply. The status of soil P improved firstly due to direct application of P to soil, and secondly through organic acids released by roots capable of solubilizing soil P. The results are in close conformity with Dadhich *et al*. (2011) [7].

Interaction effect of enriched FYM and P_2O_5 levels on available phosphorus in post harvest soil

Data presented in Table 4 shows that there was significant interaction effect of enriched FYM and P_2O_5 application on available P content of soil after harvest of rice during 2013 and 2014. The available P content of soil recorded with combined use of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) + 40 kg P_2O_5 ha^{-1} application (20.83 kg P ha^{-1}) was significantly higher than that recorded with application of alone PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (18.59 kg P ha^{-1}) and 60 kg P_2O_5 ha^{-1} (16.54 kg P ha^{-1}). The highest value of available P in soil (21.55 kg P ha^{-1}) was observed with combined application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) + 60 kg P_2O_5 ha^{-1} which was found at par with M_3P_2, M_3P_3 and M_4P_2 while except these treatment resulted significantly lower value from highest treatments i.e. M_4P_3. Treatment M_3P_2 will be preferred for application on farmer levels due to less amount of input fertilizer (P and Zn), which was at par with highest available P in the treatment M_4P_3.

The results presented in Table 4 Showed similar trend in the year 2014 as observed during 2013. The data of the present investigation have shown that the PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) along with 60 kg ha^{-1} P_2O_5 recorded highest available soil P but showed similar result with M_3P_2, M_3P_3 and M_4P_2 except these treatment combinations, treatment M_4P_3 showed significant result on the rest of the treatments. The increased availability of available phosphorus with organics could be ascribed to their solubilizing effect on the native soil phosphorus and consequent contribution of the phosphorus as solubilized to labile pool. Incorporation of FYM along with inorganic fertilizer increased the availability of P to the crop and mineralization of organic phosphorus due to microbial action and enhances mobility of phosphorus (Prasad *et al*., 2010). Organic matter (FYM) may also reduce the fixation of phosphate by providing protective cover on sesquioxides and thus reduce the phosphate fixing capacity and increase the available phosphorus in the soil (Bharadwaj and Omanwar, 1994) [3]. Similar, findings have also been reported by Patidar and Mali (2004) [19]; Subehia *et al.* (2005) [28] and Thakur *et al*. (2011) [29].

Effect on available potassium

Data on available soil potassium recorded after harvest of rice as affected by different enriched FYM along with P_2O_5 levels are presented in Table 3. Application of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) significantly increased available K of soil after harvest of the rice crop during both the years over control and FYM (without enriched) but it was at par with rest of the treatments. The available K at PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) was being 203.28 and 205.46 kg ha^{-1} during 2013 and 2014. The extent of respective increase of available K of soil was 5.74 and 6.15% over no enriched FYM application. This may be due to reduction of K-fixation of mineral potassium, solubilization and release of K due to the interaction of organic matter with clay, besides the direct potassium addition to the potassium pool of the soil (Singh *et al.*, 2008) [26]. Rathod *et al*. (2012) [21] also investigated that FYM-$Zn_{5.0}$ enriched FYM increased higher available K in the soil over control, 2.5 kg Zn ha^{-1}, 5.0 kg Zn ha^{-1} and FYM-$Zn_{2.5}$.

Available potassium of soil after harvest of rice was not influenced significantly by application of different P_2O_5 levels during 2013 and 2014 but slightly increased with increasing dose of P_2O_5. The highest soil available K, 200.17 and 202.55 kg ha^{-1} was recorded with the application of 60 kg P_2O_5 ha^{-1} in both the years, respectively. The increase in potassium availability was might be due to application of fertilizer, better proliferation of roots resulting in increased root pressure and microbial activity as well as solubilization of native potassium. The result concurs with the findings of Chand (2007) [6]; Shivakumar and Ahlawat (2008) [24] and Bhardwaj *et al*. (2010) [4].

Effect on available zinc

An examination of data presented in Table 5 had shown that available zinc in soil after the harvest of rice significantly increased with application of different enriched FYM and P_2O_5 levels. The available Zn in soil after harvest of rice increased upto application of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) and found at par with PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4). Addition of PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4) increased significantly the available zinc in soil from 0.40 ppm (No FYM) to 0.70 (ppm) during 2013 and from 0.40 ppm (No FYM) to 0.75 (ppm) in 2014. The extent of increase over no FYM was 72.5 and 82.5% due to application of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) in the respective year which was found at par with PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_4). Organic acids produced by organic manure and PGPR can mobilize soil-bound Zn and also restrict the fixation of soluble zinc by soil components by chelating with the element. Besides, mineralization of the immobilized zinc takes place at a later period (Mandal *et al*., 1993) [14].

Available zinc recorded under the treatment 40 kg P_2O_5 ha^{-1}, was found statistically at par with that recorded under the treatment 60 kg P_2O_5 ha^{-1} application and significant over control and rest of treatments during both the years of the experimentation. The maximum value of available zinc (0.59 and 0.62 ppm) was observed with the application of 60 kg ha^{-1} P_2O_5 and that of minimum (0.50 and 0.51 ppm) under control or 0 kg ha^{-1} P_2O_5 application during both the years of experimentation. The extent of increase over the control was 18.0 and 21.6% due to application of 60 kg P_2O_5 ha^{-1} along with enriched FYM during both the years, respectively. However, Available Zn in soil may also increase due to application of phosphorus along with PGPR and Zn enriched FYM which reduce fixation of chelated mineral Zn and also make available native Zn through solubilization.

Conclusion

The study indicated that the PGPR and zinc enriched FYM significantly affect the physio-chemical properties of soil at different levels of phosphorus after harvesting of soil. Results showed that combined application of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) along with 40 kg P_2O_5 ha^{-1} improved physio-chemical properties of soil and found at par with PGPR and zinc @ 5.0 kg ha^{-1} enriched FYM (M_3) + 60 kg ha^{-1} P_2O_5 in most of the soil properties. Interaction effect with PGPR and zinc enriched FYM along with P_2O_5 levels was found significantly and showed effective treatment combination of PGPR and zinc @ 2.5 kg ha^{-1} enriched FYM (M_3) + 40 kg P_2O_5 ha^{-1} which save 20 kg P_2O_5 ha^{-1} and 2.5 kg Zn ha^{-1} through solubilisation of native phosphorus and reducing the fixation of applied P by PGPR and FYM; improve the efficiency of Zn through chelating with organic manure.

Table 1: Effect of PGPR and zinc enriched FYM and phosphorus levels on Bulk density of soil after harvest of rice

Treatments	Bulk density (Mg m^{-3})		
	2013	2014	Mean
Enriched FYM			
M_0	1.39	1.39	1.39
M_1	1.36	1.36	1.36
M_2	1.36	1.35	1.36
M_3	1.35	1.34	1.35
M_4	1.35	1.34	1.35
SEm±	0.014	0.014	
CD(P=0.05)	NS	NS	
Phosphorus Levels			
P_0	1.37	1.37	1.37
P_1	1.36	1.36	1.36
P_2	1.36	1.35	1.35
P_3	1.35	1.35	1.35
SEm±	0.012	0.013	
CD(P=0.05)	NS	NS	

Table 2: Effect of PGPR and zinc enriched FYM and phosphorus levels on pH, EC and Organic carbon (%) of soil after harvest of rice

Treatments	pH			EC (dS m^{-1})			Organic carbon (%)		
	2013	2014	Mean	2013	2014	Mean	2013	2014	Mean
Enriched FYM									
M_0	8.04	8.02	8.03	0.209	0.210	0.209	0.36	0.37	0.36
M_1	8.00	7.96	7.98	0.211	0.212	0.211	0.40	0.42	0.41
M_2	7.98	7.93	7.96	0.212	0.213	0.213	0.41	0.42	0.42
M_3	7.96	7.90	7.93	0.213	0.215	0.214	0.43	0.44	0.43
M_4	7.96	7.90	7.93	0.214	0.216	0.215	0.43	0.45	0.44
SEm±	0.029	0.031		0.0012	0.0015		0.01	0.01	
CD(P=0.05)	NS	NS		NS	NS		0.03	0.04	
Phosphorus Levels									
P_0	8.02	7.98	8.00	0.210	0.211	0.210	0.39	0.40	0.40
P_1	7.99	7.95	7.97	0.212	0.212	0.212	0.40	0.42	0.41
P_2	7.98	7.92	7.95	0.212	0.214	0.213	0.41	0.43	0.42
P_3	7.97	7.92	7.94	0.213	0.215	0.214	0.41	0.44	0.42
SEm±	0.026	0.028		0.0011	0.0013		0.01	0.01	
CD(P=0.05)	NS	NS		NS	NS		NS	NS	

Table 3: Effect of PGPR and zinc enriched FYM and phosphorus levels on available nitrogen, phosphorus and potassium of soil after harvest of rice

Treatments	Available nutrient (kg ha^{-1})								
	N			P			K		
	2013	2014	Mean	2013	2014	Mean	2013	2014	Mean
Enriched FYM									
M_0	199.74	201.06	200.40	14.39	15.30	14.84	192.24	193.55	192.90
M_1	211.79	214.16	212.98	16.72	18.19	17.45	197.57	199.48	198.53
M_2	214.60	217.08	215.84	18.45	19.95	19.20	199.81	202.31	201.06
M_3	220.46	223.39	221.93	20.07	21.65	20.86	201.88	204.61	203.24
M_4	224.59	227.73	226.16	20.33	22.05	21.19	203.28	205.46	204.37
SEm±	2.00	2.10		0.20	0.21		1.88	2.08	
CD(P=0.05)	5.72	6.01		0.57	0.60		5.37	5.96	
Phosphorus Levels									
P_0	205.51	207.59	206.55	15.44	16.28	15.86	196.88	198.70	197.79
P_1	212.61	215.04	213.83	17.78	18.79	18.29	198.86	200.98	199.92
P_2	218.07	220.71	219.39	18.99	20.86	19.93	199.91	202.09	201.00
P_3	220.75	223.41	222.08	19.76	21.77	20.76	200.17	202.55	201.36
SEm±	1.79	1.88		0.18	0.19		1.68	1.86	
CD(P=0.05)	5.12	5.38		0.51	0.53		NS	NS	

Table 4: Interaction effect of PGPR and zinc enriched FYM and phosphorus levels on available P of soil after harvest of rice

Treatments	Available P (kg ha^{-1})							
	2013				2014			
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3
M_0	11.49	14.13	15.40	16.54	11.71	14.65	16.71	18.12
M_1	13.27	16.43	18.07	19.10	14.17	17.48	19.90	21.21
M_2	15.50	18.40	19.55	20.36	16.45	19.47	21.42	22.48
M_3	18.33	19.87	20.83	21.23	19.19	20.96	23.07	23.37
M_4	18.59	20.06	21.09	21.55	19.89	21.41	23.22	23.68
SEm±	0.40				0.42			
CD(P=0.05)	1.14				1.19			

Table 5: Effect of PGPR and zinc enriched FYM and phosphorus levels on available Zn of soil after harvest of rice

Treatments	Available Zn (ppm)		
	2013	2014	Mean
Enriched FYM			
M_0	0.40	0.40	0.40
M_1	0.47	0.48	0.48
M_2	0.51	0.53	0.52
M_3	0.69	0.73	0.71
M_4	0.70	0.75	0.73
SEm±	0.01	0.01	
CD(P=0.05)	0.02	0.03	
Phosphorus Levels			
P_0	0.50	0.51	0.50
P_1	0.55	0.58	0.57
P_2	0.58	0.61	0.59
P_3	0.59	0.62	0.61
SEm±	0.01	0.01	
CD(P=0.05)	0.02	0.02	

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