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Effect of Organic Manures and Fertilizers on Soil Chemical Properties

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The study was conducted to investigate the long-term application of manures and fertilizers on soil chemical properties in the rhizosphere and bulk soil under field condition. The research was conducted at ZARS, GKVK, Bangalore. There were 10 treatments and replicated thrice in an RCBD design. The treatment contains different levels of organic manures like 5t, 10t, 12.5t, 15t, 17.5t and 20t fertilizers like 25%, 50%, 75% and 100%. Soil chemical properties *viz*., Organic carbon, Ammoniacal-nitrogen, Nitrate-nitrogen, Available nitrogen and Available phosphorus were analysed in different treatments and these were found to be significantly higher in the treatment with application of 20t of FYM ha^{-1} compared to recommended NPK alone.

Key words: Organic carbon, Ammoniacal-nitrogen, Nitrate-nitrogen, Available nitrogen and Available phosphorus.

Increasing conscious about conservation of environment, health hazards associated with agro chemicals and consumer's preference to safe and hazard free food are the major factors for growing interest in organic agriculture. The main theme of organic farming is to attain sustainable agriculture production without deterioration of natural resources and to produce better quality of agricultural produce. Hi-tech modern agriculture which largely dependent on fertilizers and chemicals started from mid 1960's was responsible for bridging the gap between the demand and supply of food for the raising population. During the late 1980's, the soil system appeared to show signs of exhaustion and decline in the overall productivity per unit area of most of the crops. Despite use of modern technologies, the yields did not show the same upward trend and it continued even today itself.

In future days, the food requirement would increase and parallel the external inputs (fertilizer, pesticides *etc*) too. In turn, the situation will also pose challenge of feeding the people to the desired extent with right quality of safe food. In this context, adoption of organic farming is a remedy to cure the ill effects of modern chemical agriculture. Good tenets of soil building, increasing its carbon contents and adopting good traditional practices of using on-farm inputs or raising crops are receiving increased attention. Use of green manure, augmenting bio-mass, preparing good enriched organic manures and adopting bio-control measures to manage pests and diseases are expected to help to maintain good health with adequate production of crops that are safe and healthy.

Organic farming introduces a change in the farming systems which aims at maximum production in the cropping pattern and takes care of optimal utilization of resources. It is an imperative rather than a choice. The role of organic farming has great linkage with sustainability, since it encompasses improvement

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in soil fertility and productivity, brings down the cost of production, eliminates residual toxicity of chemicals and pesticides in soils, water, food and environment there by maintains eco-balance. The practice of organic farming to achieve the sustainability in a holistic approach is aimed at improve the crop yields through the sustainability of eco-system and fertility. In India, larger number of small and marginal holdings, rainfed situations and varied eco-systems offer greater scope to adopt organic farming. Organic farming system promotes low cost, sustainable farming approach and is an alternative to conventional farming in large rainfed areas where inputs use is low.

Organic manures in agriculture add much needed organic and mineral matter. Organic systems rely on management of organic matter to enhance the soil fertility and productivity. Organic matter has an over whelming effect on almost all soil properties. Organic matter a most precious component is also considered as store house of many nutrients. For mineralisation of organic matter, soil fauna and microorganisms are indispensible. Soil harbours a dynamic microbial population, arthropods and others (soil biota). The living phase of soil is greatly stimulated by organic manure addition which serves as a food (carbon) and energy source for soil life. Both soil and enzyme systems are associated with organic manure management which carry out a wide range of processes that are important for soil health and fertility. The proper management of these make it possible to increase the efficiency of use of soil and added nutrient (Ramesh, 2007).

MATERIALS AND METHODS

Long-term application of manures and fertilizers on soil microbial communities and their biological activities in the rhizosphere and bulk soil was conducted at ZARS, UAS, GKVK, Bangalore. The soil samples were air dried in shade, passed through two mm sieve and subjected to microbiological analysis in the laboratory of the Department of Agricultural Microbiology, UAS, GKVK, Bangalore. Treatments details. T_1 - 5t of FYM, T_2 - 10t of FYM, T_3 - 10t of FYM (partially decomposed), T_4 - 10t of FYM + mulching (glyricidia 2 t ha-1), T_5 - 20t of FYM, T_6 - 17.5t of FYM + 25% rec. NPK, T_7 - 15t of FYM + 50% rec. NPK, T_8 - 12.5t of FYM + 75% rec.NPK, T_9 - Rec. NPK + rec. FYM + phorate + herbicide + fungicide, T_{10} - Rec. NPK and all the above treatments were replicated threes. Where: Rec.NPK- 25:60:25 Kg/ha, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds) and *Rhizobium* seed treatment common to all plots. Enumeration of microbial populations, soil samples collected from study site (pot) were used for enumeration of beneficial soil microorganisms like N fixers, degrading microorganisms, Phosphorus Solubilizing Microorganism (PSM) and pseudomonads by following serial dilution agar plate method, during different growth stages (45 DAS and at harvest) for recording.

Soil chemical analysis

Organic carbon

The organic carbon was determined by following Walkely Black's wet-oxidation method using 0.5 M $K_2Cr_2O_7$ with concentrated H_2SO_4 and back titrated with standard ferrous ammonium sulphate as described by Jackson (1973).

Ammoniacal-nitrogen

The ammoniacal nitrogen in the soil samples was determined as per the procedure given by Jackson (1967). 10 g of soil was weighed and taken into glass bottles and 50 ml of acidified KCl (pH-2.5) was added and shaked for 30 minutes on an end-to-end shaker. Then. the contents were filtered using Whatman No. 42 filter paper. From the filtrate thus obtained 3ml of aliquot was taken into a tube to which 1ml of acidified KCl, 1 ml of 10% sodium tartarate solution and 2.5 ml of Nessler's reagent was added. The volume was made up to 10 ml using distilled water. The intensity of yellow colour was measured at 410 nm after 25 minutes. The concentration of NH_4–N was obtained using a standard curve developed by different concentrations of NH_4–N using analar grade ammonium sulphate.

Nitrate-nitrogen

Thenitrate nitrogen content in the soil sample was analyzed as per the procedure given by Sunitha *et al.* (1999) using the ultraviolet spectrophotometery. Ten gram of soil was placed in Erlenmeyer flask and 50ml of KCl was added and shaked for 15 to 20 minutes on mechanical shaker. Then the contents were filtered using Whatman No. 42 filter paper. Then the filtrate was directly read under UV spectrophotometer at 220nm and 275nm. Correction for the dissolved organic matter was done by subtracting two times the absorbance reading at 275nm from the reading at 220nm to obtain absorbance due to nitrate. The concentration of nitrate nitrogen was obtained using a standard curve developed by different concentrations of NO_3–N using analar grade potassium nitrate.

Available nitrogen

The available nitrogen was determined by macro Kjeldhal distillation of a soil sample following alkaline permanganate method (Subbaiah and Asija, 1956).

Available phosphorus

The available phosphorus was extracted with Bray's No.1 extractant (0.03 N NH_4F + 0.025 N HCl). The phosphorus in the extract was determined by chlorostannous reduced molybdophosphoric blue colour method in HCl acid medium. The intensity of blue colour was read at 660 mm using a spectrophotometer (Bray and Kurtz, 1945).

RESULTS AND DISCUSSION

Organic carbon

The soil organic carbon as influenced by long-term application of manures and fertilizers in the rhizosphere and bulk soil is presented in table-1. The soil organic carbon in FYM series was found to be significantly higher due to the treatment 20t FYM ha^{-1} (0.73 %) before sowing , (1.08 % and 0.94 %)in the rhizosphere and non-rhizosphere soil respectively at 45 DAS and (1.02 % and 0.86 %) in the rhizosphere soil and non-rhizosphere soil respectively at harvest stage compared to all other treatments. The least organic carbon was recorded with rec. NPK (0.46 %), (0.59 % and 0.56 %) and (0.57 % and 0.50 %) before sowing, at 45 DAS and at harvest in both rhizosphere soil and non-rhizosphere soil respectively.

Available nitrogen

The effect of long-term application of manures and fertilizers on available nitrogen in the rhizosphere and bulk soils is presented in table-2. The available nitrogen was found to be significantly higher due to the application of 20t FYM ha^{-1} (324.08 kg ha^{-1}) before sowing compared to all other treatments. These were on par with the treatment 17.5t of FYM + 25% rec. NPK (316.49 kg ha^{-1}), 15t of FYM + 50% rec. NPK (328.17 kg ha^{-1} soil) and 12.5t of FYM + 75% rec. NPK and 308.20 kg ha^{-1}) respectively. The least available nitrogen was found to be due to the application of rec. NPK (273.95 kg ha^{-1}).

The available nitrogen was found to be significantly higher at 45 DAS in the treatment 20t of FYM ha^{-1} (423.97 kg ha^{-1})in the rhizosphere soil compared to (414.84 kg ha^{-1}) non-rhizosphere soil respectively compare to all other treatments. These were on par with the treatments 17.5t of FYM + 25% rec. NPK (419.25 kg ha^{-1} and 400.59 kg ha^{-1}), 15t of FYM + 50% rec. NPK (413.03 kg ha^{-1} and 396.02 kg ha^{-1}) and 12.5t of FYM + 75% rec. NPK (410.50 kg ha^{-1} and 393.28 kg ha^{-1}) respectively in both rhizosphere and non-rhizosphere soils. The least available nitrogen was found in control treatment with rec. NPK (340.10 kg ha^{-1} and 309.57 kg ha^{-1}).

The available nitrogen in FYM series was found to be significantly higher at harvest in the treatment 20t of FYM ha^{-1} (388.77 kg ha^{-1} and 383.78 kg ha^{-1}) soilin the rhizosphere soil compare to non-rhizosphere soil respectively compared to all other treatments. These were on par with treatments 17.5t of FYM + 25% rec. NPK (383.62 kg ha^{-1} and 381.41 kg ha^{-1}), 15t of FYM + 50% rec. NPK (381.27 kg ha^{-1} and 377.46 kg ha^{-1})and 12.5t of FYM + 75% rec. NPK (379.25 kg ha^{-1} and 365.18 kg ha^{-1}) respectively in both rhizosphere and non-rhizosphere soils. The least available nitrogen was noticed due to the application with rec. NPK (301.63 kg ha^{-1} and 290.83 kg ha^{-1}).

Ammoniacal nitrogen

The effect of manures and fertilizers on ammoniacal nitrogen in the rhizosphere and bulk soils is presented in table-3. The ammoniacal nitrogen in FYM series was found to be significantly higher due to the treatment 20t FYM ha^{-1} (85.74 mg g^{-1} soil) before sowing , (174.20mg g^{-1} soil and 120.20mg g^{-1} soil)in the rhizosphere and non-rhizosphere soil respectively at 45DAS and (109.67mg g^{-1} soil and 90.67mg g^{-1} soil) in the rhizosphere soil and non-rhizosphere soil respectively at harvest stage compared to all other treatments. The least organic carbon was recorded with rec. NPK (60.51mg g^{-1} soil), (128.20mg g^{-1} soil and 84.43 mg g^{-1} soil) and (74.79mg g^{-1} soil and 62.53 mg g^{-1} soil) before sowing, at 45 DAS and at harvest in both rhizosphere soil and non-rhizosphere soil respectively.

Nitrate nitrogen

The nitrate nitrogen as influenced by the long-term application of manures and fertilizers in the rhizosphere and bulk soils is presented in table-4. The application of 20t of FYM ha^{-1} (30.47 mg g^{-1} soil) recorded significantly higher nitrate nitrogen before sowing as compared to all other

Table 1. Effect of organic manures and fertilizers on soil organic-C in soil (%)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizo-sphere	Non Rhizosphere	Rhizo-sphere	Non Rhizosphere
T1. 5t of FYM	0.56^{e}	0.69^{e}	0.64^{de}	0.67^{cd}	0.61^{c}
T2. 10t of FYM	0.62^{cde}	0.90^{c}	0.76^{c}	0.80^{b}	0.66^{c}
T3. 10t of FYM (Partially decomposed)	0.59^{de}	0.79^{d}	0.71^{cd}	0.75^{bc}	0.64^{c}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	0.64^{bcde}	0.91^{bc}	0.79^{bc}	0.81^{b}	0.68^{bc}
T5. 20t of FYM	0.73^{a}	1.08^{a}	0.94^{a}	1.02^{a}	0.86^{a}
T6. 17.5t of FYM + 25% rec. NPK	0.72^{ab}	1.01^{ab}	0.92^{a}	0.99^{a}	0.81^{a}
T7. 15t of FYM + 50% rec. NPK	0.71^{ab}	0.99^{abc}	0.90^{a}	0.95^{a}	0.78^{a}
T8. 12.5t of FYM + 75% rec. NPK	0.69^{abc}	0.99^{abc}	0.89^{a}	0.94^{a}	0.77^{ab}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	0.67^{abcd}	0.98^{abc}	0.87^{ab}	0.92^{a}	0.76^{ab}
T10. Rec. NPK	0.46^{f}	0.59^{f}	0.56^{e}	0.57^{d}	0.50^{d}
SEM±	0.03	0.04	0.03	0.04	0.04
CD at 5%	0.09	0.11	0.10	0.11	0.11

Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots

Table 2. Effect of organic manures and fertilizers on soil available nitrogen in soil (kg ha^{-1})

Treatments	Before sowing	45 DAS		At harvest	
		Rhizo-sphere	Non Rhizosphere	Rhizo-sphere	Non Rhizosphere
T1. 5t of FYM	277.70^{de}	351.93^{de}	321.34^{bc}	305.51^{c}	296.57^{b}
T2. 10t of FYM	292.56^{bcde}	381.43^{bc}	338.38^{b}	326.51^{bc}	311.82^{b}
T3. 10t of FYM (Partially decomposed)	283.41^{cde}	364.88^{cd}	326.50^{bc}	322.44^{bc}	300.16^{b}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	294.20^{bcde}	386.16^{bc}	344.02^{b}	331.92^{b}	317.90^{b}
T5. 20t of FYM	324.08^{a}	423.97^{a}	414.84^{a}	388.77^{a}	383.78^{a}
T6. 17.5t of FYM + 25% rec. NPK	316.49$_{ab}$	419.25^{a}	400.59^{a}	383.62^{a}	381.41^{a}
T7. 15t of FYM + 50% rec. NPK	328.17$_{a}$	413.03^{a}	396.02^{a}	381.27^{a}	377.46^{a}
T8. 12.5t of FYM + 75% rec. NPK	308.20^{abc}	410.50^{a}	393.28^{a}	379.25^{a}	365.18^{a}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	304.45^{abcd}	400.96^{ab}	392.75^{a}	367.67^{a}	361.88^{a}
T10. Rec. NPK	273.95^{e}	340.10^{e}	309.57^{c}	301.63^{c}	290.83^{b}
SEM±	8.51	8.00	7.78	8.01	11.50
CD at 5%	25.27	23.75	23.11	23.80	34.15

Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots

treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (29.73mg g^{-1} soil), 15t of FYM + 50% rec. NPK (27.21 mg g^{-1} soil), 12.5t of FYM + 75% rec. NPK (26.10 mg g^{-1} soil)andrec. NPK + rec. FYM + Phorate + herbicide + fungicide (25.87 mg g^{-1} soil respectively) in both the rhizosphere and non-rhizosphere soils.The least nitrate nitrogen was recorded due to the application of rec. NPK (16.17mg g^{-1} soil).

The nitrate nitrogen was significantly higher at 45 DAS due to the application of 20t of FYM ha^{-1} in the rhizosphere and non-rhizosphere soils (50.75mg g^{-1} soil and 29.15mg g^{-1} soilrespectively) and was on par with the treatment with the application of 17.5t of FYM

Table 3. Effect of organic manures and fertilizers on ammonical nitrogen (μg^{-1} soil)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizo-sphere	Non Rhizosphere	Rhizo-sphere	Non Rhizosphere
T1. 5t of FYM	72.41^{d}	140.17^{e}	90.41^{e}	80.25^{d}	71.00^{e}
T2. 10t of FYM	82.07^{b}	150.07^{d}	110.57^{c}	98.53^{b}	82.10^{c}
T3. 10t of FYM (Partially decomposed)	76.10^{c}	140.60^{e}	96.71^{d}	90.54^{c}	76.63^{d}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	82.64^{b}	152.27^{d}	110.26^{c}	98.87^{b}	82.94^{c}
T5. 20t of FYM	85.74^{a}	174.20^{a}	120.20^{a}	109.67^{a}	90.67^{a}
T6. 17.5t of FYM + 25% rec. NPK	84.03^{ab}	170.45^{b}	116.25^{b}	107.70^{a}	86.81^{b}
T7. 15t of FYM + 50% rec. NPK	82.12$_{b}$	168.13^{b}	116.10^{b}	101.10^{b}	86.37^{b}
T8. 12.5t of FYM + 75% rec. NPK	83.00^{ab}	160.35^{c}	112.19^{c}	100.83^{b}	84.13^{c}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	82.60^{b}	159.03^{c}	110.63^{c}	100.04^{b}	82.35^{c}
T10. Rec. NPK	60.51^{e}	128.20^{f}	84.43^{f}	74.79^{e}	62.53^{f}
SEM±	0.99	0.95	1.16	1.13	0.65
CD at 5%	2.93	2.83	3.45	3.35	1.94

Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots.

Table 4. Effect of organic manures and fertilizers on nitrate nitrogen (μg^{-1} soil)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizo-sphere	Non Rhizosphere	Rhizo-sphere	Non Rhizosphere
T1. 5t of FYM	20.07^{d}	30.67^{f}	20.15^{c}	20.57^{d}	12.16^{c}
T2. 10t of FYM	25.10^{c}	46.00^{d}	24.01^{b}	26.10^{c}	19.83^{a}
T3. 10t of FYM (Partially decomposed)	20.39^{d}	38.17^{e}	19.60^{c}	20.43^{d}	14.13^{bc}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	25.70^{c}	46.62^{cd}	24.23^{b}	26.73^{c}	16.61^{ab}
T5. 20t of FYM	30.47^{a}	50.75^{a}	29.15^{a}	30.87^{a}	20.70^{a}
T6. 17.5t of FYM + 25% rec. NPK	29.73^{ab}	50.00^{ab}	29.03^{a}	30.10^{ab}	20.13^{a}
T7. 15t of FYM + 50% rec. NPK	27.21^{bc}	48.21^{bc}	26.11^{b}	28.26^{abc}	18.73^{a}
T8. 12.5t of FYM + 75% rec. NPK	26.10^{c}	47.07^{cd}	26.03^{b}	27.50^{bc}	17.23^{ab}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	25.87^{c}	46.63^{cd}	25.14^{b}	27.00^{c}	16.86^{ab}
T10. Rec. NPK	16.17^{e}	28.45^{g}	14.20^{d}	16.77^{e}	10.95^{c}
SEM±	0.96	0.64	0.78	0.92	1.23
CD at 5%	2.86	1.91	2.32	2.74	3.66

Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots

+ 25% rec. NPK (50.00mg g^{-1} soil and 29.03mg g^{-1} soil). These were followed by 15t of FYM + 50% rec. NPK (48.21mg g^{-1} soil and 26.11 mg g^{-1} soil) and 12.5t of FYM + 75% rec. NPK (47.07 mg g^{-1} soil and 26.03 mg g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (46.63 mg g^{-1} soil and 25.14 mg g^{-1} soil which were also on par with each other. The least nitrate nitrogen was found in control treatment with rec. NPK (28.45mg g^{-1} soil and 14.20 mg g^{-1} soil).

The nitrate nitrogen in the rhizosphere and non-rhizosphere soils at harvest was found to be significantly higher due to the application of 20t of FYM ha^{-1} (30.87mg g^{-1} soil and 20.70mg g^{-1} soil) compared to all other treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (30.10mg g^{-1} soil and 20.13mg g^{-1} soil), 15t of FYM + 50% rec. NPK (28.26mg g^{-1} soil and 18.73 mg g^{-1} soil) and 12.5t of FYM + 75% rec. NPK (27.50mg g^{-1} soil and 17.23 mg g^{-1} soil respectively). The least nitrate nitrogen was found to be due to the application of rec. NPK (16.77mg g^{-1} soil and 10.95 mg g^{-1} soil).

Available phosphorus

The impact of long-term application of manures and fertilizers on the available phosphorus in the rhizosphere and bulk soils is presented in table-5. The available phosphorus was found to be significantly higher in the treatment 20t of FYM ha^{-1} (60.12 kg ha^{-1}) before sowing , 97.82 kg ha^{-1} and 81.02 kg ha^{-1})in the rhizosphere and non-rhizosphere soil respectively at 45DAS and (92.98 kg ha^{-1} and 72.13 kg ha^{-1}) in the rhizosphere soil and non-rhizosphere soil respectively at harvest stage compared to all other treatments. The least organic carbon was recorded with rec. NPK (39.43 kg ha^{-1}), (61.24 kg ha^{-1} and 54.40 kg ha^{-1}) and (58.64 kg ha^{-1} and 48.23 kg ha^{-1}) before sowing, at 45 DAS and at harvest in both rhizosphere soil and non-rhizosphere soil respectively.

The organic-C, available-N and available-P were found to be significantly higher in FYM applied treatments compared to the other treatments.Similar results were also reported by Devaraja (2005), Prasanna (2006), Girish (2006), Satish (2009), Rajkumar (2010), Virupaksha (2011) and Narasa Reddy (2012) who reported significantly higher soil organic carbon in treatments applied with 20 tonnes of FYM.

Meena *et al.* (2006) carried out field experiment in a sandy loamy soil using mustard as test crop and found that there was significant change in organic carbon due to Zn and Fe enriched FYM compared to no FYM application. Subbaiah and Kumaraswamy (2000) observed a significant increase in the organic carbon content due to the application of organic manures. The increase in organic carbon content in treatment that received organic manures and NPK through

Table 5. Effect of organic manures and fertilizers on soil available phosphorus in soil (kg ha^{-1})

Treatments	Before sowing	45 DAS Rhizo-sphere	45 DAS Non Rhizosphere	At harvest Rhizo-sphere	At harvest Non Rhizosphere
T1. 5t of FYM	42.14[cd]	68.57[cd]	58.38[cd]	60.61[c]	50.68[de]
T2. 10t of FYM	47.98[b]	79.16[b]	63.88[bc]	70.53[b]	56.79[cd]
T3. 10t of FYM (Partially decomposed)	45.88[bc]	74.10[bc]	61.25[bcd]	66.73[bc]	53.64[de]
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	48.12[b]	81.53[b]	66.41[b]	73.39[b]	58.86[bcd]
T5. 20t of FYM	60.12[a]	97.82[a]	81.02[a]	92.98[a]	72.13[a]
T6. 17.5t of FYM + 25% rec. NPK	57.44[a]	95.17[a]	78.23[a]	89.66[a]	69.05[a]
T7. 15t of FYM + 50% rec. NPK	56.51[a]	93.87[a]	77.54[a]	87.65[a]	67.24[ab]
T8. 12.5t of FYM + 75% rec. NPK	55.07[a]	92.00[a]	75.43[a]	86.27[a]	65.83[ab]
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	54.96[a]	91.13[a]	74.69[a]	85.81[a]	64.79[abc]
T10. Rec. NPK	39.43[d]	61.24[d]	54.40[d]	58.64[c]	48.23[e]
SEM±	1.89	2.60	2.47	2.95	2.68
CD at 5%	5.62	7.73	7.33	8.75	7.96

Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots

fertilizers could be attributed to the direct addition of organic matter through manures and more crop residues. Kaur *et al.* (2005) reported that the application of cow dung and poultry litter increased the soil pH, organic matter, N, available P, exchangeable K, Ca and Mg relative to NPK fertilizer.

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