International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 731-734

Received: 04-07-2018
Accepted: 08-08-2018

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Relationship between the distribution of various phosphate fractions and soil properties in organically amended soil in Mollisol of Uttarakhand

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Abstract
A laboratory experiment conducted to study dynamics of phosphorus in soil under different organic amendment treatments. Soil treated with FYM @ 20 t ha^{-1}, vermicompost @ 20 t ha^{-1}, poultry manure @ 20 t ha^{-1} and paddy straw @ 20 t ha^{-1} respectively with incubated up to 60 days. Different soil properties pH, EC, organic carbon, available phosphorus and different fractions of phosphorus were analysed. All organic amendments application increases the Olsen's P in comparison to no application of organic amendments respectively. The range of phosphorus availability was 15.90-26.28 mg kg^{-1} in organically amended soil during the incubation period. In general, the range of saloid-P, Al-P, Fe-P and Ca-P was observed 4.22-22.40, 8.45-32.43, 12.67-35.38 and 164.85-215.29 mg kg^{-1} respectively, in organically amended soil during the incubation period. Available P is significant correlated with saloid-P (r = 0.973*) at 21 days and Ca-P (r = 0.901*) at 60 days. Organic amendment showed significantly increase of soil EC (dSm^{-1}) and organic carbon (%) but significantly decreases with soil pH. These findings may be used as guide for increasing phosphorus use efficiency and thus fertilizer recommendation.

Keywords: phosphorus, fraction, organic amendments, soil properties

Introduction
Low availability of phosphorus is a major constraint on agricultural productivity in highly weathered tropical soils. Such soils have a significant capacity to sorbs large amounts of phosphorus, taking them out of the soil solution. This limits the availability of inorganic phosphorus for plants, whether it is already contained in the soil or added as fertilizer. The P availablity in soils depends upon many factors, namely the pH of the soil, organic matter content, type of clay and sesquioxides. Phosphorus is an essential nutrient. In spite of its wide distribution in nature, P is a limited resource (Adnan *et al*., 2003) [1]. Organic amendments addition may either increase or decrease P concentration in solution, depending upon the composition of amendments added and/or the form of P fertilizer applied. When organic amendments are added, inorganic and organic products are generated during the partial decomposition of organic waste, and humic substance and organic acids can be absorbed into soil surface, decreasing the potential P adsorption by blocking sites for the formation of complexes with Al, Fe, and Ca (Mkhabela and Warman, 2005) [12]. Organic amendments effects on P sorption ranging from nearly in significant to large reductions in P sorption and significantly increased P concentration in soil solution (Negassa *et al.*, 2008) [15]. Manure amendments soils showed the greatest reduction in P sorption and the highest equilibrium solution P concentration (Dossa *et al.*, 2008) [8].

Materials and Methods
An experiment was done under laboratory condition on the effect of organic amendments on chemical fractions of phosphorus in Mollisol at G.B. Pant University Pantnagar, Uttarakhand and found the relationship between the distribution of various phosphate fractions and soil properties in organically amended soil. Soil samples from several spots (0-15 cm soil depth) were collected from the experimental site. Composite soil samples were processed and analyzed for various physico-chemical properties. Soil treated with different organic amendments *viz*, FYM @ 20 t ha^{-1}, vermicompost @ 20 t ha^{-1}, poultry manure @ 20 t ha^{-1} and paddy straw @ 20 t ha^{-1} respectively with incubated at room temperature. Soil samples were

analyzed for, pH (1:2, soil: water) by digital pH meter (Jackson, 1967) [9], electrical conductivity (1:2, soil: water) by conductivity meter (Bower and Wilcox, 1965) [4] and organic carbon by modified Walkley and Black method (1934) [21], available phosphorus estimated by Olsen's method (Olsen *et al.* 1954) [16] and fractions of phosphorus (Saloid- P, Al-P, Fe-P and Ca-P) analysed by Murphy and Relay (1962) [13], respectively.

Results and Discussion

Effect of Organic Amendments on pH

Data presented in Table1 reveals that in initial days (2 DAI), change in soil pH in all treatments was non-significantly. But at final days (60 DAI) soil pH was decreasing significantly in all treatment during the incubation time. Soil pH range was 7.51-7.84 observed in final days (60 DAI). The maximum decreasing in soil pH during the incubation period, observed in vermicompost @ 20 t ha^{-1} (T_2) treatment while the minimum decreasing in soil pH, observed in paddy straw @ 20 t ha^{-1} (T_5) treatment, respectively. Soil pH was decreasing in all organic amendments treatments due to presence of exchangeable cation in organic amendments (Rasool *et al*., 2008) [17].

Effect of Organic Amendments on Electrical Conductivity (EC)

Data presented in Table 1 reveals that in initial days (2 DAI), change in soil EC in all treatments was non-significantly. But at final days (60 DAI) soil EC was decreasing significantly in all treatment during the incubation time. Soil EC range was 0.45-0.50 dSm^{-1} observed in final days (60 DAI). The maximum increasing in soil EC during the incubation period, observed in poultry manure @ 20 t ha^{-1} (T_4) treatment while the minimum increasing in soil EC, observed in paddy straw @ 20 t ha^{-1} (T_5) treatment, respectively. Soil EC was increasing in all organic amendments treatments due to increases salt accumulation in the soil with increasing its amount which contributes to increase in electrical conductivity of soils. These results corroborate with the findings of (Chaudhary *et al*. 1981; Chahal *et al*., 1984 and Weaver and Read, 1998) [7, 6, 22].

Effect of organic amendments on organic carbon (OC)

Data presented in Table 1 reveals that in initial days (2 DAI), change in soil organic carbon in all treatments was non-significantly. But at final days (60 DAI) soil organic carbon was increasing significantly in all treatment during the incubation time. Soil organic carbon range was 0.73-1.03 % observed in final days (60 DAI). The maximum increasing in soil organic carbon during the incubation period, observed in poultry manure @ 20 t ha^{-1} (T_4) treatment while the minimum increasing in soil organic carbon, observed in paddy straw @ 20 t ha^{-1} (T_5) treatment in organically treated soil, respectively. Addition of organic amendments increases organic matter in the soil which is directly related to organic carbon content in soil (Nand Ram, 1995 and Mathur, 1997) [14, 11].

Effect of Organic Amendments Available Phosphorus

The progressive changes on available P (kg ha^{-1}) content in soil after incubation period are given in Table 1. The general trend of available P after applied of different organic amendments was poultry manure › vermicompost › farm yard manure › paddy straw. The range of available P was 15.25–17.22, 16.55–21.40, 18.50–25.10, 17.36–26.28 and 15.90–22.15 mg kg^{-1} in control, FYM @ 20 t $ha^{-1,}$ vermicompost @ 20 t ha^{-1}, poultry manure @ 20 t ha^{-1} and paddy straw @ 20 t ha^{-1}, respectively during the incubation period of 2 to 60 days. Similar result observed by Bhatia and Harishankar (1982) [3]. Availability of phosphorus increases in organic amendments soil due to large reductions in P sorption. These observations were consistent with the finding of Negassa *et al.* (2008) [15]. Phosphorus sorption decreases possibly due to the competition between phosphate ions and organic compounds that is phenolic, carboxylic and heterocyclic compound, for P retention sites in the soil (Zhang and Mackenzie, 1997) [23].

Table 1: Effect of organic amendments on pH, EC, organic carbon (%) available phosphorus during incubation period

Treatments	pH		EC (dSm^{-1})		OC (%)		Available P (Kg ha^{-1})	
	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final Days (60 DAI)
Control	7.92	7.69	0.39	0.45	0.71	0.73	15.25	14.42
FYM @ 20 t ha^{-1}	7.91	7.51	0.42	0.50	0.72	0.92	16.55	18.06
Vermicompost @ 20 t ha^{-1}	7.90	7.60	0.41	0.48	0.73	0.98	18.50	22.34
Poultry manure @ 20 t ha^{-1}	7.92	7.73	0.38	0.49	0.72	1.03	17.30	25.52
Paddy straw @ 20 t ha^{-1}	7.91	7.84	0.41	0.46	0.72	0.87	15.90	17.11
SEm±	0.823	0.871	0.103	0.116	0.118	0.117	0.21	0.33
CD (P=0.05)	NS	0.274	NS	0.366	NS	0.369	0.68	1.06

NS= Non-significant

Table 2: Effect of organic amendments on different phosphorus fraction during incubation period

Treatments	Saloid-P		Al-P		Fe-P		Ca-P	
	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final days (60 DAI)	Initial days (2 DAI)	Final Days (60 DAI)
Control	3.28	4.41	8.14	10.90	11.77	10.32	161.83	163.91
FYM @ 20 t ha^{-1}	5.13	11.49	11.77	22.99	14.18	25.65	164.85	167.17
Vermicompost @ 20 t ha^{-1}	4.22	15.32	9.35	18.86	13.28	22.99	168.40	201.98
Poultry manure @ 20 t ha^{-1}	6.64	22.40	10.86	32.43	15.09	35.38	170.59	215.29
Paddy straw @ 20 t ha^{-1}	4.82	11.20	8.45	19.75	12.67	23.58	167.57	189.89
SEm±	0.29	0.39	0.44	0.47	0.40	0.59	0.65	0.71
CD (P=0.05)	0.94	1.24	1.41	1.49	1.27	1.85	2.07	2.25

Effect of organic amendments phosphorus fractions

Data presented in Table 2 clearly showed that the fraction of phosphorus content was observed from 3.28-22.40, 8.14-32.43, 11.77-35.38 and 161.83-215.29 mg kg^{-1} for Saloid-P, Al-P, Fe-P and Ca-P, respectively. Ca-P was the dominant inorganic P fraction due to characteristic of the experiment soil. The concentration of Fe-P is always higher then Al-P during the incubation period up to 60 days in the soil treated with organic amendment due to higher activities of Ca and Fe then Al. Similar pattern found by Aggarwal *et al.* (1987) [2]. The addition of organic amendments increases the concentration of Ca-P and Al-P fractions of phosphorus due to increase the concentration of cations present in solution (Cassandra *et al.*, 2008) [5].

Relationship between soil properties and different forms of phosphorus

Simple correlation coefficient between total and different fractions of phosphorus on one hand and various soil properties on the other hand are given Table 3.

All the forms of phosphorus showed negative but non-significant correlation with soil pH at 5 per cent significant level may be due to conversion of loosely held surface adsorbed P into less soluble forms of P (Viswantha and Doodamani, 1991) [20].

However, total-P, saloid-P, Al-P and Fe-P showed significant (at p = 0.05) positive correlation with EC, while available P, Ca-P, total inorganic P and total organic P showed positive correlation but non-significant at 5 per cent significant level.

Table 3: Relationship of different forms of phosphorus with soil properties during incubation period

Forms of phosphorus	pH	EC	OC
Total P	-0.618	0.786**	0.960**
Available P	-0.389	0.577	0.867**
Saloid-P	-0.555	0.773**	0.976**
Al-P	-0.611	0.843**	0.95**
Fe-P	-0.559	0.818**	0.939**
Ca-P	-0.344	0.612	0.888**
Total IP	-0.365	0.531	0.758*
Total OP	-0.222	-0.567	-0.811**

*Significant at 1% **Significant at 5%

Total P, available P, saloid-P, Al-P, Fe-P, and Ca-P showed significant positive correlation with organic carbon at 5 per cent level of significance while total inorganic P showed significant positive correlation with organic carbon at 1 per cent level of significance. Total organic phosphorus showed significant but negative correlation with organic carbon at 5 per cent level of significance.

Total P, available P and other P fractions had significant positive correlation with organic carbon which could be attribute to presence of organic carbon that may promote phosphorus availability presumably by complexing and solubilizing the element from various forms and then rendering them into Olsen's extractable from after mineralization and other chemical transformations. These observation were consistent with the findings of Singh and Datta (1987) [18], Jaggi (1991) [10] and Verma *et al.* (1991) [19] for some soils of Mizoram, H.P. and alluvial and *tarai* soils of U.P, respectively.

Conclusion

From the above findings it may be concluded that all the forms of phosphorus showed negative but non-significant correlation with pH due to conversion of loosely held surface adsorbed P into less soluble from of Phosphorus. Aavailable P, Saloid-P, Al-P, Fe-P and Ca-P had highly significant positive correlation with organic carbon which could be contributed to presence of organic carbon which could be attributed to presence of organic carbon that may promote phosphorus availability presumably by completing and solubilising the element from various forms and then rendering them into Olsen's extractable form after mineralization and other chemical transformations. Addition of organic amendments decreased the soil pH in all treatments while slightly increased the soil EC in soil treated with organic amendments. Maximum increase in the phosphorus availability was observed due to poultry manure @ 20 t ha^{-1} followed by vermicompost @ 20 t ha^{-1} > FYM @ 20 t ha^{-1} > Paddy straw @ 20 t ha^{-1} during the incubation period. Addition of organic amendments showed highly positive correlation with organic carbon in soil during the incubation period. It can be recommended that farmers should use organic amendment which has positive result on phosphorus availability as well as soil properties and they can reduce the cost of phosphatic fertilizers by applying organic amendments.

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