Study of Inorganic Phosphorus Fractions in Vertisols Derived from Different Parent Materials

I Y L N MURTHY, T.G. SASTRY* AND R.K. RATTAN**

Central Institute for Cotton Research, Regional Station, Coimbatore - 641 003

Abstract : *Inorganic Phosphorus fractions in five soils of Vertisol derived from different parent material were determined. On the basis of profile weighted mean; distinct P fractions in the pedons shows the following order :*

NH_4Cl-P : 4 (Granodiorite) > 1 (Grey shale) > 2 (Basalt) = 3 (Granitic-Granodiorite) > 5 (Limestone)

NaOH-P : 1> 2> 3> 4> 5;

NaCl-P : 1 > 2 > 4 > 3 = 5;

CB-P : 1 = 4 > 2 >5 >3;

CBD-P : 4 1 = 2 >5 >3;

HCl-P : 4 >2 >5 >1 >3;

Total P : 4 >1 > 2 > 3 > 5

Available P in the pedons decreased in the sequence 4>3 = 2 >1 >5. Olsen P has a significant and positive correlation with NH_4Cl-P, CB-P, CBD-P and Total P. Path coefficient analysis matrix reveals that NH_4Cl-P, NaOH-P and NaCl-P are significant direct contributors to available P in Vertisol irrespective of parent material. (**Key words** : *Vertisol, parent materials, inorganic phosphorus fractions, Olsen P).*

Parent material sets an inherent limitations to the total phosphorus content in soil. Vertisols formed on basalts, have very high phosphorus status, than that formed from sedimentary rocks. (Finck & Venkateswarlu 1982). It is therefore essential to evaluate the fractionations of soil P as the chemical nature of each form of soil P which determines its relative effectiveness to crop growth. The forms of P in Vertisols developed from different parent materials might give an indication about the availability of phosphorus in the soil *vis-a-vis* the dynamic equilibrium existing among these P fractions and their contribution towards available phosphorus for crop growth.

* Deceased ; ** IARI, New Delhi

MATERIAL AND METHODS

Soil samples from five Vertisol pedons having different parent materials *viz.* Grey shale (Pedon 1), Basalt (Pedon 2), Granitic-granodiorite (Pedon 3), Granodiorite (Pedon 4) and Limestone (Pedon 5) were collected from Suhagpur Dhana (M.P.), C.I.C.R. farm, Nagpur (Mah.), Baklavanvalli, Makthal and Undevalli (A.P.) respectively. Inorganic P fractions. *i.e.* 1N ammonium chloride extractable P (NH_4Cl-P), 0.1N sodium hydroxide extratable P (NaOH-P), 1N sodium chloride extractable P (NaCl-P), 0.3 M citrate-bicarbonate extractable P (CB-P), 0.3M citrate- bicarbonate-dithionite extractable P (CBD-P), 1N hydrochloric acid extractable P (HCl-P) and hydrofluoric-perchloric acid extractable P (Total-P) were estimated.

Since these profiles had relatively high calcium carbonate (6.5 to 46 %), inorganic P fractionation procedure developed by Syers *et al.* (1972) for calcareous soils with slight modification was followed. Phosphorus content in the extracts was determined by the molybdenum blue colour method using ascorbic acid as reducing agent (Watanabe & Olsen 1965). Available P from each horizon of pedons was determined by Olsen's method (Olsen *et al.* 1954).

RESULTS AND DISCUSSION

Distribution of distinct P fractions and available P status (on profile weighted mean basis) is presented in Table 1.

NH4Cl-P : NH_4Cl-P content in pedon 4 (granodiorite) had 10.9 mg kg^{-1}, and found to be much higher than the rest of the pedons. This fraction declined with increaseing the depth in Pedons 1 (grey shale), 3 (granitic-granodiorite) and 2 (Basalt). However, in pedon 4 (granodiorite), it is higher in the subsurface horizons.

NaOH-P : Sodium hydroxide extractable phosphorus was found to be less than 12 mg/kg in pedons 3, 4, and 5. However, in pedon 1 (grey shale) and surface horizons (Ap and A) of pedon 2, it varies from 30 to 76 mg/kg. Pedon 2 shows marked depletion of NaOH-P fraction in C horizon. In all the pedons, a gradual decrease in NaOH-P with increasing depth was noticed.

NaCl-P : Pedon 1 has higher NaCl-P fraction (17.6 to 22.9 mg kg^{-1}) than the rest of the pedons. This fraction in all the pedons decreased with increas-

TABLE 1. Phosphorus fractions and available P in pedons

Horizon	Depth (cm)	Inorganic phosphorus fractions ($mg\ kg^{-1}$) NH4Cl-P	NaOH-P	NaCl-P	CB-P	CBD-P	HCl-P	Total P	Available P ($kg\ ha^{-1}$)
Pedon 1 Grey Shale									
Ap	0-14	7.1	76.0	22.9	10.0	25.0	125.0	936.5	70.0
A	14-40	6.0	51.0	27.6	11.9	20.0	160.0	865.2	22.4
AC	40-70	4.5	27.0	18.6	11.9	16.9	155.0	840.3	15.2
C	70-110+	5.3	30.0	17.6	13.1	15.0	162.0	810.3	18.8
		(5.5)	(40.0)	(20.9)	(12.1)	(18.0)	(154.9)	(847.5)	(25.2)
Pedon 2 Basalt									
Ap	0-14	3.9	61.5	12.4	16.3	20.0	190.0	980.0	56.0
A	14-30	3.6	48.0	11.4	13.8	21.5	185.0	946.2	68.1
AB	30-46	3.0	18.0	7.1	9.4	16.3	177.5	754.3	15.7
AC	46-60	3.3	15.0	6.2	8.3	16.3	200.0	730.0	22.4
C	60-100+	3.6	9.0	7.6	6.3	16.3	190.0	720.0	15.7
		(3.5)	(24.9)	(8.6)	(9.7)	(17.7)	(188.6)	(799.5)	(30.7)
Pedon 3 Granitic-granodiorite									
Ap	0-10	6.3	31.5	8.6	8.3	13.3	102.5	710.4	68.1
A	10-40	4.5	12.0	7.6	6.7	7.5	75.0	680.5	35.8
AC	40-60	2.4	1.9	3.3	7.7	7.0	60.0	598.2	18.8
C	60-80+	1.8	2.3	2.9	8.3	6.9	47.5	464.1	18.8
		(3.5)	(9.5)	(5.5)	(7.6)	(7.9)	(67.8)	(609.6)	(31.3)
Pedon 4 Granodiorite									
Ap	0-14	9.0	9.0	5.7	10.0	24.2	172.5	1384.0	42.1
A	14-36	17.6	6.8	8.1	13.3	25.8	340.0	1267.1	56.0
AC	36-50	16.0	6.8	6.2	13.3	28.2	305.0	1198.9	84.2
C	50-100+	7.1	6.8	6.6	11.7	15.8	150.0	800.6	35.4
		(10.9)	(7.1)	(6.7)	(12.0)	(20.9)	(216.7)	(1040.7)	(47.7)
Pedon 5 Limestone									
Ap	0-10	2.4	11.3	7.6	11.7	15.0	190.0	612.1	25.1
A	10-28	3.0	7.1	5.7	8.3	15.8	187.5	590.4	25.1
AC	28-62	3.6	5.6	4.8	9.6	15.0	170.0	561.2	15.7
C	62-102+	1.8	5.3	4.8	8.3	14.2	170.0	522.4	22.4
		(2.7)	(6.3)	(5.2)	(9.1)	(14.8)	(175.0)	(556.1)	(20.9)

Figures given in parenthesis are profile weighted means.

ing depth except in pedon 4.

CB-P : Pedon 1 and 4 have higher CB-P content (10.0 to 13.3 mg kg^{-1}). granodiorite parent material have the lowest CB-P content .Soils (Pedon 3) dominant in granitic-

CBD-P : CBD-P content was higher in pedon 4 (15.8 to 28.3 mg kg^{-1}) than pedon 3 (granitic-granodiorite). In general, it is found to decrease with the profile depth in all the soils pedons 1, 2 and 3, irrespective of parent materials. In Pedon 4 a gradual increase up to AC horizon was noticed. Inconsistent trend was observed in pedon 5.

HCl-P : HCl-P content is the most dominant of all the fractions. It is found maximum in grey shale (Pedon 1), basalt (Pedon 2) and limestone (Pedon 5) parent material soils and minimum in Granitic-granodiorite (Pedon 3) parent material soils. An increase in HCl-P content with increasing depth was a characteristic feature in pedon 1, 3 and 4.

Total P : Pedon 4 has higher total P content and that of 5 the minimum. This fraction decreases with increasing the depth irrespective of the parent material, from which these have been derived.

On the profile weighted mean basis, distinct P fractions in the pedons showed the following order :
NH_4Cl-P : 4 > 1 > 2 = 3 > 5;
NaOH-P : 1 > 2 > 3 > 4 > 5;
NaCl-P: 1 > 2 > 4 > 3 = 5;
CB-P : 1 = 4 > 2 > 5 > 3;
CBD-P : 4 > 1 = 2 > 5 > 3;
HCl-P : 4 > 2 > 5 > 1 > 3;
Total P : 4 > 1 > 2 > 3 > 5.

Of all the fractions, HCl-P (Ca-P) was found to be the most dominant in calcareous Vertisols. These observations are corroborated with Murthy (1988) and Pundarikakshudu (1989).

The available P (Olsen P) content in the pedons was found to be decreased in pedon sequenced as : 4 > 3 = 2 > 1 > 5.

Correlation coefficients between different P fractions and available P (Table 2) indicated that the Olsen P has a significant and positive correlation with NH_4Cl-P, CB-P, CBD-P, and Total P. Sacheti and Saxena (1974) and Hooker *et al.* (1980) reported similar observations. Vijay *et al.* (1972) also reported in black soils that there was a positive significant correlation between available P and

TABLE 2. Correlation matrix of P fractions.

Parameters	NH_4Cl-P	NaOH-P	NaCl-P	CB-P	CBD-P	HCl-P	Total-P	Olsen P
NH_4Cl-P	1.000							0.624
NaOH-P	-0.364	1.000						0.425
NaCl-P	0.081	0.800	1.000					0.116
CB-P	0.418	0.460	0.401	1.000				0.442
CBD-P	0.714	0.383	0.356	0.604	1.000			0.625
HCl-P	0.685	-0.073	-0.005	0.520	0.773	1.000		0.343
Total P	0.798	0.252	0.244	0.568	0.841	0.606	1.000	0.612

Fe-Al bound P. This suggests that major fraction of the inorganic P is not present in readily available form. The high correlation of the Olsen P with the Fe- Al-P fraction (CBD-P) may be expected because of the greater solubility of Fe and Al bound P at higher soil pH values. NH_4Cl-P significantly correlated with CBD-P, HCl-P, Total P and Olsen P. The high correlation of Olsen P with NH_4Cl-P and Fe-Al-P (CBD-P) indicates that phosphorus might have transformed from these fractions to the less soluble Ca-P (HCl-P). The values of coefficient of simple correlation (r) are less than those of corresponding multiple correlation coefficent ($R = 0.9361$). This indicates that all the inorganic P fractions have combined effect on available P status of soil.

Olsen P was greatly influenced by the other P fractions directly, as well as indirectly. The path coefficent analysis matrix (Table 3) reveals that NH_4Cl-P, NaOH-P and NaCl-P are significant direct contributors to available P and the effect of NH_4Cl-P is negative. A close association also seem to exist between NaOH-P and NaCl-P. The CB-P content has indirect influence on Olsen P via NaOH-P; the CBD-P, HCl-P and total P contribute indirectly via NH_4Cl-P to available P content.

Inorganic P fractions were in general, high in pedons derived from grey shale and granodiorite parent materials. HCl-P (Ca-P) is the dominant P fraction, irrespective of the parent material. The NH_4Cl-P, NaOH-P and NaCl-P fractions are significant and direct contributors to Olsen's P.

TABLE 3. Path coefficient analysis matrix of the direct and indirect influence of distinct phophorus fractions on available phosphorus Direct effects are on main diagonal.

Fractions of P	NH_4Cl-P	NaOH-P	NaCl-P	CB-P	CBD-P	HCl-P	Total P
NH_4Cl-P	-0.952*	-0.0383	-0.0723	0.0267	0.2693	-0.2456	-0.2670
NaOH-P	0.035	1.0534*	-0.7094*	0.0294	0.1447	0.0264	-0.0845
NaCl-P	0.078	0.8437*	-0.8858*	0.0256	0.1343	0.0020	-0.0816
CB-P	0.398	0.4847	-0.3554	0.0638	0.2277	-0.1865	-0.1901
CBD-P	0.680*	0.4041	-0.3154	0.0385	0.3771	-0.2772	-0.2814
HCl-P	0.652*	-0.0777	0.0051	0.332	0.2917	-0.3584	-0.2029
Total-P	0.760*	0.2661	-0.2161	0.0363	0.3175	-0.2175	-0.3343

Residual 0.123; * Statistically significant at $p = 0.05$

ACKNOWLEDGEMENTS

Senior author is thankful to IARI, New Delhi for awarding fellowship and to Dr. A.K. Basu, Former Director, Central Institute for Cotton Rearch,Nagpur for granting study leave.

REFERENCES

Finck, A. & Venkateswarlu, J. (1982) Chemical properties and fertility management of Vertisols. Proc. Symp. Vertisols and Rice Soils of the Tropics. *Trans. 12th Int. Congr. Soil Sci.* New Delhi, India, 61-79.

Hooker, M.L., Peterson, G.A., Sander, D.H. & Daigger, L.A. (1980) Phosphate fractions in calcareous soils as altered by time and amounts of added phosphate. *Soil Sci. Am. J.*, **44** : 269-277.

Murthy, A.S.P. (1988) Vertisols of India and their management -*Advan. soil science*, **8** : 152-214.

Olsen, S.R., Cole, C.V., Watanabe, F.S. & Dean, L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *Circ. USDA* 939.

Pundarikakshudu, R. (1989) Studies of the phosphate dynamics in Vertisol in relation to the yeild and nutrient uptake of rainfed cotton. *Expl. Agric.*, **25** : 39-45.

Sacheti, A.K. & Saxena, S.N. (1974) Correlations between inorganic phosphorus fractions and soil tests. *J. Ind. Soc. Soil Sci.* **22** (1) : 57-59

Syers, J.K., Smillie, G.W. & Williams, J.D.H. (1972) Calcium fluoride formation during extraction of calcareous soils with fluoride : I. Implications to inorganic P fractionation schemes. *Soil Sci. Soc. Am. Proc.*, **36** : 20-25.

Vijay, K.B., Bhatnagar, R.K. & Seth, S.P. (1972) Froms of inorganic phosphorus in medium black soils of Chambal commanded area. *J. Ind. Soc. Soil Sci.* **20** (4) : 355-362.

Watanabe, F.S. & Olsen, S.R. (1965) Test of an ascorbic acid method for determining phosphorus in water and sodium bicarbonate extracts from soil. *Soil Sci. Soc. Am. Proc.*, **29** : 677-678.