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PHOSPHORUS FRACTIONS IN ALFISOLS AND ENTISOLS AND THEIR RELATION TO SOIL PROPERTIES

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ABSTRACT

Eight soil series differing in soil characteristics were analysed for discrete soil P fractions and their relationships established. Saloid P constituted only 0.5 to 0.6 per cent of the total P content of the Alfisols and Entisols. Clay content negatively correlated with saloid-P (r=-0.661**). There was a highly significant and positive correlation between saloid-P and Bray 1-P (r=0.926**). Al-P constituted 5.2 to 15.6 per cent of the total P and Fe-P contributed 7.8 to 21.0 per cent of the total P. Ca-P constituted the highest fraction occupying 23.6 to 53.3 per cent of the total P.

KEY WORDS : P fractions, Alfisols, Entisols, Distributions

Distribution of forms of phosphorus in soils are related to the organic carbon content (Weil *et al.*, 1988) active aluminium and iron content (Cajuste *et al.*, 1994 ; Mayer & Jarrell, 1995), clay and calcium carbonate contents (Guzel and Ibrikcl, 1994 ; Haffman *et al.*, 1996) and cation exchange capacity (Presetyo and Gilkes, 1994). In as much as the fixation and distribution of phosphorus in soil define its availability and uptake by plants which is especially so in Alfisols and Entisols containing high amounts of aluminium and iron with highly acidic pH. In Tamil Nadu, Alfisols and Entisols occupy considerable extent on which the economy of the formers exists. An attempt has therefore has therefore been made to evaluate the extent of distribution of the different fractions of phosphorus in these soils and to establish their relationship with the physico-chemical properties.

MATERIALS AND METHODS

Surface (0-15 cm) and sub surface (15-30 cm) soil samples representing the following eight soil series were collected, processed and taken up for physical and chemical characterisation (pH, Al and Fe) by standard procedures given by Jackson (1973). Organic carbon content was determined by rapid titration method of Walkley and Black (1934). The CEC was determined following the methods described by Schollenberger and Dreibelbis (1930). Clay content was estimated following International Pipette method and calcium carbonate was estimated by the rapid titration method described by Piper (1966).

1. Thulukkanur series - Typic Haplustalf
2. Kallivyal series - Aquic Haplustalf
3. Vannapatti series - Typic Ustorthents
4. Shyamalagounder-pudur series - Typic Ustorthents
5. Irugur series - Typic Ustorthents
6. Manupatti series - Typic Ustorthents
7. Dasarapatti series - Typic Chromusterts
8. Suryanallur series - Typic Haplustalf

The samples were further analysed for total phosphorus and different discrete forms of P namely, saloid-P, Aluminium-P (Al-P), Iron (Fe-P), Calcium - (Ca-P), Reductant soluble Fe-P (Red. sol. Fe-P), Occluded Fe+Al-P (Fe+Al-P) and organic phosphorus (Org.P) by the method of Chang and Jackson (1957) as modified by Fife (1959). Bray 1-P was also estimated (Jackson, 1973). The relationships between P fractions and soil properties were established by calculating simple correlations.

RESULTS AND DISCUSSION

The soil varied from 6.0 to 7.1 in pH, 2.2 to 9.5 g kg^{-1} in organic carbon, 12.0 to 27.3 c.mol (p^+) kg^{-1} in Cation Exchange Capacity (CEC), 15.5 to 31.3 per cent in clay content, 20.0 to 31.2 mg kg^{-1} in active aluminium, 20.4 to 80.3 mg kg^{-1} in iron content 0.29 to 0.97 per cent in $CaCO_3$ content (Table 1). Distribution of P fractions and their percentage to the total P are fertilished in tables 2 and 3

Table 1. Properties of experimental soils

Series	Depth (cm)	pH	Org.C (g/kg)	CEC c.mol (p⁺) kg⁻¹	Clay (%)	Al (mg/kg)	Fe (mg/kg)	$CaCO_3$ (%)
Tulukkanur	0-15	6.8	4.8	12.8	15.5	22.4	20.4	0.43
	15-30	6.8	4.4	12.0	20.1	23.2	22.7	0.45
Kallivayal	0-15	6.4	5.0	16.7	24.1	27.6	49.1	0.52
	15-30	6.4	4.6	15.9	21.1	28.5	45.6	0.56
Vannapatti	0-15	6.7	8.1	23.1	26.6	26.4	75.4	0.48
	15-30	6.6	7.5	22.3	29.9	26.3	69.2	0.51
Syamalagoundanpudur	0.15	6.6	2.5	14.6	24.3	24.8	44.2	0.39
	15-30	6.5	2.2	13.8	27.4	22.6	44.8	0.46
Irugur	0-15	6.8	6.3	12.0	25.4	26.4	80.3	0.70
	15-30	6.9	6.0	18.6	24.2	24.3	71.2	0.72
Manupatti	0-15	6.0	3.9	15.7	20.8	30.0	59.7	0.29
	15-30	6.0	3.5	14.8	25.2	31.2	53.2	0.35
Dasarapatti	0-15	7.0	9.5	27.3	30.4	20.0	65.3	0.97
	15-30	7.1	9.0	25.9	26.8	22.4	35.4	0.94
Suryanallur	0-15	6.4	2.8	16.9	28.9	26.2	56.5	0.86
	15-30	6.5	2.4	15.9	31.3	27.9	57.2	0.92

respectively. The correlation coefficient between physico-chemical properties and P fractions are furnished in Table 4.

The saloid P ranged from 1.19 mg kg⁻¹ in Suryanallur soil series (Typic Haplustalf) to 1.35 mg kg⁻¹ in Tulukkanur series (Typic Haplustalf) which constituted 0.5 to 0.6 per cent of the total P content of soil (Table 4). It is observed that as the clay content increased the saloid P content decreased and significantly negative correlation

Table 2. Distribution of P fractions (mg/kg) in the surface and subsurface soil

Soil series	Depth (cm)	Bray-P (kg/hg)	Saloid-P	Active-P Al-P	Fe-P	Occluded-P Ca-P	Red.sol Fe-P	Fe+Al-P	Org.P
Tulukkanur	0-15	10.7	1.35	12.5	25.0	110.9	22.6	5.3	37.6
	15-30	9.0	1.34	12.6	25.7	108.7	21.3	4.2	30.5
Kallivayal	0-15	8.2	1.28	16.2	35.0	101.0	16.5	2.5	27.5
	15-30	9.0	1.30	15.8	34.6	104.0	17.2	2.6	21.4
Vannapatti	0-15	8.5	1.28	32.5	45.0	103.3	24.0	3.9	40.0
	15-30	8.4	1.27	33.0	45.8	99.7	23.5	3.7	33.2
Syamalagoundanpudur	0-15	10.2	1.30	12.5	24.5	101.3	36.2	5.0	60.4
	15-30	9.3	1.31	12.2	23.9	101.9	33.9	4.8	53.1
Irugur	0-15	10.9	1.32	15.0	25.0	98.6	38.3	5.6	63.0
	15-30	10.5	1.34	14.8	24.2	99.7	36.3	5.3	56.2
Manupatti	0-15	7.9	1.26	32.5	45.0	57.4	37.8	4.8	59.6
	15-30	7.8	1.25	33.0	45.5	58.4	35.9	5.2	51.5
Dasarapatti	0-15	9.5	1.27	26.1	30.5	115.3	45.4	8.3	75.7
	15-30	9.7	1.29	25.9	30.9	113.7	32.8	7.9	68.2
Suryanallur	0-15	6.9	1.20	33.5	45.8	52.6	33.5	4.4	55.8
	15-30	5.6	1.19	34.2	46.2	53.2	[illegible]	3.8	[illegible]

Table 3. Percentage of P fractions of the total P

Soil series	Depth (cm)	Saloid P	Actice-P			Occluded-P		Org.P
			Al-P	Fe-P	Ca-P	Red.sol.Fe-P	Fe+Al-P	
Tulukkanur	0-15	0.63	5.8	11.6	51.5	10.5	2.5	17.5
	15-30	0.66	6.2	12.6	53.3	10.4	2.1	14.9
Kallivayal	0-15	0.64	8.1	17.5	50.5	8.3	1.3	13.8
Vannapatti	0-15	0.51	13.0	18.0	41.3	9.6	1.6	16.0
	15-30	0.53	13.7	19.1	41.5	9.8	1.5	13.8
Syamalagoundanpudur	0-15	0.54	5.2	10.1	41.9	15.0	2.1	25.0
	15-30	0.57	5.3	10.3	44.1	14.7	2.1	23.0
Irugur	0-15	0.55	6.2	10.3	40.8	15.8	2.3	26.4
	15-30	0.56	6.2	10.2	41.9	15.3	2.2	23.6
Manupatti	0-15	0.53	13.7	18.9	24.1	15.9	2.0	25.0
	15-30	0.54	14.3	19.7	25.3	15.6	2.3	22.3
Dasarapatti	0-15	0.32	6.6	7.8	29.4	11.6	2.1	19.3
	15-30	0.44	8.9	10.6	39.1	14.7	2.7	23.5
Suryanallur	0-15	0.53	15.0	20.5	23.6	15.0	2.2	25.0
	15-30	0.54	15.6	21.0	24.2	15.0	1.7	21.9

Table 4. Simple correlation between soil properties and P fractions

X	Y	r(n = 16)
pH	Bray - P	0.600*
	Fe - P	- 0.591*
	Ca - P	0.742**
	Sal - P	0.571*
Organic C	Ca - P	0.579*
Clay	Sal. P	- 0.661**
	Al - P	0.557*
Al	Sal - P	- 0.526*
	Bray - P	- 0.650*
	Fe - P	0.694**
	Ca - P	- 0.744**
Sal - P	Bray - P	0.926**
Al - P	Sal. P	- 0.824**
Al - P	Bray - P	- 0.765**
Fe - P	Bray - P	- 0.867**
Ca - P	Bray - P	0.792**
Al - P	Fe - P	0.920**
	Ca - P	- 0.639**
Fe - P	Ca - P	- 0.702**

was observed (r = -0.661**). Similar results were reported by Prakash *et al.*, (1993). Same trend was also observed in the relationship between saloid P and active aluminium (r = -0.526*). Saloid P showed positive and significant correlation with pH (r = 0.571*). One unit increase in pH increased saloid P by 0.07 mg kg^{-1}, while it decreased with increasing amount of active Aluminium.

Bray 1-P ranged from 5.6 to 10.9 kg ha^{-1} and its correlation coefficients with Al-P, Fe-P, Ca-P and organic P fractions were worked out. There was a very close positive and significant correlation between saloid P and Bray P (r = 0.926**). It was positively correlated with Ca-P (r = 0.792**) and negatively correlated with Al-P (r = -0.765**) and Fe-P (r = -0.867**). Further Bray-P was positively related to pH (r = 0.600*) and negatively with active aluminium (r = -0.650*).

The Al-P ranged between 12.5 and 34.2 mg kg^{-1} and it contributed 5.2 to 15.6 per cent of the total P in the soil. Suryanallur soil series recorded the highest and Tulukkanur series recorded the lowest. Fe-P varied from 24.9 to 46.2 mg kg^{-1} in Syamalagoundanpudur series and Suryanallur series, respectively, contributing to about 7.8 to

21.0 per cent of the total P content. Ca-P ranged from 52.6 to 115.3 mg kg^{-1} in Suryanallur and Dasarapatti series. respectively. This fraction constituted the predominant fraction occupying about 23.6 to 53.3 per cent of the total P content in the surface soils. Though the soils belong to acid soil group except Dasarapatti series, with pH ranging from 6.0 to 7.1 where sufficient amount P fixation leading to non-availability of P to crops, Ca-P was observed to be the major fraction. This peculiar situation might be due to moderately higher amount of organic carbon in these soils which might have been hydrolyzed by the acid extractant namely 0.5 N H_2SO_4 used in the fractionation procedure.

The organic P ranged from 21.4 to 25.7 mg kg^{-1} which constituted 10.9 to 26.4 per cent of the total P content of the soil.

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INFLUENCE OF ORGANIC AND INORGANIC FERTILISATION AND PLANT DENSITY ON PRODUCTION POTENTIAL OF RICE-RICE CROPPING SYSTEM

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An investigation was carried out at Agricultural College, Madurai, Tamil Nadu, to study the direct and residual effects of organic manures integrated with inorganic N levels and plant densities on the production potential of rice-rice cropping system. Application of cattle manure (FYM or sheep penning) had pronounced direct effect on rice grain yield (7.92 and 7.86 t ha^{-1}, respectively) as against 7.41 t ha^{-1} with green manure (*Sesbania rostrata*) application in *kharif* season, and residual effect with 6.01 and 5.71 t ha^{-1} respectively, in *rabi* season. Though the plant densities (8.33 and 6.67 lakh hills ha^{-1}) did not affect the grain yield significantly in *Kharif*, low plant density recorded higher grain yield (5.61 t ha^{-1}) in *rabi* season. The most economical level of N was found to be 160 kg ha^{-1} for both the seasons.

In order to meet the food demand of the ever increasing human population, it is imperative to maximise the productivity of rice, the staple food, as land and water resources are limited for extending the area under rice (Chauhan *et al.*, 1985). To harness the natural resources of crop