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DISTRIBUTION AND FORMS OF PHOSPHORUS IN THE KOLE SOILS

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Abstract: The different forms of phosphorus, such as saloid-P, Al-P, Fe-P, reductant soluble-P, occluded-P, Ca-P and organic-P, as well as total-P were determined in the surface and subsur face soils collected from 15 locations in the kole land area of Kerala State. The mean values of the different fractions showed that organic-P was the largest fraction, followed in order by Fe-P, reductant soluble-P, Al-P, Ca-P, occluded-P and saloid P. The most abundant inorganic fraction was Fe-P which constituted 29.75% of the total P in the surface layers and 37.46% in the subsurface layers. Reductant soluble-P constituted 23.91% and 22.16% respectively of the total P in the surface and subsurface horizons. Occluded-P formed 1.81% of the total P in the surface soils and 1.50% of the total P in the subsurface soils. Of the total P, 4.15 and 7.09% respectively were found in the Ca-P form in the surface and subsruface layers. The Fe-P was significantly and positively correlated to the total sesquioxides and the Ca-P was significantly and positively correlated with total CaO.

INTRODUCTION

The kole soils are highly acidic submerged rice growing soils extending over an area of approximately 11,000 hectares in the Trichur and Malappuram districts of Kerala State. Scientific studies on the fertility aspects of these soils are meagre and hence the present investigation was undertaken to obtain a clearer picture of the chemical nature and distribution of the native phosphorus in these soils.

Hameed (1975) investigated the fertility status of the kole soils and found that in the surface layers of the seven profiles examined, total P_2O_5 varied from 0.09 - 0.24%. In all the profiles, total P_2O_5 decreased with depth. No attempt was made in this study to fractionate the native soil phosphorus. Aiyer and Nair (1979) studied the phosphorus fractions in the major rice soils of Kerala. Fe-P fraction was the most dominant in all the soils accounting for 21.8 - 39.3% of the total P in the soils. Tandon (1980) has discussed the distribution of the different forms of phosphorus in Indian soils and concluded that Ca-P constituted 40-50% of total P in most neutral to alkaline soils. In acid soils the increase in Al-P and Fe-P was less than the decrease in Ca-P, mainly because of the predominance of the reductant soluble and occluded forms.

MATERIALS AND METHODS

Surface (0-20 cm) and subsrface (20-40 cm) soil samples collected from 15 locations in the kole area were used in this study. The soils after collection were air-dried, powdered, screened through a 2 mm sieve and stored. The general physico-chemical properties of the samples were determined by adopting standard analytical procedures. The fractionation of the native soil phosphorus was carried out by adopting the procedure of Chang and Jackson (1957) as modified by Peterson and Corey (1966).

RESULTS AND DISCUSSION

The general physico-chemical characters of the soils are presented in Table 1 and the results of phosphorus fractionation in Table 2. There was appreciable variation in the relative proportion of the various phosphorus fractions in the soils studied. Mean

values showed that in the surface layers organic phosphorus constituted the largest fraction followed in order by Fe-P, reductant soluble P, Al-P, Ca-P, occluded-P and saloid-P. In the subsurface layers, Fe-P was the major fraction, followed by organic P, reductant soluble P, Ca-P, Al-P, occluded-P and saloid P, in that order.

Saloid P: Saloid P varied from 4.2 - 17.9 ppm (mean 9.2 ppm) in the surface layers and from 3.0 - 11.5 ppm (mean 6.1 ppm) in the subsurface layers. The mean percentage contribution of saloid P to total P was 0.92 and 0.90% respectively in the surface and subsurface layers. The variation of saloid P between the surface and subsurface horizons was significant.

Saloid P was the smallest of the native P fractions. It was positively correlated with organic carbon (r = 0.4296) and the surface soils which contained more of organic carbon contained more of this fraction.

Al-P: This fraction varied between 13.6 - 71.2 ppm (mean 35.2 ppm) in the surface layers and from 6.8 - 44.1 ppm (mean 21.5 ppm) in the subsurface layers. The mean percentage contribution of Al-P to total P was 3.50 and 3.17 respectively in the two layers. This fraction generally decreased with depth and the variation between the two layers was significant.

The Al-P was the most abundant inorganic phosphorus fraction in the kole soils next to Fe-P and reductant soluble-P. The high percentage of aluminium sequioxide normally present in these soils and the low pH would explain the dominance of this fraction in these soils. Al-P was positively correlated with silt (r = 0.1317), clay (r = 0.2361) and Fe-P (r = 0.4087). These results are in agreement with the findings of earlier workers like Vijayachandran (1966), and Kothandaraman and Krishnamoorthy (1979) for Tamil Nadu soils.

Fe-P: The Fe-P fraction was the most abundant inorganic P fraction in the kole soils. It ranged from 167.6 - 549.2 ppm (mean 298.9 ppm) in the surface layers and from 137.8 - 447.2 ppm (mean 254.3 ppm) in the subsurface layers, the mean contribution to total P being 29.75 and 37.46% respectively in the two layers. At all locations the Fe-P decreased with depth and the variation between the two layers was significant.

The predominance of Fe-P in soils is to be attributed to the high content of the sesquioxides and low pH as reported by Chu and Chang (1960). This fraction was positively correlated to silt (r = 0.4603), clay (r = 0.5233), total sesquioxides (r = 0.6709). The present results are in conformity with the findings of Kothandaraman and Krishnamoorthy (1979) for Tamil Nadu soils and of Aiyer and Nair (1979) for Kerala soils.

Reductant soluble-P: This fraction ranged from 32.5 - 443.4 ppm (mean 240.2 ppm) in the surface layers and from 18.3 - 278.8 ppm (mean 150.4 ppm) in the subsurface layers. The extent of contribution of reductant soluble-P to total P was 23.91 and 22.16 per cent respectively in the two horizons. This fraction decreased with depth at all locations except at Kanjani. There was no significant difference for this fraction between the two layers.

Table 1. General physico-chemical characters of soils

Location	Depth cm	pH	CEC me/100g	Organic C %	Total P_2O_5 %	Total CaO %	Total sesqui-oxides %
1	2	3	4	5	6	7	8
Chettupuzha	0-20	5.0	11.4	2.16	0.34	0.15	21.5
	20-40	4.2	17.3	1.07	0.24	0.14	15.9
Manakkody Varyam	0-20	5.0	9.3	2.19	0.36	0.19	25.8
	20-40	4.6	18.4	1.62	0.20	0.27	29.0
Manakkody Anjumuri	0-20	5.2	6.4	0.98	0.19	0.19	25.8
	20-40	4.4	8.2	0.23	0.16	0.09	10.0
Eravu	0-20	5.2	6.4	1.62	0.24	0.11	16.0
	20-40	5.2	9.3	0.93	0.16	0.07	15.9
Kanjani	0-20	5.1	6.3	1.10	0.14	0.14	2.4
	20-40	4.4	7.2	2.57	0.23	0.18	4.0
Manaloor	0-20	4.0	6.4	1.65	0.24	0.11	14.2
	20-40	4.4	7.2	0.58	0.14	0.09	10.1
Thekke Konjira	0-20	4.4	7.2	2.07	0.21	0.15	11.0
	20-40	4.0	15.4	1.50	0.10	0.05	6.8
Kannothu	0-20	4.2	8.5	1.29	0.22	0.05	13.0
	20-40	4.0	15.4	0.91	0.14	0.05	12.4
Mullaseri	0-20	3.9	5.4	1.28	0.17	0.14	5.6
	20.40	3.9	6.1	0.96	0.13	0,13	7.3
Anthikad	0-20	4.1	5.6	2.28	0.17	0.14	6.5
	20-40	3.9	5.0	0.98	0.13	0.14	8.9
Chezhur	0-20	4.0	11.4	1.99	0.20	0.06	12.5
	20-40	3.4	6.5	0.85	0.09	0.06	15.5
Alappadu	0-20	5.4	5.4	0.58	0.23	0.18	24.6
	20-40	5.1	6.1	0.14	0.13	0.12	22.1
Pullu	0-20	4.6	21.5	2.16	0.30	0.16	22.0
	20-40	4.4	18.3	1.51	0.19	0.10	22.7
Fazhuvil	0-20	4.7	11.4	1.86	0.27	0.13	14.5
	20-40	4.5	12.6	1.43	0.18	0.08	15.4
Cherupu	0-20	4.6	18.5	2.58	0.17	0.10	19.1
	20-40	4.3	21.6	1.46	0.12	0.07	21.3

Table 2. Fractionation of native soil phosphorus (ppm)

Location	Death cm	Total P	Saloid P	Al-P	Fe-P	Red-P	Occl-P	Ca-P	Org. P
1	2	3	4	5	6	7	.8	9	10
Chettupuzha	0-20	1493.8	11.4	71.2	487.6	225.5	20.4	122.5	555.2
	20-40	1045.6	9.4	6.8	391.4	63.9	5.6	195.0	373.5
Manakkody Varyam	0-20	1572.0	8.0	44.1	549.2	443.4	23.1	120.8	383.4
	20-40	870.5	4.4	33.7	447.2	50.4	11.6	190.8	132.4
Manakkody Anjumuri	0-20	828.5	6.5	30.5	309.6	56.5	19.0	53.3	353.1
	20-40	698.8	5.5	25.9	280.2	109.3	8.0	83.3	186.6
Eravu	0-20	1048.5	9.3	42.2	349.3	288.9	16.4	23.8	318.6
	20-40	690.3	7.1	32.7	251.5	225.2	7.8	38.5	127.5
Kanjani	0-20	627.7	6.1	13.6	168.9	32.5	17.9	15.0	373.7
	20-40	998.2	11.5	9.6	137.8	253.6	15.0	27.5	543.2
Manaloor	0-20	1033.3	11.8	23.9	358.5	303.6	18.4	38.8	278.5
	20-40	616.3	4.7	20.9	303.5	135.7	13.3	27.3	110.9
Thekke Konjira	0-20	920.5	17.9	68.7	267.3	287.5	13.9	52.3	512.9
	20-40	446.3	9.3	44.1	236.2	18.3	11.1	17.0	110.3
Kannothu	0-20	970.5	10.4	25.5	295.2	361.3	16.2	17.8	244.1
	20-40	601.1	4.9	21.8	158.5	278.8	7.6	735	122.0
Mullaseri	0-20	724.1	11.1	48.3	167.6	184.3	14.2	14.0	284.6
	20-40	549.5	3.9	8.4	187.8	167.8	7.6	7.0	167.0
Anthikad	0-20	759.9	12.1	32.5	170.3	228.0	6.4	39.8	270.8
	20-40	549.9	6.6	20.7	150.8	166.2	7.3	42.1	156.2
Chezhur	0-20	853.9	7.1	24.7	272.9	194.5	15.8	8.3	330.6
	20-40	423.3	3.0	21.5	208.2	52.6	11.1	6.2	120.7
Alappadu	0-20	986.9	7.6	16.0	258.8	432.2	33.3	19.3	218.7
	20-40	559.9	6.2	9.4	235.5	142.5	19.8	32.3	114.2
Pullu	0-20	1313.8	9.6	23.2	320.5	258.4	21.6	47.3	631.2
	20-40	808.7	8.5	21.4	220.1	255.0	7.6	33.8	262.3
Pazhuvil	0-20	1183.9	5.5	20.2	209.4	276.3	14.4	29.0	629.1
	20-40	792.9	3.1	16.0	268.6	250.2	8.9	22.5	223.6
Cherup	0-20	752.9	4.2	43.7	296.5	130.3	22.4	21.5	234.3
	20-40	530.3	3.1	29.6	268.6	86.6	10.8	10.8	120.8
Surface mean		1004.68	9.2	35.2	298.9	240.2	18.2	41.7	354.6
Subsurface mean		678.77	6.1	21.5	254.3	150.4	10.2	48.1	184.8

Reductant soluble-P was the second most abundant fraction in the kole soils. The present results are in conformity with the findings of Vijayachandran and Raj (1978) who reported that in the acid soils of South India up to 40 per cent of all P may be reductant soluble. According to Chang and Jackson (1958) highly weathered soils always contained appreciable amounts of reductant soluble-P.

Occluded-P: The variation in the occluded-P content was from 6.4 - 33.3 ppm (mean 18.2 ppm) in the surface layers and from 5.6 - 19.8 ppm (mean 10.2 ppm) in the subsurface layers. The percentage contribution of this fraction to total P in the two layers was 1.81 and 1.50 respectively. This fraction decreased with depth at most locations and the difference between the two layers was significant.

Occluded-P showed positive correlation with total sesquioxides (r = 0.3785), Fe-P (r = 0.3343), reductant soluble-P (r = 0.4432) and organic carbon (r = 0.3624).

Ca-P: The Ca-P varied from 8.3 - 122.5 ppm (mean 41.7 ppm) in the surface layers and from 6.2 - 195.0 ppm (mean 48.1 ppm) in the subsurface layers. The mean contribution of this fraction to total P in the two layers was 4.15 and 7.09 per cent respectively. At most locations, this fraction decreased with depth, while in some places there was an increase with depth. The variation between the two layers was not significant.

As could be expected, Ca-P showed significant positive correlation with the CaO content (r = 0.6046). It was correlated positively with the soil pH (r = 0.1694), silt (r = 0.4127), clay (r = 0.4826), organic C (r = 0.1109) and CEC (r = 0.3252). Similar results have been reported by Jose (1973) and by Sharma *et al.* (1979).

Organic-P: This fraction ranged from 212.9 - 555.2 ppm (mean 354.6 ppm) in the surface layers and from 110.3 - 543.2 ppm (mean 184.8 ppm) in the subsurface layers. The average contribution of this fraction to total P was 35.29 and 27.23 per cent respectively in the two layers. At all locations, except at Kanjani, organic P decreased with depth. The variation of this fraction between the two layers was significant.

Organic P constituted the largest phosphorus fraction in the surface layers and the second largest in the subsurface layers. Brito-Mutunayagam and Koshy (1951) also observed that organic-P constituted one of the largest phosphorus fractions in the acid soils of Kerala.

Organic-P showed positive correlation with organic carbon (r = 0.6622), clay (r = 0.2288), pH (r = 0.2739), total sesquioxides (r = 0.0129).

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