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Phosphorus Fixation Capacity of Tamil Nadu Soils

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The P fixation capacity of the four major soil groups of Tamil Nadu was estimated. The P fixation capacity of the soils ranged from 20 to 183 mg P/100 g of soil with a mean value of 85 mg P/100 g of soil. The soils studied were found to differ widely in their P fixation capacity, the highest value of P fixation capacity was recorded in the high level laterite soils of Ootacamund and the lowest in the alluvial soil of Melalathur. The P fixation capacity was found to be positively correlated with clay ($r=0.632^{***}$), total R_2O_3 ($r=0.483^{**}$), Al_2O_3 ($r=0.533^{**}$). The relationships of P fixation capacity with clay, total R_2O_3, Fe_2O_3, free Fe_2O_3 and organic carbon were more close in acid soils than neutral and alkaline soils. In alkaline soils, the influence of free $CaCO_3$ was more, whereas in the neutral soils, Fe_2O_3, CEC and exchangeable Ca influenced the P fixation capacity of soils.

In the present period of economic stress and the scarcity of P fertilizer in India, the efficient use of P fertilizers and the recovery of P by plants has been the subject of many studies of P fixation. The P fixation in soil is influenced by a number of factors such as pH, sesquioxides, $CaCO_3$ and clay contents. The P fixation of the Indian soils has been reviewed by Datta *et al.* (1971). However, there seems to have been very little attempt to assess the contribution of each of the various soil characteristics influencing the P fixation in Tamil Nadu soils. Though the problems of P fixation has been studied extensively in the laterite and acid soils of Tamil Nadu (Vijayachandran, 1966; Mathan and Durairaj, 1967), the behaviour of P has not been sludied in detail in red, black and alluvial soils which form the major area of Tamil Nadu soils. The present investigation was therefore taken up to study the P fixation capacity of the important soil groups of Tamil Nadu and the soil characteristics influence the P fixation.

MATERIAL AND METHODS

Thirty four soil samples (0-15 cm) representing the four major soil groups viz., red, black, laterite and alluvial collected from the different parts of Tamil Nadu were used in this study. Phosphate fixation capacity was estimated by the method of Patel and Viswanath (1946) Mechanical analysis was done by International Pipette method, $CaCO_3$ by rapid titration method and organic carbon by Walkley and Black method as described by Piper (1950). Sesquioxides, Fe_2O_3 and Al_2O_3 were estimated from HCl extract of the soils as per standard proce-

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TABLE I. Mean values of Physico and Chemical Properties of soils and P fixation capacity

Properties	All soils	Red	Black	Laterite	Allu-vial	Group I (Acid soils)	Group II (neutral soils	Group III (Modera-tely alka-line soils)
Coarse sand %	13.95	18.24	11.97	11.39	14.21	12.83	17.81	13.22
Fine sand %	44.32	52.37	35.90	41.24	47.76	43.40	50.06	42.24
Silt %	8.12	5.53	8.10	12.28	6.78	10.59	6.10	6.57
Clay %	30.12	22.58	38.89	37.21	21.78	32.93	23.63	34 38
Total R_2O_3%	13.25	9.88	9.13	24.11	9.90	19.80	10.30	8.54
Fe_2O_3%	4.10	3.55	2.40	6.94	3.50	5.94	3.79	2.42
Al_2O_3	9.15	6.33	6.73	17.17	6.40	13.88	6.51	6.12
Free Fe_2O_3%	1.05	0.68	0.52	2.24	0.78	1.73	0.68	0.63
CEC me/100 g	20.4	15.7	39.3	10.8	16.0	12.27	14.16	32.3
Ex. Ca me/100 gm	13.9	10.4	29.9	5.5	9.8	6.6	8.6	24.8
Free $CaCO_3$%	1.70	1.10	3.40	—	0.80	—	1.07	2.66
Organic carbon %	0.55	0.28	0.31	1.09	0.53	0.80	0.35	0.33
pH	5.0 to 8.6	6.5 to 8.6	7.6 to 8.5	5.0 to 5.9	6.3 to 7.4	5.0 to 6.5	6.6 to 7.5	7.6 to 8.6
P fixation capacity (mg/100 g)	85	51	130	111	49	93	45	104

dures. Free Fe_2O_3 was estimated by the method of Coffin as described by Hesse (1971). Cation exchange capacity was estimated by the method of Schollenberger (1930) and exchangeable calcium was estimated by versenate titration method as described by Jackson (1958). The pH of the soils was determined in a Beckman pH meter using a soil water ratio of 1:2.5.

RESULTS AND DISCUSSION

The soils selected for the present study include acid, neutral and moderately alkaline soils of four major soil groups of Tamil Nadu namely, red, black, laterite and alluvial. Soil reaction is considered as one of the most important factors which influence the nature of P transformations in soils. Therefore thirty four soils under study were arranged into three groups based on the pH. Thus, the 34 soil samples collected consisted of 12 soils with a pH ranging 5.0 to 6.5 (acid soils referred as group I in this discussion), 11 soils of pH 6.6 to 7.5 (neutral soils - group II) and 11 soils of pH 7.6 to 8.6 (moderately alkaline soils-group III).

The soil characteristics and the P fixaction capacity of the soil and the mean values are furnished in the Table I. The relationship between the P fixation capacity and soil characteristics

TABLE II. Properties relating to P fixation - Correlation coefficients

Variables X	Variables Y	All soils (n=34)	Group I (acid soils) (n=12)	Group II (neutral soils) (n=11)	Group III (moderately alkaline soils) (n=11)
Clay	P fixation capacity	0.632***	0.955***	0.776**	0.137^{NS}
Total sesquioxides	,,	0.483**	0.817**	0.816**	-0.098^{NS}
Al_2O_3	,,	0.533**	0.854**	0.860**	-0.048^{NS}
Fe_2O_3	,,	0.292^{NS}	0.602*	0.535^{NS}	-0.092^{NS}
Free Fe_2O_3	,,	0.389*	0.746**	—	—
Organic carbon	,,	0.427*	0.632*	—	—
pH	,,	-0.103^{NS}	−0.727**	-0.141^{NS}	-0.074^{NS}
Free $CaCO_3$	,,	—	—	—	0.870*
Cation exchange capacity	,,	—	—	0.663*	0.520^{NS}
Exchangeable calcium	,,	—	—	0.812**	0.513^{NS}

* Significant at 5.0 per cent level

** Significant at 1.0 per cent level

*** Significant at 0.1 per cent level

NS. Not Significant

are given in Table II. The mechanical composition of the soils showed that black soils were rich in clay followed by laterite soils. Free $CaCO_3$ content, cation exchange capacity and exchange capacity and exchangeable Ca were high in black soils as compared to the red and alluvial soils. Total sesquioxides, iron oxide, alumina and free oxides of iron were found to be high in the laterite soils compared to other soils. The difference in soil properties among the three group of soils indicated that acid soils contained relatively high amount of total sesquioxides, free oxide of iron whereas the moderately alkaline soils contained relatively more free $CaCO_3$, high cation exchange capacity and exchangeable Ca with low sesquioxides.

The P fixation capacity of the soils ranged from 20 to 183 mg P/100 g with a mean value of 85 mg P/100 g of soil. The soils studied were found to differ widely in their P fixation capacity, the highest value of 183 mg P/100 g of soil was recorded in the high level laterite soils of Ootacamund and this could be

attributed to the high amount of total sesquioxides, and free oxides of Fe and Al in this soil. The mean value of P fixation for black soils was high (130 mg P/100 g of soil) as compared to that of laterite soil (111 mg P/100 g of soil), red soil (51 mg P/100 g of soil) and alluvial soil (49 mg P/100 g of soil). When the mean values of P fixation capacity were compared, the black soils were found to be high in P fixation capacity than other soils and this might be attributed to the high content of clay and free $CaCO_3$ in these soils. When the P fixation capacity of the different groups of soils (based on pH) were separately examined, it was found that P fixation capacity was in the decreasing order as follows : group III soils (104 mg P/100 g), group I soils (93 mg P/100 g) and group II soils (45 mg P/100 g).

P fixation capacity was found to be positively correlated with clay ($r = 0.632^{***}$), total R_2O_3 ($r = 0.483^{**}$), Al_2O_3 ($r = 0.533^{**}$), free Fe_2O_3 ($r = 389^{*}$) and organic carbon ($r = 0.427^{**}$) when all the soils were considered together. It was observed that in group I soils, the relationships of P fixation capacity with clay ($r = 0.955^{***}$), total R_2O_3 ($r = 0.817^{**}$), Fe_2O_3 ($r = 0.602^{*}$), Al_2O_3 ($r = 0.854^{***}$) free Fe_2O_3 ($r = 0.746^{**}$),and organic carbon ($r = 0.632^{*}$) were more close than the other two groups of soils. The P fixation capacity was more negatively correlated with pH ($r = -0.727^{**}$) in group I soil than in the other two groups. But it should be pointed out that in group III soils, the relationship of P fixation capacity with free $CaCO_3$ ($r = 0.870^{***}$) was more close than group II soils. In the case of group II soils, the relationship of P fixation capacity with cation exchange capacity ($r = 0.663^{*}$) and exchangeable calcium ($r = 0.812^{**}$) was more close than group III soils.

The importance of clay in P fixation in Indian soils has been established by a number of workers (Sinha, 1956; Srivastava, 1961; and De, 1961). Clay forms the major component involved in the phenomenon of P fixation. Similarly the role of total sesquioxide, free oxides of Fe and Al in soils had been stressed by numerous investigators (Vijayachandran, 1966; Mathan and Durairaj, 1967; Sree Ramulu *et al*., 1967; Jose, 1973).

The soil reaction was considered the most important factor in determining the extent and nature of P fixation. The negative relationship obtained in the group I soils (acid soils) between P fixation capacity and pH might be explained due to the gradual dissolution of Fe and Al oxides which were precipitated as phosphates.

The presence of free $CaCO_3$ in calcareous soils had been considered an important factor in P fixation by these soils. The presence of free $CaCO_3$ in the group III soils (moderately alkaline soils) which consisted mainly of black calcareous soils was responsible for the high P fixation capacity of these soils and this is in conformity with the work of Kanwar and Grewal (1960).

The nature of exchangeable cations present on the colloidal complex of the soils plays an important part in the P fixation of soils. The observations made in the present study indicated that the total cation exchange capacity and ex-

changeable calcium were also responsible for P fixation in the group II and III soils. This is in conformity with the work of Patel and Viswanath (1946) who reported that in Indian soils, P fixation capacity increased with increase in exchangeable bases and total cation exchange capacity. Pathak and Sukla (1963) reported similar results, that Ca in the exchangeable form was the most effective in P fixation.

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