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FORMS OF PHOSPHORUS IN RUBBER GROWING SOILS OF KERALA

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Soil physico-chemical properties and forms of phosphorus in four soil series *viz.*, Peruva (Entisol), Lahai (Ultisol), Thrikkannamangal (Ultisol) and Chandanikunnu (Inceptisol) in which rubber (*Hevea brasiliensis*) is grown were estimated. All the soils were acidic (pH 4.30 to 5.22). The organic carbon status of the soils varied from low to high (0.36 to 2.70%). The clay content ranged from 27 to 40 per cent. Texturally, the soils were sandy clay loam and sandy clay. Total P varied from 168 to 1033 g/kg and was in the order Peruva > Lahai > Thrikkannamangal and Chandanikunnu. Active forms of P comprised of saloid-P, Al-P, Fe-P and Ca-P which contributed 19 to 30 per cent of total P. Fe-P was the prominent active P form which constituted 50 to 61 per cent. Organic P comprised 58 to 69 per cent of the total P.

Key words: Central Kerala, Forms of P, Rubber growing soils.

INTRODUCTION

Phosphorus (P) is considered to be one of the least available plant nutrients in the soil. P deficiency often limits crop production in acid soils because of the strong bonding of phosphate by iron (Fe) and aluminium (Al) oxides. Plants acquire P as phosphate anions from the soil solution. Inorganic fixation and formation of organic complexes of available phosphate in the soil are the primary reasons for its low availability. In this context, phosphorus deficiency is considered to be one of the major limitations for crop production, particularly in tropics. Rubber (*Hevea brasiliensis*) growing soils in Kerala, India are mostly acidic and highly weathered in nature. In general these soils are low in available P (NBSS & LUP, 1999). The efficient utilization of P fertilizers in these soils is possible only if their reaction with soil constituents is well understood. The present study was taken up to quantify the forms of phosphorus in different soil series under rubber.

MATERIALS AND METHODS

Twenty eight small rubber holdings, seven each from *viz.*, Peruva (Prv), Lahai (Lah), Chandanikunnu (Cdn) and Thrikkannamangal (Tmg) soil series were selected for this study representing different soil orders *viz.*, Entisol, Ultisol and Inceptisol. Lahai and Thrikkannamangal soils are deep or very deep

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whereas soils of Chandanikunnu and Peruva are moderately shallow or shallow. All the soils are well drained, gravelly sandy clay and gravelly clay. Based on the stratified sampling method, representative surface samples (0 - 30 cm depth) were collected. The soil samples were dried, processed and sieved through 2 mm sieve and used for analysis of various physico-chemical properties. Soil samples were analyzed for particle size distribution by International Pipette method as outlined by Piper (1950). Standard methods were followed for determination of soil pH (1:2.5 soil; water suspension) and organic carbon (Walkely and Black method). Fractionation of inorganic P was carried out by the method of Peterson and Corey (1966). Organic P was calculated by subtracting inorganic P from total P.

RESULTS AND DISCUSSION

Physical and chemical properties of the soils are given in Table 1. Highest percentage of clay was observed in Lahai series and the least was in Chandanikunnu series. Texturally, the soils were sandy clay loam and sandy clay. The pH of the soils ranged between 4.30 and 5.22. Highest pH was observed in Peruva series followed Chandanikunnu, Thrikkannamangal and Lahai. There was a vide variation in organic carbon content. Relatively higher organic carbon (2.4%) was observed in Lahai series. The Chandanikunnu series had the lowest organic carbon (0.71%).

Different forms of P in soils are given in Table 2. The highest total P content was observed in soils of Pervua series (733 to 1033 mg/kg) followed by Lahai (367 to 800 mg/kg), Thrikkannamangal (267 to 367 mg/kg)

Table 1. **Physico-chemical properties of different soil series**

Soil attributes	Soil series			
	Peruva	Lahai	Chandanikunnu	Thrikannamangal
Sand (%)	52.03 (49.35–53.35)	48.68 (44.00-52.05)	58.26 (53.40-62.21)	51.73 (48.63-55.25)
Silt (%)	9.3 (6.08-11.49)	13.5 (7.50-16.00)	10.47 (8.70-12.40)	7.99 (4.67-11.43)
Clay (%)	35.46 (32.33-37.46)	37.08 (35.00-40.00)	29.49 (27.00-31.00)	36.98 (34.60-38.15)
Soil texture	Sandy clay	Sandy clay	Sandy clay loam	Sandy clay
Taxonomical class	Typic ustrorthents	Ustic kanhaplohumults	Ustoxic drytropepts	Ustic kandihumults
pH	5.1 (4.98-5.22)	4.78 (4.56-5.00)	5.07 (4.76-5.22)	4.79 (4.30-5.19)
Organic carbon (%)	1.41 (0.90-1.80)	2.4 (2.19-2.70)	0.71 (0.36-2.70)	1.24 (0.90-1.44)

Table 2. **Forms of P (mg/kg) in the different soil series**

P fractions	Soil series			
	Peruva	Lahai	Chandanikunnu	Thrikannamangal
Total P	871 (733-1033)	486 (367-800)	200 (168-233)	319 (267-367)
Bray II - P	8.9 (3.3-16.7)	6.8 (1.7-18.3)	5.2 (3.3-8.3)	2 (1.7-5.0)
Saloid-P	4 (1.6-7.3)	3.3 (1.0-9.4)	2.7 (1.6-4.2)	1.1 (0.5-2.1)
Al-P	36.4 (24.9-58.3)	26.8 (16.7-42.0)	10.71 (8.3-16.7)	12.7 (11.7-14.2)
Fe-P	86.4 (58.3-99.9)	61.9 (58.3-75.0)	33.3 (24.9-41.7)	47.6 (41.7-58.3)
Ca-P	32.7 (20.8-64.5)	28.7 (13.2-62.5)	11.3 (8.3-12.5)	11.9 (16.7-33.3)
R S P	76.7 (70.0-90.0)	38.8 (20.0-57.0)	20.7 (16.7-20.8)	25.6 (16.7-33.3)

Figures in parentheses are ranges; R S P = Reductant soluble phosphorus

and Chandanikunnu (168 to 233 mg/kg). Karthikakuttyamma *et al.,* (1991) reported that total P in rubber growing soils ranged from 200 to 880 g/kg. Though all forms of P in the soil are known to supply the nutrient to the soil solution, their relative contribution to liable pool from which plants absorb the nutrient depends mainly on the solubility of the phosphatic compounds as influenced by the relevant characteristics of the soils. Inorganic forms of P comprising of saloid-P, Al-P, Fe-P, Ca-P and reductant soluble P contributed 31 to 42 per cent total P. Among these forms, saloid-P is readily available and can be easily taken up by the plants. Al-P and Fe-P are relatively insoluble. Reductant soluble P is regarded as most inactive P among all forms (Beauchemin and Simard (2000). The predominance of reductant soluble P in rubber cultivated soils (of Malaysia) is considered as the main cause for the non-responsiveness to phosphatic fertilizer (Bachik and Baert (1981). Organic P ranged from 96 to 761 mg/kg, which is 58 to 69 per cent of total P.

Prasannakumari *et al.,* (2005) also reported that the organic P ranged from 64 to 794 g/kg. Forms of P comprising saloid P, Al-P, Fe-P and Ca-P fractions ranged from 136 to 192 mg/kg in Peruva, 101 to 192 mg/kg in Lahai, 46 to 67 mg/kg in Chandanikunnu and 67 to 94 mg/kg in Thrikkannamangal series with a mean of 19, 26, 30 and 25 mg/kg for these series respectively.

Fe-P was the dominant P form in all the soil series. In Peruva and Thrikkannamangal series, the forms of P were in the following order Fe-P > Red-P > Ca-P and Al-P, but in the case of Lahai and Chandanikunnu the order was Fe-P > Red –P > Al-P and Ca-P. Higher activity of Fe and Al cations in complexing P in these soils may be attributed

Table 3. **Correlation of soil properties with forms of P**

Soil properties	Total P	Saloid-P	Al-P	Fe-P	Ca-P	R S P
Clay	0.363 *	0.144	0.357	0.498 *	0.220	0.348
pH	0.163	0.243	0.114	0.102	-0.004	0.152
Organic carbon	0.355	0.260	0.517 *	0.441 *	0.393 *	0.259
Bray II– P	0.718 **	0.850 **	0.640 **	0.636 **	0.460 *	0.719 **

* significant at $p \leq 0.05$ **significant at $p \leq 0.01$

to the build up of Fe-P and Al-P over Ca-P (Karthikakuttyamm *et al.,* 1991). Further, the dominance of Fe-bound phosphate over Ca-P indicates that these soils have undergone intense weathering (Sharma *et al,.* 1995). The degree of weathering or the stage of maturity of the soil has been attributed to the relative abundance of the P forms and in early stage of weathering, the Ca-P and Al-P are the more dominant in comparison to Fe-P, but at the advanced stage of weathering, there is a shift in the relative abundance of Ca-P towards Al-P and Fe-P (Tripathi, 1992). Moreover, the Fe-P and Al-P are the main sources of available P in acid soils as most of the fertilizer P added to such soil gets transformed into relatively insoluble inorganic compounds of Al and Fe. Therefore, the value of phosphatic fertilizers depends primarily on the release of phosphorus from these reaction products rather than the fertilizer per se (Lindsay *et al.,* 1962; Ghosh and Sarkar, 1997; Charaborty *et al.,* 2002). Relatively higher quantity of calcium P in Peruva and Thrikkannamangal series over that of Lahai and Chandanikunnu series could be attributed to application of rock phosphate.

Correlation analysis of soil properties with forms of P (Table 3) indicated that clay content was significantly correlated with total P (r=0.363) and Fe-P (r=0.498). No significant correlation was observed for soil pH and different forms of P. Organic carbon was significantly correlated with Al-P (r=0.517), Fe-P (r=0.441) and Ca-P (r=0.393). Bray II-P was significantly correlated with all forms of P as reported earlier by Patiram *et al.,* (1990).

CONCLUSION

This study reveals that Fe-P is the most important fraction governing the available P in the rubber growing soils besides organic P which comprises 58 to 69 per cent.

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