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ORGANIC PHOSPHORUS STATUS OF THE MAJOR SOIL SERIES UNDER RUBBER CULTIVATION IN SOUTH INDIA

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Ten soil profiles representing the major soil series under rubber (*Hevea brasiliensis*) in the traditional rubber growing areas of South India were studied for total, organic and available P status. The total P in the profiles ranged from 112-794 ppm. The organic P ranged from 64-676 ppm and constituted 61 - 86 per cent of the total P. Available P status of the soil in general was very low and ranged from 1-82 ppm. The total, organic and available P contents in general, were high in the surface soil and declined gradually with depth. As the organic P status of the soil is high the plants' P requirement may largely be met from the organic pool. The routine soil analysis do not cover P from this pool, which to some extent explains the observed lack of response of rubber to P fertilization.

Key words: *Hevea brasiliensis*, India, Phosphorus, Soils.

INTRODUCTION

The soils of the traditional rubber (*Hevea brasiliensis*) growing tract in India, comprising Kerala and parts of Tamil Nadu are highly weathered and are mostly laterite and lateritic, developed under warm humid equatorial monsoon or tropical wet and dry monsoon climates. Red and alluvial soils are also seen in these areas. According to modern soil taxonomy, these soils were grouped into 62 series under three orders *viz.*, ultisols, inceptisols and entisols. Majority of the soils belong to ultisols and are moderately deep to very deep (NBSS &LUP, 1999). These are low base status soils with consequent higher acidity. Texture of these soils ranges between loamy and clayey. The clay content increases down the profile. Organic matter status of these soils is high because of the large quantity of litter additions through the leguminous cover crops and annual leaf fall of rubber. The system is reported to be nutritionally self sustaining (Krishnakumar and Potty, 1992., Sivanadyan *et al.*, 1995). These soils are deficient in available P, due to high fixation of applied P by hydroxides of Fe and Al (Karthikakuttyamma *et al.*, 1991; Osodeke and Kamalu, 1992). According to NBSS & LUP, (1999), 75 per cent of the soils in the traditional rubber growing tract are low in available P (<10ppm). Inorganic P fractions in the traditional rubber growing soils (comprising less than 25 per cent of the total P) is dominated by Fe-P followed by Al-P (Karthikakuttyamma *et al.*, 1991). Though the larger part of total P is in organic form,

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the organic P status in rubber growing soils has received scant attention. In most agricultural soils, organic P contributes about 30-80 per cent of the total P (Tarafdar, 1998). Of the organic P compounds in soil, inositol P forms the major part, while phospho-lipids and nucleic acid P are found in smaller quantities (Sood and Minas, 1998).

Plants can absorb only inorganic P as orthophosphate ions. In order to become available to plants, organically bound P must be hydrolysed by the enzyme acid phosphatase which may be of plant or microbial origin (Tarafdar and Classen, 1998). Under conditions of P deficiency, many plants secrete acid phosphatase through the roots to hydrolyze organic P and make it available (Tarafdar, 1998).

Lack of response of mature rubber trees to P application is widely reported (Pushpadas *et al.*, 1979; Sivanadyan *et al.*, 1995; Jessy, 2004). Oven (1953) reported that mineralization of organic P in soils recently cleared of jungle or old rubber may account for poor response to applied P by subsequent crops. This might be due to the ability of the tree to meet its P requirement from the organic P pool in soil (Pushpadas *et al.,* 1979; Jessy, 2004). The objective of the present study was to quantify the organically bound P in the major soil series under rubber cultivation in South India. The relationships between different forms of P were also studied.

MATERIALS AND METHODS

Soil profiles, representing ten major soil series under rubber cultivation were excavated and horizon wise soil samples were collected, powdered, sieved (2mm) and were analyzed for pH, OC and total, organic and available P. Total P and organic P were estimated by NaOH-HCl sequential extraction method (Mehta *et al.*, 1954). Phosphorus in the extract was determined by colorimetric method, and the difference between the phosphorus content in the extract before and after oxidation of the organic matter represented organic phosphorus. In this method, oxidation of organic matter was carried out after extraction (Jackson, 1958). Available P was extracted using Bray II extractant (0. 03N ammonium fluoride + 0.1 N hydrochloric acid) and

Table 1. **Area planted with rubber and taxonomic class under different soil series**

Soil series	Rubber planted area (ha)	Taxonomic class of soil
Vijayapuram	54,378	Clayey kaolonitic, isohyperthermic, Ustic, Kandihumults
Kunnathoor	76,580	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Tiruvanchoor	59,614	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Vazhoor	55,717	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Trikkannamangal	60,748	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kandihumults
Kaipuzha	10,183	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Lahai	40,660	Clayey, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Panachikkad	14,727	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kanhaplohumults
Kanjirappally	65,739	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kandihumults
Chingavanam	4,151	Clayey-skeletal, kaolinitic, isohyperthermic, Ustic, Kandihumults

Table 2. **Total P, organic P, available P, OC and pH of profile samples**

Series	Depth (cm)	Total P (ppm)	Organic P (ppm)	Av. P (ppm)	OC (%)	pH
Vijayapuram	0-15	298	201 (67.4)*	27	1.01	4.5
	15-40	274	179 (65.3)	11	0.70	4.7
	40-70	202	128 (63.4)	4	0.46	4.8
	70-103	112	70 (62.5)	2	0.42	4.8
	103-131	104	64 (61.5)	1	0.23	4.9
Kunnathoor	0-16	590	469 (79.5)	13	0.68	5.5
	16-38	522	415 (79.5)	2	0.68	5.4
	38-72	493	376 (76.3)	1	0.42	5.4
	72-103	508	352 (69.3)	2	0.33	5.3
	103-130	445	283 (63.6)	1	0.07	5.3
Tiruvanchoor	0-13	358	281 (78.5)	18	1.17	5.1
	13-37	243	195 (80.2)	3	0.88	5.1
	37-69	154	118 (76.6)	2	0.62	4.9
	69-104	127	92 (72.4)	2	0.52	4.8
	104-132	120	83 (68.3)	1	0.29	4.9
Vazhoor	0-12	357	290 (81.2)	8	1.47	5.4
	12-31	328	260 (79.3)	5	0.87	5.2
	31-53	195	150 (76.9)	2	0.49	5.3
	53-83	170	125 (73.5)	2	0.26	5.5
Trikkannamangal	0-14	433	315 (72.7)	15	0.70	5.0
	14-35	357	251 (70.3)	5	0.40	5.1
	35-67	685	503 (73.4)	37	0.50	5.2
	67-103	410	276 (67.3)	9	0.50	5.1
	103-152	282	173 (61.3)	4	0.50	5.0
Kaipuzha	0-12	785	558 (71.1) *	26	0.70	5.1
	12-31	428	294 (68.7)	9	0.30	5.2
	31-52	396	278 (70.2)	5	0.20	4.9
	52-71	284	188 (66.2)	3	0.20	4.9
Lahai	0-15	480	383 (79.8)	11	1.60	4.7
	15-38	424	319 (75.2)	8	1.56	4.8
	38-74	412	298 (72.3)	3	1.40	4.5
	74-104	375	259 (69.1)	3	1.43	4.6
	104-138	252	173 (68.7)	3	0.36	4.7
Panachikkad	0-15	794	671 (84.5)	82	2.10	5.9
	15-46	647	528 (81.6)	16	0.75	5.7
	46-74	491	346 (70.5)	4	0.72	5.2
	74-99	357	242 (67.8)	3	0.46	4.4

*Values shown in parenthesis indicate the percentage of total P

	99-136	308	210 (68.2)	3	0.16	4.9
Kanjirappally	0-13	785	676 (86.1)	20	1.34	4.6
	13-32	370	312 (84.3)	5	0.91	4.7
	32-56	294	242 (82.3)	1	0.49	4.8
	56-83	215	171 (79.5)	1	0.49	4.5
	83-112	170	127 (74.7)	1	0.33	4.3
	112-150	162	116 (71.6)	2	0.33	4.6
Chingavanam	0-15	353	251 (71.1)	9	1.60	4.5
	15-41	336	228 (67.8)	4	1.00	4.7
	41-66	292	194 (66.4)	4	0.90	4.7
	66-99	278	182(65.4)	7	0.60	4.8
	99-140	255	162 (63.5)	4	0.40	4.9
	140-176	238	146 (61.3)	6	0.60	4.8

estimated by molybdo-phosphoric blue colour method (Bray and Kurtz, 1945). Soil pH was measured using a glass electrode pH meter. Organic carbon was estimated by Walkley and Black method as outlined by Jackson (1958).

RESULTS AND DISCUSSION

The details of the soil series studied are given in Table 1. Texture of the soils varied from sandy clay loam to clay. Total, organic and available P, organic carbon (%) and pH of the profile samples are shown in Table 2. The soil pH ranged from 4.3 to 5.9. Organic carbon content in the surface horizon was medium to high in majority of the profiles and it ranged from 0.68 to 2.1 per cent. Total P content ranged from 112 to 794 ppm and the highest value was recorded for the surface horizon of Panachikkad series and lowest for Vijayapuram series. The quantity of organic P in the profile samples ranged from 64 to 676 ppm. In the surface soil the highest value (676 ppm) was recorded for Kanjirappally series followed by Panachikkad series (671 ppm), and the lowest value for Vijayapuram series (201 ppm). For all profiles except for Thrikkannamangal series, total and organic P contents were higher in the surface soil and declined gradually with depth. This might be due to the low downward movement of applied P in soil (Malhi *et al.*, 1992; Prasannakumari *et al.*, 2003) and due to accumulation of organic matter in the surface soil. Organic P in the profiles constituted 61.3 to 86.1 per cent. Available P ranged from 1 to 82 ppm with the highest value in surface soil observed for Panachikkad series (82 ppm) and lowest for Vazhoor series (8 ppm).

The organic P and organic carbon were positively correlated (r=0.335), indicating that organic P is a part of the organic pool and it

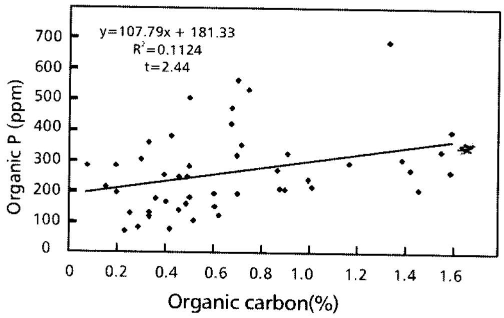

Fig.1. Relation between organic carbon and organic P

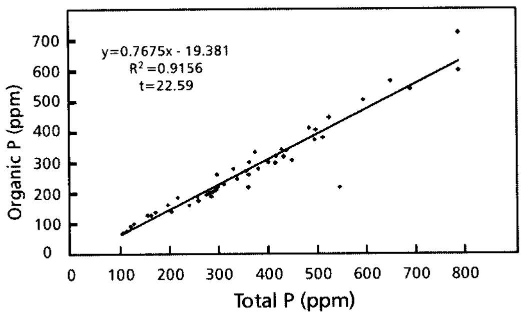

Fig.2. Relation between total P and organic P

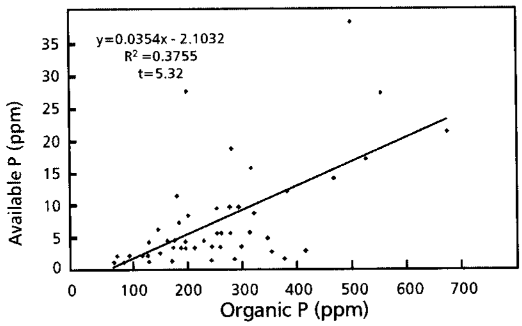

Fig.3. Relation between organic P and available P

varies with the content of organic matter in soil (Fig. 1). Total P correlated positively with organic P (r=0.957) and available P (r=0.605). Also, organic P correlated positively with available P (r=0.613). The significant positive correlation between organic P and total P (Fig. 2) shows that organic P contributes significantly to the total P pool. Even though significant positive correlation was observed between available P and organic P (Fig. 3), only 38 per cent of the variation in available P is explained by organic P indicating that routine P availability tests extract mainly the inorganic forms of P and probably underestimate the potentially available P.

Though the soils of the traditional rubber growing tract are usually low in available P, the P status of the rubber leaves is maintained in the 'medium'(0.20-0.25%) to 'high'(>0.25%) range (Krishnakumar and Potty, 1992). The plant roots may be extracting P from the organic P pool also, which constitute the major portion of the total P. Several strategies are evolved by mature rubber trees to improve P acquisition under low P situations (Jessy, 2004). Acid phosphatase activity was found to be higher in the rhizosphere soil and also in the roots of rubber trees which did not receive P fertilizer. The present study shows that a large proportion of the total P in rubber growing soils exists as organically bound which may serve as a reserve, regulating the supply of plant available P and hence play an important role in the P nutrition of rubber.

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