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DISTRIBUTION OF POTASSIUM IN THE MAJOR RUBBER GROWING SOILS OF SOUTH INDIA

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Profile studies of the major rubber growing soils of South India were undertaken to evaluate the distribution of potassium and its forms. The study revealed that the available K fractions were higher on the surface soils of all the regions. The total K content was higher in the lower depth of Kinalur, Mundakayam and Pudukad soils compared to Kulasekharam where the total K was higher in the surface soil. The major portion of the total K was in the lattice and organic bound form. The organic carbon content of the soil had positive significant correlation with water soluble K, exchangeable K, fixed K, available K (Morgan extractant) and total K. The water soluble, exchangeable and available K had positive significant relationship with fixed K. The clay content of the soil also expressed positive significant relationship with the total K.

Key words – *Hevea brasiliensis,* Soil analysis, Potassium fractions, Profile study, Particle size distribution.

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INTRODUCTION

The dynamics of potassium (K) in soils is of great practical importance as it plays a vital role in the K nutrition of crops and in the economy of K fertilization. Soil K can be divided into soluble, exchangeable, fixed and structural K. The proportion of total K in the soils held in solution and exchangeable form is usually relatively small. The majority of soil K is present in K bearing primary minerals, such as muscovite, biotite, microcline and orthoclase (Fanning and Keramidas, 1977; Huang, 1977; Sekhon, 1985). In soils, K is also present in fixed form (preferentially adsorbed) by reacting with weathered micas, vermuculite etc (Rich, 1968). Water soluble K content is too low to meet the requirement of a crop during the growing season and the exchangeable K released from clay minerals and organic matter continuously replenishes the soil solution (Rich, 1968; Sekhon, 1985).

The red and lateritic soils, where rubber (*Hevea brasiliensis*) is generally grown, are inherently deficient in K (Pushpadas and Karthikakutty Amma, 1980). Palaniswami *et al.* (1978) reported that the rubber growing soils of South India are low to medium in available K status. The requirement of K to rubber varies at different stages of growth. In *Hevea*, lack of K during early stages limits the active leaf area and reduces the photosynthetic activity of the foliage and as a result girth increases only slowly and the immaturity period gets prolonged (Sivanadyan *et al.*, 1976). However, Ananth *et al.* (1966) reported negative response of K on growth attributes of young rubber raised on laterite soils derived from granite. Punnoose *et al.* (1978) reported that application of K at 100 kg K_2O ha^{-1} had significantly increased the yield in the red loam soils of South India.

Considering the important role played by K in the nutrition of rubber, an attempt was made to evaluate the forms and distribution of K in the major rubber growing soils of South India with a view to utilising the information in the formulation of K fertilizer schedule to rubber plants.

MATERIALS AND METHODS

The study was conducted in the four major rubber growing regions of South India, viz., Kanyakumari (Kulasekharam), Calicut (Kinalur), Kottayam (Mundakayam) and Trichur (Pudukad) during the year 1986–87. Profile studies were undertaken in these regions following the established methods described in Soil Taxonomy (USDA, 1975) and the profile descriptions were recorded (Table 1). The soil samples collected from each horizon of the profiles were chemically analysed for soil reaction (pH), electrical conductivity (EC), organic carbon content (OC) and cation exchange capacity (CEC) by the established methods outlined by Jackson (1958). Particle size distribution of the samples was determined by the International Pipette Method (Piper, 1942). Water soluble, exchangeable and total K were estimated by the procedure given by Jackson (1958). Fixed K was extracted using 1 *N* HNO_3 as prescribed by Pratt (1965). The lattice and organic bound K was calculated from the difference between total K and the other three fractions. The available K was estimated by the method suggested by Morgan (1941). Correlation and regression were established using the methods prescribed by Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

The physico-chemical properties of the profile soils (Table 2) showed that all the soils were acidic in reaction and non-saline. The OC content and CEC were generally higher in Kinalur, Mundakayam and Pudukad than in Kulasekharam. The low CEC values of Kulasekharam may be due to the predominance of kaolinite and oxides and hydrous oxides of Fe and Al in these lateritic type of soils (Mukherjee *et al.*, 1971; Ghosh and Kapoor, 1982). It was also observed that the OC content and the CEC were higher in the surface soil of all the profiles irrespective of the location/region.

The dynamics of K (Table 3) clearly indicated a higher proportion of 1 *N* HNO_3 extractable K (fixed K) among the available K pool in all the soils irrespective of the depth. Fixed K content ranged from 87.6 to 287.6 kg ha^{-1}. It was followed by exchangeable K (ammonium acetate K). The water slouble K fraction was only low, ranging from 3.2 to 23.2 kg ha^{-1}. According to Rich (1968) one to three per cent of the total K might be present in adsorbed form (exchangeable) and K in the soil solution accounts for only a small percentage of the exchangeable fraction. The available K fraction ranged from 26 kg ha^{-1} (Kulasekharam) to 152 kg ha^{-1} (Pudukad). Among the four locations, the surface soils of Mundakayam and Pudukad were medium in available K and that of Kinalur and Kulasekharam were deficient according to the ratings fixed by Muhr *et al.* (1963). However, the content of available K fractions was higher on the surface soils than the subsurface horizons in all the locations. This might be due to the relatively high OC and CEC observed in the surface soil which might have enhanced the availability of exchangeable K from the total pool.

Table 1. **Morphological characters of soil**

Region/Location	Horizon depth (cm)	Description
Kanyakumari, Kulasekharam	0 — 30.0	Yellowish red (5YR 4/6, moist); gravelly loam; moderate, medium, subangular blocky; friable, slightly sticky and slightly plastic; common, medium, distinct, mottles; few fine distinct iron concretions; many roots; gradual smooth boundary
	30.0 — 58.8	Yellowish red (5YR 4/6, moist); gravelly clayey; massive moderate, medium, subangular blocky; sticky and plastic; few medium distinct mottles; few roots; diffuse wavy boundary
	58.8 — 87.5	Hard laterite
Calicut, Kinalur	0 — 10.0	Dark reddish brown (5YR 3/3, moist); clay loam; crumb; friable; slightly sticky and slightly plastic; many roots; gradual smooth boundary
	10.0 — 17.5	Reddish brown (5YR 4/4, moist); sandy loam; crumb; moderately sticky and moderately plastic; many roots; gradual smooth boundary
	17.5 — 47.5	Yellowish red (5YR 4/8, moist); gravelly loam; moderate, medium, subangular blocky; sticky and moderately plastic; few roots; clear wavy boundary
	47.5 — 102.5	Yellowish red (5YR 4/8, moist); gravelly loam; moderate, medium, subangular blocky, friable; non-sticky and non-plastic; no roots; diffuse, smooth boundary
Kottayam, Mundakayam	0 — 37.5	Very dark greyish brown (10YR 3/2, moist); clay loam; massive moderate, medium, angular blocky; very friable, slightly sticky and moderately plastic; many roots; few yellow rock out crops; clear wavy boundary
	37.5 — 62.5	Yellowish red (5YR 4/6, moist); gravelly loam; massive moderate, medium, angular blocky; very friable, slightly sticky and slightly plastic; yellowish vesicular formation; few roots; clear wavy boundary
	62.5^{+}	Lateritic formation
Trichur, Pudukad	0 — 12.5	Dark brown (7.5YR 3/2, moist); sandy loam; moderate, medium, angular blocky; slightly sticky and slightly plastic; few yellowish red mottles (5YR 4/6), common rock out crops; many roots; clear smooth boundary
	12.5 — 25.0	Dark reddish brown (5YR 3/3, moist); sandy loam; weak, medium, angular blocky; moderately sticky and moderately plastic; few yellowish red mottles (5YR 4/6); few rock out crops; common roots; clear smooth boundary
	25.0 — 70.5	Yellowish red (5YR 5/6, moist); clay loam; angular blocky; friable, moderately sticky and moderately plastic; few roots; clear smooth boundary
	70.5 — 105.0	Yellowish red (5YR 5/6, moist); clay loam; moderate, medium angular blocky; moderately sticky and moderately plastic; few roots; merging smooth boundary
	105.0^{+}	White powdery material with no structure.

Table 2. **Physico-chemical properties of profile soil samples**

Region/ Location	Horizon depth (cm)	Particle size distribution (%) Course sand	Fine sand	Silt	Clay	pH	EC dSm^{-1}	O C %	CEC (me $100g^{-1}$)
Kanyakumari, Kulasekharam	0–30.0	44.55	7.80	6.13	34.13	4.90	0.10	0.84	7.30
	30.0–58.8	37.20	5.50	5.02	45.53	5.00	0.10	0.66	5.18
	58.8–87.5	46.16	6.10	4.60	40.06	5.20	0.04	0.63	3.06
Calicut, Kinalur	0–10.0	35.00	8.20	11.60	39.68	5.20	0.04	2.49	13.10
	10.0–17.5	33.00	7.20	9.00	42.40	4.90	0.04	1.62	12.16
	17.5–47.5	36.45	7.10	8.88	40.05	5.05	0.04	1.32	12.00
	47.5–102.5	37.40	7.40	9.55	40.23	5.20	0.03	1.02	10.03
Kottayam, Mundakayam	0–37.5	37.70	14.90	8.88	20.18	5.15	0.04	1.68	14.18
	37.5–62.5	48.05	10.80	8.60	21.80	4.80	0.06	1.26	11.34
Trichur, Pudukad	0–12.5	48.00	10.90	7.28	24.80	5.70	0.05	2.16	11.16
	12.5–25.0	28.95	12.30	7.88	41.08	5.25	0.04	1.53	10.90
	25.0–70.5	33.00	9.10	3.73	39.25	5.00	0.03	0.93	10.86
	70.5–105.0	44.00	10.40	5.65	28.50	5.00	0.03	0.90	9.86

Table 3. **Forms and distribution of K in the profile soil samples (Kg ha^{-1})**

Region/ Location	Horizon depth (cm)	Forms of K: Water soluble	Exchangeable	Fixed	Lattice & Org. K.	Total K	Available K. (Morgan)
Kanyakumari, Kulasekharam	0–30.0	6.4	65.0	125.0	9403	9600 (0.48)	46
	30.0–58.8	3.2	35.0	112.6	7849	8000 (0.40)	26
	58.8–87.5	4.0	37.6	87.6	6270	6400 (0.32)	40
Calicut, Kinalur	0–10.0	7.2	82.6	175.0	10135	10400 (0.52)	58
	10.0–17.5	5.6	60.0	156.2	12978	13200 (0.68)	44
	17.5–47.5	3.2	50.0	106.2	11840	12000 (0.60)	32
	47.5–102.5	3.2	77.6	125.0	16594	16800 (0.84)	38
Kottayam, Mundakayam	0–37.5	15.2	122.0	225.0	18338	19200 (0.96)	110
	37.5–62.5	14.2	105.0	187.6	21293	21600 (1.08)	100
Trichur, Pudukad	0–12.5	23.2	167.6	287.6	21122	21600 (1.08)	152
	12.5–25.0	10.4	142.6	287.6	19959	20400 (1.02)	130
	25.0–70.5	3.2	70.0	206.2	20121	20400 (1.02)	62
	70.5–105.0	3.2	67.6	162.6	24167	24400 (1.22)	52

Figures in parenthesis are the percentage values

The total K content ranged from 9,600 to 24,400 kg ha^{-1} and was found higher in the lower depth of Kinalur, Mundakayam and Pudukad soils compared to Kulasekharam where the total K was higher in the surface soil. Among the four locations Kulasekharam recorded lower values of total K for all the three horizons studied. The fixed K fraction was only a small proportion of the total K content. This might be due to the low fixation of K in these soils dominated by kaolinite mineral (Rich, 1972). It was also observed that the proportion of lattice and organic bound K was higher in all the horizons of all the locations with values ranging from 6270 to 24167 kg ha^{-1} which are supposed to be not available to the plants as stated by Sekhon (1985). Hence, the necessity of the application of potassium fertilizers to rubber is warranted at each stage of growth.

The correlation studies (Table 4) indicated positive and significant correlation between OC and the different fractions of K, viz., water soluble K (r = 0.605*), exchangeable K (r = 0.647*), fixed K (r = 0.592*) and available K (r = 0.552*). Among the soil-separates, the clay content showed positive correlation (r = 0.680**) with total K. The total K registered positive relationships also with water soluble K (r = 0.455), exchangeable K (r = 0.606*), fixed K (r = 0.709**) and available K (r = 0.642*). Similarly the water soluble K (r = 0.754**), exchangeable K (r = 0.926**) and available K (r = 0.931**) had positive significant relationship with fixed K. The encouraging results obtained in the present investigation need indepth studies on the relationship between the uptake of K by rubber plants and the dynamics of K in soils.

Table 4. **Coefficients of correlation and regression equations between interlinked parameters**

Variables x	Variables y	Correlation coefficient r	Regression equation (linear)
Clay	Total K	0.680**	423.42x — 100.57
Organic carbon	Total K	0.207	2180.58x + 12834.07
Organic carbon	Water soluble K	0.605*	6.62x — 0.82
Organic carbon	Available K	0.552*	39.37x + 16.86
Organic carbon	Exchangeable K	0.647*	46.57x + 20.70
Organic carbon	1*N* HNO_3K	0.592*	67.43x + 84.24
CEC	Water soluble K	0.765**	0.83x + 0.59
CEC	Available K	0.435	5.62x + 11.81
CEC	Exchangeable K	0.521*	6.78x + 13.32
Total K	Water soluble K	0.455	0.0004x + 0.45
Total K	Available K	0.642*	0.004x + 0.24
Total K	Exchangeable K	0.666*	0.004x + 13.56
Total K	I *N* HNO_3K	0.709**	0.0076x + 52.35
Fixed K	Water soluble K	0.754**	0.07x — 4.63
Fixed K	Exchangeable K	0.926**	0.57x — 15.81
Fixed K	Available K	0.931**	0.58x — 32.22

* Significant at 5% level
** Significant at 1% level

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