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PROPERTIES OF SOILS UNDER TEAK

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ABSTRACT

Teak is a major component of the man-made forests in Kerala. As a result of monoculture of teak, changes may occur in soil properties and whether such changes are beneficial or detrimental to the succeeding teak crops should be of concern. The project, *properties of soils under teak,* was started with the objective of evaluating changes in soil properties due to continuous teak cropping.

Literature suggests that without proper soil management, clearfelling of natural or plantation forests and rnonoculture of teak may result in soil deterioration depending on the intitial soil conditions, topography, climate and management practices. However, in a long-rotation crop like teak, soil properties may recuperate and there may be stablization of properties provided no drastic disturbances to the sites occur.

Soil profiles were chosen from teak preservation plots at Perinthomuzhi, Elencheri and Begur for comparative study of first and second rotation profiles. One hundred and two surface samples (0-20cm) were also taken at random from several plantations for an overall evaluation of soil properties in first and to some extent in second rotation teak plantations. Particle-size separates, pH, organic carbon and cation exchange capacity analyses were done.

The data indicate similarity of the first and second rotation profiles of Perinthomuzhi and Begur in relation to distribution of particle-size separates, pH, organic carbon and cation exchange capacity. Although the second rotation Elencheri profile has a different distribution of these properties, increased levels of organic carbon and cation exchange capacity in it demonstrate no deterioration of these integrative properties. In fact, the profile data reveal recuperation of these soil parameters during the long rotation of 60-70 years. Thus, the relatively higher levels of organic carbon and cation exchange capacity in the surface horizons of profiles and in the surface samples suggest that soil parameters should not limit growth of teak in first and to some extent in second rotarion plantations.

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Key words : Soils under teak

INTRODUCTION

Kerala has a long history in man-made forestry and one of the earliest teak plantations was established here in 1842. The Forest Department has completed first rotation in several plantations, second rotation in some and recently, third rotation teak was planted on a limited scale in Nilambur area. With clearfelling of natural or plantation forests and continuous teak cropping, changes may occur in soil properties and such changes should be of concern as they may have effects on succeeding teak crops. The present project, *properties of soils under teak,* was started in April 1977 with the objective of evaluating changes in soil properties due to continuous teak cropping.

REVIEW OF LITERATURE

The literature presents a nebulous picture on the impact of continuous teak cropping on soils. Because of the long rotation of 60-70 years, comparison between rotations is often negated by effects other than those due to teak growth itself, such as taungya operations, grazing, fire and other anthropogenic disturbances.

After summarizing the soil data from several teak growing areas, Champion (1932) concludes that soil samples from teak plantations and adjacent natural forests do not differ substantially in the distribution of particle-size separates and chemical properties, except that the soils under plantations are found to be comparatively much harder due to exposure. He feels that adequate experimental evidence is lacking to prove conclusively soil deterioration in pure teak plantations and recommends protection of poorer teak soils through appropriate management practices. Blanford (1933) reports that teak cropping leads to serious soil erosion especially due to the removal of undergrowth and soil erosion is the main form of soil deterioration in Burma. After a thorough study in pure teak plantations of Burma, Castens (1933) notes that soil deterioration due to teak cropping may be slow.

From a general study on Nilambur soils, Davis (1940) comments that clearfelling, burning and weeding on the one hand and maintenance of pure teak on the other are likely to cause rapid laterization. Laurie and Griffith (1942) suggest that deterioration of soil occurs hand in hand with lowering of site quality in teak plantations. According to them laterization may be one of the factors responsible for this deterioration. However, detailed studies to determine the effect of planting teak on soils with tendency for laterization indicate that there is little change in the chemical nature of soil as a result of continuous teak cropping (Griffith and Gupta 1947). In particular, $Si0_2/R,0_3$ ratio, an index of laterization of soil, shows same trends under both natural forests and teak plantations. The laterization previously noted is due to hardening of pre-existing lateritic surface layers. Also, studies in erstwhile Mysore do not indicate any soil deterioration in teak plantations (Kadambi 1945).

While studying the effects of teak plantation on soils of evergreen and green forests in East Bengal, Ghani (1951) notes that soils in these forests are in delicate balance between the opposing forces of laterization and podzolization and caution should be exercised before altering this balance by converting forests into teak plantations. After a review on teak soils of India, Pakistan, Burma and Indonesia, Seth and Yadav (1959) conclude that sufficient quantitative data are lacking to prove or disprove the hypothesis of soil deterioration due to continous teak cropping.

Though there may be changes in physical and chemical properties of soils as a result of teak cropping, as the rotation progresses there may be recuperation in some of the properties. That recuperation occurs in some of the soil properties is shown in a study by Jose and Koshy (1 972) on the morphological, physical and chemical characteristics of soils as influenced by 1, 15, 30, 60 and 120 years of teak growth. They observe that the natural forest and the 120-year teak plantation have somewhat similar surface horizons rich in organic matter. The surface horizons of younger teak plantations show markedly higher values for bulk density and particle density and relatively lower values for pore space and water-holding capacity than those of natural forests. However, the physical properties of soils from 120-year plantation are similar to those of natural forest although there is considerable compaction in second rotation plantations.

In summary, these studies and the review on tree cropping and its impact on soils by Evans (1976) lead to the following observations. Without proper soil management practices, clearfelling of natural or plantation forests and continuous teak cropping may result in soil deterioration and the intensity of deterioration will depend on initial soil conditions, topography, climate and management practices. However, in a long rotation tree crop like teak, soil properties may recuperate and there may be stabilization of properties provided no drastic disturbances to the sites occur.

MATERIALS AND METHODS

Soil profiles were chosen from teak preservation plots at Perinthomuzhi, Elencheri and Begur for comparative study (Table 1). Except the Elencheri-1 plot other plots have nearly homogeneous conditions; in the former, frequent alluvial deposition occurred because of its proximity to river. Since soil profile studies from several teak plantations would take considerable time and since maximum changes due to teak plantation activities can occur in the topsoil, surface samples (0-20cm) were taken at random from plantations scattered throughout Kerala for an overall evaluation of soil properties in first and to some extent in second rotation teak plantations. Out of the 102 samples, 94 were from first rotation and eight from second rotation plantations (Table 8). The emphasis on first rotation plantations is justifiable in that very few teak planations are crossing the midway of second rotation. Since third rotation plantations are in the nascent stage, samples were not taken from these.

Table 1. Soil profiles from Teak Preservation Plots

Preservation Plot	Forest Division	Year of plantation	Rotation
Perinthomuzhi-I	Konni	1884	I
Perinthomuzhi-2	Konni	1963	II
Elencheri-I *	Nilambur	1842	I
Elencheri-2	Nilambur	1933	II
Begur-1	Wynad	1892	I
Begur-2	Wynad	1965	II

* Conolly Plot

The soil samples were air-dried, passed through 2-mm sieve and btored for analyses. Particle-size separates (sand = 2.0 - 0.02, silt = 0.02-0.002, clay = <0.002 mm diameter), pH in soil-water suspension, organic carbon and cation exchange capacity analyses were done according to procedures in Methods of Soil Analysis (American Society of Agronomy 1965) and Soil Chemical Analysis (Jackson 1958).

RESULTS

PROFILE DATA

Particle–size Separates

The relative proportion of sand, silt and clay separates determines soil texture and it is an important physical property of soil. Generally sand decreases and silt plus clay increases with depth (Tables 2-7). In Perinthomuzhi and Begur, particle–size distribution is relatively the same in first and second rotation profiles. In Elencheri-1, because of its proximity to river, alluvial deposition occurred in the past and this is shown by the increased sand content in it compared to Elencheri–2. However in Elencheri area, considerably more silt plus clay occurs in the second rotation profile than in the first rotation one. The texture of the surface horizons of profiles ranges from loamy sand to loam.

Soil Reaction

Hydrogen ion activity or pH value is a measure of soil reaction and any drastic change in pH value indicates drastic change in soil environment. As pH value increases, acidity decreases and vice versa. The pH values range from 4.2 to 6.6 (extremely acid to neutral reaction! in the surface horizons. Except in Begur-2, pH decreases or remains steady with depth, There is no consistent effect of teak growth on soil reaction.

Table 2. Perinthomuzhi - 1 profile and properties

Level, moderately well drained, adjacent to river, 1884 I rotation teak.

0- 15 cm Dark reddish brown (5 YR 3/3), loamy sand, granular structure, many roots.

15- 55 cm Dark reddish brown (5 YR 3/3), loamy sand, granular to massive structure, many roots

55-150cm Dark reddish brown (5 YR 3/4), loam, massive structure, few roots.

Depth (cm)	Sand (......	Silt ....%........	Clay .....)	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0- 15	82	10	8	6.3	1.52	18
15- 55	76	13	11	6.1	1.19	19
55-150	72	12	16	6.1	0.36	14

Table 3. Perinthomuzhi - 2 profile and properties

Level, moderately well drained, adjacent to river, 1963 II rotation teak.

0- 15 cm Dark reddish brown (5 YR 3/3), loamy sand, granular structure, many roots.

15- 55 cm Dark reddish brown (5 YR 3/3), loam, granular to massive structure, many roots

55-150 cm Yellowish red (5 YR 4/6), loam, massive structure, few roots.

Depth (cm)	Sand (....	Silt ....%........	Clay .....)	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0- 15	83	10	7	6.6	0.93	20
15- 55	75	13	12	6 0	1.20	20
55-150	73	13	14	5.8	0.55	16

Table 4. Elencheri- 7 (Conolly Plot) profile and properties"

Level, moderately well drained, adjacent to river, 1842 I rotation teak.

0- 15 cm Reddish brown (5 YR 4/4) , loamy sand, granular structure, many roots.

15- 60 cm Reddish brown (5 YR 4/4) , loamy sand, granular to single grain structure, few roots.

60-135 cm Yellowish red (5 YR 4/6) , loam, massive structure, very few roots.

135-155 cm Yellowish red (5 YR 5/6), loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/lOOg)
	(............%............)					
0- 15	83	9	8	5.6	0.94	17
15- 60	79	12	9	5.7	0.48	16
60 135	75	13	12	5.6	0.34	16
135-155	70	16	14	5.6	0.30	20

***Average of four profiles**

*Table 5. Elencheri - 2 profile and properties**

bevel, moderately well drained, adjacent to Conolly Plot, 1933 II rotation teak.

0- 15 cm Dark reddish brown (5 YR 3/4), silt loam, granular structure abundant roots.

15- 70 cm Reddish brown (5 YR 4/4), loam, subangular blocky to massive structure, many roots.

70-135 cm Yellowish red (5 YR 4/6), loam, massive structure, few roots.

135-155 cm Yellowish red (5 YR 4/6), loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(............% ....)					
0- 15	61	26	13	5.4	1.99	24
15- 70	58	24	18	5.4	1.04	24
70-135	57	22	21	5.5	0.48	20
135-155	56	22	22	5.5	0.45	24

***Average of three profiles**

Table 6. Begur-1 profile and properties

Level to gently undulating, well drained, 1892 I rotation teak.

0-28 cm Dark reddish brown **(5** YR **3/2),** loam, granular structure, many roots.

28-75 cm Dark reddish brown **(5** YR **3/2),** loam, granular **to** massive structure few roots.

75-150 cm Dark reddish brown **(5**YR **3/4),** clay loam, massive structure, very few roots.

Depth (em1	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(...............%...............		)			
0-28	78	9	13	4.9	0.80	17
28-75	74	10	16	4.5	0.53	15
75-150	65	11	24	4.5	0.28	14

Table 7. Begur - 2 profile and properties

Level to gently undulating, well drained, 1965 II rotation teak.

0- 25 cm Dark reddish brown **(5**YR **3/2),** loam, granular structure, many roots.

25- 67 cm Dark reddish brown (5 YR **3/3),** loam, granular to massive structure, few roots.

67-150 cm Reddish brown (5 YR **4/4),** clay loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(...............%...............		)			
0- 25	74	12	14	4.2	1.68	15
25- 67	71	9	20	4 3	0 55	15
67-150	64	9	27	4.7	0.23	15

Organic Carbon

Organic carbon is an integrative property of soil in that generally higher the level of organic carbon, higher the soil fertility. The values suggest fairly high levels of it (0.80-1.99%) in the surface horizons. Generally organic carbon decreases with depth in the profiles. In Elencheri and Begur sites, there is more of it in the second rotation profile than in the first rotation one, whereas in Perinthomuzhi site, it decreases in second rotation profile.

Cation Exchange Capacity (CEC)

The sum of exchangeable bases (principally calcium, magnesium, potassium and sodium) and exchangeable hydrogen plus aluminium is a measure of CEC of soil. Like organic carbon content, it is also an integrative property in that generally higher the CEC, higher the soil fertility. CEC values vary from 15 to 24 me/100g in the surface horizons. Except in Elencheri profiles, CEC distribution in the first and second rotation profiles is relatively the same. The higher CEC values in Elencheri-2 is expected as there is markedly more silt plus clay in this profile than in Elencheri-I. In the surface horizons. CEC data do not indicate marked changes in cation status due to teak cropping.

SURFACE SAMPLE DATA

Organic carbon (mean 1.71%) and CEC values (mean 18 me/100g) in the surface samples indicate generally high fertility of the soils under teak (Table 8). Surface sample data show wide ranges for all the properties; the ranges are 67–83% in sand, 14-39% in silt plus clay, 4.8-6.6 in pH (very strongly acid to neutral reaction), 0.77-3.15% in organic carbon and 10-28 me/100g in CEC. Rotation-wise data also demonstrate similar ranges in these properties (Table 9).

Table 9. Mean and range of Properties of surface samples (0-20cm) from I and II rotation teak plantations

Property	First & Second rotation mean	First & Second rotation range	First rotation* mean	First rotation* range	Seoond rotation** mean	Seoond rotation** range
Sand,%	75	67–83	75	67–83	73	67-77
Silt, %	11	5-18	11	5-16	15	11-18
Clay,%	14	9-21	14	9-21	12	11-15
pH in water	5.8	4.8-6.6	5.9	4.8-6.6	5.8	5.0-6.6
Organic carbon,%	1.71	0.77–3.1 5	1.74	0.77-3.1 5	1.57	1.08-2.48
Cation exchange Capacity, me/100g	18	10–28	19	10-28	18	13-28

* Samples
** 8 Samples

Table 8 Properties of surface samples (0-20 cm) from I and 11 rotation teak plantations

Location	Forest Division	Elevation (m)	Year of plantation	Number of samples	Sand (.........%...	Silt	Clay)	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
1	2	3	4	5	6	7	8	9	10	11
Ilavupalam	Trivandrum	125	1962	6	78	9	13	5.4	3.15	18
Kulathupuzha	Trivandrum	125	1951	2	80	9	11	5.4	1.82	15
Chittarmuzhi	Kallar Valley	275	1967-75	4	75	13	12	6.0	2.16	21
Palaruvi	Thenmala	225	1968 I1	2	73	16	11	6.6	1 08	15
Bourdillon Plot	Thenmala	200	1891	1	74	9	17	6 5	1.56	17
Airanallur	Punalur	75	.I941	2	67	12	21	5.4	1.92	14
Piravanthur	Punalur	75	*	1	72	11	17	5.3	1.76	18
Mannarappara	Konni	50	1933-76	6	76	12	12	6.3	1.55	18
Vadasserikkara	Ranni	100	1940-68	4	71	11	18	5.4	1.98	15
Rajampara	Ranni	400	1962 8 1968	2	77	10	13	5.8	1.84	15
Thundathil	Kothamangalam	50	1968 8 1973	3	77	10	13	5.8	2.07	23
Perumthode	Malayattur	25	1964 I1	1	67	18	15	5.5	2.48	28
Mallana	Malayattur	25	1975 I1	1	76	13	11	5.3	1.77	20
Kapirikkad	Malayattur	25	1951 I1	11	77	1	12	5.0	1.62	16

1	2	3	4	5	6	7	8	9	10	11
Nampoori Coupe	Malayattur	25	1967	1	83	5	12	5.6	1.84	19
Chuzhimed	Vazhachal	350	*	1	70	15	15	5.6	1.64	10
Pothupara	Kaladi	100	1976	1	73	12	15	5.2	1.78	20
Adirappalli	Kaladi	125	1974 & 1971	3	79	12	9	5.6	1.98	22
Chittanda	Trichur	25	1948	2	70	12	18	5.8	1.58	21
Vazhakkode	Trichur	50	1940	2	76	10	14	5.9	1.69	22
Potta	Trichur	25	1969	2	76	10	14	6.6	0.96	19
Pampatti	Trichur	25	*	1	81	7	12	5.6	1.47	17
Kanakasseri	Trichur	25	1940	1	71	10	19	4.8	1.49	18
Puthur	Trichur	25	1935	I	76	9.	15	5.2	0.83	13
Olippara	Nemmara	100	1977	1	72	10	18	6.0	2.84	26
Pothundi	Nemmara	175	1946	3	73	11	16	6.3	161	18
Parambikulam	Parambikulam	475	1961 – 73	8	74	13	13	6.2	1.73	16
Sungam	Parambikulam	475	1942 – 67	15	76	12	12	6.6	1.96	28
Kariem- Muriem	Nilambur	50	1973 & 1976	2	78	9	13	6.3	2.14	16
Nedumkayam	Nilambur	50	195581974	' 5	75	14	11	61	1.38	18
Panayamcode	Nilambur	50	193881953	2	81	8	11	5.8	0.77	14
Nellikkutha	Nilambur	50	1930	2	75	12	13	6,l	0.82	12
Karimpuzha	Nilambur	50	1947 & 1948 11	2	73	14	13	6.1	1.09	13
Edakkode	Nilambur	25	1925 I1	1	70	17	13	6.4	1.40	16
Mavinhalla	Kozhikode	800	1941	1	80	9	11	6.1	1.87	14
Chedleth	Kozhikode	900	195681958	2	72	12	16	5.8	1.68	13
Peruva	Wynad	50	1936&1941	2	68	16	16	5.9	2.00	20
Tholpetti	Wynad	750	192881962	2	74	13	13	6.3	1.98	25
Bavali	Wynad	700	194381978	3	67	15	18	6.3	1.53	28

Not available

DISCUSSION

There is no consistent effect of teak cropping on the soil profiles. In Perinthomuzhi and Begur sites, distribution of sand, silt plus clay, pH, organic carbon and CEC is relatively the same in first and second rotation profiles (Fig. 1). However, in Elencheri site there is more silt plus clay, organic carbon and CEC in second rotation profile than in first rotation one. In this site, due to nearness of first rotation profile to river, alluvial deposition occurred in the past and this overlay of coarse material is partly responsible for the lower levels of silt plus clay, organic carbon and CEC. The increased levels of silt plus clay in the second rottation profile need not be due to the absence of alluvial deposit alone, as more silt plus clay and compaction were noted in second rotation profiles in Nilambur area by Jose and Koshy (1972). Asof 1977, Elencheri second rotation is in 44th year whereas that of Perinthomuzhi and Begur second rotations are in 14th and 12th years respectively. The advanced stage of Elencheri second rotation may also be one of the reasons for increased levels of silt plus clay, organic carbon and CEC.

In a long rotation crop like teak, as the rotation progresses soils may recuperate and there may be stabilization of soil properties provided no drastic disturbances to the sites occur. That recuperation can occur in soil. properties during long roation is verified in a study by Page (1968) on the first rotation conifer plantations in Wales. His study, though from a temperate environment, suggests that most significant changes in physical paramsters of soils, as a result of tree cropping, occur at or near the surface and are related to the supply of organic matter from leaf litter. His study shows that soil properties tend to return to their initial levels by the time the trees reach 25–30m height. An investigation by Jose and Koshy (1972) in Nilambur area also indicates recuperation of physical properties of soils as rotation progresses.

Our data indicate similarity of the first and second rotation profiles in Petinthomuzhi and Begur in relation to distribution of particle-size separates, pH,organic carbon and CEC. Even though the second rotation Elencheri profile has different distribution of these properties, increased levels of organic carbon and CEC in it demonstrate no deterioration of these integrative properties after teak cropping. Surface sample data also damor,strate hardly any deterioration in second rotation samples (Fig.2). The surface sample data have been stratified into first and second rotations to see the level of organic carbon and CEC and not for comparison as these samples were taken at random from several plantations. Thus, the relatively higher levels of organic carbon and CEC, two integrative soil properties, plus wide ranges in all the properties suggest that soil parameters should not limit growth of teak in first and to some extent in second rotation plantations.

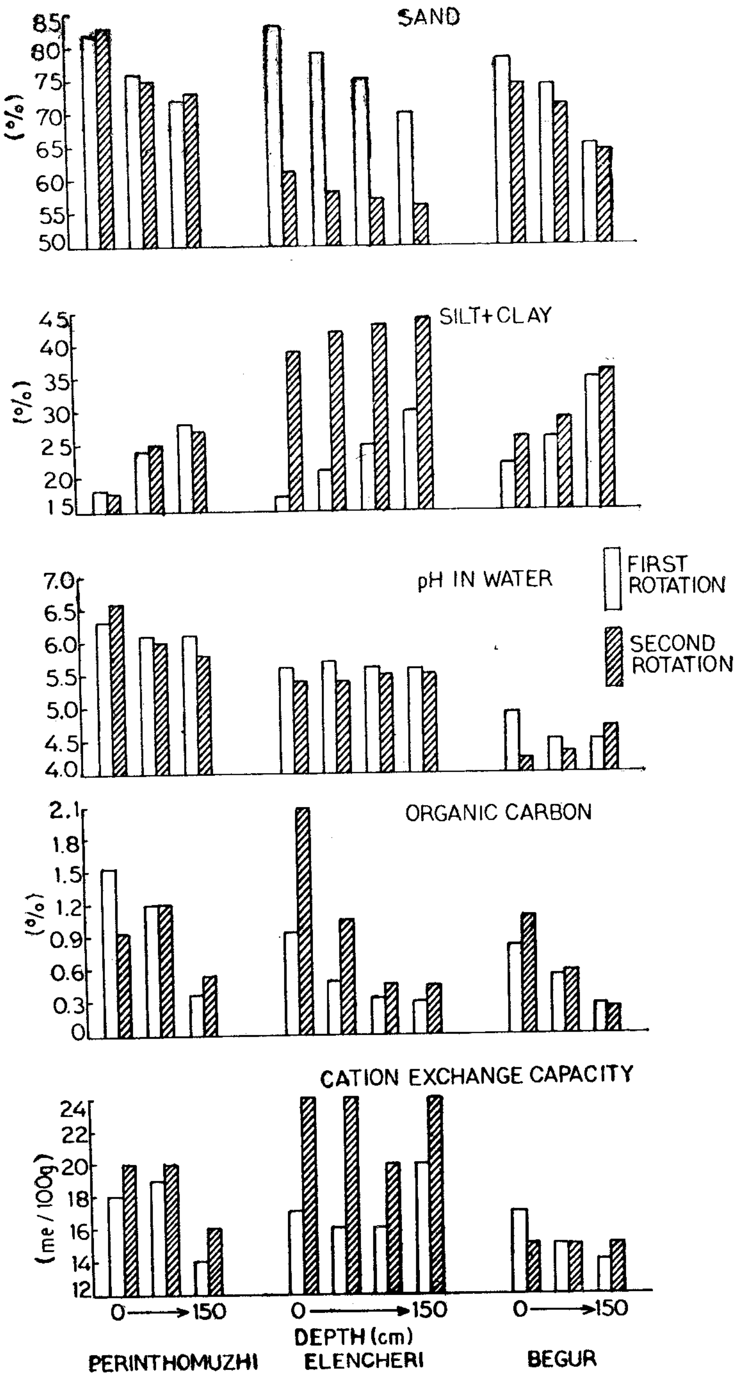

Figure 1. Properties of soil profiles from I and II rotation teak plantations

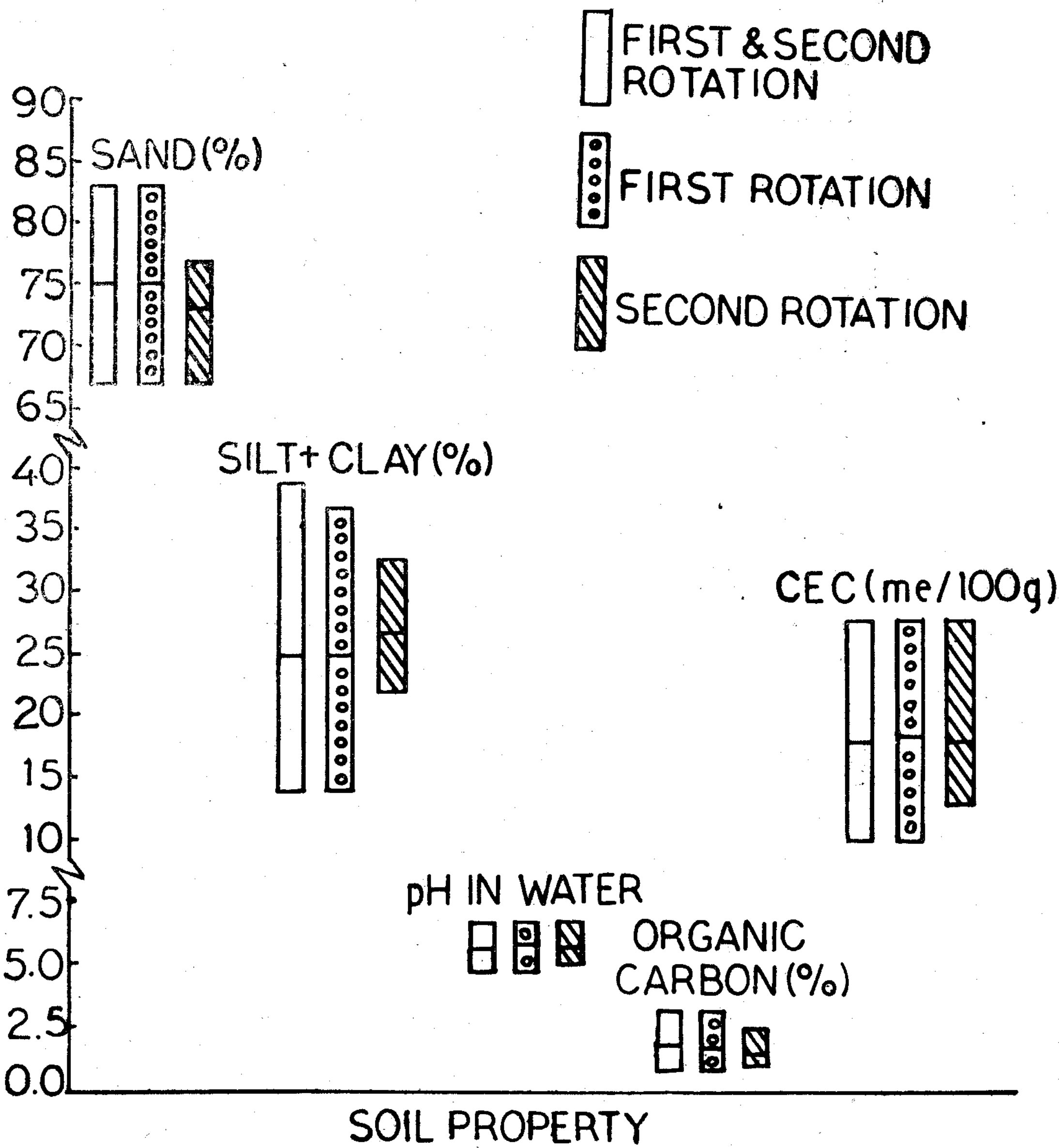

Figure 2. Mean and range of properties of surface samples from I and II rotation teak plantations (mean = inner dash; range = lower and upper dashes)

CONCLUSION

Though profile data from first and second rotation teak plantations tend to show changes in pH, organic carbon, CEC and particle-size distribution, increase of organic carbon and CEC in two of the sites suggests recuperation of these soil parameters during the long rotation of 60–70 years. Relatively higher levels of %organiccarbon and CEC, two integrative soil properties, in the surface horizons of profiles as well as in the surface samples suggest that soil parameters should not iimit growth of teak in first and to some extent in second rotations plantations.

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