

Characterization and classification of rubber growing soils of Kerala, India

Abstract

Detailed Land Resource Inventory at farm level is important for site specific Land resource management. It assists in the planning for future land use, particularly agriculture, because it assesses the variety of land management issues and its potential for sustainable agricultural production. The objective of the study was the characterization and classification of soils of the Elamdesam block, Idukki district Kerala. Detailed soil survey conducted at 1:10,000 scale and twelve major representative soils were studied in the area. Results revealed that, the soils were very deep to very shallow, well drained to somewhat poorly drained, brown, dark brown, reddish brown, dark reddish brown, dark yellowish brown, yellowish brown, dark gray, yellowish red and red in color. Soils are non-gravelly to gravelly; clay content is 11.37 to 41.60 percent in the surface soil and ranges from 8.95 to 63.52 per cent in the subsoil. The cation exchange capacity ranges 5.94 to 15.12 cmol (+) kg⁻¹ in the surface soil and 2.48 to 14.47 cmol (+) kg⁻¹ in the subsoil. Base saturation is 6 to 44 per cent in the surface soil and ranges from 2 to 55 per cent in the subsoil. The organic carbon content is medium to very high and it ranges 0.89 to 3.34 per cent. Soils acidity ranges extremely acid to moderately acid. Based on the morphological, physical and chemical characteristics soils were classified as Ustic Haplohumults, Humic Dystrustepts, Ustic Kandihumults, Lithic Ustorthents and Oxyaquic Haplustepts. The information generated can help the researchers, farmers and planners to comprehend the natural resources of Elamdesam block for future planning.

Key words: Characterization, classification, rubber growing soils, Kerala, India

Introduction

Efficient management and maintenance of soil health/ quality is the key to accomplish sustained high productivity, food security and environmental safety (Tripathi *et al.*, 2006). Characterization, classification and evaluation of soils for different land uses are the first milestone to develop sustainable and eco-friendly land use system. Systemic study of soil as

31 natural resource provides information on nature and type of soil, their constraints, potentials,
32 capabilities and their suitability for various uses (Sehgal, 1996). The spatial and temporal
33 variation in soil properties is very high, need to characterize and classify properly such way
34 that it remembered and interpreted easily for selection of crop and management practice of
35 crop production. Soil classification by following the standard system makes users and
36 researchers enable to remember logically the salient features and agro technology transfer to
37 other area, where do found similar soil series (Rajagopal *et al.*, 2013). Lack of soil
38 characterization becomes obstacle to utilize the soil production potentials and adaptation of
39 better management practice to increase the productivity of the soil (ISSS, 2000). Soil
40 resource inventory through characterization of the resources provides an insight into the
41 potentials and limitations of soils (Manchanda *et al.*, 2002). Hence, timely and reliable
42 information on soils with respect to their nature, extent, spatial distribution, potential and
43 limitation is very important (Arunkumar *et al.*, 2002). Large scale information on soil
44 resources for the state is necessary for better and sustainable farm-based or village-based land
45 use planning. Keeping this in view an effort was made to characterize and classify the soils in
46 rubber growing area of Elamdesam block, Kerala, India.

47 **Materials and methods**

48 **Details of the study area:** Elamdesam block falls under the agro-ecological zone foot hills
49 and high hills, the agro ecological units 12 and 14 i.e. southern and central foot hills and
50 southern high hills, respectively. These units are subdivided in to forests, denudational hills,
51 lateritic terrain and lateritic valley lying between north latitudes $9^{\circ} 46' 38.2''$ and $10^{\circ} 2'$
52 $18.14''$ north and east longitudes $76^{\circ} 42' 59.49''$ and $76^{\circ} 53' 46.99''$ east. There are seven
53 Panchayats namely Vannapuram, Kodikulam, Karimannor, Udumbannoor, Alakode,
54 Velliya Mattom and Kudayathoor in the Elamdesam block and eight villages covering a total
55 geographical area of 40,307 ha. Villages are further divided in to number of wards for the
56 purpose of administration. Geology of the area is charnockite and granite gneiss of the
57 Archaen age. Elevation ranges from 30 m in low land to 850 m in high hills. Climate is
58 tropical humid monsoon type. Rainfall ranges from 3462 mm to 3602 mm and mean annual
59 temperature varies between 22°C to 27°C . Length of dry period is two to two and a half
60 months. Soil High hills are covered by mixed forest whereas foot hills and midlands have
61 plantation of rubber, coconut, pepper, banana, pineapple, arecanut, cocoa, nutmeg, cashew.
62 Low land is occupied by paddy and tapioca, banana, coconut arecanut and rubber were also
63 cultivating in raised beds. Laterites and Ultisols are the major soil type which, are well
64 drained, shallow to very deep, strongly acidic in nature. Location map given in the Figure 1.

65 In Elamdesam block agriculture is the fundamental livelihood activity among the people.
66 Major land uses are rubber plantations, mixed forest plantations and paddy cultivation.

67 **Soil survey and laboratory methods:** Using toposheet (1:50,000 scale) and Google image
68 soil profiles and auger observations from selected transects were studied in such a way that
69 soil survey and mapping observations have been taken in all landform units and the location
70 of soil profiles were recorded using GPS. Horizon-wise morphological properties including
71 depth, colour, structure, texture, gravelliness, consistence, occurrence of nodules, *etc.*, were
72 described following USDA soil survey manual (Soil Survey Staff 2014). Soil samples were
73 collected horizon-wise, air dried and processed (2 mm sieve) for various analyses following
74 standard methods. Twelve soil series were identified in the block using the method employed
75 by Reddy (2006). Representative master profiles for each series were identified which also
76 represented the corresponding landform unit.

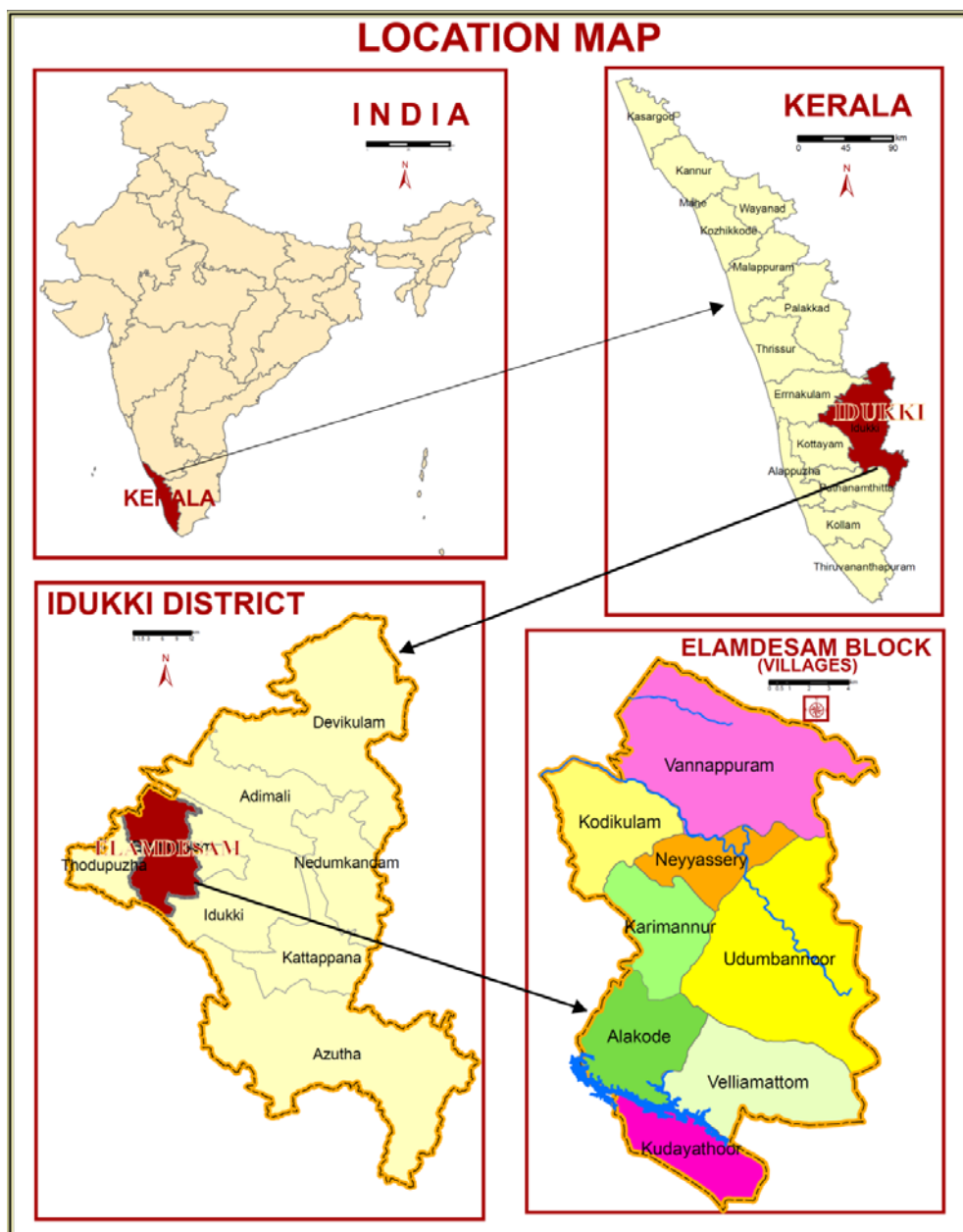


Fig. 1: Location map of the study area (Elamdesam block)

Results and discussions

Morphological Properties

Very deep (35.07 %) soils occupy the dominant position (Table 1) shows soils are well developed followed by deep (14.28 %), moderately shallow (7.04 %), shallow (5.44 %) and moderately deep (2.55 %). Well drained soils (all the pedons except pedon 12) occur in large extent (44.2 per cent) followed by somewhat poorly drained 14.79 per cent (pedon 12) and moderately well drained soils occur in 5.39 per cent area. Surface soil colour varies from

86 dark brown, dark reddish brown, reddish brown, yellowish red and red. Sub surface soils
87 colour varies from dark brown, reddish brown, yellowish red, dark reddish brown, red, dark
88 red, dark yellowish brown, yellowish brown and dark gray. In sub surfaces fine iron
89 concretions and mottles are observed which is indicative of high rainfall (Bhattacharyya *et al.*
90 1996). Patchy thin cutans present in Bt horizons which is due to clay illuviation. Similar
91 results reported by Sankar and Dadhwal (2009). In pedon 12 gleyed horizons are observed in
92 the sub-surface. These soils are found in low lands and valley plains due to the prevalence of
93 excessive wet environment under fluctuating ground water condition which is a common
94 phenomenon of waterlogged soils (Bhattacharyya *et al.* 2003). Generally surface structure
95 was weak and fine to medium with subangular blocky whereas sub surface was moderate,
96 medium with subangular blocky attributed to the presence of higher quantities of clay
97 fraction (Sharma *et. al.* 2004). Consistency is generally friable, sticky and plastic. The
98 formation of soils was highly associated with major climatic factors and parent materials
99 influenced the soils morphological and physico-chemical characteristics (Dengiz, O., 2010).

100 **Physical Properties**

101 The particle size distribution data are presented in Table 2. Sand content varies from
102 42.54 to 75.65 per cent in surface and 17.91 to 71.69 per cent in sub surface. Silt content is
103 lower among all the size classes which varied from 10.80 to 19.74 in surface and 6.60 to
104 23.43 per cent in sub surface. Clay content varied from 11.37 to 41.60 in surface and 8.95 to
105 63.52 per cent in sub surface. There is an irregular distribution of sand, silt and clay content
106 in some of the pedons indicated lithological discontinuity (Sidhu *et al.* 1976). The increase in
107 clay content in pedons 3, 5, 6, 7, and 10 with soil depth indicated illuviation of clay
108 (Bhattacharyya *et al.* 1998). In some pedons A horizon has higher content of clay compared
109 to lower horizons due to washing out of Ap horizon attributed to heavy rainfall. Texture of
110 the soil is sandy clay loam, clay loam, sandy clay to clay in surface soil to Sandy clay loam,
111 sandy loam, sandy clay, clay loam to clay sub surface soil. Coarse fragments present in
112 pedons 1, 3, 5, 6, 8 and 9, its content varied from 5 to 35 per cent. In the area surveyed, sub
113 surface gravelly occupied by 32.09 per cent area followed by non-gravelly (22.17 per cent
114 area) and gravelly throughout profile (10.12 per cent).

116 **Chemical properties**

117 Soil reaction classes of Elamdesam block (Table 2), revealed that 37.71 per cent area
118 is very strongly acid in reaction followed by 12.06 per cent area is strongly acid and 11.91

per cent area is extremely acid in reaction. Soil reaction (pH 1:2.5 soil: water ratio) of the pedons varied from 4.16 to 5.65. Soil reaction varies from extremely acid, very strongly acid, strongly acid and moderately acid. The acidification of soils is a serious constraint to crop production in the region. Organic carbon content of soil classes of Elamdesam block revealed that 45.61 per cent of area is very high in status followed by 18.23 per cent of area is high. Generally surface soil has more organic carbon content than sub surfaces attributed to addition of organic matter from rubber plantation. Electrical conductivity varied from 0.01 to 0.19 dS m⁻¹. Thus soils are non saline. Similar findings have also been reported by Nayak *et al.* (2000) and Vijayakumar *et al.* (1994). Among exchangeable bases, Ca recorded higher content which varied from 0.08 to 2.74 cmol (p+) kg⁻¹. CEC of soils varied from 2.48 to 16.22 cmol (p+) kg⁻¹ apparently due to variation in clay content which might be due to the presence of pseudo-aggregates of sesquioxides of nature and amorphous oxides of iron and aluminum which form coating on clay fractions (Bhaskar and Subbaiah 1995). Generally, low CEC in the study area which might be attributed to presence of clay minerals with low CEC and occurrence of hydrous oxides of iron and aluminium in the soils (Sarkar *et al.* 2002). The base saturation of these soils varied from 2 to 55% and it is highest in pedon 10. Lower base saturation might be due to leaching of bases from the pedons and also acidic soil reaction.

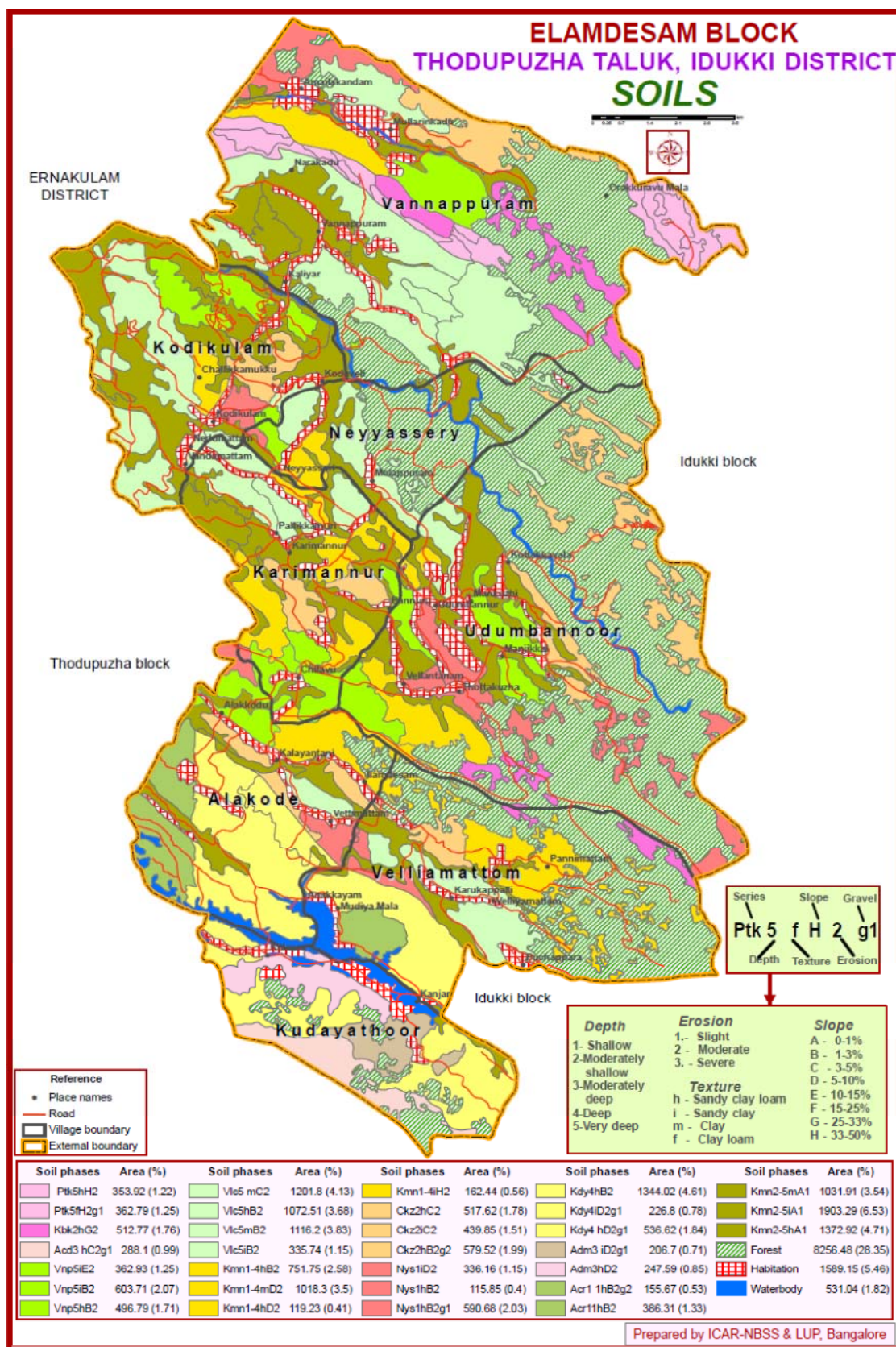
Soil classification

The soils have been classified following the latest criteria laid down in USDA and FAO (2015) soil Taxonomy using field and laboratory data (Soil Survey Staff 2014). Based on the morphological characteristics, physical and chemical properties of the typifying pedons, the soils were classified (Fig. 2) as Haplohumults (pedons 1, 4, 6, 9 and 10), Humic Dystrustepts (pedons 2, 3, 7 and 8), Kandihumults (pedon 5), Lithic Ustorthents (pedon 11) and Oxyaquic Haplustepts (pedon 12). Pedons 2, 3, 7 and 8 showed the development of colour and/or structural cambic (Bw) horizons and thus qualify for Inceptisols. The base saturation of soils is less than 60% by ammonium acetate (NH₄OAc) at a depth between 25 and 75cm from the mineral soil surface thus justifies Dystrustepts at great group level. Pedons 1, 4, 5, 6, 9 and 10 have base saturation < 35% so they are classified as Ultisols. At great group level due to presence of kandic (Bt) horizon with apparent CEC < 16 cmol(p+) kg⁻¹ and apparent ECEC < 12 cmol(p+) kg⁻¹ pedon 5 is grouped into Kandihumults, whereas pedon 1 is grouped into Humults at sub order level due to presence of > 12kg/m² organic carbon and also grouped into Haplohumults at great group level due to presence of argillic horizons. Similar results reported by Singh *et al.* (2005). The reason for extensive occurrence

of Ultisols may be due to the geomorphically stable landscapes over acid crystalline rocks (Boul *et al.* 2003). Pedons 12 has argillic/kandic horizon (Bt) with base saturation > 35% in sub surface so it has qualify for Alfisols and with apparent CEC > 16 cmol(p+) kg⁻¹ in sub surface and thus qualifies for Haplustalfs at great group level which also shows redoximorphic features and the chroma of 2 or less in the matrix and presence of gleyed horizon so it is grouped as Oxyaquic Haplustalfs. The development of deep soils belonging to Ultisols, Alfisols and Inceptisols on foot hills, high hills and midlands suggests that the materials displaced from the summits are not transported to long distances but deposited in the adjoining lower landscapes (Bhattachayya *et al.*, 2002). However, it is interesting that in the lower valley region the soils have argillic horizon may be due to stability of the landscape and uniform cropping system (Jena *et al.*, 2016). Slope is one of the most important factors controlling the pedogenic process and contributes to greater runoff, as well as to greater translocation of surface materials down slope through surface erosion and movement of soil (Dengiz, O., 2010).

Conclusion and recommendation

The study revealed that the soils in the foot hills, high hills and midlands and low land region of rubber growing soils of Kerala qualify as Ultisols or Inceptisols (Endosaturation). The formation of diverse group of soils could be attributed to the effect of topography, vegetation and climate leading to various pedogenic processes. The soils, though strongly acid semi and sub-activity clay, is fairly rich in organic matter. Correction of soil acidity and external mineral plant nutrient supplements are necessary. Soil conservation measures required for moderately sloping to steeply sloping land. Most valley lands, have been converted from rice production to other crops. The information generated can help the researchers, farmers and planners to comprehend the natural resources of Elamdesam block for future planning.



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181 Fig. 2: Soils of Elamdesam block, Idukki district, Kerala

Ethical approval and consent are not applicable.

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269 Table 1. Morphological features of soil series of rubber growing soils, Kerala, India

Pedons	Depth cm	Horizon	Colour (moist)	Structure	Consistence	Coarse fragments	Special features
<u>Pedon 1</u>	0-18	Ap	7.5YR3/3	f1sbk	s, fr, s, p	-	-
	18-42	Bt1	7.5YR3/3	f1sbk	s, fr, s, p	-	T tn p
	42-79	Bt2	5YR 4/4	m2sbk	sh, fr, s, p	10-15	T tn p
	79-111	2BC1	5YR 4/4	m2sbk	sh, fr, vs, vp	15-20	-
	111-135	2BC2	5YR 4/6	m2sbk	sh, fr, vs, vp	20-25	-
	135-160	CB	5YR 4/6	m2sbk	sh, fr, vs, vp	25-30	-
<u>Pedon 2</u>	0-14	Ap	7.5YR3/2	f1sbk	vfr, s, p	-	-
	14-30	AB	7.5YR3/3	f1sbk	fr, s, p	-	-
	30-54	BW	7.5YR3/4	m1sbk	fr, s, p	-	-
<u>Pedon 3</u>	0-15	Ap	5YR3/2	m1sbk	sh, fr, ss, mp	20	-
	15-34	AB	5YR3/3	m2sbk	fr, ss, sp	40	-
	34-75	BW	5YR3/3	m2sbk	fr, ss, sp	50	-
<u>Pedon 4</u>	0-10	Ap	7.5YR3/2	m1sbk	fr, s, p	-	-
	10-30	Bt1	7.5YR3/2	m1sbk	fr, s, p	-	T tn p
	30-50	Bt2	7.5YR3/2	m1sbk	fr, s, p	-	T tn p
	50-70	Bt3	7.5YR3/3	m1sbk	fr, s, p	-	T tn p
	70-90	Bt4	7.5YR3/4	m1sbk	fr, s, p	-	T tn p
	90-110	Bt5	5YR 3/3	m1sbk	fr, s, p	-	T tn p
	110-150	Bt6	5YR 3/3	m2sbk	fr, ss, sp	-	T tn p
<u>Pedon 5</u>	0-16	Ap	5YR 5/6	m1sbk	l, fr, s, p	-	-
	16-35	Bt1	5YR 5/6	m2sbk	s, fi, vs, vp	-	T tn p
	35-57	Bt2	5YR 5/6	m2sbk	s, fi, vs, vp	20-30	T tn p
	57-96	Bt3	2.5YR 4/6	m2sbk	s, fi, vs, vp	10-15	T tn p
	96-125	Bt4	2.5YR 4/6	m2sbk	s, fi, vs, vp	10-15	T tn p
	125-151	Bt5	2.5YR 4/6	m2sbk	s, fi, vs, vp	20-25	T tn p
	151-177	Bt6	2.5YR 4/6	m2sbk	s, fi, vs, vp	-	T tn p
	177-210+	Bt7	2.5YR 3/6	m2sbk	s, fi, vs, vp	-	T tn p
<u>Pedon 6</u>	0-15	Ap	5YR4/4	m1sbk	s, fr, s, p	20-30	-
	15-31	Bt1	5YR4/4	m2sbk	s, fr, s, p	20-25	T tn p
	31-65	Bt2	5YR4/6	m2sbk	s, fr, s, p	20-25	T tn p
	65-100	Bt3	2.5YR4/6	m2sbk	s, fr, s, p	30-35	T tn p
<u>Pedon 7</u>	0-12	Ap	7.5YR3/3	m1sbk	fr, ss, sp	-	-
	12-30	AB	7.5YR3/4	m1sbk	fr, s, p	-	-
	30-51	BW1	7.5YR3/4	m1sbk	fr, ss, sp	-	-
	51-63	BW2	7.5YR4/4	m1sbk	fr, ss, sp	-	-
<u>Pedon 8</u>	0-12	Ap	5YR4/4	m2sbk	sh, fr, s, p	5-10	-
	12-22	BW	5YR4/4	m2sbk	sh, fr, s, p	10-15	-
	22-35	BC	5YR4/6	m2sbk	sh, fr, s, p	30-35	-
<u>Pedon 9</u>	0-16	Ap	5YR4/4	m1sbk	fr, ss, sp	30	-
	16-38	Bt1	5YR4/4	m1sbk	fr, ss, sp	25	T tn p
	38-65	Bt2	5YR3/4	m1sbk	fr, ss, sp	25	T tn p
	65-83	2Bt3	5YR4/6	m1sbk	fr, ss, sp	40	T tn p
<u>Pedon 10</u>	83-102	2BC	5YR4/6	m1sbk	fr, ss, sp	45	-
	0-11	Ap	5YR4/4	m1sbk	fr, ss, sp	-	-
	11-32	Bt1	5YR4/6	m2sbk	fr, ss, sp	-	T tn p
	32-58	Bt2	5YR5/8	m2sbk	fr, ss, sp	-	T tn p
<u>Pedon 11</u>	58-82	Bt3	5YR5/8	m2sbk	fr, ss, sp	-	T tn p
	0-13	Ap	7.5YR3/2	m1sbk	sh, fr, ss, sp	-	-
<u>Pedon 12</u>	13-32	AC	7.5YR3/3	m1sbk	fr, ss, sp	-	-
	0-11	Ap	10YR 4/3	m1sbk	s, fr, s, p	-	-
	11-27	BW1	10YR 4/4	m2sbk	s, fr, s, p	-	-
	27-41	BW2	10YR 4/4	m2sbk	s, fr, s, p	-	-
	41-54	Bt1	10YR 4/6	m2sbk	s, fr, s, p	-	T tn p
	54-70	Bt2	10YR 4/6	m2sbk	s, fr, s, p	-	T tn p
	70-81	Bt3	10YR 5/6	m2sbk	s, fr, s, p	-	T tn p
<u>Pedon 12</u>	81-95	BC	10YR 4/1	m2sbk	s, fr, vs, vp	-	-

271 Table 2. Physical and chemical properties of rubber growing soils, Kerala, India

Depth cm	Horizon	Particle size distribution (% of <2 mm)			Organic Carbon (%)	pH	EC (dS m ⁻¹)	Exchangeable bases (cmol (p+) kg ⁻¹)				CEC	CEC/ Clay (%)	B.S (%)
		Sand	Silt	Clay				Ca	Mg	Na	K			
Pedon 1: Loamy mixed, isohyperthermic family of acid active Ustic Haplohumults														
0-18	Ap	53.7	17.8	28.4	2.68	4.16	0.18	0.59	0.12	0.08	0.20	13.9	0.49	7
18-42	Bt1	45.9	21.5	32.5	1.95	4.45	0.08	0.23	0.04	0.07	0.08	14.5	0.44	3
42-79	Bt2	51.7	23.4	24.8	0.97	4.75	0.03	0.17	0.01	0.03	0.04	9.3	0.37	3
79-111	2BC1	67.8	16.8	15.4	0.73	5.20	0.02	0.20	0.01	0.04	0.05	9.2	0.60	3
111-135	2BC2	71.7	13.2	15.2	0.40	5.05	0.02	0.09	0.01	0.04	0.06	8.53	0.56	2
135-160	CB	63.1	17.1	19.8	0.36	5.00	0.01	0.16	0.00	0.03	0.03	6.91	0.35	3
Pedon 2: Loamy mixed isohyperthermic family of acid semiactive Humic Dystrustepts														
0-14	Ap	59.3	14.5	26.3	1.79	4.61	0.04	0.26	0.08	0.05	0.13	8.64	0.33	6
14-30	AB	69.9	9.5	20.5	1.79	4.36	0.19	1.02	0.27	0.09	0.21	9.29	0.45	17
30-54	BW	58.4	13.7	27.9	1.47	4.49	0.05	0.23	0.01	0.04	0.12	8.75	0.31	5
Pedon 3: Loamy skeletal mixed isohyperthermic family of acid semiactive Humic Dystrustepts														
0-15	Ap	64.3	15.3	20.4	2.68	5.37	0.03	0.87	0.21	0.04	0.17	10.5	0.51	12
15-34	AB	62.2	15.9	21.9	1.76	5.18	0.02	0.27	0.06	0.00	0.09	7.75	0.35	5
34-75	BW	57.7	17.0	25.3	0.8	5.08	0.01	0.25	0.05	0.15	0.07	7.55	0.30	7
Pedon 4: Clayey mixed isohyperthermic family of acid semiactive Ustic Haplohumults														
0-10	Ap	43.4	15.0	41.6	3.39	4.44	0.14	0.60	0.18	0.09	0.27	15.2	0.36	8
10-30	Bt1	47.7	15.1	37.2	3.07	4.20	0.17	0.65	0.11	0.07	0.14	13.2	0.35	7
30-50	Bt2	46.1	15.3	38.4	3.03	4.57	0.11	0.64	0.11	0.05	0.10	13.3	0.34	7
50-70	Bt3	44.3	18.5	37.2	3.23	4.81	0.10	0.58	0.09	0.07	0.11	14.1	0.38	6
70-90	Bt4	37.7	22.9	39.3	2.06	4.97	0.03	0.22	0.05	0.05	0.10	12.7	0.32	3
90-110	Bt5	36.8	23.4	39.7	2.3	4.87	0.03	0.31	0.00	0.06	0.13	13.9	0.35	4
110-150	Bt6	37.6	22.9	39.4	1.74	5.00	0.03	0.31	0.05	0.04	0.11	11.6	0.30	4
Pedon 5: Clayey kaolinitic isohyperthermic family of Ustic Kandihumults														
0-16	Ap	53.4	10.8	35.8	1.59	5.22	0.05	0.97	0.12	0.05	0.10	5.94	0.17	21
16-35	Bt1	47.5	16.8	35.6	1.23	5.42	0.02	0.70	0.00	0.04	0.04	4.75	0.13	17
35-57	Bt2	42.8	17.3	39.9	0.99	5.11	0.02	0.42	0.00	0.03	0.02	4.86	0.12	10
57-96	Bt3	44.6	13.9	41.5	0.91	4.87	0.02	0.32	0.00	0.03	0.02	4.10	0.10	9
96-125	Bt4	44.7	15.9	39.5	0.91	4.89	0.02	0.32	0.00	0.02	0.02	4.00	0.10	9
125-151	Bt5	55.8	6.6	37.6	0.79	4.85	0.02	0.11	0.00	0.02	0.02	3.35	0.09	5
151-177	Bt6	38.9	17.5	43.6	0.59	4.81	0.02	0.10	0.00	0.02	0.02	3.78	0.09	4
177-210	Bt7	40.7	21.3	38.0	0.51	5.23	0.01	0.13	0.00	0.02	0.02	2.48	0.07	7
Pedon 6: Clayey mixed acid isohyperthermic family of semiactive Ustic Haplohumults														
0-15	Ap	45.9	16.5	37.6	3.17	4.55	0.08	0.61	0.22	0.12	0.38	13.9	0.37	10
15-31	Bt1	46.7	15.3	38.0	2.1	4.52	0.04	0.13	0.03	0.09	0.17	11.6	0.31	4
31-65	Bt2	54.6	7.4	38.0	1.27	4.62	0.03	0.08	0.00	0.08	0.12	8.86	0.23	3
65-100	Bt3	58.9	4.3	36.8	0.83	4.54	0.03	0.08	0.00	0.07	0.11	10.4	0.28	3
Pedon 7: Fine loamy mixed isohyperthermic family of acid semiactive Humic Dystrustepts														
0-12	Ap	54.7	13.8	31.5	1.61	5.01	0.09	2.17	0.52	0.03	0.31	10.3	0.33	29
12-30	AB	51.5	16.4	32.1	1.32	4.93	0.05	1.79	0.32	0.01	0.10	10.6	0.33	21
30-51	BW1	51.0	14.4	34.6	1.4	4.9	0.03	1.12	0.20	0.00	0.10	11.0	0.32	13
51-63	BW2	50.5	12.4	37.2	1.44	4.93	0.02	0.71	0.15	0.09	0.10	10.5	0.28	10
Pedon 8: Loamy mixed isohyperthermic family of acid semiactive Lithic Dystrustepts														
0-12	Ap	65.3	13.1	21.6	1.99	4.96	0.05	0.81	0.35	0.08	0.17	10.1	0.46	14
12-22	BW	61.6	15.1	23.4	1.59	5.04	0.04	0.50	0.20	0.04	0.09	8.86	0.38	9
22-35	BC	69.3	10.6	20.1	1.03	5.25	0.03	0.43	0.19	0.04	0.08	7.99	0.40	9
Pedon 9: Loamy mixed isohyperthermic family of acid semiactive Ustic Haplohumults														
0-16	Ap	42.5	19.7	37.7	2.51	5.63	0.03	1.65	0.71	0.22	0.90	14.6	0.39	24
6-38	Bt1	42.9	20.5	36.5	2.07	5.24	0.03	0.53	0.13	0.11	0.35	13.4	0.37	8
38-65	Bt2	46.9	16.7	36.4	1.55	5.15	0.02	0.28	0.14	0.10	0.15	11.8	0.33	6
65-83	2Bt3	56.1	18.5	25.5	0.83	5.12	0.02	0.14	0.11	0.08	0.15	11.5	0.45	4
83-102	2BC	65.5	16.1	18.4	0.67	5.22	0.02	0.12	0.13	0.10	0.19	8.40	0.46	6
Pedon 10: Clayey kaolinite isohyperthermic family of acid subactive Ustic Haplohumults														
0-11	Ap	55.6	15.8	28.7	1.99	5.56	0.08	2.74	0.82	0.19	0.51	9.72	0.34	44
11-32	Bt1	52.2	13.3	34.5	0.95	5.26	0.04	2.51	1.24	0.17	0.35	7.99	0.23	53
32-58	Bt2	41.4	19.7	38.9	0.71	5.53	0.03	2.01	1.65	0.18	0.43	7.78	0.20	55
58-82	Bt3	44.4	16.3	38.7	0.67	5.65	0.02	1.15	1.41	0.15	0.32	7.67	0.20	39
Pedon 11: Sandy mixed isohyperthermic family of acid subactive lithic Ustorthents														
0-13	Ap	75.6	12.9	11.4	2.55	5.18	0.06	1.16	0.48	0.10	0.15	8.96	0.79	21
13-32	AC	71.2	19.9	8.9	2.19	5.60	0.02	3.59	0.94	0.07	0.06	9.40	1.05	50
Pedon 12: Fine, mixed, acid, isohyperthermic sub-active family of Oxyaquic Haplustepts														
0-11	Ap	45.5	16.5	38.1	1.19	4.9	0.04	1.86	0.63	0.07	0.12	9.08	0.24	30
1-27	BW1	42.6	19.8	37.5	1.39	4.16	0.15	1.17	0.15	0.25	0.05	8.57	0.23	19
27-41	BW2	47.8	19.3	32.9	1.35	4.42	0.07	0.76	0.14	0.15	0.03	7.45	0.23	14
41-54	Bt1	39.2	19.2	41.7	0.99	5.3	0.03	1.72	0.66	0.05	0.04	7.14	0.17	35
54-70	Bt2	40.5	15.1	44.5	0.8	5.33	0.03	1.65	0.85	0.03	0.05	7.55	0.17	34
70-81	Bt3	47.4	11.5	41.1	0.83	5.33	0.03	1.56	0.88	0.15	0.07	6.53	0.16	41
81-95	BC1	17.9	18.6	63.5	2.59	4.77	0.06	1.97	1.09	0.13	0.12	16.2	0.26	20