Characterization and classification of rubber growing soils of Kerala, India

Abstract

Twelve major representative soils of Elamdesam block, Idukki district Kerala were studied for characterization and classification. 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.

Comment [DO1]: Provide an introductory statement, objective of the study and recommendation (based on findings

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 natural resource provides information on nature and type of soil, their constraints, potentials, capabilities and their suitability for various uses (Sehgal, 1996). The spatial and temporal variation in soil properties is very high, need to characterize and classify properly such way that it remembered and interpreted easily for selection of crop and management practice of crop production. Soil classification by following the standard system makes users and researchers enable to remember logically the salient features and agro technology transfer to other area, where do found similar soil series (Rajagopal *et al*., 2013). Lack of soil characterization becomes obstacle to utilize the soil production potentials and adaptation of

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better management practice to increase the productivity of the soil (ISSS, 2000). Soil resource inventory through characterization of the resources provides an insight into the potentials and limitations of soils (Manchanda *et al.*, 2002). Hence, timely and reliable information on soils with respect to their nature, extent, spatial distribution, potential and limitation is very important (Arunkumar *et al.*, 2002). Large scale information on soil resources for the state is necessary for better and sustainable farm-based or village-based land use planning. Keeping this in view an effort was made to characterize and classify the soils in rubber growing area of Elamdesam block, Kerala, India.

Materials and methods

Details of the study area: Elamdesam block falls under the agro-ecological zone foot hills and high hills, the agro ecological units 12 and 14 i.e. southern and central foot hills and southern high hills, respectively. These units are subdivided in to forests, denudational hills, lateritic terrain and lateritic valley lying between north latitudes 9^0 46' 38.2" and 10^0 2' 18.14" north and east longitudes 76^0 42' 59.49" and 76^0 53' 46.99" east. There are seven Panchayats namely Vannapuram, Kodikulam, Karimannor, Udumbannoor, Alakode, Velliyamattom and Kudayathoor in the Elamdesam block and eight villages covering a total geographical area of 40,307 ha. Villages are further divided in to number of wards for the purpose of administration. Geology of the area is charnockite and granite gneiss of the Archaen age. Elevation ranges from 30 m in low land to 850 m in high hills. Climate is tropical humid monsoon type. Rainfall ranges from 3462 mm to 3602 mm and mean annual temperature varies between 22 ^oC to 27 ^oC. Length of dry period is two to two and a half months. Soil High hills are covered by mixed forest whereas foot hills and midlands have plantation of rubber, coconut, pepper, banana, pineapple, arecanut, cocoa, nutmeg, cashew. Low land is occupied by paddy and tapioca, banana, coconut arecanut and rubber were also cultivating in raised beds. Laterites and Ultisols are the major soil type which, are well drained, shallow to very deep, strongly acidic in nature. Location map given in the Figure 1. In Elamdesam block agriculture is the fundamental livelihood activity among the people. Major land uses are rubber plantations, mixed forest plantations and paddy cultivation.

Soil survey and laboratory methods: Using toposheet (1:50,000 scale) and Google image soil profiles and auger observations from selected transects were studied in such a way that soil survey and mapping observations have been taken in all landform units and the location of soil profiles were recorded using GPS. Horizon-wise morphological properties including depth, colour, structure, texture, gravelliness, consistence, occurrence of nodules, *etc.*, were

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described following USDA soil survey manual (Soil Survey Staff 2014). Soil samples were collected horizon-wise, air dried and processed (2 mm sieve) for various analyses following standard methods. Twelve soil series were identified in the block using the method employed by Reddy (2006). Representative master profiles for each series were identified which also represented the corresponding landform unit.

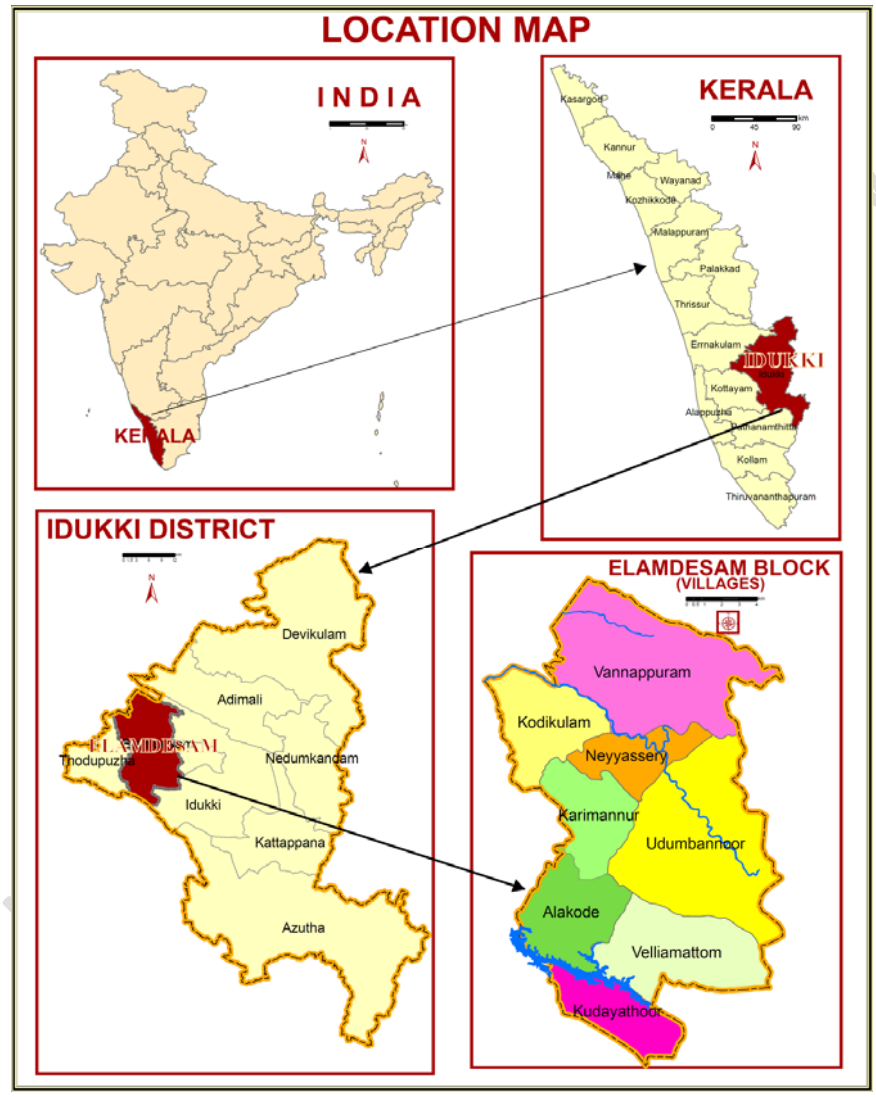

Fig. 1: Location map of the study area (Elamdesam block)

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

Physical Properties

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

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surface gravelly occupied by 32.09 per cent area followed by non-gravelly (22.17 per cent area) and gravelly throughout profile (10.12 per cent).

Chemical properties

Soil reaction classes of Elamdesam block (Table 2), revealed that 37.71 per cent area 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 basses, 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 sesquioxidic 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 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 (NH_4OAc) at a depth between 25 and 75cm from the

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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/m^2 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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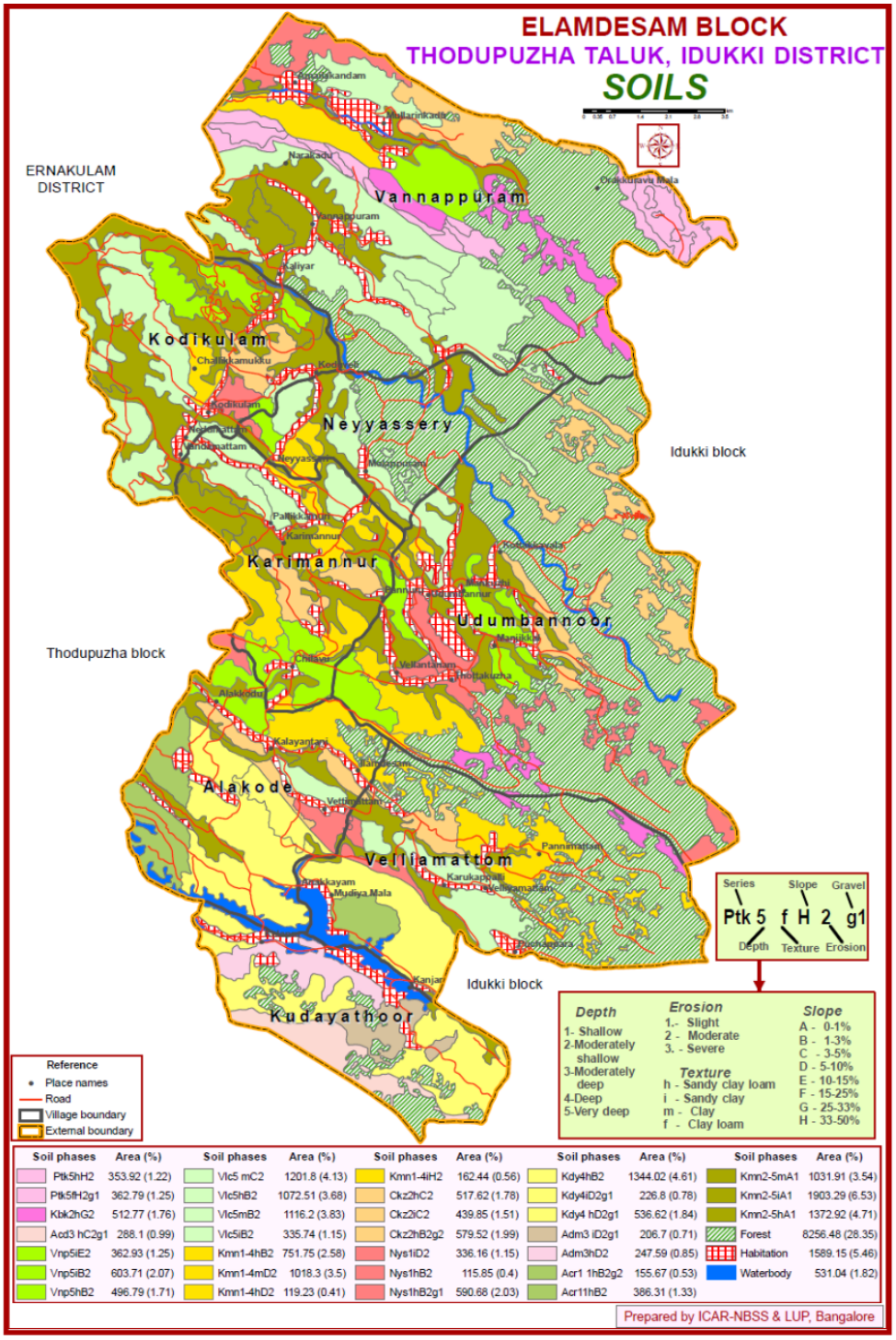

Fig. 2: Soils of Elamdesam block, Idukki district, Kerala

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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
Pedon 1	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	-
Pedon 2	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	-	-
Pedon 3	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	-
Pedon 4	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
Pedon 5	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
Pedon 6	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
Pedon 7	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	-	-
Pedon 8	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	-
Pedon 9	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
	83-102	2BC	5YR4/6	m1sbk	fr, ss, sp	45	-
Pedon 10	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
	58-82	Bt3	5YR5/8	m2sbk	fr, ss, sp	-	T tn p
Pedon 11	0-13	Ap	7.5YR3/2	m1sbk	sh, fr, ss, sp	-	-
	13-32	AC	7.5YR3/3	m1sbk	fr, ss, sp	-	-
Pedon 12	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
	81-95	BC	10YR 4/1	m2sbk	s, fr, vs, vp		-

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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	53.73	17.85	28.42	2.68	4.16	0.18	0.59	0.12	0.08	0.20	13.93	0.49	7
18-42	Bt1	45.91	21.54	32.55	1.95	4.45	0.08	0.23	0.04	0.07	0.08	14.47	0.44	3
42-79	Bt2	51.70	23.43	24.87	0.97	4.75	0.03	0.17	0.01	0.03	0.04	9.29	0.37	3
79-111	2BC1	67.80	16.82	15.38	0.73	5.20	0.02	0.20	0.01	0.04	0.05	9.18	0.60	3
111-135	2BC2	71.69	13.20	15.12	0.40	5.05	0.02	0.09	0.01	0.04	0.06	8.53	0.56	2
135-160	CB	63.11	17.02	19.87	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	59.23	14.52	26.24	1.79	4.61	0.04	0.26	0.08	0.05	0.13	8.64	0.33	6
14-30	AB	69.96	9.51	20.54	1.79	4.36	0.19	1.02	0.27	0.09	0.21	9.29	0.45	17
30-54	BW	58.41	13.70	27.89	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	64.30	15.30	20.40	2.68	5.37	0.03	0.87	0.21	0.04	0.17	10.51	0.51	12
15-34	AB	62.18	15.89	21.93	1.76	5.18	0.02	0.27	0.06	0.00	0.09	7.75	0.35	5
34-75	BW	57.74	17.00	25.26	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	43.40	15.00	41.60	3.39	4.44	0.14	0.60	0.18	0.09	0.27	15.12	0.36	8
10-30	Bt1	47.77	15.09	37.14	3.07	4.20	0.17	0.65	0.11	0.07	0.14	13.18	0.35	7
30-50	Bt2	46.09	15.32	38.59	3.03	4.57	0.11	0.64	0.11	0.05	0.10	13.28	0.34	7
50-70	Bt3	44.31	18.47	37.22	3.23	4.81	0.10	0.58	0.09	0.07	0.11	14.04	0.38	6
70-90	Bt4	37.68	22.99	39.33	2.06	4.97	0.03	0.22	0.05	0.05	0.10	12.74	0.32	3
90-110	Bt5	36.83	23.43	39.74	2.3	4.87	0.03	0.31	0.00	0.06	0.13	13.93	0.35	4
110-150	Bt6	37.63	22.98	39.39	1.74	5.00	0.03	0.31	0.05	0.04	0.11	11.66	0.30	4
Pedon 5: Clayey kaolonitic 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	45.89	16.51	37.61	3.17	4.55	0.08	0.61	0.22	0.12	0.38	13.93	0.37	10
15-31	Bt1	46.70	15.31	38.00	2.1	4.52	0.04	0.13	0.03	0.09	0.17	11.66	0.31	4
31-65	Bt2	54.63	7.38	38.00	1.27	4.62	0.03	0.08	0.00	0.08	0.12	8.86	0.23	3
65-100	Bt3	58.89	4.23	36.88	0.83	4.54	0.03	0.08	0.00	0.07	0.11	10.37	0.28	3
Pedon 7: Fine loamy mixed isohyperthermic family of acid semiactive Humic Dystrustepts														
0-12	Ap	54.67	13.83	31.50	1.61	5.01	0.09	2.17	0.52	0.03	0.31	10.30	0.33	29
12-30	AB	51.53	16.36	32.11	1.32	4.93	0.05	1.79	0.32	0.01	0.10	10.61	0.33	21
30-51	BW1	51.00	14.38	34.61	1.4	4.9	0.03	1.12	0.20	0.00	0.10	11.0	0.32	13
51-63	BW2	50.48	12.41	37.12	1.44	4.93	0.02	0.71	0.15	0.09	0.10	10.51	0.28	10
Pedon 8: Loamy mixed isohyperthermic family of acid semiactive Lithic Dystrustepts														
0-12	Ap	65.24	13.15	21.61	1.99	4.96	0.05	0.81	0.35	0.08	0.17	10.04	0.46	14
12-22	BW	61.56	15.08	23.36	1.59	5.04	0.04	0.50	0.20	0.04	0.09	8.86	0.38	9
22-35	BC	69.33	10.62	20.05	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	42.54	19.74	37.72	2.51	5.63	0.03	1.65	0.71	0.22	0.90	14.58	0.39	24
6-38	Bt1	42.90	20.55	36.55	2.07	5.24	0.03	0.53	0.13	0.11	0.35	13.39	0.37	8
38-65	Bt2	46.94	16.67	36.39	1.55	5.15	0.02	0.28	0.14	0.10	0.15	11.88	0.33	6
65-83	2Bt3	56.04	18.45	25.52	0.83	5.12	0.02	0.14	0.11	0.08	0.15	11.45	0.45	4
83-102	2BC	65.50	16.14	18.36	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	55.56	15.78	28.66	1.99	5.56	0.08	2.74	0.82	0.19	0.51	9.72	0.34	44
11-32	Bt1	52.22	13.29	34.49	0.95	5.26	0.04	2.51	1.24	0.17	0.35	7.99	0.23	53
32-58	Bt2	41.42	19.69	38.89	0.71	5.53	0.03	2.01	1.65	0.18	0.43	7.78	0.20	55
58-82	Bt3	44.35	16.92	38.73	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	75.65	12.98	11.37	2.55	5.18	0.06	1.16	0.48	0.10	0.15	8.96	0.79	21
13-32	AC	71.16	19.89	8.95	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	45.48	16.47	38.05	1.19	4.9	0.04	1.86	0.63	0.07	0.12	9.08	0.24	30
1-27	BW1	42.63	19.84	37.53	1.39	4.16	0.15	1.17	0.15	0.25	0.05	8.57	0.23	19
27-41	BW2	47.81	19.24	32.94	1.35	4.42	0.07	0.76	0.14	0.15	0.03	7.45	0.23	14
41-54	Bt1	39.17	19.12	41.71	0.99	5.3	0.03	1.72	0.66	0.05	0.04	7.14	0.17	35
54-70	Bt2	40.48	15.01	44.51	0.8	5.33	0.03	1.65	0.85	0.03	0.05	7.55	0.17	34
70-81	Bt3	47.36	11.53	41.11	0.83	5.33	0.03	1.56	0.88	0.15	0.07	6.53	0.16	41
81-95	BC1	17.91	18.58	63.52	2.59	4.77	0.06	1.97	1.09	0.13	0.12	16.22	0.26	20

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