

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. Sandy clay loam, clay loam, sandy clay and clay surface soils, soils are non gravelly to gravelly, are extremely acid to moderately acid. 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. 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. Based on the morphological, physical and chemical characteristics soils were classified as Ustic Haplohumults, Humic Dystrustepts, Ustic Kandihumults, Lithic Ustorthents and Oxyaquic Haplustalfs.

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

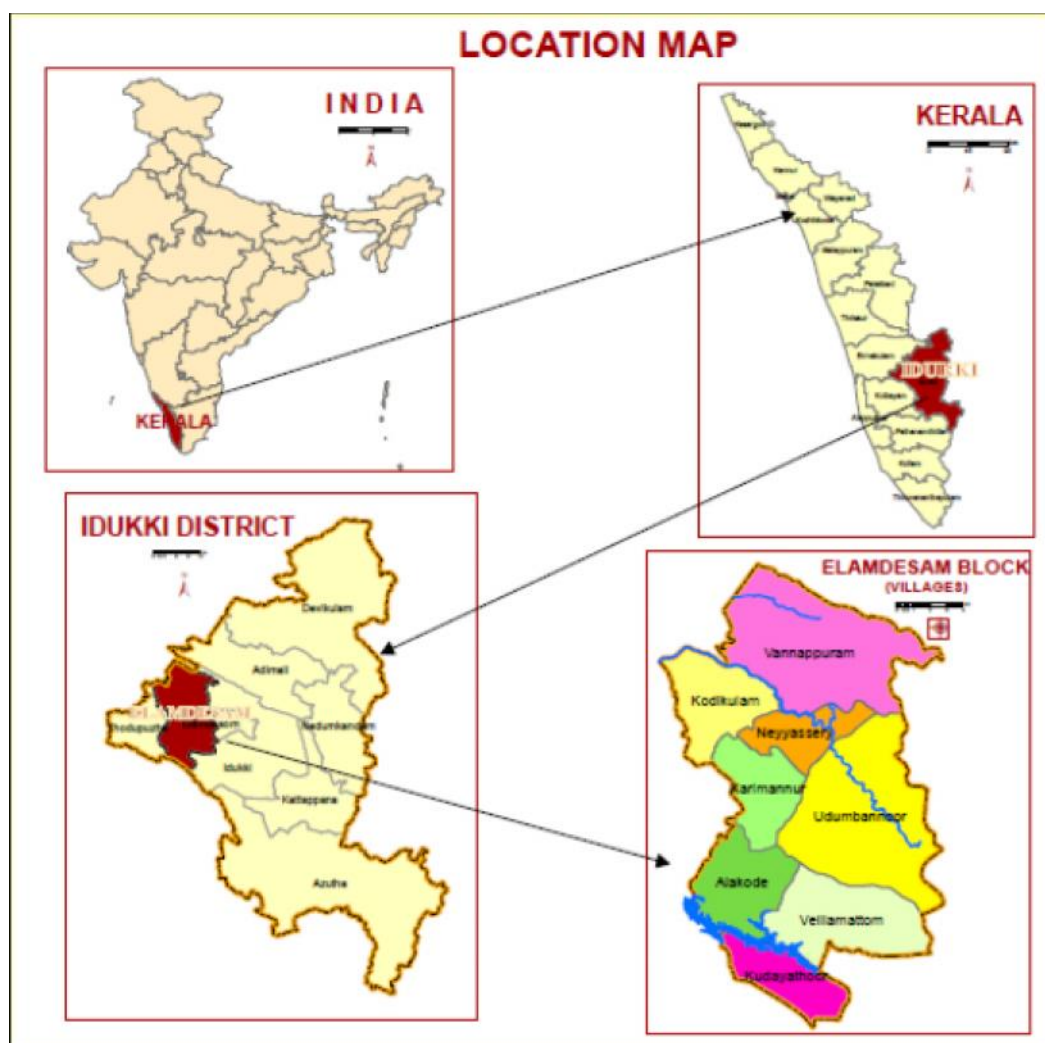
characterization becomes obstacle to utilize the soil production potentials and adaptation of better management practice to increase the productivity of the soil (ISSS, 2000). Soil resource inventory through characterization of the resources provides an insight into the potentials and limitations of 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 need based farm/ village level land use planning. Keeping this in view an effort was made to study the characteristics and classification of 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 $9^{\circ} 46' 38.2''$ and $10^{\circ} 2' 18.14''$ and east longitudes $76^{\circ} 42' 59.49''$ and $76^{\circ} 53' 46.99''$. 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°C to 27°C . Length of dry period is two to two and a half months. 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

64 depth, colour, structure, texture, gravelliness, consistence, occurrence of nodules, *etc.*, were
 65 described following USDA soil survey manual (Soil Survey Staff 2014). Soil samples were
 66 collected horizon-wise, air dried and processed (2 mm sieve) for various analyses following
 67 standard methods. The soils were analysed for their physical and chemical properties
 68 following methods described by Black (1965) and Jackson (1950). Twelve soil series were
 69 identified in the block using the method employed by Reddy (2006). Representative master
 70 profiles for each series were identified which also represented the corresponding landform
 71 unit.



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

74 Result and discussion

75 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 gleyed 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.

Physical Properties

The particle size class data presented in table 2. Sand content varies from 17.91 to 75.65 per cent. Silt content is lower among all the size classes which varied from 6.60 to 23.43 per cent. Clay content varied from 11.37 to 63.52 per cent. 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 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).

109 Chemical properties

110 The acidification of soils is a serious constraint to crop production in the region. Soil
 111 reaction classes of Elamdesam block (Table 2), revealed that 37.71 per cent area is very
 112 strongly acid in reaction followed by 12.06 per cent area is strongly acid and 11.91 per cent
 113 area is extremely acid in reaction. Soil reaction (pH 1:2.5 soil: water ratio) of the pedons
 114 varied from 4.16 to 5.65. Soil reaction varies from extremely acid, very strongly acid,
 115 strongly acid and moderately acid. Organic carbon content of soil classes of Elamdesam
 116 block revealed that 45.61 per cent of area is very high in status followed by 18.23 per cent of
 117 area is high. Generally surface soil has more organic carbon content than sub surfaces
 118 attributed to addition of organic matter from rubber plantation. Electrical conductivity varied
 119 from 0.01 to 0.19 dS m⁻¹. Thus soils are non saline. Similar findings have also been reported
 120 by Nayak *et al.* (2000) and Vijayakumar *et al.* (1994). Among exchangeable bases, Ca
 121 recorded higher content which varied from 0.08 to 2.74 cmol (p+) kg⁻¹. CEC of soils varied
 122 from 2.48 to 16.22 cmol (p+) kg⁻¹ apparently due to variation in clay content which might be
 123 due to the presence of pseudo-aggregates of sesquioxidic nature and amorphous oxides of
 124 iron and aluminum which form coating on clay fractions (Bhaskar and Subbaiah 1995).
 125 Generally, low CEC in the study area which might be attributed to presence of clay minerals
 126 with low CEC and occurrence of hydrous oxides of iron and aluminium in the soils (Sarkar *et*
 127 *al.* 2002). The base saturation of these soils varied from 2 to 55% and it is highest in pedon
 128 10. Lower base saturation might be due to leaching of bases from the pedons and also acidic
 129 soil reaction.

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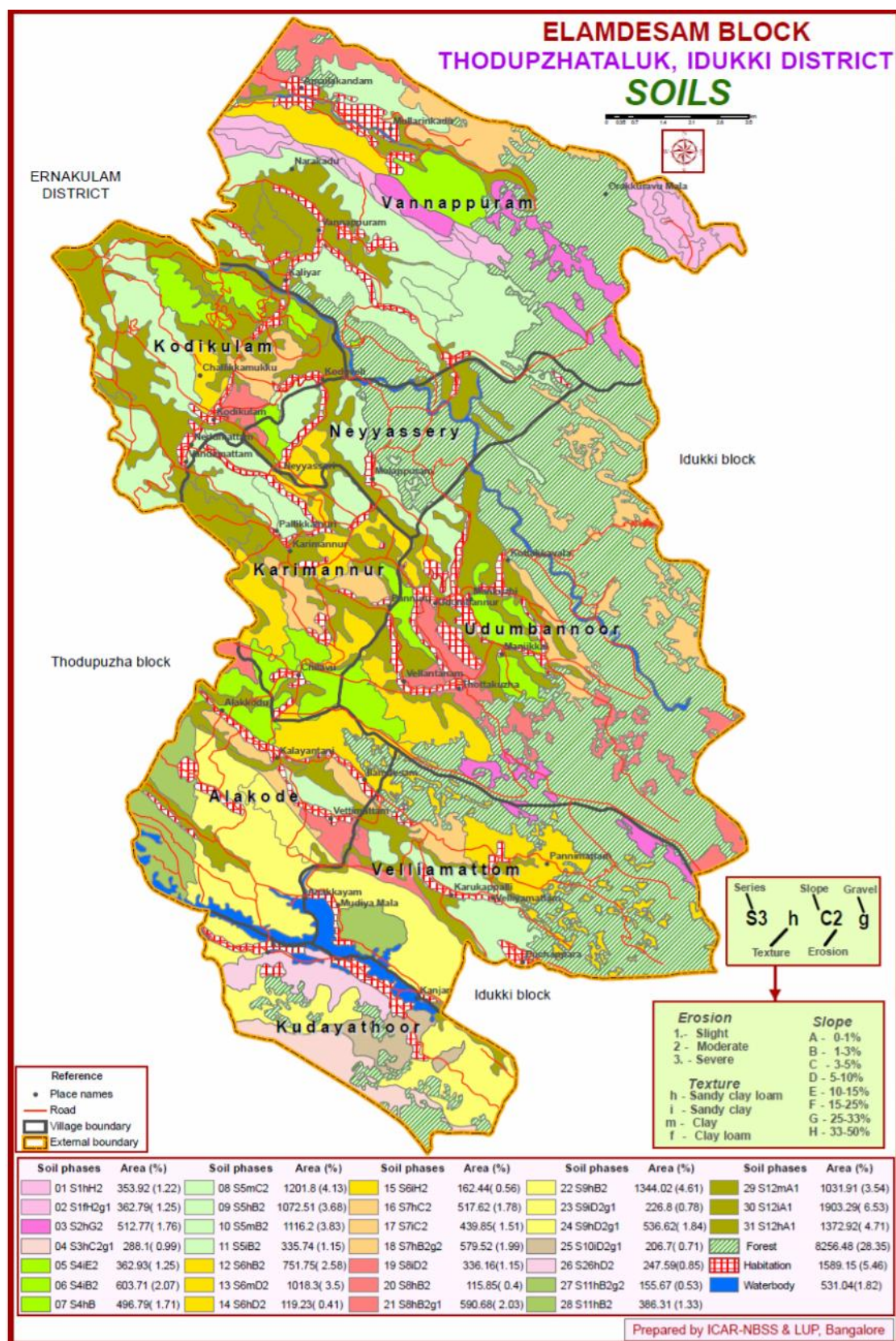
131 Soil classification

132 The soils have been classified following the latest criteria laid down in soil Taxonomy
 133 using field and laboratory data (Soil Survey Staff 2014). Based on the morphological
 134 characteristics, physical and chemical properties of the typifying pedons, the soils are
 135 classified (Fig. 2) as Haplohumults (pedons 1, 4, 6, 9 and 10), Humic Dystrustepts (pedons 2,
 136 3, 7 and 8), Kandihumults (pedon 5), Lithic Ustorthents (pedon 11) and Oxyaquic Haplustalfs
 137 (pedon 12). Pedons 2, 3, 7 and 8 showed the development of colour and/or structural cambic
 138 (Bw) horizons and thus qualify for Inceptisols. The base saturation of soils is less than 60%
 139 by ammonium acetate (NH₄OAc) at a depth between 25 and 75cm from the mineral soil
 140 surface thus justifies Dystrustepts at great group level. Pedons 1, 4, 5, 6, 9 and 10 have base
 141 saturation < 35% so they are classified as Ultisols. At great group level due to presence of

kandic (Bt) horizon with apparent CEC $< 16 \text{ cmol(p+)} \text{ kg}^{-1}$ and apparent ECEC $< 12 \text{ cmol(p+)} \text{ kg}^{-1}$ pedon 5 is grouped into Kandihumults, whereas pedon 1 is grouped into Humults at sub order level due to presence of $> 12 \text{ kg/m}^2$ 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 $> 16 \text{ cmol(p+)} \text{ kg}^{-1}$ 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).

Conclusion

The study revealed that the soils in the foot hills, high hills and midlands region of rubber growing soils of Kerala qualify as Ultisols or Inceptisols and lowland and valleys are associated with Alfisols (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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179 Fig. 2: Soils of Elamdesam block, Idukki district, Kerala

References

- Arunkumar. V., Natarajan, S. and Sivasamy, R. (2002). Characterisation and classification of soils of Lower Palar . Manimuthar Watershed of Tamil Nadu. *Agropedology* **12**, 97-103.
- Bhaskar, B.P. and Subbaiah, G.V. (1995). Genesis, characterization and classification of laterite and associates soils along the east coast of Andhra Pradesh. *Journal of Indian Society of Soil Science* **43**, 107-112.
- Bhattacharyya, T., Sehgal, J. and Sarkar, D. (1996). Soils of Tripura for Optimising Land Use, their Kinds, Distribution and Suitability for Major Field Crops and Rubber. NBSS Publ. **65** a & c. Nagpur, India.
- Bhattacharyya, T., Mukhopadhyoy, S., Buruah, U. And Chamuah, G. S. (1998). Need of soil study to determine degradation and landscape stability.*Current Science* **74**, 42–47.
- Bhattacharyya, T., Ram Babu, Sarkar, D., Mandal, D., Mandal, C. And Nagar, A.P. (2002). Soil erosion of Tripura, a model for soil conservation and crop performance. *NBSS Publication No. 97*. NBSS&LDP, Nagpur.
- Bhattacharyya, T., Pal, D.K. and Vaidya, P.H. (2003). Soil landscape model for suitable cropping pattern in Tripura. Part I. Soil resources in Tripura – their extent, nature and characteristics. DST Project Report, NBSS&LUP (ICAR) Nagpur, 114.
- Buol, S.W., Southward, R.J., Graham, R.C. and McDaniel, P.A. (2003). *Soil Genesis and Classification*. Iowa state Press, State Avenue, Ames, Iowa.
- Black, C.A. (1965). *Methods of Soil Analysis*, Part 1 and 2 (American Society of Agronomy Inc., Madison, Wisconsin, USA).
- ISSS. 2000. Fundamentals of Soil Science. (I ed.). New Delhi, India.

- Jackson, M.L. (1950). *Soil Chemical Analysis*. (Indian Edition), Prentice Hall of India Ltd. Delhi.
- Jena, R.K., Duraisami, V.P., Sivasamy, R., Shanmugasundaram, R., Krishnan, R., Padua, S., Bandyopadhyay, S., Ramachandran, S., Ray, P., Deb Roy, P., Singh, S. K. and Ray, S. K. (2016). Characterization and Classification of Soils of Jirang Block in Meghalaya Plateau. *Agropedology*, 26 (01), 47-57.
- Manchanda, M.L., Kudrat, M. and Tiwari, A.K. (2002). Soil survey and mapping using remote sensing. *Tropical Ecology* **43**, 61-74.
- Nayak, A.K., Rao, G.G., Chinchmalapture, A.R. and Singh, R. (2000). Characterization and classification of some salt affected soils of Bhal region of Gujarat. *Agropedology*, **10** (2): 152-162.
- Rajagopal V., Prabhu Prasadini P., Pazanivelan S. and Balakrishnan N., (2013). Characterisation and Classification of Soils in Warangal District of Central Telangana Zone. *Madras Agric. J.*, 100 (4-6): 432-437.
- Reddy, R.S. (2006). Methodology for correlation of soil series in soil survey and mapping. *Agropedology*, **16**, 1-11
- Sankar, M. AND Dadhwal, K. S. (2009). Characterization and classification of red soils from Tamil Nadu, *The Asian J. Hort.* **4** (1): 81-85.
- Sarkar, D., Baruah, U., Gangopadhyay, S.K., Sahoo, A.K. and Velayutham, M. (2002). Characteristics and classification of soils of Loktak catchment area of Manipur for sustainable land use planning. *Journal of the Indian Society of Soil Science* **50**, 196-204.
- Sehgal, J. (1996). *Pedology: Concepts and applications*, Kalyani publishers, New Delhi.

- 244 Sharma, V.K., Sharma, P.D., Sharma, S.P., Acharya, C.L. and Sood, R.K. (2004).
 245 Characterization of cultivated soils of Neogal watershed in north-west Himalayas and
 246 their suitability for major crops. *Journal of the Indian Society of Soil Science* **52**, 63-
 247 68.
- 248
- 249 Singh, R.S., Baruah, U., Sarkar, D., Butte, P.S. and Gajbhiye, K.S. (2005). Soil Series of
 250 Meghalaya. *NBSSPubl.* **121**, 86.
- 251
- 252 Soil Survey Staff. (2014). 'Keys to Soil Taxonomy', Twelfth Edition. (U.S.D.A.: Natural
 253 Resources Conservation Service, Washington, D.C.).
- 254
- 255 Tripathi, D; Verma, J. R; Patial, K. S. and Karan Singh. (2006). Characteristics, classification
 256 and suitability of soils for major crops of Kiar-Nagali micro-watershed in North-West
 257 Himalayas. *J. Indian Soc. Soil Sci.* **54**(2):131-136.
- 258
- 259 Vijayakumar, T., Suryanarayana Reddy, M. and Gopalakrishna, V. (1994). Characterisation
 260 and classification of soils of Northern Telangana zone of Andhra Pradesh.
 261 *Agropedology*, 4 : 31-43.

262 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	flsbk	s, fr, s, p	-	-
	18-42	Bt1	7.5YR3/3	flsbk	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	flsbk	vfr, s, p	-	-
	14-30	AB	7.5YR3/3	flsbk	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
<u>Pedon 6</u>	177-210+	Bt7	2.5YR 3/6	m2sbk	s, fi, vs, vp	-	T tn p
	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
	83-102	2BC	5YR4/6	m1sbk	fr, ss, sp	45	-
<u>Pedon 10</u>	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
<u>Pedon 11</u>	0-13	Ap	7.5YR3/2	m1sbk	sh, fr, ss, sp	-	-
	13-32	AC	7.5YR3/3	m1sbk	fr, ss, sp	-	-
<u>Pedon 12</u>	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	-	-

264 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 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	45.89	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 Haplustalfs														
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