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CHARACTERIZATION AND CLASSIFICATION OF FARM SOILS OF REGIONAL AGRICULTURAL RESEARCH STATION (RARS), NANDYAL, KURNOOL DISTRICT, ANDHRA PRADESH

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ABSTRACT

A study was conducted during the year 2019-20 to characterize and categorize the soil resources of Regional Agricultural Research Station (RARS) farm, Nandyal, Kurnool district of Andhra Pradesh. Two representative soil profiles (dry land and wet land) horizon wise were selected and analyzed for morphological, physical, chemical and physico-chemical properties. The soils were found to be moderate to strongly alkaline (8.11 to 8.66); non-saline (0.45 to 2.11 dS m^{-1}) with very deep clayey texture. The study area showed isohyperthermic temperature and ustic soil moisture regimes. The base saturation, cation exchange capacity (CEC), organic carbon (OC) were in the order of 90.6 to 98.90 %, 50.4 to 57.6 cmol (p+) kg^{-1} and 0.08 to 0.51 %. Pedons 1 and 2 were classified under *Vertsiol* due to presence of more than 30 per cent clay in all the horizons, slickensides and wedge shaped aggregates in sub-surface horizons and cracks in surface horizons and were classified as Sodic Haplustert on USDA soil taxonomy classification.

Key words: (Characterization, classification, sodic haplustert and *Vertisol*)

INTRODUCTION

Andhra Pradesh comes under semi-arid tropical monsoon climate and diversified soil types were found. Maintaining soil in good health is very much essential to meet the increasing food demands, fuel, fodder and fiber. The biggest future challenge for the mankind is to meet the basic necessities of increasing population, from ever shrinking and non-renewable soil resource (Lal, 2013). The data base of soil resource serves as a basic guide to improve the productivity of land resources by conserving and managing them in a rational manner based on their capability and by providing inputs like fertilizers, quality seeds and selection of suitable crops based on potentiality of soil and other resources.

Soil characterization determines the soils individual inherent potentials and limitations for crop production besides giving detailed information about the different soil properties. Characterization and systematic classification of dominant soil groups, is a basic tool and a pre requisite for soil fertility evaluation and efficient soil-fertilizer-water management practices and, thus, crop management. Hence, the present investigation was planned and executed.

MATERIALS AND METHODS

Location and brief description of the study area

Regional Agriculture Research Station, Nandyal, Kurnool district is functioning as headquarters for Scarce Rainfall Zone of Andhra Pradesh and functioning for the development of farming community in Kurnool and Anantapur districts under the umbrella of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India at a latitude of 15°29’ and a longitude of 78°29’. Regional Agricultural Research Station, Nandyal is one of the esteemed oldest research stations in India established during British rule (1906) and one of the 3rd premier stations in the country.

The research station is having 46.72 ha of land. The ideal Agro-climatic situation of RARS, Nandyal is having typical black cotton soils (*Vertisols*) and the rainfall pattern is very much suitable for conducting research in cotton, bengalgram, tobacco and maghi Jowar. This station is also known for producing best quality rice and geographic indicator for producing best quality Kurnool Sona. Several promising and well established popular varieties/ hybrids were evolved in paddy (Kurnool Sona and Nandyal Sona), bengalgram (Nandyal Gram 49 and Dheera) cotton (Narasimha and Srirama) and millets. Suitable varieties were evolved in sorghum, foxtail millet, sunflower, tobacco and the station is very much popular for recent advances in Farm mechanization.

A detailed study on soil survey was executed during year 2019-20 at Regional Agricultural Research Station (RARS) farm situated in semi-arid agro-ecological region by using 1:10,000 base map as per the protocol outlined by AIS&LUS (1970) and two pedons in wet land and dry land

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areas were selected and these were studied in detail and the morphological characteristics were depicted in Table 1 as per the procedure given in the Soil Survey Manual (Anonymous, 2015). Later, samples were collected horizon-wise and analyzed for key physical and physico-chemical properties by adopting standard procedures (Jackson, 1973).

Collection, processing and methods used for soil analysis

Based on the physiography and morphological characteristics two geo-referenced pedons were selected for analysis at RARS farm, Nandyal. For laboratory analysis horizon wise samples were collected from the representative two pedons. The soil samples were air-dried in shade graded by passing through a 2 mm sieve. Soil particles more than 2 mm were categorized as gravel. After sieving, packeting of the soil samples were made in the polythene bags for the analysis of physical (Texture, structure, bulk density and water holding capacity) and physico-chemical properties (pH, EC, OC, $CaCO_3$, CEC, exchangeable Ca, Mg, Na, K, base saturation (%), ESP, Ca/Mg, CEC/clay). The detailed morphological description of each horizon of soil was outlined in Soil Survey Manual (Anonymous, 1951). The representative soil samples from each horizon were characterized as physical, physico-chemical and chemical properties using standard procedures. The Soil pH, EC (1:2.5 soil water suspension), cation exchange capacity (Chapman, 1965); exchangeable sodium and potassium were determined by aspirating the leachate directly into the flame photometer (Systronics flame photometer 128). The exchangeable calcium and magnesium were determined by versenate method. The concentration of exchangeable cations Ca^{2+}, Mg^{2+}, K^+ and Na^+ were expressed in c mol (p^+) kg^{-1} soil (Chopra and Kanwar, 1991); organic carbon (Walkely and black, 1934); and free $CaCO_3$ (Piper, 1966). The classification of study areas were based on the physical, chemical, morphological and exchangeable properties of soils and climatic data (soil moisture and temperature regimes) following the keys to soil taxonomy (Anonymous, 2010).

RESULTS AND DISCUSSION

Soil morphology

The detailed description of morphological properties of the soils were depicted in Table 1. Both the pedons (1 and 2) were categorized under very deep depth of solums and the soils were poorly to somewhat poorly drained. The soil colour ranged from dark gray to very dark gray colour with a hue of 10YR, chroma ranged between 1 and 2 and value ranged from 3 to 4 in pedon 1 and 2. Very little soil colour variation with depth in pedons 1 and 2 was noticed and it might be due to the effect of impeded internal drainage conditions, high clay content, topography, parent material, complex-clay-humus, smectite type clay and moisture were the key factors responsible for the dark colour of the soils (Prasad *et al*., 2001).

The soils of research station are clay in nature. Surface and sub-surface horizons showed medium to strong and sub-angular blocky to angular blocky structure and recorded consistently firm, hard, very sticky to very plastic, sticky plastic and slightly sticky in dry, moist and wet conditions, respectively, Pressure faces and slicken sides were found to be in sub-surface horizons and surface horizon was found to be gradual and smooth boundary and clear and smooth boundary in sub-surface horizons, whereas pedon 2 surface and sub-surface horizons showed medium, moderate to strong and angular blocky structure to sub-angular blocky and consistence varied from friable to firm, soft to slightly hard and slightly sticky, slightly plastic to slightly sticky plastic and in moist, dry and wet conditions respectively, this might be due to higher clay content of soil (Sarkar *et al.,* 2001) and also due to dominance of smectite clay mineral (Leelavathi *et al*., 2009). The soil texture uniformity was due to the argillo pedoturbation working in the black soil profiles (Buol *et al*., 1998).

The pedality of vertisols was tenaciously developed because of the CEC, high clay content, PBS and dominance of smectitic type of clay. Both the surface and subsurface horizons were blocky in structure (either angular or sub angular), the peds were with strong grade (strength), medium to coarse in size. At lower topographic positions stronger pedality of soils was noticed and it might be due to smaller fractions (Shyampura *et al.,* 1994).

Soil characteristics

Physical characteristics

The data regarding soil physical characteristics are presented in Table 2. Particle size in clay content varied from 53.2 to 67.1 per cent and 52.4 to 63.1% in pedon 1 and pedon 2 respectively. Enhanced clay content with depth was an evidence of pedogenic development as their distribution and formation is time dependent (Bhaskar *et al.,* 2009). These variations could be due to the topography, parent material, *in-situ* weathering and / or pedogenesis (Gabhane *et al.,* 2006). The clay enrichment of Bw and Bss horizons was mostly due to *in situ* weathering of parent material in pedons. Silt fraction ranged from 25.6 to 18.0 per cent and 25.7 to 18.1% in pedon 1 and pedon 2 respectively, silt content with depth exhibited an irregular trend and due to variance in *in-situ* formation or weathering of parent material (Kumar and Naidu, 2012). Low sand content had been noticed in both the pedons and ranged from 13.5 to 22.1%, the reason might be due to the migration / translocation of finer particles into the lower layers and surface erosion. Surface horizons had higher amount of sand content than that of sub-surface horizons, contrary to clay content and was due to surface impoverishment of finer particles by excess runoff water (Surekha *et al.,* 1997).

The bulk density of soils in surface horizons ranged from 1.24 Mg m^{-3} to 1.28 Mg m^{-3}, whereas in subsurface horizons it ranged from 1.37 Mg m^{-3} to 1.52 Mg m^{-3}. With the increase in depth there was increase in bulk density and it might be due to calcium carbonate, more compaction, low organic carbon content and lesser aggregation (Singh and Agarwal, 2005). Rahate *et al.* (2014)

also studied five pedons of Telangkhedi garden, College of Agriculture, Nagpur and reported that the bulk density of soils varied from 1.42 to 1.56 mg m^{-3}. The high content of expanding type of clay minerals and the moisture content attributed to the inconsistency in bulk density of soils. Water holding capacity (WHC) of soils ranged from 40.76 to 44.21% in surface soils and from 38.58 % to 54.90 % in subsurface soils. Notable differences might be due to the difference in clay and organic carbon content of the pedons. Maximum water holding capacity (WHC) followed the similar trend of clay and these results were in confirmation with the findings of Thangasamy *et al.* (2004) in soils of Savagiri micro-watershed in Chittor district of Andhra Pradesh. The Highest water holding capacity (WHC) was observed in surface horizon due to existence of higher clay content and organic matter in the surface soils than in sub-surface horizon. Water holding capacity was higher in soils as they were rich in clay as evident from significant positive correlation between water holding capacity and clay content (r = +0.631**). However, water holding capacity was very less in sandy soils due to high sand and less clay content as evident by highly significant and negative correlation (r = –0.685**) between water holding capacity and sand content. Similar type of negative correlation between water holding capacity and sand was observed by Rao and Prasadini (1998).

Physico-chemical characteristics

The data regarding physico-chemical characteristics of the soils are presented in Table 3. The soil pH varied from moderate (8.11) to strongly alkaline (8.66). Increase in the depth the pH values in the pedon 1 might be due to increase in bases with depth and their complete downward leaching. Irregular distribution in pedon 2 was noticed due to downward movement of bases and they get adsorbed irregularly at different layers. The slight soil alkaline reaction may be due to the moderate to high calcareous nature of the soil (Shweta *et al.,* 2017). The electrical conductivity ranged from 0.14 to 2.11 dSm^{-1} depicting that the soils were non-saline in research station. With depth EC increased gradually due to the leaching of electrolytes to lower depth and also due to foraging of nutrient ions by the vegetation in the surface layer. Renukadevi (2003) reported that the EC value of Parambikulam Aliyar project soils ranged from 0.02 to 0.31 dS m^{-1} and in majority of the pedons EC was gradually increased with higher depth. This might be due to leaching of electrolytes to the lower depth.

Soils in study area showed organic carbon content lower in surface and sub-surface horizons, varying from 0.08 to 0.51 per cent (Table 3). The organic carbon content was comparatively higher in surface horizons than the sub-surface horizons and decreased with depth. Rajeshwar *et al.* (2009) stated increase in organic carbon might be due to the addition of farmyard manure (FYM) and plant debris to surface horizons that lead to higher organic carbon content in surface horizons compared to lower horizons.

The calcium carbonate of black soil pedons was higher in deeper layers than that of surface layers (Pedon 1 and 2) containing 9.25 to 11.87 per cent respectively, this was due to the leaching of bicarbonate during rainy season. The content was relatively higher in deeper layers than in surface layers might be due to the leaching of bicarbonate from upper layer during rainy season and their subsequent precipitation as carbonate in the lower layer (Maji *et al.*, 2005). The irregular distribution of $CaCO_3$ in the pedons 1 and 2 with depth could be due to the wavering nature of the geological material (Rajkumar *et al.*, 2005).

The Cation Exchange Capacity (CEC) of soils was relatively more in both the pedons varied from 50.4 to 57.6 cmol (p^+) kg^{-1} soil (Table 3) which denotes clay content in the horizons, organic carbon content and also clay mineral type present in these soils. The higher Cation Exchange Capacity (CEC) of the black soils was due to higher clay content and smectitic clay mineralogy (Malavath and Mani, 2015).

The CEC of soils increased with profile depths and followed the similar trend that of clay. ESP ranged from 5.19 to 34.40 per cent indicated the initiation of sodiumization in a downward direction. Important factors such as type of concentration of electrolytes , minerals and status of soluble cations plays an key role in measurement of relative amounts of exchangeable sodium comparable with the total cations in the soil. The CEC/clay ratio varies from 0.83 to 0.99. Higher CEC/clay ratio indicates the less weathered nature of soils with weatherable primary minerals (Buol *et al.*, 1998).

The exchangeable bases of both pedons 1 and 2 were in the order of Ca^{2+}> Mg^{2+}> Na^+> K^+ on the exchange complex (Table 3). Ca was dominated in soil exchange complex compared to other exchangeable cations. Ca^{+2} and Mg^{+2} distribution showed that, Ca^{+2} had shown the higher relationship with all the species, compared to these ions (Ca^{+2}, Mg^{+2}, K^+ and Na^+) and it was evident that Mg^{+2} was present in lesser amount than Ca^{+2} , it might be due to higher mobility. Thangasamy *et al.* (2004) reported exchangeable bases in the black and red soil pedons were in order of Ca^{2+} > Mg^{2+} > Na^+ > K^+ on the exchange complex. From the distribution of Ca^{2+} and Mg^{2+}, it is evident that Ca^{2+} showed the strongest relationship with all the species, comparing these ions (Ca^{2+}, Mg^{2+}, K^{2+} and Na^{2+}) it was clear that Mg^{2+} was present in low amount than Ca^{2+} because of its higher mobility. Both the black soil pedons showed very greater per cent base saturation (90.6 to 98.9%) and increase in depth increased base saturation, the reason might be due to the downward movement of bases along with water percolating from upper horizon to the lower horizons. Low clay and organic carbon content and also the presence of lime concentration resulted weak structural development of soils of Shikohpur watershed, Haryana (Sitanggang *et al.*, 2006). The relative proportion between Ca and Mg ranged from 1.25 to 2.50 and narrower Ca^{+2} / Mg^{+2} ratio was due to decrease in Ca solubility, replacement of Mg^{+2} or Ca^{+2} by plants and recycling of unusual amount of Mg (Sharma *et al.*, 2011).

Soil classification

Based on the physical, morphological, physico-chemical, chemical and exchangeable properties of soils and weather parameters like moisture regimes and temperature the classification was based on the guidelines of USDA Soil Taxonomy (Anonymous, 2010). The soils regimes of RARS farm are very deep and ideal for cultivation of cotton, redgram, greengram, sorghum, sunflower, blackgram, maize and tobacco. Both the pedons were classified as *Vertisols* because of the presence of these features. Soil layer more than 25 cm with an upper boundary within 100 cm of the mineral soil surface, clayey texture, more than 50 % clay in fine earth fraction throughout the depth, gilgai micro-relief on the surface; lower horizons having distinct intersecting slicken sides; cracks with width greater than 1 cm which remained open and close periodically to the surface from a depth of more than 40 cm and absence of paralithic or lithic contact, duripan, petrocalcic horizon within 50 cm from the surface. Based on these characters the soils are classified under the order *Vertisols* (Table 4). At sub-order level pedons 1 and 2 comes under Ustert due to the presence of ustic soil moisture regime. At great group level categorized as Haplusterts,because the pedons had not showed either salic, gypsic and petrocalcic horizons within 100 cm depth. The pedons had EC less than 4 dSm^{-1} and pH more than 4.5. At sub group level due to presence of sodic horizon (ESP > 15) and absence of gypsic, halic, petrocalcic, and calcic horizons and absence of lithic contact in both the pedons, pedons were placed under Sodic Haplusterts and because these pedons had deep cracks that remained open for more than 150 cumulative days most years reported by Walia and Rao (1996) and Singh *et al.* (1998). Similarly Nasre *et al.* (2013) taxonomically categorized soils of Karanji watershed in Maharashtra, as Sodic Haplustert at great group level. These are in confirmation with the results of Surekha *et al.* (1997) and Rajeshwar and Mani (2015) taxonomically classified some *Vertisols* of Andhra Pradesh (A.P) and some cotton growing soils in semi-arid tropics of Tamil Nadu as Typic Haplusterts

The morphological, physical and physico-chemical properties of Regional Agricultural Research Station (RARS) farm, Nandyal soils in Kurnool district were moderately alkaline to strongly alkaline in reaction, low in organic carbon, non-saline,. The Cation Exchange Capacity (CEC) and base saturation were high and exchange complex was dominated by Ca^{2+} > Mg^{2+}> Na^{+}>K^{+}. Soils of Regional Agricultural Research Station (RARS), Nandyal farm were classified as Sodic Haplusterts.

Table 1. Morphological characters of the soils

Pedon No. & Horizon		Depth (cm)	Colour	Texture	Structure			Consistence			Boundary		Cutans			Pores		Roots	
		Dry	Moist		S	G	T	Dry	Moist	Wet	D	T	TY	TH	Q	S	Q	S	Q
Pedon-1 Fine, smectitic, isohyperthermic, Sodic Haplustert																			
Ap	0.00-0.28	10 YR 4/1	10YR 3/2	c	m	2	Sbk	h	fr	vsvp	g	s	-	-	-	f	vf	f	vf
Bw1	0.28-0.60	10 YR 4/1	10YR 4/1	c	m	3	Sbk	h	fr	sp	g	s	-	-	-	f	vf	c	vf
Bss1	0.60-0.89	10 YR 4/1	10YR 3/1	c	m	2	Sbk	h	fr	sp	g	s	-	-	-	f	vf	c	vf
Bss2	0.89-1.19	10 YR 4/1	10YR 3/1	c	m	2	Abk	h	fr	sp	g	s	-	-	-	f	vf	c	vf
Bss3	1.19-1.50+	10 YR 4/1	10YR4/2	c	m	2	Abk	h	fr	ssp	c	s	+	+	-	f	vf	vf	vf
Pedon-2 Fine, smectitic, isohyperthermic, Sodic Haplustert																			
Ap	0.00-0.15	10 YR 4/1	10YR 4/2	c	m	3	Abk	s	fr	ssps	g	s	-	-	-	f	vf	f	mf
Bw1	0.15-0.40	10 YR 4/2	10YR 3/2	c	m	3	Abk	sh	fi	sp	g	s	-	-	-	f	vf	vf	f
Bss1	0.40-0.73	10 YR 4/2	10YR4/2	c	m	3	Abk	h	fi	sp	g	s	-	-	-	f	vf	-	-
Bss2	0.73-1.15	10 YR 4/1	10YR 4/2	c	m	3	Sbk	h	fi	sp	g	s	-	-	-	f	vf	-	-
Bss3	1.15-1.48+	10 YR 4/2	10 YR5/2	c	m	3	Sbk	h	fi	ssp	c	s	-	-	-	f	vf	-	-

Texture : c – clay, cl – clay loam, l – loam, s – sand, sl – sandy loam, scl – sandy clay loam, sc – sandy clay, ls – loamy sand

Structure : Size (S) – vf – very fine, f – fine, m – medium, c – coarse; Grade (G) – O – structureless, 1 – weak, 2 – moderate, 3 – strong; Type (T) cr – crumb, sg – single grain, abk – angular blocky, sbk – sub-angular blocky.

Consistence :

Dry : s – soft, l – loose, sh – slightly hard, h – hard, vh – very hard, eh – extremely hard

Moist : l – loose, fr – friable, fi – firm, vfi – very firm, efi – extremely firm

Wet : so – non-sticky, ss – slightly sticky, s – sticky, vs – very sticky; po – non-plastic, ps – slightly plastic, p – plastic, vp – very plastic

Cutans : Ty – type – t – Argillan, Th – Thickness, tn – thin, th – thick, Quantity (Q), p – patchy, c – continuous

Pores : Size (S) f – fine, m- medium, c- coarse; Q – Quantity, f – few, c – common, m - many

Roots : Size (S) f – fine, m- medium, c- coarse; Q – Quantity, f – few, c – common, m - many

Effervescence : es – strong effervescence, ev – violent effervescence

Boundary : D – Distinctness, c – clear, g – gradual, d – diffuse, T – Topography; s – smooth; w – wavy

Table 2. Physical characteristics of the soils

Pedon No. and Horizon	Depth (m)	Sand (%) (0.05-2.0 mm)	Silt (%) (0.002-0.05 mm)	Clay (%) (<0.002 mm)	Bulk density (Mg m^{-3})	Water holding capacity (%)
Pedon 1 Fine, smectitic, isohyperthermic, Sodic Haplustert						
Ap	0.00-0.28	20.4	25.6	53.2	1.24	44.21
Bw1	0.28-0.60	22.1	19.4	58.4	1.37	48.73
Bss1	0.60-0.89	17.3	17.5	65.1	1.48	54.90
Bss2	0.89-1.19	13.5	18.4	67.2	1.43	50.74
Bss3	1.19-1.50+	14.2	18.0	67.1	1.52	53.48
Pedon 2 Fine, smectitic, isohyperthermic, Sodic Haplustert						
Ap	0.00-0.15	21.1	25.7	52.4	1.28	40.76
Bw1	0.15-0.40	19.0	23.8	56.3	1.43	39.55
Bss1	0.40-0.73	19.8	21.5	58.6	1.48	42.43
Bss2	0.73-1.15	17.8	20.4	61.5	1.50	40.31
Bss3	1.15-1.48+	18.4	18.1	63.1	1.47	38.58

Table 3. Physico-chemical properties of the soils

Pedon No. & Horizon	Depth (m)	pH 1:2.5	EC (dSm^{-1})	Organic carbon (%)	$CaCO_3$ (%)	CEC (cmol (p^+) kg^{1})(1 *N* NH_4OAc, pH 7.0)	Exchangeable bases (c mol (p^+) kg^{-1}) (1 *N* NH_4OAc, pH 7.0)				Base saturation (%) (1 *N* NH_4OAc, pH 7.0)	ESP (%)	Ca/ Mg	CEC/ Clay
							Ca^{2+}	Mg^{2+}	Na^+	K^+				
Pedon 1 Fine, smectitic, isohyperthermic, Sodic Haplustert														
Ap	0.00-0.28	8.32	0.61	0.47	9.25	52.7	25.84	14.30	6.31	1.32	90.6	13.21	1.81	0.99
Bw1	0.28-0.60	8.45	0.74	0.29	11.04	53.2	24.78	18.60	8.24	0.86	98.6	15.70	1.33	0.91
Bss1	0.60-0.89	8.21	1.81	0.20	9.17	55.2	23.44	16.55	11.36	2.58	97.7	21.06	1.42	0.85
Bss2	0.89-1.19	8.11	1.87	0.11	10.27	57.3	26.76	10.70	13.45	5.76	98.9	23.73	2.50	0.85
Bss3	1.19-1.50+	8.25	2.11	0.08	11.87	55.7	21.44	13.20	12.68	6.84	98.8	23.43	1.62	0.83
Pedon 2 Fine, smectitic, isohyperthermic, Sodic Haplustert														
Ap	0.00-0.15	8.21	0.45	0.51	9.78	50.4	28.70	15.60	2.45	0.46	93.7	5.19	1.84	0.96
Bw1	0.15-0.40	8.22	0.68	0.21	9.44	52.6	28.63	14.80	7.12	0.38	96.8	13.98	1.93	0.93
Bss1	0.40-0.73	8.45	0.94	0.17	10.57	55.2	22.50	17.30	10.88	0.33	92.4	21.33	1.30	0.94
Bss2	0.73-1.15	8.63	1.14	0.14	11.36	56.3	23.50	14.60	15.67	0.28	96.0	28.99	1.61	0.92
Bss3	1.15-1.48+	8.66	1.38	0.11	10.44	57.6	19.82	15.80	18.95	0.51	95.6	34.40	1.25	0.91

Table 4. Soil classification of RARS Farm, Nandyal

Pedon No.	Order	Sub-order	Great group	Sub-group	Family
1	Vertisol	Ustert	Haplustert	Sodic Haplustert	Fine, smectitic, isohyperthermic, Sodic Haplustert
2	Vertisol	Ustert	Haplustert	Sodic Haplustert	Fine, smectitic, isohyperthermic, Sodic Haplustert

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