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Characterization, Classification and Nutritional Status of Sugarcane Growing Soils of Chittoor District of Andhra Pradesh

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ABSTRACT

Based on variation in soils and physiography, six typical pedons namely Neruvoi (P1), Palamangalam (P2), Gollapalle (P3), Vonaruvaripalli (P4), Digavapokalavaripalli (P5) and Gattivaripalli (P6) in Chittoor district, Andhra Pradesh were characterized for their physical and chemical properties and for nutritional status of sugarcane-growing soils. These pedons were shallow (P3 and P4), deep (P2, P5 and P6) and very deep (P1) and had Munsell colour notation of 10 YR / 7.5YR hue, with value 2 to 6 and chroma 1 to 6. The dominant soil structure is fine to medium, weak to moderate and sub-angular blocky. Sand, silt and clay ranged from 32.70 to 94.04, 3.97 to 39.60 and 1.99 to 35.86 per cent, respectively in different horizons and bulk density varied from 1.29 (P4) to 1.94 Mg m^{-3} (P1). These soils are neutral to strongly alkaline in reaction (7.35 to 8.21) . The CEC of the soils varied from 1.30 to 28.80 cmol(p^+)kg^{-1} in different horizons. Calcium and magnesium were found to be the dominant cations on the exchange complex. Organic carbon was low to medium . The soils were low in available N, low to high in available P and K and sufficient in available sulphur. The DTPA-extractable zinc in sugarcane-growing soils was sufficient in surface horizons and deficient in sub-surface horizons in all the pedons except in P4 (Vonaruvaripalli) and P6 (Gattivaripalli) wherein it was found to be deficient in P4 and sufficient in P6. The sugarcane-growing soils were deficient in DTPA-extractable iron and sufficient in DTPA-extractable copper and manganese. Pedon 1 showed argillic (Bt) sub-surface horizon and was classified as Ultic Haplustalf. Pedons 2, 5 and 6 showed cambic (Bw) sub-surface diagnostic horizon and were classified as Typic Dystrustept and Typic Haplustept. Pedons 3 and 4 did not exhibit any diagnostic horizon and were classified as Typic Ustorthent.

Key words : Characterisation, Classification, Sugarcane-growing soils, Nutrient status.

India ranks second in sugarcane and sugar production after Brazil and is grown in the country both in tropical and sub-tropical regions. The tropical region in India consists of states of Karnataka, Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Goa and Kerala. The sub-tropical region comprises of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Assam and the north-eastern states. Andhra Pradesh ranks fifth in sugarcane crop area of the country with a share of 4.83 per cent (Rao and Sunil, 2010). In Andhra Pradesh, the major sugarcane growing districts are Nizamabad, Vishakapatnam and Chittoor. Sugarcane is grown in an area of 1.92 lakh ha producing 149.42 lakh tonnes of cane with a productivity of 77.90 t ha^{-1} in Andhra Pradesh and it is grown in an area of 0.28 lakh ha, producing 23.11 lakh tonnes of cane with a productivity of 83.40 t ha^{-1} in Chittoor district.

Comprehensive knowledge on soil resources in terms of types of soil, their spatial extent, physical and chemical properties and limitations or capabilities for proper management to sustain soil productivity and crop yields is highly essential. Though sugarcane is a commercial crop, till now the sugarcane-growing soils were neither characterized and classified nor studied for nutrient status in particular in Chittoor district of Andhra Pradesh. Hence, the present investigation was carried out.

MATERIAL AND METHODS

Study area

The study area lies in between $12^0 37'$ and $14^0 8'$ N latitude and $78^0 33'$ and $79^0 55'$ E longitude. It represents semi-arid monsoonic climate with distinct summer, winter and rainy seasons. The annual precipitation was 893.63 mm of which 94.31

per cent was received during May to December. The mean annual soil temperature was 27.70^{0}C with mean summer and winter temperatures of 31.77^{o}C and 26.99^{o}C, respectively. The area qualifies for isohyperthermic temperature regime. The soil moisture control section remains dry for more than 90 cumulative days or 45 consecutive days in four months following summer solistice and this qualifies for ustic soil moisture regime. The natural vegetation of the study area was *Parthenium hysterophorus, Calotropis gigantia, Tridax procumbens, Pongamia pinnata, Azardirachta indica, Lantana camera, Cyperus rotundus* and *Cynodon dactylon*. The soils were developed from weathered- gneiss parent material.

Methodology

A reconnaissance soil survey was conducted in sugarcane growing soils of Chittoor district as per the procedure outlined by AIS & LUS (1970) . Six typical pedons *i.e.,* three pedons in plains and three in uplands were studied for their morphological characteristics following the procedure outlined by Soil Survey Staff (1951). Later, horizon-wise soil samples were collected and analysed for their physical and physico-chemical properties and available nutrient status using standard procedures and classified according to Soil Taxonomy (Soil Survey Staff, 2010). The soil samples were classified into low, medium and high categories as per limits suggested by Muhr *et al.,* (1965) for available N, P and K and organic carbon. Available sulphur was rated based on the limits proposed by Tandon (1991). In respect of available micronutrients, the ratings given by Lindsay and Norvell (1978) were followed.

RESULTS AND DISCUSSION

Morphological properties

The site and morphometric characteristics of the pedons have been given in tables 1 and 2, respectively. The pedons had their munsell colour notation in the hue of 10YR barring pedon P6 (7.5YR), value 2 to 6 and chroma 1 to 6 (Table 2). The dark colour of these soils may be attributed to domination of highly dispersed form of humus and smectite minerals (Zonn, 1986). The dominant soil structure was fine to medium, weak to moderate and crumb in surface and sub-angular blocky in sub-surface horizons.

Physical properties

The clay content of the pedons ranged from 1.99 to 35.86 per cent (Table 3). There was lithological discontinuity in P_2 and P_3 as evidenced from marked variation in sand/silt ratio (Ray and Reddy 1997). In general silt content ranged from 3.97 to 39.60 per cent. Bulk density of the sugarcane-growing soils ranged from 1.29 (P_4) to 1.94 Mg m^{-3} (P_1). Since sugarcane-growing soils are tilled up to 15-20 cm deep during planting and disintegration of aggregates and soil structure through tillage can result in increased bulk density with depth. Similar results were reported by Six *et al*. (1998). Higher bulk density values in the sub-surface could be ascribed to decreased organic matter and secondary accumulation of illuviated clay. Bulk density decreased in horizons just below the Ap layer and then increased with depth in pedons 3 and 6 which could be attributed to decreased organic matter content and secondary accumulation of illuviated clays, but further orientation of clay increased the bulk density value in C horizon. The water holding capacity was positively and significantly correlated with clay (r = +0.235*) and loss on ignition was positively and significantly correlated with clay (r = +0.633**).

Chemical Properties

The pH of the soils ranged from 7.35 (neutral) to 8.21 (strongly alkaline) (Table 4). Electrical conductivity of soils varied from 0.01 to 0.24 dS m^{-1} indicating the non-saline nature of soils. Organic carbon content of the soils ranged from 0.03 (low) to 0.69 (medium) per cent and decreased with depth which could be attributed to the addition of plant residues and farm yard manure to surface horizons than in the lower horizons. The $CaCO_3$ content of these soils ranged from 0.5 to 5.5 per cent. In pedons 2, 5 and 6 the $CaCO_3$ increased with depth which might be due to down ward movement of calcium and its subsequent precipitation as carbonate and / or decomposition of calcium carbonate.

In general Ca^{+2} was the dominant cation on exchange complex followed by Mg^{+2}, Na^{+} and K^{+}. Cation exchange capacity of the soils ranged between 1.30 to 28.80 cmol (p^{+})kg^{-1} in different horizons and was positively and significantly correlated with clay (r = +0.756**) and was

Table 1. Salient site features of the profiles studied.

Features	Pedon 1(Neruvoi *)	Pedon 2 (Palamangalam*)	Pedon 3 (Gollapalle *)	Pedon 4 (Vonaru varipalli*)	Pedon 5 (Digavapokala varipalli *)	Pedon 5 (Gatti varipalli*)
Physiography	Plain	Plain	Upland	Upland	Plain	Upland
Slope (%)	0-1	0-1	3-8	3-8	0-1	3-8
Elevation (msl)	120m	120m	120m	120m	120m	120m
Drainage	Moderately well drained	Moderately well drained	Moderately well drained	Moderately well drained	Moderately well drained	Moderately well drained
Parent material	Weathered gneiss	Weathered gneiss	Weathered gneiss	Weathered gneiss	Weathered gneiss	Weathered gneiss
Erosion	Very slight	Very slight	Moderate	Moderate	Very slight	Moderate

*Name of the village

negatively and significantly correlated with sand (r = -0.669**). The base saturation ranged from 53.19 to 94.05 per cent (Table 4). The higher base saturation in some pedons might be due to higher amount of Ca^{+2} occupying exchange sites on the colloidal complex and also may be due to recycling of basic cations through vegetation.

Nutrient status and soil fertility
Macronutrients

The available N in soils was low ranging from 22.40 (P_2) to 100.80 mg kg^{-1} (P_6) (Table 5) and found to be maximum in surface horizons and decreased with depth which is due to decreasing trend of organic carbon with depth. Further, the available nitrogen was significantly and positively correlated (r = +0.611**) with organic carbon. Low available N status in these soils might be due to the fact that, semi-arid condition of the area might have favoured rapid oxidation and lesser accumulation of organic matter, releasing more NO_3-N which could have been lost by leaching (Finck and Venkateswarlu, 1982). The available P was low to high and varied from 4.00 to 22 mg kg^{-1} and decreased with depth. The lower phosphorus content in sub-surface horizons could be attributed to the fixation of phosphorus by soil constituents. The available K in soils of different sites was low to high and ranged from 14.91 to 201.64 mg kg^{-1}. Sugarcane crop is a devourer of potassium due to very heavy uptake, sometimes in excess of the requirements either due to excess application or due to greater native available potassium status. The available sulphur in soils was high and varied from 12.51 to 65.01 mg kg^{-1}. Due to higher organic matter in surface layers than in deeper layers, the available sulphur was more in surface horizons than in the sub-surface horizons.

Micronutrients

These soils had relatively low zinc and iron as compared to copper and manganese. The DTPA extractable Zn ranged from 0.29 to 1.49 mg kg^{-1} soil. The sugarcane-growing soils were sufficient in surface horizons and deficient in sub-surface horizons in all pedons except in pedons 4 and 6 wherein, it was found to deficient and sufficient, respectively. The relatively high content of zinc in surface horizons may be attributed to variable intensity of the pedogenetic processes and more complexing with organic matter, which resulted in chelating of Zn (Verma *et al*., 2005). The DTPA extractable Fe content varied from 0.97 to 4.46 mg kg^{-1}. According to critical limit of 4.5 mg kg^{-1} of Lindsay and Norvell (1978), the soils were deficient in available iron. The higher concentration of DTPA -Fe in Ap horizons of the pedons may be due to accumulation of organic carbon in the surface horizons. The organic carbon due to its affinity to influence the availability of iron by chelating action might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron in the surface horizons (Prasad and Sakal, 1991). All the pedons were found to be

Table 2. Summary of the morphological characters of the pedons.

Pedon No. & Horizon	Depth (m)	Colour		Structure			Consistence			Boundary		Cutans			Pores		Roots	
		Moist	Dry	S	G	T	Dry	Moist	Wet	D	T	Ty	Th	Q	S	Q	S	Q
Pedon 1	**Neruvoi (Fine -loamy, kaolinitic, isohyperthermic Ultic Haplustalfs)**																	
Ap	0.00-0.20	10 YR 2/2	10 YR 4/1	m	2	cr	s	fr	ssps	c	s	-	-	-	f	f	f	f
Bw	0.20-0.47	10 YR 3/1	10 YR 5/3	m	2	sbk	sh	fr	ssps	c	s	-	-	-	f	f	f	f
Bt	0.47-0.65	10 YR 3/2	10 YR 4/3	c	3	abk	sh	fi	sp	c	s	-	tn	p	-	-	f	c
BC1	0.65-0.87	10 YR 3/4	10 YR 5/4	f	1	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
BC2	0.87-1.06	10 YR 3/4	10 YR 4/6	f	1	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
BC3	1.06-1.30	10 YR 4/4	10 YR 4/4	f	1	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
BC4	1.30-1.60 +	10 YR 4/3	10 YR 5/3	f	1	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
Pedon 2	**Palamangalam (Sandy, smectitic, isohyperthermic Typic Dystrustepts)**																	
Ap	0.00-0.22	10 YR 3/1	10 YR 3/2	f	1	cr	s	fr	ssps	c	s	-	-	-	m	c	f	f
Bw	0.22-0.40	10 YR 4/3	10 YR 4/4	m	2	sbk	sh	fi	sp	c	s	-	-	-	f	f	f	f
BC	0.40-0.52	10 YR 4/6	10 YR 4/4	f	1	sbk	s	fr	ssps	c	s	-	-	-	-	-	-	-
2C1	0.52-0.71	10 YR 4/4	10 YR 4/6	f	0	sg	l	l	s_0p_0	c	s	-	-	-	-	-	-	-
2C2	0.71-1.00	10 YR 4/4	10 YR 5/6	f	0	sg	l	l	s_0p_0	c	s	-	-	-	-	-	-	-
3C3	1.00-1.30+	10 YR 3/3	10 YR 4/6	m	2	sbk	sh	fi	sp	c	s	-	-	-	-	-	-	-
Pedon 3	**Gollapalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthents)**																	
Ap	0.00-0.23	10 YR 3/3	10 YR 3/4	m	2	sbk	sh	fi	sp	c	s	-	-	-	f	f	f	f
2A1	0.23-0.38	10 YR 4/6	10 YR 4/4	f	1	sg	s	fr	ssps	c	s	-	-	-	m	c	f	f
3A2	0.38-0.59	10 YR 5/6	10 YR 5/6	m	2	sbk	sh	fi	sp	c	s	-	-	-	-	-	-	-
Cr	Weathered gneiss																	
Pedon 4	**Vonaruvaripalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthents)**																	
Ap	0.00-0.15	10 YR 4/3	10 YR 5/3	f	1	cr	s	l	s_0p_0	c	s	-	-	-	m	c	f	f
A1	0.15-0.28	10 YR 4/3	10 YR 6/4	f	1	sbk	s	l	s_0p_0	c	s	-	-	-	m	c	f	f
A2	0.28-0.48	10 YR 5/4	10 YR 5/6	m	2	sbk	sh	fi	ssps	c	s	-	-	-	-	-	-	-
Cr	Weathered gneiss																	

Table 2 Cont.....

Table 2 Cont.....

Pedon No. & Horizon	Depth (m)	Colour		Structure			Consistence			Boundary		Cutans			Pores		Roots	
		Moist	Dry	S	G	T	Dry	Moist	Wet	D	T	Ty	Th	Q	S	Q	S	Q
Pedon 5	**Digavapokalavaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustepts)**																	
Ap	0.00-0.20	10 YR 6/2	10 YR 5/2	m	2	cr	h	fi	sp	c	s	-	-	-	f	f	f	f
Bw1	0.20-0.41	10 YR 4/3	10 YR 6/3	m	2	sbk	sh	fr	ssps	d	w	-	-	-	f	f	f	f
Bw2	0.41-0.60	10 YR 6/2	10 YR 6/4	m	2	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
Bw3	0.60-0.83	10 YR 5/3	10 YR 5/3	m	2	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
Bw4	0.83-1.10	10 YR 3/2	10 YR 4/3	m	2	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
Cr	Weathered gneiss																	
Pedon 6	**Gattivaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustepts**																	
Ap	0.00-0.22	7.5 YR 5/3	7.5 YR 5/3	m	2	sbk	sh	fr	ssps	c	s	-	-	-	f	f	f	f
Bw1	0.22-0.48	7.5 YR 4/3	7.5 YR 6/4	m	2	sbk	sh	fr	ssps	c	s	-	-	-	f	f	f	f
Bw2	0.48-0.73	7.5 YR 5/4	7.5 YR 5/3	m	2	sbk	sh	fr	ssps	c	s	-	-	-	-	-	f	f
Bw3	0.73-1.00	7.5 YR 4/4	7.5 YR 5/4	m	2	sbk	sh	fr	ssps	c	s	-	-	-	-	-	-	-
Cr	Weathered gneiss mixed with soil																	

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

Moist : l – loose, fr – friable, fi – firm, vfi – very 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 3. Physical Characteristics of the sugarcane-growing soils.

Pedon No. & Horizon	Depth (m)	Sand (%) (0.05-2.0mm)	Silt (%) (0.002-0.05 mm)	Clay (%) (<0.002 mm)	Textural class	Sand / Silt	Bulk density (Mg m^{-3})
Pedon 1	**Neruvoi (Fine -loamy, kaolinitic, isohyperthermic Ultic Haplustalfs)**						
Ap	0.00-0.20	69.32	7.08	23.60	scl	9.79	1.43
Bw	0.20-0.47	54.88	24.13	20.99	scl	2.27	1.79
Bt	0.47-0.65	32.70	39.18	28.13	cl	0.83	1.55
BC1	0.65-0.87	63.90	24.82	11.28	sl	2.58	1.51
BC2	0.87-1.06	62.36	25.88	11.76	sl	2.41	1.50
BC3	1.06-1.30	62.38	22.57	15.05	sl	2.76	1.45
BC4	1.30-1.60+	46.26	39.60	14.14	l	1.17	1.94
Pedon 2	**Palamangalam (Sandy, smectitic, isohyperthermic Typic Dystrustept)**						
Ap	0.00-0.22	78.35	7.22	14.43	sl	10.86	1.50
Bw	0.22-0.40	74.65	4.61	20.74	scl	16.20	1.72
BC	0.40-0.52	78.70	4.26	17.04	sl	18.47	1.55
2C1	0.52-0.71	93.97	4.02	2.01	s	23.38	1.76
2C2	0.71-1.00	94.04	3.97	1.99	s	23.69	1.76
3C3	1.00-1.30+	68.18	9.09	22.73	scl	7.50	1.47
Pedon 3	**Gollapalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)**						
Ap	0.00-0.23	56.89	10.78	32.33	scl	5.28	1.49
2A1	0.23-0.38	78.35	11.81	9.84	sl	6.63	1.44
3A2	0.38-0.59	57.78	9.38	32.84	scl	6.16	1.51
Cr	0.59	Weathered gneiss					
Pedon 4	**Vonaruvaripalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)**						
Ap	0.00-0.15	85.76	4.07	10.17	ls	21.07	1.29
A1	0.15-0.28	86.11	9.92	3.97	ls	8.68	1.59
A2	0.28-0.48	74.07	4.32	21.61	scl	17.14	1.30
Cr	0.48	Weathered gneiss					
Pedon 5	**Digavapokalavaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)**						
Ap	0.00-0.20	56.17	7.97	35.86	sc	7.05	1.59
Bw1	0.20-0.41	69.16	8.81	22.03	scl	7.85	1.68
Bw2	0.41-0.60	69.92	8.02	22.06	scl	8.72	1.41
Bw3	0.60-0.83	81.15	4.19	14.66	sl	19.37	1.65
Bw4	0.83-1.10	72.20	4.28	23.52	scl	16.87	1.46
Cr	1.10	Weathered gneiss					
Pedon 6	**Gattivaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)**						
Ap	0.00-0.22	66.19	10.57	23.24	scl	6.27	1.46
Bw1	0.22-0.48	71.34	8.19	20.47	scl	8.71	1.36
Bw2	0.48-0.73	72.70	6.30	21.00	scl	11.54	1.59
Bw3	0.73-1.00	69.01	10.33	20.66	scl	6.68	1.57
Cr	1.00	Weathered gneiss mixed with soil					

Table 4. Physico-chemical properties of sugarcane-growing soils.

Pedon No. & Horizon	Depth (m)	pH (1:2.5)		EC (dS m^{-1})	Organic carbon (%)	$CaCO_3$ (%)	CEC [cmol (p+) kg^{-1}]	Exchangeable bases [cmol (p^+)kg^{-1}]				Base satura-tion (%)
		H_2O	1*N* KCl					Ca^{2+}	Mg^{+2}	Na^+	K^+	
Pedon 1 Neruvoi (Fine -loamy, kaolinitic, isohyperthermic Ultic Haplustalf)												
Ap	0.00-0.20	7.64	7.49	0.01	0.69	3.0	8.52	5.58	1.48	0.53	0.11	90.38
Bw	0.20-0.47	7.63	7.38	0.03	0.18	1.0	8.05	4.42	1.99	0.72	0.11	89.94
Bt	0.47-0.65	7.37	6.93	0.08	0.15	1.0	9.50	2.70	2.63	0.61	0.06	63.16
BC1	0.65-0.87	7.39	6.82	0.24	0.06	0.5	4.54	1.65	1.43	0.33	0.04	75.99
BC2	0.87-1.06	7.43	6.82	0.06	0.08	0.5	4.67	1.40	1.18	0.28	0.03	61.88
BC3	1.06-1.30	7.40	6.71	0.06	0.03	2.5	5.60	2.15	1.36	0.43	0.04	71.07
BC4	1.30-1.60 +	8.21	6.73	0.05	0.08	2.0	5.38	2.63	1.90	0.48	0.05	94.05
Pedon 2 Palamangalam (Sandy, smectitic, isohyperthermic Typic Dystrustept)												
Ap	0.00-0.22	8.19	6.92	0.14	0.56	1.0	10.41	5.36	1.05	0.41	0.08	66.28
Bw	0.22-0.40	8.12	6.35	0.17	0.13	1.0	15.52	7.90	1.65	0.76	0.14	67.33
BC	0.40-0.52	8.12	6.34	0.03	0.09	1.0	11.82	5.29	0.75	0.36	0.07	54.74
2C1	0.52-0.71	8.04	6.48	0.13	0.03	5.5	1.36	0.44	0.24	0.10	0.01	58.09
2C2	0.71-1.00	7.92	6.55	0.08	0.03	2.5	1.30	0.39	0.33	0.12	0.01	65.38
3C3	1.00-1.30 +	8.03	6.14	0.13	0.11	3.0	14.10	5.50	1.43	0.48	0.09	53.19
Pedon 3 Gollapalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)												
Ap	0.00-0.23	8.05	7.28	0.06	0.41	4.5	28.12	12.30	4.85	0.91	0.36	65.50
2A1	0.23-0.38	7.80	7.10	0.10	0.32	2.0	6.52	2.00	1.62	0.84	0.25	72.24
3A2	0.38-0.59	7.64	6.91	0.07	0.12	1.0	28.80	10.47	4.75	2.06	0.29	61.01
Pedon 4 Vonaruvaripalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)												
Ap	0.00-0.15	7.51	6.83	0.14	0.30	0.5	6.95	2.90	1.45	1.30	0.03	81.73
A1	0.15-0.28	7.58	6.75	0.02	0.22	0.5	3.04	1.17	0.79	0.41	0.02	78.62
A2	0.28-0.48	7.55	6.43	0.13	0.18	0.5	17.46	7.49	5.15	2.48	0.12	87.29
Cr	0.48	Weathered gneiss										
Pedon 5 Digavapokalavaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)												
Ap	0.00-0.20	7.88	7.03	0.08	0.68	1.0	31.71	14.00	4.40	1.43	0.19	63.13
Bw1	0.20-0.41	8.08	6.83	0.10	0.20	0.5	14.32	6.01	2.24	0.57	0.06	62.01
Bw2	0.41-0.60	7.91	6.77	0.03	0.14	1.5	16.64	6.27	6.01	0.77	0.08	78.91
Bw3	0.60-0.83	7.94	6.70	0.16	0.13	2.5	6.25	2.70	1.97	0.39	0.06	81.92
Bw4	0.83-1.10	7.81	6.62	0.20	0.16	2.5	19.65	7.49	6.45	1.32	0.13	78.32
Cr	1.10	Weathered gneiss										
Pedon 6 Gattivaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)												
Ap	0.00-0.22	7.67	6.74	0.03	0.33	2.0	16.83	5.95	3.80	0.91	0.17	64.35
Bw1	0.22-0.48	7.43	6.55	0.24	0.12	1.5	13.75	5.81	3.14	1.29	0.20	75.93
Bw2	0.48-0.73	7.35	6.32	0.02	0.20	3.5	11.62	5.20	1.95	0.80	0.11	69.36
Bw3	0.73-1.00	7.42	6.36	0.18	0.09	2.5	12.38	5.40	1.95	0.92	0.14	67.93
Cr	1.00	Weathered gneiss mixed with soil										

Table 5. Available nutrient status of the sugarcane-growing soils (mg kg^{-1}).

Pedon No. & Horizon	Depth (m)	Available macronutrients				Available micronutrients			
		N	P	K	S	Zn	Cu	Fe	Mn
Pedon 1	**Neruvoi (Fine -loamy, kaolinitic, isohyperthermic Ultic Haplustalf)**								
Ap	0.00-0.20	72.80	20.67	161.17	49.99	1.49	1.54	1.75	8.90
Bw	0.20-0.47	67.20	4.33	154.07	25.05	0.70	1.97	1.14	3.38
Bt	0.47-0.65	61.60	4.00	119.99	19.08	0.90	1.69	1.63	2.55
BC1	0.65-0.87	56.00	4.10	116.44	19.86	0.47	0.74	1.02	3.30
BC2	0.87-1.06	54.00	6.33	119.28	24.99	0.55	0.71	1.05	2.82
BC3	1.06-1.30	50.40	5.00	98.69	12.51	0.69	0.94	1.21	2.36
BC4	1.30-1.60+	48.60	4.33	95.14	20.01	1.09	1.09	0.97	4.30
Pedon 2	**Palamangalam (Sandy, smectitic, isohyperthermic Typic Dystrustept)**								
Ap	0.00-0.22	78.40	22.00	86.62	47.37	1.19	1.96	4.46	8.60
Bw	0.22-0.40	72.80	12.67	83.07	30.75	0.41	1.63	1.47	10.16
BC	0.40-0.52	70.50	12.61	75.26	35.01	0.34	1.08	1.29	8.67
2C1	0.52-0.71	56.00	10.33	66.03	17.28	0.33	0.31	1.30	3.15
2C2	0.71-1.00	22.40	8.33	26.27	15.81	0.29	0.20	1.28	2.19
3C3	1.00-1.30+	44.80	8.67	14.91	46.65	0.54	1.62	2.21	5.12
Pedon 3	**Gollapalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)**								
Ap	0.00-0.23	78.40	14.33	201.64	50.01	0.66	1.92	3.63	3.71
2A1	0.23-0.38	78.40	9.67	138.45	49.62	0.49	0.78	1.54	4.85
3A2	0.38-0.59	56.00	8.33	47.57	39.99	0.53	0.48	1.45	4.93
Cr	0.59	Weathered gneiss							
Pedon 4	**Vonaruvaripalle (Fine-loamy, smectitic, isohyperthermic Typic Ustorthent)**								
Ap	0.00-0.15	95.20	9.33	26.98	65.01	0.56	1.09	3.54	4.88
A1	0.15-0.28	67.20	7.33	19.88	64.32	0.41	0.85	2.32	5.06
A2	0.28-0.48	84.00	9.00	19.17	31.77	0.47	0.88	2.46	6.45
Cr	0.48	Weathered gneiss							
Pedon 5	**Digavapokalavaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)**								
Ap	0.00-0.20	89.60	10.67	105.08	55.14	1.09	2.76	3.77	1.82
Bw1	0.20-0.41	72.80	9.67	53.25	46.29	0.69	1.35	1.39	2.13
Bw2	0.41-0.60	56.00	9.00	52.54	40.83	0.46	1.01	1.06	3.66
Bw3	0.60-0.83	50.40	7.62	82.36	40.59	0.49	0.88	1.25	2.51
Bw4	0.83-1.10	44.80	7.33	49.70	29.96	0.50	0.81	1.36	2.73
Cr	1.10	Weathered gneiss							
Pedon 6	**Gattivaripalli (Fine-loamy, smectitic, isohyperthermic Typic Haplustept)**								
Ap	0.00-0.22	100.80	8.67	93.01	50.33	1.41	2.08	4.40	9.29
Bw1	0.22-0.48	56.00	12.00	71.71	16.71	0.89	2.19	3.50	11.58
Bw2	0.48-0.73	78.40	10.00	59.64	24.99	0.92	2.47	3.19	6.76
Bw3	0.73-1.00	95.20	11.67	78.10	19.86	0.92	2.34	2.97	7.49
Cr	1.00	Weathered gneiss mixed with soil							

sufficient in available copper and manganese as all the values were well above the critical limit of 0.2 mg kg^{-1} and 1.0 mg kg^{-1}, respectively (Lindsay and Norvell (1978).

Soil classification

Pedons 2, 5 and 6 had exhibited ochric epipedon and cambic endopedon and hence these were grouped in order Inceptisol. Owing to ustic moisture regime in the area, these pedons have been classified as Ustept at sub-order level. The soils do not have duripan, calcic / petrocalcic horizon within 100 cm and less than 60 per cent base saturation with in 25 cm and 75 cm from the mineral soil surface and hence grouped under great group Haplustept (pedons 5 and 6). Pedon 2 had a base saturation (by NH_4OAC) of less than 60 per cent in all the horizons at a depth between 25 and 75 cm from the mineral soil surface and hence it was placed under Dystrustept at great group level. The pedons 2, 5 and 6 did not exhibit intergradation with other taxa or an extragradation from the central concept. Hence, pedon 2, was logically classified as Typic Dystrustept and pedons 5 and 6 as Typic Haplustept at sub-group level with sandy (P_2) and fine-loamy (P_5 and P_6) textural family classes as these pedons had less than 10 per cent clay (silt +1 ½ times clay < 15) and high sand content (weighted average > 93%) and more than 18 per cent and less than 35 per cent clay (weighted average) in the control section, respectively. These pedons had isohyperthermic temperature regime and smectitic mineralogy.

The pedons 3 and 4 did not meet the requirement of orders (viz. Gelisols, Histosols, Spodosols, Andisols, Oxisols, Vertisols, Aridisols, Ultisols, Mollisols, Alfisols or Inceptisols), further it does not meet the requirement of sub-order Aquents, Arents, Psamments, Fluvents and hence keyed out as Orthents. Because of presence of ustic moisture regime, these pedons have been classified under great group Ustorthents. As these pedons do not have lithic contact within 50 cm of mineral layer and no cracks within 125 cm of the mineral surface that are 5 mm or more wide to a thickness of 30 cm or more and linear extensibility of 6 cm or more, hence placed under Typic Ustorthent at sub-group level. These were classified under fine-loamy at textural family class with smectitic mineralogy. The presence of isohyperthermic temperature compelled its placement as fine-loamy, smectitic, isohyperthermic Typic Ustorthents.

Pedon 1 showed the presence of diagnostic argillic (Bt) sub-surface horizon as evidenced by the fact that illuvial horizon contained 1.2 times more clay than eluvial horizon and also had base saturation more than 35 % throughout the profile. However, this pedon was classified as Ustalf at sub-order level due to presence of ustic moisture regime. Pedon 1 did not show duripan, plinthite, kandic, natric or petrocalcic horizons and the argillic horizon did not exhibit a hue of 2.5 YR; hence pedon 1 was logically classified as Haplustalf at great group level. Finally the pedon 1 was classified under Ultic Haplustalfs at sub-group level due to absence of lithic or paralithic contact, cracks, pumice like fragments, volcanic ash, lamelle and calcic horizon and also an argillic horizon with a base saturation (by sum of cations) of less than 75 per cent. This pedon has more than 18 per cent and less than 35 per cent clay (weighted average) in the control section and hence classified under fine-loamy class with kaolinitic mineralogy.

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