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Characterization and Classification of Sugarcane Growing Soil of Haryana, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Eight representative pedons of sugarcane growing soil of Haryana viz., Damla, Yamunanagar (P1), Shahabaad, Kurukshetra (P2), RRS, Karnal (P3), Kaithal (P4), Mehlana, Sonipat (P5), Nidhani, Jind (P6), Mokhra, Rohtak (P7) and Meham, Rohtak (P8) were studied for morphological, physico-chemical characteristics and classified as per Soil Taxonomy. The colour of the studied pedons varied from yellowish brown (10YR 3/2) to dark brown (10YR 5/5) in colour, with dominant hue of 10YR. The range of bulk density of different horizons was 1.05 to 1.33 Mg m^{-3}. These soils were slightly alkaline to moderately alkaline in reaction. The soils of all the pedons of studied area were non saline in nature having EC < 1.36 dSm^{-1}. Exchangeable Sodium percentage (ESP) and Base Saturation Percentage (BSP) ranged from 1.65 to 47.55 % and 23.18 to 99.60 % respectively. The CEC of the soils ranged from 1.98 to 13.82 cmol (p+) kg^{-1}. The soils of the area were classified according to Soil Taxonomy as Fine loamy, Mixed, Hyperthermic, Typic Ustocrepts (Pedon 3,6 and

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7), Fine loamy, Calcareous, Mixed, Hyperthermic, Typic Haplustepts (pedon-4), Fine loamy, Mixed, Hyperthermic, Typic Haplustepts (pedon-2), Coarse loamy, Mixed, Hyperthermic, Aquic Ustochrepts (pedon-5) and Coarse loamy, Mixed, Hyperthermic, Typic Haplustepts (1 and 8).

Keywords: Pedon; sugarcane; hue; hyperthermic.

1. INTRODUCTION

Soil classification offers insight into key processes and characteristics regulating the below-ground ecosystem. The properties of the top 10 cm alone would never describe the cracking and mixing in the low layers of soils. Classification is fundamentally important to any science. Not only is it a means to impose order on diversity between and within objects and concepts, but classification also provides the avenue through which research can be addressed in a rigorously systematic manner. Classifications also have more practical applications. Classification of soils, for instance, is indispensable to the soil survey programs. Soil surveys, in turn, can be used to apply the principle functions of soil science to agriculture, forestry and engineering to predict soil behaviour under defined use and management or manipulation. The practical purpose of soil survey is to enable more numerous, more accurate and more useful predictions to be make for specific purposes than could have been made otherwise. For one to be able to advise both existing and potential land users on how to use the land in the best possible way, a good data bank on soil properties and associated site characteristics is essential. To conduct useful fertiliser trials, soil fertility experts need well-characterized sites with comparable soil and other ecological variables. Although sugarcane is a commercial commodity, the soils used for cultivating it were neither characterized nor classified in Haryana. Thus, an investigation was carried out for characterization and classification of sugarcane growing soils of Haryana.

2. MATERIALS AND METHODS

The study area comprises seven districts of Haryana(Fig. 1) viz. Yamunanagar (30^0 5’ 45" N latitude, 77^0 13’ 26" E longitude), Kurukshetra (30^0 5' 35" N latitude, 76^0 52’ 31" E longitude), Karnal (29° 43’38" N latitude, 76° 59’4" E longitude), Kaithal (29° 47'11" N latitude, 76° 26'57" E longitude), Sonipat (29° 59' 14" N latitude, 76o 57' 31" E longitude), Jind (29°15'34" N latitude76°25'28‘’ E longitude) and two pedons from Rohtak (28° 55' 12" N latitude, 76^0 24’ 35" E longitude & 28°59’13”N latitude, 76°14'30‘’E longitude).

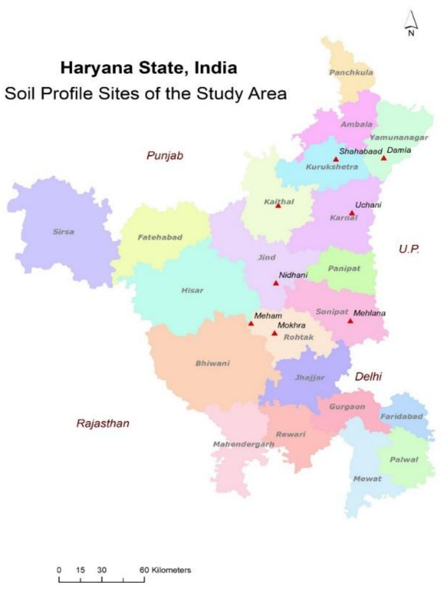

Fig. 1. Location Map of the Study area

Soils were classified according to Soil Taxonomy [1]. Based on morphological properties such as soil colour, texture, structure, consistency, pedon reaction and concretions, different horizons were demarked in each pedon in the field. Morphological characteristics for each horizon were recorded according to F.A.O, guidelines [2] for soil profile description (1993). Representative soil samples from each horizon of the pedons were collected and dried in shade for laboratory analysis. The air-dried samples were ground with a wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (>2 mm) and through 0.5 mm sieve for chemical properties. Particle size distribution of the soils was determined by International Pipette method [3]. Bulk density was determined by core method [4]. Moisture retention capacity of soils at 0.03 Mpa and 1.5 Mpa was determined with Richard's pressure plate apparatus [5]. Particle density was determined by Pycnometer method [6] using distilled water as displacing fluid. Total porosity was calculated by using equation described by Richards [7]. Infiltration rate was measured in the field by using double ring close top infiltrometer as described in laboratory manual for soil, physical analysis [8]. Soil pH was determined using pH meter consists the glass electrode in 1:2 soil: water suspension at room temperature [9].

Electrical conductivity was determined using a conductivity meter in 1:2: soil: water suspension at room temperature 25°C [9]. Organic carbon content of soil samples was estimated by wet digestion method [10]. Calcium carbonate was estimated in soil samples by rapid titration method [11]. Cation Exchange capacity was determined with normal sodium acetate solution (pH 8.2) by Hesse [12]. Exchangeable calcium and magnesium were determined in neutral normal ammonium acetate extract by Versanate Titration method [13]. Exchangeable sodium and potassium were determined by filtering the soil water 1:2 soilution on from Flame Photometer [9].

3. RESULTS

3.1 Morphological Characteristics

The soil colour is one of the most important property for soil identification. The colour of the studied pedons varied from yellowish brown (10YR 3/2) to dark brown (10YR 5/5) in colour, with dominant hue of 10YR. The values ranged from 3 to 5, whereas chromas were 2 to 5. Soil texture of pedon 1 was sand to loam, pedon 4 & 8 was sandy loam to loam, pedon 5 and 6 was loam and pedon 2, 3 & 7 was loam to clay loam.

The consistence of the soils was slightly sticky slightly-plastic for pedons 1, 2, 4, 5, 7 and sub-surface horizons of pedon 8. Sticky plastic consistence was observed in middle horizons of pedon 2, surface and sub-surface horizons of pedon 3, sub-surface horizons of pedon 6 due to more clay in these horizons as a result of eluviation process. Surface horizons of pedon 8 and sub-surface horizons of pedon 1 showed non sticky non plastic consistence due to coarse texture and very low organic matter. The soils of study area varied from weak to moderate in grade, fine to medium in class and exhibited the sub-angular blocky type of soil structure.

Among the studied pedons, 1,2,3 & 4 were very deep (200+ cm) and exhibit A-B-C horizons and Pedon 5,6,7 & 8 were shallow in profile development. Horizon boundaries of the pedon 1,3,4 & 5 varied from abrupt to smooth in the A horizon and clear to wavy in the lower horizons and pedon 2, 6, 7 & 8 were abrupt to smooth in the top horizon and clear to smooth in the lower horizons in distinctness and topography.

3.2 Physical Characteristics

The data on physical characteristics is in Table 1. Particle size analysis revealed that sand constitutes the bulk of the mechanical fraction. The sand content was maximum in pedon 1 (89.32 %) and minimum in pedon 2 (27.47 %). The soil texture variations of pedon 1 was sand to loam, pedon 4 & 8 was sandy loam to loam, pedon 5 & 6 was loam and pedon 2, 3 & 7 was loam to clay loam. The soils of the area were of alluvial parent material except pedon-8 (aeofluvium). The bulk density of studied pedons followed increased at first and then decreased with depth and was maximum in pedon 8 (1.33 Mg m^{-3}) and lowest 1.05 Mg m^{-3} in pedon 3. The particle density ranged from 2.50 Mg m^{-3} to 2.68 Mg m^{-3}. The pore space of the studied pedons ranged from 47.41 to 60.07. The infiltration rate ranged from 22 to 46.5 cm hr^{-1} and was maximum in pedon 1 (46.5 cm hr^{-1}), lowest in 7 (22 cm hr^{-1}). Water retention at 0.03 MPa and 1.5 MPa varied from 20.18 to 30.92 per cent and 3.95 to 8.43 per cent respectively in all the pedons except pedon 1 (2.26 to 8.51 and 1.13 to 3.96 per cent).

Table 1. Morpho-physical characteristics of different pedons

Horizon	Depth (cm)	Horizon boundary	Colour (moist)		Sand (%) (2.0-0.05mm)	Silt (%) (0.05-0.002mm)	Clay (%) (<0.002 mm)	Texture	Bulk density	Particle density	Pore space (%)	Percent moisture retention (Mpa)		Available water (%)
									(Mg/m^3)			0.03	1.5	
Damla, Yamunanagar														
P1 Coarse loamy, Mixed, Hyperthermic, Typic Haplustepts)														
Ap	0-25	a-s	10YR	3/2	89.32	5.52	4.12	s	1.26	2.65	52.45	3.41	1.72	1.69
B1	26-57	a-s		5/4	86.14	3.81	9.32	s	1.25	2.63	52.47	4.57	2.12	2.45
B2	57-130	c-w		5/4	56.32	23.16	19.97	sl	1.26	2.57	50.97	2.26	1.13	1.13
B3	130-164	c-s		4/4	82.68	8.19	8.75	sl	1.27	2.58	50.77	8.51	3.96	4.55
C1	164-195+	c-w		5/4	84.7	11.79	3.28	ls	1.23	2.60	52.69	3.27	1.77	1.5
Shahabaad, Kurukshetra														
P2 (Fine loamy, Mixed, Hyperthermic, Typic Haplustepts)														
Ap	0-19	a-s	10YR	4/3	46.34	28.83	23.75	l	1.28	2.54	49.60	24.13	3.95	20.18
AB	19-51	c-s		4/4	48.49	26.72	23.87	l	1.30	2.56	49.21	28.62	5.42	23.2
B1	51-104	c-s		4/4	47.29	27.86	24.08	l	1.23	2.57	52.14	27.77	4.18	23.59
B2	104-143	c-s		4/3	25.68	42.61	31.15	cl	1.21	2.53	52.17	23.25	3.50	19.75
B3	143-187	c-s		4/3	27.47	45.74	26.18	cl	1.24	2.59	52.12	28.87	6.23	22.64
C1	187-201+	c-s		4/4	50.69	30.76	18.08	l	1.32	2.50	47.41	29.54	7.21	22.33
RRS, Karnal														
P3 (Fine loamy, Mixed, Hyperthermic, Typic Ustocrepts)														
Ap	0-26	a-s	10YR	3/3	44.26	30.52	24.28	l	1.20	2.62	54.19	28.24	3.71	24.53
B1	26-77	c-s		4/3	41.11	32.15	25.84	l	1.14	2.60	56.15	29.16	4.26	24.9
B2	77-117	c-s		4/4	28.48	40.47	30.32	cl	1.16	2.59	55.21	23.31	6.55	16.76
B3	117-180	c-w		4/4	31.71	36.12	31.53	cl	1.15	2.57	55.25	24.62	8.51	16.11
C1	180-210+	c-w		5/4	33.16	38.91	27.41	cl	1.05	2.63	60.07	22.83	9.92	12.91
Kaithal														
P4 (Fine loamy, Calcareous, Mixed, Hyperthermic, Typic Haplustepts)														
Ap	0-38	a-s	10YR	4/4	49.41	31.21	19.12	l	1.23	2.60	52.69	26.37	5.32	21.05
B1	38-94	c-s		4/4	58.42	19.86	21.49	l	1.22	2.58	52.71	30.51	6.16	24.35
B2	94-132	c-w		5/4	62.35	22.54	14.90	sl	1.20	2.57	53.30	6.38	3.52	2.86
B3	132-158	c-w		4/4	64.04	23.03	12.80	sl	1.18	2.54	53.54	7.72	4.63	3.09
C1	158-195+	c-w		5/4	65.43	25.37	9.07	sl	1.23	2.59	52.50	9.12	4.07	5.05
Sonipat														
P5 (Coarse loamy, Mixed, Hyperthermic, Aquic Ustocrepts)														
Ap	0-32	c-w	10YR	3/2	47.71	27.32	24.07	l	1.19	2.62	54.58	25.24	5.81	19.43
AB	32-61	c-w		4/3	45.26	28.12	26.13	l	1.23	2.60	52.69	29.60	7.01	22.59
B1	61-113	c-w		3/3	46.44	26.73	26.45	l	1.28	2.52	49.20	30.92	7.34	23.58
B2	113-135	c-w		4/4	48.67	29.47	21.49	l	1.18	2.55	53.72	27.15	3.82	23.33
B3	135-168+	c-w		4/4	54.42	26.54	18.78	sl	1.26	2.51	49.80	20.18	8.10	12.08

Horizon	Depth (cm)	Horizon boundary	Colour (moist)		Sand (%) (2.0-0.05mm)	Silt (%) (0.05-0.002mm)	Clay (%) (<0.002 mm)	Texture	Bulk density	Particle density	Pore space (%)	Percent moisture retention (Mpa)		Avail-able water (%)
									(Mg/m^3)			0.03	1.5	
Jind														
P6 (Fine loamy, Mixed, Hyperthermic, Typic Ustocrepts)														
Ap	0-15	a-s	10YR	3/3	49.25	26.51	23.56	l	1.23	2.55	51.76	28.78	6.91	21.87
AB	15-36	g-w		4/3	47.41	24.92	27.29	l	1.28	2.57	50.19	29.19	7.41	21.78
B1	36-56	c-s		4/3	46.75	22.04	30.89	l	1.23	2.55	51.76	23.51	4.32	19.19
B2	56-92	c-s		4/3	47.58	21.72	30.44	l	1.23	2.59	52.50	25.03	5.28	19.75
B3	92-123	c-s		5/4	51.93	25.62	22.24	l	1.25	2.52	50.39	22.92	3.91	19.01
BC	135+	c-s		5/4	50.17	25.69	23.96	l	1.22	2.60	53.07	27.81	8.43	19.38
Mokhra, Rohtak														
P7 (Fine loamy, Mixed, Hyperthermic, Typic Ustocrepts)														
Ap	0-28	a-s	10YR	4/2	46.85	28.39	24.12	l	1.17	2.59	54.82	24.86	6.57	18.29
B1	28-51	c-s		4/3	37.97	24.23	37.42	cl	1.20	2.61	54.02	23.74	4.34	19.4
B2	51-93	a-s		4/4	47.02	29.65	22.95	l	1.14	2.62	56.48	27.96	3.52	24.44
B3	93-115+	c-s		5/3	49.26	30.47	19.90	l	1.06	2.54	58.26	30.38	7.65	22.73
Meham, Rohtak														
P8 (Coarse loamy, Mixed, Hyperthermic, Typic Haplustepts)														
Ap	0-15	a-s	10YR	4/3	56.15	21.78	21.53	sl	1.26	2.70	53.34	9.56	3.68	5.88
AB	15-36	c-s		3/3	54.22	22.14	23.00	sl	1.27	2.68	52.61	7.32	2.90	4.42
B1	36-43	c-s		4/4	53.72	20.96	24.94	sl	1.33	2.63	49.42	7.76	3.15	4.61
B2	43-96	a-s		5/3	51.31	26.76	21.56	l	1.19	2.57	53.69	8.11	4.23	3.88
B3	96-123	c-s		5/4	49.89	27.17	22.61	l	1.16	2.63	55.89	8.34	4.38	3.96
C1	123-136+	c-s		5/4	60.16	22.37	17.19	sl	1.12	2.61	57.08	9.13	5.53	3.6

Horizon boundary: D–Distinctness; a, abrupt; c, clear; g, gradual; d, diffuse; T – Topography: s, smooth, w, wavy; Texture: s, sand; ls, loamy sand

Table 2. Chemical properties of different pedons

Horizon	pH (1:2)	EC (dS/m)	OC (%)	$CaCO_3$	CEC cmol(p^+)/kg	Ca^{2+}	Mg^{2+}	Na^+	K^+	ESP	BSP
P1											
Ap	7.85	0.52	0.6	nil	4.75	1.66	2.01	0.61	0.26	12.84	95.57
B1	7.42	0.48	0.42	nil	4.93	3.36	0.73	0.65	0.10	13.18	98.17
B2	7.15	0.41	0.34	nil	2.88	1.83	0.35	0.52	0.08	18.05	96.52
B3	7.33	0.33	0.22	nil	3.11	1.66	0.33	0.40	0.07	12.86	79.09
C1	7.44	0.32	0.13	nil	1.98	0.50	0.12	0.50	0.07	25.25	60.10
P2											
Ap	7.71	0.52	0.62	nil	12.67	1.51	4.12	0.52	0.30	4.10	50.90
AB	7.31	0.48	0.53	nil	13.82	2.25	5.84	0.42	0.12	3.03	62.44
B1	7.27	0.41	0.44	nil	12.20	1.47	2.61	0.61	0.10	5	39.26
B2	7.51	0.33	0.32	nil	9.73	1.70	2.41	0.55	0.06	5.65	48.50
B3	7.21	0.32	0.35	nil	8.96	2.31	4.20	0.40	0.04	4.46	77.56
C1	7.32	0.36	0.27	nil	7.07	1.22	4.14	0.32	0.04	4.52	80.90
P3											
Ap	7.93	0.46	0.54	nil	11.88	2.16	4.33	0.99	0.15	8.33	64.22
B1	7.53	0.42	0.52	nil	12.52	1.83	3.66	1.17	0.12	9.34	54.15
B2	7.25	0.38	0.42	nil	10.31	2.33	4.66	2.43	0.11	23.56	92.43
B3	7.32	0.44	0.37	nil	8.23	2.66	2.33	0.9	0.11	10.93	72.90
C1	8.09	0.47	0.30	1.5	4.89	2.01	1.04	1.12	0.09	22.90	87.11
P4											
Ap	8.80	0.58	0.15	Nil	9.53	2.16	4.33	1.56	0.39	16.36	88.56
B1	9.40	0.71	0.13	0.5	10.20	0.66	1.33	1.25	0.20	12.25	33.72
B2	9.40	0.98	0.12	0.5	9.22	0.52	1.03	0.55	0.13	5.96	24.18
B3	9.35	1.07	0.07	1	7.89	2.33	2.66	0.79	0.11	10.01	74.27
C1	8.81	1.36	0.07	0.75	5.07	1.51	1.46	0.37	0.11	7.29	68.04
P5											
Ap	7.19	0.52	0.52	nil	8.87	3.53	7.06	0.59	0.27	6.65	72.71
AB	7.30	0.40	0.28	nil	9.54	3.40	6.81	0.61	0.17	6.39	83.75
B1	7.42	0.46	0.22	nil	9.28	6.93	13.8	0.62	0.26	6.68	95.79
B2	8.14	0.46	0.21	nil	7.63	3.39	0.67	1.62	0.15	48.09	76.40
B3	8.49	0.53	0.15	1.25	5.99	4.64	0.31	0.29	0.14	38.23	89.81
P6											
Ap	7.17	0.52	0.39	nil	11.33	2.16	4.32	1.15	0.12	10.15	68.40
AB	7.35	0.48	0.22	nil	12.65	1.33	2.67	0.96	0.13	7.58	40.23
B1	8.18	0.44	0.18	nil	10.68	2.52	4.05	2.46	0.18	23.03	86.23
B2	8.65	0.44	0.15	nil	8.29	1.16	2.32	2.43	0.14	29.31	72.97
B3	8.61	0.47	0.12	nil	9.69	1.83	3.67	3.36	0.08	34.67	92.26
BC	8.65	0.42	0.10	nil	6.49	2.66	1.32	1.60	0.16	24.65	88.44

Horizon	pH (1:2)	EC (dS/m)	OC (%)	$CaCO_3$	CEC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	ESP	BSP
					cmol(p^+)/kg						
P7											
Ap	8.08	0.89	0.37	0.5	10.79	2.66	5.33	0.33	0.26	3.05	79.51
B1	8.17	0.66	0.22	nil	10.96	1.51	3.51	0.24	0.10	2.18	48.90
B2	7.84	0.65	0.22	1.5	9.06	3.34	3.66	0.15	0.07	1.65	79.69
B3	7.86	0.81	0.21	1.6	7.31	2.83	3.06	0.19	0.07	2.59	84.13
P8											
Ap	7.95	0.41	0.31	0.75	8.48	3.33	6.66	0.43	0.11	5.07	88.79
AB	8.11	0.58	0.37	0.75	8.79	2.12	4.71	1.61	0.16	18.31	97.83
B1	8.26	0.65	0.22	0.62	9.52	3.32	2.67	1.64	0.17	17.22	81.93
B2	8.44	0.66	0.21	0.25	7.30	2.66	0.87	3.36	0.13	46.02	96.16
B3	8.76	0.59	0.19	1.12	5.11	2.02	0.54	2.43	0.10	47.55	99.60
C1	8.74	0.58	0.16	1.25	5.36	2.54	0.39	0.18	0.13	3.35	60.44

Table 3. Correlation matrix among physico-chemical properties

Parameter	pH	EC	OC	$CaCO_3$	CEC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	ESP	BSP	Sand	Silt	Clay
pH	1													
EC	0.627**	1												
OC	-0.634**	-0.364*	1											
$CaCO_3$	0.443**	0.482**	-0.348*	1										
CEC	-.0111	-0.023	0.364*	-0.282	1									
Ca^{2+}	-0.191	-0.135	-0.045	0.172	-0.121	1								
Mg^{2+}	-0.339*	-0.123	0.292	-0.226	0.516**	0.494**	1							
Na^{+}	0.304	-0.118	-0.209	-0.174	0.094	-0.063	-0.102	1						
K^{+}	-0.244	-0.009	.0493**	-0.295	0.397**	0.031	0.338*	-0.076	1					
ESP	0.308*	-0.146	-0.332*	0.031	-0.354*	0.159	-0.411**	0.737**	-0.227	1				
BSP	-0.098	-0.163	-0.028	0.149	-0.448**	0.539**	0.142	0.331*	-0.044	0.441**	1			
Sand	0.183	0.205	-0.145	0.034	-0.567**	-0.047	-0.344*	-0.168	0.043	0.067	0.109	1		
Silt	-0.152	-0.102	.0101	0.072	0.409**	0.028	0.251	0.067	-0.155	-0.068	-0.087	-0.923**	1	
Clay	-0.161	-0.272	0.134	-0.139	0.630**	0.062	0.376*	0.261	0.078	-0.042	-0.113	-0.896**	0.656**	1

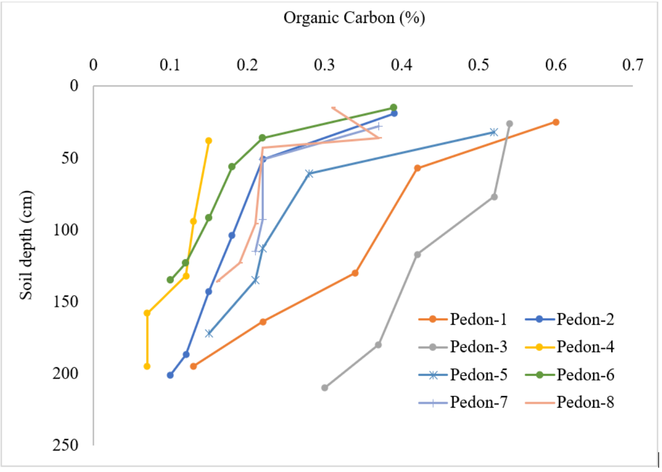

Fig. 2. Vertical distribution of organic carbon in different pedon

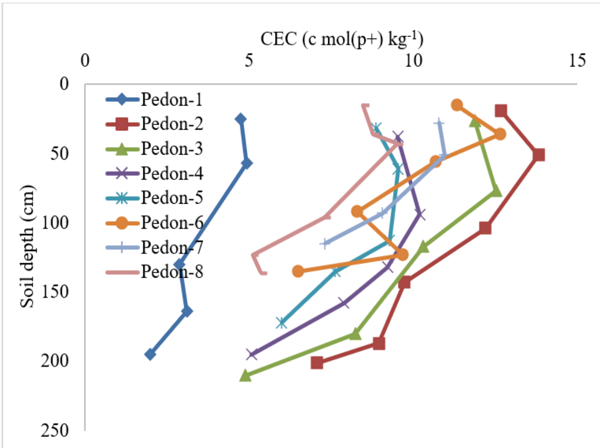

Fig. 3. Vertical distribution of CEC in different pedons

3.3 Chemical Characteristics

The pH of soil samples ranged from 7.15 to 8.65 in studied soils which indicated slightly alkaline to moderately alkaline reaction except for pedon 4 where pH ranged from 8.80 to 9.43 (Table 2). The electrical conductivity of all the pedons was < 1.36 dSm-1 (Table 2) which indicated that the soils were non- saline in nature. The organic carbon (OC) status of the soils shows that soils are low to medium (0.07-0.60 %) in OC (Table 2). The organic carbon of soils decreased with depth (Fig. 2) in all the pedons. Calcium carbonate concretions were present in the pedons- 4, 7 & 8 and ranged from 0.5 – 1.5 % (Table 2). It was also present in sub-surface horizons of pedons 3 & 6 (1.5 & 1.25 %) and absent in pedons 1, 2 & 6 (Table 2). The cation exchange capacity was found low (1.98 to 13.82 cmol (p+) kg^{-1}) in the pedons (Fig. 3) under investigation. Among exchangeable cations calcium (0.50 to 4.64 cmol (p+) kg^{-1}) & magnesium (0.12 to 7.01 cmol (p+) kg^{-1}) were dominant cations in all the pedons followed by sodium (0.15 to 3.36 cmol (p+) kg^{-1}) and potassium (0.08 to 0.39 cmol (p+) kg^{-1}) (Table 2). Sharma et al. (2011) also demonstrated similar findings. All the pedons under investigation showed non-sodic soils except sub-surface horizons of pedon 6 & 8 with ESP 20 - 40 % (Table 2). The base saturation percentage (BSP) ranging from 24.18 to 98.57 % (Table 2) which dominated the exchangeable complex.

3.4 Soil Classification

The soils of all the pedons were placed in order Inceptisols. These soils are in the primary stage of soil development. The area under investigation were grouped into two moisture regimes i.e., Ustic (rainfall 300-1000mm) and Aquic. The soil temperature regimes were found Hyperthermic (22°C to <28°C) of all the pedons. Clay accumulation was found in the sub surface horizons. The soils of all of the pedons are formed from alluvial material deposited by rivers a long time ago except for the pedon 8 where wind and water combinedly played the role of soil formation. Pedon 5 showed Aquic moisture regime due to shallow water table. The soils of the pedons 1, 2, 4 & 8 were place under the great groups of Haplustepts due to presence of calcic horizon and content of organic carbon that decreases regularly with increasing depth and pedons 3, 5, 6 & 7 were placed under great group Ustocrepts because of ustic soil moisture regime. Due to variation in texture, these soils were classified as coarse loamy (pedons 1, 5 & 8) and fine loamy family (pedons 2, 3, 4, 6 & 7).

4. DISCUSSION

The soil colour is an important property. This variation in the soil colour is due to different texture, topography, mineralogy and chemical composition of soils of pedon under investigation (Thangasamy et al. 2005). The texture of all the pedons shows inconsequential variation with depth. Sub-surface horizons displayed higher clay content because of the illuviation process happened during soil genesis (Tripathi et al. 2006) which also affects the vertical dispersal of silt and sand contents. The clay content increased with depth due to downward translocation of finer particles from the surface layers as reported by Murthy (1988) and Nasre et al. [14]. The slightly sticky slightly-plastic consistence for soils of pedons 1, 2, 4, 5, 7 and sub-surface horizons of pedon 8 was due to loam texture of these soil. According to Sharma et al. [15], non-sticky non plastic consistence indicated poor water retention characteristics of soil as indicated by surface horizons of pedon 8 and sub-surface horizons of pedon 1. The variation in soil structure is due to different physiographic position of the pedons [16], (Rao et al. 2008).

These variations in horizon boundaries are due to different clay mineralogy and chemical composition of soils. Study indicated that clay and silt content had greater influence as compare to sand on water retention behavior of soil [17]. The variations in water retention were due to the differences in depth, clay, silt and organic carbon content and low retention in sandy soils was due to the high sand and less clay content. Similar results were obtained by Devi et al. [18].

The soils were non- saline in nature due to proper irrigation facilities in these areas which leach down all the salts. Feng et al. [19] reported salt moved down to deeper soil layers with water simultaneously in the upper layers. The low organic carbon content in these soils could be due to hyperthermic temperature regime which leads to the oxidation of organic matter [20,21]. The low organic carbon content could also be due increased rate of decay as a result of intensive cultivation. The organic carbon showed a positive correlation ($r = 0.364$; $p \leq 0.05$) with the cation exchange capacity of soil (Table 3). The presence of calcium carbonate was due to the strong calcification process occurred during soil formation due to low organic matter in the soils. The distribution of calcium carbonate in soil profile invariably showed an increasing trend with soil depth, which indicates leaching down of calcium and subsequent precipitation at lower depth [22,23]. The other reason could be the presence of illite clay mineral and other clay minerals of low charge [24], (Dinesh et al. 2017). A significant positive correlation (Table 3) was observed between CEC and clay ($r = 0.630$; $p \leq 0.01$), silt ($r = 0.409$; $p \leq 0.01$) and organic carbon ($r = 0.364$; $p \leq 0.05$) which indicate that the silt and clay were the leading factors that had an impact on Cation exchange capacity.

The higher percent of BSP is due to the occurrence of cations where exchangeable Ca^{2+} is quite high. High base saturation values were recorded in the sub-surface compared to surface horizons mainly because of the leaching of bases to lower depths and accumulation of these bases in sub-soil [25]. Due to different type of clay and pH values, the soils have different CEC, BSP and water retention (Sharma et al. 2004). These soils were classified in Inceptisol order due to their primary stage of development.

5. CONCLUSION

The study inferred that the soils of the study area were found suitable for wheat, paddy and vegetables in rotation with sugarcane. The soils contain Calcium and Magnesium cation which suggests strong calcification process. Textural variations are due to different parent material and differential degree of weathering. The soils of the study area belong to the order Inceptisols.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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