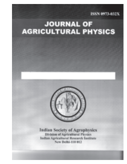
Vol. 23, No. 2, pp. 306-318 (2023)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in



Research Article

Characterizing the Morphological and Physical Properties of Soils at the Experimental Site of Department of Soil Science

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ABSTRACT

A study with nine soil profiles from the Department of Soil Science Experimental Area at CCSHAU in Hisar was exhibited and their morphological and physical properties were examined. The colour of soil of the study area was yellowish brown with dominant hue 10YR. The structure was predominantly sub-angular blocky in all pedons and the consistency of different pedons varied from slightly-sticky slightly-plastic to sticky plastic. The texture of studied pedons varied from sandy loam to sandy clayey loam with sand content being higher as compared to silt and clay in most of the pedons. All of the pedons' bulk densities ranged from 1.43 to 1.59 Mg m^{-3}, whereas their particle densities ranged between 2.81 and 2.99 Mg m^{-3}.The available water content varied from 9.6 to 13.8%.

Key words: Pedon, Available water content, Texture, Soil profiles

Introduction

Among the natural resources, soil holds the central place needed for the development and growth of any country. Soil is a natural body made up of solids (minerals and organic matter), liquids and gases that exists on the land surface and has one or both of the following characteristics: Horizons or layers, that are distinguishable from the initial material as a result of energy and matter additions, losses, transfers and transformations or the ability to sustain rooted plants in a natural environment. Many factors influence soil variations, according to Rajgopal *et al*. (2013), it includes the quality of soil parent materials, environment and weathering patterns over time. The combination of soil characterization and classification provides better understanding of the morphological and physical properties of soils, which helps precision agriculture by reducing the negative effects of soil diversity (Sharu *et al*., 2013; Ukut *et al*., 2014).

The relationships between soils properties in a specific landform may help determine the dominant pedogenic processes of these soils and provide an opportunity to manage them better and improve crop performance. Therefore, there is need to understand the interactions between soil properties influenced by dominant pedogenic processes and their effect on crop yield in the study area (Kumar *et al*., 2022). According to Yadav (2003), India's per capita cultivable land is declining and increasing in a horizontal direction. The task is not only to feed an ever- increasing population, but also to sustain the soil resource's productivity for future generations.

Based on profile wise information, soil management practices specific to that region can be recommended to the researchers and other stakeholders for its judicious use (Kumar and Prasad, 2010). Consequently, this will lead to sustainable agriculture along with environmental protection.

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Land is the greatest source of wealth and the backbone of many great civilizations. Inefficient land use would eventually result in permanent deterioration and irreversible environmental damage. Deteriorating soil fertility can be a major challenge to countries like India, where agriculture accounts for a large portion of the economy (Yadav *et al.*, 2024). The past soil survey activities are mainly conducted at regional and small-scale, which are inadequate in providing basic soil data that can help to manage soils according to the local variability. Therefore, the present study was carried out to characterize the morphological and physical properties of soils of Experimental Area of Department of Soil Science, CCSHAU, Hisar.

Material and Methods

The farm, which is part of the study area, is located to the north-west of the CCS Haryana Agricultural University campus on Hisar-Ludas road which is in the south-western part of the State (Fig. 1) and this area lies between the north latitudes of 29°08′58″ N and 29°09′08″ N and the east longitudes of 75°40′39″ E and 75°42′24″ E and comprises of 34.1 hectares (Fig. 2). The area's typical altitude is

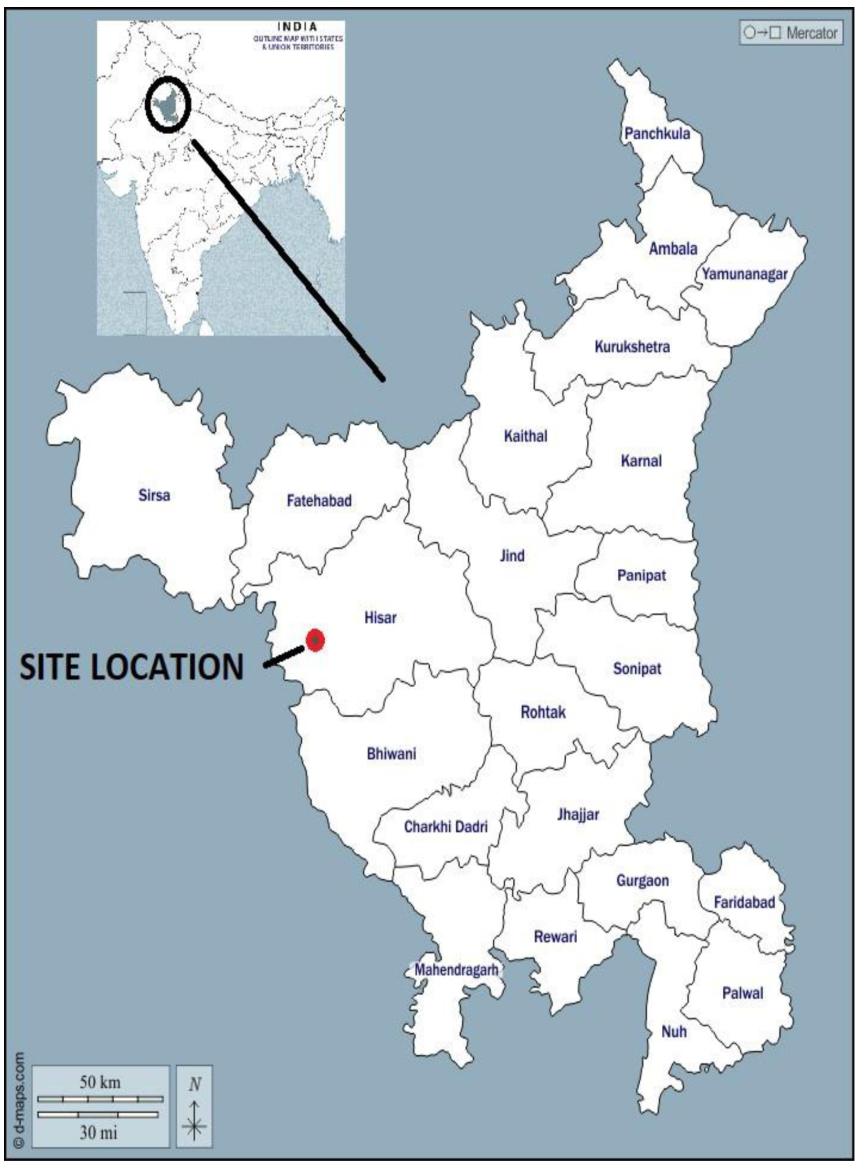


Fig. 1. Location map of the study area

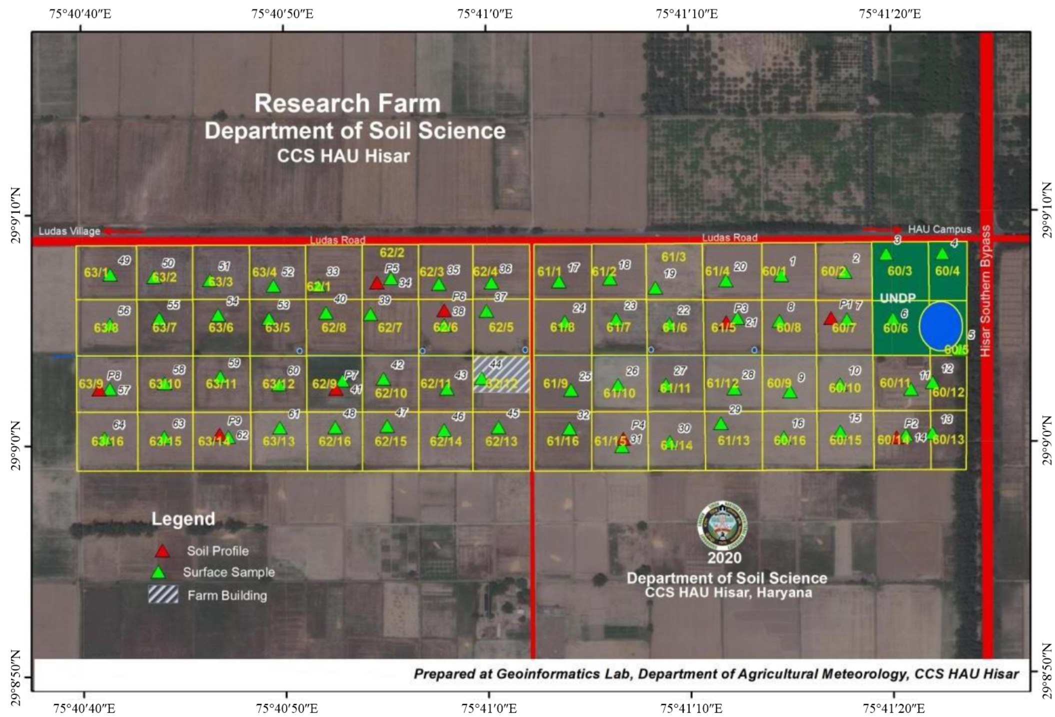


Fig. 2. Soils of Experimental Area of Department of Soil Science

215 meters above sea level. The Indo-Gangetic plain runs through the district and the study area is mostly alluvial plain with very gentle slope (1% towards north) to flat and covering of deposits brought down during Pleistocene age. The area has mainly Inceptisols order soils (Yadav *et al*., 2023). Since the area is irrigated with canal and supplemented with tube well water due to the continuous irrigation the water table of the farm appreciably raised upto surface in rainy season and received to 4-5 meters during other period of year. The occurrence of water logging is linked to the problem of salt.

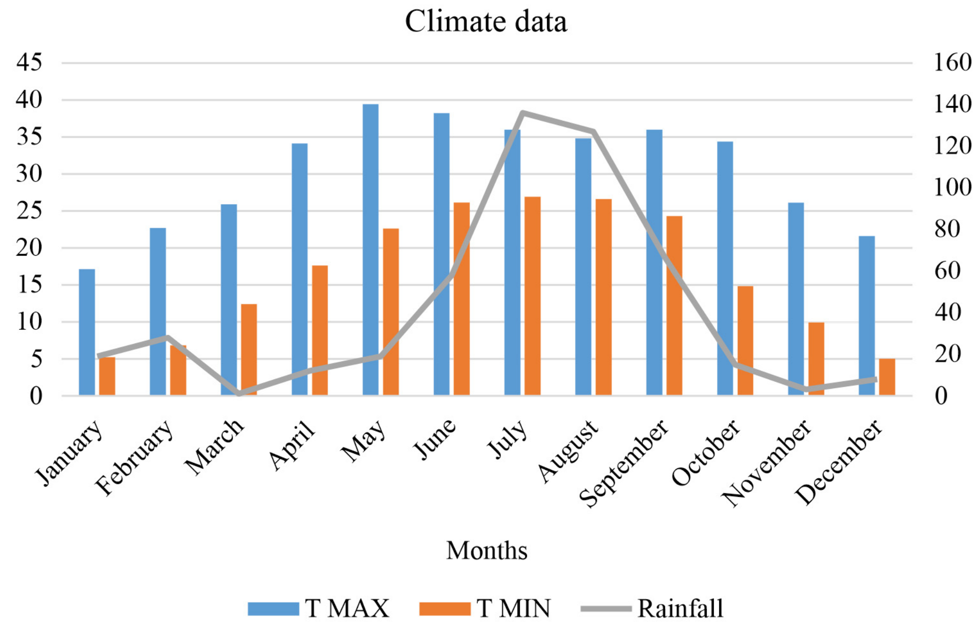
Hisar's climate is influenced by its continental location on the outskirts of the SW monsoon area. It has sub-tropical monsoonal type characterized by prolonged hot summer and cool winters and is classified as semi-arid region with average annual rainfall of 133 mm / 5 inch and the mean annual temperature of 20.8 °C | 37.5 °F whereas mean average temperature is 26.27 and hence soil temperature class is Hyperthermic (Fig. 3). The district's climate is characterized by its dryness, temperature fluctuations, and lack of rainfall.

The study area is well cultivated however Kikar, Neem, Shisham, Janti, Eucalyptus, leafless Kair and Jaal are among the principal trees present. The two primary agricultural seasons are kharif and rabi. The kharif season runs from June to October, whereas the Rabi season is from October to April. Wheat, gram, and oilseeds are the main rabi crops in the district. Barley, rabi pulses and vegetables are minor examples. The location, physiography, geology, relief, climate, drainage and current land use of the study area are all important factors in any pedogenic investigation, not only for categorization but also for interpretation of the data collected (Table 1).

For laboratory investigation, representative soil samples from each horizon of the pedons were taken and dried in the shade. The air-dried samples were pulverised with a wooden pestle and mortar.

The soils morphological properties were evaluated and points assigned to them are described below:

Boundaries: The points assigned to the boundaries as per the distinctness of the horizon to the lower or shared horizon as: D - Distinctness, a - abrupt, c - clear, g - gradual, d – diffuse, T - Topography; s - smooth, w – wavy.



Source: Annual report of CCSHAU, Hisar (2020-21)

Fig. 3. Weather data

Colour (dry and moist): The one point was assigned for any unit change in hue class and also for value or chroma. For example, a change from 10 YR 4/6 to 5 YR 3/8 would have a value of 5 for the two fold class change, the one unit change in value and two unit changes in chroma.

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

Structure: Grade (G) - 0 –structureless, 1 - weak, 2 - moderate, 3 – strong

Size (S) - vf -very fine, f -fine, m - medium, c - coarse

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 - ns - non sticky, ss - slightly sticky, s - sticky, vs - very sticky, np - non plastic, sp -slightly

Roots: Size - vf - very fine, fn - fine, md - medium, c - coarse;

Quantity - vf - very few, f - few, c - common, m - many

Reaction: 0 – no effervescence, 1 - weak, 2 - moderate, 3 - strong, 4 - violent

Particle size distribution of the soils was determined by International Pipette method (Piper, 1950) using sodium hydroxide as dispersing agent. From the dispersed suspension an aliquot of clay + silt (4 minutes) and clay (7 hours) was pipette out from 5 cm depth. Textural classes were determined using the triangular textural diagram of USDA. Bulk density was determined by using Core Method as described in laboratory manual for soil, physical analysis (1999). Particle density was determined by using Pycnometer method as described in laboratory manual for soil physical analysis (1999). Infiltration rate was measured in the field by using double ring close top infiltrometer as described in laboratory manual for soil physical analysis (1999).

Results and Discussion

Morphological characteristics

The Morphological characteristics of soils are presented (Table 2). The studied pedons were very deep (150+ cm) and exhibited A-B horizons except Pedon 2 which exhibit A-(B)-C1 horizons in profile development. Horizon boundaries of the all the

Table 1. General Characterization of Soils of Experimental Area of Department of Soil Science, Hisar, Haryana

Pedon	Profile Site	Physiography	Drainage	Erosion	Land Use	Parent Material	Slope (%)	Slope Direction
1	60/7 Soil research farm	Alluvial plain	moderately drained	Slight	Cultivated	Alluvium	Nearly flat to very gently sloping (1%)	S-N
2	60/14 Soil research farm	Alluvial plain	Well drained	Slight	Cultivated	Alluvium	Nearly flat to very gently sloping (1%)	S-N
3	61/5 Soil research farm	Alluvial plain	moderately drained	Slight	Cultivated	Alluvium	Nearly flat to very gently sloping (1%)	S-N
4	61/15 Soil research farm	Alluvial plain	moderately drained	Slight	Cultivated	Alluvium	Nearly flat to very gently sloping (1%)	S-N
5	62/2 Soil research farm	Alluvial plain	Well drained	Slight	Cultivated	Alluvium	Nearly flat	S-N
6	62/6 Soil research farm	Alluvial plain	moderately drained	Slight	Cultivated	Alluvium	Nearly flat	S-N
7	62/9 Soil research farm	Alluvial plain	Imperfectly drained	Slight	Cultivated	Alluvium	Nearly leveled	S-N
8	63/9 Soil research farm	Alluvial plain	Imperfectly drained	Nil	Cultivated	Alluvium	Nearly leveled	S-N
9	63/14 Soil research farm	Alluvial plain	moderately drained	Nil	Cultivated	Alluvium	Nearly leveled	S-N

pedons varied from clear to gradual in distinctness and smooth in topography. Roots in all the pedons varied from very few to common in quantity and very fine to medium in size. The soil color is one of the important properties among the morphological characteristics for identification of soils. The color of the studied pedons was dominant with hue 10YR. The value ranged from 4 to 6, whereas chroma was 3 to 6. This variation in the soil color might be due to variation in textural makeup, topographic position, mineralogical, chemical composition and moisture regimes of the soil (Thangasamy *et al.,* 2005; Sahoo *et al.,* 2020).

The texture of the studied pedons varied from sandy loam to sandy clay loam. The soils of the study area were derived from alluvium parent material. The texture of pedon 1 and 5 was sandy loam and show inconsequential increase in clay content with depth. The variation in texture within a profile was observed in pedons 2, 4, 8and 9 with surface horizons dominated by sandy loam to sandy clay loam in lower horizons, due to variation in parent material and differential degree of weathering (Dinesh *et al*., 2017). The texture of pedons 3, 6 and 7 was found sandy clay loam throughout the profile with slight increase in clay in sub- surface horizons. Increase in clay content in sub surface horizon, then decreased in lower horizons showing the process of stratification and lithological discontinuity. Murthy (1997) and Nasre *et al*. (2013) reported that the clay content, by and large, increased with depth, which may be due to downward translocation of finer particles from the surface layers.

The pore spaces are as important in the soil as the solid particles, soil structure may also be defined as the arrangement of small, medium and large soil pores into a structural pattern (Kohnke, 1968). The structure of the pedons in experimental area of Department of Soil Science was moderate to strong, medium, sub angular blocky. The structure of pedon 1, 3 and 5 was moderate, medium-sub angular blocky throughout the profile whereas Pedon 2, 4, 6, 7, 8, 9 exhibited moderate (surface and sub surface) to strong (lower depth), medium (surface and sub surface) to fine (lower depth), sub angular blocky structure. These results indicate that the variation in soil structure is the reflection of physiographic

Table 2. Morphological characteristics of the soil

Hori-zon	Depth (cm)	Horizon boundary	Color (moist)	Texture	Structure	Consis-tence	Cutans	Roots	Coarse fragment	Reaction
60/7 Soil research farm, CCS HAU Hisar										
Pedon 1 Coarse loamy Calcareous, Mixed, Hyperthermic, Typic Haplustepts										
Ap	0-19	c-s	10YR 5/4	Sl	2 m sbk	SSNP	-	f m	-	-
A1	19-50	c-s	10YR 5/5	Sl	2 m sbk	SSSP	-	vffn	>1.0	1
B1	50-85	c-s	10YR 5/5	Sl	2 m sbk	SSSP	-	vffn	>1.0	2
B2	85-135	c-s	10YR 5/6	Sl	2 m sbk	SSSP	-	-	>1.0	1
B3	135-180+	-	10YR 5/6	Sl	2 m sbk	SSSP	-	-	-	-
60/14 Soil research farm , CCS HAU Hisar										
Pedon 2Fine loamy, Mixed, Hyperthermic, Calcareous, Typic Haplustepts										
Ap	0-20	c-s	10YR 5/4	Sl	2 m sbk	SSNP	-	f m	-	-
A1	20-40	a-s	10YR 5/4	Scl	2 m sbk	SSSP	-	vffn	-	-
B1	40-90	c-s	10YR 4/3	Scl	3 f sbk	SP	-	vffn	>1	2
B2	58-90	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	<1	2
B3	90-128	c-s	10YR 5/4	Scl	3 f sbk	SP	-	-	-	1
B4	128-160	c-s	10YR 5/4	Sl	3 f sbk	SSSP	-	-	-	-
C1	160-210	-	10YR 5/3	Sl	3 f sbk	SSSP	-	-	-	-
61/5 Soil research farm , CCS HAU Hisar										
Pedon 3Fine loamy, Mixed, Hyperthermic, Calcareous, Typic Ustochrepts										
Ap	0-23	c-s	10YR 4/3	Scl	2 m sbk	SSSP	-	f m	-	-
A1	23-55	c-s	10YR 5/4	Scl	2 m sbk	SSSP	-	vffn	>1	2
B1	55-125	c-s	10YR 5/4	Scl	2 f sbk	SP	-	vffn	<1	1
B2	125-149	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	-	1
B3	149-180+	-	10YR 4/3	Scl	3 f sbk	SSSP	-	-	-	-
61/15 Soil research farm, CCS HAU Hisar										
Pedon 4 Fine loamy, Mixed, Hyperthermic, Calcareous Typic Haplustepts										
Ap	0-22	c-s	10YR 4/4	Sl	2 m sbk	SSNP	-	f m	-	-
A1	22-50	c-s	10YR 4/4	Scl	2 m sbk	SSSP	-	vffn	>1	2
B1	50-90	c-s	10YR 4/3	Scl	2 m sbk	SP	-	vffn	<1	1
B2	90-125	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	-	1
B3	125-160+	-	10YR 4/3	Scl	3 f sbk	SP	-	-	-	-
62/2 Soil research farm, CCS HAU Hisar										
Pedon 5Fine loamy, Mixed, Hyperthermic, Typic Haplustepts										
Ap	0-15	c-s	10YR 5/3	Sl	2 m sbk	SSNP	-	f m	-	-
A1	15-59	a-s	10YR 5/4	Sl	2 m sbk	SP	-	vffn	-	-
B1	59-115	c-s	10YR 5/4	Sl	2m sbk	SP	-	vffn	-	-
B2	115-145	g-s	10YR 6/4	Sl	2 m sbk	SSSP	-	-	-	-
Water table										
62/6 Soil research farm, CCS HAU Hisar										
Pedon 6 Coarse loamy, Mixed, Hyperthermic, Typic Haplustepts										
Ap	0-16	c-s	10YR 4/3	Scl	2 m sbk	SSSP	-	f m	-	-
A1	16-46	c-s	10YR 5/4	Scl	2 m sbk	SSSP	-	vffn	-	-
B1	46-77	c-s	10YR 5/4	Scl	3 f sbk	SP	-	vffn	-	-
B2	77-130	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	-	-
B3	130-160+	-	10YR 4/3	Scl	3 f sbk	SP	-	-	-	-

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62/9 Soil research farm, CCS HAU Hisar										
Pedon 7 Fine loamy, Mixed, Hyperthermic, Typic Haplustepts										
Ap	0-20	c-s	10YR 4/4	Scl	2 m sbk	SSSP	-	f m	-	-
A1	20-41	c-s	10YR 5/4	Scl	2 f sbk	SSSP	-	vffn	-	-
B1	41-80	c-s	10YR 5/4	Scl	2 m sbk	SSSP	-	vffn	-	-
B2	80-125	c-s	10YR 6/4	Scl	3 f sbk	SP	-	-	-	-
B3	125-155+	-	10YR 6/4	Scl	3 f sbk	VSVP	-	-	-	-
63/9 Soil research farm, CCS HAU Hisar										
Pedon 8 Fine loamy, Mixed, Hyperthermic, Typic Haplustepts										
Ap	0-17	c-s	10YR 4/3	Sl	2 m sbk	SSSP	-	f m	-	-
A1	17-52	g-s	10YR 5/4	Scl	2 m sbk	SSSP	-	Vffn	-	-
B1	52-100	c-s	10YR 4/4	Scl	3 m sbk	SP	-	Vffn	-	-
B2	100-142	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	-	-
B3	142-170+	c-s	10YR 4/3	Scl	3 f sbk	SP	-	-	-	-
Water table										
63/14 Soil research farm, CCS HAU Hisar										
Pedon 9 Fine loamy, Mixed, Hyperthermic, Typic Ustochrepts										
Ap	0-18	c-s	10YR 5/4	Sl	2 m sbk	SSNP	-	f m	-	-
A1	18-90	c-s	10YR 5/4	Scl	2 m sbk	SSSP	-	vffn	-	-
B1	90-135	c-s	10YR 4/4	Scl	3 m sbk	SSSP	-	vffn	-	-
B2	135-172	c-s	10YR 4/4	Scl	3 m sbk	SSSP	-	-	-	-
Water table										

position of pedons, pedogenic activity, irrigation and cultivation practices of the soils (Singh and Aggarwal, 2005; Rao *et al*., 2008). Sharma *et al*. (1996) reported that the soil structure was relatively better developed in genetically well developed soils of alluvial plains, moderately developed in piedmont plains and flood plains whereas weakly developed in coarse strata.

The consistence of all the studied pedons was observed from slightly sticky, non- plastic (surface) to sticky plastic (lower horizons). Pedon 1and 9 were found slightly sticky, non-plastic on surface and slightly sticky, slightly plastic in consistency, due to light texture of surface soil. The consistency, in general, was non-sticky non plastic which is indicative of poor water retention characteristics of the soils (Sharma *et al.,* 1993). The soils of pedon 2, 4 and 5 were found slightly sticky non-slightly plastic on the surface, sticky plastic on subsurface and slightly sticky, slightly plastic in lower horizons in consistency. The consistency of pedon 3, 6, 7 and 8 was observed slightly sticky slightly plastic (surface and sub-surface) and sticky plastic in lower horizons except pedon 7 which had very sticky very plastic consistency in the lowermost layer. The variation in consistence was due to variation in texture of pedons.

Coarse fragments were absent in study area except pedons 1, 2 and 3 where it was present in sub-surface horizons varied from >1% (pedon 1) and <1% in pedon 2 and 3. Calcium carbonate concretions were also present in pedons 1, 2 and 3. Slight to moderate effervescences were observed in pedons 1, 2, 3 and 4 predominantly in sub-surface horizons. The variation within the pedons may be considered to be inherent to the parent material. The possibility of in-situ formation of calcium carbonate may be due to calcification processes in some semi arid climatic conditions. Ahuja *et al*. (1997) also reported in sand dune topo- sequences of Haryana.

Physical characteristics

The soil physical characteristics of different pedons of experimental sites are illustrated (Table 3). The data revealed that the fraction of soil separates with the dominancy of sand particles. The sand content was found maximum in pedon 9 (72.2%) and minimum in pedon 6 (60.0%) as shown in Fig. 4. The silt content (Fig. 5) was highest B2 horizon in

Table 3. Physical properties of the soil

Horizon	Depth (cm)	Sand (%) (2.0-0.05 mm)	Silt (%) (0.05-0.002 mm)	Clay (%) (<0.002 mm)	Texture	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Percent Moisture retention (MPa)		Pore space (%)	Available water (%)	Infiltration Rate (cm hr^{-1})
								0.03	1.5			
60/7 Soil research farm, CCS HAU Hisar												
Pedon 1 Coarse loamy Calcareous, Mixed, Hyperthermic, Typic Haplustepts												
Ap	0-19	69.2	12.1	17.7	Sl	1.4	2.8	20.5	6.7	48.0	13.8	2.1
A1	19-50	68.5	12.5	19.0	Sl	1.5	2.9	19.8	7.2	49.1	12.6	
B1	50-85	71.2	11.8	17.0	Sl	1.5	2.9	19.7	6.8	48.9	12.9	
B2	85-135	71.4	11.6	17.0	Sl	1.5	2.9	18.5	6.4	48.8	12.1	
B3	135-180+	71.5	11.4	17.1	Sl	1.5	2.9	16.8	6.1	48.9	10.7	
60/14 Soil research farm , CCS HAU Hisar												
Pedon 2 Fine loamy, Mixed, Hyperthermic, Calcareous, Typic Haplustepts												
Ap	0-20	71.5	11.8	17.7	Sl	1.5	2.9	18.5	8.2	49.32	10.3	2.2
A1	20-40	61.6	10.4	28.0	Scl	1.5	2.9	19.9	8.7	48.99	11.2	
B1	40-90	64.7	11.0	24.3	Scl	1.5	2.9	19.8	8.5	48.98	11.3	
B2	58-90	65.6	11.2	18.9	Scl	1.5	2.9	17.7	7.2	48.16	10.5	
B3	90-128	69.2	10.1	20.7	Scl	1.5	2.9	18.2	7.1	48.14	11.1	
B4	128-160	70.1	12.5	17.4	Sl	1.5	2.9	17.1	6.4	48.16	10.7	
C1	160-210	69.5	12.4	18.1	Sl	1.5	2.9	17.2	6.5	48.32	10.7	
61/5 Soil research farm , CCS HAU Hisar												
Pedon 3 Fine loamy, Mixed, Hyperthermic, Calcareous, Typic Ustochrepts												
Ap	0-23	62.6	10.1	27.3	Scl	1.45	2.84	20.1	8.0	51.05	12.1	2.1
A1	23-55	63.7	11.2	26.1	Scl	1.49	2.88	18.8	7.9	51.73	10.9	
B1	55-125	64.6	11.5	24.9	Scl	1.54	2.96	17.8	7.4	52.02	10.4	
B2	125-149	65.2	10.5	24.3	Scl	1.57	2.98	17.2	7.1	52.68	10.1	
B3	149-180+	65.1	10.8	23.4	Scl	1.59	2.99	16.8	6.9	44.04	9.9	
61/15 Soil research farm, CCS HAU Hisar												
Pedon 4 Fine loamy, Mixed, Hyperthermic, Calcareous Typic Haplustepts												
Ap	0-22	71.8	11.0	17.2	Sl	1.47	2.94	16.8	6.9	50.58	9.9	2.2
A1	22-50	61.0	12.4	26.6	Scl	1.49	2.95	19.2	7.2	49.49	12	
B1	50-90	63.5	13.2	23.3	Scl	1.52	2.97	18.5	7.1	48.82	11.4	
B2	90-125	64.6	15.9	19.5	Scl	1.54	2.99	16.8	6.8	48.49	10	
B3	125-160+	68.3	12.6	19.1	Scl	1.54	2.99	16.1	6.5	48.49	9.6	
62/2 Soil research farm, CCS HAU Hisar												
Pedon 5 Fine loamy, Mixed, Hyperthermic, TypicHaplustepts												
Ap	0-15	69.8	12.2	18.0	Sl	1.42	2.92	18.7	6.2	51.36	12.5	2.4
A1	15-59	68.2	12.1	19.7	Sl	1.49	2.95	19.5	6.8	49.49	12.7	
B1	59-115	70.0	12.8	19.2	Sl	1.49	2.95	18.5	6.5	50.50	12.0	
B2	115-145	69.2	11.9	18.9	Sl	1.50	2.99	18.0	6.1	50.16	11.9	
Water table												

Contd...

62/6 Soil research farm, CCS HAU Hisar												
Pedon 6 Coarse loamy, Mixed, Hyperthermic, Typic Haplustepts												
Ap	0-16	64.2	13.4	22.4	Scl	1.44	2.95	18.2	7.3	57.19	10.9	2.3
A1	16-46	61.2	12.5	26.3	Scl	1.44	2.92	19.8	7.9	50.68	11.9	
B1	46-77	60.0	12.9	27.1	Scl	1.47	2.97	20.1	7.8	50.50	12.3	
B2	77-130	61.4	13.1	25.5	Scl	1.50	2.99	19.1	6.9	49.83	12.2	
B3	130-160+	60.2	13.2	26.6	Scl	1.49	2.95	19.5	6.7	49.49	12.8	
62/9 Soil research farm, CCS HAU Hisar												
Pedon 7 Fine loamy, Mixed, Hyperthermic, Typic Haplustepts												
Ap	0-20	60.6	12.8	26.6	Scl	1.51	2.97	20.3	7.9	49.15	12.4	2.4
A1	20-41	59.1	13.2	27.7	Scl	1.49	2.94	21.8	8.2	49.31	13.6	
B1	41-80	60.1	12.9	27.0	Scl	1.51	2.97	21.1	7.8	49.15	13.3	
B2	80-125	61.0	13.0	26.0	Scl	1.52	2.98	19.1	6.9	48.99	12.2	
63/9 Soil research farm, CCS HAU Hisar												
Pedon 8 Fine loamy, Mixed, Hyperthermic, Typic Haplustepts												
Ap	0-17	69.8	11.4	18.8	Sl	1.46	2.87	17.9	6.0	49.12	11.9	
A1	17-52	64.2	12.7	21.3	Scl	1.43	2.81	19.3	6.4	49.11	12.9	2.21
B1	52-100	64.0	12.5	23.5	Scl	1.52	2.97	20.5	7.3	48.82	13.2	
B2	100-142	65.2	12.9	21.9	Scl	1.55	2.99	19.8	6.7	48.16	13.1	
B3	142-170+	65.9	11.8	22.3	Scl	1.55	2.99	20.1	6.9	48.16	13.2	
Water table												
63/14 Soil research farm, CCS HAU Hisar												
Pedon 9 Fine loamy, Mixed, Hyperthermic, Typic Ustochrepts												
Ap	0-18	72.2	12.1	15.7	Sl	1.48	2.97	16.8	6.2	50.16	10.6	2.1
A1	18-90	64.1	13.2	22.7	Scl	1.51	2.97	19.6	6.8	49.15	12.8	
B1	90-135	63.8	13.4	22.8	Scl	1.59	2.98	19.2	7.2	46.64	12.2	
B2	135-172	64.6	15.9	19.5	Scl	1.55	2.99	18.9	7.1	48.16	11.8	
Water table												

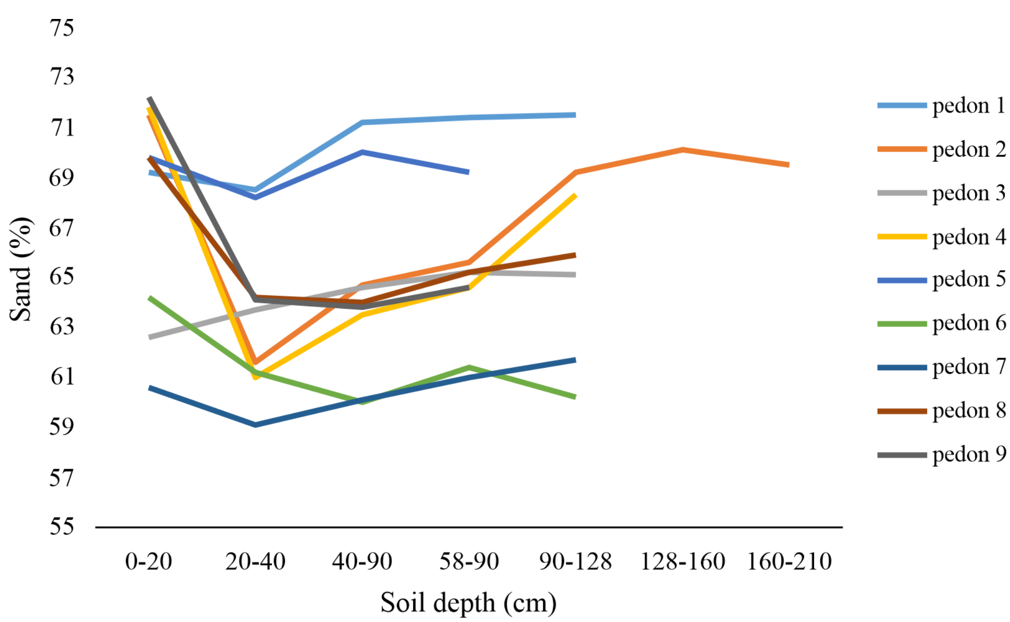

Fig. 4. Vertical distribution of sand in different pedons

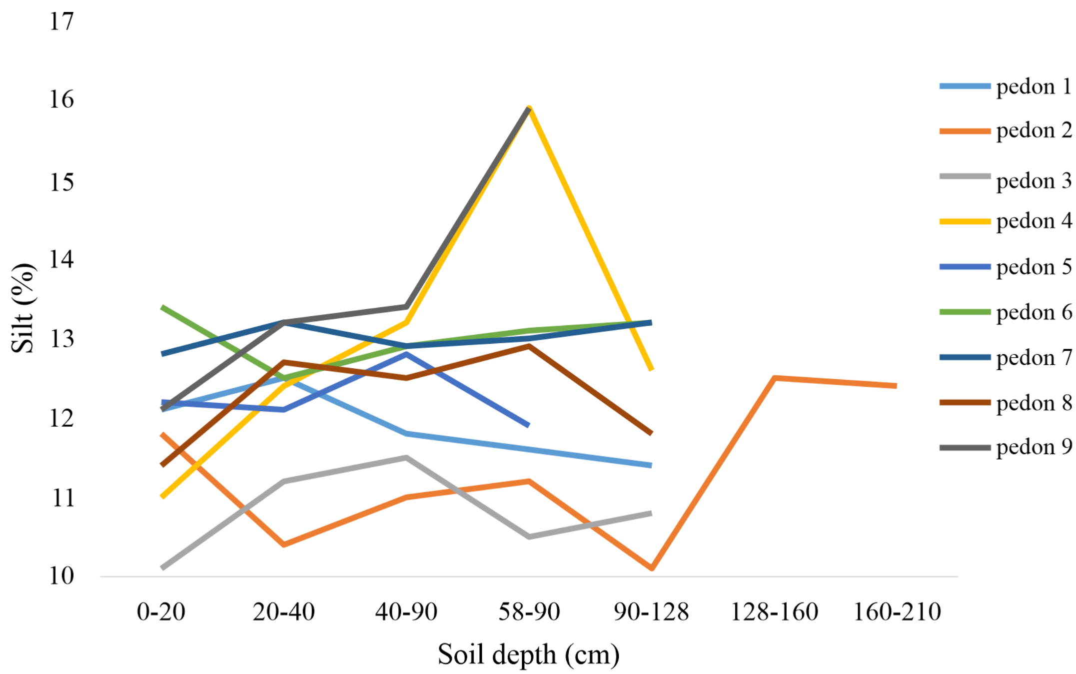

Fig. 5. Vertical distribution of silt in different pedons

pedon 4 (15.9%) and lowest in surface horizon of pedon 2 (10.1%) and clay content in different peodns shows in Fig 6. The relative proportion of sand and silt among the various horizons of pedons did not exhibit definite trend and shows irregular distribution. In general the clay content increased with depth but did not show regular distribution with depths. Mechanical study of soil particles revealed that pedon subterranean horizons had higher clay content than surface horizons, possibly due to clay translocation and buildup (Fig. 6). Tripathi *et al*. (2006) discovered that sub-surface horizons included

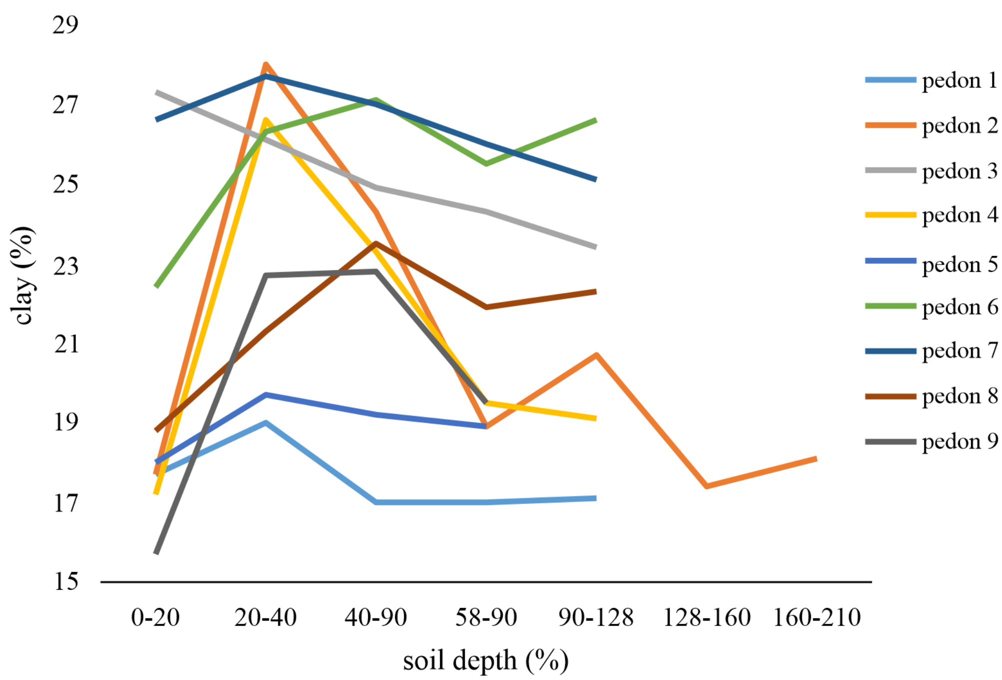

Fig. 6. Vertical distribution of clay in different pedons

more clay than surface strata which they believe is due to the illuviation process that occurs during soil development. The vertical distribution of silt and sand contents is also affected by the illuviation process. Sand makes up the majority of the mechanical fractions (Fig. 4) due to the parent material's siliceous composition and the dominance of physical weathering. Because of their proximity to Rajasthan's desert areas, these places have a low proportion of silt (Fig. 5) in comparison to sand fractions, which is related to aeolian activity (Ahuja *et al*., 1997; Chavan *et al*., 2022).

Water retention characters of horizons were shown to be highly linked to texture, with finer soil retaining more water and vice versa. In all of the pedons, water retention at field capacity and permanent wilting point ranged from 5.79 to 18.80% and 3.11 to 3.67%, respectively. Moisture retention at suctions 0.03 MPa and available water with clay were shown to have highly significant connections. Clay and silt content of soil had a stronger effect on retention behavior of different pedons than sand, according to correlation studies. The drainage that occurs when the suction pressure is increased from 0.03 to 1.5 Mpa because macro pores are emptied at lower suction levels and micro pores are emptied at higher suction levels, the effect of clay content manifests itself as a higher permanent wilting point due to the greater number of micro pores (Kumar *et al*., 2021; Nikam *et al*., 2006). The coefficient of association between clay percentage and moisture retained at field capacity (0.03 MPa) (r = 0.948; p 0.01) and available water (0.935; p 0.01) was higher than that of organic carbon (r = -0.405 to -0.49), showing that an increase in clay boosted water retention (Table 4). However, there was a strong negative association between available water content and sand (r = -0.867; p 0.01). This was because clay plays a large role in moisture retention. The influence of organic carbon was concealed by clay as OC declined with depth while clay content increased in general. Furthermore, water retention and cation exchange capacity were shown to have a positive and significant association, implying that clay mineralogy influences soil water retention characteristics since CEC is directly related to clay mineralogy. Lambooy (1984) also mentioned the influence of CEC on water retention. As a result, in

Table 4. Correlation matrix among physico-chemical properties

Parameter		Sand (%)	Silt (%)	Clay (%)	BD	PD	PS	Moisture retention (0.03 MPa)	Moisture retention (1.5 MPa)	Available water (%)	OC (%)	CEC
Sand (%)		1										
Silt (%)		-0.941**	1									
Clay(%)		-0.781**	0.672*	1								
BD		0.386	-0.348	-0.269	1							
PD		0.348	-0.538	0.072	0.289	1						
PS		-0.234	0.192	0.236	-0.947**	0.146	1					
Moisture	0.03 MPa	-0.871**	0.675	0.981**	-0.331	-0.024	0.263	1				
retention	1.5 MPa	-0.522	0.338	0.669	-0.518	0.358	0.618	0.795*	1			
Available water (%)		-0.815**	0.718*	0.917**	-0.241	-0.179	0.113	0.922**	0.564	1		
OC (%)		0.186	-0.124	-0.179	0.271	0.242	-0.173	-0.471	-0.593	-0.399	1	
CEC		-0.741*	0.795*	0.712*	-0.465	-0.224	0.386	0.739*	0.678	0.762*	-0.610	1

**Significant at 0.01 probability level
*Significant at 0.05 probability level

all pedons, silt and clay were discovered to be the primary contributors in regulating soil water content.

The bulk density of the study area ranged from 1.38 to 1.62 Mg m^3, with an increasing trend with depth due to progressive compaction caused by eluvial materials filling pores, decreased organic matter and less aggregation. Pedon 4, 6, 7 has a greater bulk density (>1.60 Mg m^3) due to reduced aggregation caused by the high sand content. Low organic matter and compaction of soil aggregates increased bulk density down the profile, according to Singh and Aggarwal (2005) and Kharlyngdoh *et al*. (2015). Singh *et al*. (1993) observed similar findings when examining the pedogenesis and taxonomy of soils in a toposequence of the central Himalayas. The particle density and total porosity varied from 2.45 to 2.64 Mg m^{-3} and 34.29 to 47.96 percent, respectively and did not show any trend with depth. The pore space of the studied pedons varied from 48.0 to 57.19% and infiltration rate of the soil ranged from 2.1 to 2.4 cm hr^{-1} in the different pedons being highest in pedon 5 and 9 and lowest in pedon 1, 3 and 5. The infiltration rate obtained throughout the research was quite high (>1 cm hr^{-1}) in all of the pedons. Infiltration rate has a positive correlation with porosity while negative correlation with the bulk density. The soils of pedon 3 were placed in suitable class for wheat, barley, Oilseeds, pearl millet and moderately to marginally suitable for forest trees like poplar, eucalyptus, shisham and horticulture trees like cirus, ber, guava etc.

Conclusion

The results revealed considerable variation in the morphological and physical characteristics of the soil. The color of the pedons varied from dark yellowish brown to yellowish brown. The texture of the study area varied from sandy loam on the surface and sandy clay loam in subsurface horizons. The structure of pedons was moderate, medium to fine sub angular blocky throughout the profile. Bulk densities of study area are showing the increasing trend with the depths. The infiltration rate obtained throughout the research was quite high (>1 cm hr^{-1}) in all of the pedons. The soils of the study area according to soil suitability criteria were found suitable (S1) for crops like wheat, barley, oilseed and horticulture crops while moderately to marginally suitable (S2) for pearl millet, cotton, pulses, vegetable and forest trees.

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Received: 31 May 2023; Accepted: 8 August 2023