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Characteristics and classification of some rice growing soils of Chandauli district of Uttar Pradesh

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Abstract

Three typical pedons representing upland, mid-upland and lowlands rice growing soils were characterised in Chandauli district of Uttar Pradesh. These soils are developed in alluvium and are deep to very deep but poor in organic carbon. The soils of upland are characterized by olive brown colour, sandy loam to sand in texture, free calcium carbonate (2.5 to 8.0 per cent) moderately alkaline reaction (pH 8.0 to 8.3), low CEC and exchangeable Na and K whereas the soils on mid-upland are greyish brown to dark greyish brown in colour, loam to sandy clay loam in texture, neutral to moderately alkaline in reaction (pH 7.1 to 8.3) and intermediate in CEC and exchangeable Ca and Mg. The soils on lowland under the influence of backwater of the river are characterized by olive grey to light olive brown colour, sandy clay loam in texture, neutral to slightly alkaline reaction (pH 7.1 to 7.5) and intermediate in CEC and exchangeable Ca and Mg. Based on the characteristics the upland soil is classified as Typic Ustifluvents, mid-upland soil as Typic Calciustepts and lowland soil as Dystric Eutrudepts.

Additional key words : Alluvial soil, rice, soil characteristics.

Introduction

The eastern region of Varanasi division is considered as the rice-bowl of eastern U.P. Flooded rice (*kharif*) cultivation is practiced throughout the area, followed by wheat in rabi for the last over 100 years. A limited information is available on the rice growing soils of the northern region of the country (Pannu *et al.* 1999, Gupta and Tripathi 1993) but such information is virtually lacking in case of soils of the eastern Uttar Pradesh and in particular Chandauli district of Varanasi division and hence present study was carried out.

Materials and methods

Study area : The study area lies between 25°10′ to 25°30′ N latitudes and 83°0′ to 83°30′ E longitudes in Chandauli district of the Varanasi division. The climate of the district

is semi-arid subtropical monsoonic type with a rainfall of 1060 mm. The MWST is 18.9°C and MSST is 33.2°C. The mean annual relative humidity is 72 per cent. The soil moisture control section of pedon 1 and pedon 2 is 'ustic' whereas it is 'udic' for pedon 3 associated with 'hyperthermic' temperature regime. The landscape is saucer shaped and soils have developed in alluvium of Ganges, Karamnasa and their tributaries.

Three pedons representing major landforms of the area, *viz.* upland (Hardhanjura village), mid-upland (Pasai village) and lowland (Shahjaur village) were studied for their morphometric characteristics (Soil Survey Division Staff 1995). Horizonwise soil samples were collected and analysed for soil separates (sand, silt and clay), bulk density, and chemical properties like pH, EC, $CaCO_3$, organic carbon, CEC, base saturation following standard procedures (Black 1965; Jackson 1967). Based on their characteristics, the soils were classified as per Keys to Soil Taxonomy (Soil Survey Staff 1998).

Results and discussion

Morphological properties : The morphological characteristics of these soils are presented in Table 1. These soils are deep to very deep (≥1.5 m). The colour of the soils of pedon 1 (close to Ganga) is olive brown in 2.5Y hue (Ap and A2) with chroma 4 throughout the depth but value ranges from 4 to 6 with depth (Table 1). The pedon 2 situated away from the river Ganga has matrix colour of brown in 2.5 and 5 Y hue and is associated with mottles of varying sizes and colours (2.5YR to 7.5YR hue) upto a depth of 1.10 m. Similarly pedon 3 (away from Ganga) has hues of 5Y in surface horizons and 2.5Y in subsoils with value of 5 but chroma ranges from 2 to 4 with depth. Mottles of 2.5YR 3/4 colour occur in all horizons except Ap. The structure of pedon 1 is dominantly fine, weak, granular whereas that of pedon 2 and pedon 3 is subangular blocky which is the reflection of their sandy loam to sandy clay loam texture with few exception. The occurrence of Fe-Mn concretions was also noticed in pedon 1 and 2 barring surface horizons whereas few very fine, many moderate and many coarse pedogenic $CaCO_3$ (2 to 3 per cent) mainly as micrite crystals in groundmass were found in Bw2, Bw3 and Ck horizons, respectively. The simultaneous occurrence of Fe-Mn concretions and calcretes were also reported in some soils of eastern Uttar Pradesh by Ram *et al.* (2000).

Soil characteristics : The particle size distribution (Table 2) indicates that sand is the dominant fraction in all the pedons. Higher content of sand was noticed in pedon 1 whereas clay was more in pedon 3. This reflects the physiographic position of pedons and their distance from river. The silt fraction did not vary significantly in pedons. The increase/ decrease in sand/clay in a particular horizon is complimented by each other. There were lithological discontinuities in profiles and that reflect their depositional feature. WHC of soils is directly depended on the clay content.

Table 1. Morphological characteristics of soils *

Horizon	Depth (m)	Boundary	Colour matrix (moist)	Mottle & it's colour	Texture	Structure	Consistency	Fe-Mn Concr--etions	Roots	Effervescence
Pedon 1 : Coarse-loamy, mixed, hyperthermic Typic Ustifluvents										
Ap	0.00-0.15	cs	2.5Y 4/4	–	sl	f_1 gr	s l sspo	–	m m	es
A2	0.15-0.40	gs	2.5Y 4/4	–	sl	f_1 gr	s vfr sopo	–	f m	es
C1	0.40-0.75	ds	2.5Y 5/4	–	sl	f_1 gr	s fr sopo	–	vf f	es
C2	0.75-1.05	ds	2.5Y 5/4	–	sl	f_1 gr	s fr sopo	–	vf f	es
2C3	1.05-1.35	ds	2.5Y 5/4	–	sl	f_1 gr	s fr sopo	–	vf f	ev
2C4	1.35-1.55	–	2.5Y 6/4	–	s	F_0 sg	l l sopo	–	–	ev
Pedon 2 : Fine-loamy, mixed, hyperthermic Typic Calciustepts										
Ap	0.00-0.15	cs	2.5Y 5/2	f1f 2.5YR 4/4	scl	m3 sbk	h fr sp	–	f c	–
A2	0.15-0.35	gs	5Y 5/3	f1d 2.5YR 4/4	scl	m2 sbk	h fr sp	vf m	f f	e
Bw1	0.35-0.60	gs	2.5Y 6/4	c2d 5YR 3/4	scl	c2 sbk	h fi sp	m m	vf f	e
Bw2	0.60-0.85	gs	5Y 5/3	m3d 7.5YR 5/6	scl	c2 sbk	vh fi sp	c m	–	e
2Bw3	0.85-1.10	gs	2.5Y 5/2	m2d 7.5YR 5/6	l	m2 sbk	vh fi sp	m m	–	es
3CK	1.10-1.50	–	5Y 6/2	–	sl	f1 sbk	s fr sopo	c m	–	ev
Pedon 3 : Fine-loamy, mixed, hyperthermic Dystric Eutrudepts										
Ap	0.00-0.20	cs	5Y 5/2	–	scl	m2 sbk	s fr sp	–	c m	–
A2	0.20-0.65	gs	5Y 6/2	m1f 2.5YR 4/4	scl	m2 sbk	sh fr sp	f m	f c	–
Bw1	0.65-0.85	gs	5Y 5/3	f2f 2.5YR ¾	scl	m2 sbk	h fr sp	f f	vf f	–
Bw2	0.85-1.20	gs	2.5Y 5/4	f1d 2.5YR ¾	scl	c2 sbk	vh fi sp	f f	–	–
Bw3	1.20-1.55	–	2.5Y 5/4	m2d 2.5YR ¾	scl	c3 sbk	vh fi sp	vf f	–	–

*Abbreviations used as per Soil Survey Division Staff (1995)

Bulk density ranged from 1.38 to 1.65 Mg m^{-1} and seems to be dependent on texture. The pH of the soils ranged from 7.1 to 8.3 being higher in pedon 1 owing to presence of free $CaCO_3$. The increase in pH down the depth indicates that it was influenced by exchangeable Mg^{+2} and Na^{+} also. The EC of soils varies from 0.10 to 0.44 dS m^{-1} (Table 3).

Table 2. Physical properties of soils

Depth (m)	Sand (0.05-2.00 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	BD (Mg m^{-3})	Pore space (%)	WHC (%)
	----------(% of <2 mm)---------					
Pedon 1 : Coarse-loamy, mixed, hyperthermic Typic Ustifluvents						
0.00-0.15	58.0	30.0	.2.0	1.48	41.5	16.3
0.15-0.40	59.0	27.9	:3.1	1.55	39.4	17.5
0.40-0.75	58.9	30.0	:1.1	1.57	38.7	20.0
0.75-1.05	58.1	31.8	0.1	1.58	39.5	16.3
1.05-1.35	62.2	30.7	7.1	1.63	38.5	16.7
1.35-1.55	86.1	08.9	5.0	1.65	38.4	11.1
Pedon 2 : Fine-loamy, mixed, hyperthermic Typic Calciustepts						
0.00-0.15	50.8	22.6	26.6	1.44	40.0	35.0
0.15-0.35	50.4	21.8	27.8	1.45	40.8	39.2
0.35-0.60	50.6	19.6	29.8	1.44	43.5	41.4
0.60-0.85	45.0	25.5	29.5	1.49	41.0	36.2
0.85-1.10	44.6	30.5	24.9	1.45	42.8	41.8
1.10-1.50	57.8	35.2	07.0	1.51	40.9	20.3
Pedon 3 : Fine-loamy, mixed, hyperthermic Dystric Eutrudepts						
0.00-0.20	53.3	23.0	23.7	1.38	43.8	40.5
0.20-0.65	48.8	25.3	25.9	1.42	42.4	42.6
0.65-0.85	45.4	27.3	27.3	1.49	40.6	43.1
0.85-1.20	46.5	27.5	26.0	1.52	41.18	43.4
1.20-1.55	47.2	27.6	25.2	1.55	39.2	42.3

Table 3. Chemical and physico-chemical characteristics of soils

Depth (m)	pHw (1:2.5)	EC ($dS\ m^{-1}$)	$CaCO_3$ (%)	Org.C. ($g\ kg^{-1}$)	CEC	Ca	Mg	Na	K	Base sat. (%)
					---------- cmol (p^+) kg^{-1} ----------					
Pedon 1 : Coarse-loamy, mixed, hyperthermic Typic Ustifluvents										
0.00-0.15	8.0	0.15	5.5	3.3	10.1	5.8	2.0	0.5	0.2	84
0.15-0.40	8.2	0.16	4.0	3.2	10.0	5.6	3.5	0.3	0.5	99
0.40-0.75	8.2	0.15	2.5	2.4	11.3	5.7	3.6	0.7	0.3	91
0.75-1.05	8.1	0.18	2.5	2.6	11.3	5.7	4.1	0.8	0.3	96
1.05-1.35	8.1	0.20	8.0	2.0	11.2	6.2	3.6	0.8	0.3	97
1.35-1.55	8.3	0.22	6.0	2.3	08.2	4.1	2.1	0.7	0.2	86
Pedon 2 : Fine-loamy, mixed, hyperthermic Typic Calciustepts										
0.00-0.15	7.1	0.33	0.0	5.1	17.5	7.5	6.5	0.6	0.1	84
0.15-0.35	7.4	0.36	0.0	3.7	20.4	8.7	8.5	0.9	0.2	90
0.35-0.60	7.6	0.40	0.0	2.4	20.4	9.5	7.0	1.3	0.2	88
0.60-0.85	7.7	0.35	1.5	1.1	21.5	8.6	8.5	1.2	0.2	86
0.85-1.10	7.8	0.29	2.5	1.0	19.6	8.8	7.0	1.5	0.2	89
1.10-1.50	8.3	0.10	17.0	1.0	07.5	4.5	1.5	0.5	0.2	89
Pedon 3 : Fine-loamy, mixed, hyperthermic Dystric Eutrudepts										
0.00-0.20	7.1	0.30	0.5	5.6	17.5	8.6	4.1	0.1	1.2	80
0.20-0.65	7.1	0.41	0.5	5.0	19.7	9.7	6.0	0.2	0.8	85
0.65-0.85	7.2	0.44	0.5	3.2	20.2	10.7	5.8	0.5	0.4	86
0.85-1.20	7.4	0.35	0.0	2.8	18.5	11.3	3.9	0.6	0.5	88
1.20-1.55	7.5	0.38	0.0	2.6	18.5	11.4	4.0	0.6	0.5	89

The organic carbon content is low (1.0-5.6 $g\ kg^{-1}$) due to rice-wheat cropping system and prevailing semi-arid environment and that need carbon sequestration. The higher CEC was noticed in pedon 2 and pedon 3 and within horizon, it was higher in the B horizons of all the pedons which is directly related to clay contents of the horizons. Barua *et al.* (1996) also reported that clay and CEC were higher in rice soils of lowland than that of upland. The exchange complex was dominated by Ca^{+2} followed by Mg^{+2}. Base saturation was more than 80 per cent.

Classification : Pedon 1 does not have any diagnostic sub-surface horizon and thus grouped under order Entisols. There is irregular distribution of organic carbon in the profile and hence are placed under Fluvents. Ustic moisture regime places it under Ustifluvents. The soil does not have characteristics of any of the subgroup recognized and therefore key out for placement under Typic Ustifluvents. Pedon 2 and Pedon 3 have ochric epipedon and

are underlain by a well developed cambic horizons within the control section as such they qualify for Inceptisols. Pedon 2 has ustic soil moisture regime and hence falls under Ustepts, whereas pedon 3 has udic soil moisture regime and therefore falls under suborder Udepts. Pedon 2 is characterized by a calcic horizon within 150 cm from the mineral surface and shows effervescence and also has a texture of loamy fine sand and, therefore, qualifies for Calciustepts. Since the soils do not have any other complexicity they are placed under Typic Calciustepts. Pedon 3 does not have any sulfuric horizon, duripan, fragipan, or free calcium carbonate but have more than 60 per cent base saturation in all the horizons and thus keys out as Eutrudepts. The Eutrudepts that do not have free carbonates throughout any horizon within 100 cm of the mineral surface are grouped under Dystric Eutrudepts.

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