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Characterization and classification of some cultivated soils of Ramganga Catchment in the hills of Uttar Pradesh

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Abstract

Twelve representative pedons of cultivated soils on terraced land for Kumaon hills under 2 to 47 per cent terrain slope and 1050 to 2100 m elevation were studied for various physical and chemical properties and classified according to Soil Taxonomy. The soils under poorly managed terraces were shallow (45 to 86 cm), coarse textured, weekly developed and had low CEC, exchangeable bases and moisture retention capacity. All the soils were acidic in reaction and had high organic carbon content except soils of poorly maintained terraces. Soils of poorly managed terraces are classified under Typic Dystrudepts and Typic Udorthents and soils of well managed terraces are placed under Typic Argiudolls, Ultic Hapludalfs and Typic Eutrudepts.

Additional keywords: Soils on terraces, hill soils.

Introduction

The hill region of Uttar Pradesh comprising of two divisions viz. Kumaon and Garhwal, covers an area of 51125 sq. km. The entire area is mountainous with intermittent valleys and the Tarai in Dehradun and Udham Singh Nagar districts. The economy of the area depends on agriculture, though, agriculture is practised only on 14 per cent of the geographical area (Anonymous, 1992). Cultivation of crops is being extended to steep slopes without considering the potential and land use capability of the land in the upper part of Ramganga Catchment. Characterisation and classification of these cultivated soils become thus imperative in view of their continuous use and management.

Materials and methods

Ramganga Catchment of U.P. hills lies between 29°30' to 39°61'N latitudes and 70°35' to 79°35'E longitudes. The area is characterised by deep, wide and narrow valleys and high mountain ridges. The elevation varies from 256 to 3109 m above mean sea level. The terrain slope ranges from moderate to steep (10 to 50%). Geological formations include mica schists, granitic gneiss, quartzitic sandstone and quartzitic limestone (Satyanarayana *et al.* 1968). The annual rainfall ranges from 730 to 2425 mm. The mean annual air temperature is 23.06°C. In winter the temperature drops to a minimum of about 2°C and therefore there is a greater difference between mean winter temperature (14.0°C) and mean annual temperature (28.2°C).

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Six representative soil profiles, three each in poorly and well managed terraces of cultivated lands were studied for morphological properties (Soil Survey Staff 1966). Horizonwise soil samples were collected, dried, processed and analysed for various physical and chemical properties by using standard analytical procedures (Black 1965; Jackson 1973). The soils were classified as per Keys to Soil Taxonomy (Soil Survey Staff 1998).

Results and discussion

Morphological features of the pedons

The depth of the pedons (Table 1) varied from shallow to deep. The soils of well maintained terraces were deeper as compared to the soils of poorly maintained terraces. The poorly managed soils had higher soil colour values (4 to 6) whereas lower soil colour values (3 to 5) were observed in the well maintained terraces. All the pedons had darker surface layers as compared to subsurface horizons. Surface soils of well maintained terraces had granular structure whereas subangular blocky structure was found in subsoils (B horizon). Granular structure in surface soils was mainly due to the higher organic matter content (Sehgal *et al.* 1985). The soils of well managed terraces had clay coatings in their 'B' horizons except Ghusela pedon. No clay coatings were observed in the pedons of poorly managed terraces due to continued surface runoff and soil erosion. Poorly maintained terraces had loose to friable consistency whereas friable to firm consistence was observed in the soils of well maintained terraces mainly due to the difference in organic matter and clay contents of the pedons.

Table 1. Morphological characteristics of some cultivated soils of U.P. hills

Soil depth (cm)	Horizon	Colour (moist)	Text-ure	Structure	Consi-stency	Clay coatings	Roots
A. Poorly managed terraces							
Naini Pedon (1700 msl, 11% slope)							
0-12	Ap	10YR 5/4	sl	F1 gr	Mvfr	–	ab
12-19	A1	10YR 5/4	sl	F1 gr	Mvfr	–	ab
19-43	Bw1	10YR 5/6	sl	F1 gr	Mfr	–	m
43-64	Bw2	10YR 5/6	sl	F1 gr	Mvfr	–	m
64-80	C	10YR 6/6	sl	F1 gr	Ml	–	f
Bina Pedon (1525 msl, 21% slope)							
0-11	Ap	2.5YR 4/2	sl	F1 gr	Ml	–	ab
11-26	A1	2.5YR 4/2	sl	F1 gr	Mvfr	–	m
26-33	A2	2.5YR 4/2	sl	F1 gr	Mvfr	–	f
33-45	A3	2.5YR 4/4	sl	F1 gr	Mvfr	–	f
45-70	C	10YR 5/8	sl	F1 gr	Mvfr	–	–
Ghingharikhal Pedon (1650 msl, 47% slope)							
0-11	Ap	10YR 6/3	ls	fl gr	Ml	–	ab
11-24	A1	10YR 5/3	ls	fl gr	Ml	–	m
24-51	A2	10YR 5/4	sl	fl gr	Mvfr	–	m
51-68	C	10YR 5/4	sl	sg	Ml	–	f

Soil depth (cm)	Horizon	Colour (moist)	Text-ure	Structure	Consi-stency	Clay coatings	Roots
		B. Well maintained terraces					
		Mehalchaura Pedon (1050 msl, 2% slope)					
0-11	Ap	10YR 3/4	l	fl gr	Mvfr	–	ab
11-25	Bw	10YR 3/4	l	m2 sbk	Mfr	–	ab
25-41	Bt1	10YR 4/3	l	c2 sbk	Mfl	tn, P	m
41-65	Bt2	10YR 4/4	l	c2 sbk	Mfl	th,P	f
65-81	Bt3	10YR 4/3	l	c2 sbk	Mfl	tn,P	–
81-91	C	10YR 4/3	l	fl sbk	Mvfr	–	–
		Gaid Pedon (1600 msl, 21% slope)					
0-10	Ap	10YR 4/3	l	m2 gr	Mfr	–	ab
10-22	A1	10YR 4/4	l	m2 gr	mfr	–	m
22-28	Bw	10YR 5/4	l	m2 gr	mfr	–	m
28-62	Bt1	10YR 5/4	l	m2 abk	mfi	tn,C	m
62-90	Bt2	10YR 4/4	cl	c3 sbk	mvfi	th,C	f
90-105	Bt3	10YR 4/3	cl	c3 sbk	mvfi	th, C	–
		Ghusela Pedon (1450 msl, 34% slope)					
0-12	Ap	10YR 4/3	sl	fl gr	ml	–	m
12-23	A1	10YR 4/3	sl	m2 gr	mfr	–	m
23-29	Bw1	10YR 5/4	sl	m2 sbk	mfi	–	m
39-62	Bw2	10YR 5/4	sl	m2 sbk	mfi	–	f
62-72	BC	10YR 5/6	sl	m1 sbk	mfr	–	f
72-100	C	10YR 5/6	sl	m1 gr	mvfr	–	f

The abbreviations are as given in Soil Survey Manual (Soil Survey staff, 1966).

Physical properties of the soils

Gravel (25 to 46%) and sand (67 to 82%) contents were higher in the soils of poorly managed terraces whereas silt and clay contents were higher in well managed terraces (Table 2). Bulk density was low (0.83 to 1.22 Mg m^{-3}) in the surface horizons and it increased with depth in all the pedons. Higher coarser fraction in poorly maintained terraces may be attributed to loss of fine soil particles due to erosion (Singh and Prakash, 1985).

Water holding capacity and moisture storage at 0.03 MPa and 1.5 MPa were higher in surface layers as compared to subsoils. They were higher in the soils of well maintained terraces as compared to other terraces. The variations in moisture retention were mainly due to the variations in organic matter and clay contents. The available water storage capacity was also low (5.3 to 5.9 cm) in poorly maintained terraces as compared to well maintained terraces (11.0 to 26.3 cm). These differences were due to the variation in the depth, clay and organic matter content of the pedons.

Table 2. Physical properties of some cultivated soils

Depth (cm)	Chert/ gravel (%)	Sand (%)	Silt (%)	Clay (%)	B.D. Mg m^{-3}	W.H.C. (%)	Moisture (%)		Water Storage Capacity (cm)
							0.03 MPa	1.5 MPa	
A. Poorly managed terraces									
Naini Pedon : Typic Dystrudepts									
0-12	25	67	22	11	0.83	34.6	16.6	6.3	
12-19	26	70	20	10	0.98	32.2	14.2	5.2	
19-43	24	70	20	10	1.03	32.0	11.3	5.0	5.9
43-64	21	71	17	12	1.14	29.3	10.7	4.2	
64-80	25	67	22	11	1.13	28.2	10.3	4.3	
Bina Pedon : Typic Udorthents									
0-11	40	78	13	9	0.98	36.4	16.1	6.0	
11-26	39	74	17	9	1.15	34.3	13.7	5.2	
26-33	36	78	13	9	1.36	31.9	11.5	5.0	5.3
33-45	38	68	22	10	1.40	31.9	10.6	4.5	
45-70	47	74	18	8	1.39	30.2	6.8	3.6	
Ghingharikhal Pedon : Typic Udrothents									
0-11	46	82	13	5	1.22	32.3	14.3	5.9	
11-24	36	76	18	6	1.12	30.5	11.6	5.2	5.4
24-51	29	62	27	11	1.04	31.5	12.9	5.3	
51-68	37	75	16	9	1.28	28.9	9.8	4.1	
B. Well managed terraces									
Mehalchaura Pedon : Typic Argiudolls									
0-11	18	42	40	18	1.15	52.3	25.7	7.3	
11-25	17	44	39	17	1.21	37.6	18.3	6.2	
25-41	16	42	35	23	1.32	36.8	18.3	6.3	16.4
41-65	9	36	40	24	1.39	37.1	19.0	6.6	
65-81	14	41	38	21	1.42	33.2	16.6	5.9	
81-91	20	58	31	11	1.51	32.8	14.5	6.0	
Gaid Pedon : Ultic Hapludalfs									
0-10	20	43	44	13	1.09	68.4	36.0	15.6	
10-22	21	40	48	12	1.28	61.5	30.6	12.3	
22-28	19	39	48	13	1.22	57.6	28.4	11.9	26.3
28-62	17	41	41	18	1.36	57.2	28.6	13.3	
62-90	17	36	35	29	1.50	60.2	29.8	14.4	
90-105	17	32	39	29	1.46	61.2	30.1	14.5	
Ghusela Pedon : Typic Eutrudepts									
0-12	22	60	32	8	1.08	45.1	24.6	8.3	
12-23	26	62	31	7	1.16	33.2	16.8	5.2	
23-29	21	60	33	7	1.28	31.0	14.7	5.5	11.0
39-62	15	55	37	8	1.24	33.0	15.4	6.0	
62-72	14	58	33	9	1.25	30.9	14.0	5.1	
72-100	26	65	37	8	1.38	30.2	13.5	4.9	

Chemical properties of the soils

The pH of the soils (Table 3) was in acidic range and did not show much variation with depth and the level of management of the terraces. The electrical conductivity was also low in all the pedons. The soils had higher (0.76 to 3.18%) organic carbon content which decreased with increasing soil depth. The surface horizons of well managed terraces had higher (1.05 to 2.51%) organic carbon content than in other terraces.

Table 3. Chemical properties of some cultivated soils

Depth (cm)	pH (1:2)	EC dS m^{-1}	O.C. (%)	CEC	Exchangeable bases Ca++	Mg++	K+	Na+	Base saturation (%)
				cmol (p+) kg^{-1}					
A. Poorly managed terraces									
Naini Pedon									
0-12	5.9	0.10	2.01	11.8	3.5	1.4	1.12	0.13	52
12-19	6.2	0.07	1.19	8.2	2.7	0.8	1.03	0.13	57
19-43	6.3	0.03	0.41	6.5	1.8	0.3	0.71	0.13	45
43-64	5.9	0.09	0.27	5.8	1.5	0.4	0.45	0.22	44
64-80	6.5	0.02	0.18	5.6	1.5	0.3	0.18	0.17	38
Bina Pedon									
0-11	5.1	0.10	1.50	11.2	3.4	1.2	0.67	0.22	49
11-26	5.1	0.11	0.96	9.3	3.1	0.6	0.36	0.31	46
26-33	5.1	0.10	0.43	8.8	2.4	1.1	0.27	0.26	45
33-45	5.1	0.07	0.27	8.1	2.7	1.2	0.31	0.26	55
45-70	4.9	0.07	0.16	7.6	3.8	1.5	0.31	0.35	78
Ghingharikhal Pedon									
0-11	6.0	0.03	0.76	9.8	2.7	0.4	0.21	0.13	35
11-24	6.0	0.02	0.43	6.8	1.2	0.7	0.14	0.13	32
24-51	6.0	0.02	0.68	7.6	1.8	0.3	0.09	0.13	31
51-68	5.8	0.01	0.33	5.6	1.5	0.2	0.08	0.13	34
B. Well managed terraces									
Mehalchaura Pedon									
0-11	6.5	0.24	2.45	18.6	6.8	2.7	0.35	0.35	55
11-25	6.5	0.24	1.36	12.4	5.7	2.4	0.26	0.35	70
25-41	6.5	0.27	1.09	14.4	5.5	2.0	0.19	0.65	58
41-65	6.7	0.22	0.62	14.8	5.5	1.9	0.18	0.39	54
65-81	6.8	0.19	0.51	16.6	5.8	2.5	0.22	0.31	53
81-91	6.7	0.19	0.29	10.4	3.8	1.8	0.14	0.26	58
Gaid Pedon									
0-10	5.8	0.10	2.51	22.8	7.8	1.3	0.59	0.17	43
10-22	6.3	0.06	2.98	19.0	5.3	2.1	0.27	0.26	42
22-28	6.2	0.04	0.70	16.4	5.7	2.1	0.26	0.26	51
28-62	6.2	0.03	0.60	18.0	4.7	1.9	0.27	0.22	39
62-90	6.2	0.03	0.58	19.6	5.5	2.2	0.36	0.26	44
90-105	6.2	0.03	0.79	20.0	6.5	2.1	0.38	0.31	47
Ghusela Pedon									
0-12	5.8	0.08	1.05	10.8	4.3	2.5	0.27	0.31	68
12-23	6.0	0.04	0.35	10.2	3.5	1.6	0.15	0.13	52
23-29	6.0	0.04	0.33	8.0	4.1	1.6	0.13	0.22	75
39-62	6.2	0.04	0.23	8.6	4.2	2.0	0.12	0.26	77
62-72	6.2	0.03	0.19	8.4	3.6	1.6	0.09	0.17	65
72-100	6.0	0.03	0.31	8.2	3.4	1.8	0.12	0.22	68

Cation exchange capacity was higher in the surface soils than the subsoils due to higher organic carbon content. However, it increased in the B horizons of well maintained terraces due to clay accumulation. In all the soils, calcium was predominant followed by magnesium, potassium and sodium and they were higher in well maintained terraces as compared to other terraces. Variations in chemical properties of differently managed U.P. hill soils were also reported by Singh and Prakash (1985).

Classification of the soils

Based on the properties, the soils were grouped under the orders Entisol, Inceptisol, Alfisol and Mollisol. Naini pedon was placed under Typic Dystrudepts subgroup as they possessed a cambic horizon. Bina and Ghingharikhal pedons qualified for Typic Udorthents subgroup as they had texture of sandy loam and coarser. Mehalchaura pedon was classified as Typic Argiudolls as it contained mollic and argillic diagnostic horizons. Gaid pedon had well developed argillic horizon with less than 60 per cent base saturation and therefore classified as Ultic Hapludalfs. Ghusela pedon qualified for Typic Eutrudepts because it possessed sandy loam texture and a cambic horizon.

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