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Morphological Physical and Chemical Characterization of Fine Textured Inceptisols of Punjab

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A B S T R A C T

A study was undertaken to characterize fine textured Inceptisols morphologically, physically and chemically. Seven profiles in fine textured and four in coarse textured Inceptisols under different cropping systems (rice-wheat, maize-wheat, sugarcane, fallow-berseem and rice-sorghum) were exposed for the morphological, physical and chemical characterization. The soils showed remarkable closeness irrespective of profile locations and horizons. All the studied soils exhibited A-Bw-C horizons in coarse textured Inceptisols and A-B horizons in fine textured Inceptisols. The lower horizon has lower chroma and value followed a definite pattern. In fine textured Inceptisols clay content varied from 26-68 % and depth distribution of bulk density did not show any definite pattern with clay content and the cropping systems. No subsurface compaction was observed in fine textured Inceptisols. The soils were non-saline and alkaline in reaction. The depth distribution of CEC did not show any definite trend and varied with clay content. Calcium plus magnesium content was the dominant cations followed by potassium and sodium among all the exchangeable cations. These soils have severe physical constraints due to the presence of large amounts of clays in the finer fractions leading to lower crop productivity in these soils.

Keywords

Physical characterization, Chemical characterization, cropping systems, Fine textured Inceptisols, depth wise distribution,

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Introduction

The soils of Punjab in north-west India has developed on alluvial parent material. The alluvial plain covers nearly two-thirds of the total geographical area of the state. The Inceptisols, in the state, are the dominant soils followed by Entisols, Aridisols and Alfisols. These soils are, intensively used for the cultivation of a variety of crops. During the last three decades, the agricultural production in Punjab has increased manifold, but these gains in productivity have mostly been, confined to Inceptisols, which cover about 60 percent of the geographical area of the state.

Inceptisols include soils from ustic and udicregimethat have altered B horizons resulting from some chemical weathering processes (Soil Survey Staff 1975). These are relatively young soils having features more weakly expressed than mature soils, and retain close resemblance to the parent material. In addition to leaching, more than one pedogenic process may be operative in these soils, which represent transition between Entisols and other orders of Soil Taxonomy.

Inceptisols are that soils which have undergone modifications of the parent material by soil-forming processes that are sufficiently great to distinguish the soils from Entisols, but not intense enough to form the kinds of horizons required for classification into other soil orders. Most Inceptisols have cambic horizons and are eluvial soils (Smith 1965).

The Inceptisols are the prime lands of the state with intensive agriculture being practised on these soils. Though the majority of the Inceptisols in the state are coarse to medium textured soils, however, some are fine-textured Inceptisols, are found in alluvial plains in the old flood plain areas.

These soils are very fine in texture and have strong angular blocky structure with pressure faces and slickensides. Due to the presence of vertical cracks up to a depth of 30 cm and the ustic moisture regime, these soils are classified as Vertic Ustochrepts. The fine textured Inceptisols have not been shown to be chemically constrained for crop productivity (Sharma *et al.,* 1997).

The characteristics of the problem soils, which limit plant growth, are specific to soil types and need to be highlighted (Sur and Singh 1973) and knowledge of these characteristics of soils helps in planning irrigation and soil and water management practices on agricultural farms. In Punjab soils have been characterized for their morphological and chemical properties in detail (Sharma *et al.,* 1997, Challa *et al.,* 2000), No isolated study of fine textured Inceptisols for physical and chemical characterization is reported in the literature.

A study is thus being initiated to characterize the fine textured Inceptisols of the state on their Morphological, physical and chemical properties so as to provide the needed basic information of these soil.

Materials and Methods

Selection of soil profiles

The fine textured Inceptisols under different cropping systems were selected in the districts of Fatehgarh Sahib (Sadhugarh), Ropar (Marinda), Patiala (Nabha) and Ludhiana. Soil profiles for detailed studies were selected on the basis of clay content under different cropping systems.

Seven profiles were selected under fine textured Inceptisols and four under coarse textured Inceptisols were exposed for the purpose of comparison. Different cropping systems: rice-wheat, maize-wheat, sugarcane, fallow-berseem and rice-sorghum were selected.

Soil sampling and field methods

Soil profiles were exposed up to a depth of 1 to 1.5 m. The morphology of the profiles was described in the field following the procedures described in Soil Survey Manual (Soil Conservation Service 1993).

The soil samples from each of the morphologically differentiated horizons were collected, air dried, crushed in wooden mortar with pestle and passed through the 2-mm sieve for various analyses. In addition *in-situ* characterization of soil profile viz. bulk density was carried out.

Table.1 Some Important features of studied Pedonss of fine and coarse textured inceptisols of Punjab

Pedon	Location	Physiography	Present land use	Soil Taxonomy
1	30^0 2' 33.87″ N, 76^0 7' 15.17″ E Nabha (district Patiala)	Slopping alluvium terraces	Maize-wheat	TypicHaplusteps
2	30^0 2' 23.65″ N, 76^0 7' 36.38″ E Nabha (district Patiala)	Slopping alluvium terraces	Fallow-berseem	TypicHaplusteps
3	30^0 2' 24.02″ N, 76^0 7' 22.59″ E Nabha (district Patiala)	Slopping alluvium terraces	Rice-wheat	TypicHaplusteps
4	30^0 35' 41.15″ N, 76^0 27' 43.53″ E Sadhugarh (district Fatehgarh Sahib)	Old flood plains	Rice-wheat	Vertic-Ustochrepts
5	30^0 35' 40.85″ N, 76^0 27' 44.32″ E Sadhugarh (district Fatehgarh Sahib)	Old flood plains	Rice-sorghum	Vertic-Ustochrepts
6	30^0 46' 55.64″ N, 76^0 28' 6.68″ E Morinda (districts Ropar)	Old flood plains	Sugarcane	Vertic-Haplusteps
7	30^0 46' 55.36″ N, 76^0 28' 6.72″ E Morinda (Districts Ropar)	Alluvial terraces	Rice-wheat	Vertic-Haplusteps
8	30^0 54' 34.69″ N, 75^0 49' 8.28″ E Ludhiana	Alluvial terraces	Sugarcane	TypicHaplusteps
9	30^0 54' 30.03″ N, 75^0 49' 8.53″ E Ludhiana	Alluvial terraces	Rice-wheat	TypicHaplusteps
10	30^0 54' 24.91″ N, 76^0 46' 50.61″ E Ludhiana	Alluvial terraces	Rice-wheat	TypicHaplusteps
11	30^0 54' 27.61″ N, 76^0 46' 47.68″ E Ludhiana	Alluvial terraces	Rice-wheat	TypicHaplusteps

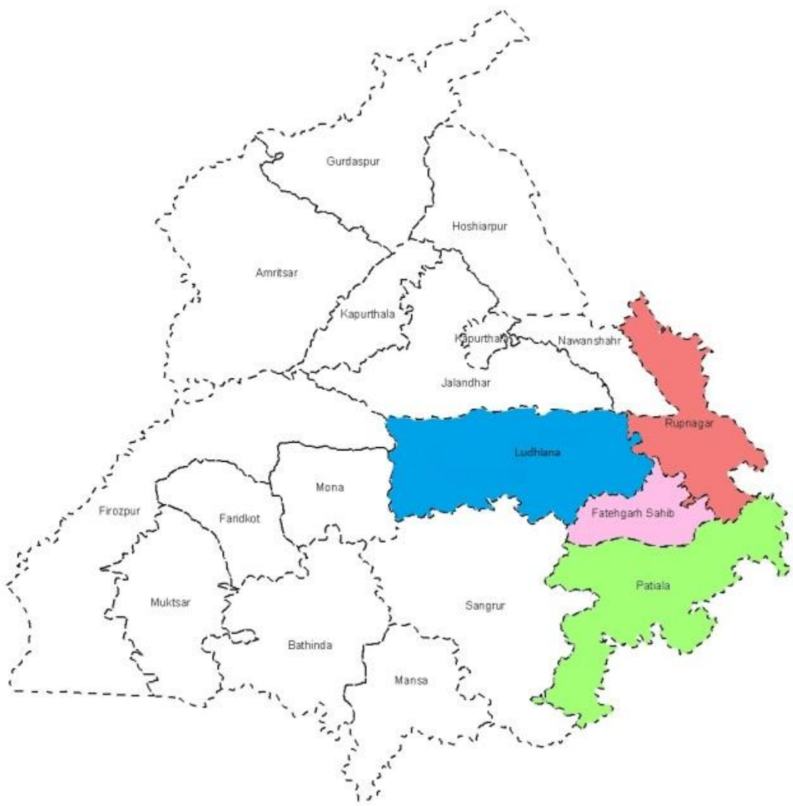

Fig.1 Location of study areas of Inceptisols in Punjab

Physical and chemical analysis

Particle size distribution was determined by the International Pipette method (Day 1965). For the determination of bulk density, fresh weight of each sample collected by soil core sampler, were taken from each depth (Blake and Hartage 1986). Soil pH was measured using Elico pH meter (Jackson, 1973).

Electrical conductivity wasdetermined as outlined by US Salinity Laboratory Staff, (1954).Rapid titration method of Puri (1930) was employed to determine calcium carbonate equivalent of soil. Total organic carbon was estimated by Walkey and Black's (1934) rapid titration method.

Normal sodium acetate (pH 8.2) was used to determine the CEC of the soils following the procedure of Bower *et al.,* (1952). Soils were extracted with 1N NH_4OAc (pH 7.0) following the procedure described by Jackson (1973). Exchangeable Na^+ and K^+ were determined by flame photometer and EDTA titration was employed for the estimation of Ca^+ and Mg^+.

Results and Discussion

Morphological characteristics

Morphological features of given soils are given in Table 2. All the studied soils exhibited A-B profiles (P1, P2 and P4 to P7) in fine textured Inceptisols and A-Bw-C horizons in coarse textured Inceptisols. The soils showed remarkable closeness irrespective of profile locations and horizons. The hue was 10YR while value was in a narrow range of 4 to 6. The chroma was 2-4 in surface horizons and 2-6 in lower horizons.

Table.2 Morphological characteristicsof fine and coarse textured inceptisols

Depth(cm)	Horizon	Colour	Texture	Structure	effervescence	Root	Boundary
Pedon 1 Maize- wheat							
0-28	Ap	10YR 5/2	l	Sbk	es	f,f	cs
28-55	AB	10YR 5/3	cl	Sbk	es	absent	df
55-68	Bw1	10YR 5/3	cl	Sbk	ev	-	df
68-91	Bw2	10YR 5/3	cl	Sbk	ev		df
91-108	Bw3	10YR 5/3	l	Sbk	ev	-	df
108-134	Bw4	10YR 5/3	cl	Sbk	ev	-	cs
134-155	Bw5	10YR 6/4	c	absent	ev	-	-
Pedon 2 Fallow-berseem							
0-23	Ap	10YR 5/3	cl	Sbk	e	f,f	cs
23-43	AB	10YR 5/4	cl	Sbk	e	f,f	ds
43-66	Bw1	10YR 5/4	c	Sbk	e	r,f	ds
66-87	Bw2	10YR 5/4	c	Sbk	e	absen	ds
87-119	Bw3	10YR 5/4	c	Sbk	e	-	cs
119-157	Bw4	10YR 5/4	sic	Sbk	e	-	cs
157-161	Bw5	10YR 5/4	c	Sbk	e	-	-
Pedon 3 Rice- wheat							
0-16	Ap	10YR 4/2	c	Sbk	es	f,f	cs
16-36	Bw1	10YR 5/2	L	sbk	es	f,f	cs
36-59	Bw2	10YR 5/2	cl	sbk	es	r,f	ds
59-82	Bw3	10YR 5/2	scl	sbk	es	absen	ds
82-107	C1	10YR 5/2	sicl	sbk	es		ds
107+	C2	10YR 5/2	sicl	sbk	es		-
Pedon 4 Rice- wheat							
0-16	Ap	10YR 4/4	l	sbk	e	c,f	cs
16-27	AB	10YR 5/4	sic	sbk	e	-	ds
27-45	Bw1	10YR 5/4	c	sbk	e	-	ds
45-68	Bw2	10YR 5/4	c	sbk	e	-	ds
68-87	Bw3	10YR 5/4	sic	sbk	e	-	ds
87-108	Bw4	10YR 5/4	c	sbk	e	-	ds
108-140	Bw5	10YR 5/4	c	sbk	e	-	-
Pedon 5 Rice-sorghum							
0-16	Ap	10YR 4/4	C	sbk	e	f	cs
16-27	AB	10YR 4/4	C	sbk	e	f	ds
27-45	Bw1	10YR 4/4	C	sbk	e	-	ds
45-68	Bw2	10YR 4/4	C	sbk	e	-	ds
68-87	Bw3	10YR 4/4	C	sbk	e	-	ds
87-108	Bw4	10YR 4/4	Sic	sbk	e	-	ds
108-140	Bw5	10YR 4/4	C	Sbk	e	-	-
Depth(cm)	Horizon	Colour	Texture	Structure	effervescence	Root	Boundary
Pedon 6 Sugarcane							
0-18	Ap	10YR 5/2	C	sbk	e	c	cs
18-32	AB	10YR 5/3	C	sbk	e	c,f	ds

32-56	Bw1	10YR 5/3	C	sbk	e	c,f	ds
56-80	Bw2	10YR 5/3	C	sbk	-	-	ds
80-108	Bw3	10YR 5/3	c	sbk	-	-	ds
108+	Bw4	10YR 5/3	c	sbk	-	-	
Pedon 7 Rice wheat							
0-18	Ap	10YR 5/2	sic	sbk	e	f,c	cs
18-32	AB	10YR 5/3	sic	sbk	e	-	cs
32-56	Bw1	10YR 5/3	c	sbk	e	-	cs
56-80	Bw2	10YR 5/3	c	sbk	-	m	ds
80-108	Bw3	10YR 5/3	c	sbk	-	-	-
108+	Bw4	10YR 5/3	c	sbk	-	-	
Pedon 8 Sugarcane							
0-15	Ap	10YR 5/4	ls	sbk	no	c	cs
15-27	Bw1	10YR 6/4	ls	sbk	-	c,f	ds
27-45	Bw2	10YR 6/6	ls	sbk	-	c,f	ds
45-63	Bw3	10YR 6/6	ls	sbk	-	-	ds
63-88	C1	10YR 6/6	ls	m	-	-	ds
88-127	C2	10YR 6/4	ls	m	-	-	ds
127-155	C3	10YR 6/6	ls	m	-	-	ds
Pedon 9 Rice- wheat							
0-22	Ap	10YR 5/4	ls	sbk	no	f,f	cs
22-38	Bw1	10YR 5/4	ls	sbk	-	f,f	ds
38-63	Bw2	10YR 6/4	ls	sbk	-	r,f	ds
63-95	Bw3	10YR 6/4	ls	sbk	-	-	ds
95-116	C1	10YR 6/4	ls	m	-	-	cs
116-151	C2	10YR 6/4	ls	m	-	-	-
Pedon 10 Rice- wheat							
0-15	Ap	10YR 5/4	ls	sbk	e	f-c	cs
15-23	Bw1	10YR 5/4	ls	sbk	-	-	cs
23-52	Bw2	10YR 6/4	ls	sbk	-	-	cs
52-78	Bw3	10YR 6/4	ls	sbk	-	-	cs
78-108	C1	10YR 6/4	ls	m	-	-	ds
108-132	C2	10YR 6/5	ls	m	-	-	-
132-15	C3	10YR 6/6	ls	m	-	-	-
Pedon 11 Rice- wheat							
0-19	Ap	10YR 6/4	ls	sbk	no	c,f	cs
19-37	Bw1	10YR 6/6	ls	sbk	-	f,f	ds
37-67	Bw2	10YR 6/6	ls	sbk	-	f,f	ds
67-89	Bw3	10YR 5/4	ls	sbk	-	f,f	ds
89-112	C1	10YR 5/4	ls	m	-	f,f	cs
122-132	C2	10YR 5/4	ls	m	-	absent	-
132-159	C3	10YR 5/4	ls	m	-	absent	-

Symbol used as per Soil Survey Manual, USDA Hb.pp.139-140

The lower horizon has lower chroma whereas value followed a definite pattern. Texture of different horizons varied regularly. Surface horizons generally have finer texture as compared to subsurface horizons. The texture was loam to clay in fine textured Inceptisols, whereas in coarse textured soils texture was consistently loamy-sand. Fine textured soils have blocky and sub angular blocky structures whereas coarse textured soils had moderate structural development.

Generally the fine textured soils showed strong effervescence in pedon 1 to pedon 5 however coarse textured soils in P8, P9 and P11 showed no reactions with dil. HCL, whereas P6, P7 and P10 showed slight effervescence. Generally the effervescence was mild in coarse textured soils and strong in fine textured soils. In most of the soils successive horizons were separated by diffuse and clear smooth boundaries.

Physico-chemical properties

In fine textured Inceptisols the clay content was highest in pedon 6 (sugarcane 56-68%) followed by pedon 7 (rice-wheat 26-63%), pedon 5 (rice-sorghum 40-56%), pedom 4 (rice-wheat 26-52%), pedon 2 (fallow-berseem 32-48%), pedon 3(rice-wheat 26-40%) and lowest in pedon 1 (maize-wheat 26-36%).

In pedon 1, silt content was highest among all the fractions especially in the upper half of the profile. The clay content of pedons under fodder bassed cropping systems varied from 32-56 per cent. The clay content was higher (40-56 %) in P5 than P2 (32-48 %). The sand fraction was lowest among all the soil fractions in both the pedons (P2 and P5). Whereas in coarse textured Inceptisolsthe clay content in P9-P11 varied from 2.7 to 6.2 percent, P8 varied from 4.8 to 5.1 %. The clay content increased with increase in soil depth in all the pedons except in pedon 1. The bulk density in all the pedons of fine textured Inceptisols under Rice-Wheat cropping system (P3, P4, P7) was almost similar (1.33-1.51 g cm^{-3}) except in the surface layer of P4 (1.14 g cm^{-3}) where it was, significantly low due to the field being freshly tilled for sowing the crop.

Under Sugarcane the bulk density in different soil layers varied from 1.37 to 1.49 g cm^{-2} in fine textured Inceptisols (P6) and 1.50 to 1.66 g cm^{-3} in coarse textured soils (P8). The bulk density under maize-wheat varied from 1.40 to 1.59 g cm^{-3}. Lower bulk density was observed in the surface (0-28 cm) and immediate sub-surface (28-55 cm) depth. The soils bulk density varied from 1.14 to 1.51 g cm^{-3} in P2 and 1.14 to 1.45 g cm^{-3} in P5. The surface bulk density of both the pedons was sufficiently lower (1.14 g cm-^{3}) as compared to lower layers. The bulk density of different layers did not show any relation with particle size distribution in all the pedons.

The bulk density of all the layers in coarse textured soils (P8, P9, P10, P11) was higher than the fine textured Inceptisols, along with subsurface compaction in all the pedons (P8, P9, P10, P11). The studies in the state of Punjab (Sur *et al.*, 1981, Aggarwal *et al.*, 1995, Kukal*et al.*, 2003) have reported the presence of subsurface high bulk density layer especially in coarse and medium textured soils. The pH value of fine textured Inceptisols ranged from 7.7 to 10.1 and in coarse textured soils ranged from 6.7 to 8.9. In general, pH of these soils was alkaline in nature and it showed an increasing trend from surface horizon to immediate subsurface horizon in all the pedons. Similar results made by Barua (1989) in the arid soils of Punjab. Relatively higher pH value was observed in coarse textured soils than fine textured soils under rice-wheat cropping system.

Table.3 Selected physical and chemical properties of pedons by horizons in the fine and coarse textured Inceptisols under different cropping systems

Soil depth	Horizon	Particle size distribution			Bulk density	pH	EC	Organic carbon	CEC	Exchangeable cations (cmol (+) kg^{-1})		
(cm)		Sand %	Silt %	Clay %	(gcm^{-3})		dS m^{-1}	(%)	(cmol (+) kg^{-1})	Ca+Mg	Na	K
Pedon 1 Maize-Wheat (Fine textured soils)												
0-28	Ap	33.8	40.20	26	1.40	8.6	0.18	0.70	16.10	8.10	0.4	3.4
28-55	AB	32.1	35.90	32	1.47	8.1	0.10	0.12	20.80	13.40	0.5	2.2
55-68	Bw1	30.7	37.30	32	1.56	8.5	0.11	0.12	20.50	13.50	0.6	2.0
68-91	Bw2	36.5	33.50	30	1.59	8.6	0.10	0.12	18.60	14.50	0.5	1.5
91-108	Bw3	44.0	30.00	26	1.51	8.4	0.19	0.12	19.10	13.50	0.4	1.2
108-134	Bw4	38.0	28.00	34	1.44	7.7	0.10	0.13	18.50	13.60	0.5	1.0
134-155	Bw5	24.0	40.00	36	1.46	8.5	0.11	0.13	22.90	14.80	0.4	1.1
Pedon 2 fallow-berseem (Fine textured soils)												
0-23	Ap	29.5	38.50	32	1.14	8.0	0.15	0.60	18.50	12.30	0.7	1.7
23-43	AB	22.5	41.50	36	1.45	8.6	0.13	0.20	20.10	13.40	0.8	1.5
43-66	Bw1	24.5	31.50	44	1.34	8.8	0.16	0.18	26.30	18.10	0.9	1.5
66-87	Bw2	29.0	25.00	46	1.49	9.6	0.17	0.17	26.40	18.50	0.8	1.8
87-119	Bw3	26.5	25.50	48	1.51	10.1	0.16	0.15	25.90	18.90	0.8	2.0
119-157	Bw4	10.5	45.50	44	1.48	10.0	0.15	0.13	25.60	16.40	0.6	1.8
157-161	Bw5	42.5	11.50	46	1.44	10.0	0.14	0.12	25.10	15.90	0.8	1.4
Pedon 3 Rice-Wheat (Fine textured soils)												
0-16	Ap	40.5	19.50	40	1.40	9.2	0.19	0.64	29.80	20.50	0.9	2.4
16-36	Bw1	24.5	49.50	26	1.46	9.4	0.14	0.21	23.40	17.10	0.9	1.5
36-59	Bw2	27.0	37.00	36	1.43	9.2	0.14	0.21	24.50	18.50	1.0	1.5
59-82	Bw3	53.0	17.00	30	1.40	9.3	0.13	0.20	22.10	18.40	1.1	0.9
82-107	C1	49.6	18.40	32	1.38	8.5	0.14	0.20	22.60	18.80	1.0	0.8
107+	C2	55.0	11.00	34	1.34	9.1	0.14	0.20	23.80	18.90	0.8	0.6

Soil depth	Horizon	Particle size distribution			Bulk density	pH	EC	Organic carbon	CEC	Exchangeable cations (cmol (+) kg^{-1})		
(cm)		Sand %	Silt %	Clay %	(gcm^{-3})		dS m^{-1}	(%)	(cmol (+) kg^{-1})	Ca+Mg	Na	K
Pedon 4 Rice-Wheat (Fine textured soils)												
0-16	Ap	42.1	31.90	26	1.14	8.1	0.18	0.72	21.80	15.40	1.1	2.8
16-27	AB	12.7	43.30	44	1.48	9.0	0.14	0.20	30.10	23.50	1.2	2.1
27-45	Bw1	11.7	39.30	49	1.46	9.0	0.13	0.15	31.30	26.40	1.4	1.8
45-68	Bw2	9.9	38.10	52	1.42	8.9	0.14	0.14	33.60	26.20	1.4	1.8
68-87	Bw3	8.6	41.40	50	1.33	8.9	0.12	0.13	34.20	26.90	1.1	1.5
87-108	Bw4	8.5	39.50	52	1.51	8.8	0.15	0.12	36.00	27.00	0.8	1.6
108-140	Bw5	12.5	39.50	48	1.43	8.8	0.14	0.11	31.00	24.60	0.7	2.0
Pedon 5 rice-sorghum (fine textured soils)												
0-16	Ap	28.7	31.30	40	1.14	8.6	0.15	0.71	27.10	17.10	0.8	5.3
16-27	AB	16.9	34.10	49	1.44	8.7	0.12	0.25	30.20	23.60	1.1	5.0
27-45	Bw1	7.9	39.10	53	1.41	8.7	0.14	0.17	35.60	26.50	1.3	2.9
45-68	Bw2	9.2	34.80	56	1.45	8.6	0.12	0.15	36.70	29.10	1.0	2.8
68-87	Bw3	8.4	37.60	54	1.43	8.6	0.13	0.15	34.50	27.40	0.8	2.6
87-108	Bw4	7.8	39.20	53	1.40	8.5	0.14	0.14	32.30	26.50	0.7	2.4
108-140	Bw5	13.4	35.60	51	1.33	8.6	0.15	0.14	30.90	25.30	0.5	2.0
Pedon 6 Sugarcane (Fine textured soils)												
0-18	Ap	11.7	32.30	56	1.37	7.7	0.18	0.27	23.50	17.10	1.2	2.1
18-32	AB	3.7	34.30	62	1.44	8.5	0.16	0.21	27.30	20.30	1.5	1.5
32-56	Bw1	5.4	26.60	68	1.49	8.8	0.17	0.18	30.10	24.60	1.7	1.3
56-80	Bw2	4.5	27.50	68	1.49	8.9	0.13	0.17	29.90	22.50	1.1	1.3
80-108	Bw3	5.2	28.80	66	1.46	8.9	0.15	0.15	26.40	20.40	0.9	1.6
108+	Bw4	5.1	27.90	67	1.37	9.0	0.15	0.14	25.60	21.80	0.5	1.0
Pedon 7 Rice-Wheat (Fine textured soils)												
0-18	Ap	9.4	41.60	49	1.51	8.4	0.16	0.69	25.40	17.90	1.1	2.7
18-32	AB	4.1	41.90	54	1.49	8.7	0.18	0.15	28.10	20.10	1.2	2.2
32-56	Bw1	3.5	39.50	57	1.50	8.9	0.17	0.15	29.30	23.60	1.5	1.5
56-80	Bw2	3.5	38.50	58	1.50	8.9	0.13	0.14	31.50	25.80	0.9	1.3
80-108	Bw3	4.3	31.70	64	1.41	9.1	0.14	0.14	35.60	28.10	0.6	1.6
108+	Bw4	3.1	33.90	63	1.48	9.2	0.12	0.11	34.80	27.80	0.5	1.1

Soil depth	Horizon	Particle size distribution			Bulk density	pH	EC	Organic carbon	CEC	Exchangeable cations (cmol (+) kg^{-1})		
(cm)		Sand %	Silt %	Clay %	(gcm^{-3})		dS m^{-1}	(%)	(cmol (+) kg^{-1})	Ca+Mg	Na	K
Pedon 8 Sugarcane (Coarse textured soils)												
0-15	Ap	81.7	13.50	4.8	1.57	8.6	0.10	0.33	5.80	3.20	0.7	0.7
15-27	Bw1	80.3	14.80	4.9	1.66	8.9	0.08	0.02	5.70	3.50	0.6	0.4
27-45	Bw2	79.9	15.00	5.1	1.62	8.6	0.08	0.02	6.00	3.90	0.7	0.5
45-63	Bw3	80.3	14.60	5.1	1.56	8.6	0.06	0.01	5.80	3.50	0.9	0.5
63-88	C1	79.4	15.70	4.9	1.50	8.5	0.08	0.01	5.40	3.30	0.5	0.3
88-127	C2	78.8	16.40	4.8	1.54	8.4	0.10	0.01	5.30	2.90	0.5	0.5
127-155	C3	79.2	15.90	4.9	1.53	8.2	0.11	0.01	5.00	3.30	0.2	0.3
Pedon 9 Rice-Wheat Coarse textured soils)												
0-22	Ap	85.1	12.00	2.9	1.54	7.2	0.20	0.44	4.70	1.60	0.8	1.6
22-38	Bw1	83.2	14.00	2.8	1.58	7.7	0.12	0.04	4.50	2.50	0.6	0.5
38-63	Bw2	84.5	12.40	3.1	1.65	7.8	0.09	0.03	5.20	3.30	0.9	0.4
63-95	Bw3	84.9	12.40	2.7	1.54	7.9	0.12	0.03	4.40	2.30	1.1	0.5
95-116	C1	85.3	11.90	2.8	1.44	7.8	0.10	0.02	4.80	2.90	0.7	0.4
116-151	C2	84.9	12.20	2.9	1.50	7.8	0.13	0.02	4.50	2.90	0.5	0.2
Pedon 10 Rice-Wheat (Coarse textured soils)												
0-15	Ap	82.5	12.40	5.1	1.39	7.0	0.28	0.50	6.10	4.80	0.7	0.3
15-23	Bw1	82.8	11.90	5.3	1.63	7.0	0.18	0.14	6.50	4.70	0.6	0.5
23-52	Bw2	82.4	11.80	5.8	1.65	6.9	0.12	0.07	7.10	4.80	0.7	0.5
52-78	Bw3	81.1	13.10	5.8	1.59	6.7	0.12	0.05	7.40	5.70	0.9	0.4
78-108	C1	80.9	12.90	6.2	1.52	6.7	0.12	0.05	7.30	5.40	0.5	0.5
108-132	C2	80.5	13.90	5.6	1.54	6.7	0.12	0.05	7.10	4.90	0.5	0.4
132-15	C3	80.8	13.10	6.1	1.55	6.7	0.10	0.04	6.40	4.40	0.4	0.5
Pedon 11 Rice-Wheat (Coarse textured soils)												
0-19	Ap	80.1	15.80	4.1	1.53	6.7	0.12	0.34	6.10	3.80	0.4	0.4
19-37	Bw1	79.3	16.40	4.3	1.86	6.7	0.11	0.11	6.30	3.90	0.5	0.5
37-67	Bw2	81.0	14.60	4.4	1.66	6.8	0.08	0.08	6.50	4.20	0.6	0.4
67-89	Bw3	84.9	11.00	4.1	1.59	6.7	0.12	0.08	6.10	4.10	0.5	0.3
89-112	C1	84.1	12.00	3.9	1.56	6.9	0.10	0.05	5.80	3.80	0.4	0.4
122-132	C2	79.6	15.80	4.6	1.60	6.8	0.12	0.05	6.20	4.10	0.3	0.4
132-159	C3	81.1	14.40	4.5	1.58	6.8	0.11	0.06	6.30	4.00	0.3	0.4

Electrical conductivity (EC) in fine textured Inceptisols P3, P4, P7 under rice-wheat cropping system ranged from 0.12-0.19 dSm^{-1}, 0.13-0.16 dSm^{-1} in Maize-wheat (P1), 0.13-0.18 dSm^{-1} in Sugarcane (P6), 0.13-0.17 dSm^{-1} in P2 (fallow-berseem) and 0.12-0.15 dSm^{-1} in P5 (Rice-Sorghum). Generally the EC was higher in the surface horizons (0.16-0.19 dSm^{-1}) except in P7 this might be due to the upward movement of soluble salts to the surface soils through capillary rise of water, which evaporation leaving behind salts in surface horizon Electrical conductivity (EC) in fine textured Inceptisols and coarse textured soils under sugarcane cropping system ranged from 0.13-0.16 dSm^{-1} and 0.06-0.11 dSm^{-1}, respectively.

In general EC decreased with increase in soil depth in both fine and coarse textured soils. EC was higher in fine textured Inceptisols than the coarse textured soils. Similar EC was observed in pedons under both rice-wheat and sugarcane cropping systems in fine textured soils. Though the soils remained under intensive cultivation for long time but are low in organic carbon content. Higher OC content was observed in the surface horizons in all the pedons than the sub-surface horizons. Fine textured Inceptisols showed higher OC content than coarse textured soils. Organic carbon content increased with increase in clay content (r=1.98).

The results are consistent with the reported increase in organic carbon content with increase in fine fraction (Young and Sypcher 1979). It suggests that OC content is associated with the particle size distribution. The cation exchange capacity (CEC) of coarse textured soils was lower than that in fine textured soils. The depth distribution of CEC did not show any definite trend but CEC of fine textured soils varied with clay content (r=0.72), It shows that clay has principle contribution to the CEC of these soils, which have been observed in the several other soils of Punjab (Sharma *et al.*, 1997). Among the cropping systems CEC was higher in rice-sorghum (27.1-36.7cmol (+) kg^{-1}) followed by sugarcane (23.3-30.1 cmol (+) kg^{-1}), rice-wheat (15.4-28.1cmol (+) kg^{-1}), fallow-berseem (18.5-26.4 cmol (+) kg^{-1}) and least in soils under maize-wheat (16.1-22.9 cmol (+) kg^{-1}) cropping systems.

Calcium plus magnesium content was the dominant cations followed by potassium and sodium among all the exchangeable cations. Depth wise distribution of Ca plus Mg and K did not show any definite trend in the other hand exchangeable Na content increased with depth due to downward movement of the Na cations as mobility of Na is higher than Ca and K.

Results of the present study suggests that these fine textured Inceptisols could be characterized as non-saline and slightly alkaline in reaction, having low to medium organic carbon content in surface horizon. No subsurface compaction was observed in fine textured soils as in coarse textured Inceptisols, but these soils have severe physical constraints due to the presence of large amounts of clays in the finer fractions which restricts air and water movement within the profile and leads to lower crop productivity in these soils.

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