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.

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 (Sadhuagarh), 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 Pedons of fine and coarse textured inceptisols of Punjab

| Pedon | Location                        | Physiography          | Present land use | Soil Taxonomy       |
|-------|---------------------------------|-----------------------|------------------|---------------------|
| 1     | 30° 2’ 33.87” N, 76° 7’ 15.17” E Nabha (district Patiala) | Slopping alluvium terraces | Maize-wheat       | TypicHaplusteps    |
| 2     | 30° 2’ 23.65” N, 76° 7’ 36.38” E Nabha (district Patiala) | Slopping alluvium terraces | Fallow-berseem    | TypicHaplusteps    |
| 3     | 30° 2’ 24.02” N, 76° 7’ 22.59” E Nabha (district Patiala) | Slopping alluvium terraces | Rice-wheat        | TypicHaplusteps    |
| 4     | 30° 35’ 41.15” N, 76° 27’ 43.53” E Sadhugarh (district Fatehgarh Sahib) | Old flood plains       | Rice-wheat        | Vertic-Ustochrepts |
| 5     | 30° 35’ 40.85” N, 76° 27’ 44.32” E Sadhugarh (district Fatehgarh Sahib) | Old flood plains       | Rice-sorghum      | Vertic-Ustochrepts |
| 6     | 30° 46’ 55.64” N, 76° 28’ 6.68” E Morinda (districts Ropar) | Old flood plains       | Sugarcane         | Vertic-Haplusteps  |
| 7     | 30° 46’ 55.36” N, 76° 28’ 6.72” E Morinda (Districts Ropar) | Alluvial terraces      | Rice-wheat        | Vertic-Haplusteps  |
| 8     | 30° 54’ 34.69” N, 75° 49’ 8.28” E Ludhiana | Alluvial terraces      | Sugarcane         | TypicHaplusteps    |
| 9     | 30° 54’ 30.03” N, 75° 49’ 8.53” E Ludhiana | Alluvial terraces      | Rice-wheat        | TypicHaplusteps    |
| 10    | 30° 54’ 24.91” N, 76° 46’ 50.61” E Ludhiana | Alluvial terraces      | Rice-wheat        | TypicHaplusteps    |
| 11    | 30° 54’ 27.61” N, 76° 46’ 47.68” E Ludhiana | Alluvial terraces      | Rice-wheat        | TypicHaplusteps    |
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 was determined 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 NH₄OAc (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 characteristics of 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 | absent | 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 | absent | 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)**

| Pedon 6 Sugarcane | Horizon | Colour | Texture | Structure | effervescence | Root | Boundary |
|-------------------|---------|--------|---------|-----------|--------------|------|----------|
| 0-18 | Ap | 10YR 5/2 | C | sbk | e | c | cs |
| 18-32 | AB | 10YR 5/3 | C | sbk | e | c,f | ds |
| Pedon 7 Rice wheat | Pedon 8 Sugarcane | Pedon 9 Rice- wheat | Pedon 10 Rice- wheat | Pedon 11 Rice- wheat |
|--------------------|------------------|--------------------|---------------------|--------------------|
| **32-56**          | **0-15**         | **0-22**           | **0-19**            | **0-19**           |
| Bw1                | Ap               | Ap                 | Ap                  | Ap                 |
| 10YR 5/3           | 10YR 5/4        | 10YR 5/4           | 10YR 5/4            | 10YR 5/4           |
| C                  | ls               | ls                 | ls                  | ls                 |
| sbk                | sbk             | sbk               | sbk                | sbk               |
| e                  | no              | no                | no                 | no                |
| c,f                | f,f             | f,f              | f,f               | f,f              |
| ds                 | cs              | cs               | cs                | cs              |
| **56-80**          | **22-38**        | **38-63**          | **15-23**           | **19-37**          |
| Bw2                | Bw1             | Bw2               | Bw1                | Bw1               |
| 10YR 5/3           | 10YR 5/4        | 10YR 6/4          | 10YR 5/4           | 10YR 6/6          |
| C                  | ls              | ls               | ls                | ls                |
| sbk                | sbk             | sbk             | sbk              | sbk             |
| -                  | -               | -                | -                | -                |
| ds                 |     ds          |     ds          |     ds            |     ds           |
| **80-108**         | **63-95**        | **78-108**         | **52-78**           | **37-67**          |
| Bw3                | Bw3             | C1                | Bw3                | Bw2               |
| 10YR 5/3           | 10YR 6/4        | 10YR 6/4          | 10YR 6/4           | 10YR 6/4          |
| c                  | ls              | ls               | ls                | ls                |
| sbk                | sbk             | sbk             | sbk              | sbk             |
| -                  | -               | -                | -                | -                |
| ds                 | ds              | ds              | ds                | ds                |
| **108+**           | **95-116**       | **108-132**       | **78-108**         | **132-159**       |
| Bw4                | C1              | C2                | C1                 | C3               |
| 10YR 5/3           | 10YR 6/4        | 10YR 6/4          | 10YR 6/4           | 10YR 6/6          |
| c                  | ls              | ls               | ls                | ls                |
| sbk                | sbk             | sbk             | sbk              | sbk             |
| -                  | -               | -                | -                | -                |
| ds                 | ds              | ds              | ds                | ds                |
| **Pedon 8 Sugarcane | Pedon 9 Rice- wheat | Pedon 10 Rice- wheat | Pedon 11 Rice- wheat |
| **0-15**           | **0-22**         | **0-15**          | **0-19**           | **0-19**          |
| Ap                 | Ap              | Ap               | Ap                | Ap               |
| 10YR 5/4           | 10YR 5/4        | 10YR 5/4         | 10YR 6/4          | 10YR 6/4         |
| ls                 | ls              | ls             | ls              | ls              |
| sbk                | sbk             | sbk          | sbk            | sbk            |
| no                 | no              | no         | no             | no             |
| c                  |     f,f        |     f,f       |     f,f         |     f,f        |
| cs                 |     cs         |     cs       |     cs         |     cs        |
| **22-38**          | **38-63**        | **15-23**         | **19-37**          | **19-37**        |
| Bw1                | Bw2             | Bw1             | Bw1               | Bw1             |
| 10YR 5/4           | 10YR 6/4        | 10YR 5/4        | 10YR 6/6          | 10YR 6/6        |
| ls                 | ls              | ls             | ls              | ls              |
| sbk                | sbk             | sbk           | sbk             | sbk             |
| -                  | -               | -             | -              | -              |
| ds                 | ds              | ds             | ds              | ds              |
| **63-95**          | **78-108**       | **52-78**        | **37-67**          | **132-159**       |
| Bw3                | C1              | Bw3           | Bw2             | C3            |
| 10YR 6/4           | 10YR 6/4        | 10YR 6/4        | 10YR 6/4          | 10YR 6/6        |
| ls                 | ls              | ls             | ls              | ls             |
| sbk                | sbk             | sbk            | sbk             | sbk            |
| -                  | -               | -             | -              | -             |
| ds                 | ds              | ds             | ds              | ds             |
| **95-116**         | **108-132**     | **78-108**       | **37-67**         | **132-159**      |
| C1                 | C2              | C1            | Bw3             | C3            |
| 10YR 6/4           | 10YR 6/5        | 10YR 6/4        | 10YR 5/4         | 10YR 5/4        |
| ls                 | ls              | ls             | ls              | ls             |
| m                  | m               | m             | m              | m             |
| ds                 |     ds         |     ds       |     ds         |     ds        |

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%), pedon 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 based 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 Inceptisols the 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, Kukalet 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 (cm) | Horizon | Particle size distribution | Bulk density (g cm\(^{-3}\)) | pH | EC (dS m\(^{-1}\)) | Organic carbon (%) | CEC (cmol (+) kg\(^{-1}\)) | Exchangeable cations Ca+Mg Na K (cmol (+) kg\(^{-1}\)) |
|----------------|---------|----------------------------|-------------------------------|----|--------------------|---------------------|--------------------------|---------------------------------|
| 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 |
|------------|---------|---------------------------|--------------|----|----|----------------|-----|---------------------|
| (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 (g cm⁻³) | pH | EC | Organic carbon (%) | CEC (cmol (+) kg⁻¹) | Exchangeable cations (emol (+) kg⁻¹) |
|------------|---------|-----------------------------|-----------------------|----|----|-------------------|-------------------|-----------------------------|
| Pedon 8 Sugarcane (Coarse textured soils) |         |                             |                       |    |    |                   |                   |                             |
| 0-15       | Ap      |                             | 1.57                  | 8.6| 0.10| 0.33              | 5.80              |                             |
| 15-27      | Bw1     |                             | 1.66                  | 8.9| 0.08| 0.02              | 5.70              |                             |
| 27-45      | Bw2     |                             | 1.62                  | 8.6| 0.08| 0.02              | 6.00              |                             |
| 45-63      | Bw3     |                             | 1.56                  | 8.6| 0.06| 0.01              | 5.80              |                             |
| 63-88      | C1      |                             | 1.50                  | 8.5| 0.08| 0.01              | 5.40              |                             |
| 88-127     | C2      |                             | 1.54                  | 8.4| 0.10| 0.01              | 5.30              |                             |
| 127-155    | C3      |                             | 1.53                  | 8.2| 0.11| 0.01              | 5.00              |                             |
| Pedon 9 Rice-Wheat Coarse textured soils |         |                             |                       |    |    |                   |                   |                             |
| 0-22       | Ap      |                             | 1.54                  | 7.2| 0.20| 0.44              | 4.70              |                             |
| 22-38      | Bw1     |                             | 1.58                  | 7.7| 0.12| 0.04              | 4.50              |                             |
| 38-63      | Bw2     |                             | 1.65                  | 7.8| 0.09| 0.03              | 5.20              |                             |
| 63-95      | Bw3     |                             | 1.54                  | 7.9| 0.12| 0.03              | 4.40              |                             |
| 95-116     | C1      |                             | 1.44                  | 7.8| 0.10| 0.02              | 4.80              |                             |
| 116-151    | C2      |                             | 1.50                  | 7.8| 0.13| 0.02              | 4.50              |                             |
| Pedon 10 Rice-Wheat (Coarse textured soils) |         |                             |                       |    |    |                   |                   |                             |
| 0-15       | Ap      |                             | 1.39                  | 7.0| 0.28| 0.50              | 6.10              |                             |
| 15-23      | Bw1     |                             | 1.63                  | 7.0| 0.18| 0.14              | 6.50              |                             |
| 23-52      | Bw2     |                             | 1.65                  | 6.9| 0.12| 0.07              | 7.10              |                             |
| 52-78      | Bw3     |                             | 1.59                  | 6.7| 0.12| 0.05              | 7.40              |                             |
| 78-108     | C1      |                             | 1.52                  | 6.7| 0.12| 0.05              | 7.30              |                             |
| 108-132    | C2      |                             | 1.54                  | 6.7| 0.12| 0.05              | 7.10              |                             |
| 132-155    | C3      |                             | 1.55                  | 6.7| 0.10| 0.04              | 6.40              |                             |
| Pedon 11 Rice-Wheat (Coarse textured soils) |         |                             |                       |    |    |                   |                   |                             |
| 0-19       | Ap      |                             | 1.53                  | 6.7| 0.12| 0.34              | 6.10              |                             |
| 19-37      | Bw1     |                             | 1.86                  | 6.7| 0.11| 0.11              | 6.30              |                             |
| 37-67      | Bw2     |                             | 1.66                  | 6.8| 0.08| 0.08              | 6.50              |                             |
| 67-89      | Bw3     |                             | 1.59                  | 6.7| 0.12| 0.08              | 6.10              |                             |
| 89-112     | C1      |                             | 1.56                  | 6.9| 0.10| 0.05              | 5.80              |                             |
| 122-132    | C2      |                             | 1.60                  | 6.8| 0.12| 0.05              | 6.20              |                             |
| 132-159    | C3      |                             | 1.58                  | 6.8| 0.11| 0.06              | 6.30              |                             |
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 (27.1-36.7 cmol (+) kg⁻¹) followed by sugarcane (23.3-30.1 cmol (+) kg⁻¹), rice-wheat (15.4-28.1 cmol (+) 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.

References

Aggarwal, G. C., Sidhu, A. S., Sekhon, N. K., Sandhu, K. S. and Sur, H. S., 1995. Puddling and N management effects on crop response in a rice–wheat cropping system. Soil & Tillage Research36:129-39.

Barua, J. P., 1989. Genesis of salt affected soils in Punjab. Ph.D. Dissertation, Punjab Agricultural University, Ludhiana, India.
Blake, G. R. and Hartage, K. H., 1986. Bulk density, In: Methods of soil analysis, Part I,Klute A (ed) Agron no. 9. Am Soc Agron Mad, USA.

Bower, C.A, Reitemeier, R. F. and Fireman, M., 1952.Exchangeable cation analysis of saline and alkali soils. Soil science73:251-61.

Challa, O., Bhaskar, B. P., Anantwar, S. G., and Gaikwad, M. S., 2000.Characterization and classification of some problematic Vertisols in semi-arid Ecosystem of Maharashtra Plateau. Journal Of The Indian Society of Soil Science48: 139-45.

Day, P. R., 1965. Particle fractionation and particle size analysis.In: Black C A, Evans D D, Write J L, Ensminger L E, Clark F E, and Dinaver R C (eds) Methods of soil analysis part I. Soil Science Society of America JournalPp 545-66.

Jackson, M. L. 1973.Soil chemical analysis. Oxford and IBH, New Delhi.

Jackson, T. L. and Reisenauer, H. M., 1984.Crop response to lime in the western United States. Pp. 333-347. In Adams F (ed.) Soil acidity and liming.2nd ed. Agron.Monogr. 12. ASA, CSSA, and SSSA, Madison, WI.

Kukal, S. S. and Aggarwal, G. C., 2003. Puddling depth and intensity effects in rice-wheat system on a sandy loam soil I. Development of subsurface compaction. Soil & Tillage Research72: 1-8.

Puri, A. N. 1930.A new method of estimating total carbonates in soils. Imp Agric Res PusaBull 206-7.

Sharma, B. D.,Sidhu, P. S., Raj-Kumar, and Sawhney, J. S. 1997.Characterization classification and landscape relationship of Inceptisols in North-West India. Journal Of The Indian Society of Soil Science45: 167-74.

Smith, G. D. 1965.Pedologic lectures on soil classification. Bulletin de la societe beige de pedoloe, Numero Special 4.

Soil Conservation Service 1993Soil Survey Manual, Washington D.C. USDAV, SCS.

Soil Survey Staff 1975Soil Taxonomy. Agric Handbook United State Department of Agriculture436.

Sur, H. S., and Singh, N. T. 1973.Water retention and transmission characteristics of soils of the Pilot Projrct, Patiala. PAU Agricultural Research Journal10: 190-98.

Sur, H. S., Prihar, S. S. and Jalota, S. K. 1981. Effect of rice-wheat and maize-wheat rotations on water transmission and wheat root development in a sandy loam soil of Punjab, India. Soil & Tillage Research1: 361-371.

USDA, Natural Resources Conservation Service 2002 Soil Conservationists.Salinity Management Guide -Salt Management.

Walkley, A. and Black, I. A., 1934.An examination of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method.Soil Science37: 29-38.

Young, J. L. and Sypcher, 1975.Water dispersible soil organic-mineral particle. 1. Carbon and organic distribution. Soil Science Society of America Journal43:324-28.

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