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Depth wise Physico-chemical properties of soils under different cropping systems in Inceptisols and Vertisols of Northern Telangana Zone

V Shalini, A Krishna Chaithanya, K Chandrashaker and CH Aruna Kumari

Abstract
A survey was carried out during 2019-2020 to find out the impact of different Cropping Systems (Rice-Rice, Rice-Maize, Cotton-Fallow and Turmeric-Sesamum) on the behavior of physicochemical properties of soil in both the soil types (Inceptisols and vertisols). Samples were collected from three depths (0-15, 15-30 and 30-45 cm at each cropping system site) of Northeren Telangana Zone (Adilabad, Nizamabad and Karimnagar). The results of the present investigation revealed that all the soil samples are neutral to alkaline in nature, low in salinity, majority of the soil samples were Sandy Clay Loam and Clay in texture in inceptisols and vertisols respectively. Low to medium in soil organic carbon content, Bulk Density and Clay had greater influence on organic carbon specially in vertisols. Sand content had showed significant negative influence, while clay has positively related SOC. Soils were low to medium in Available Phosphrous and high in potassium content. All the parameters analysed were decreasing with increasing depth, except for Electrical conductivity.

Keywords: Depth, physico-chemical, soils, inceptisols, vertisols

1. Introduction
The present investigation was carried out in Vertisols and Inceptisols of Northern Telangana Zone, as they are the major soil types found predominantly in Telangana state than other soil types. The Physico-chemical properties like pH, EC, BD, Texture and organic carbon play important role in relation to availability of nutrients in soils and thereby on crop growth and production. Also inappropriate selection of cropping system and their management practices cause Degradation of soil quality.

So there is a need to study about the suitable cropping system practice and the soil type, which is capable of maintaining soil quality and also improving crop productivity. Have selected four cropping systems which are predominantly cultivated in Northern Telangana Zone such as Rice-Rice, Rice-Maize, Cotton-Fallow and Turmeric-sesamum cropping systems. And also the behavior of Physico-chemical properties of these soils can be known through depth wise anaylsis. Therefore, in this study, an attempt was made to assess the depth-wise behavior of Physicochemocal properties of selected cropping systems of Vertisols and inceptisols of NTZ.

2. Materials and Methods
Soil samples were collected from three districts of northern telangana zone i e., Adilabad, Karimnagar, Nizamabad in which a total of 26 mandals have been covered representing 5 sites for each cropping system. A total of 4-7 representative soil samples were collected from three depths (0-15, 15-30, 30-45 cm) at each site randomly. All the soil samples were shade dried. The dried soil samples were passed through 2.0 mm sieve for the analysis of the physico-chemical properties following standard methods (Page *et al*., 1982).

2.1 pH
The pH of the soil was determined in 1: 2.5: soil: water and soil: 0.02 M $CaCl_2$ suspension by using digital pH meter (Jackson, 1973) [12].

2.2 Electrical conductivity
Electrical conductivity (EC) of soil-water suspension (1: 2) was estimated with the help of a direct reading conductivity meter (Model: systronics, 363) outlined by (Jackson, 1973) [12].

2.3 Bulk density (BD)

Bulk density was determined by core sampler (5.0 cm length and 5.0 cm diameter) method following the protocol of Blake and Hartge (1986) [2]. The method involved sampling a soil core at 0.2 m depth by using a core sampler and measured bulk density through the mass-volume relationship as:

$$\text{Bulk density (Mg m}^{-3}) = \frac{\text{Oven dry weight of the soil core at } 105^\circ \text{C}}{\text{Volume of the soil core}}$$

2.4 Soil Texture

The different size fractions of the experimental soil were determined by bouyoucos hydrometer method as outlined by Gee and Bauder (1986) [9].

2.5 Organic carbon

Organic carbon in soil sample was analysed by wet chromic acid digestion outlined by Walkley and Black (1934) [18]. To a 0.5 g of 0.5 mm sieved soil in 500 mL conical flask, 10 mL of 1 N potassium dichromate and 20 mL of conc. H_2SO_4 were added and mixed gently for a min and allowed the mixture for reaction to take place on asbestos sheet for 30 min. At the expiry of 30 min, 10 ml of orthophosphoric acid, 200 mL distilled water and 1 mL of diphenylamine indicator were added. Then the solution was back titrated against 0.5 N ferrous ammonium sulphate till the appearance of green colour. A blank was run without soil simultaneously.

$$\text{Organic carbon (\%)} = \frac{10(B-S)}{B} \times \frac{100}{\text{wt of the soil (g)}} \times 0.003$$

Where,
B – Blank titre value
S – Sample titre value

2.6 Available phosphorus

Available phosphorus content of soil was extracted with 0.5 M NaHCO3 solution at pH 8.5 following Olsen's method (Olsen *et al.*, 1954) [14]. The extract was measured colorimetrically for available phosphorus as described by Jackson (1973) [12] using micro-processor based UV-VIS Spectrophotometer.

2.7 Available potassium

Available potassium of soil was determined by shaking 5 g of soil sample with 25 ml neutral 1 N ammonium acetate solution for 5 minutes and the soil - extractant suspension was leached through Whatman No. 41 filter paper. Potassium from the clear supernatant liquid was estimated using systronics flame photometer as outlined by Jackson (1973) [12].

3. Results and discussion

3.1 Physio-chemical properties of soil

Basic physical and physio-chemical properties of the soils under different treatments are presented in Table 1.

3.2 Soil reaction pH

Soil reaction (pH) of the selected soil sites were neutral to alkaline in nature. Irrespective of cropping systems, soil pH values were significantly higher in vertisols (S_2) over inceptisols (S_1) in all the three depths (0-15, 15-30 and 30-45 cm). Results also showed that soil pH increased with soil depth in all the treatments (Table 1).

Under four cropping systems compared, the higher pH value was recorded in 30-45 cm depth under rice-rice (CS_1) cropping system (8.23) and the lowest pH value was recorded in surface soils (0-15 cm) of cotton - fallow (CS_3) (7.30) cropping system. At surface soil (0-15 cm) CS_3 has recorded significantly lower pH value (7.30), whereas other cropping systems pH values were on par with each other.

The interaction effect among soil orders and cropping systems on soil pH was found to be significant. On an average of three depths, soil pH values were in the order of rice-rice (CS_1) (8.18) followed by turmeric- sesame (CS_4) (7.76) > rice-maize (CS_2) (7.60) and cotton – fallow (CS_3) (7.16) under inceptisols. But the results of pH under vertisol order has not followed the same trend, pH was in the decreasing order of rice-maize (CS_2) (8.22) > rice-rice (CS_1) (7.88) > cotton-fallow (CS_3) (7.85) and turmeric- sesame (CS_4) (7.81).

Table 1: Effects of cropping systems on depth-wise variations of Physio-chemical properties of soil under inceptisol and vertisols.

Soil order	pH			EC (d Sm-1)			BD (Mg m-3)			SOC (g kg-1)		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
S_1	7.48	7.72	7.82	0.27	0.23	0.21	1.41	1.46	1.51	4.96	3.86	2.97
S_2	7.83	7.94	8.05	0.21	0.18	0.17	1.46	1.51	1.56	5.29	4.46	3.26
S.Em±	0.1	0.07	0.07	0.01	0.01	0.01	0.02	0.01	0.01	0.11	0.08	0.07
CD	0.29	0.2	0.19	0.03	0.02	0.02	0.05	0.04	0.04	0.33	0.23	0.2
Cropping System												
CS_1	7.84	8.02	8.23	0.27	0.24	0.21	1.38	1.44	1.5	6.16	5.25	3.99
CS_2	7.77	7.94	8.02	0.26	0.2	0.19	1.43	1.5	1.54	5.15	4.09	3.14
CS_3	7.3	7.57	7.65	0.17	0.15	0.15	1.49	1.53	1.58	4.41	3.43	2.49
CS_4	7.73	7.78	7.85	0.25	0.23	0.21	1.44	1.47	1.52	4.77	3.86	2.84
S.Em±	0.14	0.1	0.09	0.01	0.01	0.01	0.03	0.02	0.02	0.16	0.11	0.1
CD	0.41	0.28	0.27	0.04	0.03	0.03	0.07	0.06	0.05	0.46	0.32	0.28
Interactions												
S_1CS_1	8	8.18	8.35	0.32	0.29	0.24	1.33	1.41	1.48	5.99	5.14	3.84
S_1CS_2	7.46	7.62	7.71	0.26	0.22	0.22	1.41	1.49	1.51	4.88	3.56	2.96
S_1CS_3	6.76	7.34	7.38	0.2	0.16	0.18	1.47	1.5	1.55	4.28	3.11	2.38
S_1CS_4	7.71	7.73	7.84	0.28	0.24	0.21	1.41	1.45	1.51	4.68	3.63	2.69
S_2CS_1	7.67	7.86	8.1	0.22	0.19	0.18	1.43	1.47	1.52	6.32	5.36	4.13
S_2CS_2	8.07	8.25	8.32	0.26	0.18	0.16	1.45	1.52	1.57	5.43	4.62	3.32
S_2CS_3	7.83	7.81	7.92	0.14	0.14	0.12	1.5	1.55	1.62	4.54	3.74	2.59
S_2CS_4	7.74	7.83	7.86	0.23	0.22	0.2	1.47	1.5	1.54	4.86	4.1	2.98
S.Em	0.2	0.14	0.13	0.02	0.02	0.02	0.04	0.03	0.02	0.23	0.16	0.14

CD	0.58	0.4	0.38	0.05	0.04	NS	NS	NS	NS	NS	NS	NS
CV	5.87	3.95	3.7	17.1	16.4	18.6	5.67	4.41	3.58	9.84	8.4	9.9

S_1- inceptisols, S_2- Vertisols, CS_1- Rice-Rice, CS_2- Rice-Maize, CS_3- Cotton –Fallow, CS_4- Turmeric-Sesame, SE m: Standard error of mean, CD: Critical difference, CV: Critical Variance

3.3 Electrical conductivity (d Sm^{-1})

Soil electrical conductivity (EC) of all the sites were found to be low and non-saline (Table 1). Electrical conductivity values were significantly higher under inceptisols in all the three depths over vertisols. EC values ranged from 0.17 to 0.27 dS m^{-1}. Under cropping systems, rice-rice cropping system showed higher values, which were on par with rice-maize and turmeric-sesame cropping systems, on the other hand cotton-fallow showed significantly lower EC values. The values of EC ranged from 0.15 to 0.27 dS m^{-1}.

The interaction effect among soil orders and cropping systems on soil EC was found to be significant in 0-15 and 15-30 cm soil depths where as at 30-45 cm values were on par. Soil EC was in the decreasing order of R-R (0.28) >T-S (0.24) > R-M (0.23) and C-F (0.18) cropping system in inceptisol. But the results of EC under vertisol order has not followed the same trend, T-S (0.22) followed by R-R = R-M (0.20) and C-F (0.13).

3.4 Bulk Density (Mg m^{-3}): Irrespective of depth, bulk density values ranged from 1.41 to 1.56 Mg m^{-3}. Vertisols showed significantly higher values over inceptisols in all the three depths. Bulk density values increased with increasing depth which might be due to more compaction of finer particles, low organic matter and less aggregation (USDA, NRCS., 2008). Higher values of bulk density with depth are also reported by Bhattacharya *et al.*, 2003.

Cropping systems have also influenced soil bulk density significantly. At surface soil (0-15 cm) significantly higher bulk density was recorded under cotton-fallow (1.49) cropping system, which was on par with turmeric-sesame (1.44) and rice-maize (1.43), at par with rice-rice (1.38) cropping system. However, the sequence in sub surface soils (both 15-30 and 30-45 cm) were cotton-fallow > rice-maize> turmeric-sesame and rice-rice. There was a negative correlation between soil organic carbon (SOC) concentration (g kg^{-1}) and the BD (Fig.1.). Similar to the relationship were reported by Gebrehiwot *et al.*, 2018 [8]. Soil BD decreased with the increasing SOC concentration (Zhou *et al.*, 2020) [19].

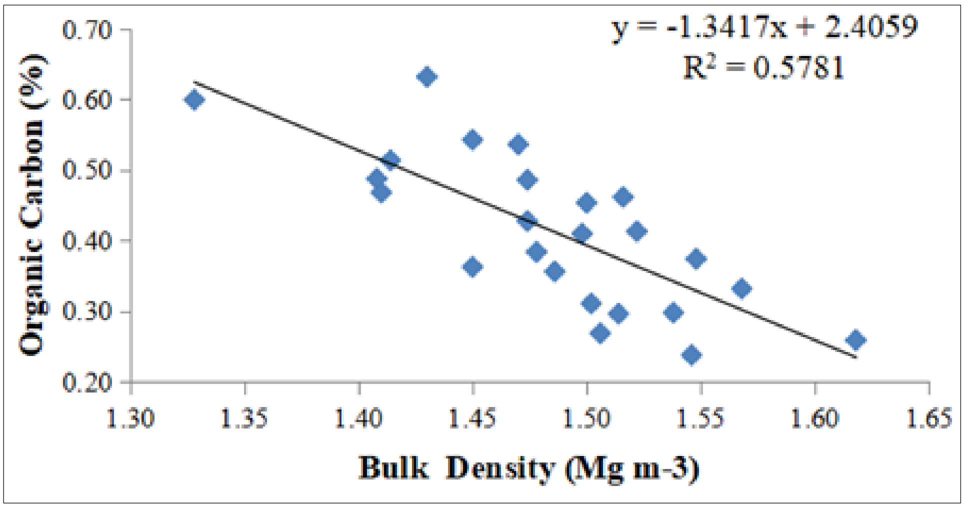


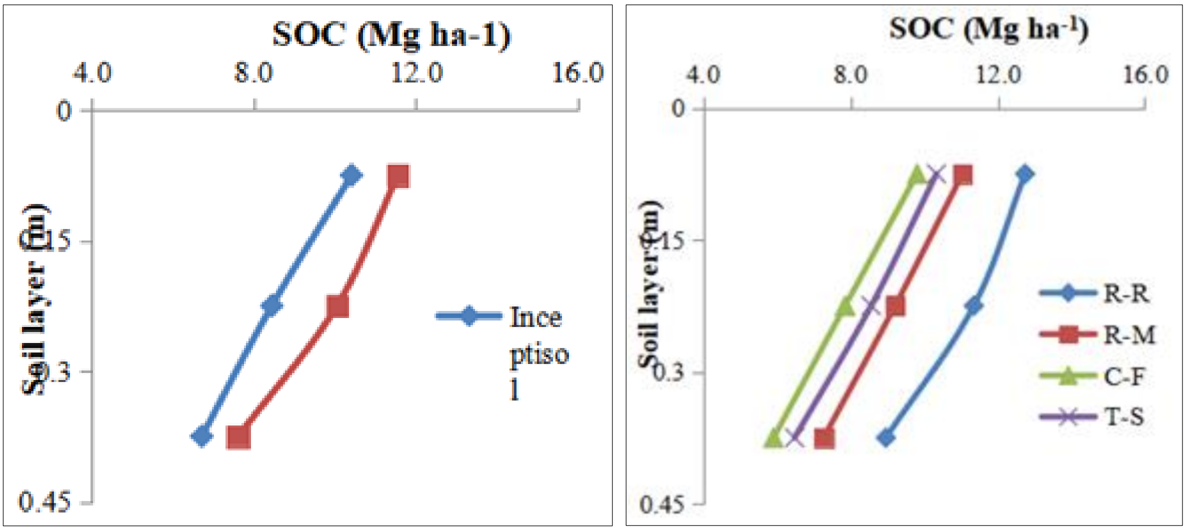
Fig 1: Relationship between soil organic carbon (SOC) concentration (%) and bulk density (Mg m^{-3}) of soils.

3.5 Soil organic carbon (SOC)

Soil orders and cropping systems have significantly influenced SOC concentration in soils. Vertisols have showed 6.65, 15.54 and 9.76% higher amount of SOC in 0-15, 15-30 and 30-45 cm depths, respectively over inceptisols (Table 2). This might be due to amount and type of clay content present in vertisols, which might bind carbon physically, chemically and biochemically (Venkanna *et al.*, 2014) [17]. Irrespective of soil order, found abrupt decline in SOC concentration along soil depth (Fig. 2. a), with middle (15-30 cm) and lower (30-45 cm) layers contained only 33.51 and 25.12% of total profile (0-45 cm) carbon content.

In cropping systems, CS_1 has maintained higher amount of SOC (6.16 g kg^{-1}) followed by CS_2 (5.15 g kg^{-1})> CS_4 (4.77 g kg^{-1})> CS_3 (4.41 g kg^{-1}) at surface soil (0-15 cm). The same trend was observed in the sub surface soils also (Fig. 2. b). CS_1 and CS_2 have shown significantly higher SOC in all the three soil depths over other cropping systems. This may be due to rice-rice cropping system was under submergence for 8-9 months in a year, prolonged water logging conditions may reduced the decomposing of added crop residues (Mandal *et al.*, 2008) [13]. Rice-maize system was under submergence for 3-4 months, which has recorded on par SOC values. On the other hand, arable condition under cotton fallow and turmeric-sesame might cause oxidation of soil organic carbon, hence showed significantly lower SOC content in soil.

Interaction effect of soil orders and cropping systems were non significant.



a b

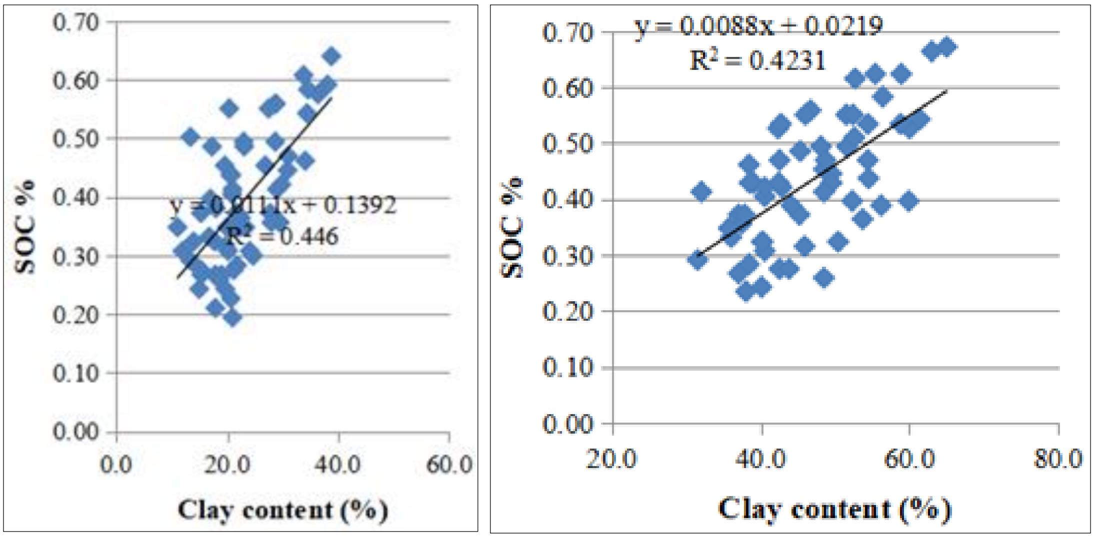
Fig 2: Soil organic carbon (Mg C ha^{-1}) content of the soils along depth under different a) soil types and b) cropping systems

3.2 Soil texture

Sand, silt and clay content of soils under different cropping system and soil types were given in Table 2. Under inceptisol sand, silt and clay contents were in the range of 45.2 to 80.0, 6.3 to 19.0 and 11.1 to 38.8 percent, respectively. Whereas, under vertisols sand, silt and clay contents were in the range of 22.8 to 57.1, 9.5 to 28.0 and 31.5 to 65.0 percent, respectively.

Results has shown that SOC and soil clay were positively correlated under both inceptisols (Y=0.011X+0.139; R^2=0.446) and vertisols (Y=0.008+0.0.21; R^2=0.423) (Fig. 3. a, b). Bonde *et al*. (1992) [3] and Saggar *et al*. (1996) [15] noted that, in general, more than half of the total SOC is associated with the clay (< 2.0 µm) fraction, probably due to the protection effect of clay on SOC mineralization. The degree of protection provided by clay appears to be dependent on the type of clays with the higher porosity (eg. allophane), expanding and high surface-charged clays (eg. montmorillonite) (Zech *et al*., 1997) offering more protection than kaolinite (Hassink, 1994; Franzluebbers *et al*., 1996) [11, 7].

With increase in sand content in soil SOC content declined proportionally i.e., sand and SOC were negatively correlated under inceptisols (Y=-0.008X+0.929; R^2= 0.360) and vertisols (Y= -0.005X+0.652; R^2= 0.241) (Fig.3. c, d). Sand particles have a limited capacity to stabilize organic compounds on mineral surfaces compared with clay (Feng *et al*., 2013) [6] and the association is more labile Christensen (1992) [4].



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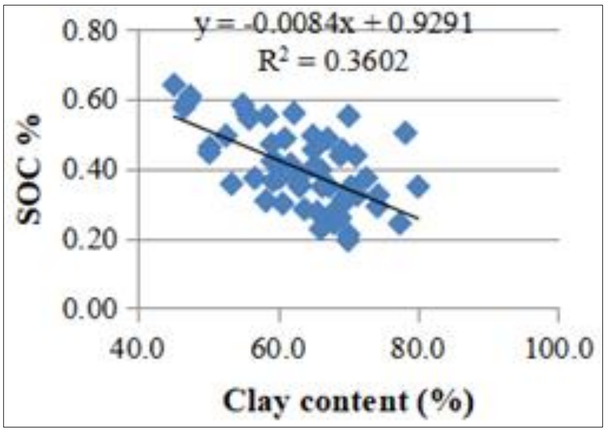

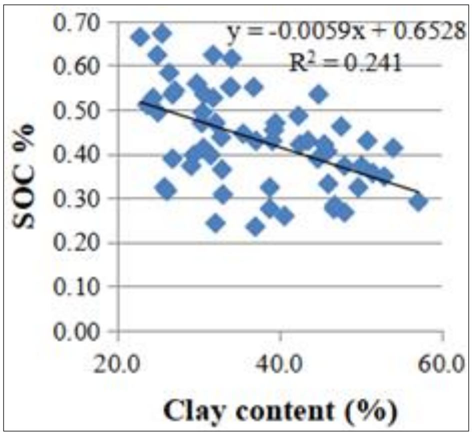

Fig 3: Relationship between SOC with soil clay and sand content a. Clay and SOC under inceptisol; b. Clay and SOC under vertisol; c. Sand and SOC under inceptisol; d. Sand and SOC unde r vertisol

3.3 Available Phosphorous

From the results (Table 2), it is observed available phosphorus content in soil was significantly influenced by soil types and cropping systems.

Vertisols have showed 54.16, 55.84 and 88.24% higher amount of available phosphorus content in 0-15, 15-30 and 30-45 cm depths, respectively over inceptisols. Irrespective of soil order, found abrupt decline in along soil depth, with middle (15-30 cm) and lower (30-45 cm) layers contained only 34.81 and 27.36% of total profile (0-45 cm) available phosphorus content.

Cropping systems had significantly influenced available P content in soil. CS_2 has maintained significantly higher amount of available P content (23 kg ha^{-1}), which was on par with CS_4, significantly lower values were recorded in CS_3 at surface soil (0-15 cm). The same trend was observed in the sub surface soils also. CS_2 and CS_4 have shown significantly higher available P content in all the three soil depths over other cropping systems. With depth, available P content in soil was declined, this is due to applied P fertilizers may be retained in the surface soils on the clay surfaces which were having charges.

Interaction effect of soil orders and cropping systems were non significant.

3.4 Potassium

From the results (Table 2), it is observed that all the soil samples were under medium to high range in available potassium content in soil.

Soil type had significantly influenced available potassium content in soil. Vertisols have showed 32.66, 31.80 and 31.89% higher amount of available K content in 0-15, 15-30 and 30-45 cm depths, respectively over inceptisols. This may be due to montmorillonite type of clay present in vertisols, which has more retention and release capacity of K than illite and kaolinite (Dhillon and Dhillon, 1990) [5]. Irrespective of soil order, found abrupt decline in along soil depth, with middle (15-30 cm) and lower (30-45 cm) layers contained only 34.12 and 25.06% of total profile (0-45 cm) available K content.

Cropping systems had significantly influenced K content in soil. CS_1 has maintained significantly higher amount of available potassium content (340 kg ha^{-1}), which was on par with CS_2 (329 kg ha^{-1}), significantly lower amount of K were recorded under CS_3 (220 kg ha^{-1}) at surface soil (0-15 cm). The same trend was observed in the sub surface soils also. CS_1 and CS_2 have shown significantly higher available K content in all the three soil depths over other cropping systems. This may be due to larger amount of fertilizers were applied in the systems (discussed in 2.2 of material and methods).

Interaction effect of soil orders and cropping systems were non significant.

Table 2: Influence of soil type and cropping systems on available phosphorus (kg ha^{-1}) and potassium (kg ha^{-1}).

Soil order	Available P (Kg ha-1)			Available K (Kg ha-1)		
	0-15	15-30	30-45	0-15	15-30	30-45
S1	15.73	14.38	10.03	246.35	206.75	151.79
S2	24.25	22.41	18.88	326.80	272.49	200.20
S.Em	0.56	0.49	0.54	10.82	7.82	5.98
CD@5%	1.63	1.42	1.58	31.35	22.65	17.31
Cropping System						
CS1	18.63	17.25	12.85	339.60	299.70	244.90
CS2	23.37	22.02	17.73	328.60	264.00	166.70
CS3	15.98	14.23	11.15	220.10	186.54	135.08
CS4	21.99	20.07	16.08	258.00	208.24	157.30
S.Em	0.79	0.69	0.77	15.31	11.06	8.45
CD@5%	2.30	2.01	2.23	44.34	32.04	24.49
Interactions						
S1CS1	13.84	12.52	9.20	285.00	277.40	245.40
S1CS2	18.22	16.90	11.62	288.80	225.80	135.20
S1CS3	12.64	11.52	8.16	181.00	151.20	105.76

S1CS4	18.24	16.56	11.12	230.60	172.60	120.80
S2CS1	23.42	21.98	16.50	394.20	322.00	244.40
S2CS2	28.52	27.14	23.84	368.40	302.20	198.20
S2CS3	19.32	16.94	14.14	259.20	221.88	164.40
S2CS4	25.74	23.58	21.04	285.40	243.88	193.80
S.Em	1.12	0.98	1.09	21.65	15.64	11.95
CD@5%	NS	NS	3.15	NS	NS	34.63
CV	12.56	11.94	16.83	16.89	14.59	15.19

S_1- inceptisols, S_2- Vertisols, CS_1- Rice-Rice, CS_2- Rice-Maize, CS_3- Cotton –Fallow, CS_4- Turmeric-Sesame, SE m: Standard error of mean, CD: Critical difference, CV: Critical Variance

4. Conclusion

Physico-chemical properties such as pH, BD, Texture, OC, N,P and K are having decreasing value with increasing depth except EC. Overall performance of all these properties monitored were better in vertisols of Rice-Rice cropping system. As Vertisols has more clay content, which may bind carbon physicaly, chemically and biochemically in it. CS1 has greater root biomass and prolonged submerged conditions.

5. References

1. Bhattacharyya T, Pal DK. Carbon sequestration in soils of the Indo-Gangetic Plains. Addressing Resource Conservation Issues in Rice-Wheat Systems of South Asia: A Resource Book. RWC-CIMMYT, New Delhi. 2003, 68-71.
2. Blake GR, Hartge KH. Bulk density. in Methods of Soil Analysis: Physical and Mineralogical Methods. Klute, A. (ed.) American Society of Agronomy, Madison, Wisc., 1986a, pp. 363-375.
3. Bonde T, Christensen BT, Cerri CC. Dynamics of soil organic matter as Reflected by Natural ^{13}C Abundance in particle size fraction of forested and Cultivated Oxisols. Soil Biology and Biochemistry. 1992;24:275-277.
4. Christensen BT. Physical fractionation of soil and organic matter in primary particle size and density separates. In Advances in Soil Science, Springer-Verlag, New York. 1992;20:1-90.
5. Dhillon SK, Dhillon KS. Kinetics of release of nonexchangeable potassium by cation saturated resins from Red (Alfisols), Black (Vertisols) and Alluvial (Inceptisols) soils of India. Geoderma. 1990;47:283-300.
6. Feng WT, Plante AF, Six J. Improving estimates of maximal organic carbon stabilization by fine soil particles. Biogeochemistry. 2013;112:81-93.
7. Franzluebbers AJ, Arshad MA. Soil organic matter pools during early adoption of conservation tillage in north western Canada. Soil Science Society of American Journal. 1996;60:1422-1427.
8. Gebrehiwot K, Desalegn T, Woldu Z, Demissew S, Teferi E. Soil organic carbon stock in Abune Yosef afroalpine and sub-afroalpine vegetation, northern Ethiopia. Ecological Processes. 2018;7:6.
9. Gee GW, Bauder JW. Particle–size analysis. In: Klute A. (Ed.), Methods of Soil Analysis. Part 1. ASA and SSSA, Madison, WI. 1986, 383-412.
10. Gee GW, Bauder JW. Particle size analysis by hydrometer: A simplified method for routine textural anal ysis and a sensitivity test of measurement parameters. Soil Sci. Soc. Am. J. 1979;43:1004-1007.
11. Hassinks J. Effect of soil texture and grassland management on soil organic C and N mineralization. Soil Biology and Biochemistry. 1994;26:1221-1231.
12. Jackson ML. Soil chemical analysis. Prentice-Hall of India Private Limited, New Delhi, 1973.
13. Mandal B, Majumder B, Adhya TK, Bandyopadhyay PK, Gangopadhyay A, Sarkar D, *et al.* The potential of double-cropped rice ecology toconserve organic carbon under subtropical climate. Global Change Biology. 2008;14:2139-2151.
14. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. U. S. Department of Agriculture Circular No. 939. Banderis, A.D., Barter, D.H and Anderson, K. Agricultural and Advisor, 1954.
15. Saggar S, Parshotam A, Sparling GP, Feltham CW, Hart PBS. C-labeled ryegrass turnover and residence times in soils varying in clay content and mineralogy. Soil Biology and Biochemistry. 1996;28:1677-1686.
16. Subbaiah BV, Asija GL. A rapid procedure for the estimation Available N in the soils. Current Science. 1956;25:259.
17. Venkanna K, Mandal U, Aluri JSR, Sharma KL, Dake RV, Pushpanjali P, *et al.* Carbon stocks in major soil types and land-use systems in semi arid tropical region of southern India. Current science. 2014;106(4):604-611.
18. Walkey A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37:29-38.
19. Zhou M, Liu C, Wang J, Meng Q, Yuan Y, Ma X, *et al*. Soil aggregates stability and storage of soil organic carbon respond to cropping systems on Black Soils of Northeast China. Scientific Reports. 2020;10:265.