International Journal of Chemical Studies

**P-ISSN: 2349–8528**
**E-ISSN: 2321–4902**
IJCS 2018; 6(2): 450-453

Received: 14-01-2018
Accepted: 15-02-2018

# Studies on physico-chemical properties of a Vertisol as influenced by land use practices

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**Abstract**
Study was conducted to evaluate the vertical variations in physico-chemical properties (pH, electrical conductivity, cation exchange capacity and soil organic carbon) of a Vertisol as influenced by land use practices after harvest of *kharif* and *rabi* seasons of 2015-16. Soil samples were collected from the fields practiced with different land uses [$L_1$: Uncultivated, $L_2$: rice-wheat system with conventional agriculture (CS), $L_3$: rice-wheat system with conservation agriculture (CA), $L_4$: soybean-wheat system with CS, $L_5$: soybean-wheat system with CA, $L_6$: maize -wheat system with CS and $L_7$: maize-wheat system with CA] at Borlaug Institute for South Asia (BISA) Research Farm, Lakhnwara, Jabalpur (M.P). For statistical analysis of data in split plot design land use practices were considered as main plot and depth (0-5 cm, 5-15 cm and 15-30 cm) as sub-plot treatments with three replications. It was found that pH and EC in surface (0-5 and 5-15 cm) and sub-surface (15-30 cm) soil were did not altered significantly due to different land use practices. Values of pH and EC were higher in post rabi season soil samples as compare to those of post kharif season in respective treatments of land use and depth. However, cation exchange capacity (CEC) and organic carbon (OC) content in soil were significantly affected by land use practices and depth of soil. Highest value of CEC (40.8 Cmol ($P^+$) $kg^{-1}$) and OC (8.16 g $kg^{-1}$) were obtained in $L_2$ and $L_3$ treatments, respectively. Also the CEC and OC in surface soil were higher than sub-surface soil. Study showed that conservation agriculture in all the cropping systems had favourable impact on soil properties as compared to conventional system.

**Keywords:** Cropping system, soil depth, pH, EC, OC, CEC, conservation agriculture

## Introduction

Soil health is the key component of agricultural system which has been reflected through its physico-chemical and biological properties. Conventionally tillage requirement under different cropping systems is variable and extent of tillage practices directly alters the soil properties, especially carbon reserve which is the most valuable component of soil health. Therefore, requirement of tillage practice in crop lands need to be evaluated for positive carbon reserve through conservation tillage practice (IPCC, 2000) [8]. Build-up of organic carbon in soil for sustaining soil health is the prime need of today's agriculture as it is declining due to intensive cultivation (Jahiruddin and Satter, 2010) [10]. Application of compost/manures, growing cover crops / green manuring crops, crop diversification and practicing conservation agriculture have been considered as some of the major agricultural exercise for maintaining physical, chemical and biological properties of soil (Alam *et al.*, 2013) [2]. Excessive tillage practices can deteriorate physico-chemical and biological properties of soil which can be minimized through reducing soil disturbance by zero-tillage practice with retaining crop residue on soil surface (Ramos *et al.*, 2011; Alam *et al.*, 2014) [19, 1].

Cropping systems has immense effect on soil physico-chemical properties of soil due to variable rooting behaviour, biomass production and nutrients uptake (Ranamukhaarachchi *et al.*, 2005) [20]. It has been reported that land uses, cropping system and land management practices significantly alters the soil properties (Rahman and Ranamukhaarachchi, 2003) [18]. Limited practices of legume based cropping systems led depletion of soil organic matter content in soils and cultivation of the land after deforestation causes change in soil pH and acidification (Smith and Doran, 1996) [23]. Type of vegetative cover is one the key factors influencing the soil organic carbon content in non-cultivated land (Liu *et al.*, 2010; Alemayehu and Sheleme, 2013) [13, 3]. Status of soil organic carbon and reaction further influences the cation exchange capacity of soils which greatly affect the nutrients dynamics in soil (Foth, 1990) [4].

Considering the above facts, the present study was undertaken with the objective to evaluate the vertical variations in physico-chemical properties of a Vertisol as influenced by land use practices.

## Materials and Methods

The study was carried out during two successive seasons of 2015-16 after harvest of *kharif* and *rabi* crops at Borlaug Institute for South Asia (BISA) Research Farm, Lakhanwada, Jabalpur (M.P). The farm is situated under semi-humid Mahakaushal region of Madhya Pradesh. Geographically BISA farm is situated at $23^0$ 33' N latitude, $80^0$ 04' E longitudes and at an altitude of 407.0 metre above mean sea level. Soil of the experimental site belongs to swell-shrink type with dark greyish brown colour. Soils of the BISA Research Farm have been classified as fine, smectitic, hyperthermic family of *Typic Haplusterts* (Vertisols) and known as medium black soil. Study was initiated with seven main plots of land use practices [$L_1$: Uncultivated, $L_2$: rice-wheat system with conventional agriculture (CS), $L_3$: rice-wheat system with conservation agriculture (CA), $L_4$: soybean-wheat system with CS, $L_5$: soybean-wheat system with CA, $L_6$: maize -wheat system with CS and $L_7$: maize-wheat system with CA) and three sub plots of soil depths (0-5 cm, 5-15 cm and 15-30 cm) with three replications in split plot design. Soil samples were collected as per the treatments with the help of posthole auger to determine the physico-chemical properties of soil following standard procedure. Soil sample was air dried in shade and ground by wooden pastle and mortar, thereafter sieved through 2.0 mm sieve and stored in the cloth bag. The soil sample thus obtained was subjected to analysis to assess the physico-chemical property of the soil. Soil pH was determined in a 1:2.5 soil-water suspension using glass electrode (Piper, 1950) [17]. Soil suspension used for pH determination was allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter (Piper, 1950) [17]. Organic carbon in soil was analyzed by Walkley and Black rapid titration method (1934) [25]. Cation Exchange Capacity of soil samples was determined employing the procedure given by Jackson, (1973) [9]. The data on different parameters as obtained from chemical analysis were analyzed for test of significance using standard statistical procedure given by Gomez and Gomez, (1984) [6].

## Results and Discussion

### Effect of land use practices on physico-chemical properties of soil

#### Soil pH

Data pertaining to effect of land use practices and soil depth on pH of soils after harvest of kharif and rabi seasons crop has been given in table 1. It was found that pH of soil samples collected after harvest of kharif and rabi season crops was not significantly due to different land use practices and soil depths. The highest pH value (7.39) was in $L_4$ followed by $L_2$ (7.38) and lowest (7.29) in $L_1$ treatments for soil samples collected after harvest of kharif season crops. However, for soil samples collected after harvest of rabi season crops the maximum value of soil pH (7.53) was obtained in $L_6$ followed by $L_2$ and minimum (7.36) in $L_1$ treatment. It is evident from the data that pH of soil collected after harvest of kharif and rabi season crops varied with depth from 7.32 to 7.39 and 7.44 -7.48, respectively. It was also found that during both the season soil pH increased with depth but the difference was statistically non-significant. Mengistu *et al.*, (2017) [14] and Ndungu *et al.*, (2017) [16] also reported that due to buffering capacity pH of soil did not change significantly across depth under different land use practices. Results also showed that irrespective of cropping system, CA practice slightly reduces the soil pH in both the seasons might be due to production of organic acids after decomposition of surface retained crop residue. Similar findings are also reported by Kibet *et al.*, (2016) [11]. Moderation in soil pH may be possible due to continuous addition of residue along with minimum soil disturbances. The interaction effect of land use practices and soil depths on pH was also found non-significant.

#### Electrical conductivity

Data presented in table 1 clearly indicated that different land use practices have no significant effect on electrical conductivity (EC) of soil after harvest of kharif and rabi season crops. The values of EC of soil under different land use practices ranged from 0.20 to 0.25 $dSm^{-1}$ and 0.21 to 0.26 $dSm^{-1}$ for the soil samples collected after harvest of kharif and rabi season crops, respectively. Highest EC value (0.25 $dSm^{-1}$) was tested in both $L_3$ and $L_6$ treatments for post kharif soil samples and lowest (0.25 $dSm^{-1}$) in $L_1$. For post rabi soil samples EC was found maximum (0.26 $dSm^{-1}$) in $L_3$, $L_5$ and $L_7$ treatments (different cropping systems under CA) and minimum (0.21 $dSm^{-1}$) in $L_1$ treatment. It was also found that EC of soil increased with depth during both seasons and the variation was significant. Lowest value of EC (0.20 and 0.22 $dSm^{-1}$) was obtained in 0-5 cm soil depth which reached to highest (0.25 and 0.26 $dSm^{-1}$) in 15-30 cm soil depth during post kharif and rabi soil samples, respectively. It was might be because of downward movement of salts along with percolating water into deeper layers of the soil. The finding is well supported with those reported by Gathala *et al.*, (2017) [5] and Kumar *et al.*, (2017) [12] which also revealed that values of EC increased with depth. The interaction effects on EC were also found to be statistically non-significant.

#### Cation exchange capacity of soil

Data on cation exchange capacity (CEC) as influenced by land use practices and depth of post-harvest soil after kharif and rabi seasons crop of 2015-16 has been given in Table 2. Data clearly showed a significant effect of land use practices and depth on cation exchange capacity of soil. It was found that under different land use practices CEC of soil varied from 37.6 - 40.5 Cmol $(P^+)$ $kg^{-1}$ and 37.5 - 40.8 Cmol $(P^+)$ $kg^{-1}$, respectively for post-harvest soil after kharif and rabi season crops. Highest values [40.5 and 40.8 Cmol $(P^+)$ $kg^{-1}$] were obtained in $L_3$ (rice-wheat in CA) and lowest [37.6 and 37.5 Cmol $(P^+)$ $kg^{-1}$] in $L_1$ (Uncultivated) treatments during respective seasons. Further it was found that CEC values of surface (0-5 and 5-15 cm) soil were higher than those of sub-surface (15-30 cm) soil and varied from 36.3 to 39.7 Cmol $(P^+)$ $kg^{-1}$ for post kharif harvest soil and 37.0 - 40.1 Cmol $(P^+)$ $kg^{-1}$ for post rabi harvested soil. It was might be because higher root biomass production in rice-wheat system and retention of crop residue on soil surface that caused build-up of organic carbon responsible for greater CEC under conservation agriculture system. Similarly, Mengistu *et al.*, (2017) [14], Muche *et al.*, (2015) [15], Rezapour, (2014) [21] and Heshmati *et al.*, (2011) [7] reported that CEC of soil was increased under forest land as compared to those in grassland and crop land.

#### Soil organic carbon

Data on soil organic carbon (SOC) content in soil after harvest of kharif and rabi season crops (table 2) clearly showed that effect of different land use practices on SOC content in soil was significant. Under different land use practices SOC values of post-harvest kharif and rabi soil samples were varied from 6.80 to 8.16 g $kg^{-1}$ and 6.87 to 8.37 g $kg^{-1}$, respectively. Maximum organic carbon (OC) content in soil samples collected after harvest of kharif (8.16 g $kg^{-1}$) and rabi (8.37 g $kg^{-1}$) season crops was found in $L_3$ followed by $L_5$ treatment, while minimum (6.80 and 6.87 g $kg^{-1}$) values were obtained in $L_6$ and $L_1$ treatments, respectively during above respective seasons. Irrespective of cropping systems greater amount of OC was found under conservation agriculture (CA) practice during both the seasons. It was might be because to minimum soil disturbances, higher biomass production and crop residue retention under CA practice which helped in increasing SOC under different cropping systems with conservation agriculture. Sapkota *et al.*, (2017) [22]; Kumar *et al.*, (2017) [12] and Vashum *et al.*, (2016) [24] also advocated that irrespective of cropping systems and nutrients management SOC content increased under CA practice as compared to those under conventional agriculture. Across different land use practices SOC content was significantly changed with soil depth. SOC content in soil after harvest of kharif season crops varied from 6.95 g $kg^{-1}$ (15-30 cm) to 7.74 g $kg^{-1}$ (0-5 cm) and 7.17 g $kg^{-1}$ (15-30 cm) to 7.62 g $kg^{-1}$(5-15 cm) in soil after harvest of rabi season crops. The interaction effect of land use practices and depths on SOC was statistically non-significant during both the seasons.

**Conclusion**

Present study concluded that reaction (pH) and electrical conductivity (EC) of soil was not altered significantly by different land use practices. Soil pH in different depth was not affected significantly, while EC was significantly changed with depth across land use practices. Cation exchange capacity and organic carbon was increased under conservation agriculture during both the seasons. Therefore, adopting conservation agriculture in different cropping system could improve the soil activity and build-up of organic carbon to sustain soil health.

**Table 1:** Effect of land use practices on pH and electrical conductivity of soil in different depths

| Main Plot (Land Uses) | After harvest of kharif crops 2015 | After harvest of rabi crops 2015-16 | After harvest of kharif crops 2015 | After harvest of rabi crops 2015-16 |
|---|---|---|---|---|
| | pH | | EC ($dSm^{-1}$) | |
| L1 : Uncultivated | 7.29 | 7.36 | 0.20 | 0.21 |
| L2 : R-W system-CT | 7.38 | 7.52 | 0.22 | 0.24 |
| L3 : R-W system-CA | 7.35 | 7.43 | 0.25 | 0.26 |
| L4 : S-W system-CT | 7.39 | 7.49 | 0.21 | 0.23 |
| L5 : S-W system-CA | 7.36 | 7.46 | 0.24 | 0.26 |
| L6 : M-W system-CT | 7.36 | 7.53 | 0.22 | 0.23 |
| L7 : M-W system-CA | 7.33 | 7.46 | 0.25 | 0.26 |
| SEm± | 0.044 | 0.111 | 0.019 | 0.017 |
| CD (p=0.05) | NS | NS | NS | NS |
| Sub-Plot (Depth) | | | | |
| D1 : 0-5 cm | 7.32 | 7.44 | 0.20 | 0.22 |
| D2 : 5-15 cm | 7.35 | 7.47 | 0.23 | 0.24 |
| D3 : 15-30 cm | 7.39 | 7.48 | 0.25 | 0.26 |
| SEm± | 0.031 | 0.070 | 0.007 | 0.008 |
| CD (p=0.05) | NS | NS | 0.019 | 0.024 |

**Table 2:** Effect of land use practices on cation exchange capacity and organic carbon of soil in different depths

| Main Plot (Land Uses) | After harvest of kharif crops 2015 | After harvest of rabi crops 2015-16 | After harvest of kharif crops 2015 | After harvest of rabi crops 2015-16 |
|---|---|---|---|---|
| | CEC [Cmol ($P^+$) $kg^{-1}$] | | SOC (g $kg^{-1}$) | |
| L1 : Uncultivated | 37.6 | 37.5 | 6.84 | 6.87 |
| L2 : R-W system-CT | 38.1 | 38.6 | 7.67 | 7.41 |
| L3 : R-W system-CA | 40.5 | 40.8 | 8.16 | 8.37 |
| L4 : S-W system-CT | 37.6 | 38.2 | 7.63 | 7.41 |
| L5 : S-W system-CA | 37.8 | 39.3 | 7.81 | 7.84 |
| L6 : M-W system-CT | 37.7 | 38.2 | 6.80 | 6.90 |
| L7 : M-W system-CA | 37.9 | 38.8 | 6.91 | 7.10 |
| SEm± | 0.61 | 0.50 | 0.310 | 0.254 |
| CD (p=0.05) | 1.82 | 1.49 | 0.929 | 0.782 |
| Sub-Plot (Depth) | | | | |
| D1 : 0-5 cm | 39.7 | 40.1 | 7.74 | 7.59 |
| D2 : 5-15 cm | 39.4 | 39.7 | 7.47 | 7.62 |
| D3 : 15-30 cm | 36.3 | 37.0 | 6.95 | 7.17 |
| SEm± | 0.55 | 0.68 | 0.216 | 0.139 |
| CD (p=0.05) | 1.60 | 1.96 | 0.625 | 0.402 |

**Reference**


1. Alam Md, Khairul Md, Monirul Islam, Salahin Nazmus, Hasanuzzaman Mirza. Effect of Tillage Practices on Soil Properties and Crop Productivity in Wheat-Mungbean-Rice Cropping System under Subtropical Climatic Conditions. Hindawi Publishing Corporation Scientific World Journal. Article ID 437283, 2014, 15.
2. Alam Md, Khairul, Salahin N, Rashid MH, Islam AB MJ, Hossain MN. Effect of tillage depths and cropping

systems on soil physical properties in grey terrace soils. Research WebPub. 2013; 1(5):70-76.
3. Alemayehu Kiflu, Sheleme Beyene. Effects of different land use systems on selected soil properties in South Ethiopia Journal of Soil Science and Environmental Management. 2013; 4(5):100-107.
4. Foth HD. Fundamentals of Soil Sciens. John Wiley & Sons. Inc., Canada, 1990.
5. Gathala MK, Jat ML, Saharawat YS, Sharma SK, Yadvinder S, Ladha JK. Physical and Chemical Properties of a Sandy Loam Soil Under Irrigated Rice-Wheat Sequence in the Indo-Gangetic Plains of South Asia. J Ecosys Ecograph. 2017; S7:002.
6. Gomez AA, Gomez KA. Statistical procedures for Agricultural research.2nd Edn. John Wiley and Sons, New York, 1984.
7. Heshmati Mosayeb, Abdu Arifin, Jusop Shamshuddin, Majid Nik Muhammad. Effects of Land Use Practices on the Organic Carbon Content, Cation Exchange Capacity and Aggregate Stability of Soils in the Catchment Zones. American Journal of Applied Sciences. 2011; 8(12):1363-1373.
8. IPCC. Land use, land-use change and forestry special report. Cambridge University Press, 2000, 377.
9. Jackson ML. Soil Chemical Analysis Prentice Hall of India Pvt. Ltd., New Delhi, 1973.
10. Jahiruddin M, Satter SA. Agricultural Research Priority: Vision- 2030 and beyond. Sub-sector: Land and Soil Resource Management. Bangladesh Agril. Res. Council, Farmgate, Dhaka, 2010.
11. Kibet LC, Canqui HB, Jasa P. Long-term tillage impacts on soil organic matter components and related properties on a Typic Argiudoll. Soil & Tillage Research. 2016; (155):78-84.
12. Kumar A, Somasundaram J, Biswas AK, Sinha NK, Mishra VN, Chaudhary RS *et al*. Short-term effect of conservation agriculture practices on soil quality of a Vertisol in central India. Applied Biological Research. 2017; 19(1):26-34.
13. Liu XL, He YQ, Zhang HL, Schroder JK, Li CL, Zhou J, Zhang ZY. Impact of land use and soil fertility on distributions of soil aggregate fractions and some nutrients. Pedosphere. 2010; 20(5):666-673.
14. Mengistu C, Kibebew K, Tarekegn F. Influence of Different Land Use Types and Soil Depths on Selected Soil Properties Related to Soil Fertility in Warandhab Area, Horo Guduru Wallaga Zone, Oromiya, Ethiopia. Int J Environ Sci Nat Res. 2017; 4(2):555634.
15. Muche M, Kokeb A, Molla E. Assessing the Physicochemical Properties of Soil under Different Land Use Types. J Environ Anal Toxicol. 2015; 5:309.
16. Ndungu CK, Bhardwaj SK, Nancy L. Impact of Mountain Cropping Systems on Soil Properties, Nutrient Availability and Their Carbon Sequestration Potential in Mid-Hills of Himachal Pradesh, India. Int. J. Curr. Microbiol. App. Sci. 2017; 6(4):203-211.
17. Piper CS. Soil and Plant Analysis. Intel Science Publishers. Inc. New York, 1950.
18. Rahman MM, Ranamukhaarachchi SL. Fertility status and possible environmental consequences of Tista Floodplain soils in Bangladesh. Tham. Int. J Sci. Tec. 2003; 8(3):11-19.
19. Ramos ME, Robles AB, anchez-Navarro AS, Gonz alez-Rebollar JL. Soil responses to different management practices in rainfed orchards in semiarid environments," Soil and Tillage Research, 2011; 112(1):85-91.
20. Ranamukhaarachchi SL, Rahman MM, Begum SN. Soil fertility and land productivity under different cropping systems in highlands and medium highlands of Chandina sub district, Bangladesh. Asia Pacific J. Rural Dev. 2005; 15(1):63-76.
21. Rezapour S. Response of some soil attributes to different land use types in calcareous soils with Mediterranean type climate in north-west of Iran. Environ Earth Sci. 2014; 71:2199-2210.
22. Sapkota TB, Jat RK, Singh RG, Jat ML, Stirling CM, Jat MK *et al*. Soil organic carbon changes after seven years of conservation agriculture in a rice–wheat system of the eastern Indo-Gangetic Plains. Soil Use and Management. 2017; 33:81-89.
23. Smith JL, Doran JW. Measurement and use of pH and electrical conductivity for soil quality analysis. In: Doran, J.W., Jones, A.J. (Eds.), Methods for Assessing Soil Quality. Soil Science Society of American Journal. 1996; 49:169-185.
24. Vashum KT, Kasomwoshi T, Jayakumar S. Soil organic carbon sequestration potential of primary and secondary forests in Northeast India. Proceedings of the International Academy of Ecology and Environmental Sciences. 2016; 6(3):67-74.
25. Walkley A, Black CA. An Examination for Degt-Jreff method for determination soil organic matter and proposal for modification of the chromic acid titration method. Soil Science. 1934; 37:29-38.