*__Original Research Article__*

# Vertical variability of physical properties under different land - use practices in Vertisols and Inceptisols of Central India

## ABSTRACT

A status was carried out after harvest of *rabi* season crop during 2020-2021 to find out the vertical variability in status of physical properties in Vertisol and Inceptisol under different land uses. Samples were collected in triplicate from six different land use practices (forest, uncultivated, soybean-wheat, rice-wheat, soybean - chickpea and maize-wheat) at four depths (0-15, 15-30 30-45 and 45-60 cm) Gwalior and Jabalpur regions. For statistical analysis of data in factorial RBD different soil type were considered as factor A ,land use practices as factor B and three replications. Physical properties significantly affected by soil type. It was observed in different land use practices significantly affected in WHC. Under different soil type content of sand, silt and bulk density were higher in inceptisol as compared to vertisol, however content of clay, porosity and WHC were higher vertisol as compare to inceptisol. WHC, bulk density and Clay was found increased down the depth except Porosity, sand in Vertisol while content of sand and bulk density was found increased down to depth except WHC, porosity and clay in Inceptisol.

**Keywords:** soil texture, bulk density, particle density, porosity, water holding capacity, soil depth, land uses, inceptisols, vertisols.

## 1. INTRODUCTION

Soil, the key natural resource is a three dimensional dynamic system and each dimension of it has unique significance and diverge according to variability in the factors and processes of formation. Inventories on variability in soil properties are crucial for proper characterization and classification of soil selection of land use practices to increase the productivity of the soil (ISSS, 2000). Vertisols reflects shrink-swell properties depending up on the moisture status which also regulates the nutrients requirement and the use efficiency of applied fertilizers. The soil moisture range in which the physical condition of Vertisols is suitable for tillage and planting operations is quite narrow (Virmani *et al.,* 1989). Inceptisol has different nature at different place from sandy loam to clay water retention capacity is poor this type of soil chemically Inceptisol rich in potash and lacks phosphorus.

As a result, there is a pressing need to assess the impact of various soil properties on soil health in different soils, which accounting for around 35% of the land under agriculture and 24.62% area under forest in India. Also, along with soybean-chickpea and soybean-mustard cropping systems, soybean-wheat is the most common cropping system in Vertisols in central India.

Physical properties of soil are equally or even more important than chemical and biological properties in the light of their direct impact on dynamics of nutrients, water and soil biota. Soil physical properties (texture, bulk density, aggregation etc.) are affected by many factors that change vertically, laterally across fields and temporally in response to climate, cultural and human activity li. E.A. *et al.,* (2012). Since variability in physical properties directly affects the plant growth, nutrients and water dynamics and other soil processes, in the depth knowledge of vertical changes in soil physical properties are necessary to understand the physical behaviour of soils at spatial scale Alloway, B.J., (2008) Alloway, B.J., (2013).

The physical properties of soil are important since they determine how it can be used either for agricultural and non-agricultural purposes. Different interdependent soil properties, viz. infiltration rate, water-holding capacity, permeability, aeration, plasticity and nutrient supplying ability, are influenced by the texture, density aggregation etc. of the soils Alloway, B.J., (2008). To a great extent, soil properties are altered by crops and cropping system because manipulation of soil for crops with contrast edaphic requirement could alter the physical properties of soil. Vertical variability of soil properties in any field position is inherent due to geologic and pedologic soil-forming factors and physical properties of soil could vary spatially due to anthropogenic activities. Soil properties are interdependent and directly influence the availability of water and nutrients to plants and regulate crop growth and productivity.

## 2. MATERIALS AND METHODS

The study were carried out during 2020-21 in different land uses across the soil type in laboratory of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. Samples were collected from different location of Jabalpur and Gwalior region from selected soil type (Vertisol and Inceptisol) sites from different land use practices (Forest, uncultivated, soybean-wheat, rice-wheat, soybean- chickpea and maize-wheat cropping system) from depths i.e. 0-15, 15-30, 30-45 and 45-60 cm after harvest of *Rabi* season crops during 2020-21 in triplicate. The soil samples were collected using core sampler for the determination of physical properties of the soil. Soil samples were processed by drying under the shade, powdering with a clean wooden mortar and pesstle and passing through a 2 mm sieve. The processed samples were stored in polyethylene bags for analysis in the laboratory. Primary soil particles (sand ,silt and clay) in samples were analysed by the bouyoucos hydrometer method (bouyoucos,1997) to characterize the soil texture, Keen's Box were used for measurement of maximum water holding capacity of soil as outlined by Richards (1954). particle density were determined using Pycnometer bottle in laboratory in soil sample (Black,1965). Porosity of soil were determined using empirical method as described by Gupta and Dhakshinamoorthy, (1980). The statistical analysis was done by using factorial Randomized Block Design (FRBD).

## 3. RESULTS AND DISCUSSION

### 3.1 Sand Content

Data related to the sand content in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table1. The results clearly indicated that sand content was non significantly affected by different land use practices and significantly affected by soil type. It is evident from data the sand content was found higher under Inceptisol compare to Vertisol. It was also found that irrespective of different land uses the sand content decreased with depths in vertisol and increases with depths in Inceptisol. It is also evident from the data that the sand content of different land uses practices ranged from 32.1 to 33.5 at 0-15 cm, 30.0 to 33.0 at 15-30 cm, 29.1 to 32.1 at 30-45 and 29.0 to 31.5 % at 45-60 cm, respectively under Vertisol and 47.4 to 49.8 0-15cm, 49.5 to 51.0 15-30cm, 50.8 to 52.4 30-45 cm and 51.7 to 53.2 45-60 cm in inceptisol. Alemayehu and Assefa (2016) reported declines of sand and silt contents from 0-15 to 15-30 cm in Vertisol. The higher content of sand in lower depth might be due to geological structure of hilly area, where proportion of rock is higher inside the surface soils. Higher sand fraction in cultivated land most likely arise from disturbance during plowing and selective removal of clay particles by erosion leaving behind the sand fractions in site EM.Fetene and MY.Amera(2018).

### 3.2 silt content

Data related to the silt content in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 2. The results clearly indicated that silt content was significantly affected by soil type and not affected by different land uses. It is evident from data the silt content was found higher under Inceptisol compare to Vertisol. It is also evident from the data that the silt content of different land uses practices ranged from 20.5 to 21.7 at 0-15 cm, 19.8 to 21.9 at 15-30 cm, 19.5 to 21.6 at 30-45 and 18.8 to 20.8% at 45-60 cm, respectively under Vertisol and 29.4 to 31.2 0-15cm, 28.2 to 29.9 15-30cm, 27.6 to 29.3cm and 27.3 to 29.0 45-60 cminInceptisol.

**Table 1:** **Variability in sand content of vertisol and inceptisol at different depths under different land use practices**

| Soil depth(cm) | Sand (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30- 45 | | | 45- 60 | | |
| Factor B | Factor A (Soil types) | | | | | | | | | | | |
| (Land Uses) | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 32.1 | 48.5 | **40.3** | 30.0 | 50.4 | **40.2** | 29.1 | 51.7 | **40.4** | 29.0 | 52.1 | **40.6** |
| **Uncultivated** | 33.4 | 47.6 | **40.5** | 32.6 | 49.5 | **41.0** | 30.2 | 50.8 | **40.5** | 29.3 | 51.7 | **40.5** |
| **Soybean- wheat** | 32.6 | 48.7 | **40.7** | 31.6 | 51.0 | **41.3** | 31.1 | 52.2 | **41.7** | 30.7 | 52. | **41.7** |
| **Rice -wheat** | 33.5 | 49.8 | **41.7** | 33.0 | 50.2 | **41.6** | 32.1 | 52.4 | **42.3** | 31.5 | 53.2 | **42.4** |
| **Soybean- Chickpea** | 32.6 | 48.6 | **40.6** | 32.7 | 51.0 | **41.9** | 31.2 | 52.0 | **41.6** | 30.8 | 52.5 | **41.7** |
| **Maize-wheat** | 33.4 | 47.4 | **40.4** | 32.4 | 50.1 | **41.3** | 31.7 | 51.4 | **41.6** | 31.4 | 52.3 | **41.9** |
| **Mean** | **32.9** | **48.4** | | **32.1** | **50.4** | | **30.9** | **51.8** | | **30.5** | **52.4** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.35** | **0.61** | **0.86** | **0.24** | **0.42** | **0.59** | **0.26** | **0.45** | **0.63** | **0.27** | **0.47** | **0.66** |
| **CD (p=0.05)** | **1.03** | **NS** | **NS** | **0.70** | **NS** | **NS** | **0.76** | **NS** | **NS** | **0.79** | **NS** | **NS** |

**S1 :Vertisol** **S2: Inceptisol**

**Table 2 : Variability in silt content of vertisol and inceptisol at different depths under different land use practices**

| Soil depth(cm) Factor(B) Land Uses | Silt (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30-45 | | | 45-60 | | |
| | Factor A (Soil types) | | | | | | | | | | | |
| | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 21.6 | 29.6 | **25.6** | 21.9 | 29.9 | **25.9** | 21.3 | 29.3 | **25.3** | 20.8 | 29.0 | **24.9** |
| **Uncultivated** | 20.8 | 30.7 | **25.8** | 20.1 | 29.5 | **24.8** | 21.6 | 28.9 | **25.3** | 20.6 | 28.6 | **24.6** |
| **Soybean- wheat** | 21.3 | 30.4 | **25.9** | 20.5 | 29.2 | **24.9** | 20.3 | 28.6 | **24.5** | 19.6 | 28.5 | **24.1** |
| **Rice -wheat** | 20.5 | 29.4 | **25.0** | 19.8 | 28.2 | **24.0** | 19.5 | 27.6 | **23.6** | 18.8 | 27.3 | **23.1** |
| **Soybean- Chickpea** | 21.7 | 30.3 | **26.0** | 20.2 | 29.2 | **24.7** | 20.3 | 28.4 | **24.4** | 20.2 | 28.2 | **24.2** |
| **Maize-wheat** | 20.5 | 31.2 | **25.9** | 19.8 | 29.8 | **24.8** | 20.0 | 29.2 | **24.6** | 19.8 | 28.6 | **24.2** |
| **Mean** | **21.1** | **30.3** | | **20.4** | **29.3** | | **20.5** | **28.7** | | **20.0** | **28.4** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.20** | **0.34** | **0.48** | **0.22** | **0.37** | **0.53** | **0.24** | **0.41** | **0.58** | **0.23** | **0.40** | **0.57** |
| **CD (p=0.05)** | **0.58** | **NS** | **NS** | **0.63** | **NS** | **NS** | **0.70** | **NS** | **NS** | **0.68** | **NS** | **NS** |

**S1 :Vertisol S2 : Inceptisol**

**Table 3 : Variability in clay content of vertisol and inceptisol at different depths under different land use practices**

| Soil depth(cm) | Clay (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30-45 | | | 45-60 | | |
| Factor B | Factor A (Soil types) | | | | | | | | | | | |
| (Land Uses) | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 46.3 | 21.9 | **34.1** | 48.1 | 19.7 | **33.9** | 49.6 | 19.0 | **34.3** | 50.2 | 18.9 | **34.6** |
| **Uncultivated** | 45.8 | 21.7 | **33.8** | 47.3 | 21.0 | **34.2** | 48.2 | 20.3 | **34.2** | 50.1 | 19.7 | **34.9** |
| **Soybean- wheat** | 46.1 | 20.9 | **33.5** | 47.9 | 19.8 | **33.9** | 48.6 | 19.2 | **33.9** | 49.7 | 18.9 | **34.3** |
| **Rice -wheat** | 46.0 | 20.8 | **33.4** | 47.2 | 21.6 | **34.4** | 48.4 | 20.0 | **34.2** | 49.7 | 19.5 | **34.6** |
| **Soybean- Chickpea** | 45.7 | 21.1 | **33.4** | 47.1 | 19.8 | **33.5** | 48.5 | 19.6 | **34.1** | 49.0 | 19.3 | **34.2** |
| **Maize-wheat** | 46.1 | 21.4 | **33.8** | 47.8 | 20.1 | **34.0** | 48.3 | 19.4 | **33.9** | 48.8 | 19.1 | **34.0** |
| **Mean** | **46.0** | **21.3** | | **47.6** | **20.3** | | **48.6** | **19.6** | | **49.6** | **19.2** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.20** | **0.34** | **0.49** | **0.21** | **0.36** | **0.51** | **0.20** | **0.34** | **0.48** | **0.15** | **0.25** | **0.36** |
| **CD (p=0.05)** | **0.58** | **NS** | **NS** | **0.62** | **NS** | **NS** | **0.57** | **NS** | **NS** | **0.43** | **NS** | **NS** |

**S1:Vertisol** **S2 : Inceptisol**

### 3.3 clay content

Data related to the clay contrent in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 3. The results clearly indicated that clay content was significantly affected by soil type and not affected by different land uses. It is evident from data the clay content was found higher under Vertisol compare to Inceptisol. It was also found that irrespective of different land uses the clay content decreased with depths in inceptisol, however increasing with depths in Vertisol. It is also evident from the data that the clay content of different land uses practices ranged from 45.7 to 46.3 at 0-15 cm, 47.1 to 48.1 at 15-30 cm, 48.2 to 49.6 at 30-45 and 48.8 to 50.2 % at 45-60 cm, respectively under Vertisol and 20.8 to 21.9  0-15cm, 19.8 to 21.6 15-30cm, 19.0 to 20.3 cm and 18.9 to 19.7 45-60 cm in Inceptisol. which found highest clay content in Vertisol might be due to presence of smetitic parent material Saha *et al.,*(2010). Results revealed that increase in per cent clay with increasing soil depth with maximum clay content at 45-60 cm and minimum at 0-15 cm. It was might be because of down ward movement of clay from upper horizons Shiferaw Bole (2004).

**Table 4 : Effect of land use practices on bulk density of vertisol and inceptisol soils at different depths**

| Soil depth (cm) | Bulk Density of soil (Mg $m^{-3}$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30-45 | | | 45-60 | | |
| Factor B (Land Uses) | Factor A (Soil types) | | | | | | | | | | | |
| | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 1.33 | 1.41 | **1.37** | 1.34 | 1.42 | **1.38** | 1.34 | 1.42 | **1.38** | 1.34 | 1.42 | **1.38** |
| **Uncultivated** | 1.34 | 1.43 | **1.39** | 1.36 | 1.44 | **1.40** | 1.37 | 1.45 | **1.41** | 1.37 | 1.46 | **1.42** |
| **Soybean- wheat** | 1.35 | 1.49 | **1.42** | 1.37 | 1.50 | **1.44** | 1.38 | 1.51 | **1.45** | 1.38 | 1.52 | **1.45** |
| **Rice -wheat** | 1.37 | 1.51 | **1.44** | 1.37 | 1.52 | **1.45** | 1.39 | 1.52 | **1.46** | 1.39 | 1.52 | **1.45** |
| **Soybean- Chickpea** | 1.34 | 1.50 | **1.42** | 1.35 | 1.51 | **1.43** | 1.35 | 1.52 | **1.44** | 1.35 | 1.53 | **1.44** |
| **Maize-wheat** | 1.36 | 1.52 | **1.44** | 1.37 | 1.52 | **1.45** | 1.38 | 1.52 | **1.45** | 1.38 | 1.53 | **1.45** |
| **Mean** | **1.35** | **1.48** | | **1.36** | **1.48** | | **1.37** | **1.49** | | **1.37** | **1.50** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.017** | **0.029** | **0.041** | **0.022** | **0.039** | **0.055** | **0.024** | **0.041** | **0.058** | **0.011** | **0.019** | **0.026** |
| **CD (p=0.05)** | **0.049** | **NS** | **NS** | **0.066** | **NS** | **NS** | **0.069** | **NS** | **NS** | **0.031** | **NS** | **NS** |

**S1:Vertisol S2: Inceptisol**

### 3.4 Bulk Density

Data related to the bulk density in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 4. The results clearly indicated that bulk density was significantly affected by soil type and not affecected by different land use practices. It is evident from data the bulk densityt was found higher under Inceptisol compare to Vertisol. It was also found that irrespective of different land uses the bulk density increased with depths. It is also evident from the data that the bulk density of different land uses practices ranged from 1.33 to 1.37 at 0-15 cm, 1.34 to 1.37 at 15-30 cm, 1.34 to 1.39 at 30-45 and 1.34 to 1.39 Mg m-$^{3}$ at 45-60 cm, respectively under Vertisol and 1.41 to 1.51 0-15cm, 1.42 to 1.52 15-30cm, 1.42 to 1.52 30-45 cm and 1.42 to 1.53 Mg m-3 45-60 cm in Inceptisol. Numerically the maximum values of bulk density (1.37,1.37,1.39 and 1.39 Mg m$^{-3}$) at respective soil depths were obtained under Rice-wheat cropping system, while minimum ( 1.33,1.34,1.34 and 1.34 Mg m-$^{3}$) at 0-15, 15-30, 30-45 and 45-60 cm under forest land in Vertisol and Inceptisol maximum values of bulk density (1.51,1.52,1.52 and 1.53 Mg m$^{-3}$),while minimum (1.41,1.42,1.42 and 1.42 Mg m-$^{3}$) at respective depth under rice-wheat. The OC content which increased root biomass production that might have augmented organic matter content of the soil hence reduced the BD Rucknagel *et al*., (2004). Increased BD was reported with increasing soil depth might be due to cumulative load of upper horizons or low organic matter Singh and Hati *et al.,*(2013).

### 3.5 Particle Density

Data related to the particle density in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 5. Data on effect of particle density under different land uses and soil type and intraction effect was also found not significant. It is evident from data the particle density was found higher under Vertisol compare to Inceptisol. Data further showed that the content of particle density at different soil depths upto 0-60 cm varied from 2.62 and 2.65 Mg m$^{-3}$ under different land use system of Vertisol and Inceptisol. It is also evident from the data that the particle density of different land uses practices ranged from 2.62 to 2.64 at 0-15 cm, 2.62 to 2.64 at 15-30 cm, 2.63 to 2.65 at 30-45 and 2.62 to 2.64 Mg m-3 at 45-60 cm, respectively under Vertisol and 2.62 to 2.64 0-15cm, 2.63 to 2.65 15-30cm, 2.63 to 2.65 30-45 cm and 2.63 to 2.65 Mg m$^{-3}$ 45-60 cm in Inceptisol. Numerically the maximum values of particle density (2.64, 2.64, 2.64 and 2.64 Mg m$^{-3}$) in Vertisol and Inseptisol maximum values of particle density (2.64, 2.65, 2.65 and 2.65 Mg m$^{-3}$) at respective soil depths were obtained under soybean-wheat cropping system. The particle density is depends on texture and exclusively on the mineralogical composition of the soil material. The particle density of soils slightly increased with depth possibly due to lower organic matter in sub-surface soil reported by Ram *et al.,*(2020)The particle density did not show any significant change due to continuous application of fertilizer Kannan *et al.,* (2013). Similar findings are also reported by Nandapure *et al*., (2018).

**Table 5 : Effect of land use practices on particle density of vertisol and inceptisol at different depths**

| Soil depth (cm) | Particle Density ($Mg m^{-3}$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30-45 | | | 45-60 | | |
| Factor B (Land Uses) | Factor A (Soil types) | | | | | | | | | | | |
| | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 2.63 | 2.62 | **2.63** | 2.63 | 2.63 | **2.63** | 2.63 | 2.63 | **2.63** | 2.62 | 2.63 | **2.63** |
| **Uncultivated** | 2.64 | 2.63 | **2.64** | 2.63 | 2.63 | **2.63** | 2.64 | 2.63 | **2.64** | 2.64 | 2.64 | **2.64** |
| **Soybean- wheat** | 2.64 | 2.64 | **2.64** | 2.64 | 2.65 | **2.65** | 2.64 | 2.65 | **2.64** | 2.64 | 2.65 | **2.65** |
| **Rice –wheat** | 2.63 | 2.64 | **2.64** | 2.62 | 2.64 | **2.63** | 2.65 | 2.64 | **2.65** | 2.63 | 2.64 | **2.64** |
| **Soybean- Chickpea** | 2.63 | 2.63 | **2.63** | 2.63 | 2.63 | **2.63** | 2.63 | 2.63 | **2.63** | 2.63 | 2.64 | **2.64** |
| **Maize-wheat** | 2.62 | 2.64 | **2.63** | 2.63 | 2.64 | **2.64** | 2.63 | 2.64 | **2.64** | 2.62 | 2.63 | **2.63** |
| **Mean** | **2.63** | **2.63** | | **2.63** | **2.64** | | **2.64** | **2.64** | | **2.63** | **2.64** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.006** | **0.010** | **0.014** | **0.005** | **0.009** | **0.013** | **0.005** | **0.009** | **0.013** | **0.005** | **0.009** | **0.012** |
| **CD (p=0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

**S1:Vertisol** **S2 : Inceptisol**

**Table 6 : Effect of land use practices on porosity of vertisol and inceptisol at different depths**

| Soil depth (cm) | Porosity (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30-45 | | | 45-60 | | |
| Factor B (Land Uses) | Factor A (Soil types) | | | | | | | | | | | |
| | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 49.4 | 46.2 | **47.8** | 49.0 | 46.0 | **47.5** | 48.9 | 46.0 | **47.5** | 48.8 | 46.0 | **47.5** |
| **Uncultivated** | 49.2 | 45.6 | **47.4** | 48.3 | 45.2 | **46.8** | 48.1 | 44.9 | **46.5** | 48.1 | 44.7 | **46.4** |
| **Soybean- wheat** | 48.9 | 43.6 | **46.2** | 48.1 | 43.4 | **45.7** | 47.6 | 43.0 | **45.3** | 47.6 | 42.6 | **45.1** |
| **Rice –wheat** | 47.9 | 42.7 | **45.3** | 47.8 | 42.4 | **45.3** | 47.5 | 42.4 | **45.0** | 47.3 | 42.4 | **44.8** |
| **Soybean- Chickpea** | 49.1 | 43.0 | **46.0** | 48.7 | 42.6 | **45.6** | 48.7 | 42.2 | **45.4** | 48.7 | 41.9 | **45.3** |
| **Maize-wheat** | 48.1 | 42.4 | **45.3** | 47.9 | 42.4 | **45.2** | 47.5 | 42.4 | **45.0** | 47.5 | 41.8 | **44.6** |
| **Mean** | **48.8** | **43.9** | | **48.3** | **43.7** | | **48.1** | **43.5** | | **48.0** | **43.3** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.65** | **1.13** | **1.60** | **0.87** | **1.50** | **2.12** | **0.92** | **1.59** | **2.25** | **0.45** | **0.77** | **1.09** |
| **CD (p=0.05)** | **1.91** | **NS** | **NS** | **2.54** | **NS** | **NS** | **2.69** | **NS** | **NS** | **1.31** | **NS** | **NS** |

**S1:Vertisol S2: Inceptisol**

### 3.6 Porosity

Data related to the porosity in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 6. The results clearly indicated that porosity was significantly affected by soil type and not afffecected by different land use practices. It is evident from data the porosity was found higher under Vertisol compare to Inceptisol. It was also found that irrespective of different land uses the porosity decreased with depths. It is also evident from the data that the porosity of different land uses practices ranged from 47.9 to 49.4 at 0-15 cm, 47.8 to 49.0 at 15-30 cm, 47.5 to 48.9 at 30-45 and 47.3 to 48.8 % at 45-60 cm, respectively under Vertisol and 42.7 to 46.2 0-15cm, 42.4 to 46.0 15-30cm, 42.2 to 46.0 30-45 cm and 41.8 to 46.0 45-60 cm in Inceptisol. Numerically the maximum values of porosity (49.4,49.0 48.9 and 48.8%) at respective soil depths were obtained underforest land , while minimum ( 47.9,47.8, 47.5 and 47.3%) at 0-15, 15-30, 30-45 and 45-60 cm under rice-wheat cropping system in Vertisol and Inceptisol maximum values of porosity (46.2,46.0,46.0 and 46.0%),while minimum (42.4,42.4,42.2 and 41.8%) at respective depth under maize-wheat. The addition of FYM promotes the total porosity of soils as the microbial decomposition products of organic manures such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents increase the porosity and decrease the bulk density of the soil by improving the aggregation. The higher soil porosity of the soil of the surface layer than sub surface layer it might be due to ready exchange of $O_2$ and $CO_2$ between the soil and atmosphere there by, promoting better root growth in soil. Similar findings were also reported by Hati *et al.*,2013, Thakur *et al*.,1992 and Moharana *et al.,* 2015.

### 3.7 Water holding capacity

Data related to the WHC in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 7. The results clearly indicated that WHC was significantly affected by different land uses and soil type. It is evident from data the WHC was found higher under vertisol compare to inceptisol. It was also found that irrespective of different land uses the WHC decreased with depths in Inceptisol, however increasing with depths in Vertisol. It is also evident from the data that the WHC of different land uses practices ranged from 41.1 to 46.5 at 0-15 cm, 41.8 to 47.0 at 15-30 cm, 42.3 to 48.3 at 30-45 and 42.9 to 48.7 % at 45-60 cm, respectively under vertisol and 29.4 to 34.2 0-15cm, 28.6 to 32.5 15-30cm, 25.2 to 29.6 cm and 25.0 to 29.2 45-60 cm in Inceptisol. Numerically the maximum values of WHC (46.5,47.0,48.3 and 48.7%) at respective soil depths were obtained under forest land , while minimum ( 41.6, 41.8, 42.3 and 42.9 %) at 0-15, 15-30, 30-45 and 45-60 cm under rice-wheat cropping system in Vertisol and Inceptisol maximum values of porosity (34.2, 32.5, 29.6 and 29.2%),while minimum (29.4,28.6,25.2 and 25.0 %) at respective depth under rice -wheat. The continuous application of FYM decrease bulk density, increase porosity and reduce crust formation thus increase macro and micro pores in soil which help to increase water holding capacity. Maximum WHC was found vertisol under forest land might be due to high organic matter *Saha et al.,* (2010) and Vengadaramana *et al.,* (2012). WHC increased with increasing soil depth might be due to higher clay content at greater depth of soil Senjobi and Ogunkunle (2011).Similar findings were reported by, FAO (2005) reported increased water holding capacity with high proportion of clay content and organic matter.

Table 7 : Effect of land use practices on WHC of vertisol and inceptisol at different depths

| Soil depth (cm) | Water Holding Capacity (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | | | 15-30 | | | 30- 45 | | | 45-60 | | |
| Factor B (Land Uses) | Factor A (Soil types) | | | | | | | | | | | |
| | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean | S1 | S2 | Mean |
| **Forest** | 46.5 | 34.2 | **40.4** | 47.0 | 32.5 | **39.7** | 48.4 | 29.6 | **39.0** | 48.7 | 29.2 | **39.0** |
| **Uncultivated** | 41.6 | 29.4 | **35.5** | 41.8 | 28.6 | **35.2** | 42.3 | 25.2 | **33.8** | 42.9 | 25.0 | **34.0** |
| **Soybean- wheat** | 44.3 | 31.0 | **37.7** | 46.1 | 30.2 | **38.2** | 48.1 | 27.7 | **37.9** | 48.5 | 25.9 | **37.2** |
| **Rice –wheat** | 42.7 | 30.5 | **36.6** | 44.2 | 30.0 | **37.1** | 45.4 | 26.8 | **36.1** | 45.8 | 25.4 | **35.8** |
| **Soybean- Chickpea** | 44.9 | 31.7 | **38.3** | 46.4 | 30.6 | **38.5** | 48.4 | 28.5 | **38.5** | 48.7 | 26.7 | **37.7** |
| **Maize-wheat** | 43.4 | 30.1 | **36.8** | 44.3 | 28.9 | **36.6** | 45.8 | 26.7 | **36.3** | 46.1 | 25.6 | **35.9** |
| **Mean** | **43.9** | **31.2** | | **45.0** | **30.1** | | **46.4** | **27.4** | | **46.8** | **26.4** | |
| | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** | **A** | **B** | **A x B** |
| ***SE m±*** | **0.51** | **0.88** | **1.25** | **0.34** | **0.59** | **0.83** | **0.60** | **1.04** | **1.46** | **0.37** | **0.64** | **0.91** |
| **CD (p=0.05)** | **1.49** | **2.59** | **NS** | **1.00** | **1.72** | **NS** | **1.75** | **3.04** | **NS** | **1.09** | **1.89** | **NS** |

**S1: Vertisol S2: Inceptisol**

## CONCLUSION

The present study concluded that physical properties of soil significantly affected by soil type. It was observed that WHC in different land use practices are significantly affected. The value of WHC, bulk density and Clay was found increased down the depth except Porosity, sand in Vertisol. Value of sand and bulk density was found increased down to depth except WHC, porosity and clay in Inceptisol. A good agreement of physical properties was found in forest land.

## REFERENCES


Virmani S M, Rao M R, Srivastava K L. Approaches to the management of Vertisols in the semi-arid tropics: The ICRISAT experience. In Management of Vertisols for improved agricultural production: Proceedings of an IBSRAM inaugural workshop, 18-22 Feb 1985, ICRISAT, Patancheru, India (Burford J R and Sahrawat K L, eds.), Patancheru 520 324, Andhra Pradesh, India: International Crop Research Institute for the Semi-Arid Tropics. 1989;17-33.

E.A., Ii. (2012). Effect of Iron Nutrient Care Sprayed on Foliage at Different Physiological Growth Stages on Yield and Quality of Some Durum Wheat (Triticum durum L.) varieties in Sandy Soil. Asian J.ofCropSci.4(4),139-149.

Alloway, BJ, (2013). Heavy metals in soils – Trace metals and metalloids in soils and their bioavailability (3rd edition). Springer, Dordrecht, The Netherlands, 613.

Alloway,BJ,(2008). Zinc in soils and cropnutrition.2nded.International Zinc Association and International Fertilizer Industry.

Bouyoucos (1927). Method For The Mechanical Analysis Of Soils Soil Science 23(5):343-354.

Richards V,Stanley, Appellant V, MANFRED S. (1954). Respondents. 43 Cal.2d 60.

Black CA. (1965)Methods of Soil Analysis, part II, Chemical and properties, No. 9 series, Agronomy, American Soc. Agron. Madison, Wisconsin, USA;.

Gupta RP and Dhakshinamoorthy C. (1980)Procedures for Physical Analysis of Soils and Collection of Agrometerological Data, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi.

Alemayehu A (2016). Effects of Land-use/Land-cover Changes on the Mean Differences of Soil Properties in the Northeastern Wollega, Ethiopia; degree of Doctor of Philosophy (PhD); Addis Ababa University, Addis Ababa, Ethiopia. J. Soil Sci. and Env Man 5: 100-107.

Eyayu Molla Fetene and Mamo Yalew Amera(2018).The effects of land use types and soil depth on soil properties of Agedit watershed, Northwest Ethiopia, Ethiop. J. Sci. & Technol. 11(1) 39-56.

Saha S, Chakraborty D, Sharma AR, Tomar RK, Bhadraray S, Sen U, Behera UK,Purakayastha TJ, Garg RN and Kalra N. (2010). Effect of tillage and residuemanagement on soil physical properties and crop productivityin maize*(Zea mays)* — Indian mustard *(Brassica juncea)* system. Indian Journal ofAgriculturalSciences80(8):679–85.

Shiferaw Bole (2004) Soil phosphorous fractions influenced by different cropping system in Andosols and Nitisols in KambataTenbaro and Wolaita Zones, SNNPRS, Ethiopia. MSc Thesis Submitted to School of Graduate Studies, Alemaya University, Ethiopia, pp. 126.

Rucknagel J, Hofman B, Olaf C. (2004). Effect of tillage on soil physical properties, total organic carbon content and winter barley yield in a long term experiment in Germany .4th International crop science congress.

Ram H, Singh Y, Timsina J, Humphreys E, Dhillon SS, Kumar K, and Kler DS, (2000). Performance of upland crops on raised beds on Northwestern India. In: C.H. Roth, R.A. Fischer and C.A. Meisner (eds). Evaluation and performance of permanent raised bed cropping system in Asia, Australia and Mexico (pp. 41-58). ACIAR Proceeding No. 121.

Kannan RL, Dhivya M, Abinaya D, Krishna RL and Krishnakumar S. (2013). Effect of integrated nutrient management on soil fertility and productivity inmaize. Bull.Env.Pharmacol.LifeSci.,2(8):61-67.

Nandapure SP, Sonune BA, Gabhane VV, Katkar RN and Patil RT. (2018). Long term effects of integrated nutrient management on soil physical properties and crop productivity in sorghum-wheat cropping sequence in a vertisol. Indian J. Agric.Res.,45(4):336–340.

Hati KM, Singh RK, Mandal KG, Bandyopadhyay KK, Somasundaram J, Mohanty M, Sinha NK, Chaudhary RS and Biswas AK. (2013). Conservation TillageEffects on Soil Physical Properties, OrganicCarbon ConcentrationandProductivity of Soybean-Wheat Cropping System. Journal of AgriculturalPhysics14(2)pp.121-12.

Vengadaramana A, Jashothan PTJ. (2012). Effect of organic fertilizers on the waterholding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka. J. Nat.Prod.PlantResour.,2(4):500-503.

Senjobi BA,Ogunkunle AO.(2011).Effectofdifferentlandusetypesandtheirimplications on land degradation and productivity in Ogun State, Nigeria. JournalofAgriculturalBiotechnologyandSustainableDevelopment3(1):7-18.

FAO.(2015). The importance of soil organic matter. Key to drought-resistant soil andsustainedfoodproduction.FoodandAgricultureOrganizationofTheUnitedNations. FAOSoilsBulletin No.80.Rome,Italy.