

**EFFECT OF SOME TILLAGE PRACTICES ON SOIL PHYSICAL PROPERTIES  
IN MUB NORTH ARABLE LANDS ADAMAWA STATE, NIGERIA.**

**BY**

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**A THESIS SUBMITTED TO THE DEPARTMENT OF SOIL SCINCE, SCHOOL  
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UNIVERSITY OF TECHNOLOGY, YOLA.**

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**DECLARATION**

I hereby declare that this research work entitled “EFFECT OF SOME TILLAGE PRACTICES ON SOIL PHYSICAL PROPERTIES IN MUBI NORTH ARABLE LANDS, ADAMAWA STATE, NIGERIA” is my original work and has not been previously submitted to any institution either in part or in full for the award of any degree or certificate. All references have been dully acknowledged.

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**SULE Thomas**

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**Date**

### APPROVAL PAGE

This thesis entitled “EFFECT OF SOME TILLAGE PRACTICES ON SOIL PHYSICAL PROPERTIES IN MUBI NORTH ARABLE LANDS, ADAMAWA STATE, NIGERIA” by THOMAS Sule meets the regulations governing the award of the degree of masters of technology(M.Tech) Soil Science of the Modibbo Adama University of Technology, Yola and is approved for its contribution to scientific knowledge and literary presentation.

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## **DEDICATOIN**

This research work is dedicated to my son Almodad Thomson Thomas and to my present and future generation of Nasara Takwanenya family.

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## ABSTRACT

*This research work is aimed at assessing the effect of conventional and minimum tillage on soil physical properties of soil in the study Area. The specific objectives pursued were: To evaluate the impact of plough dredge on soil compaction of the study area, to determine existence or absence of plough pans in the soil study area and to measure, compare the changes in some soil physical properties of the soil under conventional and minimum tillage practices by the farmers in the study area. The experiment was conducted in Mubi of Adamawa state Nigeria. The study area is located between latitudes: -  $10^{\circ} 05'$  and  $10^{\circ} 30'$  N and between longitudes  $13^{\circ} 12'$  and  $13^{\circ} 19'$  E of the Greenwich meridian. The area of the study falls within the northern guinea savannah zone characterized by mixture of grasses, shrubs and scattered tree species, which may be as a result of low rainfall and long dry periods. The study area covers about  $540m^2$  on each of the locations. Results indicates that there were no significance difference in most of the soil physical properties at  $P = 0.05$  levels. Also results on the two types of tillage shows that: Bulk density, clay, Organic Matter and Organic Carbon were all significant at  $P = 0.05$  at depth levels. Properties mention above were higher in conventional tillage plot than in Minimum tillage plot especially in the subsurface horizon of the study area. The values of the Bulk densities for Conventional and Minimum tillage were found  $1.42 g/cm^3$  and  $1.3 g/cm^3$  respectively. Infiltration rate were statistically significant at  $P = 0.05$ . It was higher in the conventional than the other practice. Conventional tillage was also higher than the minimum tillage practice with the infiltration rate of about  $12 cm/hr.$  and  $3 cm/hr.$  respectively.*

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## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background of the study**

In Mubi north of Adamawa state, dominant tillage operations involve disc ploughing with a tractor. In addition, Ox-drawn plough are employed depending on an individual economic power. Some of the farmers involved in this area to first cultivate a land manually using a hand held hoes and other simple farm tools like: rake, axe, and others. In this work, the use of tractor or Ox-drawn plough are both considered as conventional tillage whereas the use of hoe to manually cultivate the land is termed as minimum tillage. These two practices affect the soils at different depths. For instance, the use of hoes may not exceed 5- 10 cm soil depth, while the disc plough could impact depth of 30 cm and above. Literature have shown that these tillage operations could impact the soils positively or negatively. The major soil properties commonly affected by tillage operations are the soil physical properties such as: bulk density, particle density, total porosity, water holding capacity, organic matter and water content. It is also clear that reports of tillage effects on soil physical properties at the field scale are often Contradictory (Lal and Van Doran, 1990; coutadeur et al., 2002).

Tillage is the mechanical manipulation of the soil to provide soil conditions suited to the growth of crops, the control of weeds, and for the maintenance of infiltration capacity and aeration. Indiscriminate tillage, tillage without thought of topography, soil, climate, and crop conditions will lead to soil deterioration through erosion and loss of structure. Tillage is the “mechanical manipulation of the soil for any purpose” (SSSA, 2007). It is important to seedbed preparation, weed control, and incorporation of agricultural chemicals or amendments. Although no-till management is generally preferred over practices that disturb soil, an occasional tillage may be necessary, in some soils (e.g. clayey), to:

- (1) Alleviate excessive soil compaction,
- (2) Reduce interference of surface crop residues during plant establishment, and
- (3) Offset stratification of nutrients and soil organic matter due to the confinement of crop residues to the soil surface. Certain no-till planters have attachments to slightly loosen the soil and remove crop residues from the rows while placing seeds. Major concern with tillage arises when it becomes intensive. Tillage practices profoundly affect

soil physical properties. It is essential to select a tillage practice that sustains the soil physical properties required for successful growth of agricultural crops (Stevens, 2009). It is generally accepted that the type of tillage system adopted for soil manipulation prior to planting does affect the geometry of the root systems, nutrient accessibility to plants and consequently, crop establishment and growth (Ashraful et al., 2001). However, any manipulation that changes soil condition may be considered as tillage.

Hillel, 1971; Klute, 1986; Reynolds and Elrick, 2002 state that the rate at which water enters into the soil surface (infiltrability) and transmits through the soil profile (saturated hydraulic Conductivity) depends on soil structure, pore size distribution and pore continuity. More so, porosity is also a function of pore size distribution, pore continuity and hydraulic Conductivity of pore size distribution, pore continuity and hydraulic conductivity (Benjamin, 1993). Two of the most commonly measured soil physical properties affecting hydraulic conductivity and other hydraulic properties are the soil bulk density and effective porosity, as these two properties are also fundamental to soil compaction and related agricultural management issues (Strudley et al., 2008). Although in-situ saturated hydraulic conductivity ( $k_s$ ) is considered as one of the most important Parameters for water flow and chemical transport phenomena in soil (Reynolds and Elrick, 2002), relatively few studies have evaluated and compared the effects of various tillage practices on physical and hydraulic properties of the soil. These soil properties are all affected by tillage, one of the most influential management practices influencing soil physical and hydraulic characteristic (Hal and Shulka, 2004). Tillage can alter soil structure by creating macro pores that considerably increase saturated hydraulic conductivity (Bouma, 1991). Tillage can affect pore size distribution by creating temporary pore spaces that either collapse or seal during the growing season as result of raindrop impact, wetting and dry cycles (Topaloglu, 1999). And tillage practices can disrupt pore continuity and macro pores, reducing water flow between the plough layer and subsoil (Bouma, 1991) at the soil surface, the impact of raindrops on a bare soil surface can decrease porosity through the formation of surface seals and crust. These limit the rate of infiltration, leading to runoff. Any traffic in the field, such as machinery, ploughing or impact of human feet or animal hooves can put pressure on the sub-soil. Pressure destroys pore spaces, in particular the interconnected pore spaces. The soil becomes compacted and water infiltration and storage capacity are reduced. Plant roots have difficulty in penetrating compacted soil and their root system does not develop well.

The purpose of tillage is to create soil conditions favorable for seed germination and crop production. It greatly affects water resources, particularly surface water. Tillage management is an important factor to be considered when attempting to reduce soil erosion and sedimentation. Tillage practices that control soil erosion also protect water quality (Weston, 1994).

Although, incorrect soil tillage due to a failure to understand the objective and limitation of tillage techniques, can give rise to negative effects. Incorrect tillage is one of the causes of erosion and physical degradation of soil. Furthermore, excessive tillage or tillage undertaken when the soil moisture content is not appropriate causes adverse effects. Excessive tillage on the surface breaks up the aggregates, favoring the formation of surface crusts, increased run off and the erosive transport of the soil particles.

According to Topaloglu (1999), he found that tillage practices had no appreciable effect on Infiltration rates in sandy clay loam soils. Ankeny et al. (1990) noted no differences in Infiltration rates between tilled and untilled soils, while heard et al. (1988) observed higher Infiltration rates in tilled soils and attributed the difference to soil surface sealing in untilled soils. Fabrizzi et al, (2005) concluded that there is greater soil bulk density under conservation tillage than conventional tillage. In contrast Hill and Cruse (1985) reported no significant effect of tillage methods (no-tillage, ploughing-tillage, and minimum tillage) on bulk density of a loess derived lower soil. Studies conducted By Blevins and Frye (1993) in Kentucky found, no significant effect on bulk density after 20 years of corn production compared no- tillage and moldboard plough. The surface 0-5cm of the no-tillage soil had slightly lower bulk density than the surface of the moldboard-plough system

## **1.2 Objectives of the Study**

### **1.2.1 Broad objective**

To investigate the effect of conventional and minimum tillage on soil physical properties of soil in the study Area.

### **1.2.2 Specific objective**

1. To determine existence or absence of plough pans in the soil study area.

2. To measure and compare changes physical properties of the soil under conventional and minimum tillage in the study area.

### **1.3 Scope and limitation**

This research covered mainly two types of tillage practices for conserving soil based on the fact that is the most common practice in use in the study area. The study was carried out in one of the eleven wards (Vintim ward) of which is limited to the first three wards (Digil ward, Muchalla ward Lokuwa ward, Nassarawo ward, Mijilu ward, Mayobani ward, Yalwa ward, Kolere ward, Betso ward and Bahuli ward out of eleven wards because they have the same cropping system with the same arable land for crop production. Terrain and time among others. The selected soil physical properties are listed below: Water holding capacity, grave metric water content (GWC), water infiltration which was determined on-situ (on the field), organic matter, Related soil physical properties such as particle density, bulk density and porosity which were all determined in the laboratory. The different tillage practices were selected based on the research work (conventional and minimum tillage).

## **1.4 Study Area**

### **1.4.1 Location and extent**

The study area is Mubi north and its environs. Mubi is a town in Adamawa north senatorial district Adamawa State, Nigeria located between latitude  $9^{\circ} 30'$  and  $11^{\circ}$  north of the equator and longitude  $13^{\circ}$  and  $13^{\circ} 45'$  east of the Greenwich meridian. The study area is however, bounded in the north by Michika Local Government, in the East by the Republic of Cameroon, while it shares boundary with Hong Local Government as well to the south. It has a land area covering  $4728.77\text{km}^2$  (Adebayo, 2004), this is shown in figure 1.

### **1.4.2 Geology**

The study area falls within the North East basement complex of Nigeria. According to Adebayo and Dayya (2004), the rocks are pre-pan African Organic rocks (Genesis Gigmatite rocks) or pan African deformation and NE- SW making the pan Africa thermodynamic events (Bassey, 2004 in Adebayo, 2004).

### **1.4.3 Climate**

The climate type is a tropical continental which is dominated by wet and dry season, coded AW in the Copen's climate classification.

The **temperature** in the area ranges from warm to hot throughout the year due to high incoming solar radiation, even though there is usually a cool period in the month of November and February. A gradual increase in temperature is experienced in the area which commences from January through to April at which its peak is reached (Adebayo, 2004). Temperature also drops slightly in May at the onset of rain due to the effect of cloud. The wet season is followed by a cold period during Hamattan when temperature drops to minimum between the months of (October – November).

Comment [H1]:

However, the location of Mubi north has a significant effect on the microclimate of the area. Thus, temperature is very low with its mean minimum temperature ranges from  $12.7^{\circ}$  –  $32.8^{\circ}$  in January and  $18.6^{\circ}$  –  $32.7^{\circ}$  at which it's maximum is reached. These are found in some uphill settlements such as Jilvu, Mijilu, Muchalla and Mukta. Generally speaking, mean temperature in Mubi is fairly lower than what is obtained in the central part of the state around Yola (Adebayo, 2004). Mention should also be made to the relative humidity in Mubi area. Relative humidity is generally low which is experienced between January and March. It rises from April and reaches its maximum in August, which is the peak of rainy season but start to decrease from October when rain ceases. Like any other part of the tropical zone, the rainfall pattern in Mubi area is controlled by the movement of the inter Tropical Convergence Zone (ITCZ) or Inter Tropical Discontinuity (ITD), as know by sailors as the doldrums. This is the dividing zone between the cool and dusty Continental Tropical (CT) air mass and the warm and wet Tropical Maritime (MT) air mass. The movement of the ITD determines the rainfall regime and weather conditions at a particular time of the year. However, between November and March Mubi area is under the influence of ITD with scanty or no rainfall received during this period, April appears to be a month of transition between dry and wet season. During this period the amount of rainfall received is scanty which is often accompanied by strong and destructive wind storms. The month of May to September constitute the wet season. Here, rainfall increases steadily from May and reaches its peak in the month of August with a dramatic increase from September to October due to the southward movement of the ITD which is twice faster than its northward movement. Therefore, the relatively higher rainfall receives in Mubi as compared to the central zone of Adamawa State is due to aerographic factor. The high mountain ranges in the area

induce aerographic rainfall which contribute substantially to increase in the rainfall amount. And this explains why planting of crops begin earlier in the mountainous area than the lowland area due to the aerographic factor. This can be better explained by the record of rainfall data presented in table 1.1 and figure 2 respectively.

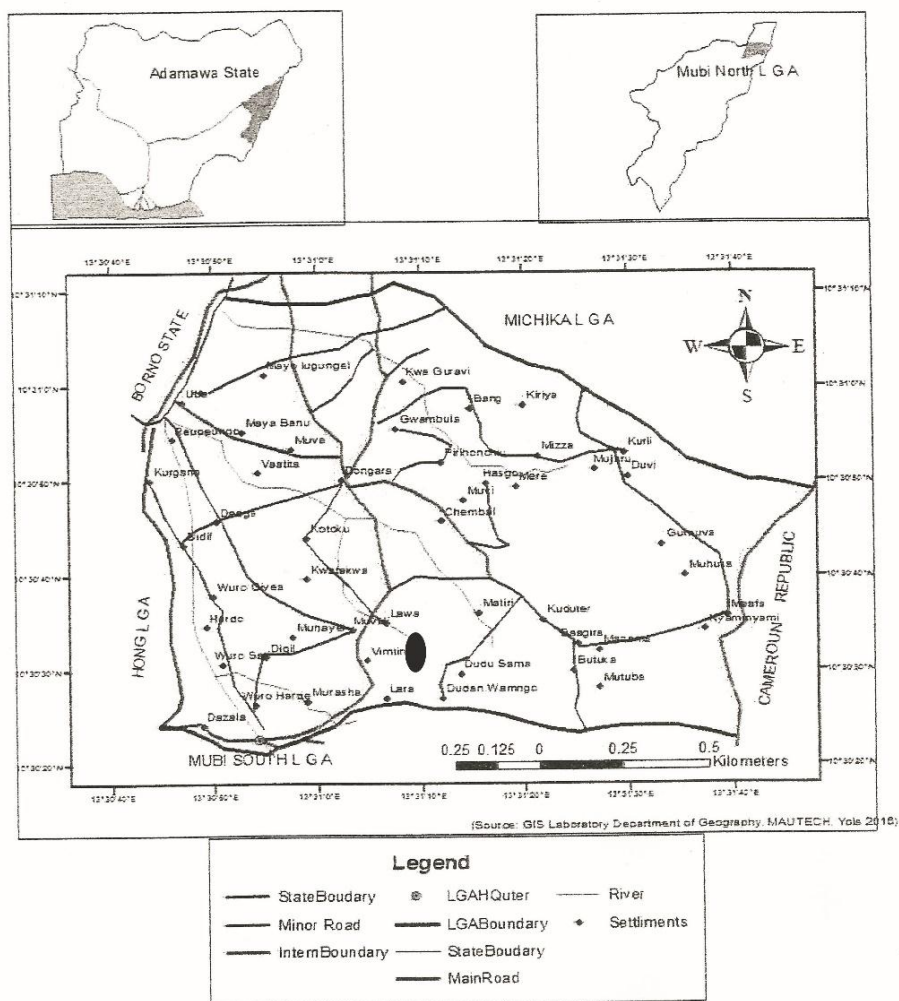


Figure 1: Map of the Study Area

The figure above shows the map of the study area. The map shows that Mubi north, is located in the northern part of Adamawa state of Nigeria. On the map, the biggest black spots indicates the exact position where the research was conducted in Vimtim ward “Baa” district Mubi North Local Government.

#### ***1.4.4 Relief and drainage***

The study area is made up of mostly high lands. The region has a distinct relief with series of mountain ranges lying along its eastern border with Cameroon. The area is characterized by hills/mountains ranges, up-land plains and lowland valleys troughs (Tukur, 1999 in Adebayo, 2004). The mountainous area rise to the heights of 455 meters to 1065 meters above sea level. The predominant drainage system in the area is Rivers Yedzaram (Adebayo and Dayya, 2004). It takes its source from Gela hills in the southernmost part of Mubi and flows through the region in a south-north direction which eventually empties into Lake Chad. The river has many tributaries that are perennial in nature which consist Mayo bani, Digil and Muvur River all within the study Area.

#### ***1.4.5 Soil***

The spatial pattern of Mubi region is generally sloppy, which gives rise to the differences in soil texture, depth and holding capacity. The soil colour ranges from yellow through red to brown and are mostly coarse in nature, stony and very shallow and undefined profiles. The soil contain much of oxide of iron and Aluminium which are responsible for their varied coloration. Mubi soils are also rich in feldspars, Mica and Hornblende, metallic minerals as well which are vital for plant growth. According to FAO/UNESCO, (1988) soil classification system, the soil in the study area is divided into three major types: these are the Lithosols, Luvisols and Gleyic Cambisols soils. Lithosols are soils with less developed profiles (<10cm depth) due to their formation over the sloppy hard rocks of Mandara Mountains. The organic matter content is moderate too low (Ray, 1999). The soils under this category are acidic in nature because of the parent materials from which they are formed. However, the soils are thicker at the foot of the hill and thin-out up the slopes. Lithosols at the bases of the Mandara Hills are mostly sandy-loam and moderate to coarse in texture (Ray, 1999). Luvisols are soil derived from basement rock parent materials that have been leached. They are alkaline in nature with clay rich base horizon. According to Ray, (1999). They are characterized by medium to high base status with PH of about 5.1 to 6.1 Luvisols are made up of low organic matter content. It has low cat ion and exchange capacity and water retention capacity are generally low. Gleyic luvisols are developed under poor drainage or excess water with mainly hydromorphic properties, which include reduce iron and other element, grey colours and mottles. Gleyic Cambisols are soil influenced by seasonal water logging by

underlying previous shale's forming scattered ferric concretion. The soils are low in nutrients but are good for dry season farming. They are mostly found in the study area along the Yedzaram river valley through Mubi and Mayo Bani

#### **14.6. Vegetation**

The vegetation of the study area falls within the Sudan savannah belt of the Nigeria's vegetation zone (Yonnana, 2004). It is made up mostly of shorter grasses, aquatic weeds found in river valleys and dry land weeds interspersed by shrubs and woody plants

The grasses and weed account for about 70% of the vegetation in the area. Their height ranges from few centimetres to about one meter tall. It is important to note that some of the weeds and grass species are used for animals' feeds, while tall grasses found serve as good materials for making "zana" used for fencing and roofing of thatched houses by the rural dwellers. The predominance grasses and weeds species include *Amaranthus spinosus*, *Seteriabarbata*, *Pennisetumpolystechion*, *Tridaxprocmbens*, *Ipomoea eriocarpa*, *Syndrellanodifera*, *chrysanthellm*, *Eraggrotistisenella*, *Schzachchyrum*.

In addition, the woody plants found in the area are of two types: the indigenous plants which form parts of the natural vegetation and the exotic species which were brought from other places. The indigenous plants that inhabit the study area include *Tarmartindusindica*, *Acacia albida*, *prosopls Africana*, *Ziziplusspinachristi*, *vitelleriaparadoxa*, *parkeabiglobosa*, *Borassuaethiopum*. While the exotic species are *Eucalyptus spp*, *Khayaseneglansis*, *Phoenix dactylifera*, *Psidiumguajava*, *Anacardiumoccidentale*, *Azadictrataindica* to mention just a few. However, vegetation distribution in the area is influenced by the region belief pattern, soils and climate. Natural vegetation in the area has been altered by human activities with little or non- on the mountainous areas. According to political wards. Most of the rural settlements in the study area have periodic village markets which operate on weekly basis.

#### **1.4.8 Population**

According to the national population commission (NPC, 2006), the study area has a total population of 151,072, with male constituting 78,222 and female 72,850. The study area has a population density of 31.94 person per square kilometres (NPC, 2006), which could be referred to as low density area. Mubi is a Multi-ethnic society with its major tribe been

Fulani, Gude, Fali, Margi, Higgi, Kilba, Hausa, with several other tribes within and outside the state such as Godogodo, Kanuri, Igbo and Yoruba.

#### ***1.4.9 Economic activities***

The predominant occupation of the study area is agriculture, even though it is influenced by some factors like climate, soil and urbanization. The cash crops produced are groundnut and beans, while food crops includes maize, guinea corn, rice, millet and cassava. The village community living on the banks of the river found in the river engages in the local fishing. Other services found in the area includes local crafts such as weaving; black smiting, pottery making and wood carving, elsewhere are Fulani nomads. Besides, civil service is another occupation found in the study area. It is associated with several civil service functions which includes politics, administrative, educational, health and legal practitioners as well. The study area been a commercial centre is made up of road networks linking all its surrounding villages. However, vegetation distribution in the area is influenced by the region belief pattern, soils and climate. Natural vegetation in the area as been altered by human activities with little or non- on the mountainous areas.

#### **1.5 Land use**

Land used in the study area comprises of agricultural, residential, administrative, and commercial among other. Agricultural land use includes: arable farming, graze land, wildlife/recreation, rangeland and fisheries among other. Agricultural activities are carried out mostly around the riparian areas. The vast part of the arable farming found in the area is cultivated during the rainy season. The crops mostly grown in the area are maize, millet, rice, cassava, sugarcane, groundnut, guinea corn to mention just a few. However, livestock production characterized rural agricultural practice in the study area, as seen among Fulani nomadic herders. There is no pocket of fish farming on small scale within the few rivers and ponds such as the Yedzaram River. Settlement pattern depicted in the rural area of Mubi region is located within vast agricultural land and on hills tops due to relief of the area. Bashir and Raji (1999) reported a nearest neighbour index of about 1.7 for the region. Along the major roads are groups of the linearly settled villages. Equally, clusters of the villages are found around the foot of mountain ranges that characterized the region. The rural community cluster in Mubi region are organized according to political wards. Most of the rural settlements in the study area have periodic village markets which operate on weekly basis.

#### ***1.4.10 Population***

According to the national population commission (NPC, 2006), the study area has a total population of 151,072, with male constituting 78,222 and female 72,850. The study area has a population density of 31.94 person per square kilometres (NPC, 2006), which could be referred to as low density area. Mubi is a Multi-ethnic society with its major tribes being Fulani, Gude, Fali, Margi, Higgi, Kilba, Hausa, with several other tribes within and outside the state such as Godogodo, Kanuri, Igbo and Yoruba.

## **CHAPTER TWO**

### **LITERATURE RIVIEW**

#### **2.1 Introduction**

The section of research reviews related literatures to the study. The review covers: importance of tillage for crop production, description of tillage practices, effects of tillage on soil physical properties, infiltrations of water in the soil, clod forming tillage, disc plough, tillage speed, frequency of tillage pass, addition of residue, animal dungs, saw dust, minimum, conventional, and soil tillage.

#### **2.2 Importance of Tillage Practice for Crop Production**

Particular objectives of tillage include preparation of a seed bed, destruction of weeds, improvement of soil- water-air relations and reduction of impedance to plant roots (Marshall and Holmes, 1979). Therefore, the main purpose for primary soil tillage is to loosen the soil which has been compacted by machinery traffic or by natural processes. However, tillage should provide a soil surface condition that enables water to be detained and Infiltrate rapidly during the part of the cropping season when runoff is most likely to occur (Allmaras, 1977). Tillage also mixes plant residues with the soil which may speed up the activity of the soil microorganisms in decomposing crop residues and soil organic matter. Mechanical tillage is the most commonly used direct method of altering the soil condition for crop production. Tillage tools including ploughs, chisels, cultivators, and harrows are designed to shatter, cut, loosen, invert or to mix the soil and to smooth or shape its surface. Ploughing turns the soil over and cover crop residues, usually producing enough cloddy surfaces. Disking breaks the clods to smaller particles and harrowing smoothes the surface to form a seed bed (Thompson et al., 1973). A good seed bed provides a suitable environment for seedling establishment.

#### **2.3 Description of Tillage Practices**

The combined primary and secondary tillage operations, normally performed in preparing a seed bed for a crop grown in a given area is called conventional tillage. A conventional tillage is made up of ploughing, disking, harrowing and planting. The operation of tillage equipment results in a number of changes in the soil, some of which are undesirable (Blakely et al., 1978). Soil structure is the physical constitute of a soil material as expressed by the size, shape and arrangement of the soil particles and associated voids including both the primary particles to form compound particles and the compound particles themselves (Brewer and Sleeman, 1960). All tillage operations change

the structure of the soil, thereby changing the pore size distribution, which alters the soil hydraulic properties of the tilled layer. The lifting, twisting and turning action of the plough leaves the soil in an aggregated and loose condition. Each type of tillage system has a different effect on surface water runoff and erosion. A tillage system that aids in moisture retention and decreases soil erosion will benefit surface water quality. Recommended tillage systems are generally categorized as either conservation tillage or conventional tillage (Weston, 1994).

#### **2.4 Tillage Effects on Bulk Density and Porosity**

Soil naturally possesses different densities owing to variations in their texture, porosity and organic matter content. Brady (2002) quotes sandy soils as having a density of 1.2 to 1.8 Mg/cm<sup>3</sup> and a porosity of 35 to 50 percent. However, the density and the porosity vary according to the type and the intensity of tillage, thus they are good indicators of the adequacy of various tillage systems, indicating the serious or minor compaction which the tillage operation have caused. Adequate values for soil density were defined by Archer and Smith (1972) as those which provide maximum moisture availability and at least 10 percent air in the pore spaces at a suction of 50mb. According to the authors, these optimum soil densities are around 1.75Mg/cm<sup>3</sup> for loams, 1.40Mg/cm<sup>3</sup> for silty loams and 1.2mg/cm<sup>3</sup> for clay loams. Modifications to the soil physical properties due to tillage systems can give rise to an increase in soil density, greater resistance to root penetration and a reduction in soil porosity, characterized by a compacted layer below the cultivated horizon. This compacted layer affects the movement of the root system due to the mechanical impediment and the lack of air. As a consequence of the increased density, there is a corresponding but much more significant increase in the resistance of the soil to root penetration. It was observed by Voorhees et al. (1978), when working in a clay silt loam under the same weight of vehicles, that the soil density increased 20 percent whilst the resistance to root penetration increased more than 400 percent. The values of the resistance to plant root penetration that limit crop development vary from one crop to another. Lipiec, (2006) found that soil aggregate bulk density and water stability were greater and rate of wetting and sorptivity were smaller in reduced and no-tillage treatments compared with CT. Greater soil organic matter and bulk density accompanied greater water stability. Smaller rate of wetting and sorptivity can be associated with lower aggregate porosity.

## **2.5 Tillage Effects on Infiltration.**

Tillage changes the physical characteristics of a soil surface in a number of ways. Among these factors are structure, surface roughness and the bulk density. Change in bulk density results in changes of porosity, pore-size distribution, infiltration rates, water retention and soil temperature. The infiltration rate of water into the soil determines the rapidity of this process and thus, the volume of water that will remain to run off over the soil surface. When the infiltration rate is low, moisture availability in the root zone can be limiting. The infiltration rate is conditioned by the state of the surface, the rate of transmission of the water through the soil profile, the soil moisture storage capacity and flow characteristics of the water. Water infiltration in the soil, reflect the soil properties. Cropping and tillage systems influence the eventual infiltration rate, both through modification to the roughness and through changes to the structure, density and porosity of the soil. Soil tillage can initially improve infiltration and also, sometimes, benefit drainage. But as time passes, tillage favours degradation of the structure and a reduction of the infiltration rate. Tillage practices can also have major influence on erosion.

## **2.6 *factors affecting infiltration rate***

The major factors affecting the infiltration of water into the soil are the initial moisture content, condition of the soil surface, hydraulic conductivity of the soil profile, vegetation cover, rainfall and viscosity of water. The antecedent soil moisture content has considerable influence on the initial rate and total amount of infiltration, but decreasing as the soil moisture content rises. The infiltration rate of any soil is limited by any restraint to the flow of water into and through the soil profile. The soil layer with the lowest permeability, either at the surface or below it, usually determines the infiltrate rate. Infiltration rates are also affected by the porosity of the soil which is changed by cultivation or compaction. Cultivation influences the infiltration rate by increasing the porosity of the soil surface and breaking up the surface seals. The effect of tillage on infiltration usually lasts only until the soil settles back to its former condition of bulk density because of subsequent irrigation. Infiltration rate are generally lower in soils of heavy texture than on soils of light texture.

It has been established that in surface irrigation, increased depth increases initial infiltration slightly but the head has negligible effect after prolonged irrigation.

Infiltration rates are also influenced by vegetal cover. Infiltration rates on grassland are substantially higher than bare uncultivated land. The hydraulic conductivity of the soil profile often change during infiltration, not only because of increasing in moisture content, but also because of the puddling of the surface caused by reorientation of surface particles and washing of finer materials into the soil. Viscosity of the water influences infiltration. The high rates of infiltration in the tropics under otherwise comparable soil conditions are due to the viscosity of warm water.

## **2.7 Bulk Density and Porosity**

Bulk density (dry soil mass per unit volume) is the most frequently used parameter to characterize the soil compaction (Panayiotopoulos *et al.* 1994), but in swelling/shrinking soil, it is recommendable to determine the bulk density at the standard moisture contents (Håkansson and Lipiec 2000). Typical resistance indicators, used nowadays, are highly precise for the soil density measurements up to the soil depth of 20 cm while for deep stratum, the stress state transducers with six earth pressure gauges that measure three dimensional stresses can be useful (Eguchi and Muro 2007). The bulk density is difficult to measure in gravelly soils (Webb 2002). For an accurate measurement of the effects of the soil compaction on all types of the soil, the soil bulk density alone is not adequate but other soil properties such as the soil strength, soil aeration, and soil moisture should also be measured (Lipiec and Hatano 2003). In an experiment on a clayey oxisol, Silva *et al.* (2008) analyzed the effects of the intensity of traffic on the soil compaction. They removed the 7-year-old Eucalyptus stand manually with chainsaw and soil was compacted with forest tractor, weighing 11,900 kg and loaded with 12 m<sup>3</sup> wood, by driving along same track zero, two, four, and eight times. They found that the first two passes of forwarder caused maximum increase in the bulk density and maximum decrease in infiltration rate. In other experiments, 30% increase in bulk density was observed after mechanical clearing of the forests and 20% increase in the bulk density was found after tree length skidding in pine hardwood stands. Decrease in the soil porosity has been widely reported in the cultivated crops and forests after mechanical operations (Silva *et al.* 2008). Herbauts *et al.* (1996) showed that a logging operation, in the loamy and acidic soils with an illuvial and frequently mottled argillic B horizon, has increased the bulk densities and decreased the total porosity of the soils up to 30 cm depth at two different sites, Terrest and Tumuli. It is reported that an increase in

contact pressure of 100 kPa caused a decrease of 5.7% in the soil porosity at 10–15 cm depth after 24 passes in the sandy humus rich forest soil (Sakai et al. 2008).

## **2.8 Water Infiltration Rate**

Infiltration is the entry of water from the soil surface into the top layer of the soil. The source of this water may be from rainfall, snowmelt or irrigation. Generally, it refers to vertical infiltration, where water movement is either by downward or gravitational flow from the soil surface (Osuji, 1984; Turner, 2006; Shahsavari *et al.*, 2010). Water applied to the soil in the form of rain or irrigation may either infiltrate into the soil profile or run over the soil surface. Those that infiltrate may either serve as source of sustenance to plant and microorganism growth in the soil or replenishment of groundwater supply to wells, streams and springs (Rawls *et al.*, 1993; Oram, 2005) while those that runoff over the surface have the potentials of causing erosion, flooding and decreasing groundwater recharge within the watershed (Gregory et al., 2006). This runoff water eventually end up reaching streams, rivers, lakes and oceans. The process of infiltration can continue only if there is room available for additional water at the soil surface. The available volume for additional water in the soil depends on the porosity of the soil (Hogan, 2010; Ahuja *et al.*, 1998) and the rate at which previously infiltrated water can move away from the surface through the soil (Mbagwu, 1995). The maximum rate that water can enter a soil in a given condition is the infiltration capacity (Hillel, 1980). If the arrival of the water at the soil surface is less than the infiltration capacity, all of the water will infiltrate. If rainfall intensity at the soil surface occurs at a rate that exceeds the infiltration capacity, ponding begins and is followed by runoff over the ground surface, once depression storage is filled (Abdulkadir, 2000). This runoff is called Horton overland flow (Horton, 1940). Infiltration of water into the soil is an unsaturated flow phenomenon involving two essentially immiscible fluids, air and water (Brustkern and Morel-Seytoux, 1975). Water moves because of force of gradient in the soil caused mostly by gravity, osmosis and capillarity. The movement of water in the soil and associated solute transport perform a role of primary importance in many applications in the field of hydrology and agriculture (Comegna *et al.*, 2012). Movement of water occurs from a higher energy state to lower energy state and the driving force for the movement is the potential difference between energy states (Turner, 2006). This potential difference is caused by gravity, osmosis and capillarity. Water moving through the profile is either held in pore spaces within the soil particles for plant use, or percolate to underground water. Soil water infiltration rate can

also be used to monitor the soil compaction status because the soil compaction reduces the total porosity of the soil (Silva et al. 2008), and mainly the number of macro pores, water infiltrates faster in un-compacted soil than in a massively compacted soil of the same type (Hamza and Anderson 2003). These are not directly related to the changes in porosity but rather to the changes in both the number of macro-pores and in the connectivity between macro pores.

### **2.9 Clod-forming Tillage.**

This produces aggregates or clods that are large enough to resist the wind force and trammelled moving particles. They are also stable enough to resist breakdown by abrasion throughout the wind erosion season. If clods are large and stable enough, as smaller particles are removed or trapped, the surface becomes stable or “armored” against erosive action. The duration of protection depends on the resistance of the clods to abrasion or changes in the wind direction. Of the factors that affect the size and stability of soil aggregates, most notable is soil texture. Sandy or coarse-textured soils lack sufficient amounts of silt and clay to bind particles together to form aggregates. Such soils form a single-grain structure or weakly cemented clods, a condition that is quite susceptible to erosion by wind. Loams, silt loams, and clay loams tend to consolidate and form stable aggregates that are more resistant to erosive winds. Clays and silt clays are subject to fine granulation and more subject to erosion.

Many other factors also affect aggregate consolidation and stability — climate, including moisture; compaction; organic matter; lime; micro-organism activity; and other cementing materials. Any process that reduces soil consolidation also increases erodibility. The persistence of aggregates is greatly affected by the climatic process of wetting and drying, freezing and thawing, or freeze-drying, which generally disintegrate clods and increase erodibility. Mechanical action, such as tillage, animal or machine traffic, and abrasion by satiating soil particles also can affect cloddiness. Tillage may either increase or decrease clods at the surface, depending on the soil condition in the tilled layer and the type and speed of the implement. Repeated tillage usually pulverizes and smoothes dry soils and increases their erodibility, especially if done with implements that have an intensive mechanical action, such as tandem disks, offset disks, or harrows. Soil water at the time of tillage also has a decided effect on cloddiness. Research has found that different soils have differing water contents at which soil pulverization is most

severe. If the soil is either extremely dry or extremely moist, smaller clods are produced than at intermediate water contents.

### **2.10 Tillage Depth**

The greater is the depth of tillage implement penetration, the more is the amount of soil available for translocation by tillage operations. In recent years, farmers using mechanized agriculture have increased the plowing depth from 20 to 30 cm, and, in some cases, to even 50 cm. Deep plowing is often used to break plow pans caused by previous tillage or naturally compact layers (e.g., fragi pan, clay pan, hardpan) Tillage erosion increases with tillage intensity and slope gradient (Courtesy T.E.Schumacher, South Dakota State Univ.). Sub-soiling causes greater soil inversion and destruction of natural soil structure. An increase in tillage depth from 20 to 40 cm can increase soil displacement by 75% (St. Gerontidis et al., 2001). Tillage depth changes during tillage as a function of changes in topography, tillage implement (e.g., flexibility), soil condition (e.g., gravel content, stoniness, soil consolidation), and consistency of the operator. Tillage depth using moldboard plow, chisel plow, tandem disc, and field cultivator can increase by about 20% and decrease by about 30% during plowing in undulating soils as compared to that in flat terrains (Lobb et al., 1999). Leached fine soil materials and nutrients to the surface and decomposition of organic matter into deeper layers, plus the primary control of weeds. Four main types of implements are used as primary tillage implements; moldboards, disc plough, chisel plough, and subsoilers plough .Each of them has its specific features (Adam, 2005).

### **2.11 Soil organic matter**

Organic matter is derived from the breakdown of plant and animal residues. It is composed of forty-five to fifty percent carbon, along with oxygen, hydrogen, nitrogen, phosphorus, and sulfur .Organic materials, when applied as mulches or incorporated into the soil, will slowly undergo breakdown by soil microbes into soil humus. Examples of organic matter include plant residues such as lawn clippings, leaves, corn stalks and straw, manures, sludges, wood and food processing wastes, and green manures (plants grown for the purpose of incorporation into the soil).Organic matter and soil humus (highly decomposed organic matter) provide the following benefits to soil health: Provide 90% to 95% of nitrogen in unfertilized soils; nitrogen is the key nutrient and controlling factor for plant growth. Supply plant-available phosphorus and plant-available sulphur

when soil humus is present (25% or more). Improve soil structure by increasing aggregation of soil particles which in turn promotes aeration, infiltration, and percolation. Furnish 30% to 70% of a soil's cation exchange capacity. The higher a soil's cation exchange capacity, the greater its ability to hold onto nutrients until needed by the plant and microbes. Increase plant available water, or water available to plants in-between field capacity (water remaining in the soil after saturated soil has drained) and permanent wilting point (when plants wilt but cannot recover despite the addition of water). Act as chelates which help mobilize metal micronutrients, increasing plant-availability of these nutrients. Reduce soil erosion. Organic matter is a carbon (food) supply for beneficial soil microbes. Nutrients in organic matter are not readily leached from the soil. Composting plant residues (either fast composting or slow composting) may be desirable. Composting will facilitate microbial decomposition of the organic matter into readily-incorporated material. *USDA National Institute of Food and Agriculture, New Technologies for Ag Extension project. Dec. 19 2017.*

## **2.12 Tillage Speed**

Tillage speed is the principal control of soil displacement and transport, which increases linearly with increase of the tractor speed. It is estimated that a reduction of tillage speed from 7 to 4 km h<sup>-1</sup> reduces tillage erosivity by about 30% (Quine et al., 2003). The expansion of agriculture has favoured the use of high tillage speeds to cover large areas, resulting in intensification of tillage erosion. The preset tractor speed changes during tillage, depending on the landscape heterogeneity and soil characteristics. The tractor speed can decrease by about 60% during upslope tillage and increase by about 30% during downslope tillage (Lobb et al., 1999).

### **2.12.1 Frequency of tillage passes**

The higher is the number of implement passes, the larger is the amount of soil displaced. In humid regions with bimodal rains, soil is normally ploughed twice a year, causing more displacement than single plowing. In tropical, semi-arid, and arid regions, soil is mostly ploughed once annually and is also accompanied by hoeing.

## **2.13 Effects of Tillage on Physical Properties Of Soil**

Loss of structure" is a characteristic, which is often used to describe soil profiles that have been tilled for a long time. Partly this is caused by a reduction in organic matter and humus content of the soil. Organic matter plays an important role in the formation

and stabilization of soil aggregates, resulting in a higher resistance to disintegration. Higher aggregate stability under conservation agriculture is the result of the following aspects (Kochhann, 1996): Presence of a mulch layer, which protects the soil surface against the impact of raindrops, No soil disturbance, presence of decomposing organic matter on the surface, which induces aggregation in the upper 0-3 cm, Increase in soil density, which makes aggregates more resistant to changes, Higher concentration of calcium and magnesium in the superficial layer, which affects the structure positively. Although their activity is temporary and will be substituted annually, the hyphae of bacteria and fungi also play an important role in connecting soil particles (Castro Filho, et al., 1998). The preservation of aggregate stability is important in order to reduce surface sealing and increase water infiltration rates. With increased stability the surface runoff is reduced (Roth, 1985). Areas that have never been ploughed and with a constant addition of vegetative material, like forests, have a low bulk density and high macrospore volume. Bulk density indicates the mass or weight of a certain volume of soil. Thus a soil which consists of many channels and pores, weighs less than the same volume of that soil when it is compacted this is explain by Relationship between bulk density and macro porosity of a soil under different types of management by Gassen and Gassen, (1996). Soil bulk density is probably the most frequently measured soil quality parameter in tillage experiments (Rasmussen, 1999). The bulk density of a soil gives an indication of the soil's strength and thus resistance to tillage implements or plants as they penetrate the soil. Soils with higher proportion of pores to solids have lower bulk densities than those that are compact and have fewer pores (Brady and Weil, 1999.). Bulk densities in excess of 1.6 Mg m<sup>-3</sup> can restrict root growth and result in low levels of water movement into and within the soil (Smith, 1988). Aikins, and Afuakwa, (2010) observed that, lowest dry bulk densities found in the disc ploughing followed by disc harrowing plots are supported by the best cowpea performance. Conversely, the highest soil dry bulk densities observed in the No Tillage plots are supported by the worst cowpea performance. The burrows dug by earthworms and the channels left in the soil by decayed plant roots

#### **2.14 Addition of Crop Residue, Animal Dungs, Saw Dust**

Constant addition of this wastes to the surface reduces wind velocity and traps moving soil particles and also improves the fertility of the soil by increasing the percentage of organic matter under disc tillage operations. It can also improve the soil structure. Almost any kind of residue, such as hay, straw, or corn stalks can be used.

Approximately 2,000 to 4,000 pounds of residue per acre is required to control erosion in areas where erosion has already begun. Residue can be distributed with a manure spreader, or even by hand if the area is small. This method is not normally used in entire fields or with row crops, but is most practical as an emergency treatment. A rotary hoe or mulch treader helps spread the residue uniformly.

Normally the residue must be anchored in place with a stubble puncher or a disk with gangs set at a minimum angle and shallow depth. Large stemmed residues such as corn stalks are effective and might not require anchoring. The direction of operation for residue distribution and anchoring should be perpendicular to the direction of the wind. As discussed previously, tillage erosion alters soil properties, which can thus be used as indicators of occurrence of erosion. Soil displacement by tillage causes dramatic changes in soil profile characteristics and soil properties.

### **2.15 Disc Plough**

Action of a disc plough is similar to the mouldboard plough. Disc plough cuts, turns and in some cases breaks furrow slices by means of separately mounted large steel concave discs. A disc plough is designed with a view to reduce friction by making a rolling plough bottom instead of sliding plough bottom as in the case of mouldboard plough. A disc plough works well in the conditions where mouldboard plough does not work satisfactorily.

A standard disc plough consists of a series of individually mounted, inclined disc blades on a frame supported by wheels. These ploughs usually have from 2 to 6 disc blades, spaced to cut 18 to 30 cm per disc. Each disc revolves on a stub axle in a thrust bearing, carried at the lower end of a strong standard which is bolted to the plough beam. The discs are tilted backward at an angle of 15 – 25° from the vertical (tilt angle) and with a horizontal diameter disc face angle of 42 – 45 ° (disc angle) from the direction of travel. Disc diameters are commonly 60 – 70 cm. In action, the discs cut the soil, break it and push it sideways. There is little inversion of furrow slice as well as little burying of weeds and trashes compared to mouldboard plough. Scrapers are furnished as regular equipment on most standard disc ploughs which assist in covering trash and prevent soil build up on discs in sticky soils. Disc ploughs are most suitable for conditions under which a mouldboard plough do not work satisfactorily, such as in hard, dry soil, in sticky soils where a mould board will not scour, and in loose push type soil such as peat lands. (A

mouldboard plough in soils and moisture conditions where it works satisfactorily does Reversible disc plough is similar to standard disc plough, except that it can turn over the furrow slice to left or right side. It not only improves the rate of work but also leaves the field flat and level. This plough is found very successful for contour ploughing because the operation can be performed back and forth on the contour line without any problem. The soil is turned in the direction required to prevent soil erosion. Slopes can also be gradually levelled just by ploughing down the slope every year. It saves water and time, improves irrigation efficiency and ensures an even crop growth.

## **2.16 Minimum Tillage**

No-till works in the same way as conservation tillage, but there is less disruption of soil (e.g. the planter does not go as deep into the soil to plant the seeds, and no crop residue is turned over.)With no-till, the improved soil structure and moisture conserving residue cover makes more water available for crop production by improving infiltration and decreasing evaporation from the soil surface. Changes in soil physical properties due to use of no tillage depend on several factors including differences in soil properties, weather conditions, history of management, intensity and type of tillage (Fabrizzi *et al.*, 2005; Osunbitan *et al.*, 2005). De Vita *et al.* (2007) studied effects of NT and CT on wheat yield. They found that greater yield is obtained with NT than as with CT. Soil organic matter is conserved with no-till because of reduced oxidation of organic matter (Wilkins *et al.*, 2002), while at the maintenance of crop residues on the soil surface has been recognized an important role in reducing soil erosion and on its positive effects on soil and water conservation

### **2.16.1 Benefits of Minimum Tillage**

The no-till farming is among the top of the portfolio of strategies to control soil erosion and reduce tillage costs. It is also a unique option to maintain crop productivity and environmental quality. It conserves soil and water while improving and increasing soil organic matter. The performance of no-till systems for improving soil functions depends, however, on the soil-specific, topographic, and climate characteristics. The major beneficial impacts of no-till are particularly noted within the upper soil horizons where most crop residues are concentrated. Most of the beneficial aspects of no-till technology are attributed to the crop residues mulch. Thus, no-till systems which leave little or no crop residues after harvest may affect soil properties as adversely as does' conventional tillage. Residue left on the surface of no-till soils absorbs and buffers the

erosive energy of raindrops and generally improves soil properties. This buffering process reduces aggregate detachment and surface sealing and crusting, thus decreasing risks of runoff and soil erosion.

### **2.17 Soil Water Content and Holding Capacity**

Minimum till management also impacts soil water storage. Because of abundant residue cover, no-till soils store more water than bare and ploughed soils. Residue mulch reduces the evaporation rates, and thus soil water content increases with increase in rates of residue application. Unmulched soils wet and dry quicker than residue-covered no-till soils. No-till farming moderates water balance by reducing runoff, evaporation and excessive percolation. Water holding capacity is the ability for a soil to hold a total water available for extraction by plants roots. The volume of water to plants that a soil can store is referred to as available water capacity (AWC). It is dependent on crop rooting depth and several soil characteristics. Units of measure are expressed in various terms: volume units as inches of water per inch or per foot of soil depth; Gravimetric percent by weight; percent on volume basis.

Moreover, in fine textured soils affected by salinity, sodicity or other chemicals, a considerable volume of water may not be available for plant use. Soil-water potentials comprehensively define water available to plants. It is the amount of work required per unit quantity of water to transport water in soil. In the soil, water moves continuously in the direction of decreasing potential energy or from higher water content to lower water content. The concept of soil-water potential replaces arbitrary gravitational, capillary and hygroscopic terms. Available water capacity is affected by soil texture, presence and abundance of rock fragments, soil depth and restrictive layers. A soil's available water capacity is also affected by organic matter and compaction. Organic matter increases a soil's ability to hold water, both directly and indirectly. Compaction increases bulk density and reduces total volume, consequently reducing available water holding capacity.

### **2.18 Particle Density**

Particle density is the mass of soil per unit volume of water. It represents the average density of all the minerals composing the soil. For most soils,  $2.65\text{g/cm}^3$  because quartz has a density of  $2.65\text{g/cm}^3$  and quartz is usually the dominant mineral. An average value for particle density of soil is  $2.66\text{g/cm}^3$ . That means soil particle that has  $1\text{cm}^3$  in volume weighs  $2.65\text{g}$ , because water has a value density of  $1\text{g/cm}^3$ .

of strength levels affecting soil compaction. Aggregates are sensitive to tillage and cropping management systems. Long-term no-till practices impact aggregate strength, density, and water retention capacity different from conventional tillage. Excessive tillage, rapid post-tillage consolidation, and low organic matter concentration in ploughed soils alter aggregate formation and properties. Increases in soil organic matter can increase or decrease the strength of aggregates depending on the soil texture, nature of organic matter, and soil water content. No-till management enhances formation of C-enriched macro- and micro aggregates. Ploughed soils often have denser, more compact, and stronger aggregates compared to no-till following post-tillage consolidation. The strength of aggregates tends to increase with increase in no-till -induced changes in organic matter concentrations in clay soils and decrease in silt loam and sandy soils (Imhoff et al., 2002; Blanco-Canqui et al., 2005).

### **2.19 Challenges in Minimum Tillage**

There are constraints to the adoption of no-till technology. No-till technology may not always be easily adopted in all soils or regions. Its expansion has been slow due to local and regional soil and climate differences. Performance of no-till farming depends on soil type, climate, and management.

### **2.20 Minimum tillage or Reduced Tillage**

Reduced tillage refers to any conservation system that minimizes the total number of tillage primary and secondary operations for seed planting from that normally used on field under conventional tillage (SSSA, 2008). It is also called minimum tillage because it reduces the use of tillage to minimum enough to meet the requirements of crop growth. Reduced tillage is a conservation management strategy that leaves at least 30% residue cover to minimize runoff and soil erosion, improve soil functions, and sustain crop production. Reduced tillage is becoming an important conservation practice like no-till. These systems reduce runoff and soil erosion and improve or maintain crop yields compared to conventional systems. Runoff and soil erosion from minimum or reduced tillage are generally between those from conventional tillage and no-till. Some of the systems within reduced tillage include mulch till, ridge-till, and strip-till. The choice of implement for mulch tillage is specific to each soil and management. In the USA, mulch tillage started in the 1930s following the severe droughts and wind erosion of the Dust Bowl. Mulch tillage became popular in the Great Plains over clean or conventional tillage to conserve soil and water. It is best suited for semiarid or dry lands because it reduces

evaporation and increases plant available water. Mulch tillage can be as effective as no-till systems for conserving soil and maintaining crop yields in dry lands. In humid regions and clayey soils, it may not substantially improve soil conditions.

### **2.21 Conventional Tillage**

Generally, conventional tillage aims at reversing and stirring a deep layer of soil; incorporating and destroying plant debris; exposing soil pests to sunshine for control; lump breaking and ground leveling. This preparation is composed primarily of harrowing for removing the residues of previous crop. It is done still in the dry season, after subsoiling, to break up the compacted layer and could be replaced by chiseling when the compacted layer is more shallow. With a harrow or a moldboard plow, ground is turned over, burying the vegetable remains to an average depth of 15–30 cm. Together with the first plowing and harrowing, we apply fertilizers such as lime and phosphate, and pesticides. After these steps, we promote lump breaking and ground leveling with harrows. This harrowing is also used to complete the application of lime or phosphate.

### **2.22 Soil Tillage**

A number of studies have shown that conventional tillage practices decrease CS in agricultural soils (Alvaro-Fuentes *et al.*, 2009; Cambardella and Elliott, 1993b; Elliott, 1986; Madari *et al.*, 2005; Six *et al.*, 2000, 2002). This decrease is related to the rate of micro aggregate production in till versus no-till systems. Although both systems may have similar rates of macro aggregate formation, the level of micro aggregates within macro aggregates of no-till systems was found to be higher. The authors attributed it to tillage that caused breakup of up soil aggregates, exposing iPOM in macro aggregates and hastening their break down (Six *et al.*, 2000). No-till, on the other hand, allowed macro aggregates to persist for longer allowing iPOM to break down slowly into more recalcitrant micro aggregates. Thus, although levels of light fraction OM are no different between tillage and no-tillage and coarse iPOM only differs slightly, the incorporation of these materials into fine iPOM and micro aggregates is greatly affected by break up of macro aggregates by conventional tillage (Six *et al.*, 1998). No-till practices are reported to have a positive effect on SOC concentrations of Oxisols too (Filho *et al.*, 2002; Madari *et al.*, 2005).

Most, if not all, of such studies on the effect of tillage on soil are in agricultural systems and are confined to surface soils. Alvaro-Fuentes *et al.* (2009) found that no-till increased the number of macro- and micro aggregates in the top 5 cm of soil in the Mediterranean. They found, however, that levels of C in the aggregates only sometimes increased in the no-till system and that the type of C rather than the quantity may be more important to aggregate formation. Other field studies on the impact of tillage on C storage have yielded contrasting results in various parts of the world. A recent study (Poirier *et al.*, 2009) showed that while no-till practices enhanced the SOC content in the soil surface layer, moldboard plowing resulted in greater SOC content near the bottom of the plow layer in a clayey-loam soil. Hence, when the entire soil profile (0–60 cm) was considered, both effects compensated each other, resulting in statistically equivalent SOC stocks for both tillage practices. An explanation of the high inter site variability of the influence of no-till on soil C storage will require that we understand the impacts of no-till on SOC sequestration for various soil and climatic conditions. In any case, the extent of tillage operations in AFSs is considerably less than in conventional agricultural systems.



## **CHAPTER THREE**

### **MATERIALS AND METHODS**

This chapter discusses the various data required for achieving the stated objectives of the study area. It describes the survey undertaken, data sources, sampling techniques methodology of data collection and analysis.

#### **3.1 Reconnaissance Survey**

Before the commencement of the main research work, a familiarisation visit was made to the study area by the researcher. The aim of the survey was to determine the limits of the study area and to get first-hand information from the target tillage practices.

#### **3.2 Data Sources**

The data for this research was obtained from both minimum and conventional tillage practices area through the sampling techniques. In addition, laboratory analysis of soil was carried out to determine whether there is a marked difference physical property of two tillage practices of farm lands in the area.

#### **3.3 Sampling Technique**

Mubi North local government Area consists of eleven (11) wards which includes:

Muchalla, Mijilu, Bahuli, Vimtim, Sabon layi, Yalwa, Mayobani, Kolere, Lokuwa, Betso, and Digil.

The sampling for this research was determined collection of the data using a core sampler to collect samples fifteen (15) at the surface and fifteen (15) at the subsurface at each location making a total sum of sixty (60) samples altogether.

#### **3.4 Field Work and Sampling Techniques**

Two (2) locations were identified where extensive tractor-based tillage operation was carried out and the other where minimum tillage are practiced under similar cropping system. grids of 30.00m x 18.00m along a transect which was divided into plots of 6.00m by 6.00m intervals within an area of 540m<sup>2</sup> at each location. After gridding each into fifteen (15) samples for each chosen site, thirty (30) samples was collected at each site of the arable land identified, making a total of sixty (60) samples altogether. Analysis was runned in the laboratory on the soil physical properties which includes: soil textural class, bulk density, particle density, total porosity, water holding capacity, organic matter and water content using analysis of variance(ANOVA).Moreover, regression which indicates the functional relation of one variable upon others was computed using the

SPSE(2012).The relation between : bulk density, water holding capacity, clay content and organic carbon making bulk density and water holding capacity as a dependent variables upon the others .Infiltration was carried out on each of the study area fields using a double ring infiltrometer with two concentric circles. Tables then computed to include the soil physical properties at surface (0 – 20) cm, and subsurface (20 – 50) cm depth obtained in the study sites for each tillage practice.

### **3.5 Laboratory Analysis**

#### **3.5.1 Measurement of soil physical properties**

The materials used in the measurement of these physical properties were:

##### **Crucibles/ tins**

The soil cores in the nylons were transferred into crucibles and placed in an oven in order to dry all the moisture content in the soil core.

##### **Oven**

The soil physical properties were determined through an oven dry method. The oven was used for drying the moisture content in the soil samples. The crucibles with the soil cores are placed in the oven for 24 hours at 105<sup>0C</sup> i.e. until it has a constant weight.

##### **Electrical weight balance**

It was used for weighing the soil sample before and after drying.

##### **Determination of soil physical properties**

The soil physical properties under each tillage operation like the bulk density, porosity gravimetric water content (GWC) and volumetric water content (VWC) were determined in the laboratory. The soils used for the laboratory experiment were collected in the experimental plots. While, the soil hydraulic properties under each tillage practice were determined on the field i.e. in-situ.

#### **3.5.2 Percentage water holding capacity (%WHC)**

The total water held by a soil is called water holding capacity (WHC), while the total volume of water available to plant that a soil can store is referred to as available water capacity (AWC).

Weight of tin was first measured and recorded in the laboratory using electrical weighing balance as 'a' and weight of tin and soil 'b'. On adding 50mls of water to the soil inside the tin, the soil is then allowed to absorb the water over a period of time and was termed to be 'c', meaning weight of wet soil. Computations of the various water holding capacity on each individual sample was computed successfully using the relation as follows:

$$WHC = \frac{(c-a)-(b-a)}{(b-a)} \times 100 \% \dots\dots\dots (1)$$

Where:

WHC = Water Holding Capacity

a = weight of tin

b = weight of tin + soil and

c = weight of wet soil.

Moreover, to obtain the percentage water holding capacity individual results was computed by multiplying by 100.

**3.5.3 Particle size analysis**

Particle size was carried out using Bouyoucos hydrometer method as described by Jaiswal (2003) where 40g of air dry sample weighed in to 250ml beaker and 50ml of 5% of sodium hexametaphosphate was added as well as 100ml of distilled water. The suspension was stirred and left to stand for some time and was poured into a liter measuring cylinder after 15 minutes in Edmund buhlerswip SM25 universal shaker. First and second hydrometer was taken at 40 seconds and two hours respectively along with temperature readings. The percentage sand, silt and clay were calculated using the following relationships:

$$\%Sand = 100 - \{H_2 + 0.2(T_1 - 20) - 2\}^2 \dots\dots\dots (2)$$

$$\%Clay = \{H_2 + 0.2(T_2 - 20) - 2\}^2 \dots\dots\dots (3)$$

$$\%Silt = 100 - \{\% sand + \% clay\} \dots\dots\dots (4)$$

Where:

H<sub>1</sub> = first hydrometer reading

H<sub>2</sub> = second hydrometer reading

T<sub>1</sub> and T<sub>2</sub> = first and second hydrometer reading respectively

Finally, texture of the soil was determined using USDA textural triangle from the result obtained (Jaiswal, 2003)

### 3.5.4 Bulk Density

Using a core sampler, soil samples were collected from 15 points on each plot at 0-20cm surface and 20-50cm subsurface depths under each tillage system on the sites. The total soil samples collected was 60. Then the samples in the core sampler were transferred into nylon and were conveyed to the laboratory. In the laboratory, the mass of the each empty crucible was found, m<sub>1</sub>. The soil sample was then transferred from the nylon into the crucible and then reweighed as m<sub>2</sub>. Afterward, the crucible with the soil samples were keep in the oven for 24 hours at 105<sup>0C</sup> for total dryness of the moisture in the soil sample.

However, the crucible was then removed from oven and then reweighed as m<sub>3</sub>. From this, the bulk density was calculated as mass of oven dried soil per volume of core (g/cm<sup>3</sup>) and gravimetric water content as mass of water in the soil sample per mass of the oven dried soil. Volume of the core sampler, V, is 313.35 g/cm<sup>3</sup>. Bulk densities were determined from the following relations:

$$Pb = \frac{(m_{ds})}{\pi r^2 h} \text{ g / cm}^3 \dots\dots\dots(5)$$

Pb = bulk density

Mds = mass of oven dry

π = 3.142

r = Radius of ring

h = height of ring.

### 3.5.5 Particle density

As described earlier, that particle density is the mass of dry soil per unit volume of water. Particle density was measured by weighing 40g of dry soil, on to it, 50ml of distilled water was added into the measuring cylinder to each of the soil sample where change in volume was obtained. From there values are computed to determine the various values for the particle density using each samples, thus;

$$\text{Particle density} = \frac{\text{mass of dry soil}}{\text{change in volume of water}} \text{ (g/cm}^3\text{)} \dots\dots\dots (6)$$

### 3.5.6 Porosity

Total porosity was determined from the relationship between bulk density and particle density. While, Particle density was taken as 2.65 g/cm<sup>3</sup> as calculated and found in the minimum tillage site. However, Porosity was determined on all plots based on bulk density values at depths 0-20 cm and 20-50 cm with their respective particle densities to compare the two with 2.78g/cm<sup>3</sup> found under the Disc tillage practices. Again, soil porosity were determined for each depth surface and sub-surface in the two locations using a mathematical relation:

$$\text{Porosity} = 1 - \frac{\text{Bulk density}}{\text{particle density}} \times 100 \% \dots\dots\dots (7)$$

### 3.5.7 Gravimetric water content:

The gravimetric water content was determined by the use of soil cores to collect samples from tillage treatment plots. Mass of water in soil sample was determined and later oven dried at a temperature of 105<sup>o</sup>C until constant weight was achieved. Mathematically:

$$\% \text{ Gravimetric water content} = \frac{\text{Mass of water in soil}}{\text{Mass of oven dry soil}} \times 100.$$

$$GWC = \frac{M_2 - M_1}{MS} \times 100\% \dots\dots\dots (8)$$

Where: -

$m_2$  = (wgt. of container + soil + water)

$m_1$  = (wgt. of container + soil)

$M_s$  = mass of oven dry soil.

### 3.5.8 Organic carbon (%)

Organic carbon was determined by wet oxidation method as described by (Jaiswal, 2003). In this method organic carbon is oxidized by  $K_2Cr_2O_7$  in the presence of  $H_2SO_4$ . The filtrate was titrated with ferrous ammonium sulphate in the presence of diphenylamine indicator to dull green end. Mathematically: -

$$OC = \frac{(B - T)N \times 0.003 \times 1.33}{\text{Weight of sample used (2g)}} \times 100 \quad \dots\dots\dots (9)$$

Where:

B = blank titre value

T = sample titre value

N = normality of ferrous sulphate.

OC = Organic carbon

### 3.5.9 Organic matter (%)

Value of organic matter was also obtained by multiplying the organic carbon content of soil by a factor of 1.724 (Jaiswal, 2003).

### 3.6 Data Analysis

Statistical analyses of data were performed using the analysis of variance (ANOVA) in the General Linear Model procedure of SPSS (SPSS Inc.1999) USA where Differences between treatments were considered under significant if  $P = 0.05$ . And Statistical package for scientist and Engineers SPSE (2012), was used for the least square's linear regression on some soil physical properties. Analytical software manual version 9.1.

## CHAPTER FOUR

### RESULTS AND DISCUSSION

This chapter describes and explain the outcome of the research obtained on the physical properties of soil on two different sites. For both practices, all physical properties were all analysed and determined in the laboratory. With the exception of infiltration which was carried out on the two different site of the study area in Mubi North Local Government in Adamawa state.

#### 4.1.1 Particle density

Table 3 and 4 present the value of particle density for the minimum tillage in the second row of the table. Moreover, table 5 and 6 also presents the value of particles density under each treatment across the second row. The result reveal that: Particle density on average has no significant difference at  $p = 0.05$ . The average value is the same as  $2.65 \text{ g/cm}^3$  at surface and subsurface. The value in the conventional tillage are also not significant at an average value. The mean values at surface and subsurface was founded to be  $2.60 \text{ g/cm}^3$  and  $2.7 \text{ g/cm}^3$  respectively. This affirms that the minimum tillage practice in the study area with a static particle's density contain a mineralogical composition in accordance with manual for soil science (Thien and gravel).

**Table 1: Particle Size Analysis for the Minimum Tillage Practice**

	Surface depth (cm)			Subsurface depth (cm)				
	% S	% CL	% SLT	TC	% S	% CL	% SLT	TC
<b>1</b>	65.5	8	26.5	S L	74.6	14.6	10.8	S L
<b>2</b>	79.6	13	7.4	S L	77.6	12	10.4	S L
<b>3</b>	79.6	10	10.4	S L	66.6	20	13.4	S L
<b>4</b>	71.6	8	20.4	S L	73.6	15	11.4	S L
<b>5</b>	75.6	8	16.4	S L	75.6	13	11.4	S L
<b>6</b>	79.6	11	9.4	S L	72.6	15	12.4	S L
<b>7</b>	83.6	7	9.4	L S	84.6	8	7.4	L S
<b>8</b>	73.6	15	11.4	S L	71.6	16	12.4	S L
<b>9</b>	80.6	11	8.4	S L	83.6	8	8.4	L S
<b>10</b>	70.6	13	16.4	S L	63.6	13	23.4	S L
<b>11</b>	74.6	11	14.4	S L	75.6	13	11.4	S L
<b>12</b>	73.6	8	18.4	S L	63.6	23	13.4	S C L
<b>13</b>	79.6	12	8.4	S L	86.6	12	1.4	L S
<b>14</b>	69.6	14	16.4	S L	71.6	16	12.4	S L
<b>15</b>	83.6	7	9.4	L S	66.6	18	15.4	S L
Mean	<b>76.1</b>	<b>0.4</b>	<b>13.5</b>	<b>S L</b>	<b>73.9</b>	<b>13.8</b>	<b>12.3</b>	<b>S L</b>

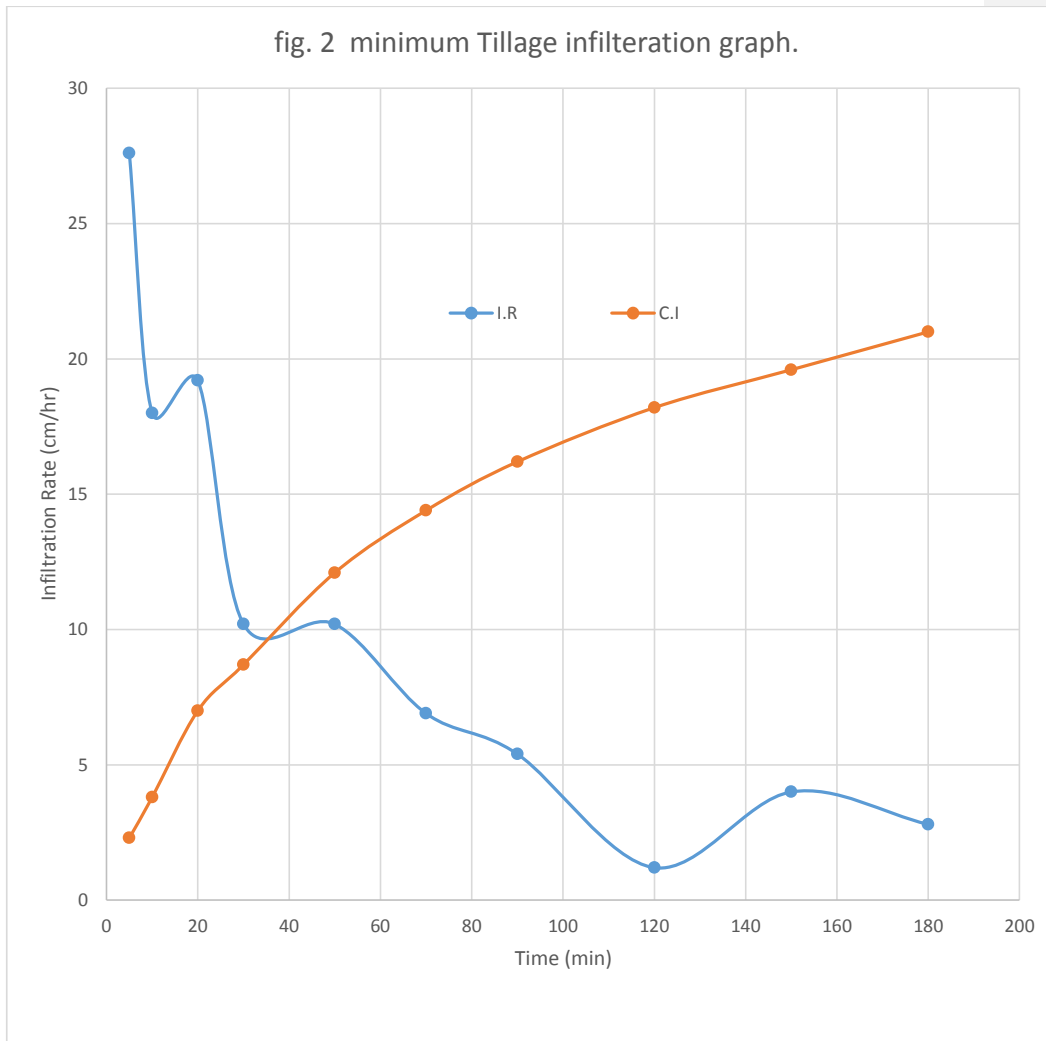
% S = percentage sand, % SLT = percentage silt, S L = sandy loam, S N = sand, S N Y = sandy, % C L = percentage clay, L S = loamy sand, S C L = sandy clay loam, T C = textural class.

**Table 2: Particle Size Analysis for Conventional Tillage Practice.**

	Surface depth (cm)				Subsurface depth (cm)			
	% S	% CL	% SLT	TC	% S	% CL	% SLT	TC
<b>1</b>	68	6	26	S L	84	5	11	L S
<b>2</b>	85	4	11	L S	79	8	13	L S
<b>3</b>	86	2	12	SNY	92	3	5	S N
<b>4</b>	91	2	7	S N	84	6	10	L S
<b>5</b>	88	3	9	S N	84	6	10	L S
<b>6</b>	90	2	8	S N	82	10	8	L S
<b>7</b>	84	5	11	L S	78	10	12	L S
<b>8</b>	84	5	11	L S	76	12	12	S L
<b>9</b>	84	6	10	L S	72	13	15	S L
<b>10</b>	84	5	11	L S	79	6	15	L S
<b>11</b>	78	5	17	L S	64	18	18	S L
<b>12</b>	77	5	18	L S	70	15	15	S L
<b>13</b>	78	4	18	L S	74	15	11	S L
<b>14</b>	86	5	9	L S	76	12	12	S L
<b>15</b>	75	15	10	S L	56	28	16	S C L
<b>Mean</b>	<b>82.5</b>	<b>4.9</b>	<b>12.6</b>	L S	<b>77</b>	<b>11</b>	<b>12</b>	<b>S L</b>

% S = percentage sand. % SLT = percentage silt. S L = sandy loam. S N = sand. SNY = sandy.

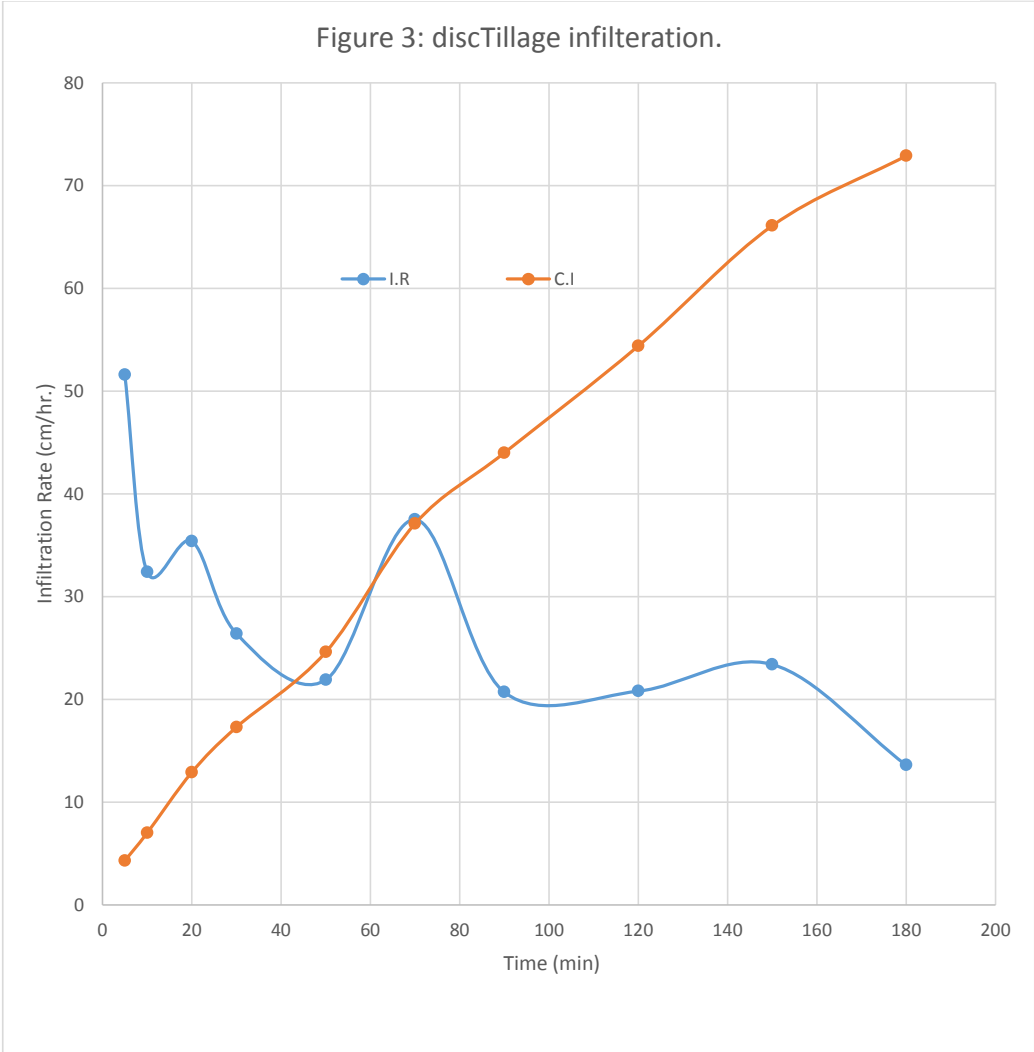
% C L = percentage clay. L S = loamy sand. SCL = sandy clay loam. T C = textural class



### Graphs

Fig 2: show the infiltration graph for the mean tillage practice carried out in the study area field. In the figure, in one hour (1hrs) time, the filtration value is 8cm/hr with 17cm cumulative infiltration. As against 31cm/hr in the conventional tillage. After two hours (2 hrs), the infiltration rate in the minimum tillage practice was observed to be 2cm/hr which corresponds to 20cm/hr.in the conventional tillage practice. Similarly, in the last 180 minutes (3 hours), the infiltration rate for the minimum tillage practice is 3cm/hr as against 12cm/hr.in the conventional till. Fig. 3: In the conventional tillage practices. The

steady infiltration rate here on both tables was observed and calculated from the graph table. The average of the last three readings on each graph gives the steady infiltration rate for each of the study area. The average infiltrations obtained are 2.7cm/hr. in the minimum tillage study area of the research and 19.3cm/hr.in the conventional till site The table used in plotting the infiltration graph is shown in fig. 2 and 3.



#### ***4.1.2 Sand***

The result of particles size analysis for the surface particle size analysis obtain from the laboratory 4.2 Analysis presented in table 4.1 reveals that the mean proportion of sand across the two practice indicates that sand is more 85.5% in conventional till site than minimum till site 76.1% . It was observed that sand is more in conventional till than the minimum till. The reason might not be far from the fact that minimum till make soil lighter than conventional till where the soil is left less disturbed. However, this difference where statistically insignificant at (P-values > 0.05) across the two types of tillage practices. Tallman (2013) expressed that tillage has small degradation effect on land which may take years to be noticed. Thus, the less sand found in the other practice indicated by this study suggested the negative effect of tillage system on soil over the conventional tillage. Moreover, Sand proportion was found in the surface 76.1% greater than subsurface 73.9% in the minimum tillage likewise in the conventional tillage. Surface sand proportion is 82.5% against 77% subsurface. Study reveals that in both site, sand proportion is greater at the surface layer of the soils 0-20cm depth.

#### ***4.1.3 Silt***

The proportion of silt across the two types of tillage presented in table 1 and 2 reveals that minimum till has a mean silt proportion of 13. 5% and 12.3 at surface and subsurface likewise with the conventional till, means silt proportion is 12.6% and 12.0% surface and subsurface respectively. Comparing the two sites, conventional till has less silt proportion at both surfaces. It reveals further that there is a significant difference at (p-value< 0.05). This result shows that most of the areas under cultivation resulting from inappropriate tillage systems have lesser silt due to soil exposure and continuous erosion. According to sing et-al., (1994) soil with relatively high content of silt and fine sand has a tendency towards structural instability and compaction, particularly if the organic carbon is low.

**Table 3: Surface Soil Physical Properties of the Minimum Tillage Site**

	Treatment															
Properties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	mean
<b>B.D</b> (g/cm <sup>3</sup> )	1.43	1.40	1.59	1.09	1.25	1.43	1.24	1.49	1.06	1.36	1.32	1.30	1.50	1.15	1.71	<b>1.35</b>
<b>P.D</b> (g/cm <sup>3</sup> )	2.7	2.86	2.22	2.50	2.58	2.50	2.82	2.53	3.03	2.67	2.82	2.67	2.70	2.58	2.50	<b>2.65</b>
<b>%P</b>	46.92	51.05	28.60	56.36	51.67	42.90	55.97	41.23	64.96	49.18	53.29	51.17	44.43	55.41	31.42	<b>48.30</b>
<b>%WHC</b>	60.64	22.58	25.41	20.78	24.57	22.51	18.59	23.42	19.96	22.84	16.74	16.55	21.06	16.92	19.25	<b>23.45</b>
<b>%O.M</b>	0.23	0.28	0.28	0.30	0.29	0.30	0.28	0.30	0.34	0.33	0.23	0.31	0.28	0.29	0.35	<b>0.29</b>
<b>%GWM</b>	54.71	38.26	27.73	24.60	19.67	32.67	25.32	24.55	27.94	23.37	15.54	40.73	32.39	28.83	26.33	<b>29.51</b>

BD =bulk density (g/cm<sup>3</sup>) , WHC = water holding capacity (%), PD = particle density (g/cm<sup>3</sup>), OM = organic matter (%), P = porosity (%)  
GWC = gravimetric water content (%).

#### ***4.1.4 Clay***

Table 1 and 2, present the mean percentages of clay across the conventional and minimum tillage practices, at two different depth surface and sub-surfaces;(0-20 and 20-50cm) in the study area. Minimum tillage has 10.4% and 13.8% surface and subsurface respectively. In table 2, Conventional tillage has a clay proportion of 4.9% and 11% surface and subsurface respectively too. Clay is more found at the subsurface of the minimum till likewise in the conventional tillage practice. The result indicates that there is a significant difference in the mean proportion of clay recorded in minimum till than the conventional till at  $p = 0.05$ . This implies that clay properties are less in conventional tillage than the other practice. It was also observed at both sample depth that intensiveness or amount of soil disturbance reduces clay content of study area.

Table 4: SURBSURFACE SOIL PHYSICAL PROPERTIES OF THE MINIMUM TILLAGE SITE

	Treatment																
<b>B.D</b> (g/cm <sup>3</sup> )	1.49	1.05	1.18	1.48	1.25	1.39	1.28	1.32	1.75	1.29	1.27	1.51	1.36	1.23	1.22	<b>1.34</b>	Prop
<b>P.D</b> (g/cm <sup>3</sup> )	2.65	3.08	2.47	2.47	2.67	2.61	2.67	2.61	2.86	2.67	2.86	2.53	2.50	2.58	2.58	<b>2.65</b>	s 1
<b>%P</b>	43.64	66.07	52.15	40.19	53.02	46.93	52.17	49.33	38.85	51.82	55.43	40.32	45.77	52.47	52.80	<b>49.40</b>	2
<b>%WHC</b>	16.55	24.66	24.54	17.35	24.17	19.28	13.84	25.12	21.06	23.65	17.03	17.41	26.73	20.56	26.99	<b>23.06</b>	3
<b>%O.M</b>	0.21	0.24	0.23	0.22	0.28	0.25	0.27	0.28	0.34	0.26	0.33	0.21	0.30	0.27	0.37	<b>0.27</b>	4
<b>%GWM</b>	28.58	25.04	28.17	24.31	31.92	25.39	19.86	30.92	25.01	23.60	23.68	28.22	31.71	24.68	24.20	<b>26.35</b>	5
	10	11	12	13	14	15	mean										6
																	7
																	8
																	9

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BD =bulk density (  $\text{g}/\text{cm}^3$ ), WHC = water holding capacity (%), PD = particle density ( $\text{g}/\text{cm}^3$ ), OM = organic matter (%), P = porosity (%)  
GWC = gravemetric water content (

#### **4.1.5 Bulk density**

Table 4 presents the values of bulk densities in  $\text{g/cm}^3$  at different depths, surface 0-20 and 20-50cm depth with their mean values under the minimum tillage practices. The results are as follows: surface and subsurface mean values, 1.35 and 1.34  $\text{g/cm}^3$  respectively. As observed from the result one can see that the bulk density of all the treatments are generally low with the exception of treatment number fifteen (15) with a value of 1.71%  $\text{g/cm}^3$ . Similarly when looked at the surface depth and subsurface, minimum tillage has lesser bulk density by average but not significant at  $p= 0.05$ . When look at two different practices conventional tillage has the highest bulk. Density of about 1.43  $\text{g/cm}^3$  by average. Because it constitute more soil disturbance. Intensive tillage system destroy more aggregates and structure and as a result create many pores and decrease bulk density. The result affirms that there were insignificant difference for almost all the recorded bulk densities for both tillage practice in the study area at  $p = 0.05$ . Bulk density is not static. Because the value can be varied due to tillage and compaction in the study area. Conventional tillage contain more compacted soil since it has the high bulk density. Bulk density when it becomes very high as in the conventional tillage over a long time practice affects infiltration, rooting depths available water capacity (AWC), Soil porosity and plant nutrient. Bulk density has a significant effect on the mechanical properties of the soil in almost all the types of tillage practices. Arsha M.A et.al 1996. Bulk density observe from the practices found higher in conventional tillage than the minimum tillage practices.

#### **4.1.6 Particle density**

Table 3 and 4 present the value of particle density for the minimum tillage in the second row of the table. Moreover, table 5 and 6 also presents the value of particles density under each treatment across the second row. The result reveal that: Particle density on average has no significant difference at  $p =0.05$ . The average value is the same as 2.65  $\text{g/cm}^3$  at surface and subsurface. The value in the conventional tillage are also not significant at an average value. The mean values at surface and subsurface was founded to be 2.60  $\text{g/cm}^3$  and 2.7  $\text{g/cm}^3$  respectively. This affirms that the minimum tillage practice in the study area with a static particles density contain a mineralogical composition in accordance with manual for soil science (Thien and gravel).

Table 5: SURFACE SOIL PHYSICAL PROPERTIES FOR CONVENTIONAL TILLAGE SITE

	Treatment																
<b>B.D</b> (g/cm <sup>3</sup> )	1.14	1.32	1.26	1.72	1.57	1.42	1.58	1.41	1.42	1.45	1.40	1.20	0.90	1.17	1.21	<b>1.34</b>	Prop
<b>P.D</b> (g/cm <sup>3</sup> )	2.22	2.50	2.70	2.50	2.50	2.58	2.50	2.65	2.50	2.86	2.86	2.50	2.76	2.67	2.67	<b>2.60</b>	s 1
<b>%P</b>	48.65	47.20	53.33	32.02	37.20	44.96	36.80	46.79	43.20	49.30	51.05	52.00	67.39	56.18	54.68	<b>48.05</b>	2
<b>%WHC</b>	13.68	13.83	11.62	21.40	17.30	14.07	18.75	13.34	14.45	13.99	13.76	13.75	9.80	12.50	13.22	<b>14.36</b>	3
<b>%O.M</b>	2.41	2.43	2.04	3.76	3.04	2.47	3.30	2.34	2.54	2.46	2.42	2.42	1.72	2.20	2.32	<b>2.54</b>	4
<b>%GWM</b>	43.37	29.78	36.02	53.08	56.42	27.21	31.31	36.73	26.91	60.39	20.96	10.79	38.77	26.39	44.63	<b>36.18</b>	5
	10	11	12	13	14	15	mean										6
																	7
																	8
																	9

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BD =bulk density ( $\text{g}/\text{cm}^3$ ), WHC = water holding capacity (%), PD = particle density ( $\text{g}/\text{cm}^3$ ), OM = organic matter (%), P = porosity (%)  
GWC = gravemetric water content (%)

#### **4.1.7 Porosity**

The mean porosity in percentage recorded across the two types of tillage practice were presented in table 3 and 4 for the minimum till and table 5 and 6 records the mean porosity under the conventional tillage surface and at subsurface respectively. The result reveals that across the two types of tillage practices, the mean percentage porosities are: 48.3 and 49.4, surface and subsurface values under the minimum tillage practices. In addition, in table 5 and 6, values for means porosity are also given 48.05 and 41.1 surface and subsurface respectively. Porosity differs at the conventional tillage. It was found to be higher at the surface of the conventional tillage practice than at each depth of the practices. It decreases on both site with respect to depth. This result implies that there was no significant differences in soil porosity in the minimum tillage at both depth at  $p = 0.05$ , likewise in the conventional tillage. But there was a significant difference between the minimum and conventional tillage at  $P = 0.05$  levels. The result also reveals that the volume of pores are much Created by conventional tillage especially at 0-20 cm depth than in the minimum till practice. It also entails that the volume fraction of soil filled with air is much greater than the minimum tillage too, which is indirectly proportional with volumetric soil water content of the area (Aeration porosity). Similarly, the relationships between the volume occupied by solid liquid and gaseous state (void ratio) is much better for most crops of the study area to be adopted.

#### **4.1.8 Water holding capacity**

Table 3 & 4, presents the values of water holding capacity (WHC) in percentage under the minimum till practice of the study area. The table present the values across the treatment for surface and subsurface depths. 0-20cm and 20-50cm respectively. The values here decreases at the surface with an average of 23.45%.while in the subsurface it increases from 16.55% to 26.99% with an average water holding capacity of about 23.06%. In this study area, water holding capacity was generally observed under the surface 60.64% under the first treatment sample. Table 5 and 6 also present the result obtained for the water hold capacity in the second site of the study area. In this site of conventional tillage practice, the water holding capacity is almost the same except in treatment 5, 7 and 13. Which may be as result of experimental errors during the data collection. It increases and decreases at the subsurface layer at the conventional tillage. It may also be as a result of soil disturbance by conventional tillage implement dredging by

a heavy machine frequently used on a farm prior to cultivation of crops. The available water for crop is uniform under the minimum till by mean of their values 23.45 and 23.06% which is not significant at  $p = 0.05$ . In the conventional tillage surface 14.36 and 21.34% subsurface is significant at  $p < 0.05$ . This is based on the mean or average values computed on the site as shown in table 5 and 6. In Comparism between the two sites, shallow rooted crops like groundnut, beans, guinea corn can be grown on the conventional till practice land. Because the total available water for crops are found in the uppermost and down layer of the land. A. Karuma 2014 also got similar findings. Generally, tillage decreases the volume occupied by pores and increase the density and strength of the soil mass in the conventional till practice.

**Table 6: Subsurface Soil Physical Properties for Conventional Tillage Site**

	Treatment																
<b>B.D</b> (g/cm <sup>3</sup> )	1.59	1.79	1.04	1.36	1.48	1.52	1.26	1.30	1.25	1.37	1.37	1.53	1.70	1.06	1.88	<b>1.43</b>	Prop
<b>P.D</b> (g/cm <sup>3</sup> )	2.58	2.52	2.89	2.67	2.72	2.58	2.67	2.70	2.67	2.76	2.67	2.86	2.86	2.67	2.58	<b>2.70</b>	s
<b>%P</b>	38.37	28.97	64.01	11.61	45.59	41.09	52.81	51.85	53.18	50.36	46.69	46.50	40.56	60.30	27.13	<b>41.10</b>	1
<b>%WHC</b>	17.37	25.13	9.86	99.13	14.17	15.96	12.01	11.77	11.16	14.34	13.41	14.41	17.90	12.39	31.11	<b>21.34</b>	2
<b>%O.M</b>	3.05	4.42	1.73	17.43	2.49	2.81	2.11	2.07	1.96	2.52	2.36	2.53	3.15	2.18	5.47	<b>3.75</b>	3
<b>%GWM</b>	32.11	29.50	57.01	30.91	23.84	23.34	43.75	34.94	28.88	23.57	22.41	18.07	21.95	22.39	10.79	<b>28.23</b>	4
																	5
																	6
																	7
																	8
																	9
																	10
	11	12	13	14	15	mean											

BD = bulk density ( $\text{g}/\text{cm}^3$ ), WHC = water holding capacity (%), PD = particle density ( $\text{g}/\text{cm}^3$ ), OM = organic matter (%), P = porosity (%),  
GWC = gravimetric water content (%).

#### **4.1.8 Organic matter**

Table 3 show the percentage organic matter (OM) across the table under each treatments obtained in the field. The result obtained was under the minimum till practice at the surface. Similar result also obtained and analyzed under the subsurface for same practice in table 4 the mean percentage of organic matter were 0.29 and 0.27, surface and subsurface respectively. In this practice (minimum tillage), they are not statistically significant at  $p= 0.05$ . Table 5 and 6 reveals the result of the percentage organic matter across the table under each treatment obtained and analyzed in the laboratory. Table 5, present the value of organic matter in percentage for conventional tillage practice at the surface while table 6 for substance. Result reveals that minimum tillage at the surface and subsurface has a value of 0.29 and 0.27, while conventional tillage practice have 2.54% and 3.75% surface and subsurface respectively. From the two different study area, organic matters has higher values on both surface and subsurface in the conventional tillage practices. This result is similar to the findings of Raczkowski; 2012. Raczkowski; 2012 found during his research work that; The extent that soil organic matter (SOM) is improved or maintained is not solely dependent on the use of minimum or no-till system; Additional practice such as; rotating crops, cover crops, climate and length of time can all have impact on the minimum tillage practice in regard to organic matter content found in sandy loam and loam sand soils over a long period of time.

#### **4.1.9 Gravimetric water content (GWC).**

Table 3 and 4 indicate and reveals the value of gravimetric water content (GWC) in percentage (%). The value was obtained in the laboratory after sample collection from the field of studies. In table 5 and 6 too, the values of gravimetric water content were also presented for the conventional tillage practices at two different depths (0-20 and 20-50) cm. The mean % GWC in the minimum till is 29.51 and 26.35 surface and subsurface respectively. That one of the conventional tillage is also found to be 36.18 and 28.23 surface and subsurface mean respectively. From table 3, 4,5 and 6, shows that the mass of water per dry soil or gravimetric water content is higher in the conventional tillage practices than the practices in the minimum tillage practice. This result also shows that the total water held by soil is much more than the minimum tillage for crop production. See table 3 to 6 the corresponding mean values for total water held by a soil (WHC

**Table 7: ANOVA for the effect of some physical properties of soil in site A (Minimum tillage)**

Parameter	Surface	subsurface	± SEM	LOS
Bulk density (g/dm <sup>3</sup> )	1.35	1.34	0.078	Ns
CLAY	10.40b	14.44a	1.299	**
Gravimetric water content (%)	29.51	26.35	2.43	Ns
Particle density (g/dm <sup>3</sup> )	2.65	2.65	0.035	Ns
POROCITY (%)	48.30	49.39	3.390	Ns
SAND	76.07	73.87	1.88	Ns
SILT	13.53	11.69	1.57	Ns
Textural class	1.13	1.40	0.15	Ns
Water holding capacity (%)	23.46	21.26	3.11	Ns
Organic carbon (OC)	0.17	0.16	7.61	NS
Organic matter (OM)	0.30	0.30	0.01	NS

**Table 8: ANOVA for the effect of Tillage Practice on Some Physical Properties of Soil**

SITE B

Parameters	Surface soil	Sub-surface soil	±SEM	LOS
Bulk density g/dm <sup>3</sup>	1.34	1.50	0.01	NS
Clay	4.93	11.13	1.12	***
Gravimetric water content %	28.23 <sup>b</sup>	40.12 <sup>a</sup>	7.19	*
Particle density g/dm <sup>3</sup>	4.20	2.69	1.61	NS
Porosity %	48.05	44.07	3.61	NS
Sand	82.53 <sup>a</sup>	76.67 <sup>b</sup>	2.11	*
Silt	12.53	12.20	1.44	NS
Textural class	6.27	5.53	1.44	NS
Water holding capacity %	14.36	21.34	5.31	NS
Organic Carbon (OC)	1.43	2.13	0.53	NS
Organic Matter	2.53	3.75	0.93	NS

\* Significantly different P = (0.05). NS Non-Significant. ± SEM = standard error of mean,

LOS = Level of significant.

**Table 9: Regression Results:**

Minimum till practice.

<b>WHC (dep.v)</b>	<b>Coefficient</b>	<b>T - value</b>	<b>BD (dep.v)</b>	<b>coefficient</b>	<b>T - value</b>
<b>B.D</b>	6.84	0.81	<b>WHC</b>	3.78	0.81
<b>CLAY</b>	-0.99	-2.17	<b>CLAY</b>	7.07	0.61
<b>R<sup>2</sup></b>	0.24	(0.120)	<b>R2</b>	0.09	(0.006)
<b>F –stat.</b>	1.97*	(0.130*)	<b>F – stat.</b>	0.59	(0.67)

Conventional till practice

<b>WHC(dep.v)</b>	<b>coefficient</b>	<b>T -value</b>	<b>B.D (dep.v)</b>	<b>coefficient</b>	<b>T -value</b>
<b>B.D</b>	0.02	0.61	<b>WHC</b>	0.71	0.61
<b>CLAY</b>	7.19	0.27	<b>CLAY</b>	0.02	1.47
<b>O.C</b>	10.02	82.04	<b>O.C</b>	- 0.70	- 0.59
<b>R<sup>2</sup></b>	1.000	(1.000)	<b>R2</b>	0.66	(0.60)
<b>F- stat.</b>	4.79	(0.000***)	<b>F – stat.</b>	11.61	(0.000***)

**4.1.10 Regression Result**

Regression are performed for each site location on some selected group of soil physical properties. The results are reported in table 10. The coefficient of bulk density is positive for water holding capacity as a dependant variable. While both clay and organic carbon are negatively and functionally related in the same table under the different practice at same depth, the coefficient of all the selected soil physical properties are positively related. In the tillage practices at the second depth, the coefficient of organic carbon are negative with all the rest of the independent variables and positively related with the dependent variables.

Moreover, the result suggest that in the No till practice (minimum till) as water holding capacity increases organic carbon reduces. Observation has also been made from the table of result that under the depth and practice factor of the plough tillage practices, the bulk density, clay, organic and carbon increases as the water holding capacity increases. Except that the organic carbon decreases as the bulk density increases at the surface layer of the plough tillage practices. The F – test for the fixed effects on this selected soil physical properties at the probability levels are: statistically significant at 99% confidence level at the plough till practice and statistically in significant at  $p > 0.05$ . In the regression equation table 12, differences across some selected soil physical properties are captured.

**Table 10: Regression equations and coefficient of determination.**

Equation	R <sup>2</sup>	Significant level at P-value
$\beta_1 = 6.84_{bd} - 15.94_{oc} - 0.99_{cla}$	0.24	(0.31 ***)
$\beta_2 = 3.78_{whc} + 7.07_{cla} - 0.19_{oc}$	0.09	0.67
$\beta_3 = 0.02_{bd} + 7.19_{cla} + 10.02_{oc}$	1.00	(0.000***)
$\beta_4 = 0.71_{whc} + 0.02_{cla} - 0.70_{oc}$	0.66	(0.000***)

$\beta_{1,2,3,4}$  = constants dependent variables for the selected soil properties.

Whc, cla, bd and oc = water holding capacity, clay, bulk density and organic carbon respectively, as independent variables.

For R<sup>2</sup>, the values of adjusted R<sup>2</sup> are given in parenthesis.

For F-Statistics, the values in parenthesis are the p-Statistics test for the significance level.

\*\*\*, \*\* and \* denotes statistical significance at 99%, 95% and 90% confidence levels, respectively, and R<sup>2</sup> is a coefficient of determination.

**Table 11: ANOVA distribution for depths**

S/N	Variable	depth	mean	Significance.
1	Sand	S	79.30	a
		SS	75.30	b
2	clay	S	7.67	a
		SS	12.79	b
3	Bulk density	S	1.35	a
		SS	1.42	a
4	porosity	S	48.18	a
		SS	46.73	a
5	WHC	S	18.90	a
		SS	21.30	a
6	Organic carbon	S	0.80	a
		SS	1.14	a
7	Organic matter	S	1.41	a
		SS	2.01	a

Difference for alpha = 0.05

Means of the same letter are not significantly different.

S = surface depth (0-20) cm.

SS = subsurface depth (20-50) cm.

MT = minimum till practice (site A).

CT = plough till practice (site B).

From the variable distributions above in table 13, bulk density ,porosity ,water holding capacity ,Organic carbon and Organic matter are not Statistically significant at  $P = 0.05$ . Only clay and sand are significantly different which may be as a result of loose of soil structure due to plough till above surface layer of the land under study.

**Table 12: ANOVA Distributions Under the Two Types of Practice.**

S/N	Variable	Practice	Mean	Significance.
1	sandy	MT	74.97	a
		CT	79.60	b
2	clay	MT	12.42	a
		CT	8.03	b
3	Bulk density	MT	1.35	a
		CT	1.42	a
4	Porosity	MT	48.85	a
		CT	46.06	a
5	WHC	MT	22.36	a
		CT	17.85	a
6	Organic carbon	MT	0.16	a
		CT	1.78	b
7	Organic matter	MT	0.28	a
		CT	3.14	b

Difference for alpha = 0.05. , MT = for minimum till practice. , CT = for plough till practice. From the table above (table 14), high sand distribution is found under the plough till practice with about 79.60 % to compare with 74.97 % in the minimum till practice. This is significantly different at  $p < 0.05$ . Intensive use of tractor and other farm machineries had caused that loose soil structure. From the result obtained here; clay, organic carbon and organic matter are significantly different due to practices. Bulk density, porosity and water holding capacity are not significantly different based on the practices as shown from the table.

## CHAPTER FIVE

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Summary and Conclusion

Soil are one of the World's most precious commodities, and continuing soil degradation is threatening food security and the lively hood of farm households throughout the World. Soil types and their various reactions to tillage are of paramount importance in determining the superiority of one practice over the other. However, it is pertinent to conclude that information dissemination should be an indispensable component of any common tillage network programme developed in Mubi North Local government Area, and its surrounding Wards and Villages involves in land cultivation activities. The following conclusions maybe drawn from the present study: -Tillage practices on the other hand decrease bulk density and moisture content but increase porosity and infiltration rate. Plough tillage practices manifested the highest infiltration rate, porosity and moisture content as against minimum tillage practices. This study also observed that soil textural class which is the most consistent soil physical properties is predominantly sandy loam under the minimum tillage practices while Loamy sand as the predominant under the plough tillage practices. The research in-situ has shown that tillage profoundly affect soil physical and hydraulic properties. The research had revealed that there is no significant different between bulk densities based on the depth and practice. More so, there is significant between the minimum tillage practices and the plough tillage on sandy soil based on the depth and practice factors. From the analysis, that is making use of mean, it has been found that there is greater values of porosity in the plough tillage practices than in the minimum tillage practices There was no significant different between the Organic matter and Organic Carbon on both fields. In addition, the result in the regression equation table shows that: In  $\beta_1$  decrease in organic carbon and clay content with increase bulk density determines the water holding capacity with about 24%. Also, in  $\beta_2$  the equation predicts that addition of water holding capacity and clay with decrease in organic carbon depends on bulk density with about 9.0% and is statistically significant at  $p > 0.05$ . In equation  $\beta_3$ , water holding capacity depends 100% on the bulk density, Clay and organic carbon. Again in equation  $\beta_4$ , bulk density depends on increase in water holding capacity and clay with about 66% confidence level and is not statistically significant at  $P = 0.05$ . Also, it has been noted that based on the result obtained bulk

density increase with depth under each tillage operation while porosity and water content decreases with depth. This indicates that there is more water in the surface than in the subsurface zone. Result of the experiment showed that several practical implications can be withdrawn from the study. Plough depth need to be controlled for successful growth of agricultural crops. No plough pan was found as a result of plough dredge but the soil was loosed which can be easily moved or washed away by the action of running water and blowing wind

### **5.3 Recommendation**

- i.** I will recommend that further research must be employed to see whether other methods of conservation like the reduced tillage (such as ridge, terracing etc.) can compete with the disc plough and minimum tillage.
- ii.** I Will also recommend that farmers should not be using tractor for soil mechanical manipulation and pulverization on every cultivation periods, it should be spaced at least a period of three to five years interval.
- iii.** Farmers should also be encouraged and need to be educated on the use of soil amendments materials in other to regain soil structure and nutrients that can be lost through such practices and other environmental degradation by the government in the study area.
- iv.** Government should sensitize farmers and give them support on the need for appropriate tillage through their extension workers.
- v.** Farmers in the study area should take note of their cultural practices, such: as late planting, types of crops to suit the soil condition on the bases of tillage operations and take good consideration of their climatic conditions.

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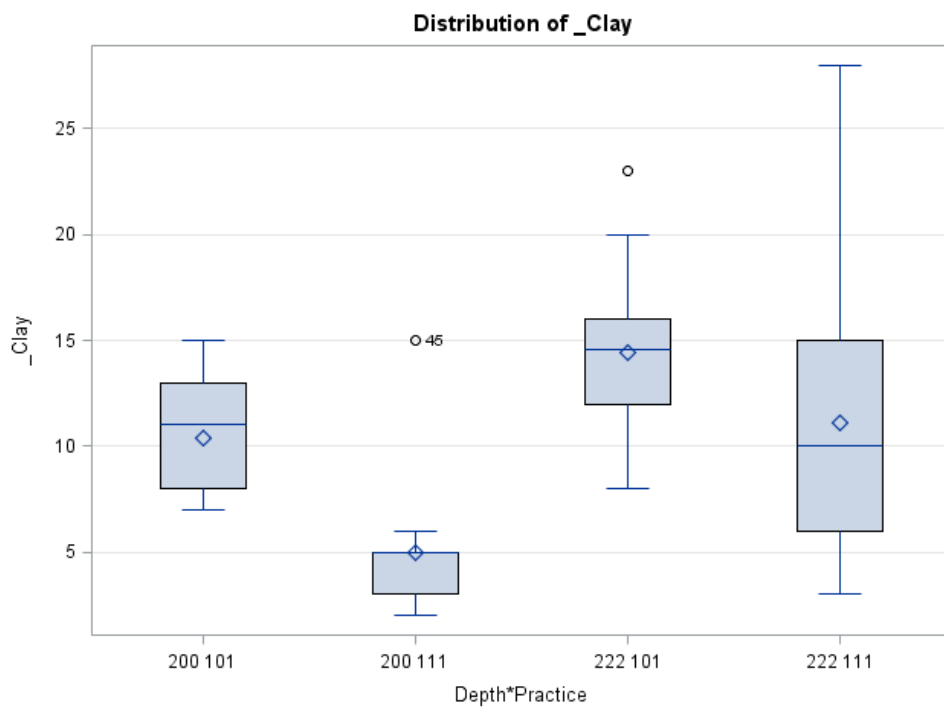
*USDA National Institute of Food and Agriculture, New Technologies for Ag Extension project. Dec. 19 2017.*

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## APPENDEXIS A



**Figure: 1** Shows a graphical relationships of percentage clay distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111). Clay is more observed in the subsurface depth of the conventional tillage than the minimum tillage with about 28 % (see 222 111) as against 23 % as in 200 101.

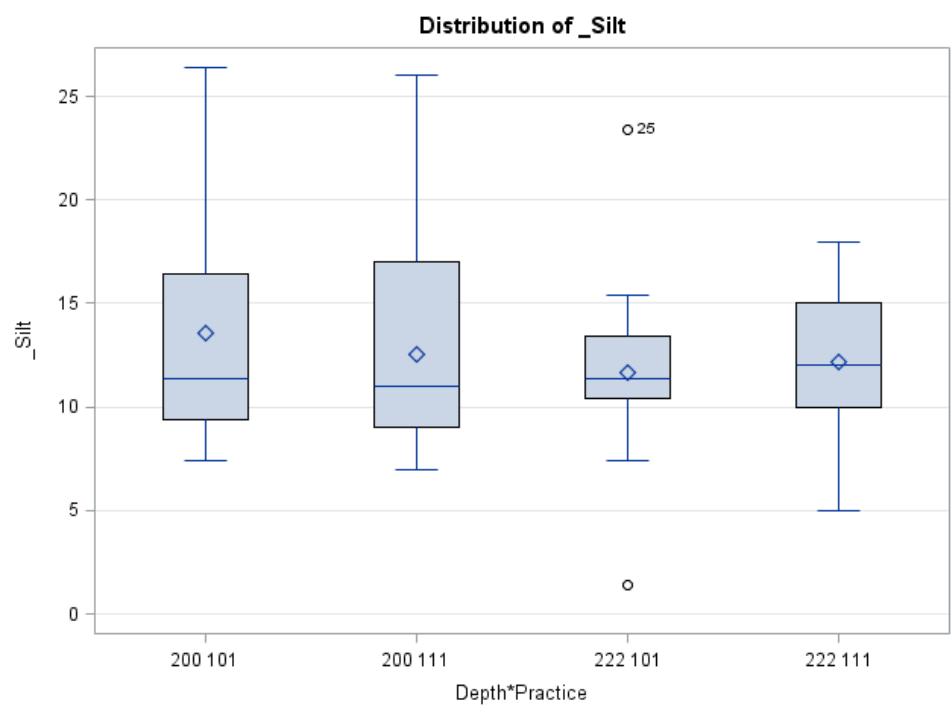
### Descriptions:

101 minimum tillage practice. , 111 conventional tillage practice.

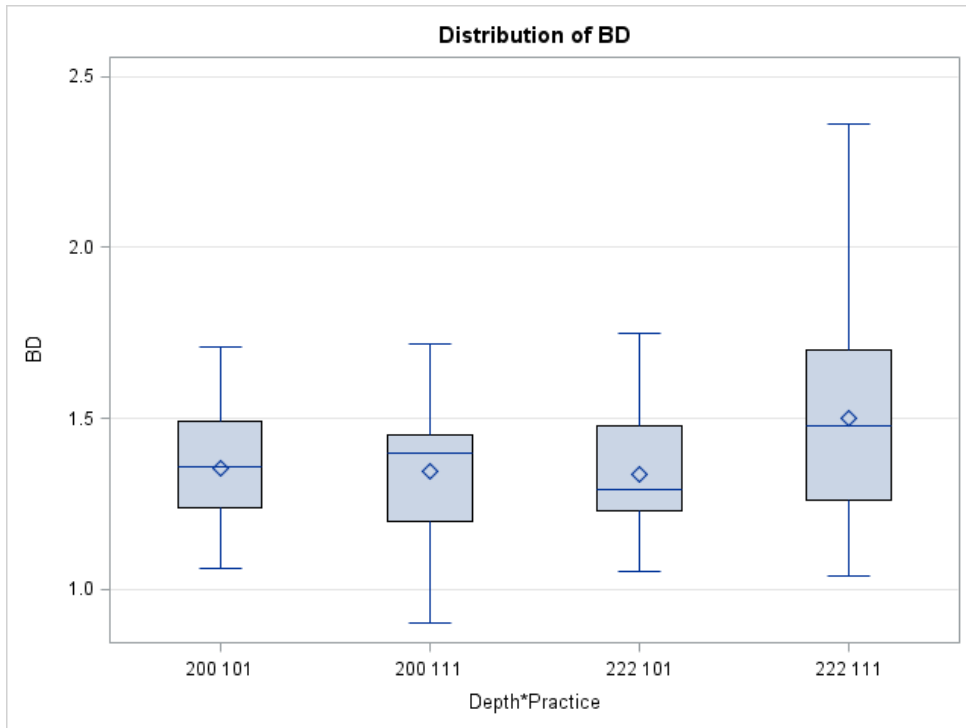
200 surface depth (0-20cm). , 222 subsurface depth (20-50)

BD Bulk density in (g/cm<sup>3</sup>), PD Particle density (g/cm<sup>3</sup>) ,WHC Water holding capacity in (%)

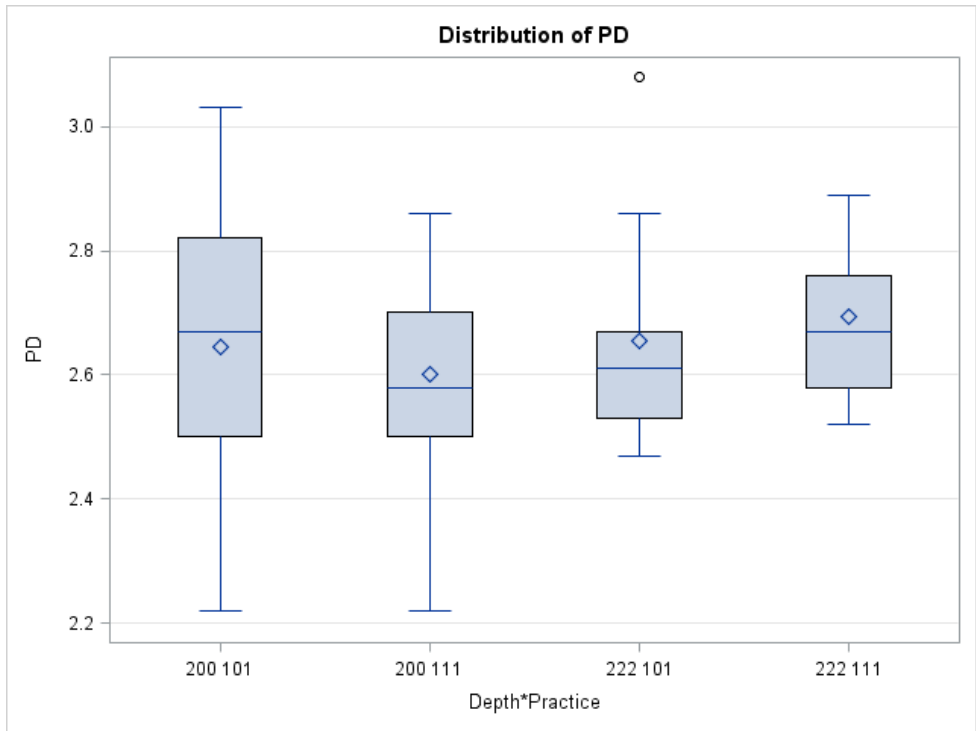
OC Organic Carbon in (%). OM Organic Matter in (%) ,GWC Gravemetric Water Content in (%)



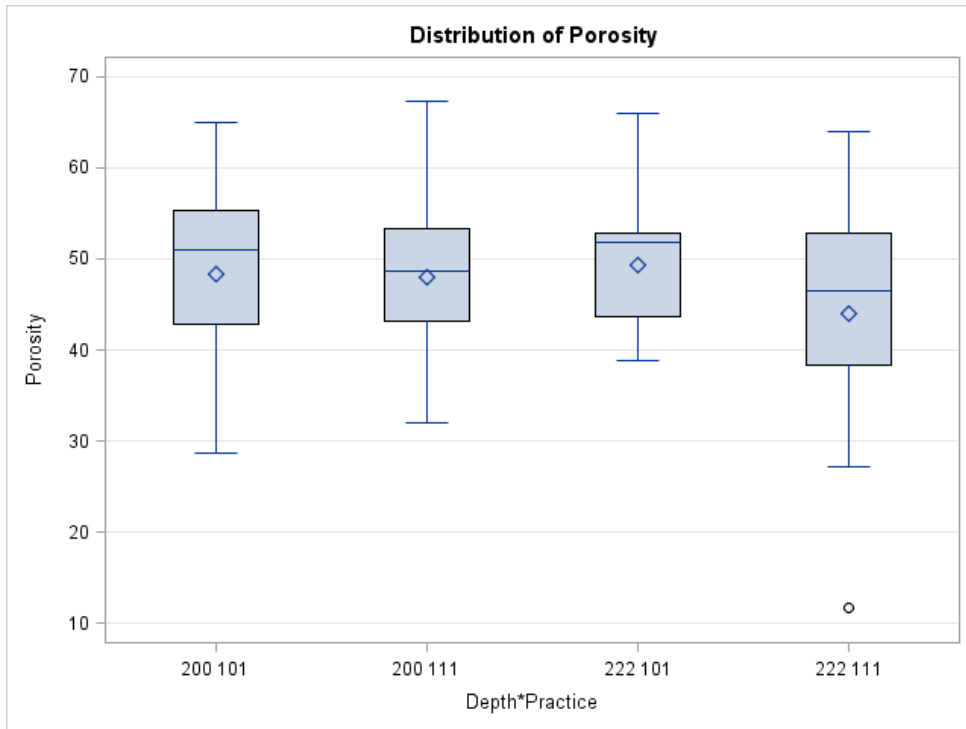
**Figure: 2** Shows a graphical relationships of percentage Silt distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111).



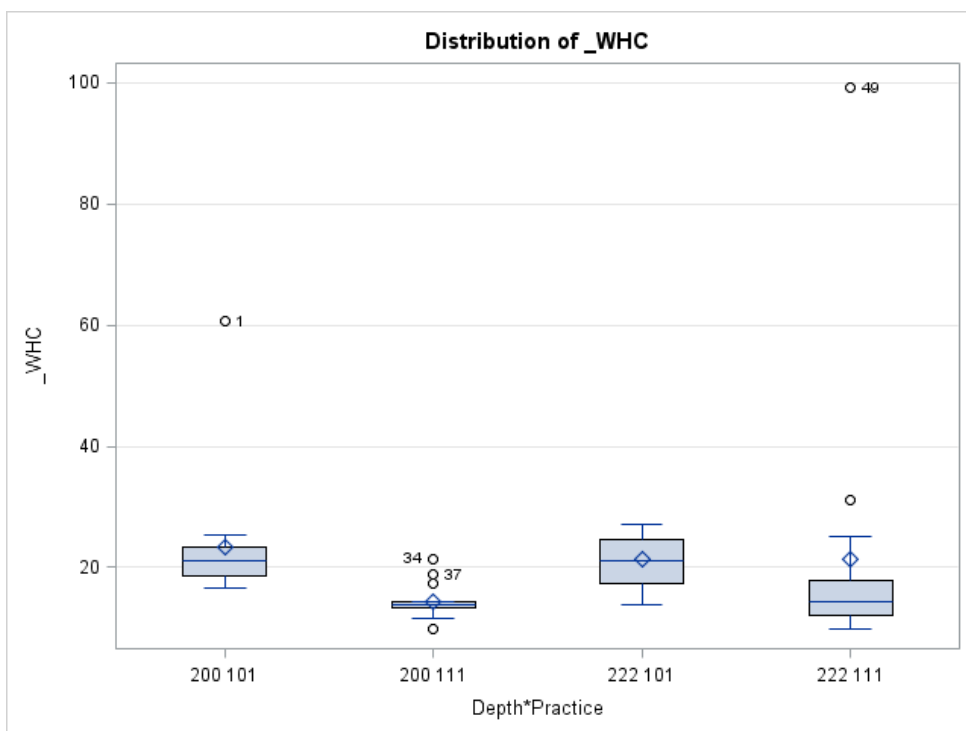
**Figure: 3** Shows a graphical relationships of bulk density in (g/cm<sup>3</sup>) at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111). Bulk density is more observed in the subsurface depth of the conventional tillage than the minimum tillage with about 1.88 g/cm<sup>3</sup> (see 222 111) as against 1.75 g/cm<sup>3</sup> as in 200 101.



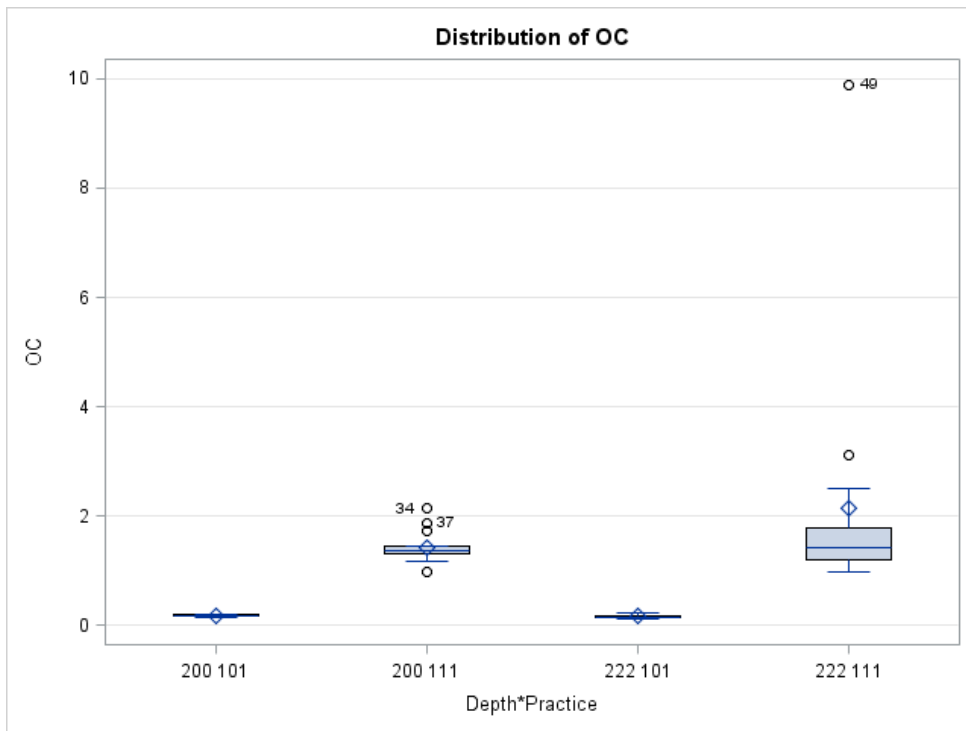
**Figure: 4** Shows a graphical relationships of percentage Particle density (PD) distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111).



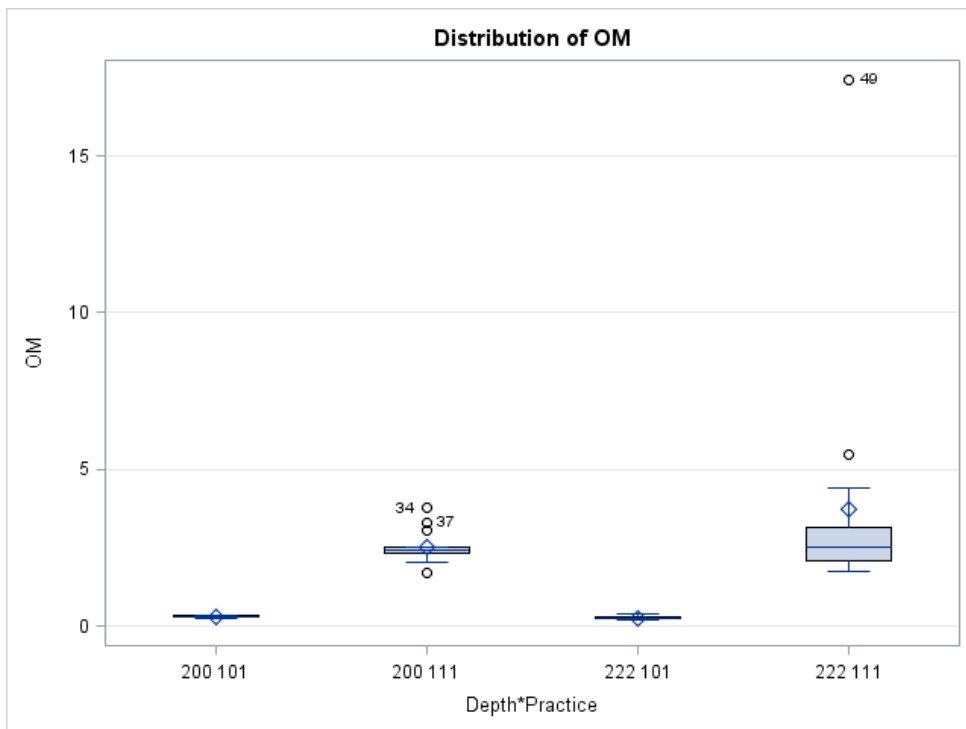
**Figure: 5** Shows a graphical relationships of percentage porosity distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111). Porosity is higher observed in the surface depth of the conventional tillage than the minimum tillage with about 67.39 % (see 200 111) as against 66.1 % as in 222 101.



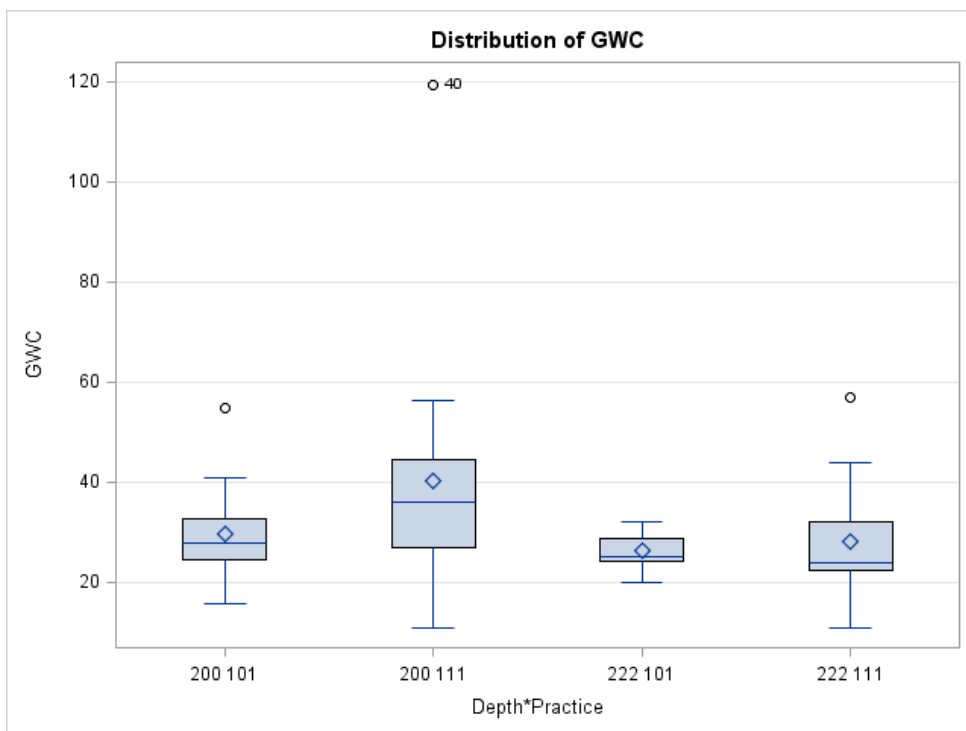
**Figure: 6** Shows a graphical relationships of percentage water holding capacity (WHC) distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111). Water holding capacity is highly observed in the subsurface depth of the conventional tillage than the minimum tillage with about 99 % (see 222 111) as against 26.99 % as in 222 101.



**Figure: 7** Shows a graphical relationships of percentage Organic Carbon (OC) distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111).



**Figure: 8** Shows a graphical relationships of percentage Organic Matter (OM) distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111). Organic Matter is highly observed in the subsurface depth of the conventional tillage than the minimum tillage with about 17 % (see 222 111) as against 0.30 % as in 222 101.



**Figure: 9** Shows a graphical relationships of gravemetric water content (GWC) distribution at the surfaces (200) of minimum tillage (101) and the conventional tillage practices (111).

**APPENDIX B**

**Table 1: Minimum Tillage Infiltration Test.**

S/N	Time (min)	Initial (cm)	Final (cm)	Actual (cm)	Infiltr. Rate (cm/hr)	cumulative (cm)
1	5.00	10.00	12.30	2.30	27.60	2.30
2	5.00	12.30	13.80	1.50	18.00	3.80
3	10.00	13.80	17.00	3.20	19.20	7.00
4	10.00	17.00	18.70	1.70	10.20	8.70
5	20.00	18.700	22.10	3.40	10.20	12.10
6	20.00	22.10	24.40	2.30	6.90	14.40
7	20.00	24.40	26.20	1.80	5.40	16.20
8	30.00	26.20	26.80	0.60	1.20	18.20
9	30.00	26.80	28.60	2.00	4.00	19.60
10	30.00	26.60	30.00	1.40	2.80	21.00
<b>Mean</b>		<b>19.83</b>	<b>22.19</b>	<b>2.02</b>	<b>10.55</b>	<b>12.33</b>

**Table 2: Conventional Tillage Infiltration Test.**

S/n	Time(min)	Initial(cm)	Final(cm)	Actual(cm)	Infilt.rate (cm/hr)	Cumulative infiltr.(cm)
1	5.00	07.00	11.30	04.30	51.60	04.30
2	5.00	11.30	14.00	02.70	32.40	07.00
3	10.00	14.00	19.90	05.90	35.40	12.90
4	10.00	19.90	24.30	04.40	26.40	17.30
5	20.00	24.30	31.00	07.30	21.90	24.60
6	20.00	31.00	43.50	12.50	37.50	37.10
7	20.00	43.50	50.40	06.90	20.70	44.00
8	30.00	50.40	60.80	10.40	20.80	54.40
9	30.00	60.80	72.50	11.70	23.40	66.10
10	30.00	72.50	79.30	06.80	13.60	72.90
<b>Mean</b>		<b>32.84</b>	<b>40.70</b>	<b>7.29</b>	<b>28.37</b>	<b>34.06</b>