# Effects of Tillage Methods on Some Soil Physical Properties under Maize Cultivation

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**Abstract - This study investigated the effects of different tillage methods on some physical properties of a sandy loam soil. This was to determine the tillage method that would produce the most favourable soil physical properties in a tropical sandy loam soil under maize cultivation. A replicated randomized complete block design with treatments consisting of no tillage (NT), disc harrowing (DH), disc ploughing (DP) and disc ploughing and harrowing (DPH) operations carried out at the research farm, Oyo State College of Agriculture, Igboora, Nigeria, was used for the study. Each treatment had four replicates. The bulk density, penetration resistance, moisture content and soil temperature values were determined for each of the treatments during 2013 season. Soil bulk density and moisture content were measured at depths of 0 – 5 cm and 5 – 10 cm, penetration resistance was measured at a depth of 0 –10 cm whilst soil temperature was measured on the surface soil (0 – 5 cm).These parameters were determined fortnightly over a period of 12 weeks after tillage operation. Data were analysed using descriptive and inferential statistics. The results indicated that all the tillage treatments were significantly ($P < 0.05$) different in their effects on soil bulk density, penetration resistance, moisture content and soil temperature. Surface soil temperature decreased as the time after tillage increased. Bulk density, penetration resistance and moisture content decreased with increase in the degree of soil loosening by tillage operations (NT > DH > DP > DPH).**

***Key words: Tillage Methods, Bulk Density, Penetration Resistance, Moisture Content, Soil Temperature***

## 1. INTRODUCTION

Soil is the mixture of minerals organic matter , gases , liquids and a myriad of micro and macro organisms that can support plant life. It is a natural body that exists as part of the pedosphere and it forms four important functions: as a medium for plant growth and of water storage, supply and purification; as a modifier of the atmosphere and finally as a habitat for organisms that take part in decomposition and creation of a habitat for other organisms. Soil is considered the ‘’ skin of the earth’’ with interfaces between the lithosphere , hydrosphere , atmosphere and biosphere (Chesworth, 2008). Soil consists of a solid phase (minerals and organic matter) as well as a porous phase that holds gases and water, (Voroney, R.P., 2006). Accordingly are often treated as a three state system (McCarthy, 1982). Tillage aims to create a soil environment favourable to plant growth.Definitions of tillage vary. Soil Tillage is defined as physical, chemical or biological soil manipulation to optimize conditions for germination, seedling establishment and crop growth. Soil tillage can also bedefined as any physical loosening of the soil carried out in a range of cultivation operations, either by hand or mechanised.

Soil manipulation can change fertility status markedlyand the changes may be manifested in good or poor performance of crops In addition , tillage operations loosen , granulate, crush or compact soil structure , changing soil proportion such as bulk density, pore size distribution and composition of the soil atmosphere that affect plant growth. Appropriate tillage practice are that avoid the degradation of soil properties but maintain crop yields as well as ecosystem stability(Lal, 1982).

Tillage is one of the important processes in Agriculture. It is carried out mainly to loosen the upper layer of soil, to mix the soil with fertilizer and organic residues,to control weeds and to create a suitable seed bed for germination and plant growth (Rasmussen, 1999). Many farmers perform tillage operations without being aware of the effects of these operations on soil physical properties and crop responses (Ozpinar and Isik , 2006 ). The objectives of tillage are to develop adesirable soil structure or suitable soil tilth for a seed bed. Tillage is crucial for crop establishment growth and ultimately yields(Atkinson*et al*,2007).

One of the reasons for reduction in food production is poor land management (Lasisi,2008). Lal (1982) listed compaction of the surface horizon of soil as one of the factors causing rapid decline in soil productivity. Soil compaction in agriculture affects the soil physical environment for crop production .Sufficient compaction establishes seed –soil contact and enhances germination. (Kayombo and Lal, 1993). Excessive compaction on the other hand is detrimental for maintaining a good root environment (Flowers and Lal,1998).About 0.3-0.5% of tropical arable land is lost to soil degradation annually , mainly as a result of uncontrolled tillage systems (Buringh,1989).Soil conservation oriented tillage must be encouraged and properly implemented to preserve the remaining available land from further degradation and nutrient depletion(Afolayan, *et al*., 2000). A lot of work has been done on the effects of different tillage methods on soil properties. The results of these investigations seem to vary with soil types and conditions, the type of crop and climates, the type of management practices and a host of other factors. The application of these tillage methods on the

Nigeria soils has shown that a particular tillage method is applicable only under certain climatic and soil conditions for optimum crop production (Anazodo, 1983; Anazodo et al, 1990). Hence, tillage methods are sight specific and should be developed for all conditions to solve specific problems of soil and water management, cropping systems and energy needs of the zone.

The objective of this study,therefore, was to investigate the effects of different tillage methods on physical properties of a tropical sandy loam soil in south western Nigeria.

## 2. MATERIALS AND METHODS

### *2.1 Location, Soil And Weather*

The experiments were carried out at the research farm of Oyo State College of Agriculture, Ignore, south-western Nigeria in 2013. Soil at the experimental site was randomly sampled from five different locations within the site before the commencement of the experiments, using 50 mm × 54 mm cylindrical cores. This sample was air dried for one week before being taken to the laboratory for analysis. The soil texture of the experimental site was sandy loam consisting of 68 % sand, 18 % silt and 14 % clay. The total annual rainfall of the study area was about 1240 mm. The average minimum air temperature ranged between 22 ºC and 25 ºC whilst the average maximum air temperature ranged between 26 ºC and 35 ºC.

### *2.2treatments And Experimental Design*

The experiment was arranged in a randomized complete block design (RCBD) with four tillage treatments in four replicates. Four different tillage methods were need to provide four treatments as follows : disc ploughing only (DP) disc ploughing followed by disc harrowing (DPH) , disc harrowing only (D.H) and no tillage (NT).

The experimental site measured 55m×35m and consisted of four blocks. Each block measured 55m×5m and was divided into four plots . Each plot measured 10m×5m and adjacent plots were separated by hedgerows of 5m, which enabled the tractor to turn conveniently without encroaching on the no tillage plots (Fig. 1). The weeds on the plots were controlled using Antraz herbicide at a rate of one litre per hectare.

### *2.3 Soil Measurements.*

The soil parameters measured in the experiment were: bulk density, penetration resistance (Cone index),moisture contentand temperature.

Bulk density was determined using cylindrical soil cores at two different depths of 0-5 cm and 5-10cm per plot immediately after planting maize seeds and every fortnight thereafter for12 weeks. A cylindrical soil core sampler of 8cm×4cm was driven into the soil and when the outer end of the ring was at the same level of soil surface, the ring was dug carefully. The soil was then sliced out to the same level as the rim of the cylinder and the content was carefully put inside a labelled polythenebag. The weight of the soil sample for each plot was determined and recorded. The samples were then put inside an oven with the temperature of the oven set at 105°C for 24 hours. The weights of the samples were monitored at intervals until there was no difference in the weights. The oven dried weights were determined and recorded. Cone penetrometer was used to measure the penetration resistance of the plots at a depth of 10.cm. Measurements were taken at four different locations within each plot and the average value for each depth was determined. Soil moisture content was measured with the TDR-100 moisture metre (Spectrum Technologies Inc.) at depths of 0 - 5 and 5-10. Soil temperatures of the plots were measured at 15.00 hours after planting and at every fortnight intervals thereafter for 12 weeks using soil thermometer inserted to 10cm depth.

## 3. RESULTS AND DISCUSSION

### *3.1 Soil Bulk Density*

Figure 2 shows the values of soil bulk density for a period of 12 weeks. It was observed that the highest set of values of bulk density was obtained on no tillage (NT) treatment whilst the least set of values was recorded on disc ploughing and harrowing (DPH) throughout the planting period for both 0-5 and 5-10 depths. It was also observed from the result that bulk density values increased with time in all tillage treatments. The general increase in soil bulk density with time in all the tillage treatments could be attributed to the combined effect of rainfall impact and cycles of wetting and drying of the soil. Osunbitan *et al.*(2005) and Aluko and Lasisi (2009) reported similar results for a loamy sand and sandy loam soils, respectively, in south western Nigeria. Soil bulk density was significantly ($P < 0.05$) affected by tillage method, bulk density decreasing with increasing degree of tillage (NT>DH.>DP.>DPH.)

### *3.2 Soil Penetration Resistance*

The result of soil penetration resistance (Cone index) at a soil depth range of 0-10cm over a period of twelve weeks is shown in Fig. 3. Penetration resistance across the three soil depths considered was consistently highest on no tillage (NT) treatment and lowest on disc ploughing and harrowing (DPH) treatment. The lower penetration resistance obtained on disc ploughing and harrowing enhanced better plant root development and nutrient absorption within the soil, which in turn, enhanced better plant growth when

compared to untilled plots (Lasisi, 2008).. It was observed from the result that penetration resistance increased with increase in soil depth for all the tillage treatments. Penetration resistance was significantly ($P<0.05$) affected by tillage treatment with penetration resistance decreasing with increasing degree of tillage (NT>DH>DPH)

### *3.3 Soil Moisture Content*

The values of moisture content at two different soil depths of 5 and 10cm are shown in Fig. 4. At both depths, plots with no tillage treatment had the highest moisture content whilst the plots treated with disc ploughing and harrowing had the lowest moisture content. The lower values obtained on conventionally tilled plots could be attributed to deep percolation on these plots. On the other hand, the higher values of the moisture content obtained on no tillage plots could be attributed to the fact that vegetation residues left on the soil provided a mulching effect which enhanced moisture conservation on these plots. Moisture content increased with the soil depth for all the treatments while the time after tillage operations had no significant effect on the moisture content of the plots. Moisture content was significantly (P< 0.05) affected by tillage method, moisture content decreasing with increasing degree of tillage (NT> DH> DP.>DPH).

### *3.4 Soil Temperature*

Figure 5 shows the values of surface (0-5cm) soil temperature obtained from the tillage treatments. Immediately after tillage operations, soil temperature values were observed to be highest on disc ploughing and harrowing treatment and lowest on no tillage treatment. These temperatures progressively declined as the time after tillage operations increased. At the 12th week after tillage, the soil temperature on plots treated with disc ploughing and harrowing (DPH) and no tillage (NT.) had declined progressively..This progressive decline in soil temperature can be attributed to the gradual development of plant foliage, which increasingly shaded the ground. The soil temperature was relatively higher on disc ploughing and harrowing plots compared to no tillage plots. The higher values obtained on disc ploughing and harrowing can be attributed to the breakup of the soil structure caused by tillage operations, which loosened the soil, making it porous. The lower values obtained under no tillage treatment can be attributed to the influence of residues on the soil surface, which intercepted incoming radiation and thus reduced soil temperature. Nangju (1979) reported that higher soil temperatures enhance better seedling emergence and early growth on a tropical soil. This suggests that better seedling emergence and early growth can be expected on conventionally tilled plots (DH, DP, and DPH) considering the relatively higher soil temperatures obtained on these plots compared to the temperatures obtained on the untilled plots (NT). Statistical analysis of these results showed that soil temperature was significantly (P < 0.05) affected by tillage treatments.

## 4. CONCLUSIONS

Soil bulk density, penetration resistance and moisture content decreased with increase in the degree of soil loosening by tillage (NT > DH > DP > DPH). Bulk density and penetration resistance increased with increase in length of time after tillage operations. All the soil properties considered (bulk density, penetration resistance, moisture content and temperature) were significantly (P < 0.05) affected by tillage treatment. Due to the development of plant foliage, which shaded the ground, surface soil temperature decreased as the time after tillage increased.

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Table 1 Soil Properties at the Experimental Site

| Soil Property | |
|---|---|
| Sand (%) | 68 |
| Silt (%) | 18 |
| Clay (%) | 14 |
| Organic matter (%) | 2.50 |
| Organic carbon (%) | 1.46 |
| pH | 5.80 |
| Total N (%) | 0.11 |
| $Ca^{2+}$ ($cmolkg^{-1}$) | 1.36 |
| $Mg^{2+}$ ($cmolkg^{-1}$) | 1.67 |
| $K^{+}$ ($cmolkg^{-1}$) | 0.21 |
| Avail. P ($cmolkg^{-1}$) | 34.50 |
| $Na^{+}$ ($cmolkg^{-1}$) | 0.32 |

Table 2 Rainfall and Temperature Distribution at the Experimental Site during 2013 Season

| Month | Rainfall (mm) | Temperature (ºC) Max. | Min. |
|---|---|---|---|
| June | 21.20 | 28.8 | 27.00 |
| July | 110.40 | 28.10 | 26.50 |
| August | 12.60 | 25.9 | 25.50 |
| September | 106.8 | 27.90 | 26.60 |

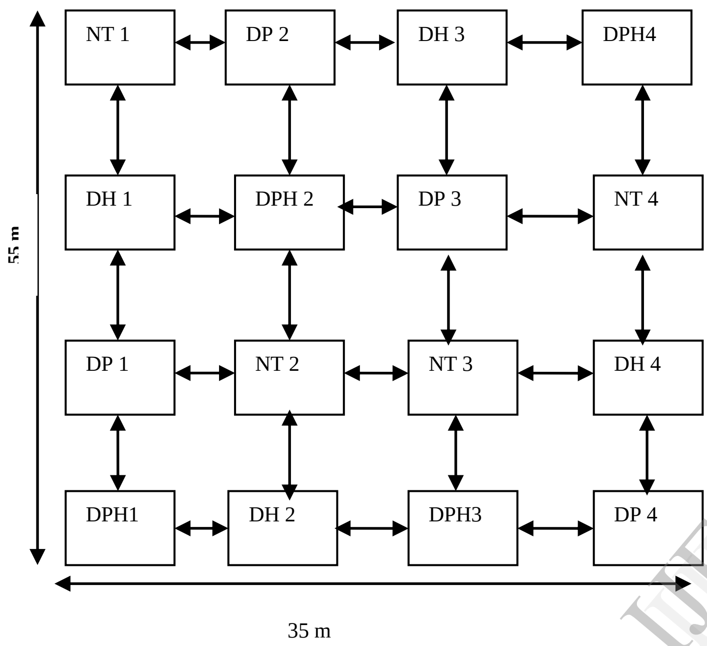
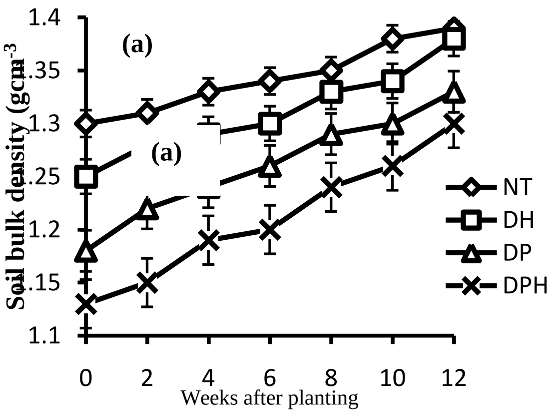



Fig. 1 Layout of the experimental site



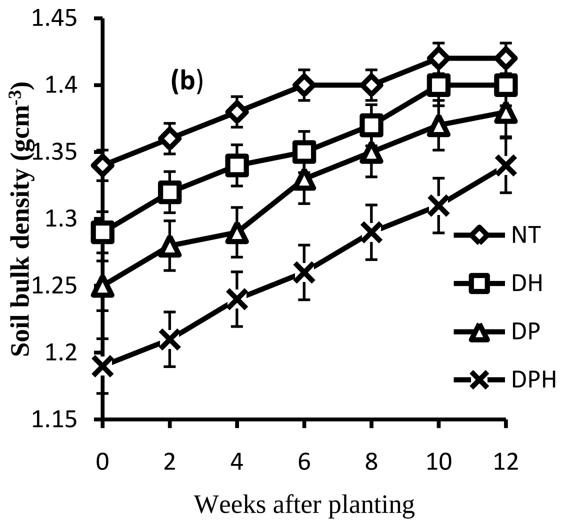




Fig. 2 Effect of Tillage Methods on Soil Bulk DensityAt depths of (a) 0 – 5 cm (b) 5 – 10 cm

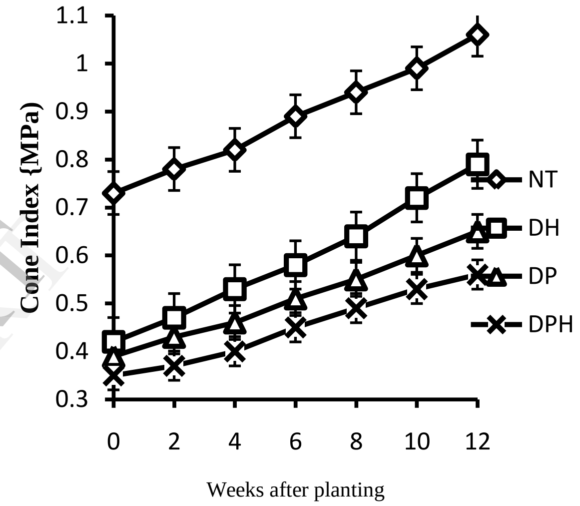
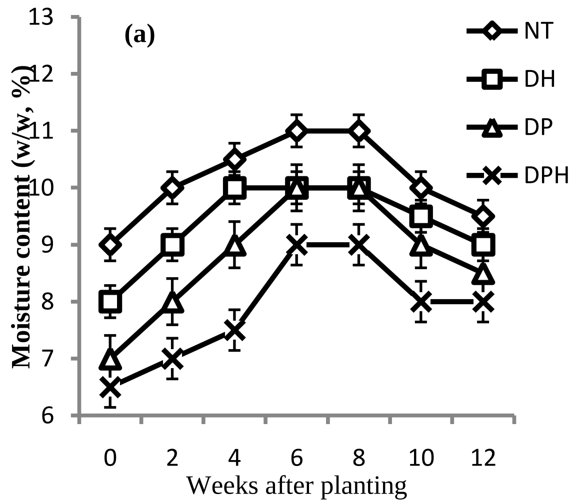



Fig. 3 Effect of Tillage Methods on Cone Index at a depth of 0 – 10 cm



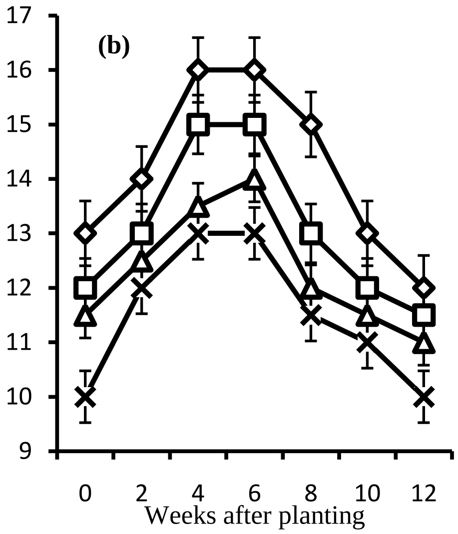



Fig. 4 Effect of Tillage Methods on Soil Moisture Content at depths of (a) 0 – 5 cm (b) 5 – 10 cm

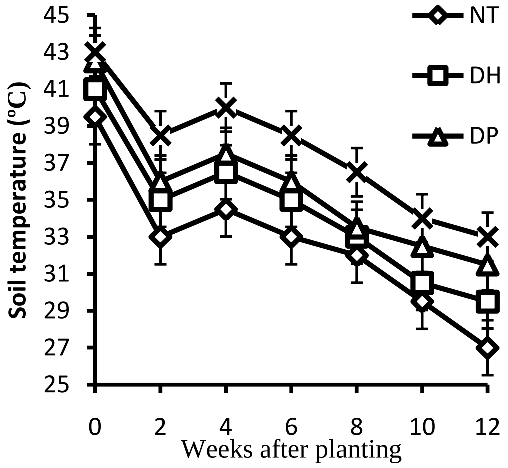



Fig. 5 Effect of Tillage Methods on Soil Temperature at a depth of 0 – 5 cm