Websites:
http://www.sciencepub.net
http://www.sciencepub.net/rural

Emails:
editor@sciencepub.net
sciencepub@gmail.com

World Rural Observations

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Effects Of Tillage Methods On Soil Physical Properties Of Sandy Loam Soil Of Wukari-Nigeria

Ezekiel Ambo Mamai [1], Audu Jibaniya [1], Tanko Bako [2]

[1] Department of Soil Science and Land Resource Management, Federal University, Wukari, Nigeria
[2] Department of Agricultural and Bio-resources Engineering, Taraba State University, Jalingo, Nigeria
E-mail: mamaiezekiel@yahoo.com, Phone: +234 7034890134

Abstract: A field study was conducted on sandy loam soil to compare the effect of different tillage practices on some selected soil physical properties. The experiment was arranged in a randomized complete block design with three replications. The treatments consisted of no-tillage, disc ploughing only, disc ploughing followed by disc harrowing and disc ploughing followed by twice disc harrowing. Compared with the other treatments, the disc ploughing followed by twice disc harrowing treatment gave the most favourable soil conditions (i.e. lowest soil penetration resistance, lowest dry bulk density, highest soil moisture content, highest total porosity and highest saturated hydraulic conductivity). The no tillage plots produced the most unfavourable soil conditions (i.e. highest soil penetration resistance, highest dry bulk density, lowest soil moisture content, lowest total porosity and lowest saturated hydraulic conductivity). Therefore, under the soil and weather conditions of the experiment, the best tillage practice identified for crop production is disc ploughing followed by twice disc harrowing.
[Ezekiel Ambo Mamai, Audu Jibaniya, Tanko Bako. **Effects Of Tillage Methods On Soil Physical Properties Of Sandy Loam Soil Of Wukari-Nigeria.** *World Rural Observ* 2020;12(2):89-97]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 9. doi:10.7537/marswro120220.09.

Keywords: No-tillage, Disc, Plough, Harrow, Treatments.

1. Introduction

Tillage is a mechanical manipulation of soil to provide a favourable condition for crop production. Soil tillage consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass, so as to enable the roots of the crops to penetrate and spread into the soil. Tillage may be called the practice of modifying the state of soil to provide favourable conditions for plant growth. Tillage is the agricultural preparation of the soil by mechanical agitation of various types, such as digging, stirring, and overturning (Sahay, 2008).

Generally, tillage systems are classified into three, and these are: intensive tillage, reduced tillage and conservation tillage. Intensive tillage systems leave less than 15% crop residue cover or less than 560 kg/ha of small grain residue on the soil. These systems involve often multiple operations with implements such as a mouldboard, disk and/ or chisel plough. A finisher with a harrow, rolling basket, and cutter can be used to prepare the seed bed. Reduced tillage systems leave between 15 and 30% residue cover on the soil or 560 to 1100 kg/ha of small grain residue during the critical erosion period. This may involve the use of a chisel plough, field cultivators, or other implements. Conservation tillage systems are methods of soil tillage which leave a minimum of 30% of crop residue on the soil surface or at least 1,100 kg/ha of small grain residue on the surface during the critical soil erosion period (Sahay, 2008).

Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20 % (Khurshid *et al*., 2006). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Alvarez and Steinbach, 2009). Jabro *et al*. (2016) reported that tillage depth and intensity alter the soil physical and chemical properties that affect plant growth and crop yields. Khan *et al*. (2010) also reported that tillage method affects the sustainable use of soil resources through its influence on soil properties. The proper use of tillage can improve soil related constrains, while improper tillage may cause a range of undesirable processes, e.g. destruction of soil structure, accelerated erosion, depletion of organic matter and fertility and disruption in cycles of water, organic carbon and plant nutrient (Lal, 1997). Use of excessive and unnecessary tillage operations is often harmful to soil. It has been observed that more tillage is being done than necessary leading to soil loss by wind and water erosion. In some instances, too many passes of tractor-machine aggregate leads to formation of soil pans thereby reducing air and water infiltration and circulation. Therefore, currently there is a significance interest and emphasis on the shift to the conservation and no-tillage methods for the purpose of controlling erosion process (Costa *et al*., 2015).

Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content. Annual disturbance and pulverizing caused by conventional tillage produce a finer and loose soil structure as compared to conservation and no-tillage method which leaves the soil intact (Rashidi and Keshavarzpour, 2007). This difference results in a change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This in turn controls erosion, runoff and crop performance (Khan *et al.,* 2001). On the other hand, conservation tillage methods often result in decreased pore space (Hill, 1990), increased soil strength (Ji *et al*., 2013) and stable aggregates (Horne *et al*., 1992). The pore network in conservationally tilled soil is usually more continues because of earthworms, root channels and vertical cracks (Senjobi *et al*., 2013). Therefore, conservation tillage may reduce disruption of continues pores. Whereas, conventional tillage decreases soil penetration resistance and soil bulk density (Khan *et al*., 1999). This also improves porosity and water holding capacity of the soil. Continuity of pore network is also interrupted by conventional tillage, which increases the tortuousity of soil. This all leads to a favorable environment for crop growth and nutrient use (Khan *et al*., 2001). However, the results of no-tillage are contradictory (Iqbal *et al*., 2005). Hemmat and Taki (2001) reported that no-tillage methods in arid regions of Iran had an adverse effect on crop yields. Ghuman and Lal (1984) while comparing conventional tillage method to no-tillage method concluded that higher moisture preservation and 13% more income was obtained in case of no-tillage. At this time, a wide range of tillage methods is being used in Wukari without evaluating their effects on soil physical properties. Therefore, the present investigation was planned to determine the effect of different tillage methods on soil physical properties in the lands of Wukari.

1.1 Statement of the Problem

Due to the limited data or more precisely, the unavailability of classified data on the required level of tillage operations for the individual crops, the expected yield is usually not achieved. Tillage operations particularly the conventional ploughing and harrowing, are carried out all across Nigeria in the same manner without giving due consideration to the variations in soil characteristics. A soil with a peculiar structure and texture does not get the appropriate tillage to suit it and to the correct level which will ultimately result in low crop yields. In most cases, crops that are not indigenous to a particular region are never imported into such areas for cultivation due to inadequate knowledge on type of tillage to suit that crop. Farmers of these areas are completely oblivious of the fact that, with appropriate levels of tillage operations, such crops may thrive better there. A lot of research has been done on soil tillage and effects of tillage on crop yield, physical, chemical, and biological properties of the soil. But more research work is still necessary; especially that soil structure, texture and characteristics vary from one place to the other. In Africa and many developing countries, limited data are available on the required level of tillage for various crops. This calls for studies on tillage systems for various crops, soil types and conditions in such regions.

1.2 Objectives of the Work

The objectives of the study are;

i. To determine the effects of four different tillage methods on soil physical properties.

ii. To determine the best tillage method for a sandy loam soil.

2. Materials And Methods

2.1 Site Description

The study was carried out at the Federal University Research Farm Wukari, during the early crop cycle of 2018. Wukari is 209 m above sea level and on latitude $7^0 52'19''$N and longitude $9^0 47'33''$E, elevation 625 ft under southern guinea savannah vegetation. The experiment was conducted during the second peak of raining season in Wukari. The explored horizon (0-25 cm) is made up of soil classified as sandy loam soil, having composition of 79.7 % sand, 5.1 % sit and 15.2 % clay, with a hydraulic conductivity of 1.47 mm/day. The average rainfall of Wukari from January to August is about 835 mm, while the annual maximum and minimum temperatures of Wukari is 36.6^{o}C and 26.6^{o}C respectively.

2.2 Description of Tractor and Machinery Used

A new Holland tractor number TT75 was used to pull the field equipment during operations. Specifications of the tractor are Gross weight: 2,200 kg; Overall width: 1,651 mm; Overall length: 3,542 mm and Ground clearance: 338 mm. Disc plough and disc harrow were used for the experiment. The plough consists of three (3) plane concave discs with a spacing of 680 mm. The disc diameter and plough width are 660 mm and 1900 mm respectively. The harrow consists of eighteen (18) gang plane concave and notched concave discs spaced 225 mm apart. The disc diameter and harrow width are 560 mm and 2200 mm respectively. The tractor was used for both the ploughing and harrowing operations on the experimental plot at the tractor speed of 3 km/hr.

2.3 Sample Collection

Soil used for this study was collected with hand auger at the Teaching and Research Farm, Federal University, Wukari. The samples were collected at soil depths of 0-7 cm, 7-14 cm and 14-21 cm.

2.4 Experimental Design

The experiment was arranged in a randomized complete block design (RCBD) with four tillage treatment consisting of no tillage (NT), disc ploughing only (PA), disc ploughing followed by disc harrowing (PH) and disc ploughing followed by disc harrowing twice only (PHH). Each plot size was 10.0×3.0 m with a buffer zone of 1.5 m spacing provided between plots. The tillage operations were carried out using a new Holland tractor number TT75. Ploughing was done with a 3-disc plough while harrowing was done with an offset harrow.

Table 1: Details of Different Tillage Treatments

Treatments	Tillage type	Description
No-till (NT)	Conservation	No tillage
Plough alone (PA)	Conservation	Disc plough once
Plough with harrow once (PH)	Conventional	Disc plough+1pass of harrow
Plough with harrow twice (PHH)	Conventional	Disc plough+2passes of harrow

2.5 Determination of Soil Physical Properties

2.5.1 Soil moisture content

Three soil samples were taken at random locations in each plot from the 0-7 cm, 7-14 cm and 14-21 cm soil layers with a soil core sampler 5 cm long and 5 cm in diameter. Samples were oven-dried at 105°C for 24 hours to determine the soil moisture content gravimetrically (ASABE Standards, 2008). The gravimetric moisture content was calculated as the mass of moisture in the soil sample divided by the mass of the dry soil multiplied by 100 (Aikins and Afuakwa, 2012).

$$\text{Moisture content (\%)} = \frac{\text{(Wet soil weight)} - \text{(Oven dried soil weight)}}{\text{(Oven dried soil weight)}} \times 100 \qquad (1)$$

2.5.2 Soil dry bulk density

Soil dry bulk density in the 0-7 cm, 7-14 cm and 14-21 cm layers were determined using the core method. Three soil samples were randomly taken per plot using a stainless steel core sampler of dimension 5 cm diameter by 5 cm height. The collected soil cores were trimmed to the exact volume of the cylinder and oven dried at 105°C for 24 hours. Precautions were taken to avoid compaction inside the core sampler. Dry bulk density was determined from the ratio of mass of dry soil per unit volume of soil cores (Aikins and Afuakwa, 2012).

$$\text{Bult density} = \frac{\text{Mass of oven dried soil (g)}}{\text{Total volume of soil (cm}^3\text{)}} \qquad (2)$$

2.5.3 Total porosity

The total porosity of the soil in the 0-7 cm, 7-14 cm and 14-21 cm layers were calculated from the values of the dry bulk density and an assumed particle density of 2.65 g/cm^3 using the following Equation (Aikins and Afuakwa, 2012).

$$\text{Porosity, \%} = \left(1 - \frac{\text{Bulk density}}{\text{Particle density}}\right) \times 100 \qquad (3)$$

2.5.4 Saturated hydraulic conductivity (*K*sat)

Saturated hydraulic conductivity (*K*sat) determinations were done in the laboratory using the constant head method as described by Klute and Dirksen (1982). Undisturbed soil core rings (5 cm depth, volume 98.13 cm^3) collected from the field were carefully trimmed to the size of the core ring. A piece of muslin cloth held with a rubber band was used on one side of the core ring to protect the soil from spilling but to allow water to pass through. The samples were then saturated for 24 hours before water percolation tests were done. The volume of water that passed through the soil sample was measured and recorded until a constant average was achieved. The *K*sat was then calculated as;

$$K_{Sat} = \mathrm{Q} \times \frac{L}{(\mathrm{A} \times \mathrm{T} \times \mathrm{H})} \qquad (4)$$

Where Q is the discharge or percolate through the soil (cm^3), L is the length of the soil core (cm), A is the cross-sectional area of the soil core (cm^3), T is the time taken (hours), and H is the hydraulic head difference (cm).

2.5.5 Soil penetration resistance

Soil penetration resistance is a measure of the soil strength and an indicator of how easily roots can penetrate into the soil. Soil strength (Ncm^{-2}) was determined by using a hand held digital penetrometer (D 1558-84 ASTM standard of needle head 0.6 cm) in each treatment at 0-7 cm, 7-14 cm and 14-21 cm soil depth. Cone base area of 1 cm^2 was used for taking a penetrometer reading in each plot (Sauwa *et al.*, 2013).

2.6 Statistical analysis

The data were statistically analyzed by using analysis of variance technique appropriate for randomized complete block design and means were compared using Duncan's multiple test range at 0.05 level of probability.

3. Results And Discussion

3.1 Effects of Tillage Practices on Soil Moisture Content

Soil moisture is the source of water for plant use in particular in rainfed agriculture. Soil moisture is highly critical in ensuring good and uniform seed germination and seedling emergence, crop growth and yield. Table 2 depicts the mean soil moisture content (%) values obtained under the different tillage practices over the course of the study in the 0-7 cm, 7-14 cm and 14-21 cm soil layers. The study shows that tillage treatments significantly affected moisture content at 5 % probability level. The moisture content increases with increasing degree of tillage. Moisture content increased with the soil depth for all the treatments while the time after tillage operations had no definite pattern for the moisture content of the plots. Plots with disc ploughing followed by disc harrowing twice had the highest soil moisture contents. The lowest soil moisture contents were located in the No-Tillage plots. The observed increases in soil moisture content with increasing degree of tillage in this study may be attributed to the fact that soil disturbance and pulverization caused by conventional tillage produced finer and loosed soil structure which tends to conserve more moisture. The low value of moisture content associated with the no-tillage treatment may be due to the decreased pore space, increased soil strength and stable soil aggregates associated with conservative tillage. This is in agreement with Khan *et al*. (1999) who reported that conventional tillage methods increase the tortuosity of the soil.

In contrast, Ojeniyi and Adekayode (1999) and Olaoye (2002) found higher soil moisture content in No Tillage plots compared with that of disc ploughed followed by disc harrowed plots. This also disagrees with Lasisi *et al.* (2014) who investigated the effects of different tillage methods on some physical properties of a sandy loam soil at the soil depths of 0-5 cm and 5-10 cm and found that 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 (Lasisi *et al*., 2014).

Table 2: Effects of Tillage Practices on Mean Soil Moisture Content (%)

Tillage Methods	Soil Depths (cm)		
	0-7	7-14	14-21
0 DAT			
No Tillage	4.90 ± 0.17^a	7.09 ± 0.71^a	8.69 ± 0.09^a
Plough Alone	5.79 ± 0.21^a	8.21 ± 0.72^a	8.74 ± 0.73^a
Plough + Harrow	9.29 ± 0.64^b	9.41 ± 0.42^a	10.07 ± 0.65^b
Plough + Harrow Twice	10.17 ± 0.64^b	11.60 ± 1.06^b	12.44 ± 1.35^b
11 DAT			
No Tillage	4.46 ± 0.68^a	5.61 ± 0.93^a	7.53 ± 0.47^a
Plough Alone	5.79 ± 0.44^a	6.44 ± 1.45^a	7.58 ± 1.32^a
Plough + Harrow	9.29 ± 0.73^b	9.67 ± 0.61^b	10.07 ± 0.76^b
Plough + Harrow Twice	10.19 ± 0.62^b	10.71 ± 1.02^b	12.44 ± 0.55^b
21 DAT			
No Tillage	4.60 ± 0.18^a	5.93 ± 0.04^a	6.69 ± 0.06^a
Plough Alone	7.10 ± 0.14^a	5.93 ± 0.04^a	8.33 ± 0.25^b
Plough + Harrow	7.38 ± 0.41^a	7.33 ± 0.03^b	8.40 ± 0.71^b
Plough + Harrow Twice	9.02 ± 0.01^b	9.46 ± 0.06^c	9.75 ± 0.09^b

3.2 Effects of Tillage Practices on Soil Bulk Density

Soil bulk density is probably the most frequently measured soil quality parameter in tillage experiments (Rasmussen, 1999). The effect of the different tillage practices on dry bulk density in the 0-7 cm, 7-14 cm and 14–21 cm layers is shown in Table 3. Over the course of the study, tillage practices significantly affected soil dry bulk density. The dry bulk density decreases with increasing degree of tillage. The values of bulk density were detected to increase in all plots as depth increases while the time after tillage operations had no definite pattern for the dry bulk density of the plots. The No-Tillage treatment recorded the highest dry bulk density significantly higher than that of the disc ploughing followed by twice disc harrowing treatment, which produced the lowest dry bulk density.

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. On the other hand, Olaoye (2002) found higher dry bulk density in disc ploughing followed by disc harrowing plots compared with that of the No Tillage plots for Ferric Luvisol in the rainforest zone at Akure, Nigeria. 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^3 can restrict root growth and result in low levels of water movement into and within the soil (Smith, 1988).

Table 3: Effects of Tillage Practices on Mean Soil Bulk Density (g/cm^3)

Tillage Methods	Soil Depths (cm)		
	0-7	7-14	14-21
0 DAT			
No Tillage	$1.90{\pm}0.08^a$	$1.96{\pm}0.02^a$	$1.98{\pm}0.23^a$
Plough Alone	$1.68{\pm}0.00^b$	$1.74{\pm}0.04^a$	$1.77{\pm}0.14^a$
Plough + Harrow	$1.55{\pm}0.18^c$	$1.63{\pm}0.00^a$	$1.68{\pm}0.11^a$
Plough + Harrow Twice	$1.51{\pm}0.02^c$	$1.60{\pm}0.07^a$	$1.62{\pm}0.11^a$
11 DAT			
No Tillage	$1.82{\pm}0.01^a$	$1.88{\pm}0.02^a$	$1.98{\pm}0.05^a$
Plough Alone	$1.75{\pm}0.14^a$	$1.76{\pm}0.10^b$	$1.77{\pm}0.10^a$
Plough + Harrow	$1.60{\pm}0.20^a$	$1.65{\pm}0.05^{bc}$	$1.67{\pm}0.06^a$
Plough + Harrow Twice	$1.53{\pm}0.10^a$	$1.60{\pm}0.10^c$	$1.61{\pm}0.03^a$
21 DAT			
No Tillage	$1.90{\pm}0.15^a$	$1.92{\pm}0.00^a$	$1.98{\pm}0.02^a$
Plough Alone	$1.68{\pm}0.02^a$	$1.68{\pm}0.01^b$	$1.77{\pm}0.00^a$
Plough + Harrow	$1.67{\pm}0.19^a$	$1.67{\pm}0.00^b$	$1.68{\pm}0.07^b$
Plough + Harrow Twice	$1.60{\pm}0.00^a$	$1.63{\pm}0.00^c$	$1.64{\pm}0.01^b$

3.3 Effects of Tillage Practices on Soil Porosity

Soil porosity and organic matter content play a critical role in the biological productivity and hydrology of agricultural soils. Pores are of different size, shape and continuity and these characteristics influence the infiltration, storage and drainage of water, the movement and distribution of gases and the ease of penetration of soil by growing roots (Kay and Vanden Bygaart, 2002). The mean total porosity obtained in the 0-7 cm, 7-14 cm and 14–21 cm soil layers under the four different tillage treatments over the field experiment period is presented in Table 4. Tillage practices significantly affected the soil porosity at 5 % probability level. The soil porosity increases with increasing degree of tillage. Soil pore space was found to decrease with increase in the soil depth for all the treatments while the time after tillage operations had no definite pattern for the soil porosity of the plots. Overall, in all the soil layers, the disc ploughing followed by twice disc harrowing treatment produced the highest total porosity while the No Tillage treatment gave lowest total porosity. Elder and Lal (2008) also reported higher total porosity in the tilled plots compared with the No-Tillage plots for organic soils.

Table 4: Effects of Tillage Practices on Mean Soil Porosity (%)

Tillage Methods	Soil Depths (cm)		
	0-7	7-14	14-21
0 DAT			
No Tillage	31.95±0.23[a]	27.68±0.42[a]	24.91±0.17[a]
Plough Alone	35.09±0.09[ab]	33.08±0.16[b]	31.19±0.12[b]
Plough + Harrow	38.79±0.16[b]	35.72±0.16[b]	35.65±0.09[b]
Plough + Harrow Twice	48.68±0.01[c]	46.41±0.17[c]	41.13±0.02[c]
11 DAT			
No Tillage	31.52±0.75[a]	29.04±0.43[a]	25.28±0.08[a]
Plough Alone	33.94±1.08[a]	33.33±0.23[ab]	30.44±0.07[ab]
Plough + Harrow	36.85±0.06[a]	36.29±0.09[b]	35.06±0.08[bc]
Plough + Harrow Twice	42.01±0.09[b]	39.37±0.05[b]	38.48±0.05[c]
21 DAT			
No Tillage	28.30±0.04[a]	27.37±0.42[a]	25.03±0.02[a]
Plough Alone	36.35±0.02[a]	32.95±0.08[b]	32.33±0.04[b]
Plough + Harrow	41.38±0.16[b]	36.98±0.03[bc]	36.61±0.08[bc]
Plough + Harrow Twice	42.70±0.01[b]	39.40±0.04[c]	38.48±0.01[c]

3.4 Effects of Tillage Practices on Soil Saturated Hydraulic Conductivity

From the values presented in Table 5, hydraulic conductivity, in the investigated period, fell in a range of 0.76 cm/hr to 6.53 cm/hr, which is classified as moderately high (Reynolds *et al*., 2003). There were significant differences among the tillage treatments in the values for saturated hydraulic conductivity at 5 % probability level. The saturated hydraulic conductivity of the soil increases with increasing degree of tillage. The saturated hydraulic conductivity of the soil decreased with the soil depth for all the treatments and the saturated hydraulic conductivity of the soil also decreases with increase in the time after tillage operations. Plots with disc ploughing followed by disc harrowing twice had the highest saturated hydraulic conductivity. The lowest saturated hydraulic conductivity of the soil was located in the No-Tillage plots. Some authors consider a range of 0.036 cm/hr to 36.00 cm/hr as acceptable values for saturated hydraulic conductivity of agricultural soils; among them clay loam soils (Topp *et al*., 1997). The hydraulic conductivity values obtained in this research were within this range. Another study considers an ideal range of hydraulic conductivity for agricultural soils, including clay loam textures, to be from 0.18 cm/ hr to 18.00 cm/hr, in this respect the values found in this study are just below that range (Reynolds *et al*., 2003).

Table 5: Effects of Tillage Practices on Soil Saturated Hydraulic Conductivity (cm/hr)

Tillage Methods	Soil Depths (cm)		
	0-7	7-14	14-21
0 DAT			
No Tillage	1.22±0.05[a]	1.03±0.04[a]	0.91±0.01[a]
Plough Alone	3.17±0.02[b]	2.56±0.02[a]	2.05±0.06[b]
Plough + Harrow	4.81±0.09[b]	4.01±0.08[b]	3.33±0.06[b]
Plough + Harrow Twice	6.53±0.03[c]	5.82±0.10[b]	4.11±0.05[c]
11 DAT			
No Tillage	1.01±0.02[a]	0.98±0.05[a]	0.87±0.01[a]
Plough Alone	2.97±0.08[b]	2.21±0.07[ab]	1.99±0.06[b]
Plough + Harrow	4.54±0.05[c]	3.88±0.03[b]	3.27±0.04[c]
Plough + Harrow Twice	6.08±0.20[d]	5.80±0.11[a]	4.01±0.08[c]
21 DAT			
No Tillage	1.00±0.04[a]	0.93±0.01[a]	0.76±0.03[a]
Plough Alone	2.78±0.01[b]	1.95±0.06[b]	1.43±0.01[a]
Plough + Harrow	4.50±0.02[c]	3.26±0.06[c]	2.84±0.05[b]
Plough + Harrow Twice	5.69±0.05[d]	5.59±0.08[d]	3.75±0.07[b]

3.5 Effects of Tillage Practices on Soil Penetration Resistance

Penetration resistance measures the energy that must be exerted by the young seedling to emerge from the soil. It indicates resistance that must be overcome by the young rootlets in their search for nutrients and water in the soil (Olaoye, 2002). Penetrometer resistance measurements of soil can be used to assess the need for tillage operations, which help maintain effective plant rooting and facilitate good water and nutrient uptake. Table 6 shows the effects of the different tillage practices on soil penetration resistance. Tillage practice significantly affected soil penetration resistance over the period of the experiment. The soil penetration resistance decreases with increasing degree of tillage. The values of soil penetration resistance were also detected to decrease in all plots as depth increases while the soil penetration resistance increases with increase in time after tillage operations. Among the tillage practices, soil penetration resistance was significantly higher under No-Tillage condition as compared with that in the tilled soil treatments. 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 *et al*., 2014). Similarly, Olaoye (2002) reported higher soil penetration resistance in the No-Tillage treatment in comparison with the disc ploughing followed by disc harrowing treatment for Ferric Luvisol in the rain forest zone of Akure in Nigeria. The observed general increase in soil penetration resistance 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.

Table 6: Effects of Tillage Practices on Soil Penetration Resistance (kPa)

Tillage Methods	Soil Depths (cm)		
	0-7	7-14	14-21
0 DAT			
No Tillage	221.15±2.30[a]	210.18±5.15[a]	197.06±1.94[a]
Plough Alone	208.62±4.22[a]	188.93±3.11[ab]	180.17±5.02[a]
Plough + Harrow	182.55±6.00[b]	178.24±3.19[b]	141.78±4.00[b]
Plough + Harrow Twice	173.00±1.53[b]	157.00±4.32[c]	95.90±6.39[c]
11 DAT			
No Tillage	250.28±3.27[a]	216.10±7.12[a]	212.40±2.67[a]
Plough Alone	210.13±4.01[b]	192.33±5.09[ab]	186.19±4.56[b]
Plough + Harrow	198.50±3.90[bc]	186.35±3.42[b]	151.88±5.11[c]
Plough + Harrow Twice	181.00±2.55[c]	160.18±2.70[c]	99.80±2.79[d]
21 DAT			
No Tillage	253.76±7.15[a]	228.10±7.10[a]	220.61±5.24[a]
Plough Alone	222.32±4.18[b]	195.24±4.81[b]	189.54±1.98[b]
Plough + Harrow	201.88±3.40[c]	188.91±6.45[bc]	162.38±4.83[c]
Plough + Harrow Twice	187.20±2.77[c]	171.25±3.07[c]	105.17±3.05[d]

4. Conclusion

From the results, the following can be concluded: Tillage treatments significantly affected soil moisture content, dry bulk density, total porosity, saturated hydraulic conductivity and penetration resistance. The disc ploughing followed by twice disc harrowing treatment presented the lowest soil penetration resistance and dry bulk density; and the highest moisture content, total porosity and saturated hydraulic conductivity. The no tillage treatment produced the highest soil penetration resistance and dry bulk density; and the lowest moisture content, total porosity and saturated hydraulic conductivity. Under the soil and weather conditions of the experiment, the results indicate that the best tillage treatment for crop production is the disc ploughing followed by twice disc harrowing.

References

1. Abagandura, G.O., Eld-Deen M. Nasr, G. and Moumen, N.M. (2017). Influence of Tillage Practices on Soil Physical Properties and Growth and Yield of Maize in Jabal al Akhdar, Libya. *Open Journal of Soil Science*, 7: 118-132.
2. Aikins, S.H.M. and Afuakwa, J.J. (2012). Effect of Four Different Tillage Practices on Soil Physical Properties under cowpea. *Agriculture and Biology Journal of North America*, 3(1): 17-24.
3. Aluko, O.B. and Lasisi, D. (2009). Effects of Tillage Methods on Some Properties of a Sandy

Loam Soil Under Soybean Cultivation. Proceedings of 3rd International Conference of NIAE, Jan. 25-29, Ile-Ife, Nigeria.
4. Alvarez, R. and Steinbach, H.S. (2009). A Review of the Effects of Tillage Systems on Some Soil Physical Properties, Water Content, Nitrate Availability and Crops Yield in the Argentine Pampas. Soil and Tillage Research, 104, 1-15.
5. Brady, N.C. and Weil, R.R. (1999). The Nature and Properties of Soils, (12th edn.), Prentice Hall, Inc, New Jersey.
6. Costa, J.L., Aparicio, V. and Cerda, A. (2015). Soil Physical Quality Changes under Different Management Systems after 10 Years in the Argentine Humid Pampa. *Solid Earth*, 6: 361-371.
7. Elder, J.W. and Lal, R. (2008). Tillage Effects on Physical Properties of Agricultural Organic Soils of North Central Ohio. *Soil and Tillage Research*, 98(2): 208–210.
8. Ghuman, B.S. and Lal, R. (1984). Water Percolation in Tropical Alfisol under Conventional Ploughing and No-Tillage Systems of Management. *Soil and Tillage Research*, 4: 263-276.
9. Hemmat A. and Taki D. 2001. Grain yield of irrigated wheat as affected by stubble tillage management and seeding rates in central Iran. *Soil and Tillage Research*, 63: 57-64.
10. Hill, R.L. (1990). Long-Term Conventional and No-Tillage Effects on Selected Soil Physical Properties. *Soil Science Society of America Journal*, 54: 161-166.
11. Horne, D.J., Ross, C.W. and Hughes, K.A. (1992). Ten years of Maize/Oats Rotation under Three Tillage Systems on a Silt-Loam Soil in New Zealand. 1. A Comparison of Some Soil Properties. *Soil and Tillage Research*, 22: 131-143.
12. Iqbal, M., Hassan, A.U., Ali, A. and Rizwanullah, M. (2005). Residual Effect of Tillage and Farm Manure on Some Soil Physical Properties and Growth of Wheat (*Triticum aestivum L.*). *International Journal of Agriculture and Biology*, 7(1): 54-57.
13. Jabro, J.D., Iversen, W.M., Stevens, W.A., Evans, R.G., Mikha, M.M. and Allen, B.L. (2016). Physical and Hydraulic Properties of a Sandy Loam Soil Under Zero, Shallow and Deep Tillage Practices. *Soil Tillage Research*, 159: 67–72.
14. Ji, B., Zhao, Y., Mu, X., Liu, K. and Li, C. (2013). Effects of Tillage on Soil Physical Properties and Root Growth of Maize in Loam and Clay in Central China. *Plant, Soil and Environment*, 59: 295-302.
15. Kay, B.D. and Vanden Bygaart, A.J. (2002). Conservation Tillage and Depth Stratification of Porosity and Soil Organic Matter. *Soil and Tillage Research*, 66 (2): 107–118.
16. Khan, F., Tahir, A. and Yule, I. J. (2001). Intrinsic Implication of Different Tillage Practices on Soil Penetration Resistance and Crop Growth. *International Journal of Agriculture and Biology*, 3(1): 23-26.
17. Khan, F.U.H., Tahir, A.R. and Yule, I.J. (1999). Impact of Different Tillage Practices and Temporal Factor on Soil Moisture Content and Soil Bulk Density. *International Journal of Agriculture and Biology*, 3: 163-166.
18. Khan, N.I., Malik, A.U., Umer, F. and Bodla, M.I. (2010). Effect of Tillage and Farm Yard Manure on Physical Properties of Soil. *International Research Journal of Plant Science*, 1(4): 75-82.
19. Khurshid, K., Iqbal, M., Arif, M.S. and Nawaz, A. (2006). Effect of Tillage and Mulch on Soil Physical Properties and Growth of Maize. *American Journal of Agricultural and Biological Sciences*, 8: 593-596.
20. Klute, A. and Dirksen, C. (1982). Hydraulic Conductivity and Diffusivity, in *Methods of Soil Analysis*, A. Klute, Ed., American Society of Agronomy. ASA, SSSA, Madison, Wis, USA. pp. 687-734.
21. Lal, R. (1997). Long-Term Tillage and Maize Monoculture Effects on a Tropical Alfisol in Western Nigeria. I. Crop Yield and Soil Physical Properties. *Soil and Tillage Research*, 42(3): 145-160.
22. Lasisi, D., Adesola, A.A. and Ogunsola, F.O. (2014). Effects of Tillage Methods on Some Soil Physical Properties under Maize Cultivation. *International Journal of Engineering Research and Technology (IJERT)*, 3(2): 2745- 2749.
23. Ojeniyi, S.O. and Adekayode, F.O. (1999). Soil Conditions and Cowpea and Maize Yield Produced by Tillage Methods in the Rainforest Zone of Nigeria. *Soil and Tillage Research*, 51(1): 161–164.
24. Olaoye, J.O. (2002). Influence of Tillage on Crop Residue Cover, Soil Properties and Yield Components of Cowpea in Derived Savannah Ectones of Nigeria. *Soil and Tillage Research*, 64(3-4): 179-187.
25. Osunbitan, J.A., Oyedele, D.J. and Adekalu, K.O. (2005). Tillage Effects on Bulk Density, Hydraulic Conductivity and Strength of a Loamy Soil in South-Western Nigeria. *Soil Tillage Research*, 82(1): 57-64.

26. Perroux, K.M. and White, I. (1988). Designs for Disc Infiltrometers. *Soil Science Society of America Journal*, 52: 1205-1215.
27. Rashidi, M. and Keshavarzpour, F. (2007). Effect of Different Tillage Methods on Grain Yield and Yield Components of Maize (*Zea mays L.*). *International Journal of Agriculture and Biology*, 9(2): 274-277.
28. Rashidi, M. and Keshavarzpour, F. (2008). Effect of Different Tillage Methods on Soil Physical Properties and Crop Yield of Melon (Cucumis melo). *ARPN Journal of Agricultural and Biological Science*, 3(2): 41-46.
29. Rasmussen, K.J. (1999). Impact of Ploughless Soil Tillage on Yield and Soil Quality: A Scandinavian review. *Soil and Tillage Research*, 53(1): 3–14.
30. Reynolds, W.D.; Yang, X.M.; Drury, C.F.; Zhang, T.Q.; Tan, C.S. (2003). Effects of Selected Conditioners and Tillage on the Physical Quality of a Clay Loam Soil. *Canadian Journal of Soil Science*, 83: 318-393.
31. Sahay, J. (2008). Elements of Agricultural Engineering. Delhi: Standard Publishers Distributors, pp. 224-225.
32. Sauwa, M.M., Waniyo, U.U., Ngala, A.L., Yakubu, M. and Noma, S.S. (2013). Influence of Tillage Practices on Physical Properties of a Sandy Loam in Semi-Arid Region. *Bayero Journal of Pure and Applied Sciences*, 6(2): 76 – 83.
33. Senjobi, B.A., Ande, O.T. and Okulaja, A.E. (2013). Effects of Tillage Practices on Soil Properties under Maize Cultivation on Oxic Paleustalf in South Western Nigeria. *Open Journal of Soil Science*, 3: 163-168.
34. Smith, M.J. (1988). Soil Mechanics, (4th edn.), Longman Scientific and Technical, Essex.
35. Topp, G.C., Reynolds, W.D., Cook, F.J., Kirby, J.M. and Carter, M.R. (1997). Physical Attributes of Soil Quality. In Soil Quality for Crop Production and Ecosystem Health; Gregorich, E.G., Carter, M.R., Eds.; Elsevier: New York, NY, USA. pp. 21-58.

6/25/2020