Effects of Level of Tillage on Soil Physical Properties of Benue River, Makurdi Flood Plains

Mohammed, K. M., Umogbai, V.I.

Abstract- ***A field experiment was conducted to determine the effects of different levels of soil tillage on soil physical properties of Benue River flood plains in Makurdi zone. The field was laid out in a randomized complete block design (RCBD) with four treatments and three replications. The treatments were ploughing and harrowing once (PH), ploughing and harrowing twice (PHH), ploughing and harrowing thrice (PHHH) and no – tillage (NT). A four – wheel drive Massey Ferguson tractor (MF 375 E), 3 – discs Massey Ferguson plough and 14 – discs offset Massey Ferguson harrow were used for the tillage operations. The soil properties studied were infiltration rate, bulk density, moisture content, particle size distribution and soil loss. The experiments were conducted during the cropping season from April to November, 2012. The total rainfall within the period was 928.7 mm. Atmospheric temperatures fluctuated between 32ºC and 39ºC and the relative humidity was between 70 % and 86 %. Results showed that infiltration rates were higher before tillage than after tillage with a mean of 23.8cm/hr. and 3.2cm/hr. before and after respectively. The soil moisture contents in the upper layer (0 – 6 cm) were higher after tillage than before tillage with percentage increase ranging between 55.6 – 87.5%. Conversely, the moisture contents at the lower layer (6 – 12 cm) were higher before tillage than after tillage with the decrease ranging between 64.1 – 77.1 %. Reason for the decrease was due to the ploughing and harrowing which mixes the soil of the drier top with the soil of the wetter lower layer. Bulk density decreases with soil tillage with mean values of 1.48 g/cm3 and 1.42 g/cm3 before and after tillage, respectively. Results of sieve analysis showed that the higher the number of harrowing, the more the values of soil particles that passed through 5 mm sieve and the less values of particles retained on 50 mm sieve. Soil loss was more with the higher number of harrowing.***

Keywords: ***Density, Effect, Infiltration, Moisture, Pulverization, Run –off, Soil, Tillage.***

I. INTRODUCTION

A. Definitions of Tillage

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 (Sahay, 2008). Tillage is the preparation of the soil for planting and the process of keeping it loose and free from weeds during the growth of crops (Smith and Wilkes, 1988). Tillage is the agricultural preparation of the soil by mechanical agitation of various types, such as digging, stirring, and overturning (http://www.en.wikipedia.org).

Tillage is defined as the physical manipulation of the soil for the purposes of managing previous crop residues, preparing a seedbed for planting, controlling competing vegetation, and incorporating fertilizers and other crop production inputs (Wolkowski, 2011).

B. Classification of Tillage Systems

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 (http://www.en.wikipedia.org).

C. Types of Tillage

There are basically two types of tillage. These are the primary and secondary tillage. Kepner, Bainer and Barger (1978) reported that a primary tillage operation constitutes the initial, major soil – working operation, normally designed to reduce soil strength, cover plant materials and re – arrange soil aggregates. Secondary tillage operations are intended to create refined soil conditions following primary tillage. Sahay (2008) reported that secondary tillage consists of operations carried out after primary tillage to create proper soil tilth for seeding and planting. Its main objectives are to pulverize the soil of the seedbeds, to destroy grasses and weeds, to cut crop residues and mix them with the top soil, to break the big clods resulting from primary tillage and to make the field surface uniform and leveled.

The plough (disk or mouldboard type) is the major implement used for primary tillage, while a wide variety of harrows and cultivators are used for secondary tillage.

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Tractors of different sizes and power ratings are required to pull the various tillage implements on the soil to perform the role and defined objectives. However, Kepner, Bainer and Barger (1978) stated that engineers, crop and soil scientists are generally agreed that more tillage is being done than is necessary to assure maximum net income from crop production.

D. 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. Jabro, Stevens, Iversen and Evans (2010) reported that tillage depth and intensity alter the soil physical and chemical properties that affect plant growth and crop yields. Khan, Malik, Umer and Bodla (2010) also reported that tillage method affects the sustainable use of soil resources through its influence on soil properties. It has also 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. Eventually, low yields result (Kepner, Bainer and Barger, 1978; Lal and Dinkins, 1979; Umogbai, 1981; Tirovska, 1982).

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. Effects of different degrees of tillage on the physical and chemical properties of River Benue alluvial flood plains and crop yield have never been studied. 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.

E. Scope of the stud

The study is limited to the determination of soil pulverization (particle size distribution), infiltration rates before and after tillage, bulk density before and after tillage, moisture content before and after tillage and soil loss.

II. MATERIALS AND METHODS

A. Experimental Plot

The experimental plot was located at the Experimental Farm of College of Engineering, University of Agriculture, Makurdi. The area, which was a virgin forest consisting basically of tall guinea grass (*Panicum maximum*), elephant grass (*Pennicetum purperum*), spear grass (*Imperata cylindrica*) and patches of deciduous trees, was cleared with a bulldozer in 2004.The field slopes into a small seasonal stream which usually dries up during the dry season. No farming activities have been carried out on the field prior this study. Makurdi lies between 7º 45’ – 7º 52’ N and 8º 35’ – 8º 41’ E. The site is characterized by undulating rolling plain with irregular river valleys. It lies within the humid zone with average annual temperature of 31.5ºC and relative humidity of 65 – 69%. The rainfall varies between 1000 mm to 2500 mm. The soil of the area is Makurdi sandstones (Makurdi formation), which is part of the sedimentary basin of Nigeria dominated by the crystalline and the sedimentary rock in about the same proportion (Isikwue and Onyilo, 2010). The slope of the experimental field, measured with a hand – held slope meter was 7º 48’.

The experimental plot was 36m wide and 40m long. The experiment was laid out in a randomized complete block design (RBCD). This design was chosen because, according to Gomez and Gomez (1984), it is especially suited for field experiments where the number of treatments is not large and the experimental area has a predictable productivity gradient. The randomization process for a RBCD for this experiment was applied separately and independently to each of the blocks following the steps described by Gomez and Gomez (1984). The plot was divided into three blocks each with four sub – plots. Four treatments viz – a - viz: plough and harrow (PH); plough, harrow, harrow (PHH); plough, harrow, harrow, harrow (PHHH); and no tillage (NT) were applied. The tillage treatments were replicated in sub – plots as shown in Table 1.

Table 1: Tillage Treatments in Sub – Plots

Block I	Block II	Block III
(SP I) = NT	(SP I) = PHH	(SP I) = PHH
(SP II) = PH	(SP II) = PHHH	(SP II) = PHHH
(SP III) = PHHH	(SP III) = NT	(SP III) = PH
(SP IV) = PHH	(SP IV) = PH	(SP IV) = NT

B. Meteorological Data

The data for rainfall, temperature and humidity were obtained from the Department of Physics, University of Agriculture, Makurdi, and the Nigerian Meteorological Agency (NIMET), Tactical Air Command (TAC), Makurdi Airport. The rainfall for the study period (April – November, 2012) is shown in Table 2.

From the table it is observed that a total of 928.7 mm of rain fell between May and November when the studies were conducted. The temperature data presented in Table 3 showed that except for April and May when the temperatures were 39ºC and 36ºC respectively, the temperatures were ranged between 32ºC and 33ºC. The data on relative humidity (Table 3) showed an increase in the relative humidity with decrease in temperature from May to October, 2012. This is in consonant with the report by Microsoft Encarta Premium (2009) which stated that a fall in temperature increases the relative humidity. The meteorological graphs for the study period are shown in Fig. 1. The mean highest temperatures and humidity for each month were used for temperature and humidity graphs.

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Table 2: Makurdi Rainfall Year 2012 (Makurdi (NECOP)

Days	Apr	May	June	July	Aug	Sept	Oct	Nov
			Daily Rainfall, mm					
1	--	--	--	--	0.2	15.9	2.9	0.4
2	--	--	--	--	--	--	--	--
3	--	--	--	12.8	7.7	--	41.0	--
4	--	--	--	--	--	23.4	--	--
5	1.3	--	1.3	0.7	12.9	--	21.4	--
6	--	--	--	--	--	--	6.9	--
7	--	--	--	--	--	--	21.8	--
8	--	--	--	--	--	7.5	--	--
9	18.2	--	--	--	--	--	6.3	--
10	--	--	34.8	3.7	--	1.5	--	--
11	--	--	7.5	0.1	0.8	--	2.7	--
12	73.2	--	6.3	--	--	--	--	--
13	1.0	--	--	2.4	0.5	13.8	3.2	--
14	1.3	1.8	--	3.3	1.6	0.8	21.4	--
15	--	--	47.2	0.7	--	0.2	--	--
16	--	4.2	--	12.1	7.6	0.6	--	0.1
17	--	0.2	--	17.1	0.1	--	0.1	--
18	21.5	--	--	0.4	--	--	--	--
19	--	--	44.2	7.6	23.6	0.7	--	--
20	--	--	2.0	--	--	--	1.3	--
21	62.6	--	26.2	1.3	36.6	--	--	--
22	--	--	5.3	--	16.9	4.8	--	--
23	--	--	32.5	--	3.4	0.1	5.4	--
24	--	6.6	0.1	1.3	--	12.0	7.1	--
25	--	7.0	0.7	--	--	0.3	9.3	--
26	--	--	10.9	0.8	18.9	--	0.1	--
27	--	--	8.1	12.0	1.2	3.6	3.6	--
28	--	--	--	0.1	6.9	--	0.8	--
29	--	26.9	--	0.1	--	--	1.5	--
30	--	--	0.5	4.6	1.5	--	0.7	--
31	--	--	--	8.1	2.0	--	0.5	--
Total:	179.1	46.7	227.6	89.2	142.4	85.2	158.0	0.5
Mean:	25.6	7.8	15.2	4.7	8.4	6.1	7.9	0.3

Source: Department of Physics, University of Agriculture, Makurdi.

Table 3: Monthly Highest Temperature Extremes (°C) and Monthly Highest Relative Humidity (%) for Makurdi (Year 2012)

Meteor Data	Apr	May	June	July	Aug	Sept	Oct	Nov
Temp(°C)	39	36	33	32	33	33	33	36
R H (%)	72	77	82	84	86	84	84	70

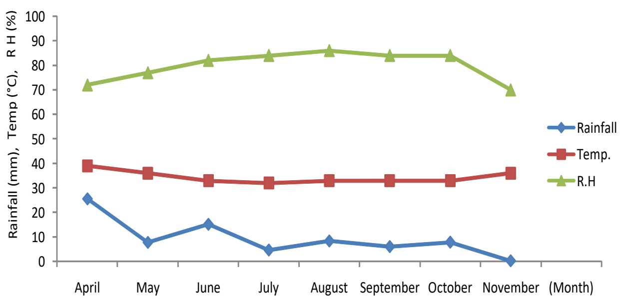

Fig. 1: Rainfall, Temperature and Relative Humidity for Makurdi in the Year 2012

C. Specifications of Tractor and Machinery Used for the Study

A four – wheel drive Massey Ferguson tractor (MF 375 E) was used. 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 (Farming Equipments, 2011).

A 3 – discs Massey Ferguson (MF) plough was used. The disc diameter and plough width are 660 mm and 1900 mm respectively.

A 14 – discs offset Massey Ferguson (MF) harrow with 560 mm diameter and harrow width of 2200 mm was used.

The MF 375 E tractor was used for both the ploughing and harrowing operations on the experimental plot at the tractor speed of 3 km/hr.

D. Determination of Infiltration Rate

Infiltration rate was determined on each of the three blocks before and after tillage operations. Standard test procedures described by LID Manual for Michigan (2012) was used. Concentric cylinder infiltrometre comprising of inner ring (Ø30 cm) and outer ring (Ø60 cm) were used for the tests.

E. Determination of Soil Moisture Content

Soil moisture content was determined using the direct reading speedy soil moisture tester before and after tillage on each of the sub – plots to ascertain the level of moisture present in the experimental plot. The moisture contents were determined at two levels, viz – a –viz upper layer (0 – 6 cm) and lower layer (6 – 12 cm). For the upper layer, a hand trowel was used to collect soil samples from a depth of 0 – 6 cm before tillage. After tillage, soil samples were again collected from the same depth for moisture content determination. For the lower layer, soil samples were collected from a depth of 6 – 12 cm.

F. Determination of Soil Bulk Density

The bulk density of the experimental plot was determined before and after tillage treatments**.** The core cutter method described by Arora (2010) was used. A set of core cutters numbering six were used. The values of moisture content determined were used in computing the bulk density using the following expression:

$$Bulk\ Density, \rho = \frac{M2 - M1/V}{1 + WC} - \left(\frac{g}{cm3}\right) \qquad 1$$

(Arora, 2010)

Where: M_2 = mass of core cutter with soil,
M_1 = mass of empty core cutter,
V = volume of cutter,
WC = water content.

After tillage operations, soil bulk density was determined on the entire sub – plots, following the procedures used before tillage. The bulk density was then determined using the following expression:

$$Bulk\ Density, \rho = \frac{M2 - M1}{V} - \left(\frac{g}{cm3}\right) \qquad 2$$

(Arora, 2010)

Where: M2 = mass of cutter, with soil
M1 = mass of empty cutter,
V = internal volume of cutter.

G. Determination of Soil Particle Size

Immediately after tillage operations, 2 kg of soil samples were collected from three different locations on each of the sub – plots that were tilled and labeled. The aim is to analyze the soil samples for particle size distribution (PSD) analysis. The soil samples were kept exposed to atmospheric air and allowed to air - dry over a period of four weeks.

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Having completely air – dried the soil samples, they were taken to the Civil Engineering Laboratory, University of Agriculture, Makurdi, for sieve analysis. Extra care was taken to make sure the soil samples did not break but analyzed in the exact state in which they were taken from the plots. A set of laboratory test sieve (BS 140) was used in the analysis. The sieve apertures selected were 5 mm, 10 mm, 20 mm, 28 mm (for 30 mm), 37.5 mm (for 40 mm) and 50 mm. Soil sample (clods) that are extra large (> 50 mm) were directly weighed using a manual weighing machine. Then one after the other, the remaining soil samples were carefully placed in the sieves and not allowed to break. Sieving was done manually by hand – shaking and all the soil particles retained on 50 mm and above were regarded according to Tirovska and Umogbai (1981) as soil conditions which can suppress germination. Soil particles that passed through 5 mm sieve into the pan were regarded as powder or ill, which can cause erosion.

H. Determination of Soil Loss

The more the intensity of soil pulverization, the more serious the run – off on such lands, and this leads to a more serious problem of soil erosion (Tirovska, 1982). Based on this, provisions were made for soil catchments at the ends of the individual sub – plots of the experimental plot following the orientation of the slope of the field. These catchments served as collectors of sediments of soil. Each catchment was 30 cm deep, 60 cm wide and ran the length of the sub – plot, which is 2.5 m. A polythene material was lined inside each of the catchments for easy collection of sediments. As a result of run – offs, each of the catchments had collected some soil sediments. Sombatpanit and Suwangerd (2011) stated that after the sediment have dried after the rainy season; the sediment in the pond should be simply weighed by using a commercial scale with acceptable accuracy. Following this, the sediments were collected from each sub – plot, air – dried and weighed. A laboratory manual weighing scale was used on the field to weigh the soil sediments. This was due to the difficulties involved in transporting the soil sediments from the farm to the laboratory. Having determined the soil loss from the individual sub – plots, it was deduced which level of tillage operation produced the highest soil loss and the least, respectively.

I. Data Analysis

An analysis of variance (ANOVA) was used to determine if the tillage treatments actually had any effect on the parameters studied.

III. RESULTS AND DISCUSSIONS

A. Infiltration Rates (Water Intake Capacity)

Table 4: Basic Infiltration Rates for the Experimental Plot

	Basic Infiltration Rates, cm/hr	
Block	Before Tillage	After Tillage
I	26.4	2.4
II	22.2	0.6
III	22.8	6.6
Mean:	23.8	3.2

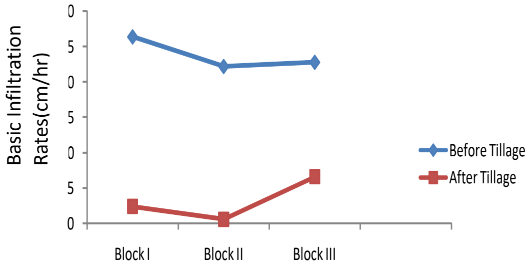

Fig. 2: Basic Infiltration Rates before and after Tillage for the Experimental Plot

The mean values of the basic infiltration rates for the experimental plot are shown in Table 4 and the graphs are shown in Fig. 2. Before tillage, it was 23.8 cm/hr while after tillage it was 3.2 cm/hr. which implies that infiltration rate was higher before disturbing the soil of the experimental plot than after the tillage operations. This confirmed the observations made after series of studies on soil compaction and effects of tillage on soil properties.

Casady (1997) reported that soil compaction is a decrease in pore space of the soil that is often caused by applying pressure to the soil with tractors and other heavy equipment. Miller et al. (2004) reported that one of the immediate effects of heavy equipment was reduced conductivity of soil to water and gas flow through a reduction in size, continuity, and total volume of pores, especially large pores. Wolkowski (2011) also reported that tillage systems that significantly disturb the soil result in lower infiltration rates as the season progress due to the loss of aggregate stability. FAO Corporate Document Repository (2012) gave typical comparative figures of infiltration for Sandy soils as 50mm/hr (5 cm/hr), Sandy loam as 25 mm/hr (2.5 cm/hr), Loam as 12.5 mm/hr (1.3 cm/hr and Clay loam as 7.5 mm/hr (0.75 cm/hr).

In Block I, infiltration test before tillage was commenced with an initial elapsed time of 30 minutes and the first reading of the water level drop was 17 cm. Since that was more than 5 cm, the test was continued with 10 minutes intervals, until a drop occurred which gave a stabilized rate of 3.0 cm. The time intervals were accumulated. Ten readings were taken. The final period drop (cumulative) was 52.6 cm and this gave a basic infiltration rate of 26.4 cm/hr.

In Block II, the test was run for 1hr. 50 minutes before tillage. The test was commenced with an initial elapsed time of 30 minutes and the first reading of the water level drop was 12 cm. Since this was more than 5 cm, the test was continued with 10 minutes intervals until a drop occurred which gave a stabilized rate of 2 cm. The time intervals were accumulated. There were nine readings. The final cumulative drop was 40.2 cm and this was used to compute the basic infiltration rate of 22.2 cm/hr.

In Block III, before tillage, the test ran for 2 hrs, beginning with 30 minutes initial elapsed time. The first reading of the water level drop was 10cm, which was more than 5 cm. Hence, the test was continued with 10 minutes intervals (cumulative) until a drop occurred which gave a stabilized rate of 2.5 cm. Ten readings were taken. The final water drop was 45.2 cm which gave a basic infiltration rate of 22.8 cm/hr. (Table 4; Fig. 2).

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In Block I, the infiltration rate test conducted after tillage gave an initial water level drop of 1.5 cm. Since this was less than 5 cm, 30 minutes measurement intervals were used. The time intervals were accumulated. The test was run for 5 hours until a stabilized rate of 1cm was achieved. All together, there were a total number of ten readings. The final water drop was 12.0 cm and with this the basic infiltration rate of 2.4 cm/hr was computed.

In Block II, the infiltration rate test after tillage also gave an initial water level drop of 1.2 cm, which was less than 5 cm. Therefore 30 minutes measurement intervals (cumulative) were used. The test was run over a period of four hours, which gave an exact number of eight readings. A stabilized rate of 0.3 cm was eventually achieved. The cumulative of the stabilized rate was 3.4 cm and it gave a basic infiltration rate of 0.6 cm/hr.

In Block III, the initial water level drop was 5 cm so 10 minutes measurement intervals were used. A total number of eight readings were obtained over a period of 1hour, 40 minutes. A stabilized rate of 0.5 cm was finally achieved. The cumulative final water level drop was 10.5 cm, which gave a basic infiltration rate of 6.6 cm/hr.

The basic infiltration rates for the entire experimental plot determined before and after tillage were used to find the overall means for both cases as shown in Table 4 and Fig. 2.

B. Soil Moisture Level (Before and after Tillage)

Tables 5 and 6 show the moisture contents at 0 – 6 cm and 6 – 12 cm for the individual sub – plots on the field before and after tillage. The percentage increase and decrease in moisture contents are given on the tables.

Table 5: Moisture Contents Determined On the Experimental Plot Before and After Tillage (Upper Layer: 0 – 6 cm)

	Moisture Contents (%, Dry Basis)											
Block	Before SP I	After SP I	% Increase	Before SP II	After SP II	% Increase	Before SP III	After SP III	% Increase	Before SP IV	After SP IV	% Increase
I	2.5	3.2	78.1	1.5	1.9	78.9	1.5	2.1	71.4	1.4	1.9	73.7
II	1.0	1.6	62.5	1.2	1.8	66.7	1.4	1.9	73.7	1.0	1.8	55.6
III	1.0	1.8	55.6	1.4	1.6	87.5	1.1	1.7	64.7	1.0	1.7	58.8

Table 6: Moisture Contents Determined On the Experimental Plot Before and After Tillage (Lower Layer: 6 – 12 cm)

	Moisture Contents (%, Dry Basis)											
Block	Before SP I	After SP I	% Increase	Before SP II	After SP II	% Increase	Before SP III	After SP III	% Increase	Before SP IV	After SP IV	% Increase
I	3.9	2.5	64.1	3.8	2.6	68.4	3.8	2.7	71.1	3.9	2.6	66.7
II	3.2	2.4	75.0	3.5	2.5	71.4	3.5	2.6	74.3	3.5	2.7	77.1
III	3.5	2.4	68.6	3.5	2.4	68.6	3.6	2.4	66.7	3.6	2.6	72.2

It was observed that the moisture levels determined at the upper layer of 0 – 6 cm were higher after tillage than before tillage. The percentage increase ranges between 55.6 – 87.5%.The increase in the moisture level at the upper layer after tillage is because the soil is drier at the top and wetter as the soil gets deeper. On the other hand, the moisture contents determined at the lower layer of 6 – 12 cm were higher before tillage than after tillage, with the decrease ranging from 64.1 – 77.1%. Reason for the decrease in the moisture levels in the lower layer after tillage is due to the ploughing and harrowing which mixes the soil of the drier top with the soil of the wetter lower layer which is in agreement with the findings of Tirovska and Umogbai (1981)

C. Bulk Densities before and after Tillage

Table 7 shows the bulk densities determined on the experimental plot before and after tillage treatments. The overall means are also shown on the tables.

Table 7: Bulk Densities Determined On the Experimental Plot Before and After Tillage

	Bulk Density, g/cm^3							
Block	Before SP I	After SP I	Before SP II	After SP II	Before SP III	After SP III	Before SP IV	After SP IV
I	1.46	1.42	1.51	1.45	1.35	1.32	1.58	1.51
II	1.49	1.42	1.56	1.52	1.53	1.49	1.51	1.46
III	1.54	1.49	1.49	1.43	1.34	1.29	1.35	1.27

Mean (Before) = 1.48g/cm^3
Mean (After) = 1.42g/cm^3

Comparing both the results of the bulk densities obtained before and after tillage, it was observed that there were significant differences. Bulk densities were higher before the soil was tilled and lower after tillage, with mean values of 1.48 g/cm^3 and 1.42 g/cm^3 respectively. This is in consonant with what was reported by Jabro, Stevens, Iversen and Evans (2010) that tillage treatments significantly affected soil bulk density and soil bulk density decreased with increasing the depth of tillage. A similar observation made by Sessiz, Alp and Gursov (2009) was that bulk density was greater before tillage treatment than after tillage for all treatments. In a two year field experiment, Rashidi and Keshavarzpour (2008) reported that the highest soil bulk density of 1.52 g/cm^3 was obtained for the no – tillage treatment and lowest (1.41 g/cm^3) for the conventional tillage treatment.

D. Particle Size Distribution after Tillage

Table 8 shows the means of the particle size distribution of the soils collected after tillage and air – dried. Values of all the particle sizes for each of the sub – plots summed up were used to find the mean retained on individual sieves. The means in kilograms were converted into percentages and used to plot the cumulative particle size distribution as shown in Fig. 3.

Table 8: Mean Values of Particle Size Distribution of the Soils Collected After Tillage

	Means of Weights Retained on Sieves (kg; %)								
Sieve	Block I			Block II			Block III		
Apertures (mm)	kg	%	Cum.	kg	%	Cum	kg	%	Cum
50	0.3	18.75	18.75	0.5	31.25	31.25	0.7	43.75	43.75
37.5	0.1	6.25	25.00	0.1	6.25	37.50	0.1	6.25	50.00
28	0.1	6.25	31.25	0.1	6.25	43.75	0.1	6.25	56.25
20	0.1	6.25	37.50	0.1	6.25	50.00	0.1	6.25	62.50
10	0.1	6.25	43.75	0.1	6.25	56.25	0.1	6.25	68.75
5	0.9	56.25	100.00	0.7	43.75	100.00	0.5	31.25	100.00
Total:	1.6			1.6			1.6		

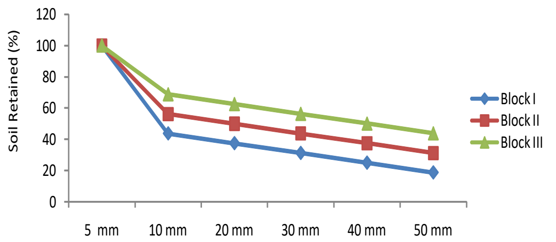

Fig.3: Cumulative Graph for Particle Size Distribution of the Soil after Tillage

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From the results of the sieve analysis performed on the soil samples, it was observed that the more the number of ploughing treatments the more the intensity of pulverization of the soil. Block I gave the highest values of particles that passed through 5mm sieve as follows: Sub – plot II (ploughing and harrowing once, PH) = 2.74kg, Sub – plot IV (ploughing an harrowing twice, PHH) = 2.16 kg and Sub – plot III (ploughing and harrowing thrice, PHHH) = 2.79 kg.

Block II gave the values that passed through the 5mm sieve as follows: Sub – plot I (ploughing and harrowing twice, PHH) = 3.2 kg and Sub – plot II (ploughing and harrowing thrice, PHHH) = 1.91 kg. Sub – plot IV (ploughing and harrowing once, PH) recorded 1.47 kg as against 1.72 kg retained on 50mm sieve. The soil conditions in Blocks I and II were therefore more powdery, and consequently the reasons for more run – offs on those blocks which led to erosions. This confirmed the observations made by Tirovska and Umogbai (1981) that soil particles that passed through 5 mm sieve were regarded as powder or ill which can cause erosion.

Block III recorded the following values that passed through 5 mm sieve: Sub – plot III (ploughing and harrowing once, PH) = 0.75 kg as against 2.48 kg retained on 50 mm sieve; Sub – plot I (ploughing and harrowing twice, PHH) = 1.09 kg as against 1.99 kg while Sub – plot II (ploughing and harrowing thrice, PHHH) = 1.85 kg as against 1.37 kg retained on 50 mm sieve. Block III did not witness as much erosions as did Blocks I and II. Germinations were however poorer in Block III because of the soil conditions provided by tillage treatments which gave higher values retained on 50 mm sieve. According to Tirovska and Umogbai (1981) soil particles that are retained on 50 mm sieve were regarded as large aggregates which can suppress germination. This could also be attributed to the fact that Block III contained more clay than Blocks I and II as observed in the chemical analysis carried out on the soil.

E. Soil Loss

The weights of the sediments collected from the catchments constructed at the end of each sub – plot are presented in Table 9 and Fig.4.

Table 9: Weights of Soil Loss on the Experimental Plot

Soil Loss, kg				
Block	SP I	SP II	SP III	SP IV
I	30.4	28.7	65.2	80.3
II	307.8	110.6	34.3	61.2
III	68.7	57.6	42.4	28.1

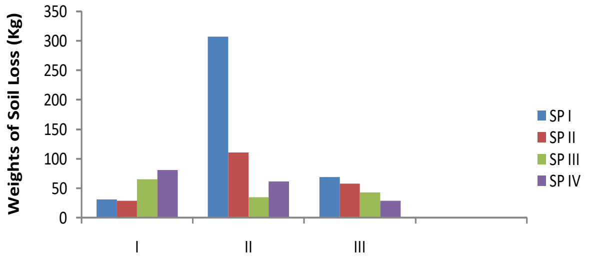

Fig. 4: Bar charts representing weights of Soil Loss on the Experimental Plot

The least sediments were collected in the no – tillage sub – plots: Block I (SPI) collected 30.4 kg, Block II (SPIII) collected 34.3 kg and Block III (SPIV) collected 28.1 kg. Tillage operations were not carried out on these plots, therefore the run – offs on them were minimal. On the other hand, it was observed that all the other sub – plots that were given tillage treatments suffered severe run – offs. Tirovska (1982) reported that the more the intensity of soil pulverization, the more serious the run – off on such lands. In conformity with this, Block II (SPI) which was served with ploughing and harrowing twice (PHH) recorded the largest soil loss with 307.8 kg.

F. Analysis of Variance (ANOVA)

Analysis of variance comparing the effects of the levels of tillage treatments with bulk density, soil loss and particle size distribution, are shown in Tables 10 – 11.

Table 10: Analysis Of Variance (RCBD) Of Treatment versus Bulk Density

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	0.02	0.01			
Treatment	3	0.01	0.003	0.3^{ns}	4.76	9.78
Error	6	0.05	0.01			
Total	11	0.08				

Key: ns = not significant.

Table 11: Analysis Of Variance (RCBD) Of Treatment versus Soil Loss

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	16356.64	8178.32			
Treatment	3	26604.47	8868.16	2.40^{ns}	4.76	9.78
Error	6	65152.42	3698.55			
Total	11	0.08				

Key: ns = not significant.

G. Treatment versus Bulk Density

The computed *F* value of 0.3 is smaller than the tabular *F* value at the 5% level of significance. The null hypothesis was accepted, which states that the levels of tillage treatments had no effect on bulk density (Table 10).

H. Treatment versus Soil Loss

Since the computed *F* value of 2.40 is smaller than the tabular *F* value at the 5% level of significance, the null hypothesis was accepted, which states that the levels of tillage treatments had no effect on soil loss (Table 11).

A non – significant *F* test in the analysis of variance indicates the failure of the experiment to detect any difference among treatments. It does not, in any way, prove that all treatments are the same, because the failure to detect treatment difference, based on the non – significant *F* test, could be the result of either a very small or nil treatment difference or a very large experimental error, or both (Gomez and Gomez, 1984).

IV. CONCLUSIONS

The effect of different levels of tillage on physical properties on the experimental plot of the Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi was experimentally investigated.

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The experimental plot which has never been cropped prior to this experimental, displayed all the potentials of a good agricultural land in terms of physical properties.

Infiltration rate was higher before tillage and lower after soil disturbance.

The moisture contents determined in the upper layer (0 – 6 cm) on the experimental plot were higher after tillage than before tillage. The percentage increase ranges between 55.6 – 87.5%. The moisture contents determined at the lower layer (6 – 12 cm) were higher before tillage than after tillage, with the decrease ranging from 64.1 – 77.1%.

The experiment also proved that bulk density decreases with soil tillage when it recorded a mean value of $1.48 gcm^{-3}$ before tillage and a mean value of $1.42 gcm^{-3}$ after tillage.

Particle size distribution determined after tillage on the air – dried soil samples showed that the treatments with higher number of harrow passes recorded highest values of particles that passed through 5 mm sieve, a soil condition regarded as powder or ill, which can cause erosion. Lesser passes of the harrow gave the highest values of particles retained on 50 mm sieve, regarded as soil conditions which can suppress germination.

Soil sediments collected from the catchments and analyzed for soil loss showed that more intense soil pulverization leads to more run – offs. The Sub – plots treated with no – tillage (NT) and ploughing and harrowing once (PH) recorded least soil losses than those treated with ploughing and harrowing twice (PHH) and ploughing and harrowing thrice (PHHH).

Results of Analysis of Variance (ANOVA) showed that effect of treatment on bulk density and soil loss were not significant with the computed *F* values of 0.3 and 2.40 respectively.

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