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RESEARCH ARTICLE

EFFECTS OF LEVEL OF TILLAGE ON GERMINATION RATE AND VEGETATION OF MAIZE CROP OF BENUE RIVER MAKURDI FLOOD PLAINS

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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 parameters studied were soil texture, maize germination and root proliferation. 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 the soil of the experimental plot is generally dark and is predominantly sandy. The best germination rates were recorded on sub – plots treated with ploughing and harrowing twice with sprouts of 25.6 % and 29.7 % sprouts/day. A no – tillage sub – plot with the highest percentage of clay yielded 27.6 % sprouts. The sub – plots treated with ploughing and harrowing thrice yielded the longest roots with 30 cm, 28 cm and 29 cm respectively. The shortest root of 1.5 cm was witnessed in the sub – plot treated with no – tillage.

INTRODUCTION

Definitions of Tillage

Tillage is a mechanical manipulation of soil to make it suitable for crop production (Sahay, 2008). 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).

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.

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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).

Types of Tillage

There are basically two types of tillage. These are the primary and secondary tillage. Kepner et al., (1978) wrote 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) stated 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.

Statement of the problem

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. 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. Effects of different degrees of tillage on the germination rate and vegetation, and root proliferation of maize (Zea mays L) of River Benue Makurdi flood plains have never been studied. In Africa and many developing countries, limited data are available on the required level of tillage for various crops.

Scope of the study

The study is limited to the determination of soil texture of the experimental plot, germination rate, vegetation and root proliferation of maize crop.

MATERIALS AND METHODS

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 the relative humidity of 65 – 69%. The rainfall varies between 1000mm to 2500mm. 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 digital 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). 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 with four sub – plots. Four treatments 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

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.

Table 2. Makurdi Rainfall Year 2012 (Makurdi NECOP)

	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
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 (ºC) and Monthly Highest Relative Humidity (%) for Makurdi (Year 2012)

METEOROLOGICAL DATA	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV
TEMP (ºC)	39	36	33	32	33	33	33	36
R H (%)	72	77	82	84	86	84	84	70

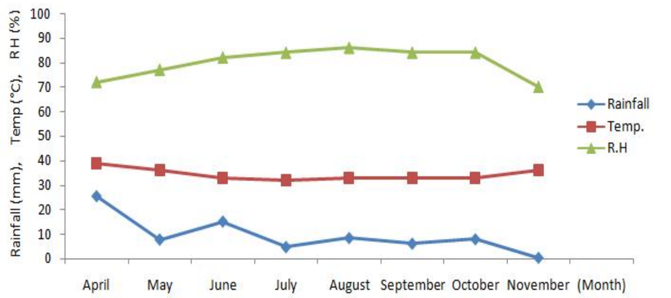

Fig. 1. Rainfall, Temperature and Relative Humidity for Makurdi in the Year 2012

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.

Determination of Soil Texture before Tillage

The soil texture of the experimental plot was determined following the procedure described by LaMotte Company (2006). The percentages of both sand and silt in the soil were calculated by dividing the readings by the total volume and multiplying by 100. For sand, the expression used is as follows:

$$Percent\ Sand = \frac{Reading\ A \times 100}{Total\ Volume} \quad 1$$

For silt, the following expression was used:

$$Percent\ Silt = \frac{Reading\ B \times 100}{Total\ Volume} \quad 2$$

(LaMotte Company, 2006).

The clay fraction was calculated by adding the sand and silt fractions and subtracting the total from the initial volume of soil used for the separation. The clay percentage was thus calculated as follows:

$$Percent\ Clay = \frac{Calculated\ Volume \times 100}{Total\ Volume} \quad 3$$

(LaMotte Company, 2006).

After separating the soil sample into sand, silt and clay, a soil textural triangle (USDA, 2011) was used to determine the textural class. The same procedure was used for all the soil samples from the entire sub – plots of the experimental plot.

Maize Planting

After tillage operations, a hybrid variety of maize, Mega 4, white was planted on the tilled sub – plots on May 16, 2012. Planting was done manually using a small hoe. Two seeds were planted per hole to a depth of 3 cm based on recommendations of 2 – 4 cm at inter/intra row spacing of 70 cm/30 cm (Obi (1991). Three rows were planted on each sub – plot, making a total number of twelve rows on each block, which consisted of four sub – plots (no – till sub – plot inclusive). Each row comprises of 86 stands, and consequently, on each sub – plot, there were 86 x 4 = 344 stands. Planting was done directly on the no – till sub – plots using a small hoe. Since these sub – plots were not tilled, the spots on which to plant the maize seeds were pulverized with a hoe to a depth of about 7 cm.

Determination of Germination Rate

Five days after planting, precisely on May 20, 2012, the maize seeds started germinating. To determine the rate of germination, the sprouted seedlings were counted on each sub – plot and recorded separately, on daily basis, cumulatively. The number of sprouted seedlings for each day was used to determine the percentage of sprouted seedlings for the entire sub – plots. Afterwards, the dynamics of sprouting (in days) was determined for each block, using the following expression:

$$D = \frac{Xa + Y + Zc + Wd \ldots.}{X + Y + Z + W + \cdots}\ days$$

(Gassner, 1936)

Key : D = dynamics of sprouting (germination) in days;
a, b, c and d = days of counting germination, where: a = day 1, b = day 2, c = day 3
and d = day 4;
X, Y, Z = percentage of sprouted seeds per day.

Determination of Root Proliferation

One month after planting, the root proliferation of the vegetative maize was determined. By this time, the maize crop was at its critical phase and has developed nine leaves and above (Dimova and Dekov, 1981). Four maize plants which have attained the 9th leaves were carefully dug down to the root system (applying water), from each of the sub – plots. A tape rule was used to measure the lengths of roots on each plant. The number of roots on each plant was also counted. The number/lengths of the roots were used to determine from which level of tillage, the roots had better proliferation in the soil. The plot producing the root system with the best proliferation can be regarded as the plot with the best soil pulverization (Tirovska, 1982).

Data Analysis

Analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) by Gomez and Gomez (1984) was used to determine if the tillage treatments had any effect on weed destruction and maize germination.

RESULTS AND DISCUSSION

Soil Texture

The soil of the experimental plot is generally dark in colour and contains small amounts of gravel. Table 4 shows the percentages of the soil texture, comprising of sand, silt and clay and their textural classifications. The means were used to plot the histogram for sand, silt and clay percentages as shown in Fig. 2.

Results showed that the soil of the experimental plot is predominantly sandy (Table 4, Fig. 2). Soils that are sand predominant are classified as coarse textured soils according to FAO Corporate Document Repository (2012). This also conforms to the report by Isikwue and Onyilo (2010) which stated that the soil of Makurdi area is Makurdi sandstones. On soil texture, http://www.appstate.edu reported that soils high in sand are easier to cultivate and are termed light, whereas soils that are difficult to cultivate and high in clay are called heavy. The sandy nature of the experimental plot therefore, made it ideal for the tillage operations.

Table 4. Percentages of soil texture of the experimental plot and their textural classes

BLOCK	SUB – PLOT	SAND	SILT	CLAY	TEXTURAL CLASS
		PERCENTAGES			
I	I	93	5	1	Sand
	II	85	2	13	Loamy Sand
	III	80	5	15	Sandy Loam
	IV	93	5	2	Sand
	Mean:	87.8	4.3	7.8	
II	I	93	2	5	Sand
	II	93	5	1	Sand
	III	87	5	8	Loamy Sand
	IV	79	7	15	Sandy Loam
	Mean:	88	4.8	7.3	
III	I	70	9	21	Sandy Clay Loam
	II	73	8	19	Sandy Loam
	III	67	15	19	Sandy Loam
	IV	87	7	7	Loamy Sand
	Mean:	74.3	9.8	16.5	

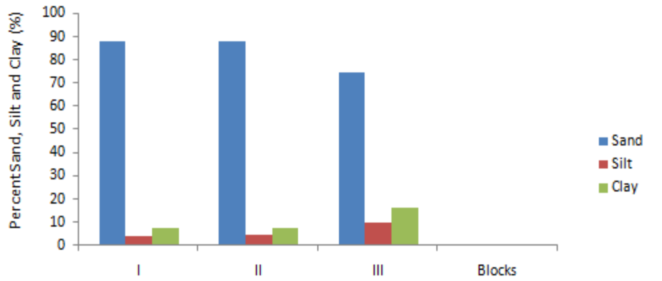

Fig. 2. Bar charts representing Percentage of Sand, Silt and Clay present in the Experimental Plot

Maize Germination

Table 5 shows the percentages of sprouted seeds per day computed over a period of four days for the entire experimental plot. Sprouting can last for more than seven days in maize, but in this experiment sprouting stopped on the fourth day.

Table 5. Percentage of sprouted seedlings per day for each sub – plot of the experimental plot

BLOCK	SUB – PLOT	DAY 1	DAY 2	DAY 3	DAY 4
		SPROUTED SEEDLINGS/DAY (%)			
I	I	5.2	11.3	15.1	15.4
	II	10.2	21.8	24.4	24.4
	III	6.7	19.5	22.7	22.7
	IV	14.0	24.7	25.6	25.6
II	I	19.5	29.4	29.7	29.7
	II	10.8	16.6	16.9	16.9
	III	6.1	21.5	24.1	24.7
	IV	15.1	18.3	18.3	18.9
III	I	13.4	17.4	17.7	18.3
	II	9.3	13.4	13.7	14.2
	III	16.3	22.4	23.8	24.1
	IV	3.5	23.3	27.3	27.6

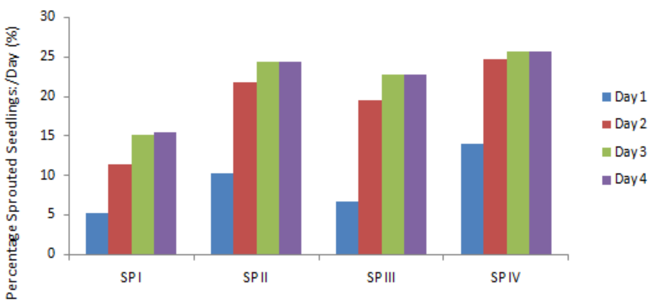

Fig. 3a. Percentage Sprouted Maize Seeds over a period of 4 days in Block I

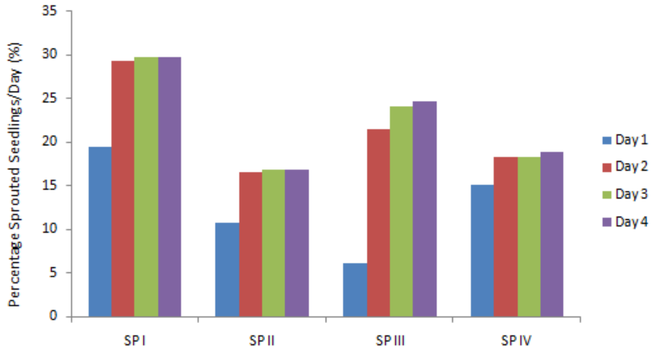

Fig. 3b. Percentage Sprouted Maize Seeds over a period of 4 days in Block II

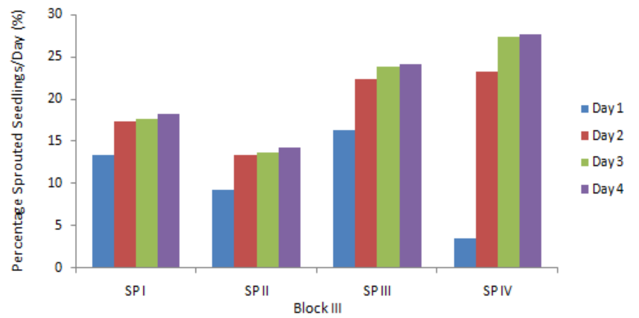

Fig. 3c. Percentage Sprouted Maize Seeds over a period of 4 days in Block III

There was only one new sprout in SP I (BL I) on the 4th day; two sprouts each in SP III and SP IV (BL II); two sprouts each in SP I and II, one sprouting each in SP III and SP IV (BL III). There was no sprouting on the 5th day. Figures 3 a, b and c show the graphs of the percentage sprouted seeds for block I, II and III respectively. The percentages were used to determine the dynamics of sprouting (germination) in days and the results obtained are as shown in Table 6 and Fig. 4.

Table 6. Dynamics of germination in days for the entire experimental plot

BLOCK	SP I	SP II	SP III	SP IV	MEAN
	DYNAMICS OF SPROUTING (DAYS)				
I	2.9	2.8	2.9	2.7	2.8
II	2.6	2.7	2.9	2.6	2.7
III	2.6	2.6	2.6	3.0	2.7

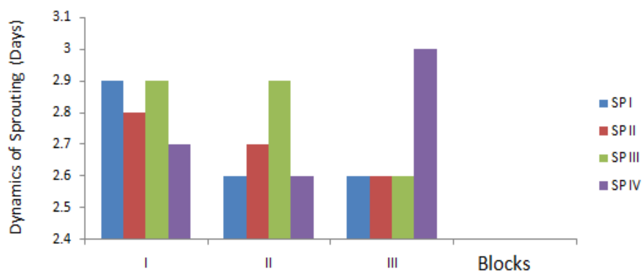

Fig. 4. Bar charts representing Dynamics of Germination in Days for the Experimental Plot

The results showed that the no – tillage sub – plots yielded the least number of sprouted seeds on the very first day of counting. In Block I, it was 18 seedlings (5.2%), Block II yielded 21seedlings (6.1%) and on Block III, it was 12 seedlings (3.5%). In Block I, the no – tillage sub – plot recorded the least sprouting up till the fourth day (53 seedlings = 15.4%). In Blocks II and III, the no – tillage sub – plots recorded the second highest and the first highest number of sprouted seeds, respectively. For the tilled sub – plots, sub – plot IV (Block I) treated with ploughing and harrowing twice (PHH) recorded the highest number of sprouted seeds on Day 1 with 48 seedlings (14.0%) up till Day 4 with 88 seedlings (25.6%). In Block II, sub – plot I treated with ploughing and harrowing twice (PHH) also recorded the highest number of sprouted seeds on Day 1 with 67 seedlings (19.5%) through to Day 4 with 102 seedlings (29.7%). In Block III, sub – plot III treated with ploughing and harrowing once (PH) yielded the highest number of sprouted seeds on Day 1 with 56 seedlings (16.3%) while by Day 4, it recorded 83 seedlings (24.1%) – second to no – tillage sub – plot with 95 seedlings (27.6%) on Day 4.

Root Proliferation

Table 7 shows the data for roots of the vegetative maize at the 9^{th} leaf from the entire experimental plot. Through direct measurements, using a meter rule, the longest and shortest roots were determined for the individual maize plants. The number of roots on each plant was also counted to determine which sub – plot had the best root proliferation.

Table 7. Root proliferations of the vegetative maize at 9^{TH} Leaf

BLOCK	SUB –PLOT	TREATMENT	NO. OF ROOT	LONGEST ROOT (CM)	SHORTEST ROOT (CM)
I	I	NT	13	14.5	1.5
	II	PH	15	17.5	2
	III	PHHH	19	30	2.5
	IV	PHH	21	16	2
II	I	PHH	20	25	2.5
	II	PHHH	17	28	2
	III	NT	15	16	2
	IV	PH	19	18.5	2.5
III	I	PHH	17	17.5	2.5
	II	PHHH	20	29	2
	III	PH	16	18	2
	IV	NT	15	15	2

Results showed that the no tillage sub – plots gave the poorest root proliferations with the least number and shortest roots due to the absence of soil pulverization. In all the three blocks, the sub – plots treated with ploughing and harrowing thrice (PHHH) yielded the longest roots with 30 cm and 19 roots, 28 cm and 17 roots and 29 cm and 20 roots respectively. Except for Block III which had 20 roots, the sub – plots treated with ploughing and harrowing twice (PHH) in Blocks I and II produced the highest number of roots with 21 and 20 respectively. Plessis (2003) reported that under optimal conditions, the total root length of maize excluding the root hairs, can reach 1,500 m.

Analysis of Variance (ANOVA)

Table 8. Analysis of variance (RCBD) of treatment versus germination

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 5%	TABULAR F 1%
Replication	2	51.5	25.75			
Treatment	3	831.58	277.19	0.704^{ns}	4.76	9.78
Error	6	2361.17	393.53			
Total	11	3244.25				

Key: ns = not significant.

Treatment versus Maize Germination

Since the computed *F* value of 0.704 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 have no effect on maize germination (Table 8).

Conclusions

From analysis of the results, the following conclusions were made:

The experimental plot which has never been cropped prior to this experiment displayed all the potentials of a good agricultural land in terms of suitability and required conditions. Germination of maize was less, especially on 4^{th} day after planting on the no – tillage sub – plots, while the entire tilled sub – plots recorded higher percentages of germination. That was an indication that tilled soils are far better for seed germination than untilled soils. Generally, ploughing and harrowing twice (PHH) gave the best germination and was followed by ploughing and harrowing once (PH). Root proliferations were better on the tilled plots especially the sub – plots that were treated with ploughing and harrowing thrice (PHHH) in terms of root lengths, while sub plots treated with ploughing and harrowing twice (PHH), produced the highest number of roots in two of the three blocks. Results of Analysis of Variance (ANOVA) showed that effect of treatment effect on maize germination was not significant with computed *F* value of 0.704.

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