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Effect of Tillage Methods on Soil Properties, Growth and Yield of Maize (*Zea mays* L.) in Makurdi, Nigeria

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ABSTRACT

The research was conducted at the Teaching and Research Farm of the University of Agriculture Makurdi to evaluate the effect of five (5) tillage methods on soil properties, growth and yield of maize. The experimental design consisted of five (5) treatments that were replicated three times and laid out in a Randomized Complete Block Design (RCBD). These treatments are: Surface tillage (T_1), ridges (T_2), zero tillage (T_3), heaps (T_4) and tied ridges (T_5). Each plot measured 5 m x 5 m with spacing of 1 m between replicates and 0.5 m between plots in the same replicate thus giving a total plot size of 17 m x 27 m (459 m^2). A composite soil sample was obtained from a plough layer (0-15 cm) at the beginning and at the end of the experiment according to the treatments and analyzed for soil properties in the Advanced Soil Science Laboratory, University of Agriculture Makurdi. Data collected for the growth and yield parameters of maize were subjected to the Analysis of Variance (ANOVA) after which significant means were separated using Least Significant Difference (LSD) at $P<0.05$. The results of the study showed that the various tillage methods had no significant effect on the soil properties. However, there was significant effect on some of the growth parameters as well as the yield of maize. It can be concluded that all the tillage methods be adopted or utilized for maize production in Makurdi sub-humid region and also the surface tillage should be utilized the most since it gave the highest grain yield of maize.

Key Words: Tillage Methods, Soil Properties, Growth and Yield of Maize

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in Nigeria and it ranks second in cultivated area and production after rice. It has greater nutritional value as it contains about 72 % starch, 10 % protein, 4.8 % oil, 8.5 % fiber, 3 % sugar and 17 % ash (Karunatilake *et al.*, 2000). Due to higher yield potential, short growing period, high value for food, forage and feed for livestock, poultry and a cheaper source of raw material for agro-based industry, it is increasingly gaining an important position in the cropping system (Karunatilake *et al.*, 2000).

It belongs to *Gramineae* family of plant kingdom. As maize is the highest yielding cereal crop in the world, it is of considerable substance for countries like Nigeria, where rapidly increasing population has already short of existing food supplies. Maize accounts for 4.8 % of the total cropped area and 3.5 % of the value of agricultural output. In Nigeria, the North western, north eastern and North Central States are the major producers of maize consisting of 57 % of the total area and 68 % of total production (Mosaddeghi *et al.*, 2009). Its importance is apparent in daily life food stuff as it used as edible oil and high valued food for human beings, feed for livestock and poultry and raw material for various agro-based industries (Khurshid *et al.*, 2006).

Soil tillage is the establishment of any crop fabrication system and is the biggest factor in maize production (Singh and Malhi, 2006). It maintains the

accessible structure or improves the poorly structured soils. Tillage is crucial for crop establishment, growth and ultimately, yield (Atkinson *et al.*, 2007). A good soil management programme protects the soil from water and wind erosion, provides a good, weed-free seedbed for planting, destroys hardpans or compacted layers that may limit root development, and allows maintenance or even an increase of organic matter (West and Post, 2002). Tillage systems are site specific and depend on crop, soil type and the climate (Rasmussen, 1999). Tillage methods influence soil physical, chemical and biological characteristics, which in turn may alter plant growth and yield (Çarman, 1997; Ozpinar and Cay, 2006; Rashidi and Keshavarzpour, 2011). Different tillage methods may affect the growth and yield of maize due to different soil conditions created. But there is inadequate information on the effect of tillage methods on maize growth and yield in the sub humid zone of Nigeria such as Makurdi. This study is therefore a necessary step taken to bridge the gap in information on effect of tillage on growth, yield and yield components of Maize.

Maize has become an important staple food in Nigeria with very high competing demands between human consumption and other industrial uses such as feed production for livestock consumption. There is need therefore to increase the production of maize to meet the increasing demand. It therefore becomes imperative that we study factors that influence growth and yield of the crop in a bid to enhance sustainable production of maize and ensure food security in the country. It is on this premise that the present study focus on assessing the effect of five different tillage methods on the soil properties, growth and yield of maize in Makurdi, Southern Guinea Savanna Zone of Nigeria.

MATERIALS AND METHODS

The research was conducted at the Teaching and Research Farm of the University of Agriculture Makurdi. The area is geographically situated on Latitude $7^{o}50^{'}$ N and Longitude $8^{o}32^{'}$ E on the Map of Nigeria. Vegetation in the area is characteristically that of the Southern Guinea Savanna ecological zone. The climate of Makurdi is sub humid with two distinct seasons: the rainy and dry seasons. The dry season lasts from April and sometimes May to October with an annual mean rainfall of between 1250 mm. The dry season starts from October to March and sometimes April. Mean monthly temperature is between 27 ^{o}C and 28 ^{o}C and may go up to a maximum temperature of 30 ^{o}C to 40 ^{o}C. The temperature gets warmer during the months of February to April ushering in the rainy season (Fagbemi and Akamigbo, 1986).

Experimental Treatments and Design

Experimental treatments included five (5) treatments that were replicated three times and laid out in a Randomized Complete Block Design. These treatments are: Surface tillage (T_1), ridges (T_2), zero tillage (T_3), heaps (T_4) and tied ridges (T_5). The land was cleared manually and ridges prepared using hoe and cutlass. The cleared grasses were collected and burnt. The land was then marked out in three replicates. Each plot measured 5m x 5m with spacing of 1 m between replicates and 0.5 m between plots in the same replicate thus giving a total plot size of 17 m x 27 m (459 m^2). Planting and other agronomic practices such as weed control, pest and disease control and fertilizer application were carried out as required. Planting was done on 9th August, 2016 at a depth of 2.3 cm with spacing 25 x 75 cm giving an approximate plant population of 35,000 plants/hectare.

Soil Data Collection and Analysis

Soil samples were collected before administering the treatments and also after the harvest. Soil samples were prepared and analyzed in the Advanced Soil Science Laboratory of the College of Agronomy

University of Agriculture Makurdi. The samples were air dried sieved (using 2.0 mm mesh) and analyzed in the laboratory for soil properties according to standard analytical procedures. The pH was determined in water (1:1) (IITA, 1979). The particle size distribution was determined by the hydrometer method (Bouyoucous, 1951). The chromic acid titration method was used to determine the O.C. and O.M (IITA, 1979). Total N in the soil was determined by the regular Macrokjeldahl method (IITA, 1979). The amount of cations held exchangeable by a unit mass of soil was determined using NH_4OAC at pH-7.0 displacement method. The exchangeable K, Ca, Mg and Na were determined using the EDTA titration method while the available P was determined by Bray-1 method. Flame photometer was used to determine K and Na whereas AAS was used to determine Mg and Ca.

Crop Data Collection and Analysis

Germination count was taken two weeks after planting. This was necessary to ascertain the actual plant population and survival rate. Plant height was measured at 3, 6, 9, and 12 weeks after planting. This was done by measuring with a measuring tape from the base of the plant to the tip of the highest shoot/leaf of the plant. Leaf area was determined at 6, 9 and 12 WAP using the leaf area meter. Each leaf was divided into two and then placed into the leaf meter machine. The appropriate mask number was used (20 cm^2 or 50 cm^2 depending on size of leaf). The machine was then set to full scale and the leaf and glass mask inserted into the machine again. After pulling the shuttle, the reading of the leaf area was obtained. Some yield parameters such as cob length, cob weight and grain yield were determined by measurement. The yield and weight were determined by weighing using a balance.

Data collected for the growth and yield parameters of maize were subjected to the Analysis of Variance (ANOVA) after which significant means were separated using Least Significant Difference (LSD) at $P<0.05$.

RESULTS AND DISCUSSION

Effect of Tillage on Soil Physical Properties

The physical properties of the soil are presented in Table 1a. The various tillage practices had no significant ($P>0.05$) effect on the pH level of the soil. The pH level of the soil ranged from 6.37 to 7.29. The heap tillage had the highest (7.29) pH level while the surface tillage had the least (6.37). The various tillage practices had no significant ($P>0.05$) effect on the percentage of sand, clay and silt of the soil. The surface tillage had the highest (79.80%) percentage of sand, which was closely followed by ridge (79.08 %). The zero and tied ridges tillage had the least (76.08 and 76.08 % respectively) percentage of sand. The zero tillage had the highest (14.92 %) percentage of clay while the surface tillage had the least (13.20 %). Silt content in the zero and tied ridges tillage were highest (9.0 and 9.0 % respectively) when compared with the other tillage practices. The surface tillage had the least (7.0 %) percentage of silt. Organic carbon was found highest (3.09 %) in the heap ridges and least (1.98 %) in the surface tillage. It was also found that organic matter was highest (5.35 %) in the ridges tillage and least (2.76 %) in the surface tillage.

Effect of Tillage on Soil chemical properties

The chemical property of the soil of the study area is presented in Table 1b. The various tillage practices had no significant effect on the chemical properties of the soil. The zero tillage showed the highest concentration (0.50 ppm) of phosphorus while the surface tillage showed the least (0.33 ppm). Nitrogen content was highest (0.06 %) in the heaps and was similar (0.05 %) in all other tillage practices. The amount of potassium content for surface, zero and tied tillage were 0.26, 0.26 and 0.20 Cmol/kg respectively.

The tied ridges tillage showed the least (0.20 Cmol/kg) amount of potassium content. Sodium content was highest (0.24 and 0.24 Cmol/kg) in the surface and zero tillage practices. The ridge and heap tillage showed the least (0.20 Cmol/kg) amount of sodium content. Magnesium content was highest (3.61 Cmol/kg) in the zero tillage. The zero tillage practice had the highest (4.02 Cmol/kg) calcium content while the tied ridges tillage showed the least (3.40 Cmol/kg). The ridges and zero tillage had the least (1.00) EA. The TEB among the various tillage practices ranged from 6.93 to 8.10. The tied ridges tillage had the least (6.93) while the zero tillage had the highest (8.10). CEC was highest (9.10 Cmol/kg) in the zero tillage and least (7.95 Cmol/kg) in the tied ridges tillage. The BS among the various tillage practices ranged from 87.5% to 89.0 %. The zero tillage practice had the highest (89.0 %) while both the surface tillage and heaps tillage had the least (87.5 %).

Effect of Tillage Methods on Maize Growth Parameters

The germination count was not significantly (P>0.05) influenced by the various tillage practices as shown in Table 2. The germination count ranged from 93 to 98. The highest germination count was obtained from the ridge tillage (98) and surface tillage (98). The least (93) was obtained from the zero tillage. Table 2 showed that the plant height at third, sixth, ninth and the twelfth weeks after planting were significantly (P>0.05) influenced by the various tillage methods. The surface tillage showed the tallest (17 cm) plant height in the first three weeks while the heap tillage method had the shortest (14 cm) plant height. At 6 WAP, ridge tillage had the tallest (76 cm) plant height followed by surface tillage practices (72 cm), while tied ridge tillage had the least (55 cm).

The plant height was tallest (217 cm) in ridge tillage method at 6 WAP and shortest (197 cm) in tied ridges tillage method. The zero tillage practice showed the tallest (215 cm) plant height at 12 WAP and it is followed by surface tillage which had the shortest plant height of 213 cm. The result in Table 2 also showed some significant (P>0.05) effects of the various tillage practices on the leaf area of the maize. The leaf area of the various tillage methods on the 6 WAP ranged from 44.3 cm to 79.5 cm. The highest (79.5 cm, 90.3 cm and 78.0 cm) leaf area were obtained from the ridge tillage method for the 6, 9 and 12 WAP respectively. The leaf area of the various tillage methods on the 9 WAP ranged from 53.4 cm to 90.3 cm. The tied ridges tillage method showed the least (44.3, 53.4 and 50.0) leaf areas in the 6, 9 and 12 WAP respectively. The leaf area of the various tillage methods on the 12 WAP ranged from 50 cm to 78.0 cm.

Effect of Tillage Methods on the Yield Parameters of Maize

The cob weight was significantly (P>0.05) influenced by the various tillage practices as shown in Table 3. The cobs weight ranged from 1.18 g to 2.13 g. The surface tillage method had the highest (2.13 g) cob weight and was closely followed by the zero tillage method which had a weight of 1.77 g, while the tied ridges tillage method had the least (1.18 g). The various tillage method showed significant (P>0.05) influence on the cob length as shown in Table 3. The cob length ranged from 13.21 cm to 15.81 cm. The zero tillage method had the highest (15.8 cm) and was followed by ridges tillage method (14.1 cm), while the tied ridges tillage method had the least (13.2 cm).

The cob diameter was significantly (P>0.05) influenced by the various tillage method as shown in Table 3. The cob diameter ranged from 12.0 cm to 13.0 cm. The tied ridges had the highest (13.0 cm) cob diameter while the tied ridges tillage had the least (12.0 cm). The various tillage methods showed significant (P<0.05) influence on the grain yield of maize as shown in Table 3. The grain yield of maize in the various tillage methods ranged from

668 to 1430 kg/ha. The surface tillage had the highest (1430 kg) grain yield and was followed by the zero tillage (1198 kg), while the tied ridges tillage practice had the least (668 kg) grain yield.

The study found no significant effect of the various tillage methods on physical properties of soil. This disagree with the study of Monzon *et al.,* (2006) which showed significant effect of three (3) tillage treatment on soil physical properties.

The organic matter content of the soil ranged between 2.76 % and 5.35 %, indicating that sufficient amount of organic matter was present in top soil layer. The various tillage methods had no significant effect on the soil chemical properties. The calcium content ranged from 3.40 % to 4.02 % suggesting that the soil was slightly calcareous in nature. This finding is supported by Moreno *et al.,* (2006) who found no significant effect of conventional and non-conventional tillage methods on soil chemical properties.

Tillage methods had no significant effect on the germination count of the maize. This could be as a result of planting the same variety of maize. This disagrees with the study of Angers *et al.,* (1997) who found significant effect of tillage methods on the germination count of maize. The study showed significant effect of the various tillage methods on the maize plant height. The result is similar to that of Diaz-Zorita *et al.,* (2002) and Ojeniyi *et al.,* (2009) who observed the shortest maize plant in the no- tillage plots in comparison with that tilled plots on a sandy clay loam in Southwestern Nigeria.

Khurshid *et al.,* (2006) also reported taller plants in conventional tillage plots in comparison with that of the minimum tillage plots in Faisalabad, Pakistan. Licht and Al-Kaisi (2005) also reported taller cowpea plants in the tilled plots compared that of the no- tillage plots. In contrast, Lampurlanes *et al.,* (2001) reported taller maize plants in the no- tillage plots in comparison with that of the tilled plots except for that in the ploughed plot followed by harrowing plus ridging on sandy clay loam soil. They reported no significant difference in plant height between the indicated treatments. These results are in disagreement with the findings by Houx *et al.,* (2011).

Leaves are the site of photosynthetic activities of crops through which biomass are produced, partitioned among various parts of crops and stored for crop productivity (Doussan *et al.,* 2006). Maize leaf area is of importance to photosynthesis and yield. The photosynthetic capacity of crops is a function of leaf area. Leaf area is important for crop light interception and therefore has a large influence on crop yield (Derpsch *et al.,* 2010). The result of the study showed some significant effects of the various tillage practices on the leave area of the maize for the period of the study.

The result showed significant effect of the various tillage methods on the dry cob weight of the maize. The lowest cob weight obtained from the tied ridges tillage may be due to the lack of soil loosening for providing conditions favourable to crop growth and yield. This is supported by Fageria (2004), who found significant effect of tillage methods on dry cob weight between the different tillage methods. These results are in agreement with that of Jitareanu *et al.,* (2006) who observed higher maize yield in conventional tillage plots in comparison with that of the no- tillage plots on the chernozem soil type in Zemun Polje, Serbia. Lipiec *et al.,* (2001) reported higher wheat grain yield under conventional tillage as compared with the tillage on sandy clay loam soil (Luvic Yermosol) in Faisalabad in the semi-arid region of Pakistan. This finding is supported by Moreno *et al.,* (2006) who found significant effect of conventional and non-conventional tillage methods on maize growth and yield.

Table 1a: Soil Properties as Influenced by Tillage Methods during 2016 Cropping Season

Treatments	pH (H_2O)	Sand (%)	Clay (%)	Silt (%)	OC (%)	OM (%)
Pre-planting	6.27	79.28	14.45	6.27	1.96	2.78
Surface tillage	6.37	79.80	13.20	7.0	1.98	3.76
Ridge tillage	7.28	79.08	13.62	7.30	2.18	5.35
Zero tillage	7.21	76.08	14.92	9.00	2.99	5.17
Heap tillage	7.29	78.08	13.92	8.00	3.09	3.41
Tied Ridge tillage	7.10	76.08	14.92	9.00	2.61	4.52

Key: OC= Organic Carbon, OM= Organic Matter

Table 1b: Soil Properties as Influenced by Tillage Methods during 2016 Cropping Season

Treatments	P	N	K	Na	Mg	Ca	EA	BS	CEC	TEB
	(ppm)	(%)	Cmol/kg					(%)	Cmol/kg	
Pre-planting	0.32	0.05	0.25	0.20	3.20	3.50	1.12	86.7	8.74	6.99
Surface tillage	0.33	0.05	0.26	0.24	3.43	3.83	1.10	87.5	8.80	7.70
Ridge tillage	0.44	0.05	0.23	0.20	3.32	3.74	1.00	88.1	8.43	7.43
Zero tillage	0.50	0.05	0.26	0.24	3.61	4.02	1.00	89.0	9.10	8.10
Heap tillage	0.46	0.06	0.21	0.20	3.40	3.91	1.10	87.5	8.81	7.71
Tied Ridges	0.40	0.05	0.20	0.21	3.30	3.40	1.02	87.8	7.95	6.93

Key:P=Phosphorus, N=Nitrogen, K=Potassium, Na=Sodium, Mg=Magnesium, Ca= Calcium, TEB=Total Exchangeable Base, CEC=Calcium Exchange Capacity, BS=Base Saturation, EA= Exchangeable Activity

Table 2: Effect of Tillage Methods on the Growth Parameters of Maize during 2016 Cropping Season

Treatments/Parameters	GC(%)	Plant Height (cm)				Leaf Area		
		3WAP	6WAP	9WAP	12WAP	6WAP	9WAP	12WAP
Surface Tillage	98	17.6	71.6	215.8	213.2	68.3	79.3	61.0
Ridges Tillage	98	17.3	76.3	217.4	211.3	79.5	90.3	78.0
Zero Tillage	93	16.2	69.9	213.1	214.7	70.0	81.0	60.0
Heaps Tillage	97	14.7	61.0	204.3	142.1	62.0	74.5	75.0
Tied Ridges Tillage	96	15.1	54.9	197.4	202.9	44.3	53.4	50.0
LSD	0.09	1.08	2.27	2.26	3.09	2.19	3.04	3.22

Key: GC= Germination Count, WAP= Weeks After Planting

Table 3: Effect of Tillage Methods on the Yield and Yield Parameters of Maize during 2016 Cropping Season

Treatments/Parameters	Cob Weight (g)	Cob Length (cm)	Cob Diameter (cm)	Grain Yield (kg)
Surface Tillage	2.13	14.0	12.90	1430
Ridges Tillage	1.68	14.1	13.80	1112
Zero Tillage	1.77	15.8	11.00	1198
Heaps Tillage	1.57	13.9	12.80	1048
Tied Ridges Tillage	1.18	13.2	12.00	668
LSD	1.10	1.25	1.11	3.03

CONCLUSION

This study examined the effect of five (5) tillage methods namely; surface, ridges, zero, heap and tied ridge tillage, on the physical and chemical properties of soil as well as its effect on the growth and yield of maize. The results of the study showed that the various tillage methods had no significant effect on the soil properties. However, there was significant effect on some of the growth parameters as well as the yield of maize. It can be concluded that all the tillage methods be adopted or utilized for maize production in Makurdi sub-humid region and also the surface tillage should be utilized the most since it gave the highest grain yield of maize.

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