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Effect of Tillage and Mulch on Growth and Performance of Maize in Makurdi, Benue State, Nigeria

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***Abstract*— *Field experiments were conducted during the 2015 and 2016 cropping season at the Teaching and Research Farm of the University of Agriculture Makurdi, Benue State, Nigeria to evaluate the effect of different tillage systems and mulch application on the growth and performance of maize. Four tillage systems (minimum tillage, flat bed, ridge tillage and no tillage) and mulch at two levels (mulched and unmulched) were used. Data was recorded on plant height (cm), leaf area (cm^2) of maize, dry cob length (cm), dry cob width (cm) 1000-grain weight (g) and grain yield (t ha^{-1}). Tillage methods significantly affected maize growth. The maximum plant height (178.8cm) leaf area (487.0cm) 1000-grain weight (0.2500g) and grain yield (1.4g) were observed in ridged tillage while no tillage as compared to minimum tillage and flat bed. Mulch significantly affected the growth of maize. The maximum values of plant height (144.5cm), leaf area (411.0cm) dry cob length (cm) (11.16cm), dry cob width (10. 52cm), 1000-grain weight (0.1717g) and grain yield (0.90 tons/ha) were obtained when mulch was applied compared to the unmulched plots. There was no significant difference between the interaction of tillage and mulch. Ridged tillage × mulch produced the best result on maize performance*

Key words*— *Tillage, mulch, maize, growth, and performance.

I. INTRODUCTION

Maize *(Zea mays L)* is one of highly consumed cereal crops ranked the first in terms of production and third in terms of consumption among the ten staples that feed the world and therefore, dominates agriculture in many regions of the world. In Nigeria, maize is an important food fodder and industrial crop grown both at commercial and subsistence levels, it is eaten fresh or made into flour and also as livestock feed. The increasing use of maize gives Agricultural production in Nigeria can be enhance through the use of various agronomic practices that ensure more efficient use of limited resources to improve the growth of crops and their yield. Management practices that leaves crop residue on soil surface have shown to enhance crop growth (Odofin, 2005).The use of inorganic fertilizer has proven to be more convenient and impactful, but the resulting rapid soil physical degradation, soil nutrient imbalance, increase soil acidity cast and security of fertilizer at the time required have drawn the attention of researcher to the use of other methods of improving productivity.

Mulch materials and tillage systems influence soil properties giving rise to significantly better root growth and yield of maize compared to no mulch treatment due to increase soil water content resulting from reduce evaporation and increase infiltration.

The aim of this work was to assess the effects of mulch application on maize growth and grain yield under four tillage systems in Makurdi, Benue State, Nigeria.

II. MATERIALS AND METHODS

Experimental Area/Site

This experiment was carried out at the Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State. Makurdi lies between latitude 7^0 and 8^{0}N as well as longitude 8^0 and 9^{0}E. Makurdi has an average relief of 120 m above the sea level. The mean annual temperature range is between 22^{0}C and32^{0}C while the relative humidity ranged between 50% and 80% and is season dependent. The highest relative humidity occurs between June and September while the lowest is December and February (Adaikwu *et al,* 2012). The mean annual rainfall is 1250mm. Two peaks of rainfall are observable, June-July and September-October. Soil textural class is loamy sand. The land use of the study site includes arable crops (yam, cassava, soya bean, cowpea, and maize) while the trees include mango and citrus. The vegetable crops include: eggplant, amaranthus, ugu and okra.

Experimental Treatments and Design

The study was made up of two factors: Tillage at four levels: minimum tillage, flat bed, ridge tillage and no tillage and Mulch at two levels: mulch and unmulch. The treatment combinations was as follow: min-till x unmulched, min-till x mulched, ridge x unmulched, ridge

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x mulched, Flat bed x unmulched, Flat bed x mulched, No-till x unmulched and No-till x mulched

Field Layout

The treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The field layout and its replication is presented in Figure 1.

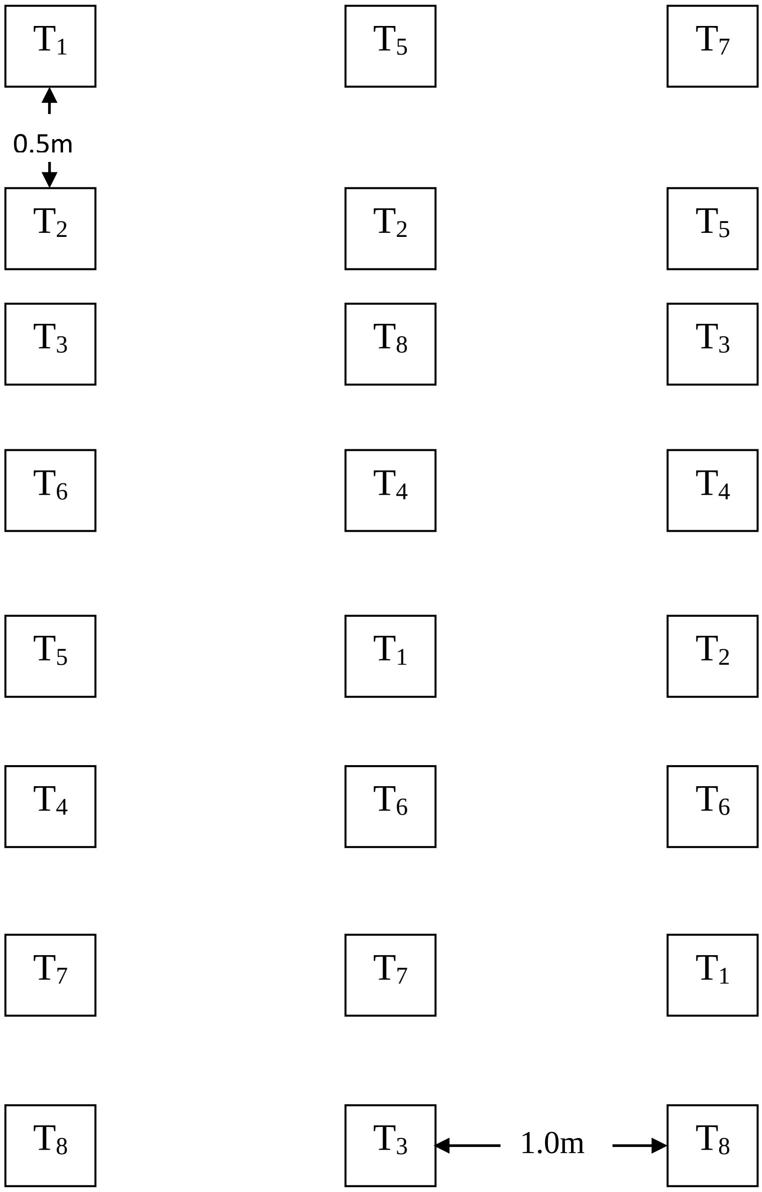

Fig.1: Experimental Layout

Land Preparation and Planting

The land was manually prepared using hoe and cutlass along the contour. Contour bond was constructed at the upper edge of the plots demarcation of the field into blocks and plots were carried out. Maize (*Zeamays* L.) seeds were gotten from the University of Agriculture Experimental Farm. Four maize seeds were planted using the standard plant spacing and latter thinned to one plant. Plant residues from the cleared plots were used to mulch the maize plots at the rate of 45 ton ha^{-1}. The plots measured 3mx5m ($15m^2$) with inter block spacing of 1 m and inter plot spacing of 0.5m were ensured and the harvest was done at maturity

Soil Sample Collection/Analysis

Initial soil sampling was carried out at a depth of 0-15cm from three locations using soil auger and core samplers. Soil samples were also collected at harvest using soil auger at 0-15cm at appropriate plots for analysis in order to assess the effect of management practices on soil. The collected soil samples were air-dried and ground to pass 2 mm sieve. Soil pH was determined in a 1:1 soil-water suspension by the glass electrode method, particle size analysis by the hydrometer method of Bouyoucos (1951) in which sodium hexametaphosphate (Calgon) was used as dispersing agent. Total organic carbon by the chromic acid oxidation procedure of Walkley and Black (1934),

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exchangeable bases by the neutral ammonium acetate saturation. Na and K in the extracts were determined by the flame photometer while Ca and Mg were determined with the Atomic Absorption Spectrophotometer (AAS), exchange acidity by the 1M KCl extraction and 0.01M NaOH titration. Nitrogen in the samples was determined by the Marco Kjeldahl method, Free Fe and Al oxides (Total oxides) were extracted by the citrate dithionate – bicarbonate method (Mebra and Jackson, 1960). Iron and Aluminum oxides in the extracts were determined with an Atomic Absorption Spectrophotometer (AAS) at 248.3 nm and 396.1nm wavelengths respectively.

Crop Data

Data was collected on plant height, Leaf length (cm) Leaf width, Leaf Area (cm^3)and Grain yield (kg)

The data generated were subjected to analysis of valiance (ANOVA). Means that showed statistically significant differences were separated using least significant difference (LSD) (Genstat, 2009)

III. RESULTS AND DISCUSSION

The information on rainfall, temperature and relative humidity is presented in Table 1. The highest temperatures are recorded at the end of dry season (November to April) when the average temperature is 35ºC. At the start of rain in April down to May, temperature decreased until August which showed 29ºC.The relative humidity was maximum in the month of August (81%) and then dropped until December (27%). However, mean annual rainfall recorded during the period of study was 80.1mm which is low, treatments that received mulch cover had the highest soil water content at the end of the cropping season. One of the major roles played by mulch cover during the cropping season was probably reducing soil water evaporation which contributed to the maintenance of soil fertility and biological activities. Based on long term experiment, Boomsma *et al,* (2010) observed that substantial crop residue cover and cool, moist early season soil conditions are common characteristics of continuous maize no-tillage systems which often delay seed germination, seedling emergence and early root and seed development. Residue removal had also a significant impact on the noon temperature and water content in the soil if soil drying can be delayed for few days as a result of surface mulch, both temperature and soil strength will be lower during the emergence of crop seedlings (Bristow 1988).

Table.1: Meteorological Data for Makurdi (2015)

Months	Rainfall (mm)	Temperature		Relative Humidity (%)
		Max (^{0}C)	Min (^{0}C)	
January	0.0	33	18	47
February	109.0	35	24	48
March	4.0	35	24	55
April	14.0	35	24	65
May	36.0	35	25	73
June	152.0	33	24	78
July	128.0	31	22	79
August	135.0	29	23	81
September	283.0	30	22	79
October	80.0	32	24	78
November	20	34	20	69
December	0.0	33	18	27
Mean	80.1	32.9	22.3	64.9

Source: Nigerian Meteorological Agency (NIMET)

Soil Properties of the study site

Table 2 shows the physical and chemical properties of the experimental site before planting. The soil of the experimental site prior to planting was characterized by low level of organic carbon (0.93), total Nitrogen(0.05%).The PH was slightly acidic(6.62) which is conducive for maize production. Exchangeable Calcium (Ca) and Magnesium were 3.01cmol/kg and 2.4cmol/kg respectively. The organic matter content of the soil was 1.60% which is low. The available Phosphorus and nitrogen was 0.31ppm. The exchangeable cations indicated low K^+ with 0.23cmol/kg and Na^+2.40cmol/kg. The percentage base saturation was 85.5%.the particle size distribution of sand, clay and silt is78.36%,8.02% and 13.62% indicating loamy sand using the textural classes. According to Metson (1961), textural class of the soil has high influence on the physical and chemical properties of the soil. The total nitrogen content

(0.5gkg-1) is moderate. The organic matter (1.60 is very low, thus the maintenance of soil organic matter is paramount to sustaining other soil quality factors (Robertson et al.,1991)

Table.2: The physical and chemical properties of soil in the study site prior to 2015 cropping season

Soil Parameters	Values
Sand (%)	78.36
Silt (%)	8.02
Clay (%)	13.62
pH	6.62
Organic Carbon (C)	0.93
Total Nitrogen (%)	0.05
Available Phosphorus (ppm)	0.31
Potassium (K^+)(Cmol/kg)	0.23
Calcium (Ca^+) (Cmol/kg)	3.01
Sodium (Na^+) (Cmol/kg)	2.40
Acidity (Cmol/kg)	0.26
Basicity (Cmol/kg)	1.00
Organic matter (%)	1.60
Effective cation exchangeable capacity (ECEC) (Cmol/kg)	6.90
Textural Class	Loamy sand
Total Porosity (%)	48.68
Bulk density (gcm^{-3})	1.36
Base Saturation (%)	85.50

Effect of Tillage and Mulch on maize Performance

The Main Effect of Tillage and Mulch on Maize Height is Presented in Table 3. Analysis of data indicated that the effect of mulch practices was not significant. Plant height was highest under mulch treatment compared to the un-mulch this might be due to moisture retention in the soil and decomposition of organic matter in the soil. According to (Holland, 2004) soil biota increase under mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years. Yonghe (1994) also reported that plastic mulch significantly raised the soil temperature keeping the soil water content stable, which resulted in faster growth with higher dry matter yield as compared to uncovered treatments. However, tillage systems showed significant differences in plant height except at 6 weeks after planting. The tallest plant was located in the ridge tillage treatment at 8 weeks after planting while shortest plant was found in the no tillage plots. This might be due to proper root penetration due to that of Kayode and Adenileuyi (2004) who observed the shortest maize plant in the no tillage plots in comparison with that in the tilled plots on a sandy clay loan Alfisols in south western Nigeria.Alkins and Afuaka (2010) also reported taller cowpea plants in the tilled plots compared to that of the No-tilled plots

The effect of interaction of tillage and mulch on maize height is presented in Table 4. There was no significant effect ($p \leq 0.05$) between the various interactions on plant. The tallest plant was found in the ridge-tillage and mulch interaction which penetration while mulch reduced recompaction of the soil, increased water and nutrient absorption. The combined positive effects led to increase in maize plant height growth and establishment

Table.3: The Main Effect of Tillage and Mulch Practices on Maize Height in Makurdi

	Treatment	Plant Height (cm)			
		2WAP	4WAP	6WAP	8WAP
1	Mulch	11.78	50.78	97.2	144.5
2	Unmulch	10.97	40.75	91.6	136.0
	LSD(0.05)	NS	NS	NS	NS
	CV (%)	8.1	6.2	14.8	13.4
	Tillage practices				
1	Flatbed	11.22	85.97	104.5	152.8

2	No-till	10.20	33.04	76.7	85.8
3	Ridge-till	11.72	37.67	85.0	178.8
4	Min-till	12.34	67.37	111.9	143.5
	LSD (0.05)	1.146	3.846	NS	23.29
	CV(%)	8.1	6.2	14.8	13.4

Table.4: The Interactive Effect of Tillage and Mulch on Maize Height

Interaction		Plant Height (cm)			
Tillage	Treatment	2WAP	4WAP	6WAP	8WAP
Flatbed	Mulch	11.78	65.48	102.4	156.8
	Unmulch	10.07	66.45	106.0	148.8
No-tillage	Mulch	10.85	84.80	80.9	90.9
	Unmulch	9.55	31.28	72.4	80.8
Ridge-till	Mulch	12.04	38.61	87.4	180.0
	Unmulch	11.40	36.66	82.6	177.6
Min-till	Mulch	12.43	64.11	118.2	150.3
	Unmulch	12.26	60.62	105.6	136.8
LSD (0.005)		NS	NS	NS	NS
CV (%)		8.1	6.2	14.8	13.4

The Main Effect of Tillage and Mulch on Leaf Area is Presented in Table 5. Results show significant differences between the mulch treatments. Leaf area was highest at 2, 4, 6 and 8 weeks after planting in the mulch treatment compared to the un-mulch. This indicated y that the presence of mulch materials on the soil surface helped to retain moisture and improved the fertility status of the soil which lead to increase in crop establishment, growth and development.

Among the tillage systems, ridge tillage produced the largest leaf area at 8 weeks after planting compared to the other systems of tillage. Leaf area was lowest under No tillage system. Although No-tillage did not hinder the establishment and early growth of maize, yet later on may have affected root development as compared to the other tillage systems. The negative effect on root development may have led to shower flow of water and nutrients from soil to the plants. These results are similar to that of Karunatilake (2000) who also reported higher leaf area plant in conventional tillage compared to no-tillage in maize and thus was attributed to higher leaf area plant in conventional tillage abundant root growth compared to that of zero tillage.

The interaction effect of tillage and mulch on leaf area is shown in Table 6. There was no significant difference between the interactions. At 8 WAP the highest leaf area was observed in the ridge tillage and Mulch treatment while the least leaf area was observed in No-tillage and un-mulch interactions.

Table.5: Main Effect of Tillage and Mulch on Leaf Area of Maize in Makurdi

	Treatment	Plant Leaf Area (cm)			
		2WAP	4WAP	6WAP	8WAP
1	Mulch	32.22	191.2	364.0	411.0
2	Unmulch	27.43	163.7	297.0	334.0
	LSD(0.05)	3.973	22.23	53.8	71.7
	CV (%)	15.2	14.3	18.6	22.0
	Tillage practices				
1	Flatbed	30.93	241.0	401.0	428.0
2	No-till	24.03	123.3	218.0	256.0
3	Ridge-till	31.24	156.9	372.0	487.0
4	Min-till	33.11	188.7	331.0	319.0
	LSD (0.05)	5.618	31.44	76.0	101.3
	CV(%)	15.2	14.3	18.6	22.0

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Table.6: The interaction Effect of Tillage and Mulch on Leaf Area of Maize in Makurdi

Interaction Tillage	Treatment	Leaf Area (cm^2) 2WAP	4WAP	6WAP	8WAP
Flatbed	Mulch	34.55	262.9	450.0	481.0
	Unmulch	27.31	219.0	352.0	374.0
No-tillage	Mulch	24.58	124.3	221.0	266.0
	Unmulch	23.49	122.2	216.0	246.0
Ridge-till	Mulch	35.23	174.5	391.0	540.0
	Unmulch	27.26	139.3	346.0	435.0
Min-till	Mulch	34.55	203.1	388.0	356.0
	Unmulch	31.66	174.3	274.0	282.0
LSD (0.005)		NS	NS	NS	NS
CV (%)		15.2	14.3	18.6	22.0

Main effect of tillage and mulch on dry cob length (cm), wt 1000g, grain yield (crop yield) of maize is presented in table 7

Analysis of variance showed no significant differences between the mulch treatments. Mulch treatment had the highest dry cob length, dry cob width, weight of 1000grains and grains yield (t/ha). The increase in grain yield of corn under mulching conditions may be due to increased soil moisture storage and suppression of weed growth (Mastana, 1988)

Similarly, Tolk *et al.,* (1999) and Liv *et al.,* (2002) concluded that mulch increases soil moisture and nutrients availability to plant roots in turn, leading to grain yield. Mulch significantly increased grain yield.

Among the tillage treatments the highest dry cob length (cm) was obtained in flat bed while ridge-tillage plot Presented the highest dry cob width, weight of 1000grains and grain yield (t/ha) this might be due to proper soil loosening which led to deep rooting ability, water utilization and nutrient uptake for crop growth and yield. The lowest dry cob length (cm), dry cob width (cm) weight of 1000grams and yield (t/ha) were obtained in no-tillage systems. These results are in agreements with that of Videnovil *et al.,* (2011) who observed higher maize yield in conventional tillage plots in comparison with that of the no-tillage plots in comparison with that of the no-tillage plots in the chenozen soil type in Cemunpolje, Serbia. This is particularly due to the fact that no-tillage environments are more likely to exhibit no-uniform germination, emergence and early growth and development which cause great plant to variability for multiple morpho-physiological traits that are associated with yield reduction (Liv*et al.,* 2004; Tokattidis *et al.,* 2004)

The effect of interaction of tillage and mulch on maize crop yield is shown in Table 8 Significant differences were not observed in all the interactions. Flat bed and mulch produced highest fry cob length, ridge-tillage and mulch produced the highest dry cob width while the highest weight of 100grains was observed in the ridge tillage and mulch and ridge tillage and un-mulch tillage and mulch interaction.

Table.7: Effects of Tillage and Mulch on Maize Crop Yield (t/ha)

	Treatment Mulch	Maize yield DCL (cm)	DCW (cm)	WT 1000g	Grain yield (t/ha)
1	Mulch	11.16	10.52	0.1717	0.90
2	Unmulch	11.14	10.12	0.1540	0.66
	LSD(0.05)	NS	NS	NS	NS
	CV (%)	17.2	10.2	29.4	67
	Tillage practices				
1	Flatbed	13.82	12.07	0.200	0.68
2	No-till	5.79	5.71	0.0788	0.29
3	Ridge-till	13.70	12.85	0.2500	1.41
4	Min-till	11.29	10.64	0.1230	0.74
	LSD (0.05)	2.372	1.300	0.05935	0.653
	CV(%)	17.2	10.2	29.4	67.5

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Table.8: The Interaction Effect of tillage and Mulch on Maize Grain Yield in Makurdi

Interaction		Maize yield			
Tillage	Treatment	DCL(cm)	DCW (cm)	Wt 1000g	Grain yield (t/ha)
Flatbed	Mulch	13.54	12.23	0.1967	0.77
	Unmulch	14.11	11.90	0.2083	0.59
No-tillage	Mulch	6.25	6.23	0.1000	0.36
	Unmulch	5.33	5.18	0.0567	0.22
Ridge-till	Mulch	14.00	13.73	0.2500	1.68
	Unmulch	13.40	11.97	0.2500	1.14
Min-till	Mulch	10.86	9.87	0.1400	0.80
	Unmulch	11.72	11.41	0.1060	0.68
LSD (0.005)		NS	NS	NS	NS
CV (%)		17.2	10.2	29.4	67.5

IV. CONCLUSION

This study examined the effect of tillage and Mulch practices on maize performance. Mulch treatment proved to be most effective in promoting maize growth, development and yield. Ridge-tillage showed to be most effective and no-tillage was least. Ridge-tillage and mulch was most beneficial while no-tillage and un-mulch were least beneficial in promoting maize growth, performance and yield in Makurdi. Much application and ridge tillage is therefore recommended for improved maize growth and yield.

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