



Performance of Maize as Influenced by Tillage and Fertilizer Treatments in Makurdi, Southern Guinea Savanna, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AA supervised the study, managed the design, analyses of the study and wrote the protocol. Author MU designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author SOO served as external examiner and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted during 2017 and 2018 cropping seasons at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi, Southern Guinea Savanna, Nigeria to determine the performance of maize as influenced by tillage and fertilizer treatments. The experimental design consisted of two factors. Tillage (flat, ridges, zero and heap tillage) and fertilizer (0, 75, 150 and 300 kg ha⁻¹ of NPK 15:15:15). Treatments were laid out in a factorial randomized complete block design (RCBD) and replicated three times. A composite soil sample was obtained from a plough layer (0-15 cm) at the beginning and at the end of each experiment according to the treatments and analyzed for particle size distribution, pH, organic carbon, total nitrogen, available phosphorus and exchangeable cations as well as cation exchange capacity (CEC). Data collected for the growth and grain yield of maize were subjected to analysis of variance after which significant

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means were separated using least significant difference (LSD) at $P < 0.05$. Results indicated that there were significant effects of tillage and fertilizer treatments with respect to all parameters studied. However, ridges and heap at 300 kg ha^{-1} NPK fertilizer applications gave the best results and produced higher growth and grain yield of maize as a result of improved access to soil nutrients when compared with flat or zero tillage. Similarly, increasing the quantity of NPK fertilizer resulted in increase in the growth and yield of maize crops. This implies that growth and yields of maize crops could still response to higher fertilizer rates which needs further investigation.

Keywords: Maize; tillage; fertilizer treatments; cropping seasons.

1. INTRODUCTION

Maize (*Zea mays* L.), is the most efficient plant for capturing the energy of the sun and converting it to food. Maize provides a major source of calories not only for humans but also for animals in Nigeria as well as other parts of the world [1]. Use of maize for direct human consumption as roasted cob, breakfast cereal, pudding, soup, fermented paste, couscous, etc., has remained stable at about 100 million tons per annum since 1988. About three quarters of maize is transformed into meat, milk, eggs and other animal's products [2]. Thus, maize more than any other crop offers the promise of meeting Africa's food needs in this millennium.

Climate and soil are the main environmental factors that determine crops yields [3]. Although maize is found to grow throughout Nigeria under a wide range of agro-climatic conditions, three broad agro ecological zones can be distinguished for maize production. These are the forest, the moist (or Guinea) savanna and the forest/savanna transition zone [2,4]. The Guinea savanna is the most important maize growing zone in Nigeria.

Tillage is performed to loosen the soil and produce a good tilth. Tillage requirement of a crop is site, environment and soil type specific [5,6]. Tillage contributes up to 20 % amongst crop production factors [7]. There have been conflicting reports on the influence of tillage on soil chemical properties; likewise contradictory reports as to the superiority of crops on tilled plots to those of no-till plots have been documented [8]. Ridge tillage was found to increase growth of okra on ultisol of central Southwest, Nigeria relative to no-tillage [9].

However, manual tillage systems including ridges, heaps and flat beds have been reported to degrade soil quality and reduce chemical and biological qualities especially on alfisols in the rainforest areas of Southwest, Nigeria [10]. The

study of relative effect of ridging and no-tillage on soil properties and yield of sweet potato in guinea savanna zone (middle belt) of Nigeria showed that no-till gave higher tuber yield of sweet potato compared to ridging, which was adduced to have higher moisture content, N, P, K, Ca and Mg status [11].

Inorganic fertilizers on the other hand are essential component of any system in which the aim is to maintain good yield in the absence of organic manure [12,13]. However, the rate of application and dosage has a greater influence on both crop yield and its environment [14,15]. Excessive application of fertilizer according to them does not really enhance sustainability, crop nutrient uptake nor significantly increase yields but tends to encourage economic waste and damage to the environment.

Inadequate application can retard growth and lower yield in short term and in the long run jeopardizes sustainability through soil mining and erosion. This precarious tilt between "excessive" and "inadequate" is the major challenge of fertilizer recommendation efforts and can only be effectively bridged when nutrients are applied at the right ratios with appropriate tillage systems.

In Nigeria, there is no adequate information on the appropriate tillage practices for maize crop in the agro-ecological zones. In order to increase the production of maize, there is need for adoption of appropriate tillage practices as well as sound fertilizer recommendations that would ensure optimum yield. The recent increase in awareness, production and cultivation of maize to fight against food security in the zones has therefore, necessitated the need to determine its response to tillage and fertilizer rates. This study was designed to assess the performance of maize as influenced by different tillage and fertilizer treatments with a view to sustaining productivity as well as enhancing the farmers' level of maize production through appropriate tillage practices and fertilizer rates in the study area.

2. MATERIALS AND METHODS

The experiment was conducted during 2017 and 2018 cropping seasons at the Teaching and Research Farm of the University of Agriculture, Makurdi-Nigeria to assess the performance of maize as influenced by tillage and fertilizer treatments. The study location falls within the Southern guinea savanna zone of Nigeria with mean rainfall of 1, 250 mm per annum and temperature of 25-30°C. The site had not been cultivated for about two years. It is located between latitude 7°40'N to 7°53'N and longitude 8°22'E to 8°35'E at an elevation of 97 m above mean sea level. The soil is classified as Typic Ustropepts (USDA) [16]. The maize variety (TZESR-W) was used as planting material for the experiment in both seasons. This variety is widely grown by farmers in the study area.

2.1 Experimental Treatments and Design

The experimental design consisted of two factors. Tillage (flat, ridges, zero and heap tillage) and fertilizer (0, 75, 150 and 300 kg ha⁻¹ of NPK 15:15:15). Treatments were laid out in a factorial randomized complete block design (RCBD) and replicated three times. The land was cleared manually and ridges, flat or heaps were prepared using hoe and cutlass. The cleared grasses were gathered and burnt. The land was then marked out in three replicates. Each plot measured 4 m x 4 m with spacing of 1 m between replicates and 0.5 m between plots in the same replicate thus giving a total land area of 54.5 m x 17.5 m (953.8 m²). 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 8th and 9th August in 2017 and 2018 respectively at a depth of 2.3 cm with spacing 25 x 75 cm giving an approximate plant population of 35,000 plants hectare⁻¹.

2.2 Soil Data Collection and Analysis

A composite soil sample was obtained from a plough layer (0-15 cm) at the beginning and at the end of each experiment according to the treatments and analyzed at the Advanced Analytical Laboratory of Soil Science Department of the Federal University of Agriculture, Makurdi. The pH was determined in water (1:1) [17]. The particle size distribution was determined by the hydrometer method Bouyoucos [18]. The chromic acid titration method was used to determine the O.C. and O.M [17]. Total N in the

soil was determined by the regular Macrokjeldahl method [17]. The amount of cations held exchangeable by a unit mass of soil was determined using NH₄OAC 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.

2.3 Crop Data Collection and Analysis

Plant height was measured at 8 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. Number of leaf was determined at 8 and 12 WAP using counting and the leaf area meter. The lengths of ten cobs from each net plot were measured from bottom of the maize cob to the cob apex using a meter rule and the average value recorded.

The diameters of ten cobs from each net plot were measured using measuring tape round the cob and the average value recorded. A total of 100 seeds from each plot were counted and weighed on an electronic top-loading Mettler balance to obtain the weight of 100 seeds. Five plants in the net plot were sampled, the number of cobs on each plant counted and average value determined and recorded. From the seed yield per plot, seed yield per hectare for each plot was computed by converting it into kilogram per hectare by extrapolation. 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 $P < 0.05$.

3. RESULTS AND DISCUSSION

The physical and chemical properties of soil of the experimental site during 2017 and 2018 cropping seasons before application of treatments are shown in Table 1. The soil is sandy loam, slightly acidic, pH (water) being 6.41 and 6.33 respectively, whilst pH (KCl) were 5.60 and 5.50 respectively. The total N (0.06 and 0.08%) and SOM (1.56 and 1.64%) were found below the average range of 2.5-2.6 % considered for good crop growth [19] in the study area. The results of soil analysis thus indicated that soil amendment was required in line with the observation of Agboola [20] who reported that

Table 1. Pre-planting soil physical and chemical properties of the experimental site

Property	2017	2018
Chemical property		
pH H ₂ O (1:1)	6.41	6.33
pH KCl (1:1)	5.60	5.50
Organic Carbon (%)	0.90	0.95
Organic Matter (%)	1.56	1.64
Total Nitrogen (%)	0.06	0.08
Available p (ppm)	3.02	3.60
Exchangeable cation (Cmol Kg⁻¹)		
Ca	3.27	3.07
Mg	1.40	1.36
K	0.26	0.24
Na	0.61	0.60
CEC	6.26	6.21
Base Saturation (%)	86.5	87.4
Particle size distribution		
Sand (%)	78.5	77.0
Silt (%)	10.2	10.9
Clay (%)	11.3	12.1
Textural Class	Sandy loam	Sandy loam

farmers in Africa requires adequate soil amendment for good crop production as a result of low inherent soil fertility.

3.1 Influence of Tillage and Fertilizer Treatments on Soil Properties

The results of analysis of the physical and chemical properties as influenced by tillage and fertilizer in 2017 and 2018 cropping seasons are presented on Tables 2 and 3 respectively. The pH at harvest decreased in all treatment plots but increased with the application of 300 kg ha⁻¹ NPK fertilizer. The increase in soil pH can be adduced to addition of NPK fertilizer and also consistent with the findings of Chukwu et al. [21] who reported that application of 300 kg ha⁻¹ of NPK fertilizer could lead to increase in soil pH in the south eastern Nigeria. The decrease in the pH of the tilled plots with low application of NPK fertilizer could be attributed to complete decomposition of organic matter as a result of enhanced activities of micro organisms and low level of inorganic fertilizer application [22].

The use of NPK fertilizer increased SOM (Tables 2 and 3) in both seasons. The soil organic matter was consistently low in no-tilled plots with zero application of fertilizer. This can be attributed to the absence of fertilizer which would have enhanced the decomposition of organic matter in the soil. According to Plaster [23], organic matter content of the soil can be maintained through

incorporation of crop residues, mulching, and addition of organic and inorganic fertilizers.

Lowest values of N and P were recorded for zero tillage and zero NPK application. Exchangeable bases, base saturation and ECEC reduced in 2017 in zero tillage and zero fertilizer treatments but remarkably increased in 2018 due to application of 150 and 300 kg ha⁻¹ on flat, heaps and ridges. This can be adduced to effect of ridging which increased nutrients (N, P, Mg, K, Ca, CEC and base saturation) in soil [10]. Tables 2 and 3 also indicated that T3+F4 (maize + ridging + 300 kg ha⁻¹ NPK) and T4 +F4 (maize + heaps + 300 kg ha⁻¹ NPK) had the highest N, OM and relatively high available P. Table 3 shows that T3+F4 (maize + ridging + 300 kg ha⁻¹ NPK) maximized available soil P and N. The results are consistent with earlier reports that N and P are limiting to maize productivity [24].

3.2 Influence of Tillage and Fertilizer Treatments on Growth and Yield of Maize

The influence of tillage and fertilizer treatments on growth and yield parameters of maize during 2017 and 2018 cropping seasons are shown in Figs. 1-6 and Table 4. Results indicated that there were significant effects of tillage and fertilizer treatments with respect to all parameters studied. However, maize grown on ridges (cob length 12.15 cm, 12.90 cm) or heaps (cob length

Table 2. Physical and chemical properties of soil after harvest (2017)

Treatments/ Plot	Particle size distribution			Textural Class	pH		Org C (%)	Org M N (%)			Bray-1 P (ppm)	Exch. cations (CmolKg ⁻¹)				Base	
	Sand (%)	Silt (%)	Clay (%)		H ₂ O 1:1	KCl 1:1		Ca	Mg	K		Na	CEC (Cmolkg ⁻¹)	Saturation (%)			
T1+F4	72.3	12.4	15.3	Sandy Loam	6.50	5.70	0.88	1.90	0.077	4.20	3.29	1.51	0.26	0.65	6.40	89.10	
T2+F3	76.2	11.2	12.6	Sandy Loam	6.65	5.90	0.90	1.56	0.070	3.50	3.01	1.30	0.21	0.52	6.10	88.60	
T3+F2	77.6	11.2	11.2	Sandy Loam	6.45	5.65	0.74	1.80	0.091	3.10	2.96	1.26	0.21	0.50	5.80	87.40	
T4+F1	77.5	11.3	11.2	Sandy Loam	6.60	5.85	0.90	1.56	0.077	4.60	2.77	1.30	0.23	0.48	5.20	90.20	
T4+F1	71.8	11.2	17.0	Sandy Loam	6.65	5.90	0.92	1.75	0.088	4.00	3.80	1.60	0.30	0.71	6.00	86.70	
T3+F4	73.3	13.0	13.7	Sandy Loam	6.40	5.60	0.80	1.81	0.097	2.90	2.84	1.28	0.24	0.55	5.40	89.40	
T2+F3	72.1	14.0	13.9	Sandy Loam	6.70	5.95	0.87	1.87	0.091	3.30	3.57	1.37	0.26	0.58	6.22	88.50	
T1+F4	71.4	13.5	15.1	Sandy Loam	6.45	5.65	0.77	1.88	0.079	4.50	3.11	1.40	0.22	0.50	6.30	87.60	
T1+F3	72.0	12.4	15.6	Sandy Loam	6.75	5.96	0.91	1.89	0.070	3.70	3.46	1.55	0.24	0.57	6.50	89.30	
T2+F2	65.4	15.4	19.2	Sandy Loam	6.58	5.90	0.86	1.73	0.090	3.60	4.12	1.70	0.30	0.76	6.70	90.40	
T3+F1	69.6	13.1	17.3	Sandy Loam	6.71	5.94	0.93	1.72	0.086	3.10	3.85	1.54	0.27	0.69	6.52	88.80	
T4+F4	65.2	15.4	19.4	Sandy Loam	6.53	5.77	0.80	1.38	0.077	4.00	4.00	1.80	0.33	0.75	6.80	87.90	
T4+F1	73.5	13.0	13.5	Sandy Loam	6.48	5.70	0.73	1.26	0.088	3.80	3.08	1.40	0.24	0.43	6.27	89.00	
T3+F2	75.2	13.5	11.3	Sandy Loam	6.60	5.93	0.91	1.57	0.080	3.50	2.71	1.20	0.20	0.40	5.10	90.30	
T2+F3	65.1	15.4	19.5	Sandy Loam	6.40	5.70	0.88	1.69	0.077	2.90	4.20	1.86	0.33	0.75	6.77	87.80	
T1+F1	67.2	15.2	17.6	Sandy Loam	6.55	5.86	0.86	1.66	0.091	3.30	4.11	1.81	0.31	0.68	6.60	87.10	

T1 = Flat Tillage, T2 = Ridging, T3= Zero Tillage, T4 = Heaps Tillage, F1 = 0 kg⁻¹ Fertilizer, F2 = 75 kg⁻¹ Fertilizer, F3= 150 kg⁻¹ Fertilizer, F4= 300 kg⁻¹ Fertilizer

Table 3. Physical and chemical properties of soil after harvest (2018)

Treatments/ Plot	Particle size distribution			Textural Class	pH		Org	Org		Bray-1 P	Exch. Cations (CmolKg ⁻¹)				Base	
	Sand (%)	Silt (%)	Clay (%)		H ₂ O 1:1	KCl 1:1	C (%)	M (%)	N (%)		Ca	Mg	K	Na	CEC (Cmolkg ⁻¹)	Saturation (%)
T1+F4	73.2	11.9	14.9	Sandy Loam	6.38	5.68	0.90	1.86	0.076	4.50	3.25	1.50	0.23	0.63	6.30	88.00
T2+F3	74.6	11.5	13.9	Sandy Loam	6.51	5.80	0.95	1.64	0.070	3.00	3.00	1.28	0.20	0.50	6.06	87.60
T3+F2	76.9	11.9	11.2	Sandy Loam	6.45	5.67	0.78	1.70	0.093	3.20	2.93	1.23	0.21	0.48	5.60	87.10
T4+F1	76.5	12.0	11.5	Sandy Loam	6.50	5.80	0.96	1.66	0.070	3.00	2.77	1.30	0.22	0.45	5.30	90.00
T4+F1	71.6	13.7	14.7	Sandy Loam	6.62	5.88	0.95	1.71	0.087	4.30	3.78	1.50	0.29	0.70	5.90	87.30
T3+F2	74.0	12.9	13.1	Sandy Loam	6.32	5.62	0.81	1.80	0.099	4.40	2.83	1.23	0.22	0.50	5.30	89.50
T2+F3	73.0	14.0	13.0	Sandy Loam	6.79	5.91	0.89	1.85	0.092	3.50	3.56	1.30	0.24	0.55	6.10	88.60
T1+F4	72.1	13.8	14.1	Sandy Loam	6.48	5.67	0.79	1.80	0.078	4.60	3.10	1.36	0.20	0.49	6.28	87.00
T1+F3	73.3	13.4	13.3	Sandy Loam	6.80	5.95	0.93	1.80	0.071	3.60	3.47	1.51	0.22	0.50	6.47	88.30
T2+F2	70.0	14.9	15.1	Sandy Loam	6.85	5.88	0.88	1.70	0.089	3.80	4.11	1.59	0.27	0.70	6.65	90.10
T3+F1	70.2	14.6	15.2	Sandy Loam	6.85	5.95	0.96	1.70	0.086	3.30	3.86	1.50	0.25	0.64	6.48	89.90
T4+F4	70.2	14.4	15.4	Sandy Loam	6.58	5.70	0.83	1.44	0.070	4.30	3.91	1.76	0.33	0.70	6.75	87.30
T4+F1	75.1	12.9	12.0	Sandy Loam	6.50	5.70	0.75	1.30	0.089	3.90	3.07	1.38	0.23	0.41	6.20	88.60
T3+F2	75.2	12.5	12.3	Sandy Loam	6.58	5.90	0.93	1.61	0.079	3.70	2.70	1.25	0.21	0.38	5.00	90.00
T2+F3	68.0	14.8	17.2	Sandy Loam	6.39	5.72	0.90	1.68	0.076	3.00	4.10	1.79	0.32	0.70	6.70	86.90
T1+F1	68.3	14.7	17.0	Sandy Loam	6.51	5.87	0.89	1.65	0.092	3.40	4.06	1.70	0.30	0.63	6.50	88.00

T1 = Flat Tillage, T2 = Ridging, T3= Zero Tillage, T4 = Heaps Tillage, F1 = 0 kg⁻¹ Fertilizer, F2 = 75 kg⁻¹ Fertilizer, F3= 150 kg⁻¹ Fertilizer, F4= 300 kg⁻¹ Fertilizer

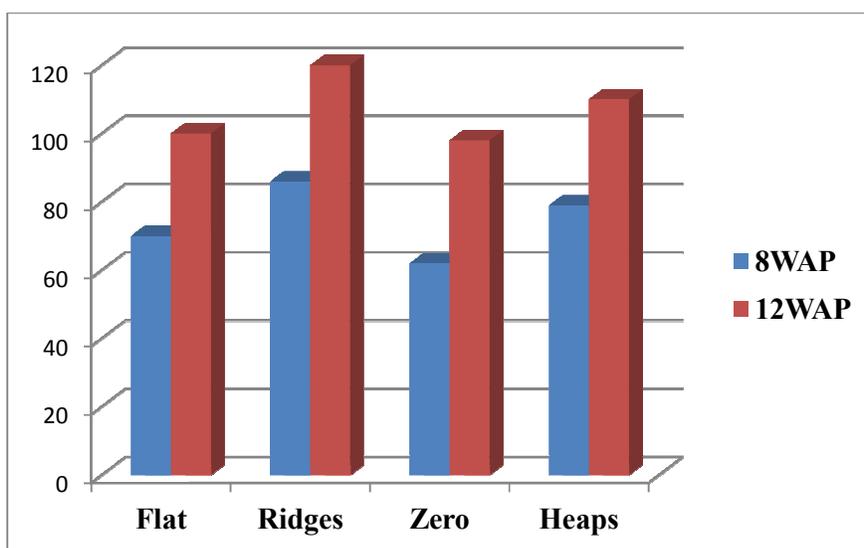


Fig. 1. Influence of tillage on maize plant height for 2017 cropping season

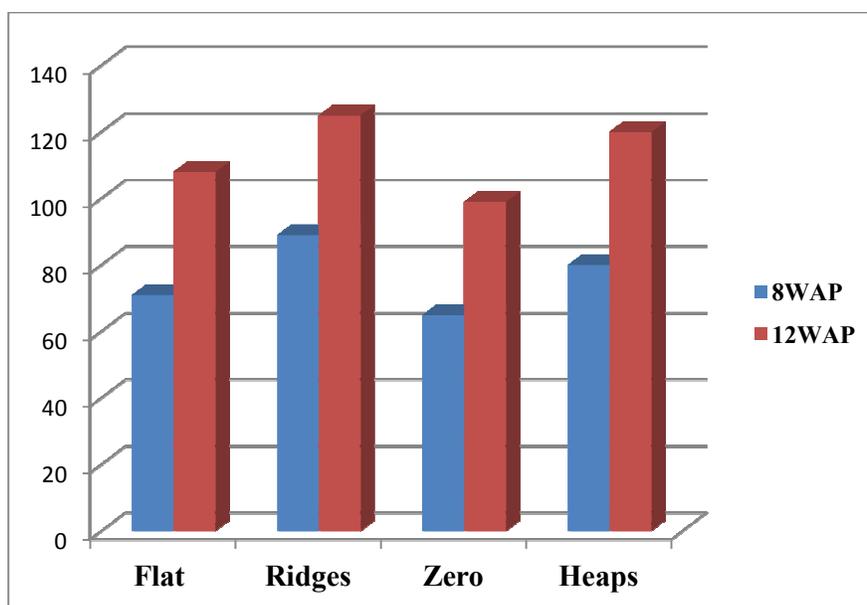


Fig. 2. Influence of tillage on maize plant height for 2018 cropping season

12.11 cm, 12.42 cm) produced statistically larger yield parameters when compared with those grown on flats (cob length 11.13 cm, 12.13 cm) or zero tillage (cob length 10.00 cm, 11.33 cm) in 2017 and 2018 respectively. This is because maize crops grown on flat or zero-tillage conditions may have experienced soil compactness which impeded the acquisition of both water and nutrients and growth of roots. Soil disturbance by tillage practices may have increased porosity and penetrability thus allowing

roots to have better access to water and nutrients [25]. In accordance with this, Carlesso et al. [26] reported that maize yield parameters were high when cultivated on ridge or heap tillage as a result of improved access to soil moisture than on zero-tillage.

Tillage methods showed significant increase in mean number of maize crop parameters studied. The growth (Figs. 1-6) and yield (Table 4) parameters were significantly lower in zero-tillage

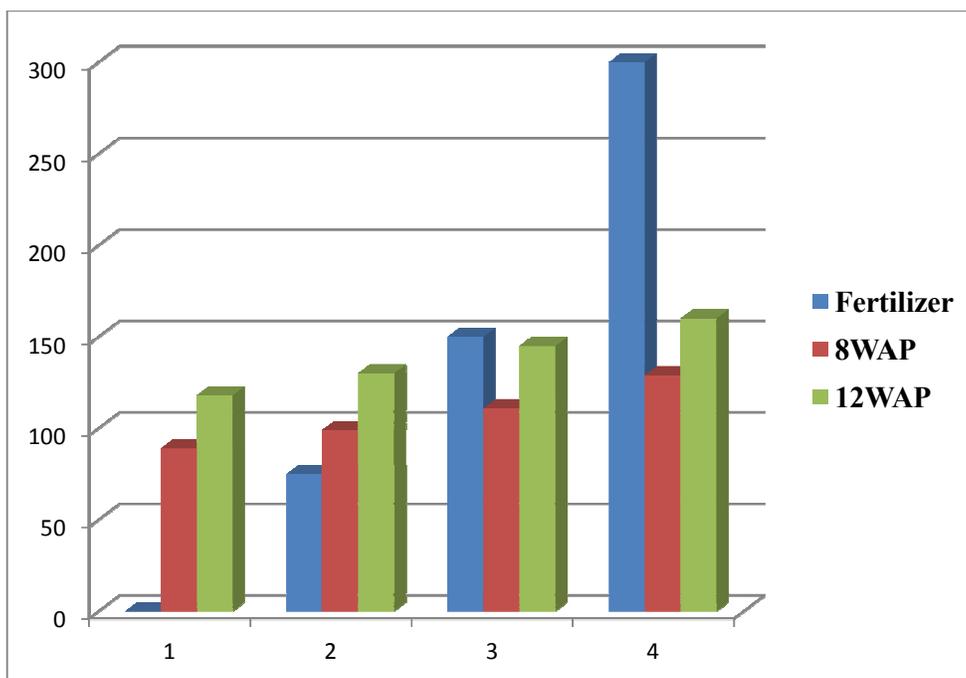


Fig. 3. Influence of fertilizer on maize plant height for 2017 cropping season

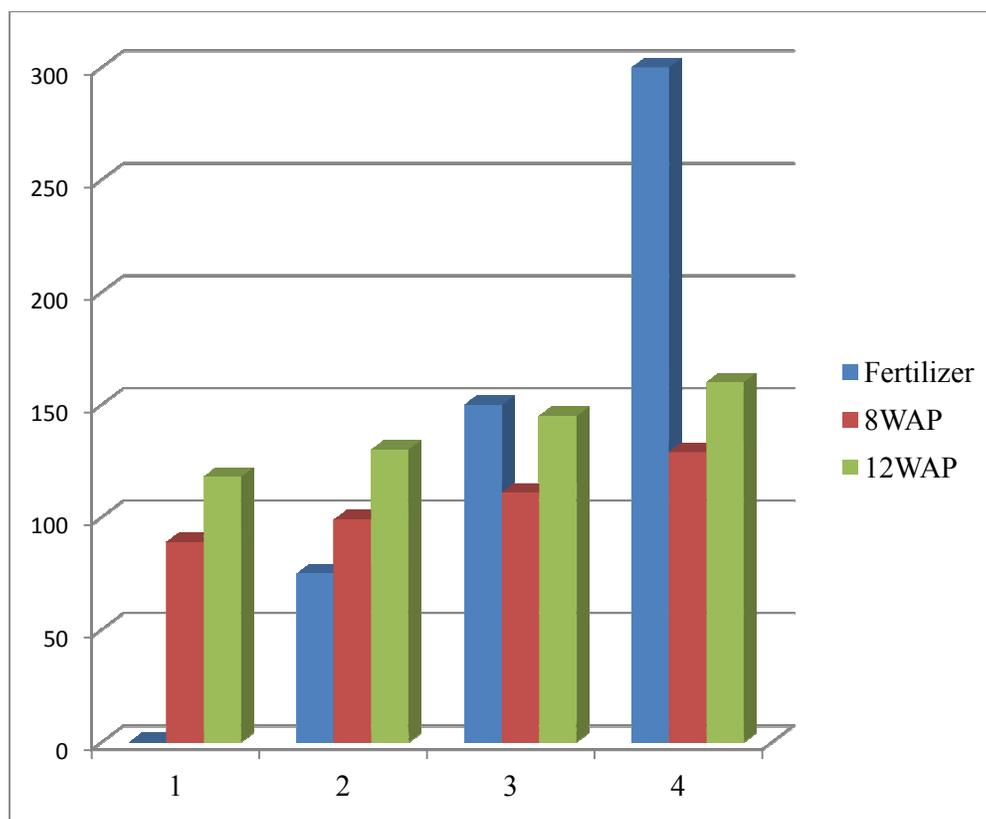


Fig. 4. Influence of fertilizer on maize plant height for 2018 cropping season

Table 4. Main influence of tillage and fertilizer on yield parameters of maize

	COB DIA		COB LNT (cm)		COB/PLT		100 S WT(g)		Grain Yield (kg ha^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Tillage										
Flat	10.19	11.00	11.13	12.13	0.87	1.41	18.10	21.60	850.00	895.00
Ridge	12.77	12.90	12.15	12.90	0.98	1.75	18.83	22.60	960.00	1075.00
Zero	9.50	10.39	10.00	11.33	0.11	1.20	17.33	21.00	657.00	776.00
Heaps	11.90	12.10	12.11	12.42	0.90	1.60	18.66	22.12	945.00	1050.00
LSD (0.05)	2.45	1.93	1.46	1.33	0.26	1.25	1.57	1.14	98.1	281.0
Fertilizer (Kgha$^{-1}$)										
0	9.23	10.99	8.61	9.61	0.79	1.41	16.45	20.40	800.00	875.00
75	10.06	11.77	11.45	12.45	0.89	1.40	19.42	21.70	901.00	1125.00
150	12.14	12.27	13.36	14.36	1.01	1.49	19.45	24.12	979.00	1250.00
300	13.12	13.90	13.50	14.65	1.60	1.66	20.22	25.00	996.00	1280.00
LSD (0.05)	2.90	1.43	1.99	1.49	0.13	0.12	1.23	2.29	74.7	121.0

NS = Not Significant, COB DIA= Cob diameter, COB LNT= Cob length, COB/PLT = Cob per plant, 100 S WT = 100 seed weight

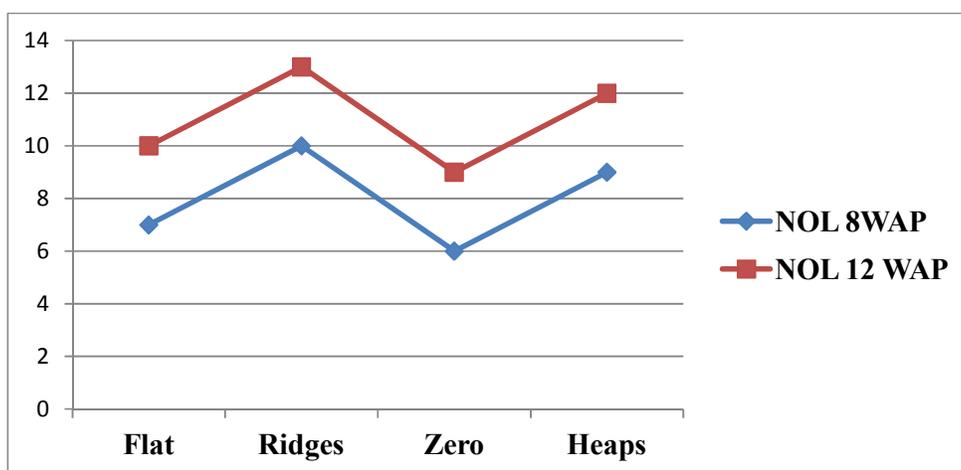


Fig. 5. Influence of tillage on maize number of leaf for 2017

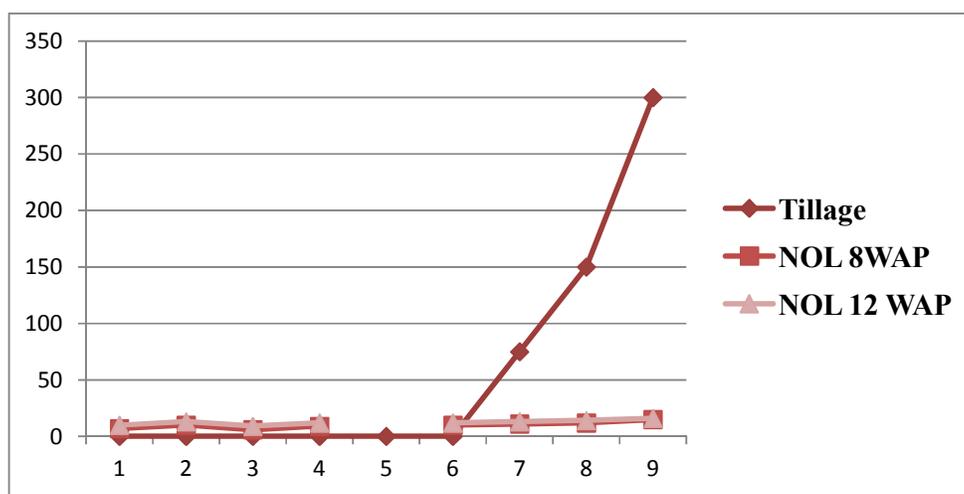


Fig. 6. Influence of tillage and fertilizer on maize number of leaf for 2018

than ridge or heap tillage. This may be partly attributed to reduced vertical root distance in zero-tilled plots, which reduced the soil depth explored by both crop roots. This indicated that certain stress prevailed in zero-tilled plots [27] that must have led to the poor performance of maize in both seasons. Scopel et al. [27] also observed that the yield response to tillage methods depended on the agro-ecological zone and the rainfall pattern during crop growth. Tillage-based soil management practices usually have relatively little effects on soil water contents at planting [28]. Several authors [29,30] reported that the yield level under the zero-tillage and ridge tillage or heap was dependent upon the production technologies in terms of fertilizer input use and other practices adopted.

Application of 300 kg ha^{-1} NPK fertilizer had significantly ($P<0.05$) effected the maize plant growth (Figs. 3 and 4) and yield parameters (Table 4) in both 2017 and 2018 cropping seasons. The application of 300 kg ha^{-1} fertilizer of NPK had significantly ($P<0.05$) higher cob length in both seasons. The highest cob lengths (13.50 and 14.65) were obtained from the application of 300 kg/ha of NPK fertilizer and the shortest cob lengths (8.61 and 9.61 cm) were obtained from the application of 0 kg/ha fertilizer in both seasons. The number of leaf per plant and plant height increased with incremental rate of NPK fertilizer application in both seasons (Fig. 6). The increased in growth and grain yield was due to the positive effects of NPK fertilizer applications on the growth (number of leaf per plant and plant height) and yield (number of cobs per plant, cob length, weight of 100 seeds and grain yield) parameters. This observation is consistent with that of Mbah et al. [31] who reported that increase in grain yield of maize is as a result of positive response of the crop to 300 kg ha^{-1} of NPK fertilizer in the south eastern Nigeria. Similar positive responses of maize to NPK fertilizer application have been observed by some researchers [32,33,15]. The zero NPK fertilizer treatment gave the least growth (Figs. 1-6) and yield (Table 4) parameters assessed for both cropping seasons. Averaged over the two cropping seasons, the highest growth and yield parameters of maize were obtained from application of 300 kg ha^{-1} NPK fertilizer, followed by 150, 75 kg ha^{-1} .

4. CONCLUSION

Results obtained from this study showed that higher growth and yields were obtained from

maize crops cultivated on ridges and heaps followed by flat and zero tillage. This may be as a result of improved access to soil moisture and nutrients. Results obtained from the study also showed that 300 kg ha^{-1} of NPK fertilizer significantly ($P<0.05$) increased the growth and yield of the maize crops when compared with 150, 75 and 0 kg ha^{-1} fertilizer application. Similarly, increasing the quantity of NPK fertilizer resulted in increase in the growth and yield of maize crop. This implies that growth and yields of maize crop could still response to higher fertilizer rates which needs further investigation. The higher values of soil pH, organic matter, total nitrogen and exchangeable cations are an indication that soil fertility can be improved by application of NPK fertilizer for agricultural production in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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