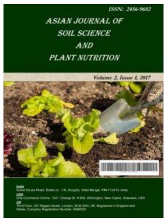

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Inter & Active Effect of Tillage and Nitrogen Fertilizer on Maize (*Zea mays* L.) Performance on a Humid Alfisol Southwestern, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author MRO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. While author IJO managed the analyses and literature searches of the study. Both authors read and approved the final manuscript.

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ABSTRACT

A field trial was conducted in 2017 to investigate the interactive effect of the land preparation methods and different rates of nitrogenous fertilizer on maize performance and yield southwestern Nigeria. The experiment was a 3 by 3 factorial; conducted in a Randomized Complete Block Design (RCBD) in a split plot management with tillage systems (T): Convectional tillage (CT), Reduced tillage (RT) and No-tillage (NT) as the main plot while nutrient amendments (N) rates (0, 50, and 120 Kg $N.Ha^{-1}$) as sub-plots factor and all treatments were replicated three times. Growth and yield parameters were subjected to analysis of variance (ANOVA). No tillage had the least plant height, stem diameter and stover weight but had the highest grains yield. Grain yield were not statistically different in all the tillage practices at different N rates applied but 60 kg N ha_{-1} seems best for maize production in the study area.

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Keywords: Soil properties; tillage methods; nitrogenous fertilizer; fertilizer interaction.

1. INTRODUCTION

The geometric increase in the world population with its increase in demand for food has led to food insecurity. Sustainable food production has been one of the global problems. The need to produce food in the right quantity and quality at affordable costs remains a priority in most of the developing nations of the world especially in all the sub-Saharan African countries. Beside the fact that the major agricultural production is largely in the hands of peasant farmers, the recent development of bio-fuel production from agricultural crops has widened the food deficit gap. In such a condition, domestic commodity producers are interested in intensifying their output to meet ever increasing demand for food products and bio-fuel materials. Maize is one of the leading agricultural produce that is used for bio-fuel (ethanol) production in Nigeria. Maize (*Zea mays* L.) belongs to the family poaceae; it is one of the major important staple food crops for most sub-Saharan Africans of which Nigeria is inclusive with per capital kg/year of 40 [1] and it is also use as animal feeds. Maize and other cereals constitute important Sources of carbohydrates, proteins, vitamin B and minerals [2]. [3] Reported that there was over 60% increase in the total lands acreage devoted to maize production from 1961 to 2005 in the sub-Saharan Africa which led to the increase of maize yield from 2.4 to 10.6 million tons for the corresponding period as shown in FAO [4] reports. [5] reported that Nigeria produced just about 1.0% of the world maize production. [6] reported that over 50% of the total maize produced in most developing countries is consumed as food. In Nigeria maize is the third most important cereal crop after sorghum and millet [7], the demand for maize as a result of various domestic Uses shows that a domestic demand of 3.5 million metric tons outstrips Supply production of 2 million metric tons [8]. It has several advantages over other crops besides the fact that it is a major source of Energy and of all cereals gives the highest yield per man-hour invested.

It is usually the first crop to be harvested for food during the hunger period; It is easy to grow as sole crop or intercropped with other crops; it is easy to Harvest and does not shatter. Its industrial demand is also increasing particularly in the food, beverage, and livestock feed industries. Maize will continue to play a large and important role in Nigeria's food production.

Nitrogen (N) is the most important and limited nutrient in maize production. Nitrogen plays a vital role in nutritional and physiological status of plants and thus stimulates changes in mineral composition of plant [9]. Nitrogen is the integral component of Chlorophyll molecule; a deficiency of N will results in a chlorotic plant condition. Nitrogen is also a structural constituent of cell walls [10]. Nitrogen fertilization increases both soil fertility and crop productivity. It also increases grain yield by about 25% and biomass yield by at least 15% in maize [11] while [12] reported that nitrogen fertilization contributes 18 to 34% increase in soil residual nitrogen. Numerous studies have reported positive effects of N fertilization on maize plant biomass, photosynthesis and grain yield [13]. Nitrogen fertilizer rate and application Timing are two important factors affecting N use efficiency.

In addition to plant nutrition, soil condition also plays a significant role in crop establishment, growth and yield. In improving soil condition, tillage is a key factor and plays a significant role in improving maize growth and Grain yield [14]. It has been established by many authors [15] submitted that intensive soil compaction has Negative effect on soil water flow and storage, impedes root growth and Therefore limits the volume of soil explored by roots. Hence, availability of Soil N is also reduced due to compaction resulting to a decreased shoot.

Soil physical, chemical and biological properties can be changed by both natural and anthropogenic impacts. Tillage is a general term used to describe the mechanical/physical manipulation of the soil and plant residues in order to create suitable conditions for seedling emergence, root development and to reduce weed competitions with crops as well as to produce grains for both human and animal consumption [16]. For an optimum result, it is important to perform tillage operations at optimum soil conditions. It will minimize the Number of required subsequent tillage operations and the total energy input for a given tillage system [17]. Appropriate tillage systems can increase the water availability for crop utilization by increasing infiltration, reducing evaporation, eliminating weed tillage or soil manipulation may induce profound changes in the soil Fertility and this may be manifested in good or poor performance of crops [18,19]. Some researchers [18,20] reported superiority of crops grown on tilled plots over that of zero-tilled plots in some agro-ecological zones of Nigeria? However, findings on the interaction between NPK 15-15-15 at 250kg/ha [21] and tillage methods have not been widely reported, the gap which this work has covered.

2. MATERIALS AND METHODS

2.1 Physical Settings of the Study Site

The study was conducted at the Institute of Agricultural Research & Training, Ibadan (7° 22'N, 3° 50'E), southwestern Nigeria. Ibadan is transitional between the tropical rainforest and guinea savannah. The climate is transitional between the humid and sub-humid tropical with Bimodal rainfall pattern with one of 1888.3 mm occurring in June, while the second one with 2000 mm occurring in Septemberwith 5 Dry months, mean annual temperature of 26.3°C, 75% relative humidity and potential evapo-transpiration (PET) of 109 mm, the climate situation of the study area fall in rainy season and dry seasons, The first growing season started from May to July while the dry season cultivation started from August to October [22]. The Study area is underplayed by acid-pre Cambrian basement complex which consists mainly of granitic gneiss, migmatites, mica-schist, quartzite and Marbles that have emplaced within the smaller bodies of granite or syenite And intrusion of more basic amphibolites and olive rich dykes [23].

2.2 Experimental Design

i. **Field study: The experimental design was Randomized Complete Block**

Design (RCBD) in a 3x3 factorial arrangement with three tillage systems (T) as Main plot and three nutrient amendments (N) rates as sub-plot factors.

Each treatment factor was replicated three times. The three tillage Systems were No-tillage (NT), reduced tillage (RT), and Conventional Tillage (CT) and the three levels of N fertilizer were 0, 60, and 120 kgNha-1. The conventional tillage (CT) consists of disc plowing to a depth of 30 cm twice and harrowing for seedbed preparation, Reduced tillage (RT) consists of disc plowing once while No tillage (NT) with residues retained on the surface. The experiment was situated on 480 m^2 (35 m x 14 m) experimental field with three blocks of 11 m x 14 m each, each block was further divided into three sub-plots with three replicates each for every treatment forming 3x3 factorial experimemt in which there were 3 blocks for main plots (tillage systems) and 3 sub-plots (N levels). Plots were separated by a buffer of 1 m.

ii. **Planting and cultural practices: The test crop was maize (*Zea mays L.*). Maize seeds (SUWAN-1) with maturity period of 70 days and resistance to maize smut diseases, maize cultivar was obtained from the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria**

Two seeds were planted at 0.75m x 0.25m spacing. Maize seedlings were later thinned to one plant per stand to obtain plant population of 53,333 Plants per hectare. The fertilizer was applied in split form at 2 and 6 Weeks after sowing. Urea fertilizer was applied to obtain 60 and 120 Kg Nha^{-1}as N1 and N2 respectively. Weeds were controlled with (i) non-selective systemic foliar herbicide (glyphosate) at a rate of 3Lha-1 before planting ;(ii) non-selective contact herbicides (Paraquat + Atrazine) at $5Lha^{-1}$ and (iii) manually to reduce competition for space, soil moisture, light and nutrients between the crops and weeds. The field borders were also kept clean to minimize pest encroachment.

iii. **Data collection**

a. Soil sampling and laboratory methods: Disturbed bulk soil samples were collected randomly from experimental block representing each tillage system before sowing.

Particle size distribution was determined by hydrometer method [24]. Bulk density (ρb) samples were collected using 5cm long and 5 cm diameter stainless steel cylindrical core. Each sample was transferred into a well labeled air tight polythene bag in order to ensure that the samples remain at their field water content. The samples were Weighed and thereafter oven-dried at 105°C to a constant weight. The bulk density (ρb) was computed as water content corrected mass to volume ratio as described by [25] using the relation

$$\rho b = M_{od}/V_T \quad (1)$$

Where M_{od} is mass of oven-dried soil and VT is the total volume, while the Gravimetric water content θg,(g.kg-1) was calculated from the relation

$$\theta g,=M_w/M_{od} \quad (2)$$

Where M_w is the mass of water and M_{od} mass of oven-dried soil [25] and porosity (ϕ)

Calculated from the relation

$$\phi= (1-\rho b/\rho d)*100 \quad (3)$$

Where ρb is the bulk density and ρd is the particle density (2.65 $Mg.m^{-3}$).

Prior to laboratory soil analysis, all samples were air-dried and sieved (2 mm sieve)

The sieved soils samples were for pH in 1:1soil to water (m/v) ratio using the Coleman's pH meter. Organic carbon was determined by the sulphuric acid and aqueous potassium dichromate mixture procedure [26] and organic matter as estimated as Organic carbon multiplied by 1.724. The exchangeable cations (K, Ca, Na, Mg) were determined by the procedures described by [27] while available phosphorus was extracted using Bray1method as outlined by [28] and read from The atomic absorption spectrometer

b. Growth and yield parameters: Growth and yield components that were monitored at different stages of crop growth and development includes days to emergence, plant height, stem girth, cob weight, numbers of cobs, numbers of maize ears and ear weight and grain yield.

iv. Data analysis: Data collected were subjected to analysis of variance (ANOVA) procedure for a split-plot design with tillage as the main plot factor and N-level as sub-plot factor using GENSTAT statistical analysis software [29]. Means were compared using the Least Significant Difference (LSD) and Duncam New Multiple Range Test (DNMRT) at 5% level of probability (LSDp≤0.0).

3. RESULTS AND DISCUSSION

3.1 Results

Soil characteristics prior to planting texturally, the soils were loamy sand in all the tillage management plots (Table 1). They were however different in terms of their particle size distribution, Bulk density and soil pH; although, they had similar organic carbon and rock fragment contents. The sand and clay contents were significantly different in all the tillage plots.

No tillage (NT) has the highest and (824.2 g kg-1) and greater than that of conventional (CT) and reduced tillage (RT) management system plots by 3.27 and 4.70% respectively (Table 1); whereas the trend was reversed in reduced tillage (RT) having the highest clay (81.7gkg-1) that was greater than that of conventional (CT) and no-tillage (NT) by 11.5 and 15.0% respectively.

Bulk densities increased in the order RT > NT > CT at planting were significantly different with1.43 Mg.m-3 being the least and 1.53 Mg.m-3 the highest representing an increase of 6.45% (Table 1). There were no significant differences in rock fragment distribution in all the tillage management plots. Reduced tillage has the highest rock fragments (418 g.kg-1) while No tillage (NT) management plots had the least rock fragment (382 g.kg-1).

The soil reaction (pH) were significantly different for all the tillage management practices, ranging from moderately acidic (5.3) in RT to strongly acidic (5.8) in NT (Table 1); whereas soil organic C do not differs significantly for all the tillage management plots, the soils were very low inorganic C [30], No Tillage (NT) management plots had the highest organic C (15.6 gkg-1) and the least organic C (12.8 gkg-1) was recorded in CT. In all the tillage management practices, the exchangeable bases (K, Na, Ca and Mg) and the available P were not significantly different and were very low.

Table 2 shows the mean values of interactive effect of no-tillage and N0 fertilizer application. It was observed that there was significant difference in the values of the plant height with the hieght value of 147.4 cm recorded in reduced tillage (RT), also, Maize yield shows no significant difference between no-tillage (NT) and reduced tillage (RT), although with highest value of 1,702 kg/ha obtained in reduced tillage (RT) while the least value of 1,541 kg/ha was obtained from convectional tillage (CT). Sheath yield and cob diameter show no significant difference between convectional tillage (CT) and no-tillage (NT), although with the least values of 4.06 kg and 3.32 cm in NT for sheath yield and cob dianeter respectively while in reduced tillage (RT), there was significant differences in both parameters. The stover height shows shows significant differences with the higest values recorded in CT while the least value recorded in no-tillage (N0). The cob weight and the ear weight show significant differences at various tillage operations with the higest values recorded from the reduced tillage (RT) while the least values were abtained from no-tillage operation (Table 2).

Table 3 shows the mean values of interactive effect of tillage systems and N_{60} fertilizer application. It was observed that there was significant difference in the values of the plant height with the hieght value of 160.1 cm recorded in reduced tillage (RT) with no appreciable significance difference between CT and NT, altough with the least value of 137.8 cm recorded in the NT tillage system, also, Maize yield shows significant difference with highest value of 2,427 kg/ha obtained in convectional tillage (CT) while the least value of 2,203 kg/ha was obtained from no tillage (NT). Sheath yield shows no significant difference between convectional tillage (CT) and no-tillage (NT), although with the least values of 3.94 kg in NT for sheath yield while in reduced tillage (RT) shows significant difference. The stover height shows shows significant differences with the higest value of 44.1 kg recorded in CT while the least value of 19.8 was recorded in no-tillage (NT). Plant diameter shows no appreciable significant differences in both CT and RT but with slight higher value of 4.48 cm in RT while the least value of 3.92 cm was recorded in NT plot. The cob weight and the ear weight show significant differences at various tillage operations with the higest values recorded from the convectional tillage tillage (CT) while the least values were abtained from no-tillage operation (Table 3).

Table 4 shows the mean values of interactive effect of tillage systems and N_{120} fertilizer application. It was observed that there was significant difference in the values of the plant height with the hieght value of 157.7 cm recordedin reduced tillage (RT) with no appreciable significance difference between CT and NT, although with the least value of 147.3 cm recorded in the CT tillage system, also, Maize yield shows significant difference among the tillage systems with highest value of 3,137 kg/ha obtained in no- tillage (NT) while the least value of 2,402 kg/ha was obtained from convectional tillage (CT). Sheath yield shows no significant

Table 1. Pre soil properties of the experimental site

Variables	CT	NT	RT	LSD (p=5%)
Bulk density ($Mg.m^{-3}$)	1.529	1.491	1.427	0.075
Sand ($g.kg^{-1}$)	797.30	824.22	785.45	30.70
Silt ($g.kg^{-1}$	130.37	106.81	132.81	34.48
Clay ($g.kg^{-1}$)	72.34	68.97	81.74	10.83
Rock fragments ($g.kg^{-1}$)	412.80	381.55	417.72	57.80
Organic C ($g.kg^{-1}$)	12.80	15.56	13.72	5.10
pH (H_2O)	5.5	5.8	5.3	0.4
Available P ($mgkg^{-1}$)	7.50	11.99	6.30	0.4
Exchangeable K ($cmolckg^{-1}$)	0.798	0.833	0.639	0.273
Exchangeable Ca ($cmolckg^{-1}$)	0.188	0.189	0.194	0.065
Exchangeable Mg ($cmolckg^{-1}$)	0.0151	.0148	0.0154	0.005
Exchangeable Na ($cmolckg^{-1}$)	0.256	0.253	0.213	0.044

CT= Conventional tillage, NT= No tillage, RT=Reduced tillage

Table 2. Mean values of interactive effect of tillage and N_0 fertilizer application on maize agronomic parameters

N-rate	Tillage	Plant height	Grain yield	Sheath yield	Stover height	Plant diameter	Average Cob weight	Average Ear weight
		cm	$kg.ha^{-1}$	kg	kg	cm	g	g
N_0	CT	123.7^b	$1,541^b$	4.41^b	55.6^a	3.43^b	126.8^b	161^b
	NT	111.2^c	$1,696^a$	4.06^b	16.9^c	3.32^b	110.9^c	154.1^c
	RT	147.4^a	$1,702^a$	5.36^a	29.4^b	4.08^a	136.5^a	177.6^a

Means on the same column followed by the same letter are not significantly different at $P < 0.05$.
CT= Conventional Tillage, NT= No Tillage, RT= Reduced Tillage

Table 3. Mean values of interactive effect of tillage and N60 fertilizer application on maize agronomic parameters

N-rate	Tillage	Plant height	Grain yield	Sheath yield	Stover height	Plant diameter	Average Cob weight	Average Ear weight
		cm	$kg.ha^{-1}$	kg	kg	cm	g	g
N_{60}	CT	140.3^b	$2,427^a$	4.35^b	44.1^a	4.14^a	145.9^a	185.1^a
	NT	137.8^b	$2,203^c$	3.94^b	19.8^c	3.92^b	103.1^c	138.9^c
	RT	160.1^a	$2,285^b$	4.94^a	34.4^b	4.48^a	126.1^b	168.8^b

Means on the same column followed by the same letter are not significantly different at P < 0.05.
CT= Conventional Tillage, NT= No Tillage, RT= Reduced Tillage

Table 4. Mean values of interactive effect of tillage and N120 fertilizer application on maize agronomic parameters

N-rate	Tillage	Plant height	Grain yield	Sheath yield	Stover height	Plant diameter	Average Cob weight	Average Ear weight
		cm	$kg.ha^{-1}$	kg	kg	cm	g	g
N_{120}	CT	147.3^b	$2,402^b$	3.52^b	34.2^a	4.42^a	102.2^b	137.4^c
	NT	149.6^b	$3,137^a$	4.79^b	26^b	4.22^a	123^a	168.9^b
	RT	157.7^a	$2,716^b$	5.05^a	32.6^a	4.27^a	121.5^a	174.2^a

Means on the same column followed by the same letter are not significantly different at P < 0.05.
CT= Conventional Tillage, NT= No Tillage, RT= Reduced Tillage

difference between convectional tillage (CT) and no-tillage (NT), although with the least values of 3.52 kg in CT for sheath yield while in reduced tillage (RT) shows significant difference with a value of 5.05 kg. The stover height shows shows significant difference in NT with value of 26 kg, however, there was no significant difference between CT and RT, although, CT recorded slight higher value of 34.2 kg recorded in CT. Plant diameter shows no appreciable significant differences in both CT, NT and RT but with slight higher value of 4.42 cm in CT while the least value of 4.22 cm was recorded in NT plot. The cob weight shows significant no significant differences between NT and RT but shows significant difference in CT with the least value of 102.2 g. Ear weight shows significant differences at various tillage operations with the higest values recorded from the reduced tillage tillage (RT) while the least values were abtained from convectional tillage operation (Table 4).

3.2 Effects of Tillage and Fertilizer on Maize Development and Yield

The germination percentage was statistically different among all the tillage management systems; reduced tillage (RT) had the highest (95.6) and No tillage (NT) produced the minimum (90.7 cm) germination percentage. Observed plant height in reduced tillage (RT) management system (155.1 cm) is significantly higher than other observed heights, it is 1.17 and 1.13 times greater than the observed plant height in no tillage (NT) and conventional tillage (CT) respectively (Table 5); likewise different N-rate also produced significant different with the highest height of 151.5 cm obtained in N_{120} plots which was 1.19 times higher than the least height of 127.4 cm recorded in N_0 rate (Tables 2, 3 & 4).

Plant stem girth was significantly different in all the tillage management systems but 4.0 cm recorded in conventional tillage (CT) was not significantly different from 3.82 cm and 4.28 cm observed in NT and RT respectively. However, different N rate showed that 127.4 cm (N0) was significantly lower by 12.8% and 15.9% for N_{60} and N_{120} respectively (Table 5).

Tillage management systems do not showed any significant differences in the average ear and cob weight but rather has the same trend of increasing from NT to CT to RT (Tables 2, 3 & 4). Similarly, different N rates do not showed any significant differences but N_{60} had the highest weigh to164.3 g and 125.0 g while N_0 produced the least ear and cob weight of 160.2 g and 115.5 g respectively (Tables 2, 3 & 4).

Sheath weight yielded was not statistically different for all tillage management systems and different N rates applied (Tables 5 and 6). Conventional tillage (CT) and reduced tillage (RT) produced the least and highest weight respectively (Tables 2, 3 & 4). Meanwhile N_{60} (4.41 Kg) and N_0 (4.61 Kg) were the least and highest heath weight recorded.

Stover weight were statistically different for tillage management systems (Tables 2, 3 & 4) but were not significantly different for different N rates applied (Table 6). Stover weight (32.1 Kg) recorded in reduced tillage (RT) was not significantly different from 44.6 Kg of conventional tillage (CT) and 20.9 Kg recorded in no tillage (NT) management systems while stover weight decreases (34.0, 32.8 and 30.9 Kg) with increasing N rates.

There was no significant difference in maize grain yield in tillage management systems (Table 6). Notwithstanding, the highest grain yield (2,346 kgha-1) was recorded in No tillage (NT) management system which was 1.11 and 1.05 times higher than the yields obtained in conventional tillage (CT) and reduced tillage (RT) respectively (Tables 2, 3 & 4). But, different N rates showed significant difference in grain yield. N_0 yield (1,646 kgha-1) was significantly lower than yields recorded in N_{60} (2,305 kgha-1) and N_{120} (2,752 Kgha-1) (Tables 2, 3 & 4).

3.3 Effects of Tillage and Fertilizer on Maize Development and Yield

Plant height: Generally, No-tillage (NT) had the least plant height when averaged over N levels and it ranged from 111–150 cm (Table 6) while reduced tillage management (RT) with highest plant height had arrange of 158-160 cm (Table 6). The highest plant height (160 cm) was recorded in N_{60} while the least height (111.2 cm) in N_0 (Table 6). However, the highest plant height 160 cm was observed in RT*N_{60} while the least (111 cm) was observed in NT *N_0 (Table 6).

Stem Diameter: The highest stem girth (4.1cm and 4.5 cm) across all the N rates were recorded in reduced tillage (RT) at N_0 and N_{60} respectively and conventional tillage (4.4cm) at N_{120}. N_0 had the least stem girth recorded for all the three tillage management systems whereas N_{120} produced the highest stem girth in conventional (CT) and no-tillage (NT) but reduced tillage (RT) had 4.5 cm highest stem girth at N_{60}. (Table 6).

3.4 Discussion

Effects of tillage and fertilizer on maize development and yield.

The observation as presented in Table 2 was due to tillage systems as there was no N fertilizer added.

Table 5. Selected agronomic characteristics as a function of tillage

Variables	CT	NT	RT	LSD (p=5%)
Germination (%)	93.6	90.7	95.6	4.8
Plant height (cm)	137.1	132.9	155.1	17.0
Plant diameter (cm)	4.00	3.82	4.28	0.39
Average ear weight (g)	161.2	154.0	173.5	59.0
Average cob weight (g)	124.9	112.4	128.0	42.8
Sheath weight (kg)	4.09	4.26	5.12	1.57
Stover yield (kg)	44.6	20.9	32.1	14.6
Yield (kg.ha-1)	2,124	2,346	2,234	378

CT= Conventional tillage, NT= No tillage, RT=Reduced tillage

Table 6. Selected agronomic characteristics as a function of N-application

Variables	N_0	N_{60}	N_{120}	LSD (p=5%)
Plant height (cm)	127.4	146.1	151.5	9.84
Plant diameter (cm)	3.61	4.18	4.30	0.24
Average ear weight (g)	164.24	164.27	160.18	30.51
Average cob weight (g)	124.8	125.0	115.5	24.42
Sheath weight (kg)	4.61	4.41	4.45	0.92
Stover yield (kg)	34.0	32.8	30.9	8.55
Yield (kg.ha-1)	1,646	2,305	2,752	485

N0=0kg.ha-1, N60 = 60kg.ha-1, N120=120kg.ha-1

3.5 Maize Grain Yield

The no significance observed at no tillage and redused tillage was in agreement with the findings of Buah et al. [31], they were of the opnion that tillage practices did not affect yiels of maize, however, higher increase in maize yield recorded in both NT and RT may be due to higher organic matter, better soil and water conservation and low leaching of solube minerals [32].

3.6 Growth Parameters

Stover height, average cob weight and average ear weight show significance difference among the tillage systems, this was in agreement with the findings of Mafongoya et al. [32]. They maintained that, low yeild in no tillage system was due to weed infestation as well as diseases/pests outbreak. They however attributed the higher yield in RT and CT to improved soil fertility, concentration of organic matter on the ridge and reduction in weed infestation. Plant height, Sheath yield and plant diameter showed no significant difference in CT and NT, this trend was in agreement with the findings of Buah et al. [31] and Alam et al. [33], they submitted that tillage nsystems have no effect on maize and soybean yield in the Guinea savanna of Ghana. On the significance difference observed in reduced (RT), this may be due to improved soil fertility, concentration of organic matter on the ridge and reduction in weed infestation as posited by Mafongoya et al. [32].

The observation as presented in Table 3 was due to interraction of tillage systems and N_{60} fertilizer.

3.7 Maize Grain Yield and Growth Parameters

The interactive effect between tillage systems and N_{60} showed significant differences in the maize grain yield, stover height, average cob weight and average ear weight for CT, NT and RT may be attrubuted to the fact that nitrogen fertilizer has different rates of dissolution in soil under different tillage systems which may inturn affect the rate of absorption by maize plant which resulted in the higher of maize in the convectional tillage practice systems [32], Table 3. They went further to sat that better soil tilth wich lead to better soil fertility management in addition to the concentration or organic matter on ridge sides as well as reduction in weed infestation/diseases outbreak were th reasons for high yield in maize grain. On the other hand, low yield of maize in NT may be due to weed infestation and diseases outbreak.

The lack of significant differences between tillage systems (CT and NT) and N fertilizer applications on plant height, sheath yield and plant diameter were in agreement with Buah et al. [31] and Alam et al. [33] they submitted that on the average crop response to fertilizer was not affected by tillage systems for all traits measured or calculated for maize and soybean in the Guinea savanna zone of Ghana.

3.8 Maize Grain Yield and Growth Parameters

The significance difference observed in some growth parameters and yield (Table 4) especially in RT may be due was in aggrements with the submission of Mafongoya et al. [32], they observed that at reduced tillage (RT), there were better soil tilth, concentration of soil organic matte rat the edges of the ploughed soil and reduction in weed infestation/diseases outbreak, however, the lack of significant interaction between tillage system and fertilizer treatment suggest that, on average, crop response to fertilizer was not affected by tillage systems for measured or calculated for maize yield calculated and all the parameters measured especially in CT and RT which was in line with the findings of Buah et al. [31] and Alam et al. [33]. They maintained that tillage sysiems have no effect on the average crop responses to nitrogen fertilizer.

3.9 Selected Agronomic Characteristics as a Function of Tillage and N-Fertilizer

Plant height: These results are similar to that of Aikins et al. [34] and Kayode and Ademuluyi, [35] that recorded the shortest maize plant in the No-Tillage (NT) plots; taller plants in conventional tillage (CT) plots Aikins et al. [34] and Khurshid et al. [36] in comparison with other tilled plots. In contrast Ojeniyi and Adekayode, [37] recorded taller maize in No-tillage (NT) plots when compared with other tilled plots except for that in the ploughing followed by harrowing plus ridging plots on sandy clay loam soil in Nigeria on a tropical alfisol They reported no significant difference in plant height between the indicated treatments. The increased plant height with increased N applied can be attributed to the fact that nitrogen promotes vegetative growth in maize [38].

3.10 Stem Diameter

Aikins et al. [34] stated that stem diameter is an expression of vegetative growth.

The smallest maize stem diameter obtained in no-tillage (NT) crop was in line with Aikins et al. [34] report while Aikins and Afuakwa, [39] had similar result for cowpea.

3.11 Average Ear and Cob Weight

There was no significant effect of tillage on both ear and Cob weight between different tillage practices. The lowest ear and cob weight Obtained in no-tillage (NT) as also obtained by Aikins et al. [34] may be due to the lack of soil loosening for providing conditions favorable to crop growth and yield.

3.12 Yield

Yields are often compared through different tillage systems and authors often report of higher yields that can be achieved with conventional tillage in comparison to other non-conventional tillage systems (reduced, conservation and no-till or zero till). Borin and Sartoil [40] also reported that among conventional tillage, minimum tillage and no-till in maize growing the highest yield has been obtained with the conventional tillage. These results are supported by those of Zamir et al. [41] and Khan et al. [42] who reported higher maize grain yield in No-tillage (NT) crop as compared to conventional and deep tillage crops contrary to other reports that grain yield in conventional tillage (CT) Is better than that no-tillage (NT) Ahmad et al. [43] and Halvorson et al. [44]. Similarly, Hussain et al. [45] noted 5% lower corn yield while Beyaert et al. [46] reported 35% lower grain yield in NT than CT. Grain Yield increased with increase in N-level from 0 kg. ha^{-1} to 120 $kg.ha^{-1}$ above which yield May decline in NT and RT except for conventional tillage where yield declined above 60 $kg.ha^{-1}$. Notwithstanding, this result agreed with other findings Beyaert et al. [46] that the delay in the early crop growth and development with NT has no detrimental effect and did not result in biological consequences sufficient enough to affect reproductive yield contrary to Halvorson et al. [44] that attributed NT lower grain yield to slow early crop growth compared with the CT system. However, no tillage (NT) remains an extremely important tool to reduce soil erosion in spite of yield differences on the highly erodible soils.

4. CONCLUSION

This study illustrates the interaction between various tillage systems and nitrogen fertilizer on a tropical alfisol. It was established that there was significance differences due to the interaction between levels of nitrogen fertilizer and various tillage systems which resulted in the increase in the maize grain yield and some parameters measured as the level of nitrogen fertilizer increases, except in the convectional tillage at N_{120}. At N_{60}, convectional tillage (CT) had the highest maize grain yield while at N_{120}, no-tillage (NT) had the highest maize grain yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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