Original Research Article

INTER&ACTIVE EFFECT OF TILLAGE AND NITROGEN FERTILIZER ON MAIZE (ZEA MAYS L.) PERFORMANCE ON A HUMID ALFISOL SOUTHWESTERN, NIGERIA

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 Zero tillage (ZT) 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

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. 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

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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; but

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 least15% 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~~ 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 levels of nitrogen fertilizers and tillage methods have not been widely reported, the gap which this work has covered.

Comment [D3]: Provide more information on levels of N recommended and levels of N used by the farmers in the study zone with references.

MATERIALS AND METHODS

Physical Settings of the Study Site

The study was conducted at the Institute of Agricultural Research & Training, Ibadan (7^o 22'N,3^o 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 (June and September) of 1,375mm annually, with 5 Dry months, mean annual temperature of 26.3^{o}C, 75% relative humidity and potential evapo-transpiration (PET) of 109mm [21].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 [22].

Comment [D4]: Give the start and the end of each rainfall period to the length of each with the amount of rainfall. This will be more informative for the experiment condition.

Comment [D5]: What was the climate situation during the study period compare to the long term average given here ?

Experimental Design

i. Field study: The experimental design was Randomized Complete Block Design (RCBD) in a split-plot 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 120kgNha-1. The conventional tillage(CT) consists of disc plowing to a depth of 30cm 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 480m^2 (35m x 14m) experimental field with three blocks of 11m x 14m each, each block was further divided into nine plots of 4m x 3m plots totaling twenty seven in all. Plots were separated by a buffer of 1m.

Comment [D6]: It is ZT in the abstract.

Comment [D7]: Nine plots for each block this means a 3x3 factorial design, not a split plot design in which case there will 3 sub-blocks (main plots, tillage systems) and 3 sub-plots (N level) in each main-plot. The ANOVA will be different.

ii. Planting and cultural practices: The test crop was maize (*Zea mays L*.). Maize seeds (SUWAN-1) medium maturing maize cultivar was obtained from the Institute of Agricultural Research and Training (IAR&T), Ibadan.

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. Compound fertilizer NPK 20:10:10 and urea were 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.

Comment [D8]: What medium maturing is, give number of days to maturity and other characteristics of the variety. Why this variety is chosen?

Comment [D9]: Why only urea was not used as the treatments are levels of N? How much NPK and urea were used to obtain 60 and 120 kg N? It will not be correct to consider comparing the 0 N level to the two other levels as N effect as you have applied P and K fertilizer.

iii. Data collection:

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

Comment [D10]: What block refers to here, repetition, tillage management plot?

Particle size distribution was determined by hydrometer method [23]. 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^oC to a constant weight. The bulk density (ρb) was computed as water content corrected mass to volume ratio as described by [24] using the relation

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

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

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

Where M_w is the mass of water and M_{od} mass of oven-dried soil [24] and porosity (ϕ)

Calculated from the relation

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

Where ρb is the bulk density and ρd is the particle density (2.65Mg.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 [25] 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 [26] while available phosphorus was extracted using Bray1method as outlined by [27] 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 [28]. Means were compared using the Least Significant Difference (LSD) at 5% level of probability (LSDp≤0.0).

RESULTS AND DISCUSSIONS

Results

Soil characteristics prior to planting texturally, the soils were loamy sand in all the tillage management plots (Tables 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 3.27and 4.70% respectively (Table1); 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 1.53Mg.m-3 the highest representing an increase of 6.45% (Table1).There were no significant differences in rock fragment distribution in all the tillage management plots. Reduced tillage has the highest rock fragments (418g.kg-1) while No tillage (NT) management plots had the least rock fragment (382g.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 (Table1); whereas soil organic C do not differs significantly for all the tillage management plots, the soils were very low inorganic C [29], No Tillage (NT)management plots had the highest organic C(15.6gkg-1) and the least organic C (12.8gkg-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 1:

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	8.87
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	0.0148	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

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 (96.6) and No tillage (NT) produced the minimum (90.7cm) germination percentage. Observed plant height in reduced tillage (RT) management system (155.1cm) 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 2); likewise different N-rate also produced significant different with the highest height of 151.5cm obtained in N120 plots which was 1.19 times higher than the least height of 127.4cm recorded in N0 rate (Table 3).

Plant stem girth was significantly different in all the tillage management systems but 4.0cm recorded in conventional tillage (CT) was not significantly different from 3.82cm and4.28cm observed in NT and RT respectively. However, different N rate showed that 127.4 cm (N0) was significantly lower by12.8% and15.9% for N60 and N120 respectively (Table 3).

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 (Table 2). Similarly, different N rates do not showed any significant differences but N60 had the highest weigh to164.3g and 125.0g while N0 produced the least ear and cob weight of 160.2g and 115.5g respectively (Table 3).

Sheath weight yielded was not statistically different for all tillage management systems and different N rates applied (Table 2 and 3). Conventional tillage (CT) and reduced tillage (RT)

Comment [D11]: The experiment has factorial treatment structure, so for the ANOVA the interaction effect of the two factors must be assessed first. The title of the study is about interactive effect of tillage and N level, so you should talk about how is the interaction and the 2 factors before giving the main effect of each factor.

produced the least and highest weight respectively (Table 2). Meanwhile N60 (4.41Kg) and N0 (4.61 Kg) were the least and highest heath weight recorded.

Stover weight were statistically different for tillage management systems (Table 2) but were not significantly different for different N rates applied (Table3). Stover weight (32.1Kg) recorded in reduced tillage (RT) was not significantly different from 44.6Kg of conventional tillage (CT) and 20.9Kg recorded in no tillage (NT) management systems while stover weight decreases (34.0,32.8 and 30.9Kg) with increasing N rates.

There was no significant difference in maize grain yield in tillage management systems (Table2). Notwithstanding, the highest grain yield (2,346kgha-1) was recorded in No tillage (NT) management system which was1.11 and 1.05 times higher than the yields obtained in conventional tillage (CT)and reduced tillage (RT) respectively (Table2). But, different N rates showed significant difference in grain yield. N0 yield (1,646kgha-1) was significantly lower than yields recorded in N60 (2,305kgha-1) and N120 (2,752 Kgha-1) (Table3)

Table 2: 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 girth (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 3: 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 girth (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

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 111–150cm (Table 4) while reduced tillage management (RT) with highest plant height had arrange of 158-160cm (Table 4).The highest plant height (160cm) was recorded in N60 while the least height(111.2cm)in N0(Table 4).However, the highest plant height 160 cm was observed in RT*N60 while the least (111 cm) was observed in NT *N0 (Table 4).

Stem Diameter: The highest stem girth (4.1cm and 4.5cm) across all the N rates were recorded in reduced tillage (RT) at N0 and N60 respectively and conventional tillage (4.4cm) at N120.N0 had the least stem girth recorded for all the three tillage management systems whereas N120 produced the highest stem girth in conventional (CT) and no-tillage (NT) but reduced tillage (RT) had 4.5cm highest stem girth at N_{60}. (Table 4).

Table 4 : Interactive Effect of Tillage and N Fertilizer Application on Maize Agronomic Parameters

N-rate	Tillage	Plant height	Yield	Sheath Yield	Stover Height	Plant diameter	Average Cob	Average Ear

Comment [D12]: The ANOVA table of the significance level of the factors and their interaction must be presented.

							weight	weight
		cm	kg.ha^{-1}	kg	kg	cm	g	g
	CT	123.7	1,541	4.41	55.6	3.43	126.8	161
	NT	111.2	1,696	4.06	16.9	3.32	110.9	154.1
N_0	RT	147.4	1,702	5.36	29.4	4.08	136.5	177.6
	CT	140.3	2,427	4.35	44.1	4.14	145.9	185.1
	NT	137.8	2,203	3.94	19.8	3.92	103.1	138.9
N_{60}	RT	160.1	2,285	4.94	34.4	4.48	126.1	168.8
	CT	147.3	2,402	3.52	34.2	4.42	102.2	137.4
	NT	149.6	3,137	4.79	26	4.22	123	168.9
N_{120}	RT	157.7	2,716	5.05	32.6	4.27	121.5	174.2
LSD(p<0.05		19.1	729.9	1.78	16.56	4.27	48.1	63.8

After de-husking, it was observed that cob weight in conventional tillage (CT) management plots declined from 145.9g in N_{60} to102.2g in N_{120}; but contrarily increases from 103.1g (N_{60}) to 123.0g (N120) in no-tillage (NT) management systems whereas it decreased with increasing N level in reduced tillage (RT) management systems (Table4). Highest sheath weights for all n-rates were recorded in RT with N_0 having 5.36Kg while NT *N_{60} produced the least weight (3.94kg). Sheath weight recorded in CT (4.41, 4.35 and 3.52kg) decreases with increasing N from N_0 to N_{120} (Table4).

At different N rates for all tillage management systems CT had the highest stover weight (55.6,441and 34.2 Kg) recorded decreases with increasing N rate but the least stover weights (16.9,19.8 and 26.0Kg)in NT increases with N rates applied.

Grain yield: There was no significant difference in yield when averaged over all tillage management systems. The highest and least yield of 2,346kg.ha^{-1} and 2,124kg.ha^{-1} was recorded in NT and CT respectively (Table 32) .N_0 with1,646 kg.ha^{-1}was the least and also not significantly different from the highest recorded yield of 2,752kg.ha^{-1} in N_{120} (Table4).The highest grain yields (3,137and 2,716kg.ha-1) were recorded in No tillage (NT) and reduced tillage (RT) plots at N_{120} while conventional tillage (CT) had the highest yield at N_{60} (2,427kg.ha^{-1}). Yield across tillage and different N levels showed that 3,137kg ha$_{-1}$ recorded in NT* N_{120} was the highest yield while CT*N^0 had the least yield of 1,541kg.ha-1(Table 4).

Discussion

Effects of tillage and fertilizer on maize development and yield

Comment [D13]: What the dote and comma indicate?

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Comment [D15]: All the discussion must consider the interaction effect of the two factors by given the effect of tillage with the rate of N, or the effect of N rate with the tillage level.

Plant height: These results are similar to that of [30] and [31] that recorded the shortest maize plant in the No-Tillage (NT) plots ; taller plants in conventional tillage (CT) plots [30] and [32] in comparison with other tilled plots. In contrast [33] 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 at Akure. 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 [34].

Stem Diameter: [30] 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 [30] report while [35] had similar result for cowpea.

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 [30] may be due to the lack of soil loosening for providing conditions favorable to crop growth and yield.

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). [36] 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 [37], [38] and [39] 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) [40]; [41]; [42]. Similarly, 43 noted 5% lower corn yield while [43] reported 35% lower grain yield in NT than CT. Grain Yield increased with increase in N-level from 0kg. ha^{-1} to120kg.ha^{-1} above which yield May decline in NT and RT except for conventional tillage where yield declined above 60kg.ha^{-1}. Notwithstanding, this result agreed with other findings [44]; [45] 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 [41] 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.

Conclusion

What is you conclusion?

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Comment [D17]: Don't you think this may be also function of the genotype used?

Comment [D18]: Where is Akure, the paper is destined to only Nigerian readers! What is climate situation compare to that of the study site.

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Remember the aims of the study in the last sentence of the introduction: "***findings on the interaction between levels of nitrogen fertilizers and tillage methods have not been widely reported, the gap which this work has covered***".

REFERENCES

1. F.A.O.FAOSTAT 2003.http//:faostat.fao.org/default. Html
2. Iken, J.E., Amusa, N.A and Obatobu, V.O. Nutrient composition and Weight Evaluation of small newly developed maize varieties in Nigeria. Journal of food Technology, Africa (Kenya). 2002; 7:25-35
3. Namakka,A.,Abubakar,I.U.,Dadari,S.A.,Ado,S.G.,Hamid,A.H.,Sharifai,A.I.,Kura, H.N., Babaji, B.A. and HalliruI.. Effect of tillage system and nitrogen level on Growth of maize (Zea mays L) in northern guinea zone of Nigeria. Greener Journal of Agricultural Sciences. 2012 Vol.2 (5)172-179.
4. FAO 2006. Conservation tillage; the end of plow. News and highlights. http://www.fao.org/News/2000/000501
5. FAO, 2010. Food and Agriculture Organization. Year book, Rome.P27
6. Kumar M A A, Gali S K, Hebsur NS. Effect of Different Levels of NPK on Growth and Yield Parameters of Sweet Corn. Karnataka J. Agric. Sci. 2007: 20(1):41-43.
7. Ojo, S.O. Factor productivity in maize production in Ondo state Nigeria. Applied Tropical Agriculture. 2000: 15 (1):57-65.
8. Akande, S. O. 1994. Comparative cost and returns in maize production in Nigeria. NISER Individual Research project Report, Ibadan.
9. Menge I K and Kirkby E A. Principles of plant Nutrition. Publ .International Potash Institute. 1982: pp.335-368
10. Schrader, L. E. Functions and transformation of nitrogen in higher plants. In: Nitrogen in crop production. R.D. Hauck (ed.), ASSA, CSSA and SSSA, Madison, WI. 1984: Pp: 55-56.
11. Ogola J.B. O., Wheeler T.R, Harris P.M. Effects of nitrogen and irrigation on Water use of maize crops. Field Crop Res. 2002: 78:105-117
12. Yang J.Y, Huffman E.C, Jong R. D, Kirkwood V, MacDonald K.B, Drury C.F. Residual soil nitrogen in soil landscapes of Canada as affected by land use practices and agricultural policy scenarios. Land Use Policy, 2007: 24:89-99.
13. Fabrizzi, K.P., F.O. Garcia, J.L. Costa and L.I. Picone. Soil water dynamics Physical properties and corn wheat responses to minimum and no-tillage systems in the Southern Pampas of Argentina. Soil Tillage Res. 2005: 81:57-69.
14. Wasaya A., Muhammad T. AbdulManaf, Mukhtar A.,Shuaib K.andIjaz A. African Journal of Biotechnology. 2011: 10 (81), pp.19025-19034, Imroving maize Productivity through tillage and nitrogen management.
15. Lipiec, J., Kus ,J., Slowinska-J urkiewicz,A. and Nosalewicz, A. Soil porosity and water infiltration as influenced by tillage methods. Soil Till. Res. 2006. 89:210–220.
16. Reicosky D.C.and Allmaras R.R.Advances in tillage research in North America Cropping systems. In: shrestha A. (Ed.) Cropping systems; Trends and advances. Haworth Press, Inc., New York. .2003: Pp. 75-125.
17. Keller, T. Arvidsson, J. and Dexter, A. R. Soil structures produced by tillage as affected by soil water content and the physical quality of soil. Soil Till. Res. 2007: 92:45-52.
18. Ogban, P.I., W.N. Ogunewe, R.I. Dike, A.O.Ajaelo, N.I. Ikeaata, U.E. Achumba and E.E. 41 Nyong.Effect of tillage and mulching practices on soil properties and growth and yield

of cowpea (Vigna unguiculata (L) Walp) in southeastern Nigeria. Agro science Journal of Tropical Agriculture, Food, Environment and Extension, 2008: 7(2):118-128.

19. Awodun, M.A. and S.O. Ojeniyi.. Response of groundnut yields nutrient status to Tillage and wood ash. Nigeria Agric. J., 2005:360:80-87.
20. Ndaeyo, N.U., E. O. Ekpe, S. O. Edem and U.G.Umoh. Growth and yield responses of *Colocasia esculenta* and *Xanthosoma saggitifolium* to tillage practices in Uyo, southeastern Nigeria. Indian Journal of Agric. Sci. 2003: 73(4):194-198.
21. Smyth, A. J .and Montgomery, R.F. 1962. Soils and land use in central western Nigeria. The Government of Western Nigeria, Ibadan.
22. D'Hoore, J.L.1964.Soil map of Africa: Scale1:5,000,000.Commission for Technical 35 Cooperation in Africa. Joint project No.11.Lagos.
23. Gee, G.W. and Or, D. 2002.Particle size analysis. In J. Dane and G.T opp (eds) methods of soil analysis, Part 4, Physical methods. Soil Sci. Soc. of Am .Madison, WI.
24. Grossman, R.B. and Reinsch, T.G. 2002. Bulk density and linear extensibility. In: J. Dane and G. T opp (eds.) Methods of soil analysis, Part4, Physical methods. Soil Sci. Soc. of Am. Madison, WI. Pp 201-228.
25. Nelson, D.W. and Sommers, L.E. A rapid and accurate method for estimating organic carbon in soil. Proceeding of the Indiana Academy of Science. 1975: 84:456-462.
26. Anderson, J.M and S.J. Ingram. (1993). Tropical biology and fertility: A handbook of methods. 587 pp.
27. Olsen, S.R. Phosphorus. In Page, A.L., Miller, R.H., Keeny, D.R.(Eds.) Methods of soil analysis. Part2,2nd edition. Agronomy monograph No 9 ASA and SSSA., Madison, WI. Pp. 1982: 403-430.
28. Genstat. 2003. Genstat for Windows. Release 7th edition, Version7.1.0.198. Lawes Agricultural Trust, Rothamsted, UK. VSN Int. Ltd. Oxford
29. Landon, J.R. Booker tropical soil manual: A handbook for soil survey and agricultural land evaluation in the tropic s and subtropics. Booer Tate Ltd., Longman Scientific and Technical, England. 1991:474pp.
30. Aikins, S.H.M., Afuakwa,J.J.,Owusu-Akuoko,O. Effect of four different tillage practices on maize performance under rain fed conditions. Agric. Biol. J.N. Am., 2012: 3(1):25-30.
31. Kayode, J.and Ademiluyi, B. Effect of Tillage Methods on Weed Control and Maize Performance in Southwestern Nigeria Location, Journal of Sustainable Agriculture. 2004: 23 (3):39–45.
32. Khurshid, K., Iqbal, M., Arif, M.S. and Nawaz, A. Effect of tillage and mulch on Soil physical properties and growth of maize, International Journal of Agriculture and Biology. 2006: 8(5):593–596.
33. Ojeniyi, S.O. and Adekayode, F.O.1999.Soil conditions and cowpea and maize yield produced by tillage methods in the rain forest zone of Nigeria, Soil and Tillage Research. 51 :(1–2):161–164.
34. Paradkar, V.K. and R.K. Sharma, Effect of nitrogen fertilization on maize (Zea mays L.) Varieties under rain fed condition. Indian J. Agron., 1993: 38(2):303-304.
35. Aikins, S.H.M. and Afuakwa, J.J. Effect of four different tillage practices on cowpea performance. World Journal of Agricultural Sciences. 2010. : 6(6):644–651.
36. Borin M and Sartori L. Barley, soy bean and maize production using ridge tillage, no tillage and conventional tillage in northeast Italy Journal of Agricultural Engineering Research. 1995: 62:229-236.
37. Zamir, M.S. I.,H.M.R. Javeed, W. Ahmed, A.U.H. Ahmed,N.Sarwar,M.Shehzad,M.A. Sarwar and S. Iqbal. Effect of tillage and organic mulches on growth, yield and quality of autum planted maize(Zea mays L.) and soil physical properties. Cercetari Agronomice in Moldova. 2013: Vol. XLVI No 2(154):17-26.

38. Khan A., M.T. Jan, K.B. Marwat and M. Arif. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillagesystems.Pak.J.Bot., 2009: 41(1):99-108.
39. Shirani, H., M.A. Hajabbasi, M. Afyun and A.Hemmat. Effect of farmyard manure and tillage systems on soil physical properties and corn yield in central Iran. Soil Till. Res., 2002: 68:101-108
40. Ahmad I., M.T. Jan and M. Arif. Tillage and nitrogen management impact on maize. Sarhad J. Agric. 2010: 26(2):157-167
41. Halvorson, A.D.,A.R. Mosier. , C.A. Reule and W.C. Bousch. Nitrogen and tillage effects on irrigated continuous corns. Agron. Journal. 2006: 98:63-71.
42. Al-Kaisi, M. and M.A. Licht, Effect of strip tillage on corn nitrogen uptake and residual nitrate accumulation compared with no-tillage and chisel plow. Agron. J. 2004: 96:1164-1171
43. Hussain, I., K.R. Olson and S.A. Ebelhar. Impact of tillage and no-till on production of maize and soybean on eroded Illinois silt loam soil. Soil Tillage Res. 1999: 52:37-49.
44. Beyaert, R.P., J.W. Schott and P.H. White. Tillage effects on corn production in a coarse-textured soil in Southern Ontario. Agron. J. 2002: 94:767-774
45. Wolfe, A.M. and D.J. Eckert. Crop sequence and surface reside effects on the performance of no-till corn grown on a poorly drained soil. Agron. Journal. 1999. 91:363-367.