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Tillage and fertilizer effects in sole maize *(Zea mays* L.*)* cropping in a degraded Nigerian Alfisol

Aduramigba-Modupe, V.O.[1*] and Idowu, O. J.[2]
[1]Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, PMB 5029, Ibadan, Nigeria
[2]Department of Extension Plant Sciences, New Mexico State University, MSC 3AE, PO Box 30003 Las Cruces, NM 88003-8003, USA
[*]Corresponding Author: vaduramigba@yahoo.com

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ABSTRACT
The choice of appropriate tillage is crucial for sustainable farming in tropical ecosystems. With high levels of soil erosion and nutrient leaching in the tropics, reducing tillage and good fertilizer management becomes an attractive option to consider for environmental conservation. A field study in a degraded alfisol in Ibadan; south western Nigeria was conducted to determine the effects of four tillage systems (TS): (plow + harrow, plow, chisel + harrow and chisel) and three fertilizer NPK 15:15:15 rates: (0, 300 and 600 kg ha^{-1}) arranged as a split plot in a randomized complete block design, with three replications on maize yields. Measurements showing significant response to treatment effects were root length, grain yield and hundred seed weight. Maize under plow + harrow TS had the highest mean root length (23.1cm), which was 38% and 28% significantly higher than chiseling and chiseling + harrowing. Root length decreased with increasing fertilizer rates in all systems (except chisel + harrow). Grain yield showed significant increase only with increasing fertilizer rates. A grain yield of 1.4 Mg ha^{-1} was obtained when 0 NPK kg ha^{-1} was combined with plow + harrow TS. Plow alone had grain yields of 1.9 and 2.0 Mg ha^{-1} with 300 and 600 kg NPK kg ha^{-1} fertilizer rates. These grain yields were not significantly different from those under plow + harrow TS at the same fertilizer rates. Only 100 - seed weight property significantly responded to TS by fertilizer interactions. From the results, plowing TS when combined with 300 NPK kg ha^{-1} fertilizer rate was sufficient for maize production.

Keywords: *Tillage; NPK 15.15.15 fertilizer; alfisol; maize; grain yields.*

Introduction

Maize (*Zea mays L.*) is one of the most efficient crops in converting sunlight into food or animal feed. It is a major food and cash crop for small-scale farmers in Nigeria; hence, its high demand in human diet and livestock feed industry requires continued efforts at increasing its production. Presently small-scale farmers in Nigeria are faced with the challenge of increasing production to meet the food and industrial demand of the rapidly growing population due to low productivity. These demands to achieve high yields required intensive tillage and application of high-technology inputs like fertilizer (Kisic *et al*., 2010). The common tillage systems in the

tropics are no-till and conventional tillage practices. No-tillage is a system in which the field is sprayed with contact herbicides to kill the weeds, while conventional tillage on the other hand involved ploughing and harrowing of the field (Okeleye and Oyekanmi, 2003). Beneficial effects of tillage practices from available data include: positive growth rate and significant build-up of soil organic matter due to reduction of the rates of decomposition of both the native soil organic matter and the crop residues (Stewart, 1993).

Also tillage increases water and fertilizer use efficiency, improve soil water content and reduce erosion (Cassel and Edwards, 1985; Unger, 1994). Fertilizer application and tillage systems interactions have been found to enhance grain yield of maize and wheat (Locke and Hons, 1988; Rao and Dao, 1992), enhance synergistic effects of irrigation and nitrogen on crop water use (Arora *et al*., 1993) and enhances the utilization of water and nutrients (Chancy and Kamprath, 1982 and Arora *et al*., 1991). The conventional soil tillage, with all its advantages also have some drawbacks, mainly in the domain of the physical, chemical and biological complex of soil fertility, which intensify soil degradation and agro ecological conditions and environmental pollution (Basic *et al*., 2004). Possible solutions to these problems are application of combined soil tillage (the concept of integrating rational tillage) systems (Basic *et al*., 2004). In addition, greater knowledge of the effects of various tillage systems on crop growth and yield is needed to assess the contribution of these systems to sustainable land use and management, nutrient use efficiencies and maize production.

The objectives of this study therefore were to identify appropriate tillage and fertilizer regime in sole maize cropping system; and assess effective root growth and grain yield in Nigerian derived savanna.

Materials and Methods

This study was conducted at the experimental farm of the Institute of Agricultural Research and Training, Ibadan ($7^{o}25'$N and $03^{o}52'$E, 160m above sea level), Nigeria during the 2001 and 2002 early rainy seasons. The rainfall data showed that the total rainfall was higher in 2002 (1446.5mm) than in 2001 (1256.5mm), but was more unevenly distributed. Before the study, the field had been left fallow for over fifteen years. The same location was used for the study in both years. The well drained and slightly acidic (pH-H_2O 5.80) sandy soil of the experimental site was classified as Oxic paleustalf and belong to Iwo series (Aduramigba-Modupe *et al*., 2001 and Idowu *et al*., 2003). The organic carbon content was 4.6g/kg, total N 0.46 g/kg, available P (Bray 2) 5.0 mg/kg, and ECEC was 1.74 Cmol(+)/kg. The experimental area of 1408 m^2 was divided into three blocks and each block was 22m x 4m and separated by 2m row. The treatments were four tillage systems (TS) (disc Plough alone; disc Plough + Harrow; Chisel alone and disc Plough + Chisel) and three fertilizer NPK 15.15.15 levels (0, 300 and 600kg/ha). These were arranged as a split plot in a randomized complete block design, with three replications. TS were the main plots (18m x 4m) and fertilizer rates were the sub plots (6m x 4m).

An improved open pollinating maize variety (SIN 9449-SR) from the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria was used as the test crop. Three seeds were planted per stand at inter and intra row spacings of 75cm x 25cm and was later thinned to one plant per stand at 2 weeks after planting (WAP). The fertilizer was applied by broadcasting immediately after thinning. Grain yield at 15% moisture content were

recorded at harvest from 4 x 4m ($16m^2$) harvest area. Analysis of variance and comparison of treatment means using Fisher's least significance difference and the Duncan's multiple range test method at P<0.05 were carried out using the Statistical Analysis System version 9.2 (SAS, 2003) package.

Results and Discussion

Root length: Tillage practices significantly increased the root length. Ploughing + Harrowing system had the longest root length of 23.2cm in both years (Tables 1a and b). However, fertilizer treatments did not significantly (P<0.05) increase root length during the two years of the study. This result is consistent with the findings of Yusuf (2006) who found out that ploughing increased root length and root length densities.

Grain yield: Yield significantly increased with increasing fertilizer rates in plough + harrow and chisel tillage systems, while in plough and chisel + harrow tillage systems, grain yield were stable at 300kg NPK/ha (Tables 2a and b).

Table 1a: Interaction effects of tillage practices and fertilizer NPK rates on maize root length (cm/plant) in a degraded Alfisol in 2001

	Root length (cm/plant)			
Tillage system	**Plough alone**	**Plough plus Harrow**	**Chisel alone**	**Chisel plus Harrow**
+Fertilizer rate (kg/ha)		**Year 2001**		
0	23.8	25.8	17.0	14.9
300	23.3	19.2	16.3	19.0
600	20.5	24.3	17.1	20.2
Mean	**22.5**	**23.1**	**16.8**	**18.0**
P>F	Tillage=**	Fertilizer=NS;	Tillage x Fertilizer = NS	

NS: Not significant, and ** significantly different at P<0.01.
+ Fertilizer NPK 15.15.15 applied at 3 rates of 0, 300 and 600 kg/ha respectively.

Table 1b: Interaction effects of tillage practices and fertilizer NPK rates on maize root length (cm/plant) in a degraded Alfisol in 2002

	Root length (cm/plant)			
Tillage system	**Plough alone**	**Plough plus Harrow**	**Chisel alone**	**Chisel plus Harrow**
+Fertilizer rate (kg/ha)		**Year 2002**		
0	21.2	17.6	21.5	18.0
300	15.9	30.7	23.9	20.2
600	22.2	21.3	21.9	18.8
Mean	**19.8**	**23.2**	**22.4**	**19.0**
P>F	Tillage=**	Fertilizer=NS;	Tillage x Fertilizer = NS	

NS: Not significant, and ** significantly different at P<0.01.
+ Fertilizer NPK 15.15.15 applied at 3 rates of 0, 300 and 600 kg/ha respectively.

Table 2a: Interaction effects of tillage practices and fertilizer NPK rates on maize grain yield (Mg/ha) in a degraded Alfisol in 2001

	Grain yield (Mg/ha)			
Tillage system	**Plough alone**	**Plough plus Harrow**	**Chisel alone**	**Chisel plus Harrow**
+Fertilizer rate (kg/ha)		**Year 2001**		
0	0.78	1.44	0.67	0.90
300	1.87	1.11	1.03	1.17
600	1.96	1.47	1.14	1.20
Mean	**1.54**	**1.34**	**0.95**	**1.09**
P>F	Tillage = NS	Fertilizer=;**	Tillage x Fertilizer = NS	

NS: Not significant, and ** significantly different at P<0.01.
+ Fertilizer NPK 15.15.15 applied at 3 rates of 0, 300 and 600 kg/ha respectively.

Table 2b: Interaction effects of tillage practices and fertilizer NPK rates on maize grain yield (Mg/ha) in a degraded Alfisol in 2002

	Grain yield (Mg/ha)			
Tillage system	**Plough alone**	**Plough plus Harrow**	**Chisel alone**	**Chisel plus Harrow**
+Fertilizer rate (kg/ha)		**Year 2002**		
0	0.85	0.58	0.56	0.66
300	1.63	1.15	0.63	1.04
600	1.62	1.47	0.76	1.04
Mean	**1.37**	**1.07**	**0.65**	**0.91**
P>F	Tillage = NS	Fertilizer = **	Tillage x Fertilizer = NS	

NS: Not significant, and ** significantly different at P<0.01.
+ Fertilizer NPK 15.15.15 applied at 3 rates of 0, 300 and 600 kg/ha respectively.

There were no statistical differences between application of 300 and 600kg NPK/ha in plough alone and chisel plus harrow TS in 2002. Tillage system provided adequate seed-soil contact which, according to Lal (1979) and Bennie and Botha (1986), is a pre- requisite for rapid emergence and good crop yields. Our results were consistent with the findings of Okeleye and Oyekanmi (2003) and Kisic *et al*., (2010) who obtained similar results with maize, wheat and barley under conventional tillage systems. The highest maize grain of 1.54 Mg ha^{-1} was obtained in 2001 under plough TS, while the lowest maize grain yield of 0.65 Mg ha^{-1} was obtained under Chisel TS treatment in 2002. Tillage effects on maize grain yield from 2001 to 2002 were in the order of Plough alone>Plough+Harrow> Chisel+ Harrow>Chisel alone.

Conclusion:

Based on grain yield performance, ploughing alone and application of a suboptimal amount of NPK (300kg/ha) plus early planting to capture nutrient flush was adequate for almost 2 tons per hectare of maize production. This tillage system is therefore recommended.

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