Evaluation Of Soil Fertility And Maize (*Zea Mays* L.) Grain Yield Performance Under Conventional And No – Tillage Systems

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ABSTRACT: Tillage has been reported to disrupt soil structural arrangement, which consequently results in soil fertility problems. Consequent upon this, critical assessment of soil fertility and crop performance under tillage treatments is imperative in order to achieve sustainability of agricultural production and environmental quality for future generations. In view of this, a two – year study was carried out at the Teaching and Research Farm of the University of Ado – Ekiti, Ado – Ekiti, Ekiti State, Nigeria, during 2011 and 2012 cropping seasons to determine the effects of tillage methods on the nutrient status of an acid Alfisol and grain yield of maize (*Zea mays* L.). The experiment was laid out in a randomized complete block design with three replications. The tillage treatments included: Conventional tillage (CT) and no - tillage (NT). The results indicated existence of significant (P = 0.05) differences between the two tillage treatments with respect to their effects on maize grain yield and soil chemical properties. At the end of 2011 cropping season, NT gave soil organic carbon (SOC) value of 0.73 g kg^{-1}, which was significantly higher than 0.20 g kg^{-1} for its CT counterpart. Similarly, at the end of 2012 cropping season, NT gave SOC value of 0.62 g kg, which was significantly higher than 0.09 g kg^{-1} for the CT treatment. At the end of 2011 cropping season, NT gave total N value of 0.49 g kg^{-1}, which was significantly higher than 0.23 g kg^{-1} for the CT. At the end of 2012 cropping season, NT gave total N value of 0.33 g kg^{-1}, which was significantly higher than 0.08 g kg^{-1} for the CT. At the end of 2011 cropping season, NT gave available P value of 0.34 mg kg^{-1}, which was significantly higher than 0.23 mg kg^{-1} for the CT. At the end of 2012 cropping season, NT gave available P value of 0.22 mg kg^{-1}, which was significantly higher than 0.09 mg kg^{-1} for the CT. The mean values of maize grain yield data over the two years of experimentation indicated that CT gave maize grain yield of 2.35 t ha^{-1}, which was significantly (P = 0.05) higher than 2.17 t ha^{-1} for its NT counterpart. In conclusion, apart from the micro – nutrients and exchangeable Al, no - tillage gave significantly higher values of other nutrients than the conventional tillage treatment at the end of both cropping seasons. Conventional tillage gave significantly higher maize grain yield than its no – tillage treatment counterpart.

Key words: Conventional, fertility, maize, tillage, yield.

INTRODUCTION

Previous studies (Angers *et al*., 1993; Kim, 2008; Olonitola, 2011) have compared soil properties and crop yield under different tillage treatments. The frequency and intensity of tillage practices alter soil properties, distribution of nutrients, as well as soil organic matter status in the soil profile, with resultant reduced soil quality (Blevin and Frye, 1993). No – tillage results in increased soil organic carbon (SOC) content, which in turn enhances soil quality and resilience (Horne *et al*., 1992; Blevin and Frye, 1993; Kim, 2008). On the other hand, conventional tillage, which involves turning over of soil, reduces SOC (Robertson *et al*., 1991; Angers *et al*., 1993; Olonitola, 2008). Studies by Beare *et al*., (1992) have indicated that when soils under vegetation or pastures were converted to arable land use, the decline in SOC overtime was more pronounced in conventional tillage than the no tillage counterpart. An organic matter gradient develops under no tillage, with a relatively high concentration of SOC at the soil surface, and a sharp decrease with depth (Carter, 1992; Bouchra, 2008). In contrast, organic matter is fairly evenly distributed throughout the plough layer in conventionally tilled soils (Angers *et al*., 1993; Bouchra, 2008).

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Studies by Francis and Knight (1993) and Deorr (2007) have shown that SOC and total nitrogen contents were higher under no – tillage than conventional tillage. However, Ellim (2006) noted that tillage had no significant effects on SOC and total nitrogen. Maize (*Zea mays* L.) is one of the most widely cultivated tropical crops under different tillage systems in southwestern Nigeria. Studies of Areb (2002); Obenbe (2004) and Dick (2007) had demonstrated significant responses of maize to tillage treatments. In all these studies, significant responses of maize to tillage treatments were reported. However, Ogan (2004) and Ayegbe (2006) noted non – significant effects of tillage treatments on the growth and yield attributes of maize. Tillage is known to disrupt soil structural arrangement, which consequently results in soil fertility problems. Olonitola (2008); Zorok (2012) and Ekwueme (2013) opined that tillage leads to rapid oxidation of soil organic matter with resultant soil structure deterioration and reduction of potential nutrient supply. In order to achieve sustainability of agricultural production and environmental quality for future generations, hence, critical assessment of soil fertility, as influenced by tillage treatments is imperative. Consequent upon this, this study was designed to determine the effects of different tillage methods on nutrient status of an acid Alfisol and performance of maize.

MATERIALS AND METHODS

Study site: A two – year field experiment was carried out at the Teaching and Research Farm of the University of Ado – Ekiti, Ado – Ekiti, Ekiti State, Nigeria, during 2011 and 2012 cropping seasons. The soil of the study site belongs to the broad group Alfisol (SSS, 2003) of the basement complex. The study site had earlier been cultivated to a variety of arable crops, among which were cassava, melon, cowpea, maize, soybean and then left to fallow for three years before the commencement of this study. The fallow vegetation (mainly shrubs) was manually slashed, and residues were incorporated into the soil in the case of conventional tillage treatment, while the residues were left on the soil surface in the case of the no – tillage treatment.

Collection and analysis of soil samples: Prior to planting, and before tillage operations were carried out during 2011 cropping season, ten core soil samples, randomly collected from 0 – 15 cm soil depth were mixed inside a plastic bucket to form a composite sample, which was analyzed for physical and chemical properties. At the termination of 2011 and 2012 cropping activities, soon after harvest, another sets of soil samples were collected in each treatment plot, and analyzed to assess changes in the soil nutrient status under the tillage methods during the two cropping seasons. All the soil samples were analyzed in accordance with the procedures, outlined by the International Institute of Tropical Agriculture (IITA) (1989).

Experimental design and treatments: The experiment was laid out in a randomized complete block design with three replicates. The tillage treatments included: No – tillage (NT) and conventional tillage (CT). Conventional tillage is a form of tillage which involves ploughing and harrowing of land prior to planting. No – tillage, as the name implies, the land is not ploughed and harrowed; the land is tilled at planting point only. Each plot size was 3 m x 3 m.

Planting, weeding, collection and analysis of data: In 2011 and 2012, planting of maize was done on March 20 and April 2, respectively. Three seeds of Oba Super 1 maize variety, dressed with Apron Plus, were planted per stand at 90 cm x 50 cm, but later thinned to two seedlings per stand (44,444 maize plants ha^{-1}), two weeks after planting (WAP). Weed control was carried out at 3, 6 and 6 WAP, using paraquat, applied at the rate 2.5 litres per hectare (Akobundu, 1987) in the no – tillage treatment plots. On the other hand, weeds were controlled manually in the conventional tillage plots, using a hoe. No fertilizer was applied throughout. Dry seed weight was measured on a metler weighing balance. All the data collected were subjected to analysis of variance, and treatment means were compared, using the Least Significant Difference (LSD) at 5% level of probability.

RESULTS

The physical and chemical properties of soil in the study site prior to 2011 cropping.

Table 1 shows the physical and chemical properties of soil in the study site before 2011 cropping season.

Table 1: The physical and chemical properties of soil in the study site prior to 2011 cropping.

Soil parameters	Values
pH	5.8
Organic carbon (g kg^{-1})	0.86
Total nitrogen (g kg^{-1})	0.68
Available phosphorus (mg kg^{-1})	0.58
Exchangeable Aluminium (cmol kg^{-1})	0.70
Exchangeable bases (cmol kg^{-1})	
Potassium	0.61
Calcium	0.50
Magnesium	0.42
Sodium	0.44
Acidity	0.37
Effective Cation Exchangeable Capacity (ECEC)	2.34
Micro – nutrients (mg kg^{-1})	
Copper	2.64
Zinc	2.50
Manganese	2.58
Iron	2.59
Texture (g kg^{-1})	
Sand	600
Silt	150
Clay	250
Textural class Sandy loam	

Changes in soil nutrient status after 2011 and 2012 cropping seasons*:* Tables 2 and 3 show the influence of tillage methods on the soil nutrient status after 2011 and 2012 cropping seasons. At the termination of 2011 cropping, NT gave pH value of 4.6, which was significantly higher than 3.1 for the CT treatment. Similarly, at the end of 2012 cropping season, NT gave 4.2 pH value, which was significantly higher than 2.8 for the CT. At the end of 2011 cropping season, NT gave soil organic carbon (SOC) value of 0.73 g kg^{-1}, which was significantly higher than 0.20 g kg^{-1} for its CT counterpart. At the end of 2012 cropping season, NT gave SOC value of 0.62 g kg^{-1}, which was significantly higher than 0.09 g kg^{-1} for the CT. At the end of 2011 cropping season, NT gave total N value of 0.49 g kg^{-1}, which was significantly higher than 0.23 g kg^{-1} for the CT. At the end of 2012 cropping season, NT gave total N value of 0.33g kg^{-1}, which was significantly higher than 0.08 g kg^{-1} for the CT. At the end of 2011 cropping season, NT gave available P value of 0.34 mg kg^{-1}, which was significantly higher than 0.23 mg kg^{-1} for the CT. Similarly, at the end of 2012 cropping season, NT gave available P value of 0.22 mg kg^{-1}, which was significantly higher than 0.09 mg kg^{-1} for the CT. At the end of 2011 cropping season, CT gave exchangeable Al value of 0.59 cmol kg^{-1}, which was significantly higher than 0.43 cmol kg^{-1} for the NT. At the end of 2012 cropping season, CT gave exchangeable Al value of 0.66 cmol kg^{-1}, which was significantly higher than 0.50 cmol kg^{-1} for the NT. At the end of 2011 cropping season, NT gave exchangeable K value of 0.39 cmol kg^{-1}, which was significantly higher than 0.21cmol kg^{-1} for the CT. Similarly, at the end of 2012 cropping season, NT gave exchangeable K value of 0.28 cmol kg^{-1}, which was significantly higher than 0.09 cmol kg^{-1} for the CT. At the end of 2011 cropping season, NT gave exchangeable Ca value of 0.38 cmol kg^{-1}, which was significantly higher than

0.20 cmol kg^{-1} for the CT. At the end of 2012 cropping season, NT gave exchangeable Ca value of 0.30 cmol kg^{-1}, which was significantly higher than 0.13 cmol kg^{-1} for the CT. At the end of 2011 cropping season, NT gave exchangeable Mg value of 0.29 cmol kg^{-1}, which was significantly higher than 0.13 cmol kg^{-1} for the CT. Similarly, at the end of 2012 cropping season, NT gave exchangeable Mg value of 0.22 cmol kg^{-1}, which was significantly higher than 0.05 cmol kg^{-1} for the CT. At the end of 2011 cropping season, NT gave exchangeable Na value of 0.30 cmol kg^{-1}, which was significantly higher than 0.17 cmol kg^{-1} for the CT. At the end of 2012 cropping season, NT gave exchangeable Na value of 0.25 cmol kg^{-1}, which was significantly higher than 0.08 cmol kg^{-1} for the CT. At the end of 2011 cropping season, CT gave Cu value of 2.48 mg kg^{-1}, which was significantly higher than 2.32 mg kg^{-1} for its NT counterpart. Similarly, at the end of 2012 cropping season, CT gave Cu value of 2.56 mg kg^{-1}, which was significantly higher than 2.38 mg kg^{-1} for the NT. At the end of 2011 cropping season, CT gave Zn value of 2.48 mg kg^{-1}, which was significantly higher than 2.26 mg kg^{-1} for the NT. At the end of 2012 cropping season, CT gave Zn value of 2.48 mg kg^{-1}, which was significantly higher than 2.30 mg kg^{-1} for the NT. At the end of 2011 cropping season, CT gave Mn value of 2.49 mg kg^{-1}, which was significantly higher than 2.34 mg kg^{-1} for the NT. Similarly, at the end of 2012 cropping season, CT gave Mn value of 2.53 mg kg^{-1}, which was significantly higher than 2.39 mg kg^{-1} for the NT. At the end of 2011 cropping season, CT gave Fe value of 2.47 mg kg^{-1}, which was significantly higher than 2.29 mg kg^{-1} for the NT. At the end of 2012 cropping season, CT gave Fe value of 2.52 mg kg^{-1}, which was significantly higher than 2.35 mg kg^{-1} for the NT.

Table 2: Soil nutrient status as affected by tillage methods after 2011 cropping season.

Tillage		Org. C	Total N	Av. P	Exch. Al	Exch. bases (cmol kg^{-1})				Micronutrients (mg kg^{-1})			
methods	pH	(g kg^{-1})	(g kg^{-1})	(mg kg^{-1})	(cmol kg^{-1})	K	Ca	Mg	Na	Cu	Zn	Mn	Fe
NT	4.6a	0.73a	0.49a	0.34a	0.43b	0.39a	0.38a	0.29a	0.30a	2.32b	2.26b	2.34b	2.29b
CT	3.1b	0.20b	0.23b	0.23b	0.59a	0.21b	0.20b	0.13b	0.17b	2.48a	2.38a	2.49a	2.47a
LSD (P=0.05)	1.1	0.23	0.14	0.04	0.08	0.09	0.11	0.10	0.14	0.10	0.04	0.06	0.05

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05.
NT = No – tillage; CT = conventional tillage; LSD = Least significant difference.

Table 3: Soil nutrient status as affected by tillage methods after 2012 cropping season.

Tillage		Org. C	Total N	Av. P	Exch. Al	Exch. bases (cmol kg^{-1})				Micronutrients (mg kg^{-1})			
methods	pH	(g kg^{-1})	(g kg^{-1})	(mg kg^{-1})	(cmol kg^{-1})	K	Ca	Mg	Na	Cu	Zn	Mn	Fe
NT	4.2a	0.62a	0.33a	0.22a	0.50b	0.28a	0.30a	0.22a	0.25a	2.38b	2.30b	2.39b	2.35b
CT	2.8b	0.09b	0.08b	0.09b	0.66a	0.09b	0.13b	0.05b	0.08b	2.56a	2.48a	2.53a	2.52a
LSD (P=0.05)	1.2	0.23	0.12	0.07	0.09	0.10	0.12	0.13	0.14	0.12	0.11	0.10	0.12

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05.
NT = No – tillage; CT = conventional tillage; LSD = Least significant difference.

Grain yield and number of days to 50% flowering of maize: Table 4 shows grain yield and number of days to 50% flowering of maize as affected by tillage treatments. The two – year average values indicated that, CT gave 2.35 t ha^{-1} maize grain yield, which was significantly (P=0.05) higher than 2.17 t ha^{-1} for its NT counterpart. On the contrary, NT gave 75 days, being the value of number of days to 50% flowering, which was significantly higher than 65 days, adduced to its CT counterpart.

Table 4: Effects of tillage methods on maize grain yield at harvest and number of days to 50% flowering.

	Maize grain yield (t ha^{-1})			Number of days to 50% flowering		
Treatments (Tillage methods)	2011	2012	Mean	2011	2012	Mean
No – tillage	2.23b	2.10b	2.17	74a	75a	75
Conventional tillage	2.40a	2.30a	2.35	65b	65b	65
LSD (P = 0.05)	0.11	0.15	0.13	4	6	6

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05.
LSD = Least significant difference.

DISCUSSION

The chemical properties of soil in the study site, prior to cropping, indicated that the soil was slightly acidic, with a pH of 5.80. The soil organic carbon (SOC) value of 0.86 g kg^{-1} was below the critical level of 5.6 g kg^{-1} for soils in Southwestern Nigeria (Olonitola, 2008). The total nitrogen content of 0.68 g kg^{-1} was below the critical level of 1.29 g kg^{-1}, according to Angers *et al*., (1993) and Zorok (2012).

The K status of 0.61 cmol kg^{-1} was below the critical level of 0.87 cmol kg^{-1} (Olonitola, 2008; Ekwueme, 2013). The Ca, Mg and Na contents were all below the established critical levels for soils in Southwestern Nigeria (Angers *et al*., 1993; Kapa, 2013). After cropping, the significantly higher pH value, adduced to the no – tillage treatment, can be attributed to the significantly higher values of exchangeable bases on the exchange sites of soil in the no – tillage plots. The significantly lower SOC value, associated with the conventional tillage, compared to the no - tillage, agreed with the findings of Francis and Knight (1993); Blevin and Frye (1993); Angers *et* al., (1993) and Olonitola (2011), who noted that conventional tillage resulted in a significantly lower SOC value after cropping, compared to its no – tillage treatment counterpart. The significantly lower SOC value that attended the conventional tillage treatment, compared to the no – tillage treatment, was probably due to higher rate of oxidation of soil organic matter (SOM) in the conventional tillage plots, due to the exposure by the tillage operation, of previously inaccessible and preserved SOM to action of the soil microbial biomass (Beare *et al*., 1992; Carter, 1992; Angers *et al*., 1993). So, the higher rate of oxidation of SOM in the conventional tillage plot can be implicated for the lower SOC value, adduced to the conventional tillage treatment. This is because part of the organic carbon content of the organic matter may have been oxidized or converted into CO_2 gas, and consequently, carbon is lost in the form of carbon dioxide – C emission from the soil system. This observation suggested that, the practice of conventional tillage, especially on a long term basis, will consequently result in fast depletion of SOC or SOM, with resultant declined soil fertility and crop yields. Thus, to avert this kind of problem, and hence, achieving sustainability of crop production, the addition of organic manures to soil under conventional tillage is strongly recommended. The significantly lower total nitrogen value recorded in the conventional tillage plots, is in conformity with the findings of Horne *et al*., (1992) and Deorr (2010). This observation was due perhaps to loss of N in the conventional tillage plots through leaching, due to increased porosity of the soil, occasioned by the conventional tillage. Although, conventional tillage is known to stimulate flush of SOM mineralization, with resultant better supply of N to crops (Beare *et al*., 1992; Angers *et al.,* 1993). However, much of the mineralized N may have been lost to leaching in the conventional tillage plots, especially in the rainy season (Deorr, 2010). The significantly higher pH value of soil in the no - tillage plots, compared to what obtained in the conventional tillage plot, can be attributed to the significantly higher values of exchangeable bases or basic cations on the exchange sites of soil in the no – tillage plots. The significantly higher values of total N, available P and the exchangeable bases for the no – tillage treatment than those for the conventional tillage, can be ascribed to the significantly higher SOC value, adduced to the no - tillage treatment. This is because SOM has been reported to be a reservoir or natural source of other plant nutrients and cation exchange capacity (CEC), that is, other plant nutrients are integrally tied to it (SOM). Thus, the maintenance of SOM is paramount to sustaining other soil quality factors (Robertson *et al*., 1991; Zynth, 2013). The significantly lower available P value, associated with the conventional tillage treatment, can be attributed to the significantly lower pH value of soil in the conventional tillage plots. This is because, the availability of P in the soil, depends on the pH of the soil medium, with available P decreasing with decreasing pH (Zorok, 2012). The decreasing available P phenomenon, associated with increasing acidity or decreasing pH, is due to the conversion of P into unavailable forms under acid soil conditions, as a result of fixation by micro – nutrients, such as Fe and Al, which abound in acid soils (Zorok, 2012; Zynth, 2012). The significantly higher values of exchangeable Al, adduced to the conventional tillage treatment, can be ascribed to the significantly lower pH value of soil in the conventional tillage plots. This is because, the availability of exchangeable Al depends on the pH of the soil medium, with exchangeable Al value decreasing with increasing pH (i.e. decreasing acidity) (Ekwueme, 2013). The decrease in exchangeable Al, associated with increasing pH, can be adduced to precipitation of aluminium hydroxide [$Al(OH)_3$], which occurs at increased soil pH (Zorok, 2012). According to Havlin (2010) and Sekar (2013), aluminium exists in an unavailable form in the soil, as insoluble aluminium hydroxide [$Al(OH)_3$] at soil pH above 6.0. The significantly higher values of the micro – nutrients (Cu, Zn, Mn and Fe), adduced to the conventional tillage treatments than those for the no – tillage treatments, can be attributed to the significantly lower pH values (i.e. higher acidity) for the former than the latter. This is because previous studies (Aritoff, 2012; Kapa, 2013) had demonstrated the correlation between availability of micro – nutrients in the soil and the pH of the soil medium, with the micro – nutrients availability increasing with decreasing soil pH (i.e. increasing acidity). Thus, the significantly lower pH values of soil in the conventional tillage plots accounted for the observed higher concentrations of micro – nutrients of soil in the conventional tillage plots. The significantly higher maize grain yield for the conventional tillage than that for the no – tillage, agrees with the findings of Areb (2002); Obenbe (2004); Dick (2007), who noted that maize in conventionally tilled plots significantly out – yielded that in the no – tillage plots. However, this observation sharply contrasts those of Ogan (2004) and Ayegbe (2006), who reported non - significant difference in maize grain yield between the conventional tillage and the no – tillage treatments. This observation shows sensitivity of maize to tillage treatments, implying that, the yield of maize, among other factors, depends on the method of seedbed preparation. The significantly higher maize grain yield for the conventional tillage, compared to the no - tillage treatment, is a pointer to the superiority of the former to the latter, as far as maize grain yield is concerned. The superiority of the conventional tillage to the no - tillage emanates from the conventional tillage considerably improving certain soil physical properties, with resultant provision of good seedbed conditions for maize (Suyad, 2012; Zuzuki, 2012). Baunt (2006) noted that the conventional tillage enhanced root growth by encouraging the vertical and horizontal proliferation of roots, through reduction in soil strength in the sub – soil. Davis (2004) reported higher nutrient and water use efficiency under the conventional tillage than the no - tillage. The conventional tillage has also been reported to increase aeration and water infiltration, due to increased pore volume (Lio, 2006).

Bozur (2005) recommended the conventional tillage by the virtue of its encouraging deeper and denser rooting, which make it possible for roots to capture downward moving water and nutrients, and extract them from greater depths. Maize in the conventional tillage plots flowered 65 days after planting, while maize in the no - tillage plots flowered 75 days after planting, suggesting that, the tillage treatment did not only result in a significantly higher grain yield of maize in the conventional tillage plots, it also enhanced earlier commencement of flowering in maize planted in the conventional tillage plots.

CONCLUSION

The results of this study have shown that, apart from the micro – nutrients and exchangeable Al, no - tillage gave significantly higher values of other nutrients than the conventional tillage treatment at the end of both cropping seasons. Conventional tillage gave significantly higher maize grain yield than its no – tillage treatment counterpart.

REFERENCES

[1]. Akobundu, I. O. 1987. Weed Science in the Tropics: Principles and Practices. John Wiley and Sons. New York. 522 pp.

[2]. Angers, D. A., N.Samson and A. Legege 1993. Early changes in water stable aggregate induced by tillage in a soil under barley production. Canadian Journal of Soil Science. 73: 51 – 59.

[3]. Areb, E. G. 2002. Effects of NPK fertilization and tillage practices on grain yield of maize. Journal of Applied Sciences. 13:11 – 16.

[4]. Aritoff, C.O. 2012. The effects of nitrogen nutrition on the development of soil acidity in Southwestern Nigeria. Soil Chemistry. 28(2):111 – 117.

[5]. Ayegbe, S. S. 2006. The growth and yield of maize as influenced by sowing time and tillage methods. Food and Agricultural Research Journal. 22:23 – 28.

[6]. Baunt, F. E. 2006. Influence of tillage practices on physical and chemical properties of an acid Alfisol. Soil Science and Land Development. 26(19):87 – 93.

[7]. Beare, M.H., Parmelee, R.W and D.A. Crossley 1992. Microbiology and fauna interactions and effects of litter nitrogen and decomposition in agro – ecosystems. Ecology Monograph. 62:569 – 591.

[8]. Blevin, R.L., W.F. Frye1993. Conservation tillage: An ecological approach to soil management. Advanced Agronomy. 51:34 – 77.

[9]. Bouchra, K.L. 2008. Influence of tillage practices on soil physical and chemical properties after five years of continuous cropping. Advanced Journal of Soil Science. 5:211 – 216.

[10]. Bozur, M.F. 2005.Effects of sub – soiling on yield and quality of rice under different levels of NPK fertilization. Soil and Plant Nutrition Research. 14:80 – 85.

[11]. Carter, M.R. 1992. Influence of reduced tillage systems on organic matter, microbial biomass, macro - aggregate distribution and structural stability of surface soil in the humid climate. Soil Tillage Research. 23:361 – 372.

[12]. Davis, L.O. 2004. Managing plant nutrients for optimum water use efficiency and water conservation. Advanced Agronomy. 53:85 – 90.

[13]. Deorr, A.J. 2010. Soil organic matter and total nitrogen in the soil profile, as affected by tillage intensity. Plant and Soil Science Research. 20:221 – 227.

[14]. Dick, K.M. 2007. Effects of increasing organic fertilizer rates and tillage methods on the performance of maize. Agricultural Research Journal. 25:444 – 449.

[15]. Ekwueme, F. R. 2013. Observations on the use of wood ash and goat manure in improving fertility of a degraded Alfisol and maize yield. Journal of Biological Sciences. 21: 212 – 217.

[16]. Ellim, F.O. 2006. Effects of tillage methods on soil chemical and physical properties. Soil Science. 26:217 - 222

[17]. Francis, G.S., T.L. Knight 1993. Long – term effects of conventional tillage on selected soil properties and crop yields. Soil Tillage Research. 26:193 – 210.

[18]. Havlin, F. M. 2010. Influence of different wood ash levels on nutrient content of maize and chemical properties of an acid Alfisol. Global Journal of Agricultural Research. 58:331 – 337.

[19]. Horne, D.J., C.W. Ross and K.A. Hughes 1992. Ten years of maize/oats rotation under three tillage systems on a silt loam in New Zealand. A comparison of some soil physical and chemical properties. Soil Tillage Research. 22:131 – 143.

[20]. Jones, I.B. 2006. Effects of cowpea/maize rotation and tillage practices on some soil physical and chemical properties. Plant and Soil Science. 13:177 – 183.

[21]. Kapa, A. A. 2013. Phosphorus requirements of groundnut and soybean as affected by nitrogen nutrition. Plant Nutrition Research. 42:57 – 63

[22]. Kim, F.S. 2008. Study on conservation tillage systems in the humid and sub – humid tropics. Tillage Science Research. 20:183 – 188.

[23]. Lal, R. 1997. Conservation tillage for sustainable agriculture: tropics vs. temperate environments. Advanced Agronomy. 42:85 – 97.

[24]. Lio, O.M. 2006. Influence of tillage practices on the yield of cereals and tuber crops. Crop Science. 13:102 - 107.

[25]. Obenbe, F. S. 2004. The growth and yield attributes of cassava as influenced by tillage and potassium fertilization. Plant Nutrition Research. 21:213 – 218.

[26]. Ogan, B.B. 2004. Effects of urea fertilizer application and tillage on growth and yield of cassava. International Journal of Agriculture and Environmental Studies. 29:263 – 269.

[27]. Olonitola, L.O. 2011. Reduced tillage and soil chemical properties. Advanced Journal of Soil Science and Land Development.16(12):241 – 246.

[28]. Robertson, E. B., S. Sarig and M.K. Firestore 1991. Cover crop management of polysaccharide – mediated aggregation in an orchard. Soil Science Society of American Journal. 55:734 – 739.

[29]. Sasiba, T.O. 2004. Influence of tillage systems on soil nutrient dynamics. Soil Science Research. 20:281 – 287.

[30]. Sekar, M. P. 2013. Effects of liming on exchangeable acidity and grain yield of maize. International Journal of Agricultural Sciences. 39(2):412 – 417.

[31]. Soil Survey Staff(SSS) 2003. Keys to soil taxonomy, 9th edition. USDA Natural Resources

[32]. Conservation Services, U.S. Department of Agriculture, Washington D.C. 306 p

[33]. Suyad, N. S. 2012. Maize grain yield and chemical properties of an Alfisol under tillage methods. Journal of Applied Biological and Physical Sciences. 18:263 – 269.

[34]. Zorok, A. A. 2012. Suitability of wood ash – amended rock phosphate on growth and yield of maize and chemical properties of an Alfisol. Plant and Soil Science. 28(2):361 – 367.

[35]. Zuzuki, M.B. 2012. Maize performance in relation to tillage practices. Journal of Food and Agricultural Research. 27:503 – 508.

[36]. Zynth, C. F. 2012. Evaluating the relative efficacy of wood ash, poultry manure and rock phosphate in enhancing nitrogen and phosphorus availability in corn production. Journal of Sustainable Agriculture. 22(2):1111 – 1117.