academicJournals

Vol. 12(26), pp. 2215-2222, 29 June, 2017
DOI: 10.5897/AJAR2017.12333
Article Number: 7A9589965002
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Organic carbon dynamics and changes in some physical properties of soil and their effect on grain yield of maize under conservative tillage practices in Abakaliki, Nigeria

James Nte Nwite[1]* and Chukwuebuka Christopher Okolo[2]

[1]Department Of Soil Science and Environmental Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, P. M. B 053 Abakaliki, Nigeria.
[2]Department of Land Resources, Management and Environmental Protection, Mekeele University, Ethopia.

Received 22 March, 2017; Accepted 25 May, 2017

In Nigeria and other Sub-Saharan Countries of Africa, erosion is pervasive and major source for loss of soil and productivity. This has necessitated continued search for appropriate soil management technologies to ensure sustained and profitable crop production. An experiment was carried out using maize (*Zea mays* L.) to evaluate organic carbon dynamics and changes in some physical properties of soil and grain yield of maize under conservative tillage practices on an ultisol in Southeastern Nigeria. The study consisted of three conservative tillage practices which were laid out in the field using randomized complete block design replicated seven times. Data were analyzed using statistical analysis for agricultural science. Results showed that tillage reduced seedlings emergence by 5 days compared to zero tillage. Highest grain yield of maize, significantly higher by 4 and 20% was obtained in deep tilled plot when compared to yields in shallow and zero tilled plots. Deep tilled plot had 2-9% significantly lower bulk density and 20-36, 1-8 and 27-55% higher total porosity, gravimetric moisture content and saturated hydraulic conductivity when compared to shallow tilled and zero tilled plots. Deep tilled plot had 15 and 55% significantly organic carbon when compared to their counterparts in shallow and zero tilled plots. Conservative tillage practices are recommended for sustainable and profitable production of maize crop in Nigeria.

Key words: Edaphic, grain yield, organic carbon, soil properties, tillage practices.

INTRODUCTION

Abakaliki of Southeastern Nigeria is predominantly agrarian. The farmers in the area grow intensively stapple food crops which range from cereals to tubers. Maize (*Zea mays* L.), rice (*Orzyae sativa*), yam (*Dioscorea* spp),

*Corresponding author. E-mail: nwitejamesn@yahoo.com Tel: +234864764764659.

cassava (*Manihot* spp), cocoyam (*Colocasia esculenta*) and potato (*Impomea batata*) are most commonly grown. These crops have adapted to the ecological and edaphic conditions prevailing in the area. Of all these, maize crop constitute about 30% of annual production (NPAFS, 2010). The agroecological conditions which facilitate crop production in Abakaliki include adequate sunlight and moisture regime, favourable temperature, soil nutrient storage and rooting depth (Anikwe, 2006; NPAFS, 2010).

Tillage is an important agronomic practice which has direct influence on soil condition. It is the physical manipulation of soil carried out to create conditions suitable for seeds germination, seedling emergence, poor growth and reduce weeds (Ibudialo et al., 2015). Mostly affected are temperature regime, porosity, compaction, moisture content and root proliferation (Anikwe et al*.,* 2007). Furthermore, tillage practices improve soil properties, crops growth and development and promote their resilience to drought and other adverse environmental conditions (Atkinson et al*.,* 2007). Tillage practices also create favourable edaptic and ecological environment for seedling emergence (Anikwe et al*.,* 2007). Conservation tillage minimizes soil disturbances, protects the soil against degradation and improves sustainability (Melero et al., 2009).

In addition, soil condition is critical to nutrient dynamics. Since soils in southeastern part of Nigeria is sandy and deficit in organic carbon (Ohiri and Ano, 2012), there is need to intensify studies into acceptable management practices to stabilize and improve condition of the soil, their fertility and productivity (Mbah and Nneji, 2010) especially as management strategies have many effect on organic carbon content of soil (Ojeniyi and Ighomrore, 2004). In this part of the country, farmers engage in conventional tillage practices; which involves raised heaps as means of preparation of their soil for crop production.

This management strategy may be associated with physical degradation and nutrient losses. Certainly, there is need to avoid these problems (Mbah and Nneji, 2010) through adoption of proper soil management techniques. In their separate studies, Ibudialo et al. (2015) and Omoju and Ojeniyi (2012) corroborated that tillage increased cocoyam and sweet potato yields in Akure, Nigeria. Agbede and Adekiya (2011) studied no tillage and conventional tillage and reported that conventional tillage improved yield of potatoes as well as physical properties of soil. Evolving sustainable tillage practices for sustenance of soil fertility and productivity is important for planning of future farming operation and developing appropriate soil management system for higher productivity. Although, there had been studies on tillage research in the area, these experiments are not exhaustive as such researches often bothered on raised heaps, beds or ridges. Besides, information on conservation tillage practices on soil physical properties, organic carbon dynamics and maize yield is completely lacking or non-existence in the ecology. This necessitated the research aimed to study organic carbon dynamics and changes in some physical properties of soil and grain yield of maize (*Z. mays* L.) under different conservative tillage practices.

MATERIALS AND METHODS

The study was carried out in 2013 planting season at Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki (Figure 1). The experimental site is located by latitude 06° 4 N and longitude 08° 65 E in the derived Savannah Zone of the Southeastern agroecological area of Nigeria. The area experiences a bimodal pattern of rainfall which is spread from April to July and September to November with a break in August known as “August break”. The total annual rainfall within the area ranges from 1500 to 2000 mm with an average of 1800 mm. At the beginning of rainy season, it is normally characterized by torrential rainfall, often violent and accompanied with heavy lightning and thundering. The rain sometimes lasts for few hours. Daily mean temperatures range from 27 to 31°C for minimum and maximum throughout the year. Minimum daily temperature occurs during cold harmattan periods between December to January while maximum temperature is experienced during the hottest periods of the year which is between February to April. Relative humidity is normally high (80%) during rainy season but declines to 60% or even less in dry season. The soil of the area is derived from sedimentary rocks from successive marine deposits of the cretaceous and tertiary periods. Abakaliki agricultural Zone is reported to lie within “ASU river group” in the geology of soil formation in the area and consists of Olive brown sandy shales, fine grained sandstones and mudstones (FDALR, 1985). The soil is shallow often with clay pan concretion with unconsolidated parent materials (Shale residuum) within 1m depth and belongs to the order ultisol which is classified as Typic Haplustult (FDALR, 1985).

Field methods

A land area that measured 30 m x 30 m approximately 0.09 ha was used for the study. The site was cleared of existing vegetation with matchet and debris removed without burning. The field was laid out using Randomized Complete Block Design. The plots measured 10 m x 10 m and were separated by 0.5 m spaces while the seven replicates were each set apart by 1 m alley. There were three treatments which consisted of Zero tillage (ZT), shallow tillage (ST) and deep tillage (DT). These tillage practices were replicated seven times to give a total of twenty one plots. Zero tilled plot was cleared of vegetation and debris removed without any kind of tillage carried out on it. Whereas in shallow tilled plot, hand held hoe was used to till the soil flat to a depth of 10 cm and in deep tilled plot, the soil was tilled flat with hoe to a depth of 15 cm. The soil in each case was not upturned.

Planting and other agronomic practices

Maize seed (Suwan–1-SR-hybrid) variety which was sourced from FADAMA office Onuebonyi Izzi, Abakaliki, Ebonyi State of Nigeria was used as a test crop. The maize variety is resistant to stem borer attack, does not lodge and high yielding. Two maize seeds were planted per hole at a depth of 5 cm and planting distances of

Figure 1. Map of Abakaliki, Ebonyi State.

50 cm x 50 cm for both intra and inter row spacings. After two weeks of seedling emergence, those that failed to germinate including weak ones were all replaced by replanting to achieve optimum plant population. There were 40,000 maize plants per hectare. Fertilizer NPK 20:10:10 was applied at 400 $kgha^{-1}$ to all the plots two weeks after germination. The fertilizer was drilled and 5 cm away from the maize plants. Weeds were removed with hand at three weekly intervals till harvest.

Soil sampling

Soil samples were collected randomly with steel auger at 0-20 cm depth at twenty different points after clearing the site. The samples were composited and bulked for pre-planting soil analysis. Five undisturbed cores and auger each of soil samples were further collected at 0-20 cm depth from each plot at maize tasselling for determination of some post-harvest physical properties and organic carbon. The soil core samplers used were 6 cm in height and open faced, analyzed separately and average results used for evaluation, whereas the auger samples were mixed and composited for laboratory analysis.

Agronomic data collection

Maize seedling emergence was taken after five days of planting (DAP) since a viable seed is supposed to emerge between 5-10 days. Percentage germination count was calculated using the formula:

$$\text{Germination Count \%} = \frac{\text{Number of germinated maize seeds per plot}}{\text{Total number of planted maize seeds per plot}} \times 100 \qquad (1)$$

For grain yield of maize twenty (20) plants representing 50% of total plant population per plot were selected and tagged from the net plot and sampled. The maize cobs were harvested when the husks had turned brown and dry. The cobs were dehusked, shelled, grains dried to constant weight and grain yield determined at 14% moisture content.

Laboratory methods

Composite soil samples collected from twenty points in the experimental site before the initiation of study were used for pre-planting analysis. Auger soil samples collected from each plot were dried, passed through 2 mm sieve and used for determination of organic carbon. Core samples were used for measurement of some physical properties of soil. Particle size distribution was determined by hydrometer method of Gee and Or (2002). Dry bulk density was calculated using the formula:

$$\text{Dry bulk density} = \frac{\text{Oven dry weight of soil (g)}}{\text{Bulk volume of soil (cm}^3)} \qquad (2)$$

Bulk volume of soil approximated volume of core as $\pi r^2 h$.

Where $\pi = {}^{22}/_{7}$, r of Core = 2.5 cm and height of core = 6 cm. Total porosity value was estimated from bulk density data as follows:

$$TP = \left(\frac{1 - Bd}{pd}\right) \times \frac{100}{1} \qquad (3)$$

Where

TP = Total porosity
Bd = Bulk density
Pd = Average particle density of soil was assumed at 2.65 Mgm^{-3}.
Gravimetric moisture content (GMC) was determined using Obi (2000) procedure. The procedure is

$$GMC\% = \frac{WWS - DWS}{DWS} \times \frac{100}{1} \qquad (4)$$

Where
WWS = Wet Weight of soil sample (g)
DWS = Dry Weight of soil sample (g)

Saturated hydraulic conductivity was determined by constant head method of Obi (2000). The value was calculated using the formula:

$$K_S = \frac{Q}{At} \times \frac{DH}{L} \qquad (5)$$

Where

$$K_S = \frac{\text{Mean volume of water conducted}}{\text{Cross sectional area of Core x Time}} \times \frac{\text{Hydraulic head change}}{\text{Soil sample length}} \qquad (6)$$

Total N was determined by the macro-Kjedahl method (Bremmer, 1982). Available phosphorus and organic carbon determinations were done using Bray-2 method and Walkley and Black procedure as reported in Page et al. (1982) respectively. Soil pH in KCl was determined by the glass electrode pH meter (Mclean, 1982). The exchange cations and cation exchange capacity were extracted using the method described by Mba (2004). Base saturation was determined with formula:

$$\%BS = \frac{TEB}{CEC} \times \frac{100}{1} \qquad (7)$$

Where:
%BS = percent base saturation
TEB = Total exchangeable bases
CEC = Cation exchange capacity.

Data analysis

The data obtained from the study were analyzed using analysis of variance (ANOVA) test based on RCBD using F-LSD at $P<0.05$ according to Statistical Analysis for Agricultural science (SAS, 1985). Significance was accepted at 5% probability level.

RESULTS AND DISCUSSION

Soil properties at initiation of study

Results (Table 1) show properties of soil at initiation of study. Sand was predominantly higher than other fractions giving sandy loam texture. Soil pH in Kcl was 5.0. Organic carbon, organic matter and nitrogen had respective values of 0.68, 1.17 and 0.10%. Available phosphorus had a value of 24.00 $mgkg^{-1}$. Exchangeable cations were 5.10, 2.41, 0.24 and 0.12 $cmolkg^{-1}$ respectively for calcium, magnesium, potassium and sodium. Cation exchange capacity was 8.08 $cmolkg^{-1}$ while base saturation recorded a value of 78.0%.

The preliminary investigation showed that the soil was strongly acidic (Schoeneberger et al*.,* 2002). The organic carbon, organic matter, nitrogen and available phosphorus were very low (FMARD, 2002) bench mark for tropical soils. The exchangeable cations except calcium and cation exchange capacity were of low values (Anikwe, 2006) but base saturation was moderate. The results depict a soil that is poor, degraded and of low fertility status.

Table 1. Soil properties at initiation of study.

Soil properties	Values
Sand (gkg^{-1})	650
Silt (gkg^{-1})	190
Clay (gkg^{-1})	160
Textural Class	Sandy loam
pH in KCl	5.0
Organic carbon (%)	0.68
Organic matter (%)	1.17
Nitrogen (%)	0.10
Available phosphorus ($mgkg^{-1}$)	24.00
Calcium ($cmolkg^{-1}$)	5.10
Magnesium ($cmolkg^{-1}$)	2.41
Potassium ($cmolkg^{-1}$)	0.24
Sodium ($cmolkg^{-1}$)	0.12
Cation exchange capacity ($cmolkg^{-1}$)	8.08
Base saturation (%)	78.00

Table 2. Influence of conservative tillage practices on percent maize seedling emergence at 5 and 10 DAP**.**

Tillage practices	Days after planting	
	5	10
Zero tillage	38	98
Shallow tillage	48	100
Deep tillage	50	100
Mean	42.7	99.3
FLSD ($p<0.05$)	NS	NS

Influence of tillage practices on maize seedling emergence

Maize seedling emergence count started on 5 days after planting (DAP). Results (Table 2) showed that there was neither significant ($p<0.05$) treatment effect of tillage practices on seedling emergence for both 5 and at 10 DAP nor significant differences on the seedling emergence among tillage practices. Nevertheless, deep tilled (DT) plot had higher percent maize seedling emergence (50%) compared to those of shallow tilled (ST) and zero tilled (ZT) (48-38%) plots respectively after 5 DAP. At 10 DAP, both shallow tilled and deep tilled plots had maize seedling emergence of 100% whereas zero tilled plot had 98%.

The result show that at 5 DAP, deep tilled plot had the highest rate of maize seedling emergence, followed by shallow tilled plot and zero tilled plot had lowest. Whereas, both shallow and deep tilled plots had optimum maize seedling emergence at 10DAP compared to zero tilled plot. These findings imply that shallow and deep tillage more than zero tillage enhanced number of days required to obtain optimum maize seedling emergence by 5days in both 5 and 10 DAP. The results further indicate that deep tilled plot had more improved soil tilth and moisture content (Table 3). This suggests that good soil tilth, improved soil warmth, aeration and higher moisture content in deep tilled plot have positive influence on maize seedling emergence more than adverse effect of mechanical impedance although there was no significant differences in seedling emergence among tillage practices. Anikwe et al*.* (2007) reported that higher moisture content facilitated seedling emergence in tilled plots compared to untilled plot. This observation was supported by Gajiri et al*.* (2002) that seed germination and crop emergence were affected by seed zone soil water potential, oxygen diffusion rate and mechanical impedance. Seedling emergence is affected by soil physical properties in the order of soil temperature > soil matric potential > soil aggregate size distribution. It is instructive that depth of planting and seed soil contact (Obi, 2000; Anikwe et al*.,* 2007) influenced seed germination and seedling emergence. It could be inferred from the results that soil tilth more than soil warmth, air, moisture content and depth of tillage influenced maize

Table 3. Effect of conservative tillage practices on grain yield of maize.

Tillage Practices	Yield (tha^{-1})
Zero tillage	1.83
Shallow tillage	2.20
Deep tillage	2.30
FLSD (p<0.05)	0.04

seedling emergence in deep and shallow tilled plots than in zero tilled plot. The effect of mechanical impedance and edaphic environment did not have much influence because even in zero tilled plot, seed holes were opened for planting of maize seeds and this reduced soil compaction to of little or no effect. This finding contradicts earlier report of Anikwe et al. (2007) which noted that both increased temperature and moisture content influenced corm emergence more than mechanical impedance.

Grain yield of maize as influenced by conservative tillage practices

Highest grain yield of maize was obtained in deep tilled plot (2.30 tha^{-1}) (Table 3). This was significantly ($p<0.05$) higher than yields obtained in shallow and zero tilled plots by 4 and 20%. The grain yield of maize in shallow tilled plot was significantly higher by 17% when compared to yield recorded in zero tilled plot. There were significant differences in grain yields of maize among the different tillage practices.

These results show that tillage practices influenced grain yields of maize. For instance, the high percent of grain yield of maize advantage obtained in deep tilled plot relative to their respective yields in shallow and zero tilled plots could be due to differences in soil tilth and edaphic conditions of soil as a result of impact of tillage. Tillage improved soil physical conditions, reduced seedling emergence time, weed competition, diseases and pests incidence and these resulted in better grain yields of maize. Furthermore, comparing grain yields of maize between deep and shallow tilled plots, results showed a total grain yield difference of 0.10 tha^{-1} for deep tilled plot. This difference is made possible because of deeper tillage. The hoe penetrated deeper thereby loosening soil aggregates and creating channels for water transmission into the crop root rhizosphere. Anikwe (2007) as corroborated by Agbede and Kiya (2011) noted that zero tilled plot had lower yield than tilled plots. Similarly, tillage provided favourable soil edaphic conditions for organic carbon decomposition and mineralization (Anikwe et al., 2007) which made more nutrients available in tilled plots. The grain yield of maize was 26 and 20% lower in zero tilled plot than the respective yields in deep and shallow tilled plots. These differences in grain yields of maize may be because of the techniques employed in tillage.

Generally, zero tilled plot had the least grain yield of maize and this could be attributed to least suitable edaphic conditions provided for the maize crop. Zero tilled plot had highest bulk density, least total porosity and moisture content as well as water transmission. These imply root restriction, poor aeration and impeded drainage which could have affected microbial activities and hampered nutrients release. The result is the low grain yield of maize obtained in zero tilled plot when compared to yields in other tilled plots.

Changes in some physical properties of soil under conservative tillage practices

Results of changes in some physical properties of soil under conservative tillage practices are shown in Table 4. There were significantly ($p<0.05$) higher changes in studied soil physical properties among different tillage practices. Results show significant treatment effect on bulk density value of 1.30 mgm^{-3} in zero tilled plot with their counterparts in shallow and deep tilled plots (1.20 and 1.18 mgm^{-3}). Shallow tilled plot had significant bulk density of 1.20 Mgm^{-3} which was higher than the value obtained in deep tilled plot (1.18 mgm^{-3}). The result of total porosity showed a reciprocal trend of corresponding values of bulk densities recorded under different tillage practices. Total porosities obtained in shallow and deep tilled plots (55.00 and 55.50%) were significantly higher than its corresponding value in zero tilled plot (51.00%). There was no significant difference in total porosity between shallow tilled and deep tilled plots. The gravimetric moisture content (GMC) in deep tilled plot was significantly higher (25.00%) than their counterparts in shallow and zero tilled plots (20.00 and 16.00%). The value of GMC in shallow tilled plot was significantly (20.00%) higher than the one recorded in zero tilled plot (16.00%). Result further shows that deep tilled plot had significantly higher saturated hydraulic conductivity (11.00 cmh^{-1}) than their corresponding values in shallow and zero tilled plots (5.00 and 8.00 cmh^{-1}). There was significantly lower saturated hydraulic conductivity (8.00$cmhr^{-1}$) in shallow tilled plot when compared to value obtained in zero tilled plot (5.00 cmh^{-1}). Generally, in deep tilled plot, bulk density was 8 and 10% lower than in shallow and zero tilled plots whereas GMC, total porosity and saturated hydraulic conductivity were 20-36, 1-8 and 27-55% higher in deep tilled plot compared to values obtained in shallow and zero tilled plots.

Tillage significantly reduced bulk density from 1.30 mgm^{-3} in zero tilled plot to 0.10 and 0.12 mgm^{-3} in shallow and deep tilled plots, respectively. The change in soil bulk density due to tillage was more glaring in deep tillage. This positive impact on soil bulk density by tillage is

Table 4. Changes in some physical properties of soil due to conservative tillage practices.

Tillage practices	BD (Mgm^{-3})	TP (%)	GMC (%)	K_s (cmh^{-1})
Zero tillage	1.30	51.00	16.00	5.00
Shallow tillage	1.20	55.00	20.00	8.00
Deep tillage	1.18	55.50	25.00	11.00
FLSD(p<0.05)	0.02	1.20	0.03	0.23

BD – Bulk density, GMC – Gravimetric moisture content, TP – Total porosity, K_S – Saturated hydraulic conductivity.

expected since hand hoe was used than tractor in effecting tillage practices (Omoju and Ojeniyi, 2012). The soil was loosened rather than compacted and this increased the bulk volume of soil which reduced soil compaction. This finding contradicts the observations of Anikwe et al. (2003, 2007) that soil bulk density was increased after tillage as a result of trafficking after field operations. Anikwe et al. (2007) noted that effect of tillage in increasing bulk density dissipates with time but the use of hand hoe reduced impact of trafficking which could have resulted to decreased soil volume and increase in bulk density. Low bulk density is a positive indicator for assessing soil productivity (Obi, 2000; Anikwe, 2006) as it enhances nutrient retention and supply, moisture retention and resilience to degradative forces· High bulk density in zero tilled plot could be attributed to forces of crusting, sedimentation or sealing which reduced soil volume. This finding is supported by Obi (2000) who reported that crusting and sealing propensity caused soil compaction and increased its bulk density. Tillage caused significant change from lowest total pore volume in zero tilled plot to higher total pore volume which was highest under deep tillage· Bulk density and total porosity has reciprocal relationships and so the values of total porosity under different tillage practices followed the trend of their corresponding values of bulk density· According to Anikwe et al. (2007), soil compaction increased bulk density and decreased pore volume (Agbede and Adekiya, 2011; Ojeniyi et al., 2012). The general trend in increase in soil total porosity due to tillage practices is deep tillage > shallow tillage > zero tillage.

There was significant positive change in gravimetric moisture content as influenced by tillage practices. Retention of water in soil due to tillage practices followed the trend of bulk density and total porosity. Tillage practices created fine soil particles and or soil tilth which increased moisture retention as opposed to zero tillage. This finding is intandem with the observation of Anikwe et al. (2007) and Omoju and Ojeniyi (2012) that tillage created favourable edaphic environment which reduced evaporation losses and conserved moisture. On the other hand, the result is in support of the report that compaction increased proportion of soil pores filled with water as average pore size decreased (Anikwe et al., 2007). Low proportion of pores could lead to aeration stress. This suggests that zero tillage cannot only cause soil compaction and reduction in total pores but also “moisture stress” which is detrimental to productivity.

Result (Table 3) further indicated that tillage practices had significantly higher change in saturated hydraulic conductivity when values obtained in deep and shallow tilled plots are compared to the zero tilled plot. This change is highly pronounced under deep tillage. The trend in saturated hydraulic conductivity as influenced by tillage practices is deep tillage > shallow tillage > zero tillage. Higher saturated hydraulic conductivity obtained in deep and shallow tilled plots could be attributed to low bulk density and high total porosity as well as gravimetric moisture content in those plots (Ibudialo et al., 2015).

The highest saturated hydraulic conductivity obtained in deep tilled plot is attributable to corresponding lowest bulk density and highest total porosity and gravimetric moisture content in the plot. However, beyond this observation, it is believed that hand hoe caused “bulb tire” elliptical impact (Obi, 2000) on the soft soil that created “micro, meso and macro pores” which facilitated higher water transmission on the soil. High water conductivity or transmission is a soil productivity indicator as it could lead to free drainage of water, increased aeration and microbial activities as well as reduce denitrification process. If water conductivity becomes slow or too slow, it will cause water logging or even ponding and that could constitute limitation to soil productivity due to negative associated impacts that it could initiate.

Effect of conservative tillage practices on changes in particle size distribution

Table 5 shows that conservative tillage practices did not cause pronounced change in distribution of particle of soil. Nevertheless, sand fraction was dominant in different tillage practices which ranged from 740 – 780 gkg^{-1} for the tillage practices. Clay fractions were higher (120, 150 and 180 gkg^{-1}) in deep tilled plot than silt

Table 5. Effect of conservative tillage practices on changes in particle size distribution.

Tillage practices	Soil particle sizes (Gkg^{-1})			
	Sand	**Silt**	**Clay**	**Texture**
Zero tillage	780	100	120	Sandy loam
Shallow tillage	760	90	150	Sandy loam
Deep tillage	740	80	180	Sandy loam

Table 6. Influence of conservative tillage practices on organic carbon dynamics.

Tillage practices	Organic carbon (%)
Zero tillage	0.90
Shallow tillage	1.70
Deep tillage	2.00
FLSD (p<0.05)	0.07

fractions (100, 90 and 80 gkg^{-1}) for the zero, shallow and deep tilled plots for the different tillage practices.

Tillage caused higher concentration of sand fraction through podzolization and eluviations of finer particles from upper to lower depth since sampling depth was 0-20 cm. This finding was corroborated by Akamigbo (2010) that pedoturbation caused elluviation of finer particles of soil which led to concentration of sand fraction and silica on upper soil layer. The higher clay fraction could be attributed to effect of illuviation through channels created by hand hoe. On the other hand, high clay fraction in deep and shallow tilled plots could be due to higher total porosity and water transmission in those plots which influenced its movement downward. There was no obvious change in texture due to tillage practices. This is expected because according to Obi (2000) short term cultural practices do not modify the texture. From practical point of view, tillage practices had the same effect on soil particle size distribution probably because the data on particle size distribution were not statistically analyzed. Texture is a factor of soil productivity indicator (Anikwe, 2006) and it has good relationship with nutrient storage, water retention, compatibility and compressibility (Smith et al*.,* 1998) all of which affect inherent productivity of soil. Sandy loam is associated with high nutrient storage and supply, water retention, aeration, friability and aggregation which are positive indicators of soil productivity.

Influence of conservative tillage practices on organic carbon dynamics

Results (Table 6) shows that there were significant ($p<0.05$) differences in organic carbon dynamics among different tillage practices. Deep tilled plot had significantly ($p<0.05$) higher organic carbon (2.00%) compared to corresponding values obtained in shallow and zero tilled plots (1.70–0.90%). Tillage practices increased organic carbon from 0.9% in zero tilled plot to 2.00 and 1.70% in deep and shallow tilled plots. These represent 55 and 47% increments in organic carbon in deep and shallow tilled plots compared to value obtained in zero tilled plot. Generally, the trend in organic carbon dynamics from highest to lowest values is in the order of deep tilled plot < shallow tilled plot > zero tilled plot.

From these results, deep tilled plot had higher organic carbon when compared to their counterparts in shallow and zero tilled plots. This indicates that tillage impacted on organic carbon content of soil positively. Tillage as inferred improved soil heat content, decomposition, mineralization and microbial activity which influenced organic carbon content soil more than in zero tillage (Omoju and Ojeniyi, 2012). Organic carbon content of different tillage practices except that of deep tillage ranged from very low to low values (FMARD, 2002) benchmark for tropical soils. Asadu (1990) reported low organic carbon content of soils in the tropics due to high temperatures which caused high mineralization. Low organic carbon content in zero tilled plot could be as a result of low mineralization and negative effects of untilled soil. Poor physical properties of soil such as low water transmission which can possibly cause denitrification and leaching of organic carbon content from soil. Although, organic carbon content in zero tilled plot is low compared to shallow and deep tilled plots but not limiting to soil productivity (FMARD, 2002).

Conclusion

The results of this study have shown that tillage practices could affect organic carbon content and changes in some physical properties of soil as well as grain yield of maize. Tillage could influence maize seedling emergence, organic carbon dynamics, bulk density, total porosity, soil moisture content and transmission and grain yields of maize. Deep tilled plot had the highest grain yield of maize of 2.30 tha^{-1} while shallow tilled grain and zero tilled plots had 2.20 and 1.83 tha^{-1} of grain yield of maize respectively. This suggests that deep tilled plot provided better edaphic conditions for higher yield of maize crop than other tillage practices. Conservative tillage practices are important soil management approach for sustainable productivity as it could be used to manipulate soil environment and increase organic carbon content and improve bulk density, porosity, moisture content and transmission for profitable production of maize in tropical environment. Although, the difference between shallow and deep tilled plots in organic carbon dynamics and grain yield of maize is significant, however, both are recommended as conservative practices to enhanced soil sustainable productivity and increased grain yield of maize. Improved physical properties and organic carbon content should be enhanced as they are crucial for sustainable and profitable maize crop production under tropical environment.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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