EFFECT OF DIFFERENT TILLAGE PRACTICES ON SELECTED PHYSICO-CHEMICAL PROPERTIES OF SOILS IN OWERRI AREA OF IMO STATE, NIGERIA.

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Abstract
A study was carried out in the Research and Demonstration Farm of the Federal College of Land Resources Technology to determine the effect of different tillage practices and sampling depth on selected physical and chemical properties of soils of Oforola in Owerri Area of Imo State Southeastern Nigeria. Tillage practices considered were: zero, primary, and secondary tillage, while two sampling depths (0 – 7 and 7 – 14 cm) were investigated. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data generated were subjected to Analysis of Variance (ANOVA) while means were separated using LSD at 5% level of probability. Results obtained showed that secondary tillage significantly improved all the physical parameters considered more than other tillage practices. This tillage practice recorded significantly ($P < 0.01$) highest soil moisture content (29.2%), total porosity (56.23%), Ksat (11.21 cm/hr) and lowest bulk density of 1.16 g/cm^3. The average steady state infiltration which is the maximum velocity at which water enters the soil surface at equilibrium time varied according to tillage practice in this order: Primary tillage (163.3 cm/hr) > Secondary tillage (155.7 cm/hr) > Zero tillage (17.7 cm/hr). Bulk density (BD) increased with depth, being higher at 7 – 14 cm (1.26 g/cm^3) than at 0 – 7 cm (1.22 g/cm^3). Moisture content (%), total porosity (%), and saturated hydraulic conductivity (Ksat) (cm/hr) decreased with increase in soil depth. This could be attributed to increased BD at 7 – 14 cm soil depth. The predominant particle-size fraction was sand, averaging more than 71%. Soil texture in all the tillage plots was loamy sand. Tillage practice significantly ($P < 0.01$) increased soil acidity by 9.9 and 7.6% in primary and secondary tillage plots, respectively. Soil organic carbon (SOC) level increased remarkably by about 53.7 and 18.7% in zero tillage plots when compared with values obtained from secondary and primary tillage practices, respectively. The decline in soil organic carbon and soil organic matter in primary and secondary tillage plots was attributed to cultivation, which exposed the stored SOC to degradation. Secondary tillage enhanced soil physical and chemical parameters better than zero and primary tillage practices and is therefore, recommended for soils of the study area.
Keywords: Agronomy, Edaphic, Tillage practices, Humid tropics

Introduction

The national task of achieving self-sufficiency in food production for the increasing population as well as fiber and raw materials for our increasing industries makes it absolutely necessary for us to pay more attention to the effect of tillage practices on the physical and chemical properties of soils. Tillage practice is an important agronomic practice which has a direct influence on the condition of the soil in relation to interactions with moisture, temperature, porosity and unimpeded root development (Licht and Al-Kaisi, 2005). Good tillage improves soil properties for better seed bed preparation and the growth of crops (Gupta 1986; Atkinson *et al.*, 2007; Jabro *et al.*, 2009). Tillage operations are widely divided into primary and secondary tillage, minimum and zero tillage (Arakeri 1993).

Different research works showed great benefits from management of soils through various tillage practices. They noted improved soil properties such as bulk density, pore size distribution, aggregate stability and infiltration characteristics (Lugo-Lopez *et al* 1981; Hamblin, 1985 and Wood *et al*.1987). According to Adeoye (1982), deep tillage of Alfisol in Northern Nigeria resulted in increased porosity, while Tollner *et al.*, (1984) reported that the beneficial effects of tillage on soils included an increase in the number of drainage pores in the soil. However, for exposed soils especially, highly degraded soils in the tropics, water retention is reduced and is attributable to runoff and possibly a reduction in porosity due to high bulk density (Enyioko *et al.*, 2012). No work had been done on the effect of tillage practices on soils of Oforola in Owerri West LGA of Imo State. This work is an attempt to fill this gap in knowledge. The objective was to evaluate the effect of different tillage practices on selected physico-chemical properties of the study soil.

Materials and Methods

The study was conducted in the Research and Demonstration Farm of Federal College of Land Resources Technology, Oforola in Owerri West Local Government Area. Oforola lies within Latitude 5^0 41′N and 6^0 31′E and Longitude 7^0 34′N and 6^0 15′E (Uwakwe and Iwuala, 2012). The climate falls within the humid tropical climates. The rainfall distribution pattern is bi-modal with peaks in July and September. There is normally a short period of low precipitation between end of July and early August usually termed "August break". The rainfall pattern gives rise to two distinct growing seasons, the early season (April to July) and the late season (mid-August to mid-October or November). There are four to five months of dry season part of which is characterized by cool dry northeastern wind called harmattan. The major occupation of the people is farming, from where they generate income to support livelihood.

Soil Sample Collection

Composite soil sample were collected before clearing the experimental site. Subsequently two samples were collected at each plot at 0 – 7 and 7 – 14 cm depth for the determination of the physical properties of the soil. Composite samples were collected from 0 – 15 cm depth for the determination of chemical properties.

Experimental Design

The experimental design was a 3 x 2 factorial experiment in randomized complete block design (RCBD) replicated three times. Tillage practices of zero (0T), primary (PT) and secondary (ST) tillage constituted factor A, while sampling depth (0 – 7 and 7 – 14 cm) constituted factor B. The zero tillage plots were left undisturbed. The primary tillage plots were pulverized in one direction to a depth of 5 cm while that of secondary tillage plots were tilled in two directions to a depth of 10 cm with a spade.

Laboratory Analysis

Soil samples were analyzed based on selected physical and chemical properties. Samples collected were dried under room temperature for 2 weeks. The large lumps were crushed with a wooden roller, and sieved with a 2 mm sieve. The following physical and chemical properties were determined. Particle size distribution was measured by the hydrometer method (Day, 1965). Infiltration rates were determined using the double ring method. Undisturbed soil core samples were taken from all the treatment plots at 2 depths (0 - 7 cm and 7 - 14 cm). The samples were used to determine bulk density (BD) according to Blake and Hartage (1986). Total porosity (P_T) was obtained from bulk density (d_B) values, with assumed particle density (d_P) of 2.65 g cm^{-3}, as follows:

$P_T = 100\ (1- d_B\ /\ d_P)$-----------------(1)

Saturated hydraulic conductivity (K_{sat}) was determined by the constant head method as described by Klute (1986) using the equation

$K_{sat} = \theta\ /\ At \times L\ /\ \Delta H$ --------------(2)

Where θ = volume of water per unit time; A = area of core sampler; t = unit time in minutes / hour; L = length of core; and ΔH = hydraulic head difference.

Soil pH (H_2O) was measured (soil / water ratio of 1:.2.5) with a digital pH Meter (McLean, 1982). Percent organic carbon (%OC) was determined by the dichromate oxidation method of Walkley and Black, 1934 (Nelson and Sommers, 1996). Organic matter (OM) was determined by multiplying %OC with the conventional van Bemmelen factor of 1.724.

Statistical Analysis

Soil data generated were subjected to analysis of variance for randomized complete design using Genstat discovery (Edition 4). Significant treatment means were separation using Least Significant Different (LSD) at 5% probability level.

Results and Discussion

Initial physical properties of the soil before land clearing are as shown in Table 1. Mean values of bulk density (BD), moisture content, total porosity and saturated hydraulic conductivity (Ksat) were 1.45 g/cm^3, 17.84%, 45.47% and 5.02 cm/hr, respectively.

The effect of different tillage methods and sampling depth and tillage method X sampling depth interaction on selected physical parameters is as shown in Table 2. Tillage method significantly ($P< 0.01$) affected bulk density, moisture content, total porosity and saturated hydraulic conductivity of the study soil. Significantly highest value of BD (1.35g/cm^3) was obtained in zero tillage. However secondary tillage recorded the lowest value of BD (1.16g/cm^3), results obtained indicate that primary and secondary tillage significantly reduce BD of the study soil. Moisture content (%) significantly varied due to tillage method in this order ST > PT > OT. Results obtained showed that tillage practice improved the moisture content (%) of the study soil being highest in secondary tillage, followed by primary tillage.

Tillage practices significantly ($P < 0.01$) influenced the total porosity of the study soil. Highest value (56.23%) was recorded in secondary tillage with the lowest value obtained on zero tillage (49.06%). This result showed that tillage practice improved the percent void space available to crops in the soil which increased as the bulk density of the soil reduced due to tillage.

Saturated hydraulic conductivity (Ksat) was significantly influenced by tillage practice. Highest value (11.21cm/hr) was obtained under secondary tillage, followed by zero tillage with (7.86cm/hr). This could be attributed to the improvement and maintenance of transmission pores in the soil in plots that received secondary tillage. The results, therefore, demonstrated the beneficial effect of soil loosening by tillage. Secondary tillage significantly improved all the physical parameters considered more than other tillage practices. This makes secondary tillage a necessary practice in Oforola soil.

Bulk density (BD) increased with depth, being higher at 7 – 14 cm (1.26 g/cm^3) than at 0 – 7 cm

(1.22 g/cm^3) (Table 2). Moisture content (%), total porosity (%), and saturated hydraulic conductivity (Ksat) (cm/hr) decreased with increase in soil depth. This could be attributed to increased BD at 7 – 14 cm soil depth. Lal (1979) reported that Ksat correlated negatively with BD and positively with total porosity.

Table 1. Initial properties of soils before clearing/treatment

Core sample	Bulk Density (g/cm^3)	Moisture Content M.C %	Total porosity (%)	Hydraulic Conductivity (cm/hr)
CS 0 – 7 cm	1.34	19.00	49.43	8.62
CS 7 – 14 cm	1.55	16.67	41.51	1.42
Mean value	1.45	17.84	45.47	5.02

Tillage x sampling depth interaction significantly (P < 0.01) influenced BD, moisture content, total porosity and Ksat (Table 2). Sampling secondary tillage plots at 0 – 7 cm produced the lowest reduction in BD of 1.11 g/cm3 and the highest improvement in moisture content (29.93%) and total porosity (58.11%). Secondary tillage plots sampled at 7 – 14 cm soil depth recorded the highest Ksat value of 12.92 cm/hr as opposed to 9.50 cm/hr obtained from 0 – 7 cm depth in secondary tillage plots. This deviation in 0 – 7 cm depth may be attributed to initial soil loosening, and that soil settling may have counteracted the effect of reduced BD.

Table 2. Effect of tillage practice and sampling depth (cm) on some selected soil physical parameters of Oforola Soil sampled at two soil depths after 2 months

Treatment	Bulk density (g/cm^3)	Moisture content (%)	Total porosity (%)	Ksat (cm/hr)
Tillage practice				
0T	1.35	17.05	49.06	7.86
PT	1.21	26.29	54.34	4.84
ST	1.16	29.20	56.23	11.21
LSD (0.05)	0.03**	0.04**	1.21**	0.25**
Sampling depth (cm)				
0 – 7 cm	1.22	24.37	54.09	6.33
7 – 14 cm	1.26	23.98	52.33	9.61
LSD (0.05)	0.03**	0.04**	0.98**	0.20**
Tillage practice x sampling depth interaction				
0T x 0 - 7 cm	1.38	15.17	47.92	9.74
0T x 7 – 14 cm	1.32	18.92	50.19	6.98
PT x 0 – 7 cm	1.16	28.01	56.23	0.76
PT x 7 – 14 cm	1.26	24.57	52.45	8.93
ST x 0 – 7 cm	1.11	29.93	58.11	9.50
ST x 7 – 14 cm	1.21	28.46	54.34	12.92
LSD	0.05**	0.07**	1.71**	0.35**

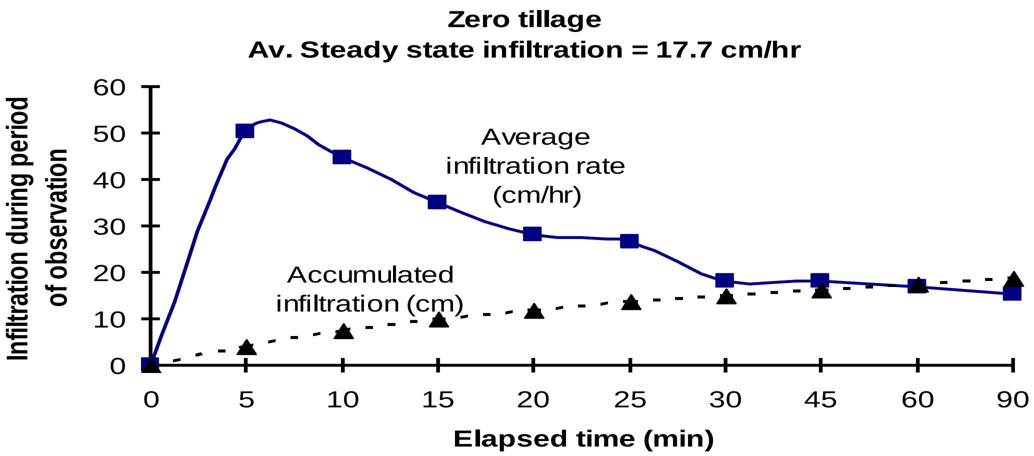
** = Significant at 1% probability level.

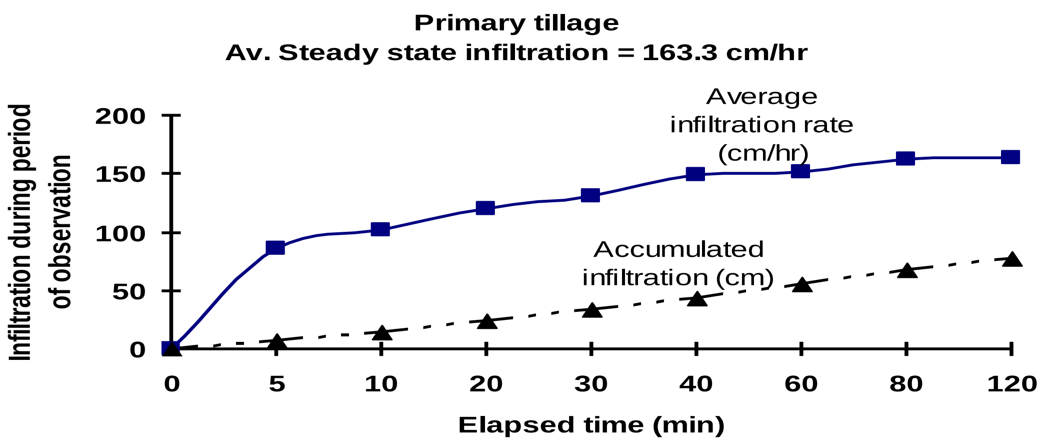
Table 3 showed the result of some selected soil physico-chemical properties as affected by the different tillage practice. The predominant particle-size fraction was sand, averaging more than 71%. Soil texture in all the tillage plots was loamy sand. This could be attributed to the parent material which is coastal plain sands of sandstone origin. Tillage practice significantly (P < 0.01) affected the sand content of the soil, which decreased as intensity of tillage increased, from primary to secondary tillage. Zero tillage plots recorded the highest sand content of 78%.

Tillage practice significantly (P < 0.01) increased soil acidity by 9.9 and 7.6% in primary and secondary tillage plots, respectively. This may be attributed to improved water movement down the soil profile and the attendant leaching loss of exchangeable bases.

Soil organic carbon (SOC) level increased remarkably by about 53.7 and 18.7% in zero tillage plots when compared with values obtained from secondary and primary tillage practices, respectively. The decline in soil organic carbon and soil organic matter in primary and secondary tillage plots could be attributed to cultivation, which exposed the stored SOC to degradation.

Average and accumulated infiltration due to tillage practice in soils of Oforola are as shown in Fig, 1. Average infiltration rate for zero tillage was high within the first five minutes of the start of the infiltration runs (up to 50 cm depth) and dropped till 30 minutes when it assumed a steady state. The accumulated infiltration had a gradual rise up to the period of 90 minutes. Zero tillage plots had an average steady state infiltration rate of 17.7 cm/hr. Primary tillage had an average steady state infiltration rate of 163.3 cm/hr which commenced at 80 min of the infiltration run. Secondary tillage showed an upward rise for average infiltration rate. Accumulated infiltration rose gradually and peaked at 120 mins. Average steady state infiltration rate of 155.7 cm/hr was obtained in secondary tillage plots which commenced at 45 min of the infiltration run. Low rate of infiltration in Zero tillage restricts water from entering the soil and it either ponds on the surface or runs off the land. Consequently, less water is stored in the soil profile for plants use. Human traffic on the Zero tillage plots may have compacted the soil, restricting entry of water into the soil. Relatively high OM recorded in Primary tillage plots may have increased the stability of soil aggregates in the plots and this was earlier reported by Anikwe (2006).





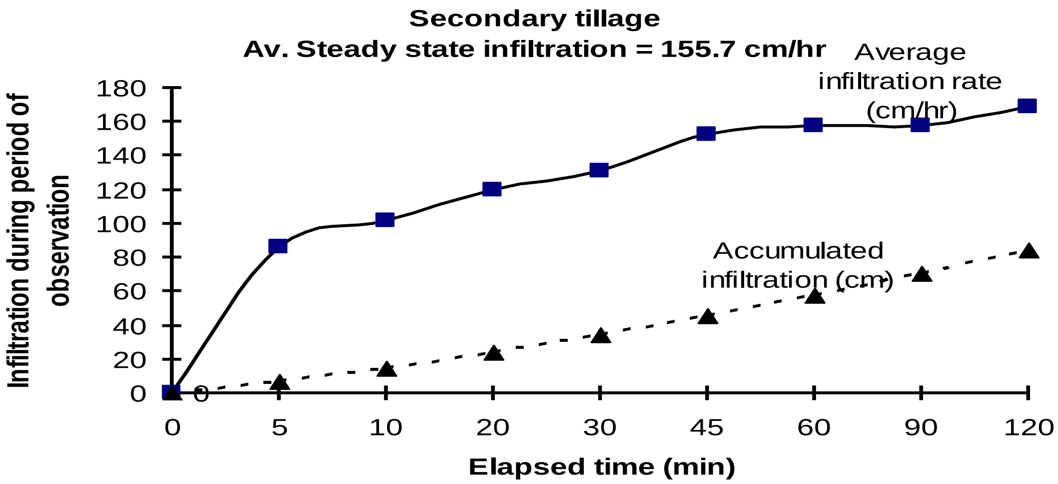


Fig. 1. Average infiltration rate (cm/hr) and accumulated infiltration (cm) obtained from Oforola soil due to tillage practice.

Conclusion and Recommendations

Conclusively, secondary tillage practice enhanced soil physical and chemical parameters studied better than zero and primary tillage practices. Based on the finding of this study we recommend that secondary tillage should be adopted in the study area to improve crop productivity. Government should sensitize farmers in the study area on the need to adopt secondary tillage instead of zero and primary tillage which have been their tradition.

Table 3: Selected soil physico-chemical properties of Oforola soil as influenced by tillage practice.

Tillage practice	Sand (%)	Silt (%)	Clay (%)	pH (H_2O)	Organic carbon (%)	Organic matter (%)
OT	78.60	6.00	15.40	5.67	2.03	3.50
PT	74.60	4.00	21.40	5.11	1.65	2.85
ST	71.60	8.00	20.40	5.24	0.94	1.62
LSD(0.05)	4.14*	NS	NS	0.09**	0.08**	0.15**

*,** = significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.

References

Adeoye, K. B. (1982). Effect of tillage depth on physical properties of a tropical soil and on yield of maize sorghum and cotton. Soil Tillage Research, 2; 225-231.

Anikwe, M. A. N. (2006). Soil quality assessment and monitoring: A review of current research efforts. Chapter Eight; Example Three, pp. 147-158.

Arakeri H.R. (1993). Soil management in India. Pg 26, Bombay Agricultural Research Institute, 1993.

Atkinson, B. S., Sparkes, D. L. and Mooney, S. J. (2007). Using selected soil physical properties of seedbed to predict crop establishment, Soil and Tillage Research, 97(2): 218-228.

Blake, G. R. and Hartage, K. H. (1986). Bulk density. In: Klute, A. (Ed). Methods of soil analysis, Part 1. Physical and Mineralogical Methods, American Society of Agronomy, Madison, Wisconsin, USA,

Day, P.R. 1965. Particle fractionation and particle-size analysisp.545-567. In C.A. Black et al (ed.) Methods of soil analysis, Part 1.Agronomy 9:545-567.

Enyioko,C.O., Obi,M .E And Eneje, R. C (2012). Soil Water Characteristics And Structural Stability Of A Typical Paleustult Under Different Vegetation Cover. Publication of Nasarawa State University, Keffi. Pp. 145-155

Genstat release 10.30DE (PC/Window 7) 04 December (2012). The Genstat discovery edition

used for educational or non-profit research purpose. Genstat procedure Library release PL18.2 http://discovery.genstat.co.uk.

Gupta, J. P. (1986). Effect of tillage and mulch on soil and the growth and yield of cowpea grown in the arid tropics. Arid Soil Research and Rehabilitation Volume 1, Issue 3, 1987

Hamblin, A.P. (1985). The influence of soil structure on water movement, crop root growth, and water uptake. Adv. Agron. 38:95–158.

Jabro, J. D., Stevens, W. B., Evans, R. G and Iversen, W. M. (2009). Tillage effects on physical properties in two soils of the Northern Great Plains. Applied Engineering in Agriculture 25, 377-382.

Klute, A. (1986). Laboratory measurement of hydraulic conductivity of saturated soil: Methods of Soil Analysis. Eds. C. A. Black et al., 1, Agro. 9: 210 – 221.

Lal R (1979). Physical characteristics of soils of the tropics: determination and management. In: Soil physical properties and crop production in the tropics. R. Lal and D.J. Greenland (eds.), John Wiley and Sons, Chichester, pp. 7-46.

Licht, M. A. and Al-Kaisi, M. (2005). Strip-tillage effects on soil temperature and other soil physical properties. Soil and Tillage Research 80, 233-249.

Lugo, Lopez, M. A., Wolf, J. M. and Perez Escolar, R. (1981). Water loss, intake, movement retention and availability in major soils of Puerto Rico. University of Puerto Rico Bulletin 264. pp 7-8.

Mclean, E.O. 1982. Soil pH and line requirements. In Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. Ag. Monograph No. 9, 2nd edition.

Nelson, D. W. and Sommers, L. E. (1996). Total carbon, organic carbon and organic matter. In: Methods of Soil Analysis, Part 2, 2nd ed., A.L. Page et al., Ed. Agronomy. 9:961-1010. Am. Soc. Of Agron., Inc. Madison, WI.

Tollner, E. W. Hargrove, W. L. and Laongdale, G. (1984). Influence of conventional and no-till practices on soil physical properties in the southern Piedmont. Journal of Soil and water conservation. 39: 72-76.

Uwakwe, F. E. and Iwuala, M.O.E. (2012). Studies on the Characteristics and Public Health Implications of Waste Dumpsites in Owerri, Imo State, Nigeria. International Journal for Environmental Health and Human Development. Vol 3(2)pp. 1-11.

Walkley, A. and I.A. Black, (1934). An Examination of the Degtjareff Method for Determining Soil Organic Matter and Proposed Modification of the Chromic Acid Titration Method. Soil Sci. 37:29-38.

Wood, J.C., Wood, M.K and Tromble, J.M., (1987). Important Factors Influencing Water Infiltration and Sediment Production on Arid Lands In New Mexico. Arid Environs. 12:111-118.