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Effect of Tillage on Soil Physico-Chemical Properties in South-Western Nigeria

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ABSTRACT

Intensive tractorized tillage practices especially in the tropical and subtropical climate produces compaction in crop root zone; degradation of soil quality; loss of organic matter and declining soil and crop productivity. The effects of tillage on soil physical and chemical properties, on an intensively mechanized and degraded Alfisol classified as clayey skeletal Oxic-Paleustalf (USA, 1999) was conducted during the 2013 major crop growing season in a farm located in South-Western Nigeria; the soil texture in the farm is loamy and it was a rain-fed agriculture. Soils samples were randomly taken from the farm (after second ploughing) and also undisturbed soil from adjoining forest, at depths of between 0 and 15 cm; moisture content, bulk density, porosity, pH, soil organic matter, total organic carbon, available P, exchangeable bases (K, Ca, Na, Mg), extractable micronutrient (Fe, Mn, and Zn) were determined. From the results obtained there were significant effects of the tillage operations on the parameters measured when compared with those from the control site; these were higher at the control site than the farm site, indicating that tillage operation considerably degrade soil, with the highest effects being on soil organic matter, total organic carbon, K, Ca, Mg, exchange acidity, Fe, moisture content and porosity. These are in spite of the moderate level of tractorization in the farm from where the samples were taken. It is concluded that environmental control measures should be put in place even in the farms operating under low level mechanization.

Keywords: *Degradation, environmental control, micro and macro nutrient, soil, tillage, physico-chemical*

INTRODUCTION

Tillage is the mechanical manipulations of soil to keep it loose for plant growth and free from weed during the growth of plant while its fundamental purposes include: preparing suitable seed bed for plant growth, destroying competitive weed and, improving the physical condition of soil. Soil tillage management can affect factors controlling soil respiration, including substrate availability, soil temperature, water content, pH, oxidation-reduction potential, kind and number of microorganisms, and the soil ecology (Robinson *et al*., 1994, Kladivko 2001). Tillage affects the physical, chemical and biological properties of soils as observed from research results on soils in several parts of Africa where it was seen to affect soil aggregate, temperature, water infiltration and retention (Ofori 2009); while the unfavourable effects on microorganisms and earthworms are well established, these microorganisms, earthworms and others are disturbed and several are killed during tillage especially tillage using heavy equipment. According to Unger *et al*, (1991) the two practices with major impact on soil conservation are crop residue management and tillage; traditional ploughing-in of crop residues is now giving way to surface soil residue management which is more related to soil and water conservation, particularly in the semi-arid tropics. Although tractorization in South-Western Nigeria is minimal, there is the need to determine whether even this limited application have noticeable effects on soil in the area, hence the objective of this study was to determine the effects of tillage operations on soil properties.

MATERIALS AND METHODS

Study Site

The study area is in Ilora, Afijio Local Government Area of Oyo State, Nigeria; its geographical coordinates are on latitude 7° 48' 0'' North and longitude 3º 54' 0'' East. The average daily temperature in the study area ranges between 25 °C and 35 °C while the rainfall over the State varies from an average of 1200 mm to 1800 mm at its peak in the southern and between 800 mm and 1500 mm at the northern part of the state. The experiment was conducted during the 2013 major crop growing seasons with the experimental plots located on a well-drained sandy loam soil, an Alfisol classified as clayey skeletal Oxic – Paleustalf (USA, 1999).

Experimental Design

The experiments were arranged in a randomized complete block design with two tillage treatments consisting of zero tillage and second disc ploughing. Six soil samples were randomly collected; three from the site and three from the adjoining forest (zero tillage).

Samples and sampling Technique

Soil samples were randomly collected three from the farm and three from zero tillage area; each of the soil samples was taken at a depth of between 0 to15 cm using a soil auger after clearing with cutlass. The sharp end of the soil auger was carefully screwed into the soil in a vertical position with uniform entry to the desired depth. The samples were transferred to a tray for homogenizing before storing in sample bags; Precaution was taken to ensure that the samples were not taken near the roots of large trees, roads, foundations of buildings or constructions. Samples were also not taken near piles of manure, compost, lime or harvested crops. The precaution was taken so as to avoid contamination of the samples and compaction within sample points. Each sample was labeled immediately after collection and taken to the laboratory for analysis.

Determination of Soil Properties

The moist soil sample were oven-dried at 103 ± 2 °C until constant weight was attained in accordance with ASABE Standard, (2008); the moisture content was calculated as the weight of moisture in the soil sample divided by the weight of the oven dry soil. Bulk density values were evaluated using the ratio of weight of each oven-dried soil sample per unit volume of the soil corers (Blake and Hartage (1986). Total porosity was calculated from the values of the dry bulk density and an assumed particle density of 2.65 $Mg.m^{-3}$ (Chancellor, (1994). Samples of soil collected were analyzed in the laboratory for chemical constituents and properties; these include pH, soil organic matter, total organic carbon, available P, exchange bases (K, Ca, Na and Mg), exchangeable acidity and micronutrients (Fe, Zn, Mn). Soil pH was determined in soil-water medium at ratio 1:1 using the Coleman's pH meter; particle size analysis was carried out using hydrometer method according to the method of Bouyoucos, (1951). Soil organic carbon (SOC) was determined by the Wakley and Black procedure according to Nelson and Sommers, (1982); soil organic matter was estimated as organic carbon multiply by 2.724 Odu *et al.* (1986), available (P) by Bray's P1 method (Bray and Kurtz, 1945) and read on the atomic absorption spectrophotometer, while exchangeable cations (K, Ca, Na and Mg) were first extracted using the method of Jackson, (1958), thereafter, K, Na and Ca were determined by the flame photometer while Mg was read from the Atomic Absorption Spectrophotometer (AAS). Micronutrients (Fe, Zn and Mn) were extracted with sodium bicarbonate and their concentrations determined on the AAS; titration method was used to determine exchangeable acidity as described by Yuan (1959).

RESULTS AND DISCUSSION

Soil Properties

The mean of soil chemical and physical properties for samples taken from the two sites (site A and control site B) are presented in Table1. Soil samples from both sites were acidic with low soil organic matter at the site. The total organic carbon was higher at the control than at the site. The percentage of available P was higher at the site and lower at the control. The percentages of exchangeable bases were all also generally lower at the site except sodium which recorded the higher percentage while the control recorded the higher percentage that is Potassium, Calcium, and Magnesium respectively. The percentage of extractable micronutrients Mn and Zn were higher at the site except Fe which recorded the lower percentage. The percentage of exchangeable acidity was higher at the control site than site A. The soils at the sites were sandy-loam soil.

Table1. *Mean Values of physical and Chemical Properties Constituent of Soils on Sites A and B*

Soil Properties	Unit	Site		% Diff
		A	B	
PH		5.45	5.30	+2.75
Soil Organic Matter	g/Kg	29.76	40.01	−34.44
Total Organic Carbon	g/Kg	17.26	23.21	−34.47
Available P	mg/Kg	51.30	21.72	+57.66
Exchangeable K	cmol/Kg	0.38	0.40	−5.26
Exchangeable Ca	cmol/Kg	1.24	2.48	−100
Exchangeable Na	cmol/Kg	1.27	1.22	+3.94
Exchangeable Mg	cmol/Kg	0.95	1.38	−45.26
Exchangeable acidity		0.28	0.43	−53.57
Fe	mg/Kg	55.45	64.75	−16.77
Zn	mg/Kg	5.67	3.49	+38.45
Mn	mg/Kg	202	86.60	+57.13
Moisture Content	%	13.99	22.65	−61.90
Bulk Density	mg/cm^3	0.42	0.38	+0.10
Porosity	%	22.04	23.47	−6.9
Sand	g/Kg	778	798	−2.57
Silt	g/Kg	94	104	−10.64
Clay	g/Kg	128	98	−23.44
Textural Class		Sandy-loam	Sandy-loam	

Soil Physical Properties

The percentage of dry bulk density produced by tractorized plot (after second ploughing) was higher than that of the site B. This is expected as the level of compaction itself is an indication of the pressure on microorganisms in the soil causing their death. Soil compaction causes three problems, viz, killing of microorganisms, moisture removal and difficult root penetration; these are factors which affect plant growth and yield, this is line with the findings of Ojeniyi and Agboola (1995) which reported that repetitive tillage degraded soil qualities and caused rapid collapse of soil structure. In the sub-humid and humid regions of the tropics, the high intensity rainstorms tend to increase the loosening effects of tillage. Intensive soil cultivation which may increase soil bulk density is intimately connected with reduced porosity and the alteration of pore size distribution (Ojeniyi 1990). Even in the site examined, with relatively moderate level mechanization there was loose low porosity.

Soil moisture, a source of water for plant use particularly in rain fed agriculture is highly critical in ensuring good and uniform seed germination and seedling emergence (Arsyid *et al*. (2009), crop growth and yield. The No-tillage plot recorded higher percentage of soil moisture content than that of second ploughing plot, this is in line with the result of the studies conducted on an Afisol, in South-Western Nigeria by Ndaeyo *et al*. (1995) which indicated that zero tillage had higher soil moisture content in the profile than ploughed plots attributed to the soil moisture reserve through rainstorm amelioration. The zero tillage plots recorded higher percentage of total porosity of 1.43% higher than that of the ploughed plot, which produced the lower percentage of total porosity, this is in accordance with the observation of Ahn and Hintze (1990) in their work that tillage practices lowered porosity due to decline in organic matter and weakening of soil structure.

Soil Chemical Properties

The pH of the soils studied was strongly acidic, and the order of increase is the zero tillage site (site B) less than that of the ploughed site (site A); the strongly acidic nature of the soils could be attributed to high cropping intensity which result to the assimilation of most of the basic cations by the crops and moderate rainfall that causes leaching. Organic matter plays a major role in soil physical, chemical and biological properties and acts as a source of nutrients, which increase nutrients exchange of the sites and also affecting the fate of applied pesticides (Alabandan *et al*., 2009); it may form natural chelates aiding in maintaining iron in a soluble form. The site B had the higher percentage of soil organic matter content that provides more available boron to plants, but decreases copper availability due to strong bonding of copper to organic matter and may possibly tie up manganese into unavailable organic complexes, while low organic matter soils are low in boron and often low in zinc, especially sandy soils. The percentage of organic carbon recorded at site A was lower than that of the control site B. This could be attributed to the effect of continuous cultivation that aggravates organic matter oxidation. These results are in agreement with the findings of Negassa (2001) and Malo *et al*. (2005) that both reported less organic carbon in cultivated soils than grassed soils. Exchangeable bases (K, Ca and Mg) where generally lowered at the site A except Na which recorded a higher percentage; the decline in the nutrient reserve of tilled soils (after second ploughing) could be adduced to the destruction of soil structure during land preparation which intensified soil erosion (soil wash) that preferentially removed colloidal fraction with high "enrichment ratio" resulting in a progressive depletion of its nutrient reserves in line with Agbede (2008) and Agbede and Ojeniyi (2009) findings, and low exchangeable Ca and Mg observed on tilled plot might be due to leaching, soil erosion and crop harvest as reported by Negassa (2001). On the other hand, available phosphorus was found to be greater in site A, this might have been influenced by the soil pH since the availability of phosphorus and its solubility is pH dependent in accordance to the observation of Ozubor and Anoliefo (1999) that soils with low pH value result in the reaction of phosphorus with aluminum and iron to form complex compound such as aluminum phosphate (Al_3PO_4) and iron phosphate ($FePO_4$), which are fixed in the soil and not readily available for plants.

Micronutrients, Zn and Mn recorded the higher percentage on the tilled site, while Fe recorded the higher percentage on the zero tillage site; Zn is known to synthesize tryptophan, a protein compound needed for the production of growth promoting hormones called auxins. Amount of Zn available in the soil is affected by soil pH, soil texture, soil phosphorus, and weather conditions while its availability to plant decreases as soil pH increases and become deficient in soils with a pH above 6.5 this is in accordance to Negassa (2001) who observed that low Zn concentration in tillage plot might be due to continuous harvesting of crop, organic matter oxidation, removal of the topsoil by sheet and rill erosion that is aggravated by tillage activities. Manganese (Mn) like Mg promotes enzyme transformations and its availability in soils is affected by soil pH, organic matter content, soil moisture, and soil aeration. Iron is essential for synthesis of chlorophyll, the green color of plants which functions in photosynthesis but it is not part of chlorophyll molecule; its decrease in the soil solution is as result of increase of soil pH, while the decreases observed in some micro-nutrients may be attributed to loss of soil organic matter which has been reported to correlate very well with soil micro-nutrient.

Conclusions

Results from this study revealed that tillage practices resulted in the decline of soil macro and micro nutrients, higher declines were observed after second disc ploughing plot. The reduction in Ca, K and Mg are reflected by the decline in soil organic carbon in mechanically tilled plot due to rapid breakdown and mineralization of the soil organic carbon. The reduction observed in some of the micro-nutrients (Fe, Zn and Mn) may be attributed to loss of soil organic matter. The higher moisture status of zero tillage sites could be adduced to the minimum soil disturbance with little exposure of the soil surface to the atmospheric demand and consequent reduction in soil water. The result of this study showed that zero tillage was the most productive soil. It is hereby concluded that even where low to moderate level mechanization are employed, observable level of soil degradation were found; it is therefore necessary that precaution need to be taken even in farms in this category.

Recommendations

The following recommendations are made with due considerations to the above findings:

1. Since tractorization depletes soil and chemical status, it is advisable that the use of tractors be limited to minimum in small farms. Mounds or ridges can be made across the slope and these must be tied by cross checks. The soil should be covered immediately with cover or other crops while soil conservation measures should be adapted;
2. If tractorization is inevitable, as in large farms, available data on land use classification should be used and the recommended land use planning adhered to;
3. Inappropriate tillage operations over a long time impede sustainable soil and crop productivity; it is imperative that the operator be very conversant with the requirements of his job; and
4. Zero tillage still remains the best, as soil integrity is preserved, however, there is need to develop tools and labour management

techniques that will boost crop and soil productivity under zero tillage.

References

[1] Agbede, T. M. (2008). Nutrient Availability and Cocoyam Yield under Different Tillage Practices. *Soil Tillage Research*; 99: 49 - 57.

[2] Agbede, T. M. and Ojeniyi, S. O. (2009). Tillage and Poultry Manure Effects on Soil Fertility and Sorghum Yield in Southwestern Nigeria. *Soil Tillage Research*; 104: 74 - 81.

[3] Ahn, P. M. and Hintze, B. (1990). Zero tillage, Minimum Tillage, and their Influence on Soil Properties. IBSRAM Proceedings; 10: 341 - 349.

[4] Alabadan, B. A. Adeoyo, P. A. Folorunso, E. A. (2009). Effect of Different Poultry Wastes on Physical, Chemical and Biological Properties of Soil. *Caspian J. Environ. Sci*. 7(1): 31 - 35.

[5] Arsyid, M. A, Camacho, F. T. and Guo, P. (2009). Corn Basics: Core Crop Management, Available Online: http://www.dekalb-CornCro Management.pdf

[6] ASABE Standards (2008). ASAE S358.2 DEC1988 (R2008): *Moisture Measurement-Forages*. ASABE St. Joseph, Michigan.

[7] Blake, G. R. and Hartage, K. H. (1986). Bulk Density. In: A.K. Klute (editor) Methods of Soil Analysis Part 1. Physical and Mineralogical Methods pp.363-375. Madison, WI. *America Society of Agronomy/ Soil Science Society of America.*

[8] Bouyoucos, G. H. (1951). A Recalibration of the Hydrometer Method for Making Mechanical Analysis of Soil. *Agronomy Journal*, 43: 434 - 438.

[9] Chancellor, W. J. (1994). *Advances in Soil Dynamics: Volume 1, Chapter 2*, ASAE, St. Joseph, Michigan.

[10] Jackson, M. L. (1958). *Soil Chemical Analysis*. Prentice-Hall, Inc. Englewood, New Jersey.

[11] Kay, B. D. and VandenBygaart, A. J. (2002). Conservation, Tillage and Depth Stratification of porosity and Soil Organic Matter, *Soil & Tillage Research;* 66(2): 107 - 118.

[12] Kladivko E. J. (2001). Tillage Systems and Soil Ecology. *Soil Tillage. Research*; 61: 61 - 76.

[13] Malo, D. D. Schumacher, T. E. Doolittle, J. J. (2005). Long-term Cultivation Impacts on Selected Soil Properties in the Northern Great Plains. *Soil Tillage Research*; 81: 277-291.

[14] Ndaeyo, N. U., Aiyelari, E. A. and Agboola, A. A (1995). Evaluation of Different Tillage Practices for Monoculture Cowpea *(Vignaunguiculata* (L.) Walp) Production in Ibadan, Southwestern Nigeria. *African Soils;* 28: 475 - 488.

[15] Negassa, W. (2001). Assessment of Important Physicochemical Properties of Nitosols under Different Management Systems in Bako Area, Western Ethiopia. *M.Sc. Thesis, Alemaya University, Alemaya*.p. 109.

[16] Nelson, D. W. and Sommers, L. E (1982).Total Organic Carbon and Organic Matter. In: Methods of Soil Analysis Part 2: Agronomy Monograph 9: ASA, Madison WI: 539-594.

[17] Odu, C. T. I., Babalola, O., Udo, E. J., Ogunkunle, A. O., Bakare, T. A. and Adeoye, G.O (1986). *Laboratory Manual for Agronomic Studies in Soil, Plant and Microbiology*. Department of Agronomy, University of Ibadan, Nigeria. 83p.

[18] Ofori, C. S. (2009). The Challenge of Tillage Development in African Agriculture. Soil Resource, Management and Conservation Service, Land and Water Development Division, FAO, Rome. *Soil Tillage in Africa*; **7:** 1 - 2.

[19] Ojeniyi, S. O. (1990). Effect of Bush Clearing and Tillage Method on Soil Physical and Chemical Properties of Humid Tropical Alfisol. *Soil Tillage Research*; 15: 269 - 277.

[20] Ojeniyi, S. O. and Agboola, A. A. (1995). A Review of Tillage Requirement of Food Crops in Africa. *African Soils*; 28: 259 - 266.

[21] Ozubor, C.C. and Anoliefo, G.O. (1999). Inhibition of Germination and Oxygen Consumption of Cucumeropsis Manni Naudin by Nigerian Crude Oil. *Journal of Evironmental Science and Health;* 2(1): 39 - 42.

[22] Rasmussen, K. J. (1999). Impact of Ploughless Soil Tillage on Yield and Soil Quality: A Scandinavian Review, *Soil & Tillage Research*; 53(1)**:** 3-14.

[23] Robinson, C. A., Cruse, R. M., and Kohler, K. A. (1994): Soil Management. In: Hatfield J.L., Karlen D.L. (eds.): Sustainable Agricultural Systems. Lewis Publ., Boca Raton, FL: pp. 109 -134.

[24] Unger, P. W., (1991). Overwinter Changes in Physical Properties of No-tillage Soil. *Soil Science Society of American Journal;* 55: 778 - 782.

[25] Yuan, T. L. (1959). Determination of Exchangeable Hydrogen in Soil by a Titration Method. *Soil Science*; 88**:** 164 - 167.

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