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Influence of oil palm cultivation on topsoil properties in Nigerian institute for oil palm research, Akwa Ibom State.

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ABSTRACT

The thin layer of soil covering the surface of the earth represents the difference between survival and extinction for most land-based life. Four oil palm blocks of varying ages: 57 years (B-57), 39 years (B-39), 17 years (B-17), and no oil palm block (B-0), which served as the control, were identified and used for the study. The result showed that in B-0, B-17, B-39 and B-57; 7 (22.58%), 10 (32.26%), 8 (25.81%) and 5 (16.13%) soil properties, out of the 31 soil properties, had higher values when compared to one another respectively. Also, the means of the topsoil depths for the different blocks was: B-0 (30cm), B-17 (23cm), B-39 (24cm) and B-57 (28cm). The result showed that oil palm influenced most of the topsoil properties in the study area, especially in B-17, compared to the no oil palm block. B-17 had the highest mean values in most topsoil properties, followed by B-39, B-0 and B-57. The topsoil depth also increased with the age of the oil palm. This has shown that the age of oil palm had a major influence on the topsoil depth and their properties. Oil palm, can be used as a soil management technique seeing it improves soil status with time.

1.0 Introduction

Soil is a critically important component of the earth' biosphere, functioning not only in the production of food and refibre but also in ecosystem function and the maintenance of local, regional and global environmental quality (Gebreyesus, 2014). Soil is the basis of agricultural and natural plant communities. Thus the thin layer of soil covering the surface of the earth represents the difference between survival and extinction for most land-based life. However, inventories of soil productive capacity indicate human-induced degradation of nearly 40% of the world's agricultural land due to soil erosion, atmospheric pollution, extensive soil cultivation, overgrazing, land clearing, salinization, and desertification (Sample, 2007). Oil palm cultivation can influence soil properties such as structure, aggregation, aggregate stability and overall soil health can be (Castro et al., 2002; Ovie *et al*., 2013). Irrespective of the gross development, oil palm cultivation has been seen as the culprit of deforestation and cause of biodiversity (Fitzherbert *et al*., 2008; Koh and Wilcove, 2008; Brul and Eltz, 2010; Edwards *et al*., 2010). In particular, mechanical cultivation and the continuous production of the row crops have resulted in physical loss of soil, displacement through erosion, and significant decrease in soil organic matter content with a concomitant release of CO_2 to the atmosphere. Further, the projected doubling of the human population in the next century threatens the accelerated degradation of soils and other natural resources (Gebreyesus, 2014). Thus, to preserve agriculture for future generations, we must develop production systems that conserve and enhance soil quality.

The study area, Nigerian Institute for Oil Palm Research, is located in Oruk Anam Local Government Area, Akwa Ibom State, Nigeria, and constitutes most of the coastal plain sands parent material. Coastal plain sands are primary parent material in Akwa Ibom State, Southeastern Nigeria. It is characterized by low pH, low base saturation (<50%), low cation exchange capacity and is mostly sandy. Several studies have examined the ecological requirements and environmental impact of oil palm on soil (Irvine 1969; Onwueme & Sinha 1991; Aweto and Ekiugbo 1994; Aweto and Enaruvbe 2010). This study examines the influence of oil palm cultivation on topsoil properties in NIFOR Akwa Ibom State. Topsoil is described as the soil on the earth's surface, which ranges from 0– 30 cm of the soil profile, and they contain most of the soil nutrients suitable for arable crops. The objectives used for the study includes: (i) to characterize some of the soil properties available in the topsoil, under oil palm cultivation in the study area, and (ii) to evaluate the influence of oil palm on the topsoil properties in the study area

2.0 Materials and Methods.

2.1 Description of the Study Location.

Nigerian Institute for Oil Palm Research (NIFOR) substation Ibesit Ekoi in Oruk Anam Local Government Area of Akwa Ibom State Nigeria. Oruk Anam Local Government Area, which is bounded by latitudes 4°'45' and 5°'00' N and longitudes 7°'30' and 7°`45' E was the study site. Oruk Anam Local Government Area falls within the area covered by coastal plain sands. Coastal plain sands soils are dominantly sandy with low organic matter content, clay, and pH and have a deep profile (Udoh, 2003).

The area is of the humid tropical climate, which is characterized by heavy rainfall with a mean annual rainfall of about 4000 mm and a mean annual temperature of 27°C. It has high relative humidity and cloud covers, resulting in low incipient solar radiation. Quaternary sedimentary deposits, forms the soils of the area. Also, the area has primary topographic units: Alluvial plains (mangrove and flood plains), beach ridge sands and sandy plains (Udoh, 2003). The area is of the forest vegetation in the tropical forest zone.

2.2 Field Studies

Four oil palm blocks of varying ages: (i) 1960-2017 (B-57); (ii) 1978 -2017 (B-39); (iii) 2000-2017 (B-17), and no oil palm block (B-0), which served as the control were identified in the Nigerian Institute for Oil Palm Research (NIFOR) sub-station located at Ibesit Ekoi in Oruk Anam Local Government Area of Akwa Ibom State, Nigeria, and used for the study. The NIFOR plantation covers an area of 286 hectares. The area covered by each block was 5.8 ha (B0), 5.2 ha (B-17), 5.0 ha (B-39) and 5.75 ha (B-57). The oil palm plantation of 57 years, was selected because it was the oldest palm in the NIFOR plantation as of 2017 and had far past the expected age of replacement of oil palm stand (35 years) as reported by Ukwuteno *et al*. (2012). The available palm block, which was a little, past the suggested age for replacing oil palm (35 years), was the oil palm block of 39 years, that was selected too. The age of optimum yield of oil palm is 15-20 years (Verheye, 2010). The 17-year-old palm was selected because it falls within this range. While the no-oil palm block (B-0), was used as the control.

Representative positions for profile pits were selected using the free survey method. To maintain uniformity in topography, the profile pits were sunk along the middle slope in each of the four blocks. Twelve profile pits were used for the study, with three profile pits in each of the four blocks (B-57, B-39, B-17 and B-0). Top Soils were sampled according to how they appeared in the profile pits making a total of 12 samples collected for the study. The soil samples collected were air dried, sieved with a 2mm mesh sieve and analyzed in the laboratory.

2.3 Laboratory analysis

Particle size distribution was determined by the hydrometer method using the procedure of Gee and Or (2002). Bulk density was estimated by the method of Grossman and Reinsch (2002). Total porosity was calculated using the formulae Porosity = 1- e_b/e_s. Moisture Content was determined from the difference between the weight of wet core samples and the weight of oven-dried core samples, dried to a constant weight at a temperature of 105°C. The difference was divided by the weight of oven dried sample and multiplied by a hundred. Moisture content was expressed in percentage (Udo *et al*., 2009). Saturated hydraulic conductivity was determined with the constant head permeameter as described by Topp and Dane (2002). Mean weight diameter (MWD), as an indicator of aggregate stability using the wet and dry sieving method described by Grossman *et al*. (1996) as modified by Edem and Edem (2008), was determined using sieve sizes of 2.0mm and 1.0 mm, 0.5 mm and 0.25 mm in diameter.

Soil pH was determined using the pH meter (2603 model) and read at a soil: water ratio of 1:2.5 (Thomas, 1996). Available phosphorus was determined by Bray P-1 extractant and P in the extract was determined using the Murphy and Riley method described by Udo *et al*. (2009). Exchangeable acidity (H and Al^3), was extracted with 1NKC1 potassium chloride solution and titrated with 0.02 M solution of sodium hydroxide to the first permanent pink endpoint described by Mclean (1982). Organic carbon was measured by Walkely and Black Wet digestion method (Nelson and Sommers, 1982). Total Nitrogen was determined by the micro Kjeldahl digestion and distillation method as described by Udo *et al*. (2009). Exchangeable bases were extracted with neutral normal ammonium acetate buffered at pH 7.0 (Thomas, 1982). Potassium (K^+ and sodium (Na^+) content were read with the aid of a flame emission spectrometer (FP640), while calcium (Ca^2+) and magnesium (Mg^{2+}) were determined by the EDTA complexometric titration method (Thomas, 1982). Effective cation exchange capacity (ECEC) was determined by the summation of the exchangeable bases and exchangeable acidity. Base saturation was estimated as a sum of exchangeable basic cations divided by ECEC and multiplied by 100%. Electrical conductivity was measured in the extract obtained from 1:2.5 soil: water suspension using a conductivity bridge (Richard, 1965). Micronutrients (Cu, Mn, Fe, Zn), the soil samples were digested with perchloric and nitric acid and extracted, and the extracts were read using the Atomic Absorption Spectrophotometer. (UNICA 936 model) (AOAC, 2005). Microbial respiration rate (MR) was measured using the Draeger- Tube method described by Doran *et al*. (1996). Bacteria density was determined using method by Nester *et al,* (2006).

2.4 Statistical Analysis

The statistical analysis used was descriptive statistics to evaluate the mean, minimum and maximum values. Also, Analysis of Variance (ANOVA) was used to compare the differences in topsoil characteristics among the blocks in the study location.

3.0 Results and Discussion

3.1 Top Soil Properties under Oil Palm Cultivation of Different Ages

The result of the topsoil properties in the four blocks of the study area (B-0, B-17, B-39, B-57) are presented in Table 1.

The result

showed that in B-0, 7 (22.58%) out of the 31 soil properties had higher values than the oil palm blocks. The soil properties include coarse sand, total sand, base saturation, Magnesium, Sodium, C: N and respiratory rate. Similarly, B-17 had 10 (32.26%) out of the 31 soil properties, which had higher values than the other blocks. The soil properties include hydraulic conductivity, total porosity, moisture content, zinc, manganese, pH (KCl), pH (H_2O), organic carbon, calcium and bacterial density.

Table 4.1: Means of topsoil properties in the four blocks of the study area

Soil properties	Unit	0 Years	17 Years	39 Years	57 Years
Ks	(cm/min)	1.93	2.64	0.80	1.45
BD	(g/cm^3)	1.36	1.27	1.35	1.40
TP	(%)	48.67	52.33	49.33	47.33
Clay	(g/kg)	59.33	86.67	93.33	120.00
Silt	(g/kg)	47.33	31.80	94.00	60.67
f/sand	(g/kg)	68.00	62.00	76.00	73.33
c/sand	(g/kg)	825.33	581.47	740.00	746.00
T/sand	(g/kg)	893.33	879.33	716.00	520.33
MWD-dry	(mm)	0.72	0.82	1.40	0.88
MWD-wet	(mm)	0.69	0.65	0.74	0.70
MC	(%)	16.03	17.10	12.39	13.82
Chemical Properties					
Exch. Ca	(cmol/kg)	3.96	4.41	3.63	3.58
Exch. Mg	(cmol/kg)	1.73	0.63	1.60	1.61
Exch. K	(cmol/kg)	0.15	0.17	0.18	0.16
Na	(cmol/kg)	4.94	1.34	1.20	1.17
E/A	(cmol/kg)	0.87	0.93	2.70	1.67
OC	(%)	0.75	1.99	0.51	0.71
pH (H_20)		5.44	5.52	5.27	5.19
pH (KCl)		4.76	5.09	4.57	4.49
EC	(ds/m)	No observation			
TN	(%)	0.19	0.16	0.12	0.25
C/N		33.14	15.10	7.49	2.79
Av. P	(mg/kg)	2.27	6.63	5.40	6.67
B.sat	(%)	88.86	87.62	71.23	79.71
ECEC	(cmol/kg)	7.98	7.48	9.35	8.19
Biological Properties					
Bac. D	($cfug/x10^5$)	7.00	7.10	6.37	6.00
RR		3.85	3.17	3.50	3.00
Micro Nutrient Elements					
Zn	(mg/kg)	2.06	10.73	2.52	5.23
Cu	(mg/kg)	0.78	0.90	0.37	1.28
Mn	(mg/kg)	8.23	13.38	2.60	5.86
Fe	(mg/kg)	56.60	79.43	93.70	69.83
Topsoil depth	(cm)	30	23	24	28

Source: Field data, (2017).

OC=Organic Carbon, TN= Total Nitrogen, Av.P= available Phosphorus, Exch.Ca= exchangeable Calcium, Exch. Mg= exchangeable Magnesium, Exch. Na= exchangeable Sodium, Exch. K= exchangeable Potassium, ECEC= effective cation exchange capacity, EA= exchangeable acidity, Bsat= base saturation, EC= electrical conductivity, Fe= Iron, Zn= Zinc, Cu= Copper, Mn= Manganese, BD= bulk density, MC= moisture content, MWD= mean weight diameter, TP= total porosity, Ks= saturated hydraulic conductivity, Bac. Dens= bacterial density, RR= respiratory rate, C/sand= coarse sand, T/sand= total sand, F/sand= fine sand, C/N= Carbon to Nitrogen ratio.

Furthermore, in B-39, 8 (25.81%) out of the 31 soil properties, which were: silt, fine sand, MWD(wet), MWD (dry), Iron, Potassium, exchangeable acidity and effective cation exchange capacity, had higher values compared to other blocks. In B-57, 5 (16.13%) out of the 31 soil properties (bulk density, clay, Copper, Nitrogen and available Phosphorus) had higher values than the other blocks. Also, the mean of the topsoil depths for the different blocks as follows: B-0 (30cm), B-17 (23cm), B-39 (24cm) and B-57 (28cm).

The result showed that oil palm influenced most of the topsoil properties in the study area, especially in B-17, compared to the no oil palm block. B-17 had the highest mean values in most topsoil properties, followed by B-39, B-0 and B-57. The topsoil depth also increased with the age of the oil palm. That is to say, the longer the oil palm stayed on the soil, the more the topsoil depth increased.

The result has shown that the age of oil palm had a significant influence on the topsoil depth as well as their properties. This corresponds with the findings of Ogeh and

Osionwan (2013), that the ages and species of oil palm can have a significant influence on the characteristics of soil properties.

Therefore, time can be a significant factor in the management of these soils. Also

cultivation of oil palm and leaving the palm longer on the soil can improve soil nutrients.

References

AOAC (Association of Official Analytical Chemists) (2005). *Methods of Analysis*. 12th Edition. Association of Official Analytical Chemists, Washington DC, 79p.

Aweto A.O. and Enaruvbe G. O. (2010). Catenary Variation of Soil Properties under Oil Palm Plantation in South Western Nigeria. *Ethiopian Journal of Environmental Studies and Management*, Vol.3 No.1, pp 1-7.

Aweto, A.O. and Ekiugbo, U.E. (1994), Effect of an oil palm plantation on a tropical forest soil in south western Nigeria. The Indonesian Journal of Geography, 26, 51-59.

Bruhl, C. A. and Eltz, T. (2010). Fuelling the biodiversity crisis: species loss of ground-dwelling forest ants in oil palm plantations in Sabah, Malaysia (Borneo). *Biodiversity Conservation*, 19: 519 -529.

Doran, J. W. and Jones, A.J. (Editors) (1996). *Methods for assessing soil quality*. Academic Press, San Diego, CA. 114p.

Edem, D. and Edem, S. O. (2008). *Insitu Erosion variability Measurement under Vetiver Hedges in Alfisol*. Lambert Academic Publishing GMDH & Co. KG Deutschland, 143p.

Fitzherbert, E. B., Struebig, M. J., Morel, A., Danielsen, F., Bruhl, C. A., Donald, P.F. and Phalan, B. (2008). How will oil palm expansion affect biodiversity: Yield and soil chemical properties. *Journal of Oil Palm Research*, 14(2): 1- 9.

Gebreyesus, B. T. (2014). Soil Quality Assessment Strategies for Evaluating Soil Degradation in Northern Ethiopia. *Applied and Environmental Soil Science*, pp1-14.

Gee, G. W. and Or, D. (2002). Particle Size Analysis, pp9 -10. *In*: J. H. Daneand G. C. Topp (Editors) *Methods of Soil Analysis*. Madison, Wisconsin: Agronomy Society of America and Soil Science Society of America, 69p.

Grossman, B., Arshad, M. A. and Owery, B., and Grossman, B. (1996). Physical Tests for monitoring soil quality, pp23-41. *In*: Doran J. W. Jones A. J. (Editors) *Methods for Assessing Soil Quality.* Madison Wisconsin, 71p.

Grossman, R. B. and Reinsch, T. B. (2002).Bulk density and linear extensibility, pp255- 293. *In*: J. H. Dane, and G. C. Topp (Editors.), *Methods of Soil Analysis.*Part 4. Physical Method.Soil Science Society. Madison, W. I: Am. Book Series No. 5. Agronomy Society of America and Soil science Society of America, 315p.

Irvine, F.R. (1969), West African Crops, Oxford University Press, London. Kravchenko, ANN and Bullock, D.G.(2000), Correlation of corn and soybean grain yield with topography and soil properties. Agronomy Journal, 92, 75-83.

Koh, L. P. and Wilcove, D. S. (2008). Is oil palm agriculture really destroying tropical biodiversity? *Conservation and Biology*, 1: 60- 64.

Mclean, E. V. (1982). Aluminium, pp1978-1998. *In:* A. L. Page, R. H. Miller and D. R. Keeney (Editors). *Methods of Soil Analysis.* Part 2. American Society of Agronomy, Madison, Wisconsin, 2058p.

Nelson, D. W. and Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. pp539–580. *In:* A. L. Page (Editor) *Methods of soil analysis*. Part 2. American Society of Agronomy, Madison, 780p.

Nester, E. W. and Robert, C. E., and Nester, M. T. (2006).*Microbiology human perspective*. The USA. WMC. Brown Publishers. Pp. 23: 514-530.

Ogeh, J. S. and Osionwan, G. E. (2012). Evaluation of the effect of oil palm on some physical and chemical properties of *Rhodic paleudults*. *Nigerian Journal of Basic and Applied Science,* 20(1): 78-82.

Onwueme I.C. and Sinha, T.D. (1991). Field Crop Production in Tropical Africa. CTA, Ede.

Ovie, S. Obande, A. O. and Ataga, E. 2013.Effects of land use on the properties of soils formed on makurdi sandstones in North central Nigeria. *Nigerian Journal of Agriculture, Food and Environment,* 9(4):43-47.

Sample, I. (2007, 31st August). Global food crisis looms as climate change and population growth strip fertile land. *The Guardian*, 6p.

Thomas, G. W. (1996). Soil pH and soil acidity, pp475–490 *In*: D. L. Sparks (Editor) *Methods of Soil Analysis: Chemical Methods.* Part 3. Madison, Wisconsin, USA, 540p.

Topp, G. C. and Dane, J. H. (2002). *Method of Soil Analysis: Physical Methods.* Part 4. Soil Science of America Book Series No 5. Madison, Wisconsin, 228p.

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O. and Esu, I. E (2009). *Manual of Soil, Plant and Water Analysis.* 1st Edition. Lagos: Sibon Blocks Limited, 183p.

Udoh, B. T. (2003). *An Evaluation of the Soil Map of Akwa Ibom State for Agricultural Land Use.* MSc (Ed) Dissertation. University of Ibadan, Nigeria, 130p.

Ukwuteno, S. O., Okoroji, E. C. and Opaluwa, H. I. (2012). Determination of economic optimum replacement of age of oil palm age in Kogi state, Nigeria. *International Journal of Applied Research and Technology*, 1(2): 68 -76.

Verheye, W. (2010). Growth and production of oil palm, pp6-10. In: W. Verheye (Editor) *Land Use, Land*