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Differences in Physicochemical Properties of Soils under Oil Palm Plantations of Different Ages in Ohaji/Egbema, Imo State

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ABSTRACT

The study was carried out to evaluate the differences in physicochemical properties of soils under oil palm plantations of different ages in Ohaji/Egbema in Imo State, Nigeria. Soil samples were collected from three different oil palm plantations planted in different years: 1978, 1990 and 2005 respectively. Soil samples were also collected from a bush fallow land close by. Surface soil samples were collected randomly from these plantations at 0-15cm depth. Five surface soil samples were collected from each plantation. Core samples were also collected for bulk density determination. The samples were bagged and taken to the laboratory for analyses. From the results, it was shown that there were differences in the physicochemical properties of the different soils studied. Bulk density, total porosity, and moisture content in 1978 oil palm plantation significantly differed from other soils studied. Furthermore, the pH (6.61), organic carbon (43.94g/kg) and total Nitrogen content (3.26) in 1978 oil palm plantation were significantly higher than in other soils. Moreover, available phosphorus (5.14mg/kg) and potassium (0.306cmol/kg) in 1990 oil palm plantation were higher than those from other soils studied. In addition, soil properties like; organic matter, percentage base saturation, total nitrogen, percent clay, total porosity and bulk density varied significantly at ($P<0.05$) while percent sand, exchangeable calcium, potassium and sodium did not show any significant difference in their variability at ($P<0.05$) among oil palm plantations. In conclusion, the findings of the work showed that soil properties differed under oil palm plantations of different ages and therefore, should be treated differently based on their properties.

Keywords: Oil palm plantations, tropical soils, Imo State, Soil properties

INTRODUCTION

Oil palm (*elaeis guinensis*) is one of the world's number one fruit crop according to Reiger (2006). He further stated that the world production is approximately 153,578,600 tonnes per hectare, which is approximately twice any other food crop production level. The most important constraint to oil palm production is soil fertility and proper nutrient distribution. It was estimated that more than 95% of oil palms grown in south east Asia are on acid, low fertile and highly weathered soils (Mutert, 1999). Soils are characterized by high degree of spatial variability due to the combined effects of physical, chemical or biological processes that operate with different intensities and at different scales (priyabrata et al. 2008).

Crop age also contributes to variability in soil properties because as the crops grow older, nutrients are removed from the soil during harvest either for food, fiber or wood and crop residues. Nutrient removal may result in a decline in soil fertility if replenishment with fertilizers or manure is inadequate.

One of the first studies investigating long term changers under oil palm was conducted by Tinker (1963) in west Africa. His studies showed that during the first five years of the plantations, there was marked increase in soil fertility, soil organic carbon content remained constant (kowal and Tinker, 1959; Tinker. 1963),

Many other researchers have worked on oil palm plantation in Nigeria and other countries, but information on the effects of different ages of oil palm on soil physico – chemical properties is scarce. Therefore this work will be of great benefit to researchers and oil palm formers

MATERIALS AND METHODS

The study was carried out in Egbema, Imo State. Egbema lies between latitude $5^0 45^1$N and longitude $6^0 43^1$E. The mean annual temperature range of the study area is about 26.5^0C to 27.5^0C (WWW.nigeriaclimatemaps.com). The study area has a humid tropical climate with mean relative

humidity of about 70%-80%. The soils are derived from coastal plain sands which is the parent material of the study area. Free survey technique was used to locate sampling points. Soil samples were collected from three oil palm plantations planted in different years and also from an adjacent fallow land. The oil palm plantations were planted in the years 1978, 1990 and 2005 respectively. Five surface soil samples were collected per plot at 0 to 15cm depth. The soil samples were air dried, crushed and sieved using a 2mm sieve and then taken to the laboratory for analyses. Core samples were also collected for bulk density determination. Bulk density was determined using the core method (Grossman and Reinsch, 2002), particle size analysis was done by the hydrometer method according to the procedure of Gee and Or (2002). Porosity was calculated from the bulk density value. Soil pH was determined using 1:2.5 soil-water ratio with a pH electrode and values were read out from the pH meter (Hendershot et. al, 1993). Total nitrogen was determined using walkley and Black oxidation method (Nelson and Sommers, 1982), available phosphorus was determined using Bray 2 solution method according to (Olsen and Sommers, 1982). Exchangeable calcium and magnesium were determined by EDTA versenate titration method as outlined by (Mclean, 1982). Exchangeable Na and K were determined by flame photometer method. Exchangeable acidity was determined by leaching the soil with IN Kcl and titrating with 0.05N NaOH (Mclean, 1982). Organic carbon was determined using wet oxidation method (Olsen and Sommers, 1990). Data collected were presented in tables. Analysis of variance was used to determined degree of variability.

RESULTS AND DISCUSSION

Physical Properties

The results of the physical properties of the study area are shown in Table 1. The result shows a preponderance of sand over other particle size, which can be attributed to the nature of their parent materials which is coastal plain sand. Aggressive weather conditions of the area may have contributed to the nature of the soils texture (Jungerius and Levelt, 1964). High precipitation in the area resulting in clay lessivage could also have led to the sandiness of the soils (Unamba-Oparah et.al, Eshett et. al, 1990).

Table1. *Physical properties of the study area*

Year oil palm plantation was established	Sand g/kg	Silt g/kg	Clay g/kg	Silt/Clay	Textural class	Bulk density	Total Porosity%	Moisture Content(g/kg)
1978	816	52	132	0.39	LS	1.276	49.72	115.16
1990	840	68	92	0.74	LS	0.808	69.32	261.1
2005	836	56	108	0.52	SL	0.924	64.96	150.06
Fallow	772	64	164	0.39	SL	1.04	60.32	137.60
$LSD_{0.05}$	NS*	NS	36,37*			1.31*	6.65*	45.55*

The soil texture of the area ranged from loamy sand to sandy loam. These textural characteristics of the area might have led to the low bulk density of the soils and therefore high porosity (Landon, 1991). The bulk density value was highest in the 1978 oil palm plantation (1.276/kg) and lowest in the 2005 oil palm plantation (0.808g/kg). The low values reveal that the soils were not compacted. The bulk density values were significant at (p=0.05). The values for the total porosity and moisture content were highest in the 1990 oil palm plantation and lowest in the 1978 oil palm plantation. The values were significantly at (P =0.05). Results of the silt/clay ratio showed very low values (0.39, 0.74, 0.52 and 0.39 for the 1978, 1990 and 2005 oil palm plantations and the fallow land respectively). These low values reveal that the soils were formed from parent materials that are at a more advanced stage of weathering.

Chemical Properties

The values of the chemical properties of the study area are shown in Table 2.

Table2. *Chemical properties of the study area*

Year oil palm plantation was established	pH H_2O	pH KCl	OC g/kg	OM g/kg	TN g/kg	AP g/kg	Ca ←	Mg	K	Na Cmol/kg	AI →	H	TEA	ECEC	BS
1978	6.614	6.034	43.94	75.08	3.26	3.012	2.82	1.62	0.216	0.128	0.8	0.34	1.14	6.004	78.78
1990	6.118	5.636	9.52	16.26	0.76	5.136	2.12	1.48	0.306	0.088	0.36	0.24	0.60	4.866	87.7
2005	5.524	4.9	6.74	11.7	0.54	0.998	1.72	1.12	0.21	0.136	0.5	0.52	1.02	4.196	75.72
Fallow	6.04	5.34	7.38	12.82	0.58	3.002	2.2	1.4	0.25	0.122	0.7	0.42	1.12	5.092	77.56
$LSD_{0.05}$	0.52*	0.39*	4.19*	6.89*	0.58*	NS	NS	0.37*	NS	NS	0.32*	0.28*	0.31*	1.309*	7.64*

The pH of the soils shows that the soils were slightly acidic. The value was highest at 1978 oil palm plantation (6.61) and lowest in the 2005 oil palm plantation (5.52). The values varied significantly (P< 0.05) among the different plots.

The values were adequate for the production of oil palm because they were below the value of 7.5 beyond which doesn't favour oil palm production.

The mean organic carbon content in 1978 oil palm site was significantly (p< 0.05) higher (43.94/kg), followed by the 1990 oil palm site (9.52g/kg), fallow land (7.38g/kg) and lastly, 2005 oil palm site (6.74g/kg). The significantly higher organic carbon content in the 1978 oil palm plantation is probably due to the accumulation of organic matter over the years on the soil surface. Total nitrogen (TN) followed similar trend with organic matter and organic carbon. Similar result was observed by Okon et al. (2014) who recorded increases in total nitrogen with associated increase in organic carbon. The highest value of total Nitrogen (3.26 g/kg) and the lowest (0.54g/kg) were recorded in 1978 and 2005 oil palm plantations respectively. Following the rating of Landon (1991) for total nitrogen, the total nitrogen in the 1978 oil palm plantation was rated medium (0.02 to 5%) while others were rated very low (<0.1). the highest value of phosphous recorded was in the 1990 oil palm site (5.13mg/kg) and the lowest (0.998 mg/kg) was recorded in 2005 oil palm site. According to Landon (1991), Available soil p level of <5mg/kg is rated as low. This implies that only 1990 oil palm plantation recorded medium value (5.13mg/kg).

The ECEC values was significantly (p< 0.05) higher in the 1978 oil palm plantation (6.004 cmol/kg) than in other plots. The value was lowest in the 2005 plantation with balue of (4.196 mol/kg). The values of Ca and Mg were also higher in the 1978 oil palm plantation than in other plots. The values of Mg were significantly higher at (p< 0.05) while that of Ca was not.

Table3. *Variability among soil physical properties in the studied areas*

Property	Sand	Silt	Clay	Bulk density	Total p	Moisture c
1978 oil palm plantation						
CV (%) Ranking	3.2 Low	21.1 Medium	17.3 Medium	6.1 Low	11.8 Low	50.2 High
1990 oil palm plantation						
CV (%) Ranking	4.6 Low	16.1 Medium	33 Medium	10.2 Low	4.5 Low	7.4 Low
2005 oil palm plantation						
CV (%) Ranking	5.2 Low	46.6 High	55.6 High	9.4 Low	7.7 Low	25.6 Medium
Fallow land						
CV (%) Ranking	49.4 High	14 Low	15.9 Medium	12.8 Low	7.9 Low	6.9 Low

CV= *coefficient of variability, 0 – 15% = low variation, 15 – 35% = medium variation. Above 35% = high variation*

Table3. *Variability among Soil Chemical Properties In The Studied Areas*

Property	**pH(H^20)**	**pH9 KCl)**	**OC**	**OM**	**TN**	**AP**	**Ca**	**Ma**	**K**	**Na**	**AI**	**H**	**TEA**	**CEC**	**BS**
1978															
CV (%) Ranking	3.2 LOW	2.8 Low	9 Low	9.1 Low	22.4 Medium	83.2 High	31.6 Medium	19.7 Medium	41.5 High	45.4 High	23.4 Medium	33.5 medium	17.1 Medium	16.4 Medium	12.4 Low
1990															
CV (%) Ranking	8 Low	7.1 Low	20.7 Medium	21.7 Medium	23.9 medium	82.5 High	50.6 High	74 Medium	92 High	33.5 Medium	52.5 High	63.2 High	20.4 Medium	10.8 Low	1.7 low
CV (%) Ranking	4.6 Low	3.4 Low	42.7 High	42 High	48.3 High	97 High	13.3 Low	27.1 Medium	22.3 Medium	44.9 High	42.4 High	56.7 High	32.8 Medium	16.8 Medium	9.4 Low
Fallow land															
CV (%) Ranking	8.3 Low	5.8 Low	35.8 High	35.4 High	41.2 High	91.9 High	28 Medium	26.7 medium	10.6 Low	36.8 high	36.4 high	15.9 Medium	19.4 medium	22.7 medium	3.9 low

CV= *coefficient of variability, 0 – 15 % = low variation, 15 – 35% = medium variation, above 35% = high variation*

CONCLUSION

The findings of this research revealed that particle size distribution of the studied soils did not differ significantly since they were formed from the same parent material (coastal plain sands). Bulk density, total porosity and moisture content in the 1978 oil palm plantation significantly differed ($P<0.05$) when compared to other soils studied. This could be as a result of age and compaction of the soils by tractors. Furthermore, the 1978 oil palm plantation had pH (6.61), organic carbon (43.94g/kg), calcium (2,86cmol/kg) total nitrogen (3.26g/kg) and exchangeable magnesium (1.62cmol/kg). These values were significantly higher ($P<0.05$) than in other soils studied. Available Phosphorus (5.136mg/kg) and Potassium (0.306cmol/kg) in the 1990 oil palm plantation were higher than in other soils studied but they were non significantly different. The 1978 oil palm plantation had the highest ECEC value (6.004cmol/kg) which was significantly different at ($P<0.05$) while the 1990 oil palm plantation had the lowest total exchangeable acidity (0.06) which was also significantly different at ($P<0.05$).

RECOMMENDATION

Based on these research findings, it is therefore recommended that; bulk density which is a reflection of soil compaction should be reduced by limiting the number of times heavy tractors are used. Organic residue accumulation on the plantation floor should be encouraged as this will assist in maintaining increasing organic matter levels. In addition, intercropping of the oil palm plantation with legumes which supply nitrogen can be practiced in order to make maximum use of the land resources and maintain soil fertility. Finally, further research should be done to study the soil micronutrient levels in the study area as this will aid in proper fertilizer program.

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