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FERTILITY ASSESSMENT OF SOILS UNDER DIFFERENT LAND USE IN OGUTA, NIGERIA

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ABSTRACT

Soil fertility assessment is essential for effective land management practices. This study was carried out to investigate the impact of three land use types Cassava farm (CF), Oil palm plantation (OPP) and Rubber plantation (RP) on soil properties in Oguta area of Imo State, Nigeria. Randomized sampling technique was implored in the collection of nine soil samples from each of the different land use within a depth of 15cm. Samples obtained from each land use were homogenized to form three composite samples per land use. The data generated from laboratory analysiswere subjected to analysis of variance (ANOVA). Sand particles had a mean of 82.7 %, 66.7 % and 76.0 % for soils under CF, OPP and RP respectively. The mean values of silt and clay particles were 8.3 % and 9.0 %; 21.0 % and 12.3 %; 13.0 % and 11.0 % in CF, OPP and RP respectively. The other soil chemical properties did not differ significantly with the exception of pH and exchangeable K. The pH (H_2O) had mean of 6.43, 6.17 and 5.73 of soils under CF, OPP and RP respectively while exchangeable K had mean of 0.38 Cmol/kg for CF, 1.71 Cmol/kg for OPP and 0.61 Cmol/kg for RP. Despite not showing significant difference, OPP and RP have more soil quality attributes than CF. However, the result from this study pointed that land use influence soil properties at various rates. Hence, use of good soil management practices is required to improve the soil quality attributes.

Keywords: Soil fertility, Land use, Soil properties, Oguta

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INTRODUCTION

The potential of a soil to generate or produce a substantial yield is very critical. As such, proper maintenance of soil fertility primarily depends on the knowledge of the physical, chemical and biological properties of the soil including the climatic and geological characteristics of the area the soil is situated (Augusto et al., 2002). Anthropogenic activities such as farming and deforestation play a very important part in the maintenance of soil fertility (Gan et al., 2002). Land use is the term used to describe how human utilizes land. It symbolizes the various economic and cultural endeavors, encompassing agriculture, housing, industry, mining, education and recreation taking place in a specific location (USEPA, 2022). Vink (1975) also explained land use as any permanent or recurring human engagement aimed at fulfilling human needs using a combination of natural and artificial resources that make up the land. According to Akanmigbo and Asadu (2001), when multiple land use types coexist on the same soil, it creates a complex interaction between the land's resources and the historical, cultural, social and economic factors for both past and present.

Land uses impact both on the quality of the soil and its productivity. These manifests as change in soil properties such as nutrient contents, pH, organic matter, CEC and structure occurs with land use (Aluko & Fagbenro, 2000; Akinrinde & Obigbesan, 2000; Akamigbo & Asadu, 2001). For instance Aluko and Fagbenro (2000) observed higher pH and organic matter for soil under *Gmelina aborea* (teak) in comparison with those under *Pins canaborea*, *Treculia africana*, agro forestry and fallow land. Also, Akanmigbo and Asadu (2001) observed high phosphorus in fallow relative to other land uses. In all, it is necessary to understand the efficiency of land use systems in terms of nutrient cycling and soil conservation. Additionally, agricultural practices such as fertilization, tillage, irrigation and crop residue left on the field alter soil chemical properties and nutrient dynamics throughout the soil profile (Wright et al., 2007; Panday & Maharjan, 2018). Changes in land use can also disrupt carbon and nitrogen dynamics and organic matter content in soil (Ye et al., 2009).

According to Lechisa et al. (2014), having up-to-date information about the physical and chemical characteristics of soil across various types of land use is essential for increasing production and productivity in sustainable manner. Nevertheless, in this study area, there has been a lack of practical and basic information regarding the status and management of soil physicochemical properties, together with their impact on soil quality. This backdrop has led to limited recommendations for the optimal and sustainable use of land resources. Hence, this research is therefore conducted to assess whether there are significant differences in the nutrient status of soil under different land use with the aim of establishing the associated problems and making recommendations for best soil management practices.

MATERIALS AND METHOD

Study Area

The research took place in Oguta area of Imo State, Nigeria. The study area lies between latitude 5^o42'25.19"N and longitude 6^o48'20.39"E. Oguta is located within the equatorial rainforest belt with an mean annual rainfall of 3,100 mm and mean monthly temperature of 27.0^{o}C. The relative humidity of the study area ranges from 51 % to 75 %. The study area's soil originated fromCoastal plain sands (Benin formation). The land surface configuration of Oguta consists of plains, gentle and undulating slopes at a height below 50m above sea level.

Site Description

The examined sites under different landuse are cassava farm (CF), oil palm plantation (OPP) and rubber plantation (RP) and the descriptions are as stated on Table 1.

Field Studies

Three different land uses were selected for the study. The three different land uses have three representative fields each. Three surface samples were collected at random (beginning, middle and end) from each representative field of each land use to form a composite sample. Three composite soil samples were collected from each land use making a total of 9 composite soil samples for the research. The soil samples were collected at a depth of 15 cm using an auger. The collected soil samples were prepared for routine laboratory analyses.

Laboratory analyses

Particle size distribution was determined by hydrometer method (Gee & Or, 2002). Soil pH was measured using 1:2.5 soil–water ratio using a pH meter (Thomas, 1996). Organic carbon was measured using modified Walker-Black wet digestion method (Nelson and Sommers, 1982). Total nitrogen was determined by MicroKjeldahl digestion technique (Bremner, 1996). Available phosphorus was extracted using Bray 2 method and the phosphorous determined by the molybdenum method (Olsen & Sommers, 1982). Exchangeable acidity was gotten by the method described by McLean (1982). Exchangeable bases were determined by neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982).

Data analysis

The data generated from the laboratory analysis were analyzed statistically using the completely randomized design of analysis of variance (ANOVA) at 5 % level of probability. The means were compared by using Tukey's HSD test at $P < 0.05$.

RESULTS AND DISCUSSION

Physical Properties of the Soil:

The particle size distribution of the soils under different agricultural land use is presented on Table 2. The textural class of all the land use types considered fall within loamy sand to sandy loam.The percentage sand ranged from 78.0 – 86.0 % for soil under cassava farm (CF), 62.0 – 72.0 % for soil under oil palm plantation (OPP) and 68.0 – 82 % for soil under rubber plantation (RP). The sand content under the different land use differ significantly ($P < 0.05$) with its highest mean value of 82.7 % on the soil under CF. Despite the significant difference on % sand, the soils under the different land-uses in this study have high sand particle compared to other fine earth fractions. This is because of the predominance of sand fraction in the study area.This is similar to the findings of Onyekanne et al.(2012) that the soils of the coastal plain sand are coarse grained and are devoid of cementing agents such as organic and inorganic colloids. The silt fraction differs significantly ($P < 0.05$) among the three different agricultural land uses. The percentage silt ranged from 8.3 % to 21.0 % with the OPP (21.0 %) having the highest silt mean value. The clay fraction was not significantly influence with the different land uses. The Silt-clay ratios also gave no significant different among the three different land use evaluated in this study. The mean values were 0.93, 1.72 and 1.19 in CF, OPP and RP respectively. Silt-clay ratio (SCR) plays a critical role in assessing clay movement, the degree of weathering and the age of both parent material and soil (Yakubu & Ojanuga, 2013). The highly weathered soils are associated with lower silt fraction. According to FAO (1990), a silt-clay ratio of less than 0.20 signifies low degree of weathering. However, Ayolagha (2001) posits that old parent materials usually have a SCR below 0.15 while SCR above 0.15 is indicative of young parent materials. Interestingly, results of this study showed that all the soils had silt-clay ratios above 0.2 and 0.15 indicating a high degree of weathering potentials in all the soils.

The Chemical Properties of the Soil:

The variation in agricultural land use had a significant impact on the soil pH (Table 3). The results of the soil pH of the agricultural land use types were generally acidic according to the rating of Singer and Munns (1999). The mean values showed that CF (6.43) and OPP (6.17) were weakly acidic while RP (5.73) was moderately acidic. Results from Table 3 showed that there is no change in total nitrogen (TN) level in the three different land use systems. The TN ranges from 0.13 - 0.15% with the highest mean value from the RP (0.15%) and the lowest from CF (0.13%). Yimer et al.(2007) found that the N content is significantly lower in cropland in comparison with grazing and forest lands. The lower N contents in the cropland which is represented by CF in this study may be due to tillage, since soil tilling enhances susceptibility to erosion (Funderbury, 2016).

The land use type showed no significant difference with soil organic matter and phosphorus content (Table 3). Soil organic matter (SOM) ranges from 1.33 – 2.25% which is generally lower than the critical level of 3% as specified by Akinrinde and Obigbeson (2000). The higher amount of SOM found in soils under OPP and RP land uses could be linked to the loads of litter deposit. It might also be due to the accumulation of organic matter over years (Ogeh & Osiomwan, 2012) and low mineralization (Osujieke et al., 2017). Available P has means of 34.2, 36.1 and 41.4 mg/kg in CF, OPP and RP respectively. The phosphorus content of the different land uses are generally high (>20 mg/kg) based on the rating of Enwezor (1990) who worked on Nigerian soil. Adepetu (2000) in corroboration stated that available P < 15 mg/kg was not high for Nigerian soils. Uzoho and Oti (2004) opined that elevated level of acidity (pH < 5.0) tend to result in reduced phosphorus availability in the soil as P is fixed more in highly acidic soils. Nevertheless, the studied soils under different agricultural land use had pH > 5.5 which is well within the ideal pH (5.5 – 7.0) for optimal crop growth and sustainability. The moderate soil pH resulted in elevated phosphorus (P) content of the studied soils.

Table 4 showed the mean values of Ca, Mg, K and Na, respectively (2.52, 1.92, 0.38 and 0.443) Cmol/kg for soils under CF land use, (2.52, 1.04, 1.71 and 0.453) Cmol/kg for soils under OPP land use and (2.07, 1.03, 0.61 and 0.447) Cmol/kg for soils under RP land use. Critical values of basic cations as reported by Esu (1991) showed that soils under this study have medium to high basic cations for various agricultural land use types. Ca was medium in all the land uses while

Mg, K and Na were high in all the land uses. There is no significant ($P < 0.05$) variation in the basic cations evaluated on the different land use except that found in K. The low mean value of K (0.38) in CF could be attributed to loss of K due to burning of crop stubbles after crop harvest on soil with low clay content to retain the available K (Hargreaves, 2015).

Aluminum and hydrogen had the highest value record at RP (0.73 Cmol/kg) and CF (0.80 Cmol/kg) land uses respectively while the lowest was found at CF (0.07 Cmol/kg) and OPP/RP (0.60 Cmol/kg) land uses respectively. Elevated aluminum toxicity is prevalent on most soils suffering acidity problems; most plants are affected when Aluminum has a percentage greater than 5 (FAO, 2002). However, the pH value obtained in this study indicates a moderate to weakly acidic pH value for the different agricultural land use evaluated. In this study, the aluminum values obtained were seen to be in accordance with the submission of the FAO (2002).

Cation exchange capacity (CEC) of the different land uses has the highest value at CF land use (22.7Cmol/kg) with OPP and RP having the same value of CEC (19.2 Cmol/kg). The soil CEC under the different land uses were generally high (>12 Cmol/kg) when compared with the ranking of (Esu, 1991). According to Landon (1991), CEC is a determinant of the capability of the soils to withhold nutrient and water. However, CEC showed no significant variation among soils under the studied land use types. The low CEC obtained from OPP and RP of the studied soils can serve as an indicator of low chemical weathering activity of the soil and the soil's pH level (Okunsami & Oyediran, 1985).

CONCLUSION

This study assessed the physicochemical (soil texture, pH, organic matter, total Nitrogen, available Phosphorus, exchangeable bases (calcium, Potassium, magnesium and sodium), exchangeable acidity (aluminum and hydrogen) and cation exchange capacity) parameters of soil under different land uses (cassava, Oil palm and rubber) in Oguta area of Imo State. Soil texture, soil pH and exchangeable potassium showed significant difference among all the parameters investigated in the three different agricultural land uses. This implies that the agricultural practices in the study area mostly impacted on soil texture, soil pH and exchangeable potassium but had little effect on the other parameters evaluated. Despite not showing significant effect, OPP and RP gave higher values of organic matter and available phosphorus. In general, OPP and RP have more soil quality attributes than CF land use. This is largely attributed to the substantial presence of organic matter and dense vegetative cover, which helps reduce the impact of erosion. Nonetheless, the implementation of effective management techniques like composting, biomass transfer and the utilization of organic fertilizers together with the enforcement of strong land use policies, should be incorporated into the plan for achieving sustainable agricultural progress in the area.

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APPENDICES

Table 1: Details of sampling points

Land use	Description of sampling points	GPS coordinates of sampling points	Elevation (meters)
Cassava Farm (CF)	1	Lat 5.636726; Long 6.757144	23.6
	2	Lat 5.636202; Long 6.757078	23.3
	3	Lat 5.635548; Long 6.757234	17.0
Oil Palm Plantation (OPP)	1	Lat 5.638774; Long 6.760768	24.8
	2	Lat 5.639019; Long 6.760922	27.0
	3	Lat 5.637740; Long 6.760718	21.2
Rubber Plantation (RP)	1	Lat 5.638421; Long 6.760287	31.7
	2	Lat 5.639412; Long 6.759951	22.1
	3	Lat 5.636957; Long 6.757416	22.8

Table 2: The results of the physical properties of the soil under different land use

Crop	Sites	Sand	Silt	Clay	SCR	Texture
			(%)			
Cassava Farm (CF)	1	86.0	5.0	9.0	0.56	Loamy sand
	2	84.0	7.0	9.0	0.78	Loamy sand
	3	78.0	13.0	9.0	1.44	Sandy loam
Mean		82.7^{a}	8.3^{b}	9.0^{a}	0.93^{a}	
Oil Palm plantation (OPP)	1	66.0	23.0	11.0	2.09	Sandy loam
	2	62.0	25.0	13.0	1.92	Sandy loam
	3	72.0	15.0	13.0	1.15	Sandy loam
Mean		66.7^{b}	21.0^{a}	12.3^{a}	1.72^{a}	
Rubber plantation (RP)	1	82.0	9.0	9.0	1.00	Loamy sand
	2	78.0	13.0	9.0	1.44	Sandy loam
	3	68.0	17.0	15.0	1.13	Sandy loam
Mean		76.0^{ab}	13.0^{ab}	11.0^{a}	1.19^{a}	

Note: The distinct alphabet in a column displayed statistical difference ($P < 0.05$).

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Table 3: The results of soil pH, organic matter (OM), total nitrogen (TN) and available phosphorus (Av. P) under different land use

Crops	Sites	Soil pH	Total Nitrogen (TN)	Soil Organic Matter (SOM)	Available Phosphorus
			(%)		mg/kg
Cassava Farm (CF)	1	6.7	0.098	1.31	33.6
	2	6.5	0.140	1.24	35.4
	3	6.1	0.141	1.45	33.7
Mean		6.43^{a}	0.13^{a}	1.33^{a}	34.2^{a}
Oil Palm Plantation (OPP)	1	5.9	0.098	1.65	37.3
	2	6.3	0.126	3.23	31.7
	3	6.3	0.151	1.86	39.2
Mean		6.17^{ab}	0.13^{a}	2.25^{a}	36.1^{a}
Rubber Plantation (RP)	1	5.7	0.168	2.96	27.1
	2	5.5	0.151	2.00	55.96
	3	6.0	0.126	1.72	41.04
Mean		5.73^{b}	0.15^{a}	2.22^{a}	41.4^{a}

Note: The distinct alphabet in a column displayed statistical difference ($P < 0.05$).

Table 4: The results of Exchangeable Ca, Mg, K, Na, Al, H and Cation exchange capacity (CEC) under different land use

Crops	Sites	Ca	Mg	K	Na	Al^{3+}	H^{+}	CEC
					(Cmol/kg)			
Cassava Farm	1	2.66	1.77	0.44	0.046	0.0	0.6	15.2
	2	2.22	1.78	0.32	0.044	0.2	0.8	40.8
	3	2.67	2.22	0.40	0.043	0.0	0.0	12.0
Mean		2.52^{a}	1.92^{a}	0.38^{b}	0.443^{a}	0.07^{a}	0.80^{a}	22.7^{a}
Oil Palm Plantation	1	3.11	0.89	1.71	0.046	0.0	1.2	23.6
	2	2.22	0.44	1.91	0.047	0.6	0.4	18.4
	3	2.23	1.78	1.51	0.043	0.6	0.2	15.6
Mean		2.52^{a}	1.04^{a}	1.71^{a}	0.453^{a}	0.40^{a}	0.60^{a}	19.2^{a}
Rubber Plantation	1	2.65	1,33	0.72	0.045	0.0	1.0	15.6
	2	1.77	0.44	0.48	0.046	0.6	0.4	18.4
	3	1.78	1.33	0.64	0.044	1.6	0.4	23.6
Mean		2.07^{a}	1.03^{a}	0.61^{b}	0.447^{a}	0.73^{a}	0.60^{a}	19.2^{a}

Note: The distinct alphabet in a column displayed statistical difference ($P < 0.05$).