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CHARACTERIZATION OF SOME FOREST SOIL UNDER TEAK (*Tectona grandis*) PLANTATION IN A HUMID FOREST REGION OF NIGERIA

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ABSTRACT
Designer foods are the processed foods that are supplemented with food ingredients naturally rich in disease preventing Characterization of some forest soil under Teak (Tectona grandis) cultivation was carried out in Delta State of Nigeria. Four mapping units that are extensively cultivated with Tectona trees were used for the study. Representative profile pits were dug in each soil unit and described accordingly. Soil samples were collected from each pedogenetic horizon and analyzed. The results of the study showed that the soil of the mapping units were generally deep, and in most cases above 120 cm in depth. The dominant clolour matrix were dark reddish brown (5 YR 3/3) top soil horizons that graded into yellowish red (5 YR 4/8) sub soil. The texture ranged from loamy sand top soil to sandy clay loam sub soils that are characterized by moderate structure sub angular blocky, with firm and non-sticky consistence at the top soil, to slightly sticky, and very plastic down the sub soil horizons. The soil were generally acidic with a mean pH value of 5.63. The organic matter and total nitrogen contents were moderate with means values of 27.49 and 1.43 gkg^{-1} respectively. Available phosphorus and exchangeable cations were moderate with mean vales of 16.82 $mgkg^{-1}$ for P; 3.74 $cmolkg^{-1}$ for Ca; 1.89 $comlkg^{-1}$ for Mg; 0.12 and 0.17 $cmolkg^{-1}$ for K and Na respectively. The exchange acidity was high with a mean value of 2.25 $cmolkg^{-1}$, while the cation exchange capacity (CEC) and effective cation exchange capacity (ECEC) were low to medium depicting the kaolinitic nature of the soil and low to moderate fertility status.

KEYWORDS: Characterization, Forest Soils, Teak, humid forest, region.

INTRODUCTION

Teak (Tectoma grandis) belongs to the family verbenacaea. It is a forest tree of distinct quality that provides one of the most important hard wood in any circumstance that demands a hard, durable, straight grained wood of excellent is required. The tree is traditionally known to be indigenous to Burma Keay (1989), and it thrives best in regions with a rainfall range of about 1250 – 3750 mm per annum and a pronounced dry season of 4 – 5 months (Evans, 1999). Characteristically, Teak tree has a leathery smell with slight grassy feel and enjoys high reputation for its strength, durability and stability in fluctuating atmospheric pressure (Ettah and Ogar, 1994). The economic importance of wood products of teak is well documented. In the Sub – saharan African regions where conduit wiring is not yet in place, electric poles of choice are from teak wood plants. This is due to its rebilent body that is only temporary altered by fire, wind thrown and other acts of nature (Egbuchua and Ideozo 2006). Because of its excellent decorative appearance, it is prounoucely used for high quality furniture, cabinet making, decking of ship, boats, hand rails in houses and various planking works.

In most Sub – saharan regions, with little technological influence, many people are currently involved in teak cultivation due to the attractive price of the wood for rural electrification without good knowledge of the soil characteristics in which the wood plant is grown. Characterizing the soil therefore will provide basic information for better management of the soil resources, and equip the local resource farmers on how best to improve on their productivity and ensuring environmental sustainability. The objective was therefore to evaluate the physical, of the study morphological and chemical characteristics of soil under teak cultivation in a typical humid region of Nigeria.

MATERIALS AND METHODS

The study was conducted in Anwai in Delta State, Nigeria. Anwai lies essentially between latitude 06^0 14^1N and longitude 06^0 49^1E and, about 3419 km^2 in size. It falls within the tropical rainforest zone that is characterized by high amount of rainfall which ranges from 2290 – 2980 mm, with a mean annual of about 2560 mm in 110 rain days. The mean monthly temperature varies between 27^0C in August and 30^0C in March. The relative humidity is high in the rainy season (over 75%) and drops during the dry season to about 55% during the harmattan. The relief is very gently undulating to nearly level and the drainage is well drained. The land use is mainly crop farming based on rainfed agriculture with small to medium teak, oil palm and rubber plantation holdings found all over the state.

Field study

Three locations namely Anwai – North (about 1136.2 km^2), Anwai South (about 1130.4 km^2) and Anwai East (about 1136.8 km^2) that are extensively cultivated with teak (tectoma gradis) were identified and chosen for the study. Three profile pits were duged to represent the soil in each location, and the coordinated and altitude above sea level at the selected sites obtained using Garmin etrex (2000) GPS meter. Field characterization of the profiles were carried out based on the guideline of the USDA Soil Survey Manual (Soil Survey Staff 1993). Composite soil

samples were collected from the pedogenetic horizons and analyzed for soil physico-chemical properties.

Laboratory studies

Soil samples were air – dried at 25 – 27^{0}C and screened through a 2 mm sieve mesh. The particle size distribution of the samples were done according to Bouyouous hydrometer method (Juo, 1979) using sodium hexametaphosphate as the dispersant. Soil pH was determined in a 1:2 soil/water ratio using a pH – glass electrode meter. Soil organic carbon was determined by the Walkley and Black (1934) method, while total nitrogen was by the Kjedhal digestion method. Available phosphorus was determined by Bray and Kurtz No 1 method (1945). Exchangeable bases (Ca, Mg, K and Na) were extracted in 1 N NH_4OAC at pH 7. Na and K were determined in a flame – photometer, while Ca and Mg were determined by EDTA titration method. Exchangeable acidity was determined by titrimetric method using 1 M KCL extract (Mclean, 1965). Cation exchange capacity (CEC) was determined by neutral ammonium acetate solution, while the effective cation exchange capacity (ECEC) was determined by the summation of all exchangeable bases and exchange acidity.

RESULTS AND DISCUSSION

Morphological characteristics

The important morphological characteristics of the study locations are given in Table 1. The soil across the pedons have effective depth that is greater than 100 cm which is considered adequate for teak performance in any humid environment. FAO (1986), has recommended that most crops give good to excellent yields with effective soil depths of only 45 cm. The colour matrix of the soils ranged from dark reddish brown (5 YR 3/3) that graded into yellowish red in the sub soil horizons. The observed colour matrix could be attributed to the immobilization of iron during redox cycles in the soil thereby causing dispersion with progressive oxidation of iron (Boul *et al* 1980). On the other hand, Foster *et al* (1971) postulated a biogenetic process for the coloration due to mechanical mixing by plant roots and soil fauna. The profiles are generally non-mottled depicting non reducing condition of the soil and highly oxidized state. Surface soil are generally coarse, gravelly, and texturally loamy sand that graved into sandy clay loam down the profiles. The structure were dominantly moderate, strong and sub-augular blocky. The consistence were firm and non-sticky at the surface to sticky and plastic at the sub surface horizons. The non sticky and non-plastic consistence at the surface horizons were due to low clay content and the dominance of sand fractions indicating the sandy nature of the parent material. The major inclusions observed were coarse gravelly stones which virtually decline with depth of profile with few roots. The distinctiveness and outline of horizons within the profile varied from smooth to diffuse down the profile.

Particle size distribution

The data for particle–size distribution Table 2, showed that sand was the dominance soil separate across the pedons, which in most cases, were greater than 78% at the surface horizons. The soil were generally coarse with reasonable amount of rock fragments which may increase air penetration, water as well as the rate of soil warming (Wooldridge 1970). However,a coarse skeleton is known to dilute the soil and this may be detrimental to tree growth especially if it occupies a significant volume in sandy soils. It also reduces the already low water holding capacity and exhcnage capacity of forest soils (Egburchua and Ideozo 2007). The high sand content depicts the sandy nature of the parent material and this is responsible for the high aeration, transmissivity and porosity of most tropical forest soils.

Chemical characteristics

The chemical characteristics data is shown in Table 3. The soil was generally acidic in nature with a mean pH value of 5.63 across the pedons. The acidity of forest soils is of great importance in determining the type and quality of forests that occur on any particular site. In most tropical humid environment, most tree species grow best in soil within a pH range of 4.5 – 6.5. The high acidic nature of the soil are due to the rainfall characteristics of the environment with its associated leaching effects. The organic matter content was generally high with a mean value of 27.49 gkg^{-1}. This could be attributed to the vegetational attributes of teaks that are characterized by enormous litter falls that forms litter layer. The litter layers apart from preventing soil erosion, and suppressing weeds, they promote excellent micro bial activities in the soil (Evan, 1999 and Ogogo 1999). The total nitrogen content was moderate with a mean value of 1.43 gkg^{-1}. This could be as a result of high organic matter content which supplies nearly all the soil nitrogen (85 – 90%) in unfertilized soils (Amalu 1997). The carbon/nitrogen (C:N) ratio was found to range between 13.06 – 23.21 with a mean value of 16.49. The values were lower than 25 that is being used as separating index for mineralization and immobilization of nitrogen (Paul and Clark 1989). This implied that high nitrogen content due to mineralization, and high organic carbon content due to high accumulation of organic matter, are results of frequent litter falls from the teak plants. The available phosphorus content was moderately high with a mean value of 16.84 mgkg^{-1} reflecting the importance of organic matter as the principal source of soil phosphorus for many soils (Evans, 1999, Pritchett and Fisher, 1987). The exchangeable cations and cation exchange, capacity across the pedons were low to medium with mean values of 3.74 cmolkg^{-1} for Ca, 1.89 cmolkg^{-1} for Mg; 0.12 cmolkg^{-1} for K, 0.17 cmolkg^{-1} for Na and 9.55 cmolkg^{-1} for CEC respectively. This is because very little of these can be leached below the rooting zone in undisturbed forest ecosystem due to the influencing of litter built up which suppresses leaching and erosion effects Pritchett and Fisher 1987, Egbuchua and Ideozo 2007).

The effective cation exchange capacity (ECEC) ranged from (6.46 – 10.60 cmolkg^{-1}) with a mean of 8.41 cmolkg^{-1}. This is considered low to medium in tropical environment. However, they are above the critical value of 4 cmolkg^{-1} established by Agboola and Ayodele 1997, Sanchez 1976). The low values could be attributed to low colloidal content of clay which are the estsential materials for cation exchange and adsorption in the soil. There is a general decrease in ECEC value with soil depth, following the distributional pattern of organic matter. It was generally higher at the surface soil horizon, decreasing with depth below their critical levels.

CONCLUSION

The characteristics of soils under Teak (tectona grandis) showed that the soils are generally rich and contain sufficient primary and secondary minerals that can ensure optimum growth and adequate cycle of cations through normal weathering processes. The high acidic nature of the soil under tropical humid is environment irrelevant in the tree performance as most hard woods and other forest species are well adapted to acid soil environment.

TABLE 1. Some morphological characteristics of forest soil under Teak plantation in a humid forest region of Nigeria

Mapping unit.	Hori.	Depth (cm)	Munsel colour	Mottling	Texture	Structure	Consistence	Rootlets	Boundary
Anwai – North	Ap	0 – 15	5YR 3/3	-	LS	2, sbk	fi, ns.	m	s
	A	15 – 35	5YR 5/6	-	SL	2, sbk	fi, ns.	m	s
	AB	35 – 55	10YR 7/8	-	SCL	2, sbk	fi, spl.	m	d
	BC	55 – 120	10YR 7/8	-	SCL	2, sbk	fi, st, pl.	f	d
Anwai – South	Ap	0 – 25	5YR 5/6	-	LS	2, sbk	fi, ns.	m	s
	A	25 – 50	5YR 5/6	-	SL	2, sbk	fi, ns.	m	s
	AB	50 – 75	10YR 6/8	-	SCL	2, sbk	st, spl.	m	d
	BC	75 – 125	10YR 7/8	-	SCL	2, sbk	st, pl.	f	d
Anwai – East	Ap	0 – 20	5YR 3/3	-	LS	2, sbk	ns, fi.	m	s
	AB	20 – 55	5YR 5/6	-	SL	2, sbk	ns, fi.	m	s
	Bt_1	55 – 85	10YR 7/8	-	SCL	2, sbk	spl, st.	m	d
	Bt_2	85 – 135	10YR 7/8	-	SCL	2, sbk	st, pl.	f	d
Anwai – West	Ap	0 – 15	5YR 5/6	-	LS	2, sbk	ns, npl.	m	s
	A	15 – 45	5YR 5/6	-	SL	2, sbk	ns, fl.	m	s
	Bt_1	45 – 85	10YR 7/8	-	SCL	2, sbk	st, spl.	m	d
	Bt_2	85 – 130	10YR 7/8	-	SCL	2, sbk	pl, st.	f	d

Abbreviation: Texture: SL = sandy; loam; SCL = Sandy clay loam, CL = clay loam.
Structure: 2, moderate; 3, strong, sbk = sub angular block.
Consistence: fi, = firm; ns = none sticky, spl = slightly plastic, st = sticky pl = plastic.
Rootlets: m = many; f = few .
Boundary: s = smooth, d = diffuse.
Munsell colour: 5YR 3/3 = dark reddish brown YR 5/6 = yellowish red 10 YR 7/8 = yellowish red.

TABLE 2. Particle size distribution of forest soil under Teak plantation in humid forest region of Nigeria

Mapping units	Horizon design.	Depth (cm)	Sand (%)	Silt (%)	Clay	Silt/clay	Gravel	Textural class.
Anwai – North	Ap	0 – 15	80.0	13.0	7.0	0.65	g	LS
	A	15 – 35	76.0	9.0	15.0	0.38	g	SL
	AB	35 – 55	70.0	12.0	18.0	0.40	f	SCL
	BC	55 – 120	65.3	13.7	21.0	0.65	-	SCL
Anwai – South	Ap	0 – 25	86.0	6.0	8.0	0.75	g	LS
	A	25 – 50	78.0	9.0	13.0	0.69	g	SL
	AB	50 – 75	65.0	12.5	22.5	0.56	f	SCL
	BC	75 – 125	59.6	13.4	27.0	0.49	-	SCL
Anwai – East	Ap	0 – 20	82.7	11.3	6.0	1.88	g	LS
	AB	20 – 55	78.5	12.7	8.0	1.59	g	SL
	Bt_1	55 – 85	70.8	13.2	16.0	0.83	f	SCL
	Bt_2	85 – 135	64.3	14.4	21.3	0.68	-	SCL
Anwai – West	Ap	0 – 15	83.8	10.7	5.5	1.94	g	LS
	A	15 – 45	77.6	11.7	10.7	1.09	g	SL
	Bt_1	45 – 85	72.2	13.8	14.0	0.99	f	SCL
	Bt_2	85 – 130	63.7	15.1	21.2	0.71	-	SCL
	Mean values		73.34	11.97	14.64	0.92		

Abbreviations: Gravel: g = gravelly, f = few
Texture classification: LS = loamy sand, SL = Sandy loam, SCL = Sand clay loam

TABLE 3. Chemical characteristics of forest soil under Teak plantation in a humid forest region of Nigeria

Location	Hori.	Depth (cm)	pH (H_20)	Org. matter (gkg^{-1})	Total N (gkg^{-1})	C:N ratio	Avail P ($mgkg^{-1}$	Ca	Mg	K ($cmolkg^{-1}$)	Na	Exch. Acidity	CEC ($cmolkg^{-1}$)	ECEC ($cmolkg^{-1}$)
Anwai – North	Ap	0 – 15	5.3	27.54	1.86	14.84	19.75	5.21	2.38	0.18	0.2	2.15	12.35	10.12
	A	15 – 35	5.2	27.35	1.84	14.86	18,47	5.05	2.29	0.15	0.2	2.13	10.14	9.82
	AB	35 – 55	5.5	21.10	1.02	20.69	16.92	3.21	1.46	0.07	0.13	2.21	7.38	7.01
	BC	55 – 120	6.7	19.35	0.85	22.76	16.75	2.76	1.38	0.09	0.17	2.32	7.25	6.72
Anwai – South	Ap	0 – 25	5.4	25.42	1.76	14.44	18.33	5.10	2.76	0.15	0.2	2.24	13.14	10.45
	A	25 – 50	5.3	23.19	1.58	14.68	17.97	5.01	2.54	0.12	0.2	2.15	11.12	10.02
	AB	50 – 75	5.2	17.86	1.34	13.33	16.36	3.74	1.36	0.05	0.13	2.31	9.76	7.59
	BC	75 – 125	6.5	14.35	0.98	14.64	16.14	3.02	1.24	0.10	0.15	2.35	8.14	6.86
Anwai – East	Ap	0 – 20	5.7	28.76	1.84	15.63	18.71	5.14	2.42	0.17	0.2	2.18	12.30	10.11
	AB	20 – 55	5.8	23.18	1.78	13.02	17.01	4.03	2.15	0.13	0.2	2.15	10.15	8.66
	Bt_1	55 – 85	5.3	21.05	1.35	15.19	15.35	3.02	1.41	0.08	0.13	2.34	8.10	6.98
	Bt_2	85 – 135	5.7	18.10	0.78	23.21	12.31	2.78	1.31	0.12	0.14	2.37	6.35	6.72
Anwai – West	Ap	0 – 15	5.2	30.10	1.81	16.63	18.78	5.21	2.56	0.18	0.2	2.45	12.14	10.60
	A	15 – 45	5.3	27.35	1.65	16.58	17.37	4.85	2.34	0.13	0.2	2.10	10.01	9.62
	Bt_1	45 – 85	5.3	21.19	1.35	15.39	15.21	3.10	1.33	0.07	0.14	2.15	8.36	6.79
	Bt_2	85 – 130	6.6	18.76	1.01	18.57	14.01	2.57	1.28	0.09	0.15	2.42	6.10	6.46
Mean values:			5.63	27.49	1.43	16.49	16.48	3.74	1.89	0.12	0.17	2.25	9.55	8.41

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