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FERTILITY STATUS OF SOILS OBTAINED FROM COASTAL PLAIN SOILS AND INLAND TRANSITION FORMATIONS

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ABSTRACT

The study was conducted to investigate the fertility status of coastal plain and inland transition soils in South-south and South west of Nigeria. Soil morphological characterization and sampling were obtained from the coastal plain area at Lagos Island and environs, while the Inland transition soils were obtained at Obaretin near Benin City, Edo State, Nigeria. Laboratory analyses of selected physico-chemical properties were conducted using standard methods. The results obtained were subjected to statistical analyses using SPSS version 16. The results obtained showed that the soils from the coastal plain area were generally, slightly acidic with a mean pH of 4.5 ± 0.4 while the Inland transition soils were slightly alkaline with a mean pH of 8.2 ± 1.1. Total organic carbon in both locations were 6.50 ± 1.90 g/kg for Lagos Island and environs and 10.0 ± 3.0 g/kg for Obaretin respectively. They were both low. Similarly, the mean value of other basic macro nutrient elements are 0.40 ± 1.0 g/kg for nitrogen in Lagos Island and environs and 0.80 ± 3.0 for nitrogen in Obaretin, while phosphorous had a mean of 52.39 ± 35.0 meg/kg in Lagos Island and environs and Obaretin had 20.77 ± 14.41 meg/kg. Also, the mean value of potassium were 0.03 ± 0.01 meg/kg for Lagos Island and 0.11 ± 0.04 meg/kg for Obaretin respectively. The values were low with the exception of phosphorous when compared with the recommended standard. This suggests poor soil fertility that may require occasional inorganic and organic fertilization to conserve the soils and high crop productivity on sustainable basis when the coastal and inland transitions are transformed into intensive agro-ecosystem.

INTRODUCTION

Coastal plain soils occupy nearly level coastal plain with very long interfluvial slope, they constitute a distinct transition between the poorly drained soils at the lower slope positions and the well drained dark red sandy loam to sandy clay loam soils occupying the top slope position (Daniels *et al.*, 1999). The physical properties and the taxonomy vary with location. The warm, humid climate and long time for pedogenesis create distinct soil profile, mineralogical, and chemical characteristics. Extensive clay eluviation creates shallow A horizons, well-developed E horizons that have sand, loamy sand, or sandy loam textures and relatively thick Bt horizons with sandy clay to clay textures (Shaw *et al.*, 2004). Intensive leaching of bases also resulted in low soil pH values, extensive clay mineral weathering, low cation exchange capacity (CEC) and high levels of exchangeable Al (Daniels *et al.*, 1978). These soil characteristics severely limit soil fertility and agricultural management options.

Inland transition formation composed of land area between upland and hydromorphic valley fringes and seasonally flooded valley bottoms. Inland valleys are a common feature in sub-Saharan Africa and have substantial potential for agricultural production (WARDA, 1999). Their area coverage in West Africa is estimated to range from 22 to 52 million hectares (Andriesse and Fresco, 1991). This gently undulating landscape characterized the majority of the humid zone of West Africa. Inland valleys and its associated transition soils are significant ecosystems because they have the potential to be used for agriculture in a sustainable way and have a diverse physical potential for increasing food production compared with the adjacent uplands where the degradation of the resource base of agriculture is occurring (Juo and Hossner, 1992; IITA, 1990, 1994; Coraf Action, 1997). However, the potentials of inland Valleys have remained relatively untapped and under-utilized besides that, Inland Valley and its associated transition agro ecosystems are highly complex and heterogeneous (IITA, 1990).

Soil fertility refers to the inherent capacity of soils to supply nutrients to plant in adequate amount and suitable proportions (Agronomy in Nigeria, 2000). Given this strong physical interactions between the inland transition and the adjoining land units, meaningful land use planning tool for sustainable agriculture is required in soil fertility perspective of this peculiar landscape. Therefore, this study was conducted to examine the fertility status of soil in these ecologies.

MATERIALS AND METHODS

Study Site

In this study, the area investigated comprised Lagos Island and its environs in Lagos State Nigeria which lies on latitude E 003^0 25.160' and longitude N 06^0 25.564, with an average rainfall of 2000 mm and temperature of 30^0 C. The second location is at Obaretin near Benin City in Edo State Nigeria which lies at latitude E 005^0 44.169' and longitude N 06^0 08.604' with mean annual rainfall of 1800 mm and temperature of 30^0 C respectively. Both locations are in South-West and South-South regions of Nigeria. Lagos Island and its environs consist of massively built-up commercial and residential buildings adjoining beach and shoreline, lagoons and a few creeks. While in Obaretin, the land is fallow with grasses and shrubs, it bordered on the east with streams and creek and on the west with oil palm plantation.

Soil samples were obtained at selected area using soil auger at 0 – 15 cm and 15 – 30 cm depths respectively. The augering was done at three core points forming a composite per sampled position and then transferred into labelled polyethylene bags for storage, processing and analyses. All sampled locations (points) were geo-referenced with the Garmin Geographic Positioning Systems (GPS) equipment. In addition, the following features were examined; Soil physical properties as it affects presence of concretions and impediment, texture, mottling, colour, drainage pattern and landuse. The soils collected were taken to the laboratory for analyses of physicochemical properties; the composite soil samples collected were air dried at room temperature and sieved through a 2 mm sieve. The resulting soil samples were analyzed as follows: Particle size was determined by hydrometer method (Gee and Border, 1986). Available Phosphorous (P) was determined by Bray P-I method (Anderson and Ingram, 1993). Total Nitrogen (N) was determined by macro-kjedhal method (Brookes *et al.*, 1985). Soil pH was determined in a 1:2 soil to distilled water suspension using a pH meter (Maclean, 1982). Exchangeable bases were extracted using NH_40Ac buffered at pH 7.0 (Thomas, 1982). While Potassium (K) and Sodium (Na) were read from a flame photometer, Exchangeable Calcium (Ca) and Mg were determined using atomic absorption spectrophotometer. Total Exchangeable acidity, Hydrogen and Aluminium ($H^+ + Al^{3+}$) was by titration method (Anderson and Ingram, 1993) while effective cations exchange capacity (ECEC) was determined by summation of exchangeable cations and exchangeable acidity (Tan, 1996). Furthermore, the levels of NO_3- and NO_2-, were determined as described by Jackson (1960). Statistical analyses were also carried out on the results obtained using SPSS 16.0 version at $\leq$ *0.05* probability levels to determine the level of significance and correlation between organic matter and cation exchange capacity (CEC).

RESULTS AND DISCUSSION

The field investigation studies in Lagos Island, which comprised Saka Tinubu on the Victoria Island and Lekki phase 1, Bonny camp and Ozumba Mbadiwe showed that the entire area is fairly homogenous and flat with gradient not exceeding 2^0. The soils are well drained but wet due to low lying topography of the entire coastal plain. Soil colour ranged from grey to white at the Saka Tinubu and off the right of way on Adeola Odeku respectively and grey to olive at Bonny camp, Ozumba Mbadiwe and Lekki Phase 1. In all, there were no indications of on-going redox processes such mottles and concretions. The soils did not have structural impediments within the layers except in already impacted areas due to on-going building/construction works. Table 1 shows the results of the physicochemical properties in Lekki Phase 1.

Table 1: Physicochemical Properties of the Soil in Lagos Island and Environs

	SAQ_1	SAQ_1	SAQ_2	SAQ_2	SAQ_3	SAQ_3	SAQ_4	SAQ_4	SAQ_5	SAQ_5	SAQ_6	SAQ_6
Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	5-30	0-15	15-30	0-15	15-30
pH	8.8	9.1	8.8	9.0	8.5	8.7	7.2	5.0	8.3	8.6	8.2	8.3
Electrical conductivity (EC)uS/cm	480.5	465.5	52.5	50.4	67.2	65.8	182.5	187.9	293.5	285.7	180.5	183.7
Total Organic Carbon (TOC) g/kg	5.10	3.50	4.80	3.90	7.50	6.40	7.30	5.90	9.70	8.20	8.80	6.90
Total Nitrogen g/kg	0.3	0.2	0.3	0.2	0.6	0.4	0.7	0.3	0.6	0.5	0.4	0.3
Available Phosphorus (P)mg/kg	23.091	22.730	63.140	47.505	50.4	62.51	31.871	64.102	18.401	29.946	147.80 8	67.229
Exchangeable Potassium (K)meq/100g	0.04	0.04	0.02	0.04	0.03	0.03	0.04	0.06	0.07	0.04	0.02	0.03
Exchangeable sodium (Na)meq/ 100g	0.07	0.65	0.62	0.75	0.84	0.95	0.93	1.05	1.37	1.28	0.93	0.98
Exchangeable calcium (Ca) Meq/100g	2.06	3.29	3.92	4.83	4.90	5.18	4.80	5.12	7.35	8.11	3.90	3.82
Exchangeable magnesium (Mg)meq/100g	1.48	1.60	2.35	2.00	1.77	1.63	1.50	1.64	1.38	1.50	2.17	2.24
Exchangeable Acidity (EA)meq/100g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cation Exchange Capacity (CEC)meq/100g	3.65	5.58	6.91	7.62	7.54	7.79	7.72	7.87	10.17	10.93	7.02	7.07
Base Saturation (BS)%	100	100	100	100	100	100	100	100	100	100	100	100
Nitrate ($N0_3$) mg/kg	3.20	1.84	2.27	3.30	4.04	3.25	5.07	5.08	9.95	11.32	4.50	4.30
Nitrate ($N0_2$) mg/kg	1.93	1.65	1.01	0.95	1.20	1.09	2.51	3.17	3.12	3.75	2.48	2.59
Sand g/kg	920.0	940.0	935.0	920.0	936.0	945.0	900.0	910.0	940.0	940.0	915.0	920.0
Silt g/kg	60.0	40.0	45.0	60.0	54.0	50.0	80.0	70.0	40.0	40.0	65.0	60.0
Clay g/kg	20.0	20.0	20.0	20.0	10.0	15.0	20.0	20.0	20.0	20.0	20.0	20.0
Total hydrocarbon content (THC)mg/kg	8.25	8.25	4.43	4.21	3.15	3.00	3.93	4.15	4.39	4.58	2.11	2.07

ND = Not Detected

In the same vein, the entire land area investigated in Obaretin was generally flat and the soils were wet and fairly well drained. Soil colour varied from light brown 2.5YR to yellow 2.5YR 7/6. At some other points very dark grayish brown 2.5YR 3/2 and dark grayish brown 2.5YR 4/2 were observed. The soil physical properties as observed in both locations are in agreement with the description of a typical coastal plain soil by Daniel *et al.*, (1999). Table 2 shows the results of physicochemical properties of soils in Obaretin.

In terms of physico-chemical properties in both locations (Tables 1 and 2), the entire soils were generally sandy with mean sand fraction of 96.6 ± 1.4 % for Lagos Island and environs and 90.42 ± 2.7 % for Obaretin, this is consistent with soils formed on coastal plain or marine alluvial deposits.

Table 2: Physicochemical Properties of Soils from Obaretin

S/N	**Sample Code**	**Coordinate**	**pH**	**EC μS/cm**	**g/kg**			**P(mg/ kg)**	**Meq/100g**							**g/kg**			**Meq/100g**		**Mg/kg**	
					C	N	OM		Ca	Mg	K	Na	H+	Al^{3+}	ECEC	Clay	Silt	Sand	CEC	EA	NO^-_3	**NO^-_2**
1.	PSS_1	N0608.604^1	5.6	51.8	14.08	1.13	24.34	39.37	1.60	0.64	0.232	0.580	0.4	1.4	4.852	48.0	75.0	877.0	3.1152	1.8	5.93	**3.121**
2	PSS_1	N005^0 44.169^1	5.0	70.9	11.52	0.94	19.92	42.56	1.52	0.40	0.176	0.767	0.0	1.6	4.463	68.0	65.0	867.0	2.863	1.6	7.82	**2.13**
3	PSS2	N06^{0}08.647^1	4.3	52.2	9.60	0.71	16.60	48.30	1.92	0.48	0.098	0.733	0.4	0.4	4.0031	33.0	50.0	917.0	3.631	0.8	4.51	**2.11**
4	PSS2	N0005^{0}44.162^1	4.9	52.6	10.88	0.86	18.81	10.44	2.32	0.32	0.108	0.733	0.4	0.3	4.181	18.0	60.0	922.0	3.881	0.7	11.3	**1.82**
5.	PSS3	N06^{0}8.708^1	4.9	52.3	8.96	0.69	15.49	12.99	1.92	0.96	0.077	0.665	0.2	0.4	4.22	23.0	55.0	922.0	3.822	0.6	14.61	**1.35**
6.	PSS3	E005^{0}44.159^1	4.7	64.6	4.48	0.27	07.75	43.98	1.20	0.40	0.098	0.597	0.1	0.4	2.795	58.0	45.0	897.0	2.395	0.5	5.12	**1.42**
7.	PSS4	E06^{0}8.740^1	4.4	37.1	10.88	0.86	18.81	13.22	2.08	0.24	0.093	0.639	0.5	0.2	3.752	28.0	50.0	922.0	3.552	0.7	7.24	**2.81**
8.	PSS4	E005^{0}44.177^1	4.5	76.9	11.52	0.94	19.92	10.12	1.44	0.16	0.083	0.557	0.3	0.8	3.340	48.0	75.0	877.0	2.540	1.1	8.95	**3.53**
9.	PSS5	.06^{0}08.795^1	4.2	57.6	3.52	0.19	6.09	18.77	0.88	0.40	0.072	0.588	0.0	1.2	3.140	28.0	55.0	917.0	1.940	1.2	12.33	**2.02**
10.	PSS5	E005^{0}44.155^1	4.4	43.0	12.80	1.21	24.13	19.55	2.16	1.12	0.119	0.571	0.0	0.3	4.270	68.0	50.0	882.0	3.970	0.3	16.35	**1.95**
11.	PSS6	N06^{0}8.850^1	4.3	49.3	5.76	0.33	09.96	12.21	2.48	1.28	0.176	0.656	0.3	0.7	5.592	48..0	75.0	877.0	4.892	1.0	10.01	**2.16**
12.	PSS6	E005^{0}44.147^1	4.4	76.5	11.20	0.86	19.36	9.84	2.08	1.12	0.083	0.520	0.4	0.9	5.103	48.0	75.0	877.0	4.203	1.3	11.25	**1.33**
13.	PSS7	N06^{0}08.921^1	4.1	80.9	10.56	0.74	18.26	13.76	8.12	2.72	0.103	0.674	1.0	1.1	13.74	38.0	65.0	877.0	12.044	2.1	14.31	**1.85**
14.	PSS7	E005^{0}44.147^1	4.2	41.3	8.64	0.67	14.94	13.90	2.40	1.04	0.103	0.741	0.8	0.4	5.484	18.0	60.0	922.0	5.084	1.2	12.22	**2.61**
15.	PSS8	N06^{0}09.005^1	4.2	41.8	8.00	0.65	13.83	15.68	3.60	2.96	0.093	0.682	0.5	1.4	9.235	38.0	36.0	926.0	7.835	1.9	9.30	**2.09**
16.	PSS8	E005^{0}44.134^1	4.2	42.6	16.32	1.66	28.22	14.17	1.36	0.80	0.119	0.810	1.1	0.9	5.089	28.0	40.0	932.0	4.189	2.0	10.12	**2.17**
17.	PSS9	E06^{0}09.122^1	4.5	92.7	13.12	1.32	22.68	8.25	3.04	2.48	0.077	0.784	0.1	1.1	7.581	38.0	40.0	922.0	6.481	1.2	6.98	**1.49**
18	PSS9	E005^{0}44.124^1	3.8	66.4	9.60	0.78	16.60	48.07	1.52	0.32	0.067	0.818	0.0	1.8	4.525	48.0	55.0	977.0	2.725	1.8	7.00	**1.53**
19.	PSS10	E06^{0}09.273^1	4.3	53.9	9.8	0.8	16.90	10.45	2.53	1.16	0.13	0.64	0.3	1.0	5.76	48.0	75.0	877.0	4.760	1.3	11.50	**1.69**
20.	**PSS10**	**E005^{0}44.112^1**	**4.2**	**54.2**	**9.4**	**0.7**	**16.20**	**9.82**	**2.49**	**1.29**	**0.10**	**0.60**	**0.4**	**0.8**	**5.68**	**58.0**	**45.0**	**897.0**	**4.880**	**1.2**	**8.39**	**1.40**

The soils in Lagos Island and environs were alkaline with a pH of 8.2 ± 1.1; this could be due to calcium carbonate presents in the soils of the area. While the soils in Obaretin were acidic with a pH of 4.45 ± 0.39, also the electrical conductivity were 207.9 ± 149.3 µS/cm for soils in Lagos Island and 37.1 ± 92.7 µS/cm for Obaretin respectively. The total organic carbon and nitrogen content of the soils in both locations were 0.65 ± 0.19 % for carbon and 0.04 ± 0.01 % for nitrogen in soil of Lagos Island and environs and 1.00 ± 0.30 % for carbon and 0.08 ± 0.03 % for nitrogen in soils of Obaretin respectively. The values were low when compared with the critical levels as recommended by the Federal Department of Agricultural Land Resources (FDALR, 2004). The low level of organic carbon and nitrogen may be due to low amount of plant and animal residues associated with spared vegetation or reclaimed land as observed in the study area. Also, increased rate of mineralization of organic matter associated with high soil moisture and temperature. The soils in Obaretin had a mean cation exchange capacity (CEC) of 4.45 ± 2.26 meq/100g (Table 3), while the soils in Lagos Island and environs had a mean CEC of 7.45±1.86 meq/100g (Table 4).

Table 3: Mean Concentration of Physicochemical Properties of soils from Lagos Island and Environs

Parameter	Mean	Standard Division
pH	8.2	1.1
Electrical conductivity (EC)uS/cm	207.9	149.3
Total Organic Carbon (TOC) g/kg	6.05	1.90
Total Nitrogen (N)g/kg	0.40	0.10
Available Phosphorus (P)mg/kg	52.39	35.06
Exchangeable Potassium (K)meq/100g	0.03	0.01
Exchangeable sodium (Na)meq/100g	0.86	0.33
Exchangeable calcium (Ca) meq/100g	4.77	0.65
Exchangeable Acidity (EA)meq/100g	1.76	0.32
Cation Exchange Capacity (CEC)meq/100g	7.45	1.86
Base Saturation (BS)%	100.0	0.00
Nitrate ($N0_2$) mg/kg	4.88	2.91
Nitrate ($N0_3$) mg/kg	2.12	0.95
Chloride (C1) mg/kg	289.65	351.01
Sand g/kg	926.0	14.0
Silt g/kg	55.0	12.8
Clay g/kg	18.0	3.0

Table 4: Mean ± Standard deviation of the Physicochemical properties of Soils from Obaretin

Parameter	Mean	Standard Deviation
pH	4.45	0.39
EC(µS/cm)	58.08	15.40
C (g/kg)	10.0	3.0
N (g/kg)	0.80	0.30
OM (g/kg)	17.30	5.30
P (mg/kg)	20.77	14.41
Ca (meq/100g)	2.33	1.50
Mg (meq/100g)	1.01	0.82
K (meq/100g)	0.11	0.04
Na (meq/100g)	0.66	0.08
H^+ (meq/100g)	0.36	0.31
Al (meq/100h)	0.85	0.47
CEC (meq/100g)	4.45	2.26
ECEC (meq/100g)	5.29	2.51
Clay (g/kg)	40.5	15.9
Silt (g/kg)	57.30	13.0
Sand (g/kg)	904.2	27.9
EA (meq/100g)	1.21	0.52
$N0_3$ (mg/kg)	9.75	3.25
$N0_2$ (mg/kg)	2.20	0.01

Two important components in soil could be responsible for the CEC; clay content and amount of organic matter. In this present assessment, these two components were generally low, although, soil in Lagos Island and environs shows good association between organic carbon and CEC (R = 0.617 and R^2 = 31.9 %), while poor relationship existed between organic matter and CEC in soils of Obaretin (R = 0.102 and R^2 = 0.01%). In all calcium dominated the exchange sites and phosphorous (P) was high in both locations.

CONCLUSION

In general, the soils in the studied area had no impediments with respect to soil physical properties. However, they were low in major macronutrients with exception of phosphorous (P), this suggests poor soil fertility that may require some mitigating measures to improve. Furthermore, the results also revealed positive correlation between total organic carbon (TOC) with CEC in soils of Lagos Island and environ while there was a negative correlation between TOC and CEC in soils of Obaretin. Therefore, for the soils of the study area to be considered for crop base agricultural purposes, further investigations may be carried out to determine appropriate mitigating measures to increase the fertility status of the soil. In addition, if it is correct to assume similar trends in other coastal and inland transition soils in other parts of the country, then there is urgent need for information on their fertility status and appropriate soil management practices that can increase its agricultural productivity. Similarly, planned exploitation of this peculiar landscape may enhance sustainable crop productivity for farmers.

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