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CHARACTERIZATION OF SELECTED VALLEY BOTTOM SOILS IN UNIVERSITY OF IBADAN, IBADAN NIGERIA

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ABSTRACT

A Study was conducted to characterize and determine the potentials of valley bottom soils at University of Ibadan, South Western Nigeria. Soil survey was carried out using rigid grid method where three soil types were identified as Jago series, Matako series and Matako series “browner variation”, soil samples were collected from genetic horizons and were subjected to laboratory analysis using standard procedure. The soils were characterized based on their physical and chemical properties. The soil texture ranged from sandy loam to loamy sand. Saturated hydraulic conductivity (Ks) in Jago series ranged from 10.00 to 18.20 cm/hr; for Matako series it ranged from 16.00 to 22.10 cm/hr and for Matako series (browner variation) it was from 13.31 to 28.33 cm/hr. Bulk density for Jago and Matako soil series, increased with soil depth while for Matako series “browner variation” it fluctuates across the profile. Jago soil series showed neutral (6.58) pH (H_2O), while Matako series had 6.36 and Matako (browner variation) had 6.48 which are slightly acidic. Organic carbon (OC) content, were all high in the series with Jago having (8.22 g/kg) while Matako series had (16.36 g/kg) and Matako (browner variation) had (17.13 g/kg). Total Nitrogen (TN) content was low for all soil series (0.50 g/kg) for both Jago and matako series, Matako series (browner variation) had (0.95g/kg). Available Phosphorous (P), Potassium (K), and Base Saturation (BS), for Jago series had values of 27.5 mg/kg, 1.05 cmol/kg, 98.85 %; Matako series had 26.80 mg/kg, 0.7 cmol/kg, 98.82 %, and Matako series (browner variation) had 27.06 mg/kg, 1.20 cmol/kg, 98.65 %, respectively. The soils were generally very deep with no evidence of rock outcrops and are imperfectly to poorly drained due to the high water table, therefore, there is need for good drainage to harness the potentials and utilization for crop production and other uses.

Keywords: Soil; Characterization; Valley bottom

INTRODUCTION

Characterization of soils for different land uses are the first milestone to develop database for classification, land evaluation and formulating land use models. Soil is one of the most important natural resources and proper understanding of its properties is necessary for judicious, beneficial and optimal use on suitable basis (Jagdish *et al*., 2009). A thorough and proper understanding of morphological, physical, and chemical characteristics of the soils gives greater insight of the dynamics of the soil. Valley bottom soils are generally flat-floored, relatively shallow, especially in the drier undulating savanna lands of Africa. They are called "dambos" in East and Central Africa (Mackel 1974) and "Fadamas" in Northern Nigeria and Chad (Savvides 1981). Common characteristics of valley bottom soils is their heterogeneity in physical and chemical properties, which differs from soils of surrounding upland, making the soils to be more productive (Andriesse, 1986). Their physical and chemical properties also reflect the influence of poor drainage. In the wetter south western Nigeria Basement Complex Area, the inland valleys become less prominent in the landscape due to narrowing down resulting from deeper incision into the pediplains (Keay, 1959). Fagbami and Francis (1990), observed that fadamas are extensively cultivated in Northern Nigeria, especially in the dry season, but are usually ignored in southwestern Nigeria because of their generally narrow extent, their wetness and the generally forested vegetative cover. In spite of the generally higher annual rainfall and longer rainy season (7 to 8 months of the year) than in the dry northern savannas. Ogban and Obi (2014) also observed that valley bottom soils are abundant in Nigeria, their utilization has been limited by poor knowledge of the nature and properties of such soil. Therefore, this study was carried out to characterize some valley bottom soils in the University of Ibadan, southern western Nigeria to enhance effective and planned use of the soils for crop production.

MATERIALS AND METHODS

Description of the Experimental Site

The experimental site was located in the University of Ibadan, Organic Agriculture Farm, Practical Year Training Plot (PYTP), covering about 1.2 hectares (ha), which lies on latitude 7˚ 27’ 42.2’’N and longitude 3˚ 53’ 60.3’’ E (Fig.1). The area is generally low lying with elevation ranging approximately between 188m and 195 m above sea level. The geology is made up of crystalline Basement Complex rocks, mainly magmatite with some granite, gneiss and schist’s (Jones and Hockey, 1964). In addition to the gneisses are many varieties of simple ortho-gneisses. There are no visible rock out-crops on any part of the location.

A field studies was first carried out to know the major features of the terrain in terms of the vegetation, topography and other biophysical features of the landscape. A rigid grid soil survey was then undertaken for the purpose of identification and mapping the soils of the area. A series of parallel traverse lines (10m x 10m) were set out and observation were made at every 10m intervals. Identification of the kinds of soils was done using Dutch auger at every 15cm depth intervals down to 120 - 130cm. At each interval the properties examined were mainly soil profile characteristics. The soils were separated based on the three criteria, which are texture, color and inclusions. Areas with similar kinds of soil were put under one mapping unit and areas with dissimilar kind of soil were further examined for accurate location of the boundary between them.

Three different kinds of soil were identified; profile pits were dug, from each soil to a depth of about 2m, with the depth varying depending on the peculiarity of the water table, for the purpose of characterization, in accordance with FAO (1990) soil description procedures. Undisturbed core samples were collected at each horizon for determination of bulk density, and saturated hydraulic conductivity using metal rings.

Soil samples collected from experimental field were brought to the laboratory for both physical and chemical analyses. The physical properties analyzed were particle size distribution, bulk density and saturated hydraulic conductivity, while the chemical properties analyzed were: organic carbon, soil pH (H_2O), total nitrogen, available phosphorus, exchangeable bases, exchangeable acidity, effective cation exchange capacity (ECEC) and percentage base saturation (BS).

Laboratory Analysis

Particle size analysis was carried out by the Bouyoucos (1951) hydrometer method as cited in Klute (1986). Bulk density was determined according to Blake (1965**).** Saturated hydraulic conductivity was determined by the method of Hillel (1980). Exchangeable acidity was determined by the KCl extraction method (Mclean, 1965). Organic carbon was determined by the dichromate wet oxidation (Walkley and Black, 1934) method. Soil pH was determined using pH meter with glass electrode in 1:2 (soil: water). The Micro-Kjehldal method (Jackson, 1962) was used to determine Total Nitrogen. Available Phosphorous was determined according to Mehlich 3 (pH 7.0) method Mehlich (1984). Exchangeable cations were determined using (Mehlich, 1984). The Effective Cation Exchange Capacity (ECEC) was taken as the sum of exchangeable cations and the exchangeable acidity (Rhoades, 1982).The percentage base saturation was calculated as follows:

$$\%\text{ Base saturation} = \frac{(Ca^{2+}+Mg^{2+}+K^{+}+Na)}{ECEC} \times 100$$

Data Analysis

Descriptive statistics (mean, standard deviation and coefficient of variation) was used to analyze the physical and chemical characteristics data generated from field and laboratory investigations.

RESULTS AND DISCUSSION

Physical Properties

The physical properties of the soils are presented in Table 1. Jago soil had texture of sandy loam in the surface horizon and sandy clay loam in the subsurface horizon, the content of sand and silt decreases down the slope while that of clay increases. Ojanuga and Nye (1969) attributed the increase in the clay content in the subsurface horizons to the differential sorting of clay from the surface horizon to the subsurface horizon. Smyth and Montgomery (1962) had earlier attributed biological, physical, and at times, chemical processes as major causes of clay eluviation from the surface horizon to the subsurface horizon.

The texture of Matako soil fluctuates irregularly from loamy sand at the surface horizon to sandy loam/loam sand at subsurface horizons, and sandy clay loam at the last layer of the subsurface horizon, the fluctuation in the textural class of the soil signifies the nature of valley bottom soils, where different materials are deposited constantly, and these agrees with the studies of Andriesse, (1986), which states that valley bottom soil texture are highly variable. And according to Hekstra and Andriesse, (1993), Lithologically, the texture differences indicate that the soils are derived from granitic materials derived from metamorphosed materials of the basement complex. The soils of Matako "browner variation" ranged from silty loam to loam sand at the surface horizon and sandy loam at the subsurface horizons, the silty loam and loam sand could be due to the nature of parent materials from which the soil are formed. The silt fractions in the soils indicate the abundance of weatherable minerals which are derived from erosion in the adjacent uplands and alluvium both of the pre-Cambrian basement complex (Ogban and Babalola, 2009). In comparism, Jago had the highest value of clay but with lower value of total sand. The highest value of total sand was recorded in Matako series although it had the lowest value of clay. Matako browner variation recorded the lowest value of total sand but had highest value of silt. The texture encountered in the soils were due to the Basement Complex parent materials which according to Ibanga (2006) weathers into medium to coarse separate. The values of bulk density are presented on Table 1. According to Arshad *et al*., (1996), sandy clays, silty clays and clay loams with 350 – 450 g/kg clay, that have a bulk density of $<1.10(g/cm^3)$, is ideal for crop growth, while bulk density $> 1.58 g/cm^3$ restricts root growth. Furthermore he stated that soils with sand or loamy sands texture having bulk density $<1.60(g/cm^3)$ is ideal soils for crop production but bulk density between 1.69 (g/cm^3) to 1.79 (g/cm^3) affect root growth while bulk density of $>1.80\ g/cm^3$ will restrict root growth. Silts and silt loams texture that have bulk density $<1.30\ g/cm^3$ will support crop growth adequately but bulk density $> 1.60\ g/cm^3$ will affect root growth.

Jago soils had bulk density results, ranging from 1.40 to 1.57 g/cm^3, according to Arshad *et al*., (1996), it showed that the soil had ideal bulk density for crop production. This result is also similar to the findings of Jewitt *et.al* (1979), who stated that the bulk density of a wet land soils vary between 1.0 g/cm^3 to 2.0 g/cm^3.

Table 1: Some Physical properties of the Soils of the study area

Soil series	HD	Soil depth (cm)	TS ←	Silt (g/kg)	Clay →	TC	BD (g/cm^3)	HC (cm/hr)
JAGO	A1	0 – 29	790.4	90.6	110.0	SL	1.57	18.20
	A2g	29 – 45	730.4	120.0	140.6	SL	1.52	16.81
	A3g	45 – 88	670.4	40.0	280.6	SCL	1.41	12.50
	ABc	88 – 132	710.4	40.0	240.6	SCL	1.44	11.20
	Bgc	132– 164	630.4	80.0	280.6	SCL	1.40	10.10
	Bg	164– 180	710.4	20.0	260.6	SCL	1.43	10.00
MATAKO	A1	0 – 22	870.4	20.0	100.6	LS	1.59	22.1
	A2	22 – 50	770.4	80.0	140.6	SL	1.53	18.2
	ABgc	50 – 69	650.4	200.0	140.6	SL	1.50	17.9
	B1g	69 – 105	830.4	40.0	120.6	LS	1.56	16.4
	B2g	105– 170	610.4	60.0	320.6	SCL	1.38	16.00
MATAKO (BROWN) VARIATION	A1	0 – 20	250.4	560.0	180.6	SIL	1.39	28.33
	A2	20 – 40	490.4	340.0	160.6	L	1.45	22.46
	ABg	40 – 65	770.4	160.0	60.6	LS	1.64	16.33
	Bg	65 – 90	770.4	140.0	80.6	SL	1.60	16.14
	B2g	90 – 130	730.4	100.0	160.6	SL	1.50	14.42
	B3	130– 160	710.4	120.0	160.6	SL	1.49	13.31

Key: HD=Horizon Designation, TS= Total Sand, TC= Textural Class, BD= Bulk Density, and HC= Hydraulic Conductivity

Matako soil had its bulk density results similar to that of Jago soil with value ranged from 1.38 to 1.59 g/cm^3, it showed that the soil are ideal for crop growth. Matako "browner variation" had Bulk density that is ideal at the top soil layers, but increasing to high values with depth (Table 1). The low bulk density or high macroporosity of the top soil depth according to Ogban and Babalola (2009) indicate a soil zone favorable to root activity (water and nutrient uptake). The higher bulk density with depth indicates soil compaction and a preponderance of capillary pores (Table 1) both of which inhibit water movement. This may explain the observed slow rate of saturated hydraulic conductivity (Ks) and tendency for high water table. However, the capillary fringe may be high with adequate soil water availability, underlying the prolonged growing conditions in the valley bottom soil.

Results of saturated hydraulic conductivity (Ks) of the soils are shown in Table 1. In Jago soil series it ranged between 18.2cm/hr at the surface soil to 10.0cm/hr subsurface, the reason for higher saturated hydraulic conductivity at the surface horizon is because of the presence of more sandy texture at the upper horizon and more of clay at the subsurface horizon. Brady and Weil (1999) noted that soils with stable granular structure conduct water much more rapidly than those with unstable structure units which break down upon being wetted. The result indicates that the saturated hydraulic conductivity decreases with an increase in soil depth. The studies is similar to Okafor, (2005) which state that increase in clay content with soil depth, decreases conductivity.

According to Henry (1975), soils with slow saturated hydraulic conductivity range from less than 0.125 cm/hr to 0.500 cm/hr, while soils with 0.510cm/hr to 12.00cm/hr have medium saturated hydraulic conductivity; Soils with rapid saturated hydraulic conductivity have conductivity in the range of 12.5 cm/hr to more than 25 cm/hr. Thus, a sandy soil could have a saturated hydraulic conductivity that is several hundred times greater than that of a clay soil.

Saturated hydraulic conductivity for Matako series, ranged between 22.1cm/hr at the surface to 16.0cm/hr at the subsurface. According to Henry (1975) it shows that there is rapid hydraulic conductivity in the soil, the reason for higher saturated hydraulic conductivity is because of the presence of granular structure across the profile. From this study it shows that hydraulic conductivity is directly dependent on texture, the coarser the texture the higher the hydraulic conductivity and vice versa.

Saturated hydraulic conductivity for Matako browner variation, ranged between 28.33cm/hr at the surface horizon to 13.31cm/hr at the subsurface horizon. It shows that it has same trend with Matako soil discussed above, except it has more hydraulic conductivity than the later, and this is due to the presence of much sandy soil particles across the profile than Matako soil.

Chemical Properties

The chemical properties of the soils are presented in Table 2: The pH in the soils of Jago series ranged from 5.9 - 6.9, with a mean of 6.4 which is neutral according to (FFD, 2012), the neutral soil pH is due to the moderate rainfall, and low content of carbonate minerals in gneiss parent material according to Mullen e*t al., (*2007). The pH in Matako series ranged from 5.2 at the surface to 7.1 at the subsurface which shows that it is strongly acidic at the surface and neutral at the subsurface according to (FFD, 2012), the fluctuation of pH could be due to the alluvial parent materials which the soil are derived from (Alison, 2007). Matako “browner variation”, the pH ranged from 5.6 at the surface to 7.6 at the subsurface which is moderately acidic to slightly alkaline, the soil pH of the environment fluctuates from upper to lower horizons due to the nature of the environment which is valley bottom (Fagbami and Francis, 1990).

pH is a critical soil factor as it affects soil reaction, action of microbes, organic matter production among others (Landon , 1984; Alison *et al.*, 2007). However, a pH value of 5.5-7.5 is adequate for optimum vegetable production (Landon, 1984; Alison *et al.*, 2007). The soils studied satisfy this condition and can be suitable for arable crop production.

Organic carbon content of Jago series was high at the surface horizon (20.1 g/kg) and low down the profile with 2.5 – 8.6 g/kg, the Organic Matter content decrease with depth showed that the activity of organisms is more pronounced in the upper horizon, for Matako soil its high at all horizons (13.6 - 32.3g/kg) except the last horizon which had little organic carbon content of 0.82 g/kg. Matako “Browner Variation”, Organic carbon content is high at the surface horizons with 45.2 and 28.4 g/kg respectively, while at the subsurface horizon the organic carbon content were low, the high organic carbon content in the surface horizon of the soil showed that a lot of organic materials have been deposited in the area, due to its nature of depression.

Table 2: Chemical properties of the soils of the study site

Name	Horizon designation	Depth	pH (H_20)	OC	OM	TN	Av. P	Ca	Mg	Na	K	EA	ECEC	BS
					g/kg		mg/kg			cmol/kg				%
(OFP1)	A1	0 – 29	5.9	20.1	34.7	1.8	43	23.1	1.1	1.2	2.0	0.4	27.8	98.6
JAGO	A2g	29 – 45	6.5	3.7	6.4	0.3	31	20.9	1.2	1.4	0.8	0.4	24.7	98.4
SERIES	A3g	45 – 88	6.5	2.5	4.5	0.2	22	21.6	2.6	2.1	0.9	0.4	27.6	98.6
	ABc	88 – 132	6.8	8.6	14.9	0.3	22	22.6	5.2	1.6	0.9	0.4	30.7	98.7
	Bgc	132 – 164	6.9	6.9	12.1	0.3	20	28.8	4.3	1.9	0.9	0.2	36.1	99.4
	Bg	164 – 180	6.9	7.4	12.8	0.1	27	28.5	4.9	1.4	0.8	0.2	35.8	99.4
(OFP2) MATAKO	A1	0 – 22	5.2	32.3	55.7	0.9	32	21.2	1.6	1.0	0.7	0.4	24.9	98.4
SERIES	A2	22 – 50	6.0	18.9	32.5	1.1	29	18.3	0.9	1.3	0.8	0.2	21.5	99.0
	ABgc	50 – 69	6.2	16.3	28.1	0.3	31	21.9	6.5	1.2	0.7	0.2	30.5	99.3
	B1g	69 – 105	7.2	13.6	23.4	0.4	19	18.3	0.8	10.7	0.6	0.4	30.8	98.7
	B2g	105 – 170	7.1	0.8	1.42	0.3	23	22.7	4.9	1.5	0.7	0.4	30.2	98.7
(OFP3) MATAKO	A1	0 – 20	5.6	45.2	77.9	2.5	38	30.2	2.5	11.3	1.0	0.6	45.6	98.7
SERIES	A2	20 – 40	5.6	28.4	48.9	1.9	34	21.2	1.5	1.4	0.8	0.4	25.3	98.4
“Brown	ABg	40 - 65	6.3	7.8	13.5	0.6	30	23.5	1.4	1.4	1.7	0.6	28.6	97.9
Variation”	Bg	65 – 90	6.5	7.8	13.5	0.2	22	20.9	1.1	1.7	0.8	0.2	24.6	99.2
	B2g	90 – 130	7.4	6.6	11.3	0.4	16	18.6	2.3	1.3	2.2	0.2	24.7	99.2
	B3	130 – 160	7.6	6.9	12.1	0.1	22	20.6	2.4	2.0	0.7	0.4	26.1	98.5

Nitrogen content for both Jago and Matako soils was also low with a value of 0.1 - 1.8 g/kg and 0.3 - 1.1 g/kg respectively and these could be attributed to leaching and uptake of plants. The Nitrogen content of Matako “Browner Variation” soil was high at the first layer of surface horizons with a value of 2.5 g/kg, while the rest of the sub horizons had a lower content of Nitrogen, it was high at the upper horizon because it occupied the lower position of the map OFP3 (Fig.1) and the amount of wash down is pronounced in the mapping unit.

The content of available phosphorous (Table 2) was high in all the soil series and these is due to the ephemeral nature of valley bottom land, it can also be due to the continuous constant wash down and deposition of material year in year out to the valley bottom. Jago series had the highest value with 43.0 mg/kg at the uppermost horizon followed by Matako browner variation with 38.0 mg/kg while Matako soil series had the lowest value with 32.0 mg/kg, the result showed that all the soil sample had adequate supply of available phosphorous since value gotten were above 20.00 mg/kg critical value of FFD, (2012).

Result of exchangeable bases are presented in table 2; Calcium (Ca), for Jago series it ranged from 23.1 cmol/kg at the uppermost horizon to 28.5 cmol/kg at the lowest horizon with a mean of 24.26 cmol/kg, Matako soil had the lowest calcium content ranging from 21.2 cmol/kg at the uppermost horizon to 22.7 cmol/kg at the lowest horizon with a mean of 24.3 cmol/kg, Matako browner variation had value ranging from 20.6 cmol/kg at the lowest horizon to 30.2 cmol/kg at the uppermost horizon with a mean of 22.5 cmol/kg, the result showed a irregular fluctuation in the trend and this is due to the continuous constant deposition of material year in year out at the valley bottom. According to Landon (1984), the critical value of calcium is 4.0 cmol/kg; therefore calcium content is high for all the soil series as recommended by Landon (1984). For Mg content according to FFD (2012) Jago series had value ranged from 1.11 cmol/kg at the uppermost horizon which is medium down to the third horizon, from the forth horizon it shows that it had high value of 5.2 cmol/kg down to the lowest horizon, for Matako normal and browner variation the content of Mg were moderate as shown in Table 2.

The result showed that the entire soil sample had adequate supply of both Ca and Mg since values gotten are above their critical levels. The high content of Ca and Mg, could be due to the high chemical composition of their oxides in gneiss parent material (Best, 1982).

The exchangeable potassium content of all the soil series were high, Jago series had value ranged from 0.8 cmol/kg at the subsurface horizon to 2.0 cmol/kg at the surface horizon, Matako browner variation had value of 0.7 cmol/kg at the lower horizon to 1.0 cmol/kg at the surface horizon, Matako soil had the lowest value of 0.6 cmol/kg at the topmost to 0.7 cmol/kg at the lower horizon. Table 2 showed that all the soil samples were high in K as contained in FFD (2012). The high content could be due to the high chemical composition of their oxides in gneiss parent material (Best, 1982).

The mean value of ECEC for Jago soil is 30.45 cmol/kg, Matako soil is 27.58 cmol/kg and Matako “Browner variation” is 29.45 cmol/kg. The ECEC fluctuates from low to high across their profiles and it could be attributed to the nature of valley bottom soils. Valley Bottom soils tend to fluctuates from high to low due to addition of materials Year in year out (Best, 1982).

CONCLUSION

Wetland soil from University of Ibadan, Ibadan, Oyo State, Nigeria was characterized. Three soil series (Jago Series, Matako series and browner variation of Matako series) were identified from the study area. Results obtained from the chemical parameters studied, showed that Jago soil series had neutral pH (H_2O), while Matako series and Matako browner variations are slightly acidic. Organic Carbon contents were all high, out of which Jago had the lowest compared to Matako series and Matako browner variation. Total Nitrogen content of all soils studied were low, however, this may be due to its susceptibility to leaching losses and plant uptake, while Available P, Ca, Mg, K, Base Saturation were high, The soil texture was predominantly coarse textured with a textural class of sandy loam. The soil had ideal bulk density across the profile, saturated hydraulic conductivity was also high. The valley bottom soils are relatively fertile but are limited by high water table, susceptibility to flooding and poor drainage. The soils were found to be hydromorphic and their profile development is just beginning (at inception). Therefore, with good drainage their potentials and utilization for crop production and other uses will be met.

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