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Characterization and Classification of Soils of Adarawa Village, Tangaza Local Government, Sokoto State

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Abstract

In an attempt to characterize and classify the soils of Adarawa Tangaza local government area of Sokoto state, a toposequence representative of the whole area was selected and three profile pits were excavated on different topographic positions (upper slope, middle slope and lower slope) represented as Pedons 1, 2 and 3, respectively, for the purpose of this study. The results of the finding revealed that soils of Pedon 1 and Pedon 2 are texturally sandy loam to sandy clay loam. Soils of Pedon 3 are texturally sandy. Bulk density was slightly higher in soils of Pedon 2 and 3. The soils were generally low in chemical properties particularly N, percentage base saturation, available P, exchangeable bases and organic matter. The soils of Pedon 1 and Pedon 2 were classified as Haplustults according to USDA soil taxonomy system and correspond to Haplic Acrisols in the FAO/UNESCO system while soils of Pedon 3 were classified as Ustipsamment according to USDA soil taxonomy and correlate to Haplic Arenosols of the FAO/UNESCO Soil

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map of the world legend. Generally the soils require addition of organic and/or inorganic fertilizers to increase its fertility.

Keywords: *Soil Toposequence, Characterization, Classification, Adarawa, Sokoto State.*

Introduction

Soil is undoubtedly the most valuable and dependable natural resource but it is non renewable in human time and therefore it has to be managed to maximize its conservation and productivity in order to feed the population (Olaitan and Lombin, 1984). Studies of soil throughout the world has shown that the kinds of soils developed are largely determined by five major factors; climate (particularly temperature and precipitation), living organisms (especially vegetation, microbes, soil animal and human beings), nature of parent material, topography of the site and the time that parent materials are subjected to soil formation. In fact, soils are often defined in term of these factors as dynamic natural bodies having properties derived from the combined effect of climate and biotic activities, as modified by topography, acting on parent material over period of time (Foth, 1978). However the influence of topography on soil properties has been recognized by most pedologists, disparate result have been obtained when toposequence researches are carried out in different areas. Where related areas differ in their properties primarily because of the influence of topography; Brady (1974) refers to such a sequence of soil as a toposequence. Juo and Moormann (1981), however, defined topsequence as a succession of sites from the crest to a valley bottom, which contains a range of soil properties that are representative of the landscape and soils. The study of soil development in Adarawa area of Sokoto State will be helpful in providing necessary information required with regard to fertility status of the area, soil classification, desirable crops to be grown, appropriate land improvement measures and fertilizer recommendation. Therefore, the study is aimed at characterizing and classifying soils of Adarawa village.

MATERIALS AND METHODS

Description of the Study Area

A toposequence of about 2 km was chosen in the study site, a representation of the soils of Adarawa village. The village is located in Tangaza local government area of Sokoto state and is about 30 km away from Sokoto town the administrative headquarters of Sokoto State. Sokoto State is located between latitude 11^0 13^1 and 13^0 0^1 N and longitude $4^0 0^1$ and 6^0 0^1 E (SSGOD, 2003). It lies within the Sudan savannah belt. It enjoys semi arid climate characterized by a long dry season and short rainy season. The annual rainfall varies from 580-710mm decreasing northwards (SADP, 1992). The maximum and minimum temperatures of the area were 40^0C and 15^0C respectively (Arnborg, 1988).

Sample Collection and Preparation

Three profile pits were excavated on different topographic positions and represented as Pedon 1, Pedon 2 and Pedon 3, respectively. Soil samples were collected in labeled polyethene bags from each horizon. Core samples were also taken using core sampler at various depths, and clods were taken where core sampler could not be used to take samples. The soils were described in the field using a soil profile description manual (FAO, 1977). Soil samples collected were air-dried and sieved to remove materials coarser than 2 mm and subjected to laboratory analysis.

Soil pH was determined using a pH meter, in water and 0.01 M $CaCl_2$ (Bates, 1954). Organic carbon was determined by dichromate oxidation method as described by Nelson and Sommers (1982). Nitrogen was determined using micro Kjedahl method (Jackson, 1962), while available phosphorus was determined by Bray No. 1 method (Bray and Kurtz, 1945). The cation exchange capacity was determined using ammonium acetate saturation method (Chapman, 1965). Exchangeable bases were determined by extaction with ammonium acetate at pH 7 (Kundsen *et al.*, 1982). Particle size analysis was carried out using the Bouyoucos hydrometer method as described by (Gee and Bouder, 1986) where core samples could not be obtained, clod method of Blake (1965) was used. The textural classes were established using USDA textural triangle.

RESULTS AND DISCUSSION

Morphological Properties of the Soils

Results of the soil morphological characteristics are presented in Table 1. The results show that soils of pedon 1 were generally weak red (7.5R 4/4) in color at the surface and changed to yellowish red (5YR 5/6) in the subsurface. The structure was weak sub-angular blocky with a consistence that is generally friable in dry condition. The soils of pedon 1 were sandy loam to sandy clay in texture with many fine roots at the surface while few fine roots were observed deep down the profile (Table 1).

The soils of pedon 2 were generally yellowish red (5YR 4/6) in the surface to reddish yellow (5YR 6/6) and white (5YR 8/1) at the subsurface (120-190 cm) Table 1. The structure of soils in pedon 2 varied from structureless at the surface to strong subangular blocky in the sub-surface. Their consistency varied from friable at the surface to hard in the subsurface. The predominant color of the soils in pedon 3 were found to be strong brown (7.5 YR 5/6) at the surface to dark brown (7.5 YR 3/4) in the subsurface. The structure of the soils in pedon 3 were found to vary from weak subangular blocky to strong sub-angular blocky with a consistency that was generally friable in dry condition. The soils of pedon 3 were generally sandy in texture throughout the profile (Table 1), with few fine roots at the surface that extends up to 95 cm in the sub-surface (Table 1). Generally, all pedons had diffuse or clear boundaries at both surface and/or subsurface layers. While soils of pedon 2 were found having kaolinite clay mineral at the subsurface. The results obtained were in conformity with findings of Brady and Weil (1999) who reported that, angular blocky and subangular blocky structures are the commonly found structural forms in soils of the tropics.

Physical properties of the soils

The results of physical properties of the soils in Adarawa village, Tangaza local government of Sokoto state were presented in Table 2. The particle size distribution indicated that, the soils of pedon 1 were sandy loam to sandy clay in texture with sand content that ranged from 55.1 to 74.6% having mean of 61.6%. The silt contents of the soils ranged from 7.2 to 13.1% with a mean of 9.8%, while clay content of the soils ranged from 12.3 to 37.7% having a mean of 28.6% (Table 2). Sand and silt contents of the soils decreased with depth, while clay content of the soils fairly increased with depth. Soils of pedon 2 were texturally sandy loam to silt loam with sand content ranging from 33.2 to 74.5% which decreases with depth (Table 2). The silt and clay content of the soils ranged from 15.2 to 50 % and 10.3 to 16.75 respectively which fairly increased with depth. This increase in clay content of the soils with depth in all pedons, could be attributed to the removal and transfer of finer materials (Clay eluviation) vertically and laterally down the slope surface and subsurface through the action of rainfall or run off, pointing that topography does influence soil development through eluviation-illuviation process. The results obtained are in line with findings of Jones and Wild (1975) that, savanna soils are sandy at least in the surface layer. Similarly, Kowal and Kassam (1978) reported that, the bulk of savannah soils are predominantly sandy at least at the cultivated depth, and this underlines many of the problems associated with soil fertility, soil water availability and soil management. The texture of the soils at the surface layers ranged from sandy to sandy loam. The bulk density values of the soils presented in Table 2 ranged from 1.48 to 1.51 Mgm-3 with mean of 1.49 Mgm-3 in pedon 1, 1.5 to 1.8Mgm-3 with a mean of 1.70 Mgm-3 in pedon 2 and 1.65 to 1.80 Mgm-3 with a mean of 1.71 Mgm-3 in pedon 3. Bulk density values observed varied appreciably from pedon 1 to Pedon 3. Singh and Babaji (1990), attributed this variation in the bulk densities of soils of different topographical positions to probably close packing of accumulated fine sand particles. Ayolagha (2001), reported bulk density values ranging from 1.27 to 1.82 Mgm -3 due to differential topography.

Chemical properties of the soils

Results of chemical properties of the soils are presented in Table 3. The results show that pH of the soils ranged from strongly acidic (4.8) to slightly acidic (6.5) down the profile and varies across the profiles, with soils of pedon 3 been less acidic than those of pedon1 and pedon 2. The change in pH values (pH in water minus pH in $CaCl_2$) are positive for the pedons, this indicates that the soils are predominantly negatively charged which could be attributed to the Kaolinitic nature of the soils (Opuwaribo and Odu, 1978). Furthermore, electrical conductivity (EC) values of the soils show that the soils are non-saline as their EC values are below 4 dSm-1 (Brady and Weil, 1999). The exchangeable bases of the soils are shown on Table 3. The results revealed that, the soils were generally low in exchangeable bases, which could be attributed to the low exchangeable capacity of the savannah soils as reported by Kowal and Kassan (1978). The soils also had low cation exchange capacity (CEC) Table 3. This was earlier reported to be one of the characteristics of savanna soils. Generally the soils were low in base saturation (BS), organic carbon and total nitrogen contents (Table 3). This was in agreement with the findings of Nye and Greenland (1960), Singh and Tsoho (2002) and Jones (1971), respectively. In addition, available phosphorus (AP) content of the soils were also low except for pedon 1 where most values were moderate (Table 3).

The trend observed in the chemical properties of the soils showed that, the soils were less productive as evidenced by lower fertility and thus, could require application of organic and/or inorganic fertilizer.

Soil classification

The soils were classified using the USDA soil taxonomy (Soil Survey Staff, 1975) and the FAO/UNESCO soil map of the world legend (1990).

Based on the USDA system of soil classification, the soils were classified into two orders namely: Ultisols and Inceptisols. Pedon 1 and 2 were classified as Ultisols because of the low Base saturation (<50% by NH_4OAC) with Bt Horizons.They were further classified as Ustults at sub-order level because they were having Ustic moisture regime. The soils belong to Haplustults at great group. The soils (pedon 1 and 2) corresponds to Haplic Acrisols of the FAO/UNESCO soil map of the world legend (1990).

Soils of pedon 3 are classified as Inceptisols according to the USDA system of soil classification . They were further classified as Ochrepts at sub-order level because they had ochric epipedon and have bulk density values >0.85 Mgm-3 in all horizons (Table 2).

The soils belong to the Ustochrepts at great group level because they have Ustic moisture regime. They corresponds to Haplic Arenosols of the FAO/UNESCO soil map of the world legend (1974) as they have base saturation <50%.

Conclusion

The characterization and classification of Soils Adarawa village will be helpful in providing necessary information required about the physical, chemical and morphological properties as well as classification of the Soils.

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TABLE 1: MORPHOLOGICAL PROPERTIES OF THE SOILS

Horizon	Depth (cm)	Colour (dry)	Texture (field)	Consistency	Root	Structure	Horizon boundary	Identifiable mineral
	Pedon 1: Ustipsamments (USDA soil taxonomy) Haplic Acrisols (FAO/UNESCO)							
A	0-30	7.5R4/4	SL	fr	mfr	1sbk	D	None
Bt_1	30-70	5YR 5/6	C	fr	mfr	1sbk	D	None
Bt_2	70-100	5 YR 5/8	C	fr	ffr	1sbk	C	None
	Pedon 2: Haplustults (USDA soil taxonomy) Haplic Acrisols (FAO/UNESCO)							
A	0-30	5YR 4/6	SL	fr	mfr	O	D	none
$2Btw_1$	30-50	5YR 5/6	C	h	ffr	3sbk	D	Kaolinite
$2Btw_2$	50-85	5YR 6/6	C	h	nr	3sbk	C	Kaolinite
3Bc	85-120	7.5 YR 7/7	C	h	nr	3sbk	D	Kaolinite
4C	120-190	5Y 8/1	C	h	nr	3sbk	C	Kaolinite
	Pedon 3: Ustipsamments (USDA soil taxonomy) Haplic Arenosols (FAO/UNESCO)							
Ap	0-18	7.5 YR 5/6	S	fr	ffr	1sbk	C	None
AC_1	18-32	7.5 YR 5/8	S	fr	ffr	1sbk	C	None
AC_2	32-95	5 YR ¾	S	fr	fr	1sbk	D	None
C_1	95-150	7.5 YR ¾	S	fr	nr	1sbk	C	None
C_2	150-210	7.5 YR 4/6	S	fr	nr	1sbk	C	None

Texture: S = sand, SL= sandy loam, C = clay *Consistency: fr = friable, H = hard*
Root: mfr = many fine roots, ffr = few fine roots *nr = no root*
Structure: 1sbk - week subangular blocky, 2sbk = moderate subangular blocky, 3sbk = strong subangular blocky, O = structureless
Horizon boundary: c = clear, d = diffuse

TABLE 2: PHYSICAL PROPERTIES OF THE SOIL

Horizon	Depth (cm)	Particle size distribution			Texture	Bulk density (Mgm^{-3})
		Sand (%)	Silt (%)	Clay (%)		
Pedon 1: Haplustults (USDA soil taxonomy) Haplic Acrisols (FAO/UNESCO)						
A	0-30	74.6	13.1	12.3	Sandy loam	1.48
Bt_1	30-70	55.1	7.2	37.7	Sandy clay	1.48
Bt_2	70-100	55.1	9.2	35.7	Sandy clay	1.51
Mean		**61.6**	**9.8**	**28.6**		**1.49**
Pedon 2: Ustochrepts (USDA soil taxonomy) Haplic Acrisols (FAO/UNESCO)						
A	0-30	74.5	15.2	10.3	Sand loam	1.80
$2Btw_1$	30-50	58.8	17.2	24.0	Sandy clay loam	1.70
$2Btw_2$	50-85	62.9	23.9	13.2	Sandy loam	1.80
3BC	85-120	56.9	26.4	16.7	Sandyloam	1.80
4C	120-190	33.2	50.6	16.2	Silt loam	1.50
Mean		**57.3**	**26.7**	**19.2**		**1.70**
Pedon 3: Ustipsamments (USDA soil taxonomy) Haplic Arenosols (FAO/UNESCO)						
Ap	0-18	96.0	1.7	2.3	Sand	1.80
AC_1	18-32	95.0	1.0	4.0	Sand	1.70
AC_2	32-95	94.3	3.2	2.5	Sand	1.72
C_1	95-150	96.2	2.3	1.5	Sand	1.68
C_2	150-210	97.0	0.5	2.5	Sand	1.65
Mean		**95.7**	**1.7**	**2.6**		**1.71**

TABLE 3: CHEMICAL PROPERTIES OF THE SOILS

Horizon	Depth (cm)	pH (1:1) H_2O	pH (1:1) $CaCl_2$	E.C (dS/m^3)	Exchangeable bases (cmol/kg)				C.E.C (Cmol/kg)	B.S %	O.C %	N %	Avail. P (mg/kg)
					Ca	Mg	Na	K					
Pedon 1: Haplustults (USDA soil taxonomy) Haplic Acrisols (FAO/UNESCO)													
A	0-30	5.8	5.0	3.07	0.10	0.75	0.61	0.54	3.2	63	0.65	0.04	3.07
Bt_1	30-70	4.8	4.3	3.32	0.35	0.75	0.69	0.38	6.8	32	0.49	0.03	10.70
Bt_2	70-100	5.2	4.7	3.40	0.20	0.65	0.69	0.59	6.6	35	0.13	004	13.07
	Mean	**5.3**	**4.7**	**3.26**	**0.22**	**0.72**	**0.66**	**0.50**	**5.5**	**43**	**0.42**	**0.04**	**8.96**
Pedon 2: Haplustults (USDA soil taxonomy), Haplic Acrisols (FAO/UNESCO)													
A	0-30	5.9	4.9	3.60	0.35	0.65	0.43	0.33	3.2	42	0.08	0.03	3.06
$2Btw_1$	30-50	5.6	4.6	2.78	0.30	0.60	0.48	0.26	5.2	32	0.02	0.03	2.55
$2Btw_2$	50-85	5.6	4.6	3.06	0.25	0.75	0.48	0.18	4.2	40	0.05	0.02	3.98
3BC	85-120	5.5	4.7	3.03	0.30	0.50	0.57	0.23	5.8	28	0.06	0.02	5.60
4C	120-190	5.5	4.9	3.30	0.30	0.75	0.33	0.30	8.2	27	1.31	0.03	3.35
	Mean	**5.6**	**4.7**	**3.15**	**0.30**	**0.65**	**0.46**	**0.26**	**5.3**	**34**	**0.30**	**0.03**	**3.70**
Pedon 3: Ustipsamments (USDA soil taxonomy), Haplic Arenosols (FAO/UNESCO)													
Ap	0-18	6.5	4.6	3.80	0.25	0.65	0.61	0.26	3.2	55	0.03	0.02	3.36
AC_1	18-32	6.3	4.5	3.82	0.30	0.70	0.57	0.30	3.0	62	0.29	0.02	3.83
AC_2	32-95	6.1	4.6	3.84	0.30	0.70	0.43	0.23	2.8	59	0.30	0.02	3.8
C_1	95-150	6.2	4.7	3.04	0.35	0.45	0.57	0.26	2.8	58	0.30	0.02	3.73
C_2	150-210	6.3	4.8	3.97	0.25	0.5	0.48	0.28	3.0	50	0.34	0.02	3.32
	Mean	**6.3**	**4.6**	**3.69**	**0.29**	**0.60**	**0.53**	**0.27**	**3.0**	**57**	**0.25**	**0.02**	**3.61**