Journal of Agriculture and Environment Vol. 14 No. 2, 2018: 257-266
ISSN 1595-465X

PROPERTIES AND CLASSIFICATION OF SOILS DEVELOPED UNDER DIFFERENT LAND UTILIZATION TYPES IN GIDAN SULE, DUNDAYE DISTRICT, WAMAKKO L.G.A., SOKOTO STATE

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ABSTRACT

This study was carried out to determine the properties and classify the Soils developed under different land utilization types in Gidan Sule, Dundaye District, Wamakko Local Government Area, Sokoto State. A reconnoiter was conducted around Gidan Sule and its fringes. Three land utilization types (LUTs) were identified and studied following the procedure described by FAO (2006). The study found out that most of the important soil morphological properties particularly colour, texture, structure, consistency were influenced by different land utilization types, especially at the surface horizons. The three Pedons were classified using USDA Soil Taxonomy and correlated with World Reference Base (WRB) for Soil Resources. The soils of Rainfed, Irrigated and Orchard were classified as Typic Kanhaplustalfs (Sodic Cambisols (Oxyaquic), Aeric Endoaquerts/Haplic Vertisols) and Leptic Endoaquerts (Haplic Vertisols), respectively.

Keywords: Land utilization types; morphological properties; Dundaye District; Cambisols and Vertisols

INTRODUCTION

The overriding objective of research in Soil Science and particularly in Pedology is the understanding of the nature, properties, dynamics and functions of the soil as part of landscapes and ecosystems. A basic requirement for attaining that objective is the availability of reliable information on soil morphology and other characteristics obtained through examination and description of the soil in the field during soil inventory. Soil characterization provides the information necessary for the understanding of the physical, chemical, mineralogical and microbiological properties of the soils we depend on to grow crops, sustain forests and grasslands as well as support homes and society structures (Ogunkunle, 2004).

Sharu *et al*. (2013) reported that coupling of soil characterization and classification provides a powerful resource for the benefit of mankind especially in the area of food security and environmental sustainability. Similarly, Lekwa *et al*. (2001) reiterated that soil characterization provides the basic information necessary to create functional soil classification schemes and assess soil fertility in order to unravel some unique soil problems.

Gidan Sule under Dundaye District is blessed with vast agricultural lands managed under different land use systems. These land use systems directly or in directly have some effects on the properties and functions of the soils. It is against this background that the present study was conducted and aimed at examining the genesis and properties of soils developed under different land utilization types in Gidan Sule, Dundaye District, Wamakko Local Government Area, Sokoto State in order to classify the soils and recommend appropriate sustainable land management systems for the soils.

MATERIALS AND METHODS

The Study Area

The study was carried out in Gidan Sule village, Dundaye District, Wamako Local Government Area, Sokoto State, about 15 kilometers away from Sokoto town the administrative headquarters of the state. The study site is located on latitude 13^0 11’ N and longitude 5^0 20’ E with an average elevation of 247 m above sea level, covering a total of area of about 20 hectares. It has a typical Sudan Savannah vegetation type. The area is intensively cultivated to array of crops such as onions, tomatoes, cowpea and millet. The length of the growing period varied between 90-150 days (Ojanuga, 2006). The average annual rainfall is 629 mm (Climate-Data.org, 2012). From late October to February, during the cold season, the climate is dominated by the Harmattan wind blowing Sahara dust over the land. The average temperature ranges from 24.5 °C to 33.2 °C (Climate-Data.org, 2012). Most of the arable land consists of well drained upland with flat or slightly undulating topography which supports one growing season under rainfall conditions (Singh and Babaji, 1989).

Field Work Procedure

Formal contact was made with community leaders and people whose lands were used in the research to create awareness and sought for permission on the conduct of the research on their farmlands. During this visitation, enlightenment on the significance of the research was made. A reconnoiter was conducted around Gidan Sule and its fringes to identify and document different land utilization types and to collect information on land forms, vegetation, cropping history, topography and slope of the area, drainage characteristics, erosion hazard and general soil conditions. This was to enable the identification and selection of the area that represents the soils of the study area. SPOT-5 image of the study area was obtained and processed in the GIS Laboratory, Department of Geography, UDU, Sokoto and used as the Base map (Figure 1). Mapping of the land utilization types was by imagery interpretation. The different land utilization types observed were documented. Three land utilization types were selected for soil examination at soil series level using free survey procedure as guided by land use, soils and covariates (topography, parent material, vegetation, anthropogenic effects etc). The boundaries of the study site were set by using the Global Positioning System (GPS) by taking the coordinates and elevation of each boundary. The different land utilization types within the boundaries were demarcated using pegs and stones. The pedons that were dug under different land utilization types were geo-referenced by taking the coordinates and elevation. Three pedons were dug one per land utilization type. The pedons were described following the procedure described by FAO (2006). For each horizon, colour, texture, structure, consistence, roots, pores, concretions and boundary characteristics were recorded.

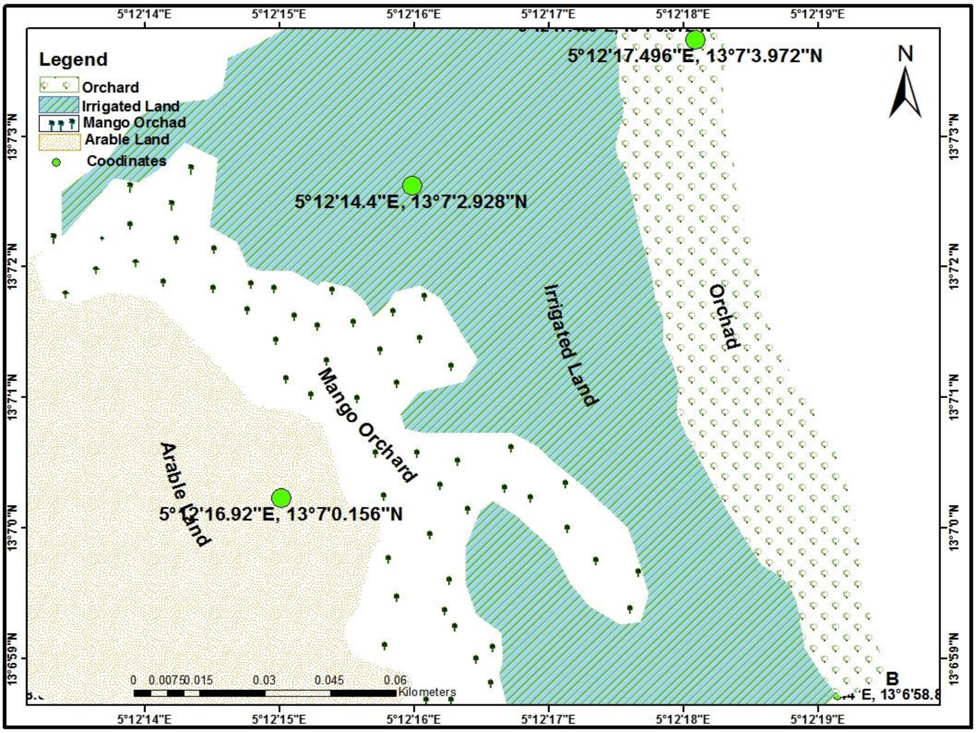

Figure 1: SPOT-5 Image showing LUTs such as rainfed, irrigated and orchard land

Soil Classification

The soil under different land utilization types were classified using USDA Soil Taxonomy (2010) and correlated with WRB for Soil Resources (2014).

RESULTS AND DISCUSSION

Effect of Land Utilization Types on Soil Colour

The results of the effect of land utilization types as affected by soil colour is presented in Table 1a. The colour of the soil in the surface horizons of the pedons under different land utilization types varied between strong brown (7.5YR 5/6) to dark grey brown (2.5YR 3/2). In the subsurface horizons the colour varied between reddish yellow (7.5YR 6/8) to very dark gray brown (2.5Y4/2) (Table 1a). The strong brown colour observed in the surface horizon

(Ap 0- 57cm) of rainfed farming (arable land) could be attributed to hydrated forms of iron oxide, whereas the dark grayish and grey brown colour observed in irrigated and orchard pedons respectively could be due to poorly drained or redoximorphic condition of the soils. This research finding is in line with that of Inglett *et al.* (2005) who reported that gray colours generally are indicators of soil anaerobiosis. More so, all the pedons had darker colour in the surface horizon than the subsurface horizons which may be ascribed to the high organic matter content in the surface horizons. The result however is contrary to the findings of Abayneh (2005) who reported soil profiles with darker B horizons compared to their surface counterparts while working on reddish soils of Sidamo, Ethiopia.

Effect of Land Utilization Types on Soil Texture

The soil texture of the surface horizons of pedons under different land utilization types was clay loam while in the subsurface horizons, the texture varied between sandy clay to sandy loam (Table 1a). The clay loam texture observed in the surface horizon of all the pedons could be attributed to alluvial process whereas the sandy clay texture observed in sub surface horizons of orchard and irrigated pedons could be due to illuviation process. According to Ojanuga (1975) and Malagwi *et al.* (2000), sand content observed in the sub surface horizons in the pedons can be as a result of illuviation process.

Effect of Land Utilization Types on Soil Structure

The soil structure of the surface horizons of the pedons under different land utilization types ranges between sub angular blocky to prismatic (Table 1a). In the sub surface horizons, the structure varied between sub angular blocky to angular blocky (Table 1a). The prismatic structure found at surface horizon (Ap 0-60cm) of irrigated pedon could be attributed to alternating wetting and drying processes, whereas the angular blocky observed in both sub surface horizons of irrigated and orchard pedons could be due to compaction which can cause granular structure on the soil surface to break down and form a blocky structure or sub angular blocky structure in the subsoil. This result confirms previous findings by Sheleme (2017), who reported that horizons of irrigated soils were formed by wetting and drying cycles that aggregated the clay-textured into wedge-shaped angular blocks with pressure faces.

Effect of Land Utilization Types on Soil Consistence

The soil consistence of the surface horizons of pedons under different land utilization types ranges between loose to hard (Table 1a). In the sub surface horizons, the soil consistence also varied between loose to hard. The hard consistence observed in both surface layers of rainfed farming and irrigated soils could be attributed to high clay content, whereas the loose consistence (Table 1a) observed in surface horizons of orchard could be due to the high organic matter content of the soils due to fallen leaves and decayed debris in the orchard. This finding is similar to the findings by Sheleme (2017) who reported hard consistence on irrigated soils in Southern Ethiopia.

Soil Classification

USDA Soil Taxonomy

Soils under Rainfed Farming (Arable land)

At order level, the soils were classified as Alfisols due to its Kandic characteristics i.e. they have regular decrease in organic carbon with increasing depth and also have high percent base saturation (Table 1b). At suborder level, the soils were classified as Ustalfs due to its Ustic soil moisture regime. At great group level, they were classified as Kanhaplustalfs. At subgroup level, the soils were classified as Typic Kanhaplustalfs for not belonging to other great group under the suborder Kanhaplustalfs.

Soils under Irrigated Farming

The soils at order level were classified as Vertisols due to alternating wetting and drying condition (shrink-swell property) and vertical cracks that extend from surface to subsurface horizons of the soils. At Suborder level, they were classified as Aquerts, due to periodic aquic condition and >30% chroma of 2 at Ap horizon. At great group level, the soils were classified as Endoaquerts for having saturation in the subsurface horizon. At subgroup level, the soils were classified as Aeric Endoaquerts for having an Ap and Btg horizons > 50% Colours as 2.5Y hue and a Colour value (moist) of 5.

Soils under Orchard Farming

The soils at order level were classified as Vertisols, due to shrink-swell characteristics and vertical cracks that extend from surface to surface horizons of the soils. At suborder level they were classified as Aquerts because it experiences aquic condition for some time in a normal year and has chroma of 2 and 1 in Ap and Bt horizons respectively. At great group level they were classified as Endoaquerts for having saturation in the subsurface horizon. At subgroup level, the soils were classified as Leptic Endoaquerts due to the densic horizon.

WRB for Soil Resources

Soils under Rainfed Farming (Arable Land)

At Reference Soil Group (RSG) the soils were classified as Cambisols owing to its profile differentiation. At Principal Qualifier (PQ) level, the soils were classified as Sodic because they have layers > 20cm thick and starting < 100 cm from soil surface that have sodium > 15%. At Supplementary qualifier (SQ) level, the soils were classified as Oxyaquic Cambisols because it has layer > 25 cm thick and starting from mineral soil surface that was saturated with oxygen reach water during a period of greater or 20 consecutive days that has no stagnic or gleyic properties in any layers within < 100 cm of the mineral surface.

Soils under Irrigated Farming

At Reference Soil Group level, the soils were classified as Vertisols owing to shrink-swell characteristics and vertical cracks that extend from surface to sub surface horizons of the soils. They were further classified at Principal qualifier level as Haplic Vertisols, for having a typical expression of Vertisols and no further or meaningful characteristics.

Soils under Orchard Farming

At Reference Soil Group level, the soils were classified as Vertisols due to alternating wet-dry condition (shrink-swell characteristics) and vertical cracks extending from surface to sub surface horizons of the soils. At Principal qualifier level, they were classified as Haplic Vertisols for having a typical expression of Vertisols.

Table 1a: Morphological Properties of the Soils of Gidan Sule Series

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence	Roots	Pores	Horizon Boundary
Rainfed Farming_Gidan Sule Series-P1 [Typic Kanhaplustalfs/Sodic Cambisols (Oxyaquic)]								
Ap	0-57	7.5YR5/6	CL	sab	h	Mmfr	ffp	dw
Bt	57-144	7.5YR7/6	CL	ab	h	ffr	ffp	ds
BC	144-200	7.5YR6/8	SL	sab	L	-	mlp	ds
Irrigated Farming_Gidan Sule Series Series-P2 [Aeric Endoaquerts/Haplic Vertisols]								
Ap	0-60	2.5Y3/2	CL	pm	h	mmr	mlp	ds
Btg	60-129	2.5Y4/2	CL	sab	h	ffr	fsp	ds
BCg	129-170	5Y5/1	SC	ab	l	vffr	fsp	ds
Orchard Farming_Gidan Sule Series-P3 [Leptic Endoaquerts/Haplic Vertisols]								
Ap	0-104	10YR4/2	CL	sab	l	mlr	mmp	dw
Bt	104-149	5YR3/1	SC	ab	h	fmr	fsp	ds

CL = Clay Loam, SL = Sandy Loam, SC = Sandy Clay, ab = angular blocky, sab = sub angular blocky, pm = prismatic, h = hard, l = loose, mmfr = many medium fine root, vffr = few fine root, mmr = many medium root, mlr = many litle root, fmr = few medium root, fsp = few small pores, mmp = many medium pores, fsp = few small pores, mlp=many little pores, dw =diffuse wavy, ds =diffuse smooth

Table 1b: Some Chemical Properties of the Soils of Gidan Sule Series

Horizon	Depth (cm)	pH (water)	OC	OM	TN	AP (mgkg^{-1})	Exchangeable Bases (Cmolkg^{-1})				CEC (Cmolkg^{-1})	BS (%)
			gkg^{-1}				Ca	Mg	K	Na		
Rainfed Farming_Gidan Sule Series P1 (Typic Kanhaplustalfs (Sodic Cambisols (Oxyaquic)												
Ap	0-57	7.3	2.0	3.45	0.28	1.5	1.3	1.3	0.60	0.43	7.0	52
Bt	57-144	7.2	0.8	1.38	0.35	1.8	1.4	1.4	1.28	1.43	9.3	60
BC	144-200	7.1	0.7	1.21	0.03	1.7	1.5	1.8	0.90	0.61	6.8	71
Irrigated Farming_Gidan Sule Series P2 (Aeric Endoaquerts (Haplic Vertisols)												
Ap	0-60	6.7	1.5	2.59	0.35	0.6	1.3	2.1	0.49	0.35	13	32
Btg	60-129	7.0	1.8	3.10	0.32	0.7	0.4	1.8	0.26	0.22	10	26
BCg	129-170	6.6	0.9	1.55	0.39	0.6	0.3	1.7	0.18	0.09	7.8	29
Orchard Farming_Gidan Sule Series P3 (Leptic Endoaquerts (Haplic Vertisols)												
Ap	0-104	6.9	1.3	2.24	0.42	1.4	0.9	3.4	0.21	0.43	12	41
Bt	104-144	7.5	1.2	2.07	0.06	0.5	0.6	1.1	0.81	0.22	12	17

OC= organic carbon, OMC= organic matter content, TN= total nitrogen, AP= available phosphorus, Ca= calcium, Mg= magnesium, K= potassium, Na= sodium, CEC= cation exchange capacity, BS= base saturation

CONCLUSION

From the results of this study, it can be concluded that the soils were formed from aeolian and alluvial deposits. The soils were found to belong to three textural classes namely; sandy loam, sandy clay and clay loam. The result also showed that different LUTs had influence on the morphological features of the soils particularly colour, texture, structure and consistence.

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