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Description and Characterization of Some Alfisols under Two Different Land-Use (Groundnut and Maize) Patterns in Chanchaga, Minna, Niger State

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Abstract
Characterization of soils under two different types of land-use options - groundnut (GNL) and maize (ML) was carried out. An overview of the study area was obtained through a free survey technique. One profile pit was sank in each land-use option and described following FAO guidelines and soil samples were collected from each identified genetic horizon for laboratory analyses. The result indicates that the soils under GNL were brownish and well drained; while soils under ML were very dark grayish brown and poorly drained. The soils under both land-use options generally have favorable pH, high base status, but low to medium fertility status. The soils under GNL are classified as Typic Haplustalfs/Haplic Luvisol; while the soils under ML are classified as Aquic Haplustalfs/ Anthraquic Luvisol.

Introduction
Soil characterization gives a potent resource for the benefits to man in regard to food sustainability and environmental protection (Esu, 2004). It provides data on the potentials, constraints and distribution of major soils types. Agricultural landuse typifies the arrangements, activities, and inputs by individuals to produce, change and maintain a certain land cover for crop production and sustainability (Di. Gregoria and Jansen, 1998). Chanchaga (Minna) have great agricultural potential for both wet season and dry season farming due to its proximity to river Chanchaga. The major agricultural landuse in Chanchaga are suited for the cultivation of yam, maize, rice and groundnut. The study aims at providing and comparing data on the properties of some Alfisols under two different landuse (G/nut and maize) in Chanchaga, Minna, Niger State.

Methodology
The Study Area
The study area is located in Chanchaga, Minna, Southern Guinea savanna and lies within latitude 9º 31′ 54.94″ N and latitude 9º 31′ 21.4″ N, and longitude 6º 35 53.3″ E and longitude 6º 35 55.29″ E with elevation range of 209 m to 258 m above sea level. Two locations within the study area with different land-use options (G/nut and maize) were selected by free survey. The first location underground-nut land-use (GNL) was situated on a nearly flat land and lies within latitude 9º 31′ 50.12″ N and longitude 6º 35 58.64″ E. The second location under maize land-use (ML) was located on gently sloping land and lies within latitude 9º 31′ 38.69″ N and longitude 6º 36′ 4.08″ E. Minna falls under sub-humid tropical climate, with two distinct seasons, namely dry and rainy season. Minna possess an ustic moisture condition with mean annual rainfall of 1229 mm, and an isohyperthermic temperature condition. Its temperature (about 35ºC) remains high throughout the month of March and June (Ojanuga, 2006).

Field Study
A free survey technique was first carried out in the month of February and the first week of March 2017; in order to have an overview of the study site, and to generate information that could aid in the planning of the detailed field work. One profile pit was dug in each land-use location. The profile pits were described based on FAO guidelines for soil description and bulked soil samples were collected from each identified genetic horizons, and taken to the laboratory for analysis.

Taxonomic classification of the soils were according to USDA Soil taxonomy (Soil Survey Staff, 2014) and WRB for Soil Resources.

Laboratory Analysis

The soil samples were air-dried and sieved with 2 mm. The following soil physical and chemical properties were determined: Particle size distribution was by determined by the Bouyoucous hydrometer method, and textural classes established from the USDA soil textural triangle; Bulk density was determined by the undisturbed soil core method; Soil pH in water solution (soil ratio 1:1) was determined using the electrometric method; Soil organic carbon (OC) was determined by the wet dichromate method; Total N was obtained by the Macro-Kjedahl method; Available P was determined calorimetrically after Bray-1 extraction; Exchangeable bases (Ca, Mg, Na, K) was determined using 1N NH_4OAc extractant method, after which Ca and Mg was obtained from an Atomic Absorption Spectrometer, while Na and K obtained by the Flame Photometer; Exchangeable acidity ($Al^{3+} + H^+$) was determined by titremetric method; CEC was obtained by the NH_4OAc displacement; and base saturation (BS) calculated as follows:

$$BS = \frac{\text{total exchangeable bases}}{CEC} \; X \; 100$$

Results and Discussion

Morphological and Physical Characteristics

The field morphological and physical properties of the study area are presented in Table 1. The soils under GNL were well drained, while poor drainage condition featured in soils under ML. Soil colour varied predominantly from brown (7.5YR 4/4) in soils under GML to very dark grayish brown (10YR 3/1) in soils under ML. The structural groupings featured on surface horizons were massive structureless (ML) and moderate medium crumby structure (GNL). Sand particles were the dominant fractions in both soils, and generally decreased with depth in the soils; while clay particles alternately increased with soil depth. According to Fasina *et al.*, (2005) smaller size mineral particles usually increase down profile depths due to sorting, migration, and eluviation. Sand fractions ranged from 720 g kg^{-1} in surface horizons to 430 g kg^{-1} in sub-horizons (GNL), and 520 g kg^{-1} to 420 g kg^{-1} in surface and sub-horizons of soils under ML. Silt particles exhibited irregular pattern of increase and decrease down profile depth in soils under GNL, varying from 200 g kg^{-1} to 220 g kg^{-1} in surface and sub-horizons respectively. Both soils (under ML and GNL) also exhibited sandy loam texture on surface horizons. Generally the Bulk density values of the soils ranged from 1.41 g cm^{-3} to 1.55 g cm^{-3}, and were considered favorable for plant growth, falling within the range of 1.00 – 1.60 g cm^{-3} for mineral soils (Akapan-Idiok *et al.*, 2012).

Soil Chemical Properties

The field chemical properties of the study area are presented in Table 2. Soil pH increased irregularly with depth in the soils of GNL, but decreased irregularly in soils of ML, varying from 6.31 to 6.37 and 5.86 to 6.21 respectively. The soils are generally slightly acidic in reaction. Organic carbon content in the soils was generally low, and ranged from 2.59 g kg^{-1} to 8.18 g kg^{-1}. Land use activities such as livestock grazing, bush burning and the kind of arable farming in the area may have contributed to the low carbon content in the soils. For most Nigerian soils, optimum crop production can be achieved when critical level of carbon content stands at about 10 g kg^{-1} to 15 g kg^{-1} (Esu, 1991). Carbon values below this critical level may encourage more leaching losses of basic cations into sub-soils. Total N in all the soils were high i.e. > 0.2 g kg^{-1}. The application mineral fertilizers by the farmer in the area may have contributed to the high N values recorded in the soils. The N values generally ranged from 0.48 g kg^{-1} to 0.50 g kg^{-1} in surface horizon, and considered adequate for plant uptake. Distributions of available P contents in the soils (3.33 mg kg^{-1} to 3.50 in surface horizons) were irregular down the profile depths in both horizons and were considered low to moderate. The concentration of exch. bases (Ca, Mg, K, Na) in soils were also irregular in distribution across both profile depths. Ca ranged from 1.50 cmol kg^{-1} to 6.22 cmol kg^{-1}, Mg ranged from 0.36 cmol kg^{-1} to 1.04 cmol kg^{-1}, Na ranged from 0.21 cmol kg^{-1} to 0.24 cmol kg^{-1}, and K ranged from 0.05 cmol kg^{-1} to 0.13 cmol kg^{-1} on surface horizons. CEC ranged from 5.80 cmol kg^{-1} to 9.40 cmol kg^{-1} in soils under ML, and 3.20 cmol kg^{-1} to 5.40 cmol kg^{-1} in soils under GNL. The soils generally exhibited high base saturation values (66.3 % to 91.2 %). The base saturation values of the soils agrees with the results of Lawal *et al.*, (2012) and Afolabi *et al.*, (2014) that the soils of Minna have high base saturation values. High base status of the soils shows that basic nutrients may occur in available form for plant uptake despite low cation reserve in the soils (Aki *et al.*, 2014).

Table 1: Morphological and Physical properties of the Soils

Profile/ landuse	Horizon Designa Tion	Profile Depth (cm)	Soil Colour (moist)	Mottles	Consistence dry	moist	Structure	Sand →	Silt kg g^{-1}	Clay ←	Textural Class	Silt/Clay Ratio	Bulk density (g cm^{-3})
PGNL	Ap	0-28	7.5YR4/4 (B)	-	s	v.fr	2m cr	720	200	80	SL	2.50	1.47
	Bt1	28-104	5YR 4/6 (YR)	-	h	fi	2m sb	420	180	400	SL	0.45	1.53
	Bt2	104-166	5YR 4/6 (YR)	2.5YR3/6 (DR)	h	fi	2mc sb	440	260	300	CL	0.87	1.55
PML	Ap	0-32	10YR 3/1 (VDGB)	-	v.h	fi	Ms	520	340	140	SL	2.43	1.49
	Bt	32-75	10YR 4/2 (DGB)	10YR 5/4 (YB)	h	fi	1m sb	420	380	200	L	1.90	1.41

Table 2: Chemical Properties of the Soils

Profile/ landuse	Horizon Designation	Profile Depth (cm)	pH (H_2O)	OC (g kg^{-1})	Total N (g kg^{-1})	Avail P (mg kg^{-1})	Ca	Mg	K	Na	Exch. Acidity	CEC	BS (%)
							← cmol kg^{-1} →						
PGNL	Ap	0-28	6.37	4.49	0.48	3.33	1.50	0.36	0.05	0.21	0.60	3.20	66.3
	Bt1	28-104	6.24	3.79	0.39	1.75	3.52	0.43	0.10	0.31	0.40	5.40	80.7
	Bt2	104-166	6.31	2.59	0.39	2.45	3.76	0.39	0.10	0.29	0.60	5.80	78.3
PML	Ap	0-32	6.05	6.38	0.50	3.50	6.22	1.04	0.13	0.24	0.40	8.50	89.8
	Bt	32-75	5.86	8.18	0.50	3.15	6.83	0.87	0.14	0.22	0.80	9.40	85.7
	*	75-105	6.26	4.39	0.45	4.03	4.79	0.53	0.07	0.20	0.60	6.70	83.4
	*	105-135	6.21	6.58	0.25	4.20	4.58	0.37	0.09	0.25	0.40	5.80	91.2

PGNL = soil profile under Groundnut land use; PML = soil profile under maize land use; * auger sample depth

Conclusion

Under the USDA soils taxonomy, both soils under GNL and ML are classified as Ustalfs at Suborder level, and Haplustalfs at Great group level. However, under Subgroup level, the soils are classified as Typic Haplustalfs (GNL) and Aquic Haplustalfs (ML). The soils are also classified as Haplic Luvisol (GNL) and Anthraquic Luvisol (ML) under WRB for soil resources. The soils of the study area generally have favorable pH, high base status, but low to medium fertility status. However, with adequate application of mineral fertilizers and organic inputs, the soils can be more productive. Soils of ML will require the installation of drainage structures in order to manage the poor drainage condition of the location.

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