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CHARACTERIZATION, CLASSIFICATION AND MANAGEMENT OF SOME SOILS IN UJAM DISTRICT OF MAKURDI, BENUE STATE

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ABSTRACT: *An intensive soil survey was carried out in Ujam District, the two sites chosen were designated: (1) Tse-Tswam and (11) Tse-Ordam. The aims were to characterize, classify and proffer management practices for the soils. At each site, three profiles pits were sunk and morphologically described. Samples collected from identified genetic horizons were subjected to analyses using standard analytical procedures. The soil profiles ranged from deep (118cm) to very deep (200cm); well to imperfectly drained; epipedons' colour varied from very dark brown (7.5YR 2/3)/brownish black (7.5 YR 3/1) due to melanisation; subsoils were dull reddish brown (5YR4/4) due to rediomophism and brownish gray (10 YR 5/1) as imprint of gleization; Mottles on the subsoils may be attributed to drainage impedance; sandy loam or loamy sand surfaces with clay to sandy clay loam subsoils to sandstone parent material and weak fine crumb to moderate/strong fine-coarse subangular blocky structures. The soils had medium to high sand (41.20-83.00%), very low to medium clay (06.02.58- 43.25%) and low silt (10.65-16.96%) fractions; medium bulk density (1.19-1.38gmcm^{-3}) and porosity (48.68-56.60%). Soil reaction was slightly acid (5.67-6.50); low organic carbon (1.05-0.30%), nitrogen (0.03-0.18%), Available phosphorus (3.00-10.10%) and EC (0.10-0.13dms^{-1}). CEC was very low (6.34-9.10cmolkg^{-1}) likewise $CaCO_3$ (0.00-2.00%); medium to high base saturation (48.80-91.90%). All soil units (1-V1) possessed argillic horizons with base saturations that were ≤50%(NH_4OAc at pH 7) and were classified into Alfisols at soil order level; units 1 and 111 further qualified into Eutric Epiaqualfs (Vertic luvisols Clayiec,kandic), 11 into Dystric Haplustalf (Dystric Luvisol Kandic, Clayiec) and 1V into Arenic Haplustalfs (Vertic Luvisols arenic, Dystric). Units V was placed into (Haplic Eutrustalf (Glayeic Luvisol Eutric,kandic) at subgroup while soil unit V1 was keyed into Glayiec Haplustalf (Glayeic Luvisol Kandic, Clayeic). Organic/mineral fertilizers incooporation into these soils will improve soil fertility, structure and water retention.*

KEYWORDS: soil profiles, characterization, classification, management, argillic, base saturation, haplustalfs, vertic epiaqualfs, fertilizers.

INTRODUCTION

In recent times, world food production is on the decline, indicating that productivity of agricultural lands worldwide is undergoing some kinds of degradation. The trends is attributed to ever growing population, discovery of new uses such as bio-fuels from agricultural products, and weather based abnormalities associated with climate change often culminating in decline in rainfall, thus, resulting into low incomes of populous nations (Sidhu and Kamal 2007). To improve the agricultural productivity of the world in general and the research sites in particular, soil productivity must be checked by effectively monitoring soil health. Even the available agricultural lands are not being optimally utilized by their users for a number of reasons: lack of sufficient technical information such as fertilizers status, land use plans as well as management; urbanization and over dependence on oil and white kola job.

Soil characterization provides information for assessment and monitoring of soil behaviour. Classifications systematically arrange soils into groups or categories base on distinguishing characteristics as well as criteria that dictate choices in use. Such system fosters global communication about soils, soil scientists and people saddled with land management and conservation of soil resources. The management option that will guarantee high soil productivity principally depends on the nature and properties of that soil. Characterization is key to soil productivity and determines options for soil management (Onyekwere *et al.*, 2017)
This study was therefore set out to characterize, classify and Proffer possible soil management practices that will ensure food security.

MATERIALS AND METHODS

LOCATION: The study area lies in Ujam District between latitude 07^o 08.65'N, longitude 009^o 14.22'E, and latitude 7^{0}45,48,N, longitude 8^{0}38, 35,E covering an estimated area of 60,000m^2 (6ha). Profiles' locations, slope and height above sea level were taken by employing Geographic Positioning System (GPS). Two sites designated (1) Tse – Ordam (2) Tse – Tswam were selected and subjected to detailed soil survey through the conventional grid method.

Soil Sampling: Three profile pits each (Profiles 1- 111 at Tse-Ordam; 1V-V1 at Tse-Tswam) were sunk at least to 2.0m depth or impenetrable layer or whichever is shallower in site 1 and 2 and morphologically characterized using the pattern outlined in the soil survey manual (Soil Survey Staff, 2010; Gutherie and Witty, 1982). Soil samples collected from genetic horizons were package in properly labelled sample bags and taken to the laboratories for physical and chemical analysis. After air drying and passed through a 2mm sieve, the samples were subjected to laboratory analysis using the Manual of Selected Methods of Plants and Soil Analysis, IITA (1994).

RESULTS AND DISCUSSION

Physical Properties: The soil units lie in a low-lying topography with a slope of 0-3% and narrow cracks (≥5mm) as the major surface characteristic. Profiles depths were deep (118cm) to very deep (200cm), well to imperfectly drained with mottled B-C horizons in most profiles. Soil colour varied from very dark brown (7.5YR 2/3)/brownish black (7.5 YR 3/1) due to melanisation from organic: to dull reddish brown (5YR4/4) surfaces due attributed to redoxmorphism but brown (7.5 YR 4/3) brownish gray (10 YR 5/1) subsoil attributed to imperfect drainage condition (gleization).

Mottles observed on sub soils (Table 1), were attributed to oxidation-reduction cycles due to ground water fluctuation (Babalola *et al;* 2011). The sandy loam underlain by sandy clay loam with weak fine crumbs to moderately sub angular blocky structures of the sites make them suitable for all agriculture practices.
Occurrences of higher clay contents in the subsurface horizons of profiles may be attributed to elluviation from epipedons and illuvation of these finer particles in the subsoils; indicating that the soils were well developed. Silt content shows irregular distribution pattern in all profiles; lowest values were accumulated in the C-horizon. Naidu (2002) observed an irregular trend in silt content with sugarcane growing on soils of Kamataka, India. Higher sand percentages were observed in the epipedons of all profiles. This is expected; as the finer silt and clay particles were iluviated in to the lower horizons at the detriment of the sand fraction hence sandy loam surfaces. Abagyeh (2017) observed that parent material's grain sizes are the main determinant of the soil texture. The progressive increase in bulk density of the sub-soils as indicated in Table 1 may be related to the filling of pores by eluviated materials which showed that "the soils were not compacted enough" to undermine irrigation agriculture in the area. Porosity decreased with increase in profile depth and ranged from 56.60% to 47.92%. This could be as a result of illuviatin of clay in these subsoils, thereby reducing the pore spaces (Sharu *et al.*, 2013) and making them suitable for irrigation.

Chemical Properties: Table 2 shows that soil reaction was slightly acidic to moderately acidic (pH 5.05 - 6.50). Similar result had been reported by Abagyeh (2018); Lawal *et al.* (2012). These values are within the pH requirement for most available nutrients up take by arable crops (Brady and Weil, 1999) and subsequent irrigation. Organic carbon contents of the surface (1.05%) soils were higher than that of the subsoils (0.05%) in all profiles. This may be attributed to addition of farmyard manures and plant residues to the surface horizons. This agreed with Abagyeh (2016). Nitrogen values follow the trend in OC (0.18% to 0.03%) in all soils. Total nitrogen is mobile in soils as a result, its losses through various mechanism like NH_3 volatilization, succeeding denitrification, chemical and microbial fixation, and leaching and runoff results in residual/available nitrogen becoming poor in soils (Abagyeh *et al.*, 2016). The soils were medium to very low in phosphourus content. Low values of phosphorus were due to low cation exchange capacity (CEC), clay content and soil reaction of less than 6.5 in conformity to Abagyeh (2016) on the soils of Lower Benue River Basin. Electrical conductivity was rated very low ($0.02dms^{-1}$ to $0.13dms^{1}$) indicating non –saline status of the soils.

Exchangeable bases occurred in the order of Ca>Mg>K>Na on the exchange complex and were rated medium to very low in all the profiles examined. This may be attributed to the nature of the underlying materials, intensity of weathering, leaching, low activity clay content, very low organic matter content and the lateral translocation of bases according to Kang (1993). It was clear that Mg was present in lower amount than Ca^{2+} because of its higher mobility. These results are in conformity with findings of Abagyeh (2016). Higher CEC values were found mostly in horizons with higher clay contents. Similar trends were observed in some Nigerian Southern Guinea Savanna soils (Ojanuga and Awujoola, 1981). The surface horizons of profiles I to 1V had higher values which could be linked to the active plant litter decomposition process which incorporates cations from the litter into the soil surface. Profiles V and V1 where the subsurface (B- horizon) possessed higher base saturation than the surface horizon (A) was attributed to leaching of bases from surface horizons to the subsoil by Mohan (2008).

The very low Calcium carbonate ($CaCO_3$) percentage of the soils may be linked to the low basic cations Ca^{2+} on the exchange sites to take up anions (HCO^-, CO^{-2}) in these soils.
USDA Soil Taxonomy Classification: Table 3 shows that, six (6) soil units possessed an orchric epipedons and argillic horizons and base saturations that were more than 50 % (NH_4OAc at pH 8.0). Soil units 1, 11, 111, 1V, V and V1 were therefore keyed into Alfisols at the soil order level. They were placed into suborder Ustalfs by virtue of their ustic soils moisture regime as the soils control sections were dry for more than 90 cumulative days but less than 180 cumulative days or 90 consecutive days during the year. Units 1 and 111 had aquic soil moisture regime and were classified as Aqualfs.

Soil unit 1 possessed high bas saturation (BS) through entire profile depth, cracks within the 125cm of mineral surface that were 5 mm or more, low cation exchange capacity (CEC) and gray subsurface soil colour; it was classified as Eutric Epiaqualf. Units 11 was low in base saturation and CEC with high sand fraction and was placed into Dystric Haplaqualf. Unit 111 had high base saturation, low CEC, relative high sand fraction with clayed subsoils therefore fall into Eutric Epiaqualf. On the other hand, soil Unit 1V was classified as Arenic Haplustalf as the soil possessed cracks within the 125cm of mineral surface that were 5 mm or more, very high sand fraction through entire profile depth and low BS. Unit V has very high BS (irregular distribution) and sand fraction with gray Clayed subsoils, low CEC through the profile depth and was put in Haplic Eutrustalf while unit V1 fall into the Haplustalfs at great group and Clayiec Haplustalf at subgroup levels for possessing clayed and grayeic subsoils with low CEC.

Worild Refence Base: Soil units 1, 11, 111, 1V, V and V1 were classified as Vertic Luvisols. Kandic, Glayiec; Dystric Luvisols. Kindic Clayiec; Vertric Luvisols, Kindic, Arenic; Vertic luvisols Dystric; Gleyiec Luvisols Kandic and Glayiec luvisols Kandic, Clayiec in that order based on the reasons advanced in USDA Classification.

Management: Highly acid sensitive crops may need slight liming (to raise pH) while highly acid loving crops may require further acidification (to lower pH) for the soils' better performance. Incorporations of organic with mineral fertilizers application will not only improve soil fertility but also general soil structural settings.

CONCLUSIONS

Generally, soils' characteristics were very low to low in their levels; all soil units were keyed into the Alfisols at soil order level in the USDA Soil Taxonomy and Luvisols in the WRB soil correlation systems while incorporations of organic with mineral fertilizers application will improve the soil fertility and structural settings.

Table 1: Selected Physical Characteristics of Some Soils in Ujam District of Makurdi, Benue State, Nigeria

Horizon		**Morphological Characteristics**						**Other Physical Properties**					
									Particle Size Dist.			**Whole Soil**	
DS	**Depth**	**Colour**		**Texture**	**Str.**	**Bd**	**Remark**	**Porosity**	**Sand**	**Silt**	**Clay**	**gravel**	**BD**
	(cm)	**Matrix**	**Mottles**	**Class**	**-**			**%**				**%**	**gmcm^{-3}**
Unit 1		**Eutric Epiaqualf/Vertic Luvisols. Clayiec, Kandic**											
Ap	**0-27**	7.5YR 2.5/3	-	LS	1fcr	DS	Cracks	56.60	78.08	14.45	7.47	0.30	1.15
A	**27-60**	7.5YR 4/3	7.5YR 5/8	SL	2f-msbk	DS		55.47	70.36	17.34	12.30	0.20	1.18
B	**60-130**	7.5YR 5/1	7.5YR 6/8	SCL	2f-msbk	DS		54.72	65.20	10.68	24.12	0.20	1.20
C	**130-200**	10YR 5/1	7.5YR 4/6	SCL	2fmsbk	-		53.96	52.12	11.67	36.21	0.10	1.22
M				SCL	**1fcr**			55.19	66.44	13.54	20.03	0.20	1.19
Unit 11		**Dystric Haplaqualf/Dystric Luvisols. Kindic Clayiec**											
A	**0-22**	5YR 3/2	-	SL	2f-mcr	DS		51.70	75.24	12.60	12.16	0.20	1.28
B	**22-77**	7.5YR 5/6	-	SCL	3f-csbk	DS		50.19	69.30	10.20	20.50	0.40	1.32
C	**77-150**	2.5YR 6/5	2.5YR 4/6	SCL		-		49.81	60.31	11.58	28.11	0.30	1.33
M				SCL				50.57	68.28	11.46	20.26	0.30	1.31
Unit 111		**Eutric Epiaqualf/Vertric Luvisols, Kindic, Arenic**											
Ap	**0-38**	5YR 3/2	-	SL	1fcr	DS	Cracks	54.72	70.26	18.54	11.20	0.10	1.20
A	**38-60**	7.5YR 4/4	-	SL	1fcr	GS		52.83	65.60	19.18	15.22	0.60	1.25
B	**60-100**	2.5YR 6/5	2.5YR 4/6	SL	2f-csbk	GS		49.06	60.36	17.52	22.12	1.00	1.35
C	**100-150**	2.5YR 5/4	2.5YR 5/3	SCL	3F-csbk	-		48.68	56.30	12.60	31.10	1.20	1.36
M				SCL				51.32	63.13	16.96	19.91	0.73	1.36
Unit 1V		**Arenic Haplustalf/Vertic luvisols Dystric, Arenic**											
Ap	**0-30**	5YR 3/2	-	LS	1fcr	DS	Cracks	48.30	83.00	10.98	6.02	0.30	1.37
A	**30-80**	5YR 4/6	-	SL	1fcr	DS		47.92	77.10	11.60	11.30	0.20	1.38
B	**80-200**	10YR 7/2	10YR 5/8	SCL	1fcr	-		47.92	64.26	9.38	26.36	0.20	1.38
M				SL	2f-msbk			48.05	74.79	10.65	14.58	0.23	1.38
V		**Haplic Eutrustalf/Glayiec luvisols, Eutric, Kandic**											
Ap	**0-16**	5YR 2.5/2	-	LS	1fcr	DS		50.19	80.24	12.66	7.10	0.30	1.32
A	**16-77**	5YR 4/4	-	SL	1fcr	DS		49.81	77.25	10.40	12.35	0.30	1.33

Table 2: Chemical Properties of Selected Soils in Ujam District, Makurdi, Benue State, Nigeria.

Horizon	**pH**	**OC**	**OM**	**N**	**AP**	**EC**	**ESP**	**SAR**	**Exchangeable Properties**	**BS**	**$CaCO_3$**

B	**77-118**	7.5YR 6/3	-	SCL	2f-msbk	-	49.06	58.35	11.36	30.29`	0.20	1.35
M				SL			49.69	71.95	11.47	16.58	0.27	1.33
V1		**Glayiec Haplustalf/Glayiec luvisols Kandic, Clayiec**										
A	**0-29**	7.5YR 3/1	-	SCL	1fcr	DS	54.72	58.32	12.56	29.12	0.20	1.20
B	**29-65**	7.5YR 3/2	-	SCL	1fcr	DS	52.83	50.25	16.75	33.00	0.30	1.25
C	**65-120**	10YR 5/1	10YR 7/6	C	2f-msbk	-	52.08	41.20	15.54	43.26	0.20	1.27
M				SCL			53.21	49.92	14.95	35.13	0.23	1.24

KEY: DS – Designation**; Texture**: C - Clay, SL –Loamy Sandy, SL -Sandy Loam, SCL – Sandy Clay Loam; **Structure:Str**. – Structure, 1fcr – Weak fine crumb, 1f- mcr,- Weak fine-medium crumb, 2f-csbk – Moderate fine to coarse subangular blocky, 3f-csbk – Coarse subangular blocky; **Boundary :**Bd – Boundary, AS - Abrupt Clear, GS – Gradual smooth, DS - Diffuse smooth and BD –Bulk Density, Cracks - ≤5mm Cracks

Design	**Depth**	**H_2O**								**Ca**	**Mg**	**K**	**Na**	**TEB**	**CEC**		
Unit	**cm**		**%**			**$mgkg^{-1}$**	**dms^{-1}**	**%**		**$cmolkg^{-1}$**						**%**	**%**
Unit 1		**Eutric Epiaqualf/Vertic Luvisols. Clayiec, Kandic**															
Ap	0-27	6.30	0.90	1.56	0.12	7.68	0.12	1.43	0.06	3.40	2.80	0.13	0.10	6.43	7.00	91.9	
A	27-60	6.05	0.70	1.21	0.10	6.50	0.13	1.26	0.05	3.24	2.84	0.11	0.09	6.28	7.12	88.2	
B	60-130	5.90	0.50	0.86	0.06	5.00	0.10	1.40	0.06	2.82	2.42	0.15	0.10	5.49	7.16	76.7	
C	130-200	5.95	0.30	0.52	0.03	4.10	0.12	1.60	0.08	2.18	2.12	0.12	0.12	4.54	7.48	60.7	
M		6.05	0.60	1.04	0.08	5.82	0.12	1.42	0.06	2.91	2.55	0.13	0.10	5.69	7.19	79.38	0 – 2
Unit 11		**Dystric Haplaqualf/Dystric Luvisols. Kindic Clayiec**															
A	0-22	6.00	0.65	1.12	0.11	7.00	0.13	1.25	0.07	2.60	1.78	0.11	0.10	4.59	8.02	57.2	
B	22-77	5.84	0.40	0.69`	0.07	6.10	0.12	1.3	0.27	2.30	1.86	0.14	0.12	4.42	8.68	50.9	
C	77-150	6.05	0.30	0.52	0.05	4.45	0.13	1.21	0.08	2.08	1.76	0.13	0.11	4.08	9.10	44.8	
Mean		5.96	0.45	0.78	0.08	5.85	0.13	1.28	0.14	2.33	1.80	0.13	0.11	4.36	8.60	50.97	0 – 2
Unit 111		**Eutric Epiaqualf/Vertric Luvisols, Kindic, Arenic**															
Ap	0-38	6.20	0.80	1.38	0.18	7.20	0.12	1.90	0.07	3.00	2.20	0.14	0.12	5.46	6.34	86.1	
A	38-60	5.97	0.65	1.12	0.10	5.40	0.12	1.58	0.07	2.86	2.58	0.12	0.11	5.66	6.96	81.3	
B	60-100	5.80	0.40	0.69	0.06	3.00	0.13	1.69	0.09	1.84	2.12	0.11	0.12	4.19	7.12	58.8	
C	100-150	5.95	0.30	0.52	0.05	3.20	0.13	1.67	0.08	1.78	2.46	0.14	0.12	4.50	7.20	62.5	
Mean		5.98	0.54	0.93	0.10	4.7	0.13	1.71	0.08	2.37	2.34	0.13	0.12	4.10	6.91	72.18	0 – 2
Unit 1V		**Arenic Haplustalf/Vertic luvisols Dystric, Arenic**															
Ap	0-30	5.90	0.68	1.18	0.16	6.60	0.10	1.46	0.08	2.80	1.80	0.21	0.12	4.93	8.20	60.1	

A	30-80	5.86	0.50	0.86	0.08	4.20	0.12	1.34	0.07	2.76	1.84	0.11	0.11	4.82	8.36	57.7	
B	8-200	5.67	0.05	0.09	0.08	2.20	0.13	1.13	0.07	2.20	1.86	0.21	0.10	4.37	8.83	49.25	
Mean		5.81	0.41	0.71	0.11	4.33	0.12	0.31	0.07	2.59	1.83	0.18	0.11	4.71	8.46	55.68	0 – 2
Unit V		**Haplic Eutrustalf/Glayiec luvisols, Eutric, Kandic**															
Ap	0-16	6.50	0.84	1.45	0.12	7.10	0.12	1.77	0.07	3.30	2.30	0.18	0.12	5.90	6.78	87.0	
A	16-77	5.98	0.58	1.00	0.09	5.20	0.13	1.70	0.07	3.16	2.90	0.14	0.12	6.32	7.06	89.5	
B	77-118	6.20	0.30	0.52	0.08	3.10	0.13	1.40	0.07	3.20	1.90	0.16	0.11	5.37	7.80	68.8	
Mean		6.23	0.57	0.99	0.10	5.13	0.13	1.62	0.07	3.22	2.37	0.16	0.12	5.86	7.21	81.77	0 – 2
Unit V1		**Glayiec Haplustalf/Glayiec luvisols Kandic, Clayiec**															
A	0-29	6.08	1.05	1.82	0.08	10.00	0.02	1.35	0.06	4.00	2.90	0.11	0.11	7.12	8.12	67.7	
B	29-65	5.05	0.65	1.12	0.04	8.20	0.02	1.27	0.06	3.40	2.00	0.12	0.10	5.62	7.88	71.3	
C	65-120	5.40	0.40	0.69	0.02	6.80	0.05	1.37	0.06	2.80	2.26	0.10	0.10	5.26	7.30	72.1	
Mean		5.51	0.70	1.21	0.05	8.33	0.03	1.33	0.06	3.40	2.39	0.11	0.10	6.00	7.77	70.37	0 – 2

Key: Design = Designation

Table 3: Soil Classification According to Soil Taxonomy (USDA) and World Reference Base (WRB) in Ujam District of Makurdi, Benue State, Nigeria

Site	Soil Unit	USDA	WRB
Tse-Ordam	I	Eutric Epiaqualf	Vertic Luvisols. Clayiec, Kandic
Tse-Ordam	II	Dystric Haplaqualf	Dystric Luvisols. Kindic Clayiec
Tse-Ordam	III	Eutric Epiaqualf	Vertric Luvisols, Kindic, Arenic
Tse-Tswam	IV	Arenic Haplustalf	Vertic luvisols Dystric, Arenic
Tse-Tswam	V	Haplic Eutrustalf	Glayiec luvisols, Eutric, Kandic
Tse-Tswam	VI	Glayiec Haplustalf	Glayiec luvisols Kandic, Clayiec

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