International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 05, Issue: 06 "November-December 2019"

CHARACTERIZATION AND IRRIGATION SUITABILITY OF SOILS AT TSE- ORDAM AND TSE-TSWAM IN UJAM DISTRICT, MAKURDI, BENUE STATE.

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ABSTRACT

Grid method approach was adapted to conduct a detailed soil survey to characterize and rate the suitability of Tse-Tswam and Tse-Ordam soils. Three profiles pit were dug in each site and morphologically described. Samples collected from genetic horizons were analysed and parametric evaluation method used to evaluate the soils' suitability for surface and subsurface irrigations. Results show: profiles were deep (118cm) to very deep (200cm); well to imperfectly drained; sandy loam/loamy sand to sandy clay loam textures and weak fine crumb to moderate fine-coarse subangularblocky structures with slopes between 0 to 3%; indicating almost flatland surface The soils had medium - high sand (49.99-83.00%), low - medium clay (14.58- 35.13%) and low silt (10.65-16.96%) fractions. The soils were slightly acid (5.96-6.05); low in organic carbon (0.45-0.60%), nitrogen (0.08-0.10%), Available phosphorus (4.70-5.85%) and EC (0.12-0.13dms^{-1}); very low CEC (6.91-8.60cmolkg^{-1}), $CaCO_3$ (0.00-2.00%) with medium to high in base saturation (50.97-79.38%). ESP(1.13-1.77%) shows the sites were not characterized by excessive degree of saturated extract with exchangeable sodium (ESP > 15 percent and pH ≥ 8.5), therefore, cannot be alkali (Sodic)/ saline and therefore highly suitable for irrigations. The lands have no limitations with regards to depth, $CaCO_3$, electrical conductivity and slope thereby qualifying these parameters into highly suitable (S1) subclass; the soils were optimal for all types of irrigation. For the surface irrigation; soil units 1, 11. 111 and V1 were rated as moderately suitable (S2w) due drainage defects, units 1V and V were rated highly suitable (S1) as no parameters had substantially reduced their irrigation suitability. For the drip or localized irrigation, all the soil units 1 to V1 were highly suitable, even the limitations due to drainage defect did not substantially reduced the soils' suitability for the subsurface irrigation.

Keywords: Characterize, Parametric Evaluation, Gravity, Drip Irrigation, Limitations, Drainage, Textural Defects

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INTRODUCTION

Statistics regarding world food production shows that food production worldwide is on the decline (FAO, 2008), indicators that the productivity of agricultural soils worldwide are declining. The trends is attributed to ever growing population, lowered incomes of populous nations, 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 (Sidhu and Kamal, 2007).

The continued decline in soil productivity could be checked by effective monitoring of the soil health. At present, most systems of land evaluation are interpretative classification based on limitations of land characteristics, as best illustrated in the USDA land capability classification. The classification points out automatically the possibilities and limitations of the climate for each crop and type of agriculture. Unfortunately, climate mitigation takes time for arable production, the most limiting factor in the tropical environment being rainfall (Doran and Parkin, 1994). To ensure all year round crop production where temperature is not limiting, the alternative source of water is irrigation. Unfortunately, even in the excellent class for irrigation water, the parcel of land to be irrigated must meet the requirement for irrigation. The soil characteristics of concern in this concept include but not limited to soil texture, depth, drainage, electrical conductivity, calcium carbonate concentration as well as the general slope of the terrain.

Irrigation is not only important in the drier environment but even in humid area; supplemental irrigation ensures all year round crop production as witnessed in tropical India. In North-West Nigeria, total irrigation in the dry seasons has seen unseasoned production of high value crops with resultant high farmer income and attendant better living standard (Abagyeh, 2017). Irrigation, be it short or long term, is capital intensive in nature, and requires very high value crop with high payment capacity, wide marketability and high nutritive value and popularity.

Where water is limited and unsuitable, an irrigation project is executed at extremely high cost. Tse-Tswam and Tse-Ordam lie at the NorthBank of River Benue with its distributaries having sufficient water for total irrigation in the dry season and supplemental irrigation during dry spell. Scanty irrigation activities are conducted in the lengthy dry season. This study is to characterize and rate irrigation suitability of soil in the area for the purposes of surface and subsurface irrigation practices that will encourage irrigation agricultural activities along the benue river banks.

MATERIALS AND METHOD

LOCATION: The study area belongs to the Savannah ecological region, a typical subtropical region with 5 months of dry season. The area experiences a hot tropical climate with distinct wet

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and dry seasons with mean annual rainfall between 1220 and 1493mm; monthly maximum temperature between 29°C to 38°C; minimum from 15°C and 26°C. Relative humidity of the area is season dependent and ranges from 38 to 86 per cent and high solar radiation all year round with monthly range from 09.1 to 15.6 $mjcm^{-2}d^{-1}$. Irrigation agriculture can be adopted during this dry period or as supplementary mode during the rainy season when water stress occurs. Two sites (i) Tse – Ordam (ii) Tse – Tswam were selected and subjected to detailed soil survey. They lie between latitude 07° 08.65'N, longitude 009° 14.22'E, and latitude $7^0$45'48'N, longitude 8^0 38' 35'E covering an estimated area of $300x200m^2$ (6ha). Profiles' 'locations, slopes and heights above sea level' were noted using, global positioning system (GPS)

Soil Sampling: Three profile pits [1-11 (Tse-Ordam)] and 1V-V1 (Tse-Tswam) were sunk atleast 2.0m depth or impenetrable layer or whichever is shallower in each site and morphologically characterized using the pattern outlined in the soil survey manual (Soil Survey Staff, 2010; Gutherie and Witty, 1982). Soil samples were collected from genetic horizons into properly labelled sample bags and taken to the laboratories for physical and chemical analysis. Standard laboratory procedures were employed to investigate the soils' physical and chemical characteristics. 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).

Irrigation Suitability: The criteria employed in irrigation suitability ratings as adapted by Abagyeh (2016) from Sys *et al.,* (1991) are contained in Table 1. The parameters were rated and used to calculate the capability/suitability index (Ci/Si) for irrigation according to the formula:

$$Ci = A\ x\ \frac{B}{100}\ x\ \frac{C}{100}\ x\ \frac{D}{100}\ x\ \frac{E}{100}\ x\ \frac{F}{100}$$

Where: Ci/Si = Capability/Suitability index for irrigation; A = soil texture rating; B = soil depth rating; C = $CaCO_3$ status; D = electro-conductivity rating; E = drainage rating and F = slope rating. Suitability classes are defined considering the value of the capability index in Table 1.

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Table 1: Suitability Index for the Irrigation Capability Indices (Ci) Classes

Capability/ Suitability Index	Class	Definition	Symbol
>80	I	Highly suitable	S1
60-80	II	Moderately suitable	S2
45-60	III	Marginally suitable	S3
30-45	IV	Currently not suitable	N1
<30	V	Permanently not suitable	N2

Source: Instituto Agronomico per I'oitremare (2014)

RESULTS AND DISCUSSION

Table 2 contains terrain and soil characteristics used for land suitability evaluation for irrigation agriculture.

Table 2: Mean Terrain and Soil Characteristics Used for Land Suitability Evaluation for Irrigation Agriculture

Soil Characteristics	Units	1	2	3	4	5	6
A. Texture	**Class**	**SCL**	**SCL**	**SCL**	**SL**	**SL**	**SCL**
B. Depth	**Cm**	**200**	**150**	**150**	**200**	**118**	**120**
C. $CaCO_3$	**%**	**0 - 2**	**0 – 2**	**0 – 2**	**0 – 2**	**0 – 2**	**0 – 2**
D. EC	**dsm^{-1}**	**0.12**	**0.13**	**0.125**	**0.125**	**0.13**	**0.03**
E. Drainage	**Class**	**ID**	**ID**	**ID**	**WD**	**WD**	**ID**
F. Slope	**%**	**0 - 1**	**0 – 1**	**0 – 2**	**0 – 3**	**0 – 2**	**0 – 1**
Gravel Content	**%**	**0.2**	**0.3**	**0.7**	**0.2**	**0.3**	**0.2**

Physical Properties: The soil units lie in a low-lying topography with a slope of 0-3% with 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 rediomophism but brown (7.5 YR 4/3) brownish gray (10 YR 5/1) subsoil attributed. to imperfect drainage condition (gleization) The mottles observed on sub soils is an indication of soil wetness; oxidation-reduction cycles due to ground water fluctuation (Babalola *et al.*, 2011).

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Soils surfaces were sandy loam or loamy sand underlain by clay/sandy clay loam textures; these coupled with weak fine crumbs to moderately sub angular blocky structures resulted to imperfect drainage of the sites make them suitable for irrigation practices.

The higher clay content often observed in subsurface horizons of many soils may be attributed to elluviation and pedoturbation processes (Malgwi, 2001). 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 eluviated 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. From profiles' clay content distributions, the soils are well developed. Progressively increase in the bulk density of the sub-soils may be related to the filling of pores by eluviated materials which showed that "soils were not compacted enough" to undermine irrigation agriculture in the area. Porosity decreased with increase in profiles' depth and ranged from 56.60% to 47.92%. Abagyeh *et al.* (2017) reported similar results to illuviatin of clay in the subsoils, thereby reducing the pore spaces and making them suitable for irrigation. Gravel content was very low(0.00-0.30%) indicating that it cannot impede crop roots penetration and development in these soils.

Chemical Properties: Table 3 shows that soil reaction was slightly 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 for arable crops up take (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 the 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.,* 2014). 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 Basi n. Electrical conductivity was rated very low (0.02dms^{-1} to 0.13dms^{1}) indicating non –saline status of the soils. Jamila (2017) reported similar findings in Northern Guinea Savannas soils of Nigeria. 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.

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Table 3: Selected Physical / Chemical Characteristics of Soils at Tse-Swam and Tse- Ordam Areas of Makurdi, Benue State

Horizon		Morphological Characteristics			Particle Size Dist.			Physical Properties			Chemical Properties				
DS	Depth	Colour		Text	Sand	Silt	Clay	Grav	BD	Poro	pH	OC	N	AP	ESP
	(cm)	Matrix	Mottles	Class	%	%	%	&_	$gmcm^{-3}$	%		%	%	$mgkg^{-1}$	%
Unit 1					**Eutric Haplustalf / Dystric Luvisols. Clayiec**										
Ap	**0-27**	7.5YR 2.5/3	-	LS	78.08	14.45	7.47	0.30	1.15	56.60	6.30	0.90	0.12	7.68	1.43
A	**27-60**	7.5YR 4/3	7.5YR 5/8	SL	70.36	17.34	12.30	0.20	1.18	55.47	6.05	0.70	0.10	6.50	1.26
B	**60-130**	7.5YR 5/1	7.5YR 6/8	SCL	65.20	10.68	24.12	0.20	1.20	54.72	5.90	0.50	0.06	5.00	1.40
C	**130-200**	10YR 5/1	7.5YR 4/6	SCL	52.12	11.67	36.21	0.10	1.22	53.96	5.95	0.30	0.03	4.10	1.60
M				SCL	66.44	13.54	20.03	0.20	1.19	55.19	6.05	0.60	0.08	5.82	1.42
Unit 11					**Dystric Haplaqualf / Dystric Luvisols. Clayiec**										
A	**0-22**	5YR 3/2	-	SL	75.24	12.60	12.16	0.20	1.28	51.70	6.00	0.65	0.11	7.00	1.25
B	**22-77**	7.5YR 5/6	-	SCL	69.30	10.20	20.50	0.40	1.32	50.19	5.84	0.40	0.07	6.10	1.30
C	**77-150**	2.5YR 6/5	2.5YR 4/6	SCL	60.31	11.58	28.11	0.30	1.33	49.81	6.05	0.30	0.05	4.45	1.21
M				SCL	68.28	11.46	20.26	0.30	1.31	50.57	5.96	0.45	0.08	5.85	1.28
Unit 111					**Eutric Haplaqualf / Kandic Luvisols. Arenic, Clayiec**										
Ap	**0-38**	5YR 3/2	-	SL	70.26	18.54	11.20	0.10	1.20	54.72	6.20	0.80	0.18	7.20	1.90
A	**38-60**	7.5YR 4/4	-	SL	65.60	19.18	15.22	0.60	1.25	52.83	5.97	0.65	0.10	5.40	1.58
B	**60-100**	2.5YR 6/5	2.5YR 4/6	SL	60.36	17.52	22.12	1.00	1.35	49.06	5.80	0.40	0.06	3.00	1.69
C	**100-150**	2.5YR 5/4	2.5YR 5/3	SCL	56.30	12.60	31.10	1.20	1.36	48.68	5.95	0.30	0.05	3.20	1.67
M				SCL	63.13	16.96	19.91	0.73	1.36	51.32	5.98	0.54	0.10	4.7	1.71
Unit 1V					**Arenic Haplustalf / Vertic luvisols Dystric, Aeric**										
Ap	**0-30**	5YR 3/2	-	LS	83.00	10.98	6.02	0.30	1.37	48.30	5.90	0.68	0.16	6.60	1.90
A	**30-80**	5YR 4/6	-	SL	77.10	11.60	11.30	0.20	1.38	47.92	5.86	0.50	0.08	4.20	1.58
B	**80-200**	10YR 7/2	10YR 5/8	SCL	64.26	9.38	26.36	0.20	1.38	47.92	5.67	0.05	0.08	2.20	1.69

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M				SL	74.79	10.65	14.58	0.23	1.38	48.05	5.81	0.41	0.11	4.33	1.67
Unit V				**Haplic Eutrustalf / Glayiec luvisols, Eutric, Kandic**											
Ap	**0-16**	5YR 2.5/2	-	LS	80.24	12.66	7.10	0.30	1.32	50.19	6.50	0.84	0.12	7.10	1.77
A	**16-77**	5YR 4/4	-	SL	77.25	10.40	12.35	0.30	1.33	49.81	5.98	0.58	0.09	5.20	1.70
B	**77-118**	7.5YR 6/3	-	SCL	58.35	11.36	30.29	0.20	1.35	49.06	6.20	0.30	0.08	3.10	1.40
M				SL	71.95	11.47	16.58	0.27	1.33	49.69	6.23	0.57	0.10	5.13	1.62
V1				**Clayiec Haplustalf / Glayiec luvisols Kandic, Clayiec**											
A	**0-29**	7.5YR 3/1	-	SCL	58.32	12.56	29.12	0.20	1.20	54.72	6.08	1.05	0.08	10.00	1.35
B	**29-65**	7.5YR 3/2	-	SCL	50.25	16.75	33.00	0.30	1.25	52.83	5.05	0.65	0.04	8.20	1.27
C	**65-120**	10YR 5/1	10YR 7/6	C	41.20	15.54	43.26	0.20	1.27	52.08	5.40	0.40	0.02	6.80	1.37
M				SCL	49.92	14.95	35.13	0.23	1.24	53.21	5.51	0.70	0.05	8.33	1.33

KEY: **DS** = Designation; **Text. = TEXTURE**: C **-** Clay, LS – Loamy Sand, SL **-**Sandy Loam, SCL – Sandy Clay Loam; **Grav**. – Gravel; **Poro.** – Porosity; BD – Bulk Density

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Exchangeable sodium (ESP) percentage was low generally (1.13-1.77%). The sites were not characterized by excessive degree of saturated extract with exchangeable sodium (ESP > 15 percent and pH ≥ 8.5), therefore, cannot be alkali (Sodic) Sites. The sites were not likely to be saline – alkali as they lack excessive quantities of both salts. The soils are therefore highly suitable for irrigation.

Irrigation Suitability: The lands have no limitation with regards to depth, $CaCO_3$, electrical conductivity and soil slope thereby classifying the parameters in to highly suitable (S1) subclass. Thus, indicating that the soils were optimal for all types of irrigation agricultural practices.

Surface or gravity irrigation: Soil mapping units 1, 11, 111 and V1 were classified as moderately suitable (S2w). The soils had sandy loam or loamy sand surfaces that substantially reduced their suitability for gravity irrigation. The imperfect drainage status due to the sandy clay loam textures underlain these soils with moderate porosity, water infiltration and medium water holding capacity were not very adequate for gravity irrigation as reported by Abagyeh (2018). The soil units cover 66.67 percent and 4 hectares of the total landmass studied. Soil units 1V and V had either sandy loam or loamy sand through the profiles depths that permit rapid infiltration and drainage. These had reduced the soils' suitability for irrigation into moderately suitable subclass (S2t) as gravity irrigation requires heavier textures. They cover 33.67% (2hectares) of the examined landmass.

Drip or localized irrigation: The imperfect drainage of the units due to sandy loam or loamy sand underlain by sandy clay loam or clay textures may have influenced high surface soil water infiltration, moderate water retention and moderate to slow permeability rates making the soils and very adequate for drip or localized irrigation according to Abagyeh (2016). The highly suitable land for drip irrigation covers 6 hectares (100.00 %) of total landmass under study.

Workings and results of suitability index for the irrigation capability indices (Ci), classes with symbols and their definitions are presented in Tables 4 and 5.

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Table 4: Soil Suitability Classes for Irrigation Capability Indices for Gravity and Drip Irrigations

Irrigation Type		G	D	G	D	G	D	G	D	G	D	G	D
Soil	**Unit**	**1**		**11**		**111**		**1V**		**V**		**1V**	
Characteristics													
A. Texture	**class**	95	95	95	95	95	95	75	95	75	95	95	95
A. Depth	**cm**	100	100	100	100	100	100	100	100	100	100	100	100
B. $CaCO_3$	**%**	95	95	95	95	95	95	95	95	95	95	95	95
C. EC	**dsm^{-1}**	100	100	100	100	100	100	100	100	100	100	100	100
D. Drainage	**class**	80	90	80	90	80	90	100	100	100	100	80	90
E. Slope	**%**	100	100	100	100	100	95	100	95	100	95	100	100
Ci(Si)		**72.2**	**81.2**	**72.2**	**81.2**	**72.2**	**81.2**	**71.3**	**85.7**	**71.3**	**85.7**	**72.2**	**81.2**
SC		**S2w**	**S1**	**S2w**	**S1**	**S2w**	**S1**	**S2t**	**S1**	**S2t**	**S1**	**S2w**	**S1**

KEY: D = Drip/Localized, G = Gravity/Surface, t = Texture, w = Drainage, S1 = highly and S2 = moderately Suitable

Table 5: Suitability Index (Si) for the Irrigation Capability Indices (Ci) Classes

Pedon	Capability Index	Class	Definition	Symbol
		Gravity or Surface Irrigation		
1	72.2	11	Moderately Suitable	S2w
11	72.2	11	Moderately Suitable	S2w
II1	72.2	11	Moderately Suitable	Sw
1V	71.3	11	Moderately Suitable	S2t
V	71.3	11	Moderately Suitable	S2t
V1	72.2	11	Moderately Suitable	S2w
		Drip or Localized Irrigation		
1	81.2	1	Highly Suitable	S1
11	81.2	1	Highly Suitable	S1

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II1	81.2	1	Highly Suitable	S1
1V	85.7	1	Highly Suitable	S1
V	85.7	1	Highly Suitable	S1
V1	81.2	1	Highly Suitable	S1

CONCLUSION

Findings revealed that:

Soil characteristics were very low to low; implying low fertility soils.

All Soils were classified as moderately suitable for surface irrigation; units 1, 11, 111 and V1 due to impeded drainage while 1V and V had textural defects as major limitations.

All soil units were classified into the highly suitable class for drip or subsurface irrigation as no limitations had substantially reduced the soils' suitability for the purpose.

REFERENCES

Abagyeh, S. O. I. (2016).Characterization and Irrigation Suitability Ratings of Soils of Mid-Benue Valley Using Okra (*Abelmoschus esculentus* L. Moench) as a Test Crop. Department of Soil Science, College of Agronomy, Federal University of Agriculture Makurdi, Nigeria.

Abagyeh, S. O. I.; Ibo P. I. and Idoga, S. (2017). Irrigation Suitability Ratings and Okra Productivity of Some Mid-Benue Trough Soils: A Comparative Analysis. Nigerian *Journal of Soil Science*. 27: Pp. 230 – 244.

Abagyeh, S. O. I., Idoga, S. and Odiaka, N. I. (2018). Soils' Properties, Irrigation Suitability and Okra Productivity. LAP LAMBERT Academic Publishers. 17 Meldrum Street, Beau Basin 71504, Mauritius. 178p.

Abagyeh, S. O. I.; Idoga S. and Ibrahim, F. (2018). Characterization and Suitability Evaluation of Soils of a Toposequence at University of Agriculture Makurdi Teaching and Research Farms for the Production of Rice (*Oryza sativa*) in Makurdi, Benue State. *International Journal of Enviroment, Agriculture and Biotechnology (IJEAB)*. 3(3): 1019 – 1027. http://dx.doi.org/10.22161/3.3.39

Abagyeh, S. O. I.; Wuese, S. T. and Ezenwa, M. I. S. (2017). Characterization, Classification and Management of Integrated Landscapes in the Middle Benue Valley of Benue State. Nigerian *Journal of Soil Science*. 27: Pp. 267 – 281.

Babalola, T. S.,Osu, T., Fasina, A. S. And Godonu, K. (2011). Land Evaluation Studies of Two Wetland Soils in Nigeria. International Research. *Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) vol.(6) PP193-204*. Http:www.interesjournal.org/IRJAS

Brady, N. C. and and Weil, r. R\. (1999). The Nature Properties of Soils.12 ed.Pretence Hall Upper Saddle River, New York. 881p

Doran , J. W. and Parkin, T. B. (1994). Defining and assessing soil quality for sustainable environment. *Soil Science Society Special Public*. ♯ 35. P1-21.

FAOSTAT. 2008. Food and Agricultural Organization of United Nations. Online and Multilingual Statistics Datadbase, http://www.apps.fao.org//

Gutherie R.L and Witty, I. (1982). New designation for soil horizons and layers and the New Soil Survey manual. *Soil Science Society of America Journal*. 46:443-444.

IITA (1994). Manual of Selected Methods of Plants and Soil Analysis,.

Malgwi, W. B.. (2001). Characterization of Salt Affect Soils of Some Selected Locations in the North-West Zone of Nigeria.An Unpublished Thesis Submitted to Soil Science Department, ABU Zaria

Maniyunda, L. M. and Gwari, M. G. (2013). DEVELPMENT OF A Toposequence on Loessial Deposit in Northern Guinea Savanna of Nigeria. *Journal of Agricultural and Biological Science. Vol. 9(3) (ISSN 1990-614).* Retrieved from www.arpnjournals.com

Mohan M. M. (2008). Characterization and Classification of Soils and Land Suitability of a Micro watershed in Hanagal Taluk. M Sc. Thesis University of Agricultural Sciences, Dharwad. 117p.

Naidu, L. G. K. (2002). Characterization of sugarcane soils of Karanataka. *Agropedology*, 12: 157-163.

Ojanuga A.G and Awujoola, A.I. (1981). Characteristics and classification of the soils of the Jos plateau, *Nigerian Journal, Soil Science*. 2: 201-119.

Sharu, M., Yakubu, M. And Tsafe, A. I. (2013). Characterization and Classification of Soils on an Agricultural Landscape in Dingyadi District, Sokoto State, Nigeria. *Nigeria Journal of Basic and Applied Science. 21(2)137-147*

Sidhu, M. S. and Kamal V. (2007). Development experience of Indian agriculture : An appraisal of post-reform period. *Southern Economist*, 11: 9-14.

Soil Survey Staff, (2010). Key to Soil Taxonomy, 11 Edition. Basic system of Soil Classification for Making and Interpreting Soil Survey, National Reserve Conservation Services, Agricultural Dept. Soil Survey Division. Washington DC USA. 126p.

