



LAND SUITABILITY APPRAISAL FOR SWEET POTATO (*Ipomoea batatas*)
CULTIVATION ON A TOPOSEQUENCE AT OVIM ISIUKWUATO, SOUTH EAST
NIGERIA

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ABSTRACT

Land suitability assessment for sustainable cultivation of sweet potato was carried out on a toposequence at Ovim, Isiukwuato LGA, Abia State, Nigeria. A stratified random sampling technique was adopted and following the attributes of the terrain, the toposequence was delineated into upper, middle, lower slopes and valley bottom. Four profile pits (OVA, OVB, OVC and OVD) were then excavated; one on each of upper slope, middle slope, lower slope and valley bottom respectively. The pits were described and soil samples taken from genetic horizons were analyzed for physical and chemical properties. Results showed that OVA and OVB were deep (>18 cm) and well drained. Soil unit OVC was deep (165cm) but imperfectly while OVD was moderately deep (85cm) and poorly drained. The soils were strongly to moderately acidic (pH 5.3-5.9) with high base saturation (71.05 - 85.16). Organic matter contents were high for epipedons and low for the subsoils. The soils were low in ECEC averaging (6.26, 6.89, 7.65 and 6.55 cmolkg⁻¹), available P (12.55¹, 12.88, 5.75 and 12.40 mgkg⁻¹) and total N. (0.09, 0.06, 0.07 and 0.08 gkg⁻¹), for OVA, OVB, OVC and OVD respectively. The suitability assessment by simple limitation confirmed that all the soil units were currently not suitable (N1) as the optimal performance were constrained by fertility (N1-f). In addition, OVD is limited by poorly drained condition (N1-fw) for the cultivation of sweet potato in the area. Adequate management of the soils through organic manuring and split application of NPK should be adopted. More so, proper drainage of OVD is necessary to control the inflow and outflow of water into the field. Otherwise, the unit could be devoted to cultivation of lowland rice.

Key words: Cultivation, Properties, Soil, Suitability and Toposequence

INTRODUCTION

Topography is an important factor for the analysis and mapping of landforms (Reddy, 2018; Adesemuyi *et al.*, 2019). This is because it influences surface flow, soil properties, water content and the erosion potential of a given area. Local topography is often referred to as toposequence. As a general rule, soil profile on the convex upper slope in a toposequence are shallower and have less distinct sub surface horizons than soils at lower slope. As such, variations in most soil properties could be closely related to their landscape position (Surwase *et al.*, 2023).

Studies of various geomorphological processes provide inferences to understand landscape evolution, pedology, hydrology (Manjare *et al.*, 2022) and status of land degradation (Reddy, 2018). Soil survey provides an accurate and scientific inventory of different soils, their kinds, nature, and extent of distribution so that one can make predictions about their characters and potentialities (Nwaoba and Lekwa, 2016).

Studies relating to soil and site characteristics and crop requirements form the basis for soil suitability evaluation (Osinuga *et al.*, 2020). Land evaluation provides information on the constraints and opportunities for the use of the land and also guides decisions on potential and optimal utilization of resources, whose knowledge is an essential pre-condition for land use planning and development (AbdelRahman *et al.*, 2016). Moreover, such analysis allows identification of the main limiting factors for the agricultural production. This enables decision makers such as land users, land use planners, and agricultural support services to develop crop



management practices able to overcome such constraints and increase productivity. Land suitability of a particular land is a function of matching the land characteristics with the crop requirements (Mustafa *et al.*, 2011; Nwaoba *et al.*, 2021).

Sweet potato is an important food security and early maturity crop that can be intercropped with crops like maize and yam. In Nigeria, more than 85% of the sweet potato production is done by farmers who maintain small scale farming and carry out their operation manually with traditional farm tools (FAO, 2019). Optimal sweet potato production of soils on a toposequence in Ovim area is possible through a systematic survey of the soils, evaluating their potentials for a wide range of land use options and formulating land use plans which are environmentally, socially and economically acceptable and viable (Addeo *et al.*, 2001; Sathish and Niranjana, 2010).

The current shortage of food and increasing demand for food in the rapidly expanding population necessitate that soils on topographic positions be brought under intensive agricultural land use. Available information about soils on toposequence is insufficient for efficient scientific planning for the future use of the soils for agriculture in Ovim area of Abia State. This has led to indiscriminate application of mineral fertilizers which poses more risk on the fragile soils. A clear understanding of the characteristics and suitability evaluation of soils of the various topographic positions is essential for efficient management and increased productivity of the soils especially for sweet potato cultivation. Therefore, the specific objectives of this study were to characterize and evaluate the suitability of soils on a toposequence for sweet potato production in Ovim area of South East Nigeria.

MATERIALS AND METHODS

The Study area

The study was carried out at Ovim, Isiukwuato LGA, Abia State, South-eastern Nigeria. The area located between Latitudes 5°40' N - 6°30' N and Longitudes 7° 20' E - 7° 35' E (Fig. 1). The area, underlain mainly by lower coal measures is typical rainforest vegetation in south-eastern agro-ecological zone of Nigeria (IITA, 1996). The general climate is sub-humid tropical, having distinct rainy season that begins from April to October and dry season from November to March. The total annual rainfall is 2200 mm, the mean annual temperature is about 31 °C and the annual relative humidity is about 75 %. The average minimum and maximum temperatures are about 22 °C and 30 °C, respectively (Abia GIS, 2020). The relief is moderately to strongly sloping (4-7 %). The area records the deposition of fluvio-deltaic sediments which consists mainly of clastic rocks (claystones, shales, siltstones, sandstones, conglomerates) interstratified with the beds of coal. Coal was discovered in the Mamu Formation (formerly called the 'Lower Coal Measures') of the Anambra Sedimentary Basin of south-eastern Nigeria (Abia GIS, 2020).

The major land use of the area is arable cropping which includes cassava (*Manihot spp.*), sweet potato (*Ipomea batatas*), yam (*Dioscorea spp.*), maize (*Zea mays*), cocoyam (*Colocasia esculentus*). Also, palm trees, native pear (*Dacryodes edulis*), mango (*Magnifera indica*), orange, grape, lemon (*Citrus spp.*) etc are grown. Melon and garden vegetables which include fluted pumpkin (*Telferia occidentalis*), pepper (*Capsicum spp.*) are the vegetable crops.

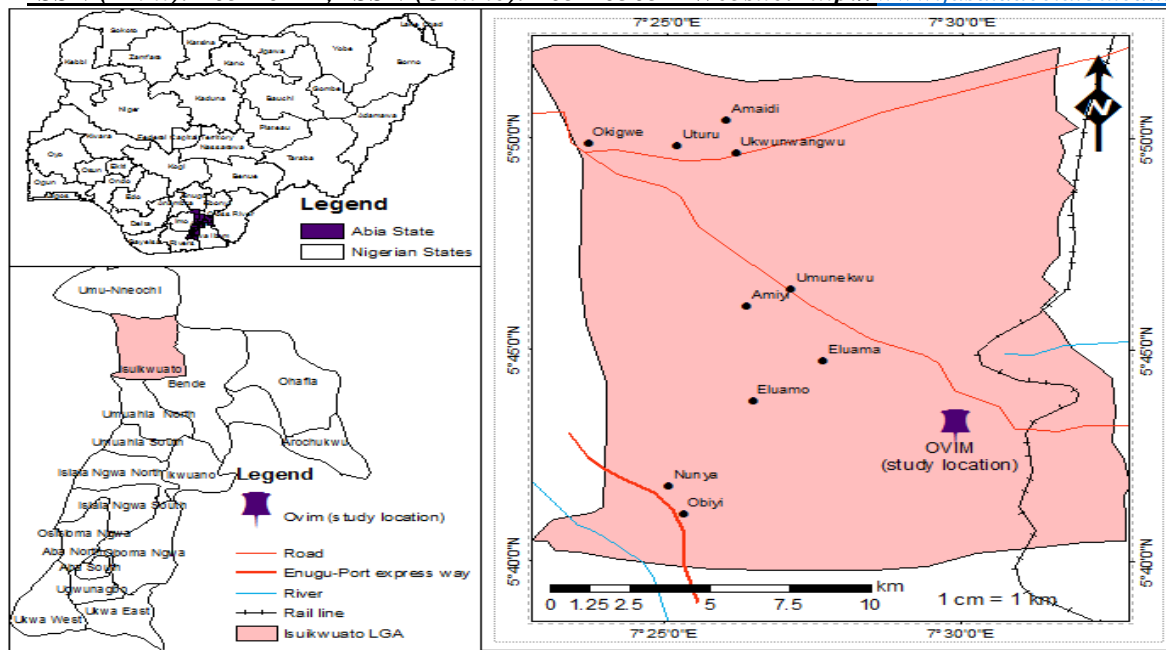


Figure 1: Location map of the study area

Field Work and soil sampling

A stratified random sampling technique based on topographic attributes of the terrain was adopted for use in the study. The toposequence was stratified into upper slope, middle slope, lower slope and valley bottom. Four profile pits were excavated, one on each at the upper, middle, lower and valley bottom slopes. A hand-held geographic positioning system (GPS) was used to determine the coordinates of the toposequence. The representative soil profiles designated as OV/A, OV/B, OV/C and OV/D for the four slopes respectively were described and horizons were designed in-situ according the guidelines of FAO (2014). Soil samples were collected from the identifiable horizons of the profile pits in each of the topographic units for physical and chemical analysis.

Laboratory studies

Particle size distribution was determined by Bouyoucous hydrometer method according to the procedure of Gee and Or (2002) where sodium hexametaphosphate (calgon) solution was used as a dispersing agent. Bulk density was determined by core sampler method according to the procedure of Grossman and Reinsch (2002).

$$\text{Bulk Density} = \frac{\text{Mass of oven dry soil}}{\text{Volume of core sampler}} \quad \dots(1)$$

It was expressed in g/cm^3 (Brady and Weil, 2002)

Total porosity was calculated from the result of bulk density and particle density.

$$\frac{Db}{Dp} \times \frac{100}{1} \quad \dots(2)$$

Where P = Porosity Db = Bulk density (gcm^{-3}) Dp = Particle density (assumed to be 2.65g/cm^3)

Soil reaction (pH) was measured in a suspension as soil/water ratio of 1:2:5 and 1:1 soil for H_2O and in KCl respectively. Standardization of pH meter was done using buffer solutions of pH 7.0 (water) and 4.0 (in KCl) and determined using glass electrode pH meter as described by Thomas (1996). Organic carbon was determined by the wet oxidation procedure (Nelson and Sommers, 1982). Total nitrogen was determined using the modified micro kjeldahl method according to the procedure of Bremner (1996). Available phosphorus was done using the molybdenum blue color Bray II method (Olsen and Sommers, 1982). In which P was extracted by

adding 40.0ML of 0.5N NaHCO₃ as extracting solution, including a method of blank and standard quality control samples. Exchangeable basic cations were determined with Ammonium Acetate (NH₄OAc) leachate of the soil (Thomas, 1996). Exchangeable calcium and magnesium was determined by the EDTA (Ethylene diamine tetra-acetic Acid) titration method where Ca and Mg indicator (EBT) complex were dissociated by titrating with standard EDTA solution. While exchangeable sodium and potassium was determined by flame photometer method. Exchangeable acidity (Al + H) was determined by titration as described by (Thomas, 1996). It was extracted with one normal potassium chloride solution. The exchangeable hydrogen was obtained by subtracting exchangeable aluminum from the exchangeable acidity. Exchangeable acidity (Al + H) - Exchangeable Al = Exchangeable H. Effective cation exchange capacity (ECEC) was derived by the summation of the total exchangeable bases (TEB) and exchangeable acidity (TEA) (Brady and Weil, 2002).

Percentage base saturation (%BS) was calculated as: $\%BS = \frac{TEB}{ECEC} \times \frac{100}{1}$... (3)

Where % BS = Percentage base saturation, TEB = Total exchangeable basic cations, ECEC = Effective Cation Exchange Capacity.

Land Suitability Evaluation

The suitability of the pedons for potato production was evaluated by limitation (non-parametric) method (Ezeaku, 2009). The pedons was placed in suitability classes by matching their characteristics with the land use requirements of the test crop (sweet potato). The suitability class of the pedons are indicated by an Arabic number attached to the letter indicator such as highly suitable (S₁), moderately suitable (S₂), marginally suitable (S₃), currently not suitable (N₁) and permanently not suitable (N₂) (Ezeaku, 2009). Table 1 below shows the land use requirement for sweet potato cultivation.

Table 1: Land Use Requirements for sweet potato

Land qualities	Land characteristics	Unit	S ₁ 100-95	S ₂ 94-85	S ₃ 84-40	N ₁ 39-20
Climate (c)						
Water Availability	Mean annual Rainfall	(mm)	1600-1100	1100-900	900-500	<500
Temperature regime	Mean annual Temp.	(°C)	21-30	>18	>12	<12
Wetness (w)						
Oxygen Availability	Soil drainage		Well drained	Moderate or Im- perfectly drained	Poorly drained	Very poorly drained
Fertility (f)						
Nutrient Availability	Total N	(gkg ⁻¹)	>0.2	0.1-0.2	<0.1	-
	Avail P	(mgkg ⁻¹)	>25	6-25.	<6	-
	Exch. K	(cmol/kg)	>6	3.-6.	<3	-
	Ph		6.1-7.3	7.4-7.8or 4.8-6.0	>8.4or <4.0	-
Nutrient retention	CEC	(cmol/kg)	>16	3-16.	<3	-
	Base saturation	(%)	>35	20.35	<20	-
Soil physical characteristics (s)						
Water retention Capacity	Soil texture		L, SC, SL	LS, SiC, SL	S, SCL	C
Rooting Condition	Soil depth	(cm)	>100	100-75	75-50	<50
Topography (t)	Slope	(%)	0-5	5-12	12-20	>20

(Modified from Sys *et al.*, 1993)

Key: S₁ = highly suitable, S₂ = moderately suitable, S₃ = marginally suitable, N₁ = currently not suitable, C = Clay, CL= clay loam, L = loam, SiC = silty clay, LS = loamy sand, SL= sandy loam, SCL = sandy clay loam, S = sand, SC = sandy clay, EC = electrical conductivity

RESULTS AND DISCUSSION

Morphological Characteristics

The morphological characteristics of the soils are presented in table 2. Under moist conditions, OVA had reddish black (5YR 4/1) surface colour over Reddish (10 R 4/6) sub surface colour (Table 2). Soil unit OVB had dark reddish brown (2.5 YR 2/4) to reddish Brown (2.5 YR 4/4) surface colours over reddish (10 R 4/8) sub surface colour. Soils colour at soil unit (OVC) had dark grey (5 YR 4/1) to weak red (10 YR 4/4) surface soils over reddish brown (2.5 YR 4/4) to reddish (10 R 4/6) sub surface soils while soil unit OV/D had very pale brown (10YR 8/4) to brown (7.5 YR 5/4). This agreed with the findings of Obi (2018) in her study of wetland soils in Abia state agricultural zone south Eastern, Nigeria. Mottles were observed both at the top of soil unit OV/D and sub soils of OV/C and OV/D. It ranged from few faint yellow (10YR 8/6) to reddish yellow (7.5 YR 5/6) which is evidence of gleization. The mottling could be attributed to cyclic oxidation reduction of iron compounds associated with fluctuation of water table that contains dissolved iron products. The soil colours observed in the study area are in conformity with the findings of Nsor *et al.* (2016) who worked on topographic soils of Ohiya Autonomous community in Abia State, Nigeria.

The drainage condition, parent material and physiographic position may have influenced the soil colour matrix of the mapping units studied, the effect of colour variation also further agrees with the findings of (Esu *et al.*, 2008). The texture of the soils of the study area indicated that soil unit OV/A had sandy loam surface and sub-surface texture, sandy loam to sandy clay loam surface and subsurface texture for soil unit OV/B. Soil unit OV/C had sandy loam surface and sandy loam to sandy clay loam sub-surface textures. Soil unit OV/D had sandy clay loam surface soils over sandy clay subsurface soils. The structure of the soils in the study area indicated that Soil unit OV/A had moderate medium granular structure occurring over moderate medium sub angular blocky structure. Soil unit's OV/B and OV/C were characterized by moderate medium granular structure occurring over moderate medium sub angular blocky structures while for soil unit OV/D, the surface soils were characterized with moderate medium sub angular blocky structures and strong medium sub angular blocky structures at the subsurface soils. Few fine pores were observed on the surface horizons and few medium and large pores were on the subsoils as water slowly drips from the pores through capillary action because of high water table. Obi (2018) made similar observation in her study of land capability and suitability studies in Okoko Item, Bende LGA, Abia state.

The consistence of soils unit OV/A indicated a loose (dry and moist), non-sticky to non-plastic (wet) surface soils over soft (dry), firm (moist), slightly sticky to non-plastic (wet) sub surface soils. Soil unit OV/B indicated a soft (dry), very friable (moist), non-sticky to non-plastic (wet) to soft (dry), friable (moist) and slightly sticky to slightly plastic (wet) surface soils over hard (dry), firm to very firm (moist), very sticky to very plastic subsurface soils. Soils of unit OV/C indicated a soft (dry), friable (moist), slightly-sticky to non-plastic (wet) surface soils over hard to very had (dry) firm to very firm (moist), slightly- sticky to plastic (wet) to sub surface soils while soil unit OV/D indicated hard and firm (dry and moist), slightly sticky to slightly plastic (wet) consistence. Nsor *et al.* (2016) also encountered similar morphological characteristics in soils on a toposequence around Ohiya Autonomous community, south Eastern Nigeria. The horizon boundary in all the pedons studied indicated clear wavy horizons over gradual wavy and clear smooth sub soil horizons.



Table 2: Morphological properties of the soil units

Horizon Designation	Horizon (cm)	Colour	Mottles	Texture	Consistence		Wet	Structure	Horizon Boundary
					Dry	Moist			
OV/A									
AP	0-18	5YR 4/1; RB	None	SL	l	fr	ns-sp	2mg	cw
AB	18-59	2.5YR 4/4; RB	None	SL	s	fr	ns-p	2mg	gw
B	59-98	10R 4/6; R	None	SL	s	vfr	ns-np	3msbk	gw
BC	98-182	10 R 4/6; R	None	SL	s	f	s-vp	2msbk	
OV/B									
Ap	0-11	2.5YR 2/4; DRB	None	SL	s	vfr	ns-np	2mg	gw
AB	11-53	2.5YR 4/4; RB	None	SL	s	fr	ss-sp	2msbk	gw
B	53-92	2.5YR 4/6; R	None	SL	sh	f	ss-sp	2msbk	gw
Bt1	92- 121	10R 4/6; R	None	SCL	h	f	ss-sp	3msbk	gw
Bt2	121- 180	10R 4/8; R	None	SCL	h	vf	s-vp	2msbk	
OV/C									
Ap	0-12	5YR 4/1; DG	None	SL	l	fr	ss-np	2mg	cw
AB	12-58	10YR 4/4; WR	None	SL	s	fr	ns-sp	2mg	gw
Bt	58-93	2.5YR 4/4; RB	None	SCL	h	f	ss-sp	3msbk	gw
BCg	93-165	10R 4/6; R	2.5YR5/6fff; Bb	SL	vh	vf	vs-p	2msbk	
OV/D									
Apg	0-15	10Y R8/4 (PB)	10 YR 8/6 fff:Y	SCL	sh	fm	ss-sp	2msbk	cw
Btg	15-36	10YR 7/3 (VPB)	10YR 6/3 fmd: PB	SC	h	fm	ss-sp	2msbk	cs
BC	36-85	7.5 YR 5/4 (B)	7.5 YR 5/6 fff; RY	SC	h	fm	ss-sp	2msbk	

key

1. Colour: RB= Reddish brown, DRB= Dark reddish brown, R= Red, DG= Dark Gray, WR=Weak Red, Bb= Brownish Black, VPB=Very Pale Brown Mottles: FFF= Few fine faint, Fmd= Few medium distinct.
2. Texture: SL= sandy loam, SCL sandy clay loam
3. Consistence: s= soft, sh= slightly hard, l= loose, h= hard, vh= very hard, vfr= very friable, fr= friable, f= firm, vh= very firm, ns-sp= non sticky-slightly plastic, ss-p= slightly sticky to plastic, ns-np= non sticky to non-plastic, ss-sp= slightly sticky to slightly plastic
4. Structure: 1= weak, 2= moderate, 3= strong, f= fine, m= medium, g= granular, sbk= sub angular blocky, msbk= medium sub angular blocky
5. Boundary: gw=gradual wavy, cw = clear wavy, cs= clear smooth.

Physical Characteristics

The physical characteristics of the study area is shown in Table 3. Sand content was observed to dominate silt and clay contents. Clay contents generally increased down the profile suggesting clay illuviation while sand content decreased down the profile. This could be due to their coastal plain sand materials as reported by Nwaoba and Lekwa (2016). The bulk density values ranged from 1.53gcm^{-3} to 1.57gcm^{-3} , 1.39gcm^{-3} to 1.53gcm^{-3} , 1.53gcm^{-3} to 1.60gcm^{-3} and 1.45gcm^{-3} for surface soils but 1.78gcm^{-1} , 1.75gcm^{-1} , 1.68gcm^{-1} and 1.67gcm^{-3} for sub-surface soils of soil units OV/A, OV/B, OV/C and OV/D respectively. The subsurface soils have values very close to the critical value for root penetration contrary to the values for the surface soils, this could be attributed to soil compaction at the root zone primarily from topographic effect (Oti and Mbe, 2020). Least bulk density values were recorded at the surface soils with corresponding high organic matter revealing the influence of organic matter on soil compaction (Nsor and Okonkwo, 2014).

Table 3: Physical Properties of the Soil Units

Pedon	Horizon	Depth (cm)	Sand ← % →	Silt ← % →	Clay ← % →	TC	Bulk Density gcm^{-3}	Total Po- rosity %
OV/A (Upper Slope)	AP	0-18	75.20	11.8	13.0	SL	1.53	42.26
	AB	18-59	73.20	12.8	14.0	SL	1.57	40.75
	B	59-98	71.20	12.8	16.0	SL	1.78	32.45
	BC	98-182	71.20	12.8	16.0	SL	1.79	32.83
	Mean		72.70	12.50	14.75		1.66	37.07
OV/B (Middle Slope)	Ap	0-11	75.20	12.80	12.0	SL	1.39	47.54
	AB	11-53	71.20	12.80	16.0	SL	1.53	42.26
	B	53-92	70.20	11.80	18.0	SL	1.71	35.47
	Bt1	92- 121	63.20	11.80	25.0	SCL	1.75	33.96
	Bt2	121- 180	65.20	11.80	23.0	SCL	1.75	33.96
	Mean		69.00	12.20	18.80		1.63	38.64
OV/C (Lower Slope)	Ap	0-12	75.20	13.80	11.0	SL	1.53	42.26
	AB	12-58	70.20	15.80	14.0	SL	1.60	39.62
	Bt	58-93	67.20	12.80	20.0	SCL	1.61	39.24
	BCg	93-165	68.20	14.80	17.0	SL	1.68	36.60
	Mean		70.20	11.53	15.50		1.61	39.43
OV/D (Valley bottom)	Ap _g	0-15	50.00	26.00	24.00	SCL	1.45	45.28
	Bt _g	15-36	46.00	16.00	40.00	SC	1.57	40.75
	BC	36-85	44.00	16.00	38.00	SC	1.67	36.98
Mean								

Key: TC= Textural Class; SL= Sandy Loam; SCL= Sandy Clay Loam; CL= Clay Loam; SC= Sandy Clay

Chemical Characteristics

The chemical characteristics of the study area are presented in Table 4. The soil pH in the study area ranged from 4.30 – 5.70 averaging 5.45 in soil unit OV/A, 5.60 in OV/B, 5.75 in OV/C and 5.10 in soil unit OV/D. These values were rated strongly to moderately acidic. The acidic nature of the soils may be due to high intensity of rainfall in the area. Enwezor *et al.*, (1990) stated that leaching of Ca and Mg is responsible for development of acidity. The values of total Nitrogen in the study area ranged from 0.02 – 0.11 gkg^{-1} , averaging 0.09 gkg^{-1} , 0.06 gkg^{-1} , 0.07 gkg^{-1} and 0.08 gkg^{-1} for soil units OV/A, OV/B, OV/C and OV/D respectively. The values were rated low to moderately low. This could be attributed to the high intensity of agricultural activities such as continuous cultivation of field and rapid turnover (mineralization) of organic substrates derived from crop residue (Nsor and Okonkwo, 2014).

The organic carbon contents are high for epipedons and low (<2.0 %) for the subsoils based on organic carbon rating of the South-eastern Nigerian soils by Enwezor *et al.* (1989). This is evidence of organic material incorporation into the soils. In all soil units, the values of organic carbon content decreased with soil depth below the critical level. The low values of organic carbon in the subsoils would encourage a rapid leaching of cations into the subsoils from the surface. Thus, the soils are low in ECEC (<12.04 cmol kg⁻¹) and low in available P and total N. According to Chikezie *et al.* (2009), the environment of eastern Nigeria is characterized by high temperature and relative humidity conditions that favour rapid decomposition and mineralization of organic matter. Therefore, organic matter content has to be substantially increased through effective crop residue management.

The available phosphorus varied from 5.75 mgkg⁻¹ to 12.88 mgkg⁻¹. The values were low to moderately low. This observation agreed with Chikezie *et al.* (2009) who observed that most Nigerian soils are moderately low in phosphorus partly due to the existence of parent rocks low in phosphorus but complicated by high phosphate fixing capacity of the soil. Considering the critical value for phosphorus, the soils may require phosphate fertilizer application for a sustainable crop yield. The exchangeable cations were very low for Na (0.17 – 0.29 cmolkg⁻¹); K was very low to moderate (0.15– 0.26 cmolkg⁻¹); Mg was low to moderate (0.80 – 2.40 cmolkg⁻¹) and Ca was low (2.60 – 4.80 cmolkg⁻¹) in all the soil units. These observations are similar to the findings of Nsor *et al.* (2016) around Ohiya community South Eastern Nigeria who attributed low exchangeable bases to high leaching arising from the coarse textured nature of the soil. The exchangeable acidity of the soil units averaged (0.97 cmolkg⁻¹) H⁺ (0.50 cmolkg⁻¹) Al³⁺ for soil unit OV/A, (0.92 cmolkg⁻¹) H⁺ and (0.49 cmolkg⁻¹) Al³⁺ for soil unit OV/B, (0.62 cmolkg⁻¹) H⁺, (0.48 cmolkg⁻¹) Al³⁺ for soil unit OV/C and (1.16 cmolkg⁻¹) H⁺ (0.47 cmolkg⁻¹) Al³⁺ for soil unit OV/D.

The ECEC in the study area ranged from 5.25 – 9.09 cmolkg⁻¹ averaging 6.26 cmolkg⁻¹ at OV/A, 6.89 cmolkg⁻¹ at OV/B, 7.65 (cmolkg⁻¹) for soil unit OV/C and 6.55 (cmolkg⁻¹) for soil unit OV/D these were rated low (Enwezor *et al.*, 1990). The low values of ECEC encountered in the study area might be due to the medium to coarse texture soils of the area this agreed with the findings of Nsor *et al.*, (2016). The low ECEC content of the soil could likely be attributed to high rate of weathering. The values of the silt/clay ratio of the soils were above 0.25 at the top soils, an indication that the soils are not old soils derived from old parent materials and are of intense degree of weathering; as old soils usually have silt/clay ratio less than 0.15, with low degree of weathering. Brady and Weil (1999) pointed out that the cation exchange capacity (ECEC) of most soils increases with pH; thus at very low pH values, the ECEC is also generally low. Base saturation by sum of cations ranged between 71.05 and 85.16 % which is rated very high (Enwezor *et al.*, 1990). The high base status showed that the soils had high native fertility, which is confirmed by the luxuriant growth of the vegetation of the soil. This agreed with findings of Igomu and Idoga, (2017); Oti and Mbe, (2020).



Table 4: Chemical Properties of the soil Units

pedon	Horizon	Depth (cm)	Table 1. Chemical Properties of the Soil Units														
			pH	Total N	OC	OM	TEA	EA cmol/kg	Avail P. mgkg ⁻¹	Exchangeable cation				ECEC	BS %		
										Ca	Mg Na	K					
										cmolkg ⁻¹							
H ₂ O	KCL	← % →				H ⁺	Al ³⁺	← cmolkg ⁻¹ →									
OV/A (Upper Slope)	AP	0-24	5.50	4.60	0.11	1.11	1.91	1.48	0.99	0.49	14.80	3.20	1.80	0.25	0.27	7.00	78.86
	AB	24-53	5.70	4.60	0.10	1.08	1.86	1.38	0.90	0.48	15.30	3.80	1.80	0.26	0.28	7.51	81.62
	B	53-85	5.20	4.30	0.06	0.67	1.15	1.52	1.00	0.52	10.30	2.60	0.80	0.18	0.18	5.28	71.21
	BC	85-150	5.40	4.20	0.06	0.62	1.07	1.52	1.00	0.52	9.80	2.60	0.80	0.16	0.17	5.25	71.05
	MEAN		5.45	4.43	0.09	0.87	1.23	1.48	0.97	0.50	12.55	3.05	0.40	0.21	0.23	6.26	75.69
OV/B (Middle Slope)	Ap	0-11	6.00	5.40	0.12	1.38	2.38	1.28	0.84	0.44	15.80	4.80	2.20	0.28	0.29	8.86	85.55
	AB	11-53	5.80	5.20	0.08	0.88	1.52	1.36	0.90	0.46	15.40	3.80	2.00	0.27	0.28	7.71	82.36
	B	53-92	5.50	4.60	0.05	0.55	0.95	1.44	0.94	0.50	12.60	3.00	1.80	0.20	0.21	6.65	78.34
	Bt1	92- 121	5.30	4.40	0.02	0.23	0.40	1.48	0.96	0.52	10.50	2.80	1.20	0.15	0.18	5.81	74.53
	Bt2	121- 180	5.40	4.10	0.02	0.21	0.36	1.48	0.96	0.52	10.10	2.60	1.00	0.15	0.17	5.40	72.59
MEAN		5.60	5.93	0.06	0.65	1.12	1.41	0.92	0.49	12.88	3.40	1.64	0.21	0.23	6.89	78.67	
OV/C (Lower Slope)	Ap	0-12	5.70	5.20	0.12	1.30	2.24	1.42	0.94	0.48	15.20	4.40	2.10	0.28	0.28	8.48	83.25
	AB	12-58	5.90	5.50	0.11	1.11	1.91	1.32	0.86	0.46	16.30	4.60	2.40	0.29	0.29	8.90	85.16
	Bt	58-93	5.80	5.20	0.05	0.28	0.48	1.36	1.92	0.46	13.60	3.00	1.80	0.21	0.22	6.58	79.33
	BCg	93-165	5.60	4.70	0.03	0.25	0.43	1.52	1.14	0.52	12.40	3.00	1.80	0.17	0.18	6.67	77.21
	MEAN		5.75	5.13	0.07	0.73	1.27	1.41	0.62	0.48	5.75	3.75	2.03	0.95	0.24	7.65	81.24
OVD (Valley Bottom)	Apg	0-15	5.80	5.30	0.05	1.84	3.17	1.42	1.38	0.40	16.40	5.20	2.00	0.24	0.22	9.09	84.37
	Btg	15-36	5.20	4.10	0.04	0.57	0.98	1.52	1.04	0.48	11.60	3.10	1.40	0.11	0.10	6.24	75.64
	BC	36-85	4.30	3.90	0.04	0.57	0.98	1.60	1.06	0.54	9.20	2.00	0.60	0.06	0.06	4.33	63.04
	Mean		5.10	4.40	0.08	0.99	1.71	1.51	1.16	0.47	12.40	3.43	1.33	0.14	0.13	6.55	74.35

Key: O.C= Organic carbon, O.M= Organic matter, N= Nitrogen, TEA= Total Exchangeable Acidity, EA= Exchangeable Acidity, P= Phosphorus, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Suitability Evaluation of Soils in the Study Area

The suitability evaluation of soils in the study area was obtained by matching the land characteristics of the area studied (Table 5) with the agronomic requirement of sweet potato (Table 1) to obtain suitability class scores of sweet potatoes in the study area (Table 6). Aggregate suitability scores and suitability classification indicating limiting characteristics is presented in (Table 7). This was achieved by using the guidelines suggested by FAO (1976) and Sys *et al.* (1993).

Table 5: Land Characteristics/Quality of the Study Area

Soil Units land characteristics	OV/A	OV/B	OV/C	OV/D
Rainfall (mm)	1900 – 2200	1900 – 2200	1900 – 2200	1900 – 2200
Temperature ($^{\circ}\text{C}$)	27 – 28	27 – 28	27 – 28	27 – 28
Organic Carbon	1.23	1.12	1.27	0.99
Total N	0.09	0.06	0.07	0.08
Avail. P	12.55	12.58	14.38	12.40
Exch. Ca^{2+} (cmol/kg)	3.05	3.40	3.75	3.43
Exch. Mg^{2+} (cmol/kg)	0.40	1.64	2.03	1.33
Exch. K^{2+} (cmol/kg)	0.21	0.21	0.95	0.14
Exch. Na^{2+} (cmol/kg)	0.23	0.23	0.24	
TEA				
H^{+}	0.97	0.92	0.62	1.16
Al^{3+}	0.50	0.49	0.48	0.47
B.S	75.69	78.67	81.24	0.13
CEC	6.26	6.89	7.65	6.55
Texture (Surface)	LS	LS	LS/SCL	SCL/SC
Soil Drainage	Well	Well	Moderate	poor
Bulk density	1.66	1.63	1.61	1.56
slope (%)	0 – 2	2 – 4	0 – 2	0-2
Soil depth	180	182	165	85

Table 6: Suitability Class Scores of Soil Units for Sweet Potato Cultivation

Soil Units	OV/A	OV/B	OV/C	OV/D
Land characteristics				
Climate				
Rainfall (mm)	S1	S1	S1	S1
Topography				
Slope gradient	S1	S1	S1	S1
Wetness (w)				
Soil drainage	S1	S1	S2	N1
Fertility (f)				
Organic carbon	S3	S3	S3	S3
Total Nitrogen (gkg^{-1})	N1	N1	N1	N1
Available phosphorus (gkg^{-1})	S2	S2	S2	S2
Base saturation (%)	S1	S1	S1	S1
Exch. K (cmolkg^{-1})	N1	N1	N1	N1
Soil physical characteristics				
Soil texture	S1	S1	S3	S2
Soil depth	S1	S1	S1	S2
Aggregate suitability	N1 – f	N1 – f	N1 – f	N1-wf

Key S1 = Highly suitable; S2 = Moderate suitable; S3 = Marginally suitable; N1 = Currently unsuitable; N1 = Potentially unsuitable

CONCLUSION AND RECOMMENDATIONS

The study site was characterized by poorly, imperfectly and well drained moisture conditions. The soils were strongly to moderately acidic in reaction with moderately low and low values of available P, total N and exchangeable potassium. The suitability assessment by simple limitation confirmed that climate, topography and base saturation are optimum for the cultivation of sweet potato. All the soil units were currently unsuitable (N1) as the optimal performance was constrained by fertility (f) thus (N1-F). Soil unit OV/D is also limited by poorly drained condition (w) thus, (N1-fw) for the cultivation of sweet potato in the area. It was recommended that adequate and proper drainage of soil unit OV/D is necessary through construction of drainage channels to control the inflow and outflow of water into the field. Otherwise, the unit could be devoted to cultivation of lowland rice. Consequent upon the



fragility of the soils, heavy equipment such as bulldozer should not be used to carry out any farm operation like stumping rather, manual stumping should be encouraged. The strongly acid nature of the soils will require proper liming for adequate availability of nutrients to crops.

REFERENCES

- Abia State Geographic Information system (GIS) (2020). Abia state geographical Report. Secretariat complex Umuahia, Abia State, Nigeria.
- AbdelRahman, M. A. E., Natarajan, A. and Hegde, R. (2016). Assessment of land suitability and capability by integrating remote sensing and GIS techniques in Chamarajanagar District, Karnataka, India. *Egyptian J. Rem. Sens. Space Science*, 19, 125-141
- Addeo, G., Guastadisegni, G. and Pisante, M. (2001). Land and water quality for sustainable and precision farming. 1st World Congress Conservation Of Agriculture, Madrid, Spain, pp. 1-4.
- Adesemuyi, E. A., Nwaoba, O. W. and Bassey, E. O. (2019). Influence of Topography on Soil Formation and Classification of Coastal Plain Sands in Humid South-eastern Nigeria. *Nigerian Journal Soil & Environmental Resources*, 1(8):1 – 10.
- Brady, N. C. and Weil R. R. (2002). The nature and properties of soils. Prentice-Hall, New Jersey.
- Bremner, J. M (1996). Total Nitrogen. In: Sparks, D.L. (Ed.). *Methods of Soil Analysis. Part 3. Chemical methods. Book Series 5. American Society of Agronomy and Soil Science Society of America*, Madison, Wisconsin, pp. 1085-1121.
- Ezeaku, P.I. (2009). Methodologies for Agricultural Land-Use Planning – Sustainable Soil Management and Productivity. Great AP Express Publishers Ltd, Nsukka, Nigeria. Pp69.
- FAO (2019). Nigeria at a glance. Retrieved from: <http://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en>.
- Manjare, B. S., Reddy, G. P. O., Meshram, U. P. (2022). Morphotectonic imprints on the evolution of the fluvial landscape in central India inferred from remotely sensed data and GIS Environmental Earth Sciences. 2022;81: Article 378. Available: <https://doi.org/10.1007/s1266502210500>.
- Mustafa A.A., Man S., Sahoo R.N., et al. (2011). Land suitability analysis for different crops. A multi criteria decision making approach using remote sensing and GIS. Indian Agricultural Research Institute, New Delhi-110 012
- Nwaoba, O. W. and Lekwa, G. (2016). Characterization and Classification of soils of Ndegwu, Owerri west L.G.A, Imo State, Nigeria. *Proceedings of SSN. Calabar, Nigeria*. 4(40):284-295.
- Olsen, S. R. and Sommers, L.E. (1982). Phosphorous, pp. 403-430. In: Page, A.L. et al. (eds). *Methods of soil analysis, Part 2. Agronomy Monograph*, no. 9, 2nd Ed. ASA and SSSA, Madison, WI.
- Osinuga, O. A., Aiboni, V. U. and Oyegoke, C. O. (2020). Classification and Suitability Evaluation of Soils for Rice Production in Southwest, Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension*, 19(4):43 – 50.
- Reddy G.P.O. (2018). Remote sensing and GIS for geomorphological mapping, In: Reddy G.P.O. and Singh S.K. (eds) *Geospatial Technologies in Land Resources Mapping, Monitoring and Management. Geotechnologies and the Environment*, Springer, Cham. 2(1):223-252, DOI: 10.1007/978-3-319-78711-4_12.
- Sathish, A. and Niranjana, K.V. (2010). Land suitability studies for major crops in Pavagadataluk, Karnataka using remote sensing and GIS techniques. *Journal of Indian Soc. Rem. Sens.*, 38(1):143-151
- Storie, R. E. (1978). Storie index soil rating (revised). Special Publication Division of Agricultural Science: University of California, Berkeley, California.
- Surwase, S. A., Singh, S. K., Reddy, G. P. O., Kadu, P. R., Mohekar, D. S., Naitam, K. R., Konde, N. M., Aage, A. B. and Desmukh, P. S. (2023). Characterization and classification of soils in a toposequence of the semi-arid Basaltic landscape of Western India. *International Journal of Plant & Soil Science*, 35(19):876-887. Article no. IJPSS.103882 ISSN: 2320-7035.
- Sys, C. Van Ranst E and Devaveye J. (1993). Land Evaluation and Crop Production and Calculations, Agric Publication, No 7. General Admin for Development Corporation, Brussels: 247.