

SURVEY, CHARACTERIZATION AND LAND SUITABILITY APPRAISAL FOR FRUITED VEGETABLES AT IKOT AKPA NDU, SOUTHERN NIGERIA

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ABSTRACT

A study on the survey and land suitability appraisal for fruited vegetable production at Ikot Akpa Ndu, Southern Nigeria, of about 36.6 ha was conducted. The aim was to characterize and appraise the soils suitability for cucumber, pepper and eggplant. A free soil survey methodology delineated study area into two (2) soil mapping units. The result indicated a dominance of sand fraction (65-88%), decreasing towards the sub soils. Clay fraction was next (4-30%), generally increasing down the profile. The soil pH ranged from moderately acid (pH 5.2 – 5.9) in mapping unit 1, to strongly acid (pH 4.1 – 4.6) in mapping units 2. Aggregate suitability rating, rated the soils of mapping unit 1, represented by pedons A, B, C and F as marginally suitable (S_{3f}) by both parametric and non parametric methods due to fertility limitation. Soils of mapping unit 2 represented by pedons D and E were rated as currently unsuitable (N_{1f}) for fruited vegetable cultivation on grounds of severe fertility constraints. Site specific fertilizer protocol with the use of NPK integrated with farm yard manure and leguminous cover cropping will improve the fertility of these soils and enhance their suitability for fruited vegetables in the study area.

Key words: Survey, Characterization, Suitability Appraisal, fruited vegetables.

INTRODUCTION

Suitability appraisal of parcels of land for specific agricultural utilization is a major step towards achieving agricultural development in Nigeria. Aderonke and Gbadegesin (2013) posited that poor knowledge of soil resources result in land misuse, low productivity and land degradation. In order to avoid wrong use of land, poor farm management practices and unnecessary high cost of production, there is need to appraise its suitability before commencement of any agricultural investment.

Land suitability appraisal is the process of evaluating land, which identifies the major limiting factors for a particular use. It is also described as a process of interpreting soil survey data, such that every parcel or kind of land is utilized based on its potentials (FAO, 2007). Senjobi (2007) noted that land appraisal is very vital, especially now that precision farming is gaining wider acceptance and its relevance is

particularly more in the developing world where the use to which a land is put is very often not related to its capacity. Lin *et al* (2005) posited that land appraisal reports provides practical approaches towards enhancing land quality, efficient utilization and effective amelioration of land's limitation. It is pertinent to carry out land suitability appraisal before its utilization for any agricultural venture to avert loss and environmental degradation (Nsor and Akpan, 2021).

Currently in southern Nigeria, the amount of land suitable for agricultural production is limited. This is due partly but not limited to increased population density, urbanization, infrastructural development, loss of soil fertility and land degradation. There are instances of poor land utilization due to lack of proper knowledge of land appraisal. The need to change from extensive to intensive agriculture and increase agricultural production of selected fruited vegetable in precision agriculture

necessitated the present study on survey, characterization and suitability appraisal of selected soils of Ikot Akpa Ndua covering about 36.6 ha for fruited vegetables. The objectives of the study are to survey, characterize, classify and appraise its suitability for fruited vegetables.

MATERIALS AND METHOD

Study Area

This study was conducted on soils of Ikot Akpa Ndua in Akwa Ibom State, Southern Nigeria. Ikot Akpa Ndua is located at Latitudes 4°53'20" and 4°53'40"N and Longitudes 7°56'00" and 7°56'30"E. The study area is a humid tropical climate divided into wet and dry seasons.

The rainfall is in the range of 2000 – 3000mm. Annual air temperature ranges from 26°C to 28°C. The relative humidity is about 75 – 79% Petters *et al.* (1994). The study area is under

lain by one main geological formation, the coasted plain sands comprising largely of poorly consolidated sands (Udosen, 2012).

Field work / sampling

Using a hand held Global positioning system (GPS), the Easting (Latitudes), Northing (Longitudes) and elevation, on the base map was cross-checked in the field. Random soil augering was carried out at representative areas to establish the predicted soil mapping units and their boundaries. A total of six (6) profile pits were later sunk, four (4) in mapping unit 1 and two (2) in mapping unit 2. Each profile pit was described in accordance with FAO (2006) guidelines. Soil samples were collected from different genetic horizons for routine analysis undisturbed soil samples were also collected at the top soil (0-25cm) and sub soil (50 – 75cm) using core ring samplers for bulk density determination.

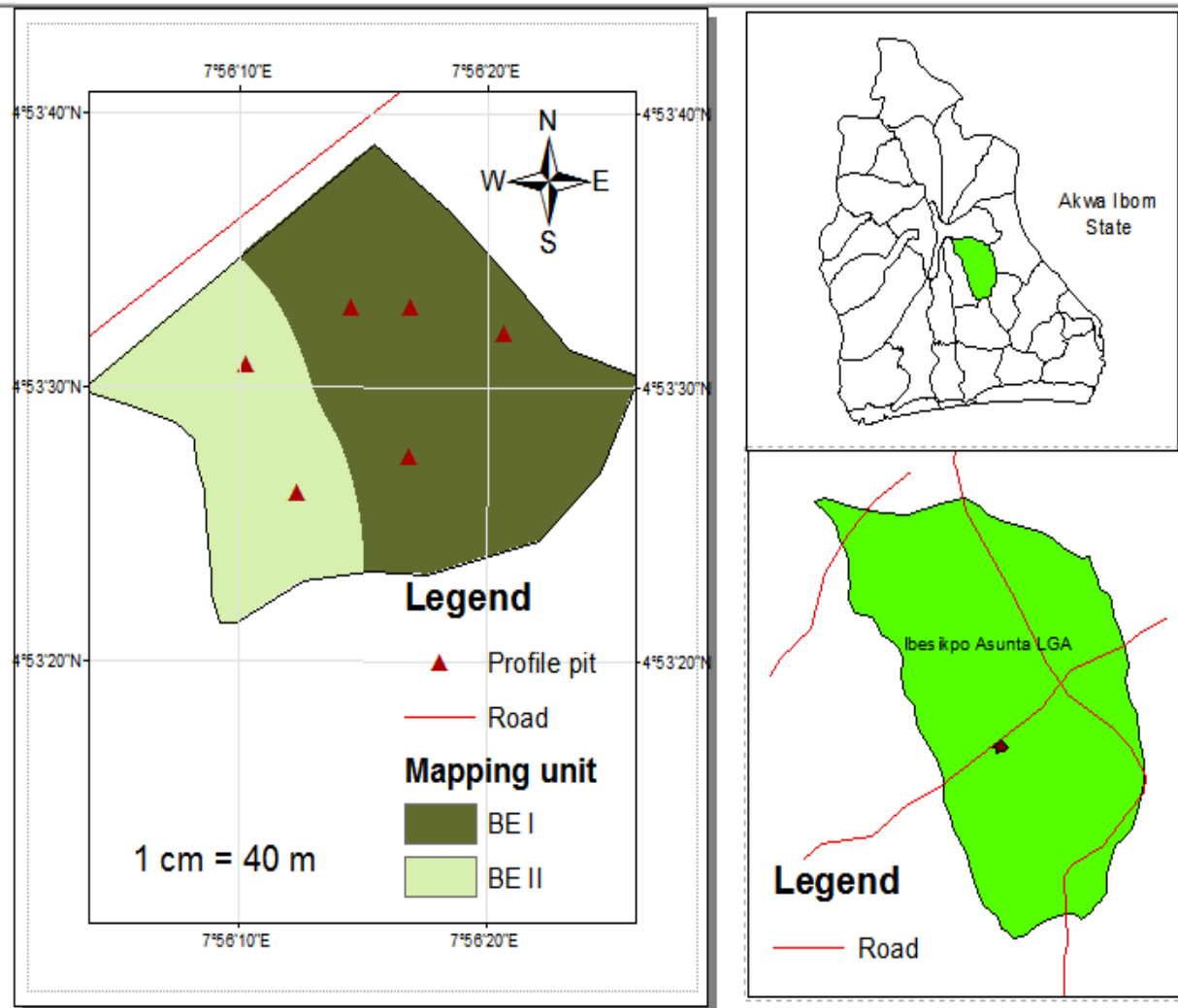


Fig. 1: Map of the study site showing mapping units and profile pit locations

Sample Preparation and Analysis

Soil samples for routine analysis were air dried, crushed gently with a wooden roller and sieved through a 2mm diameter mesh sized sieves and laboratory analysis. Particle size distribution was done by the hydrometer method as outlined in Gee and Or (2002). Bulk density was measured by the cylindrical core method (Anderson and Ingram 1996). Porosity was evaluated using the relationship.

$$\text{Porosity} = (1 - \text{Bd}/\text{Pd}) 100 \% \quad \dots \text{Equation 1.}$$

Where

Bd=bulk density, Pd = particle density (2.65 g/cm⁻³).

Soil erodibility index was determined using the relationship.

Soil Erodibility index = %sand + % silt/% clay...Equation 2

Soil pH in H₂O was determined by using a pH meter in 1:2.5, soil : water ratio respectively, according to the method of Thomas (1996). Available phosphorus was determined by Bray and Kurtz as modified by Oslen and Sommers (1982). Organic carbon was determined by using Walkley and Black (1934) wet oxidation method as outlined by Nelson and Sommer (1996). Total nitrogen was determined by the Kjeldahl method as modified by Bremner (1996). Exchangeable bases were extracted with neutral NH₄OAc solution; exchangeable Ca and Mg were determined by the use of an Atomic Absorption Spectrometer (AAS) while exchangeable K and Na were determined by flame photometry (Grant,1982).Cation exchange capacity (CEC) was measured using ammonium acetate leaching at pH 7.0 (Rhodes,1982). Base saturation percentage was calculated as follows

$$\text{BS} (\%) = \frac{\text{Total Exchangeable Bases}}{\text{Cation Exchange Capacity}} \times 100 \quad \dots \text{Equation 3}$$

Available Micro nutrients (Fe,Zn,Mn and Cu) were extracted with 1N HCl and determined by atomic Absorption Spectrophotometry (AAS) using Association of Analytical chemist (AOAC) 1990 methodology.

RESULT AND DISCUSSION

The results and discussions of the data obtained in the field as well as the suitability of the soil units encountered in the field for selected fruited vegetables is presented below. The data is presented in Tables and maps. The study area consisting of about 36.6 ha of land was delineated into two (2) mapping units based on surface soil texture and chemical characteristics.

Morphological Characteristics

Table 1 presents the morphological characteristics of the representative pedons. The soils of mapping unit 1 are represented by pedons A, B, C, and F, occur on nearly flat to undulating surfaces of 3-6 % gradients with an almost uniform distribution of coarse sand and medium sand with silt having the least proportion of the soil separates. The typical morphological properties of the soil profile representing this soil unit consist of a well drained very dark brown (7.5 YR 3/1) to brown (7.5YR 4/2) loamy sand epipedon over strong brown (7.5YR 5/8) sandy loam endopedon (Table 1). The consistence revealed a soft to slightly hard top soil over hard sub soil (dry), very friable to friable top soil over firm sub soils (moist), and non sticky – non plastic top soils over slightly sticky – slightly plastic sub soil (wet). The soil of this unit are deep (>150cm) and relatively gravel free. This observations corroborates Obi *et al.*, 2014 in their characterization and classification of similar soils of coastal plain sand parent materials within Uyo, Nigeria. The soils of mapping unit 1 predominantly had weak fine to medium sub angular blocky surface soil structures over moderate medium sub angular blocky sub soils (Table 1).

Table 1: Morphological Characteristics of Selected Soils at Ikot Akpa Ndua , Ibesikpo Asutan AKS, Southern Nigeria

Pedon	Horizon Designation	Horizon Depth (cm)	Soil colour (Moist)	Structure	Texture	Consistence Dry	Consistence Moist	Wet	Pores	Roots	Boundary
A	Ap	0-18	7.5YR3/1,vdb	1F sbk	LS	s	vfr	ns-np	cc	cm	cw
	AB	18-40	7.5YR4/2,B	1M sbk	LS	sh	fr	ss-sp	cm	fm	ds
	Bt ₁	40-72	7.5YR4/4,B	2M sbk	SL	h	fr	ss-sp	ff	ff	ds
	Bt ₂	72-131	7.5YR5/8,sb	2M sbk	SL	h	F	sp	mm	ff	
B	Ap	0-14	7.5YR3/1,vdb	1F sbk	LS	s	l	ns-np	cc	cm	cw
	AB	14-27	7.5YR3/4,Db	1M sbk	SL	s	vfr	ns-np	cc	fvf	ds
	Bt ₁	27-68	7.5YR4/4,B	2M sbk	SL	sh	fr	ss-sp	mm	fvf	ds
	Bt ₂	68-148	7.5YR4/6,sb	2M sbk	SL	h	fr	s-p	cm	ff	
C	Ap	0-13	7.5YR3/2,Db	1F sbk	LS	s	l	ns-np	cc	cm	cw
	AB	13-48	7.5YR4/4,B	1M sbk	LS	s	fr	ns-sp	cc	mm	gw
	Bt ₁	48-70	7.5YR5/6,sb	2M sbk	LS	sh	fr	ss-sp	cm	fm	dw
	Bt ₂	70-139	7.5YR5/8,sb	2M sbk	LS	sh	F	s-p	cm	fm	
D	Ap	0-14	7.5YR3/2,Db	1F gr	SL	s	l	ns-np	cc	cm	gw
	Bt ₁	14-26	7.5YR3/4,Db	1M sbk	SL	s	l	ss-np	cm	cm	gw
	Bt ₂	26-60	7.5YR4/4,B	2M sbk	LS	sh	fr	ss-sp	cm	fvf	dw
	Bt ₃	60-148	7.5YR4/6,sb	2M sbk	LS	h	F	ss-sp	cm	fvf	
E	Ap	0-15	7.5YR3/2,Db	1F gr	S	s	l	ns-np	cm	fc	cw
	AB	15-39	7.5YR3/2Db	1M sbk	S	sh	l	nn-np	mm	fm	gw
	Bt ₁	39-71	7.5YR4/3,B	2M sbk	LS	sh	Fr	ss-sp	cf	cf	gw
	Bt ₂	71-136	7.5YR4/4,B	2M sbk	LS	h	F	ss-sp	fvf	ff	
F	Ap	0-10	7.5YR3/1,vdb	1F sbk	SL	s	vfr	ns-np	cm	cm	cw
	AB	10-33	7.5YR4/2,B	1M sbk	SL	s	vfr	ss-sp	cm	cm	gw
	Bt ₁	33-61	7.5YR4/4,B	2M sbk	SL	sh	Fr	ss-p	mm	fm	gw
	Bt ₂	61-129	7.5YR4/6,sb	2M sbk	LS	sh	F	s-p	cf	fm	

Key:

1. Colour: vdb = very dark brown , B = Brown, sb = strong brown, Db = Dark brown
2. Structure: 1 = weak, 2 = moderate, F=fine , M = medium, sbk = sub angular block, gr = granular.
3. Texture: LS = loamy sand, SL = sandy loam, S = Sand.
4. Consistence: s = soft, sh = slight hard, h = hard, vfr = very friable, fr = friable, l = loose, f = firm, ns – np = non stickv- non nlastic. ss-sn = slightrv. stickv – slightrv nlastic. s-n = stickv-nlastic. ss-n = slightrv stickv – nlastic.
5. Pores/Roots: cc = common coarse, cm = common medium, ff = few fine, mm = many medium, cf = common fine, fvf = few very fine, fc = few coatse.
6. Boundary: cw = clear wavy, ds = difuse smooth, gw = gradual wavy

Horizon boundary characteristics were clear wavy from the Ap up to the transition AB horizon, but diffuse smooth within the Bt illuvial horizons. Clay cutans were quite conspicuous and obvious on faces of peds and along pore surfaces, an indication of active clay migration (eluviation-illuviation) process in the soil. Earth worm casts and common ant holes were active on the soil surfaces and within the solum, indicating active faunal pedoturbation in this soil unit.

The soils of mapping unit 2 represented by pedons D and E also occur in nearly flat to undulating landscapes of 3-6% gradient with an almost uniform distribution of coarse sand fragments in its surface soils and high sub soil clay (15-27 %). The typical morphological properties of a profile representing this unit consist of a well drained Dark brown (7.5YR 4/2) sandy epipedon over brown (7.5YR 4/3) to strong brown (7.5YR 4/6) loamy sand endopedon. The consistence of the soils of this unit indicate a soft

top soil over a slightly hard to hard sub soil (dry), loose top soil over friable to firm sub soil (moist), and a non sticky- non plastic top soil over slightly sticky- slightly plastic sub soil (we).

Structurally, this soil unit has weak fine granular epipedons over moderate medium sub angular blocky structural endopedons (Table 1). Horizon boundary characteristics were clear wavy from the Ap, but gradual wavy in the Bt horizons. Surface peds and pores were also coated with clay skins, indicating clay eluviations-illuviations.

Physical Characteristics

The physical characteristics of soils in the study area are shown in Table 2. The textural composition of the study location indicates a dominance of sand fraction (65-88 %), decreasing towards the sub soils. Clay fraction was next in dominance (4-30 %) generally increasing down the profile (Table 2).

Table 2 : Selected Physical Characteristic of Soils of the Study Area

Pedon	Horizon Designation	Horizon Depth (cm)	Sand %	Silt %	Clay %	TC	BD g/cm ³	Porosity %	Silt: Clay Ratio	Soil Erodibility Index
A	Ap	0-18	79	10	11	LS	1.14	57.0	0.91	8.1
	AB	18-40	70	20	10	LS			2.0	9.0
	Bt ₁	40-72	61	20	10	SL	1.84	30.5	1.1	4.3
	Bt ₂	72-131	60	14	26	SL			0.5	2.8
B	Ap	0-14	80	07	13	LS	1.18	55.5	0.5	6.7
	AB	14-27	74	02	24	SL			0.1	3.4
	Bt ₁	27-68	66	03	31	SL	1.43	46.0	0.1	2.2
	Bt ₂	68-148	62	05	30	SL			0.3	2.3
C	Ap	0-13	84	06	10	LS	1.10	58.5	0.6	9.0
	AB	13-48	81	04	15	LS			0.3	5.7
	Bt ₁	48-70	72	06	22	LS	1.69	36.2	0.3	3.5
	Bt ₂	70-139	70	07	23	LS			0.3	3.3
D	Ap	0-14	88	08	04	SL	1.13	57.4	0.6	6.1
	Bt ₁	14-26	87	07	06	SL			0.4	5.3
	Bt ₂	26-60	69	10	21	LS	1.41	46.8	0.5	3.8
	Bt ₃	60-148	65	08	27	LS			0.3	2.7
E	Ap	0-15	86	10	04	SL	1.19	55.1	0.4	6.1
	AB	15-39	87	03	07	LS			0.2	4.0
	Bt ₁	39-71	76	02	22	LS	1.74	34.4	0.1	3.5
	Bt ₂	71-136	73	04	23	LS			0.2	3.3
F	Ap	0-10	80	03	17	SL	1.16	56.2	0.4	13.3
	AB	10-33	80	05	15	SL			0.5	8.1
	Bt ₁	33-61	76	05	19	SL	1.88	29.1	0.3	4.3
	Bt ₂	61-129	70	04	26	LS			0.2	2.8

Silt fraction was least (2-20 %) and fluctuated within the profile in all the pedons studied. All the pedons were coarse textured in their top soils, however with medium textured sub soils. Coarse textured soils are prone to erosion and leaching of nutrients (Olaniyan, 2013).

Bulk density values (1.10-1.88 gcm⁻³) showed that the soils were non- compacted and possessed no serious agricultural limitation. These bulk density values are within the range 1.0-1.9 g/cm reported by Wild (1993) as ideal for agronomic activities in most mineral soils. Bulk density values in all the pedons evaluated increased downward from top soil. This increase with soil depth might be due to decreasing organic matter content, less aggregation and compaction caused by overlying weights of soil layers. Increasing bulk density value was also reported by Ayolagha and Opene (2012) in some selected soils of Ndoni in the meander belt of the Niger Delta. Total porosity was observed to decrease down the profile. Top soil porosities of 55.1-58.5 % and sub soils (29.1-46.8 %) indicate that, the soils in the study area are well aerated within the soil solum. The total porosity values were inversely proportional to the soil's bulk density (Table 2)

The Silt: clay ratio of the soil in the study area were generally low (0.1-2.0). Low silt: clay ratio is an indication that the soil are at an advanced stage of weathering. In terms of degradation potential and vulnerability, Lal (1994) and Ikemefuna, (2010) indicated that

when the silt: clay ratio is 5 (none), 3 (moderate), 2 (high) and 1 (very high). Consequently, since all the pedons in the study area, had silt: clay ratio less than 2, the soils studied are therefore high to very high in degradation potential and vulnerability. Soil erodibility index values were also high especially in top soils (5.7-13.3). These high values indicate that these soils are highly vulnerable to erosion.

Chemical Characteristics

Chemical characteristics of selected soil of Ikot Akpa Ndua for two mapping units is presented in Table 3. The soil of mapping unit 1 represented by pedons A, B, C and F indicated a moderately acid (pH 5.2- 5.9) soil reaction which sharply contrasted the strongly acid (pH 4.1- 4.6) condition of mapping unit 2 represented by pedons D and E (Table 4.3) The pH in all the pedons was observed to be increasing down the profile from topsoil. This might be due to high colloidal clay in sub soils as a result of eluviation-illuviation processes. Ajiboye and Ogunwale (2010) found the same trend in soils developed over talc in Kogi State. However Nwaka and Bababe (2007) observed the opposite trend in some Regosols derived from Aeolian deposits in Maiduguri, Sudan Savanna. The soils exchangeable acidity (H⁺ and Al³⁺) in all the pedons in the study area were generally very high (>1.10cmol kg⁻¹) suggestive of a very high acidifying capacity.

Pedon	Horizon Design.	Horizon Depth (cm)	pH (H ₂ O)	Org. C	OM g/kg	TN	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	CEC	AL ³⁺	H ⁺	Av.P	BS	Fe	Zn	Mn	Cu
				←		→	←			cmol/k g		→		mg/kg	%	←	mg/kg	→	
A	Ap	0-18	5.5	4.0	6.90	1.20	0.20	0.21	2.4	0.41	10.7	0.15	1.2	13.5	30.1	20.1	0.7	2.1	0.09
	AB	18-40	5.4	2.1	3.62	1.10	0.10	0.17	2.10	0.31	9.5	0.21	1.33	12.4	28.2	22.2	1.3	3.2	0.10
	Bt ₁	40-72	5.6	2.8	4.83	1.00	0.10	0.19	2.20	0.45	11.2	0.10	.10	12.2	26.3	20.5	2.2	2.2	0.20
	Bt ₂	72-131	5.8	2.0	3.45	0.60	0.06	0.24	2.40	0.46	12.4	0.40	0.85	11.5	25.5	21.4	2.8	3.3	0.21
B	Ap	0-14	5.4	3.0	5.17	1.40	0.10	0.24	2.60	0.30	12.8	0.20	1.25	12.0	25.3	18.4	0.9	1.8	0.15
	AB	14-27	5.6	2.5	4.31	1.10	0.10	0.18	2.20	0.20	10.5	0.25	1.20	12.6	25.5	16.5	1.0	3.1	0.18
	Bt ₁	27-68	5.5	2.1	3.62	1.10	0.05	0.15	2.00	0.40	9.5	0.10	1.00	11.6	27.4	25.2	1.5	2.2	0.19
	Bt ₂	68-148	5.7	2.3	3.97	0.80	0.05	0.30	2.70	0.50	13.2	0.15	0.70	9.4	26.9	23.0	1.2	2.4	0.16
C	Ap	0-13	5.3	1.4	2.41	1.00	0.06	0.40	1.20	0.70	8.1	0.30	0.90	8.8	29.1	19.4	1.4	0.8	0.31
	AB	13-48	5.6	1.4	2.41	0.60	0.04	0.40	1.60	1.00	9.1	0.10	1.10	8.3	33.4	16.3	2.0	1.1	0.30
	Bt ₁	48-70	5.5	1.3	2.24	0.20	0.10	0.30	2.40	1.10	12.2	0.40	0.80	8.1	32.0	20.1	2.2	1.3	0.25
	Bt ₂	70-139	5.9	1.1	1.90	0.10	0.11	0.50	2.60	1.60	14.6	1.00	1.20	6.3	32.9	22.5	1.8	1.2	0.58
D	Ap	0-14	4.5	1.3	2.24	0.04	0.04	0.08	1.60	0.06	8.2	0.20	1.45	6.0	22.2	20.2	5.1	22.2	1.01
	Bt ₁	14-26	4.4	1.1	1.90	0.03	0.05	0.08	1.82	0.06	8.6	0.45	1.45	5.0	23.4	31.7	5.9	20.4	1.21
	Bt ₂	26-60	4.6	1.0	1.72	0.02	0.06	0.09	1.86	0.10	8.7	0.60	1.50	5.0	23.7	30.9	3.2	28.1	1.30
	Bt ₃	60-148	4.6	0.6	1.03	0.02	0.06	0.10	1.90	0.20	9.0	0.80	1.60	4.0	25.1	34.1	5.1	23.4	1.40
E	Ap	0-15	4.2	1.1	1.90	0.05	0.10	0.06	1.40	0.04	7.5	0.35	1.10	6.2	21.3	21.3	6.2	22.4	1.10
	AB	15-39	4.1	1.0	1.72	0.03	0.06	0.08	1.60	0.08	8.2	0.50	1.30	6.1	22.2	24.6	6.1	20.5	1.15
	Bt ₁	39-71	4.4	1.1	1.90	0.03	0.06	0.08	1.60	0.10	8.3	0.60	1.40	6.5	22.2	26.1	5.9	21.0	1.12
	Bt ₂	71-136	4.5	0.3	0.52	0.02	0.05	0.09	1.80	0.16	9.1	0.70	1.40	7.0	23.1	24.8	6.4	28.0	1.14
F	Ap	0-10	5.2	4.7	8.10	1.50	0.06	0.25	2.30	0.24	10.1	0.20	1.10	10.0	28.5	10.2	0.4	0.6	0.16
	AB	10-33	5.4	4.6	7.93	1.40	0.05	0.30	2.40	0.30	11.0	0.10	1.00	12.1	27.7	10.1	0.6	0.8	0.18
	Bt ₁	33-61	5.4	4.3	7.41	1.20	0.05	0.31	2.50	0.34	11.5	0.15	1.15	13.2	27.8	15.2	0.5	1.5	0.17
	Bt ₂	61-129	5.6	4.5	7.76	1.30	0.05	0.40	2.50	0.40	11.8	0.12	1.15	11.1	28.4	18.3	0.5	2.2	0.20

Organic carbon in mapping unit 1 was moderate to high ($1.1\text{--}4.7\text{ gkg}^{-1}$) but low ($0.3\text{--}1.3\text{ gkg}^{-1}$) in soil unit 2 (Table 3). The moderate to high contents of organic carbon in soil unit 1 might be due to previous soil management practice of application of farm yard manure which is not the case in soil unit 2. Kihanda *et al.* (2008) indicated that application of manure enhanced soil properties including organic carbon.

Total nitrogen values in mapping unit 1 were moderate ($0.1\text{--}1.5\text{ gkg}^{-1}$) but very low ($0.02\text{--}0.05\text{ gkg}^{-1}$) in soil unit 2 (Table 4.3). These very low total nitrogen values in soil unit 2 are below the critical level for the requirement of most crops in productive soils (Donahue *et al.*, 1983).

In terms of exchangeable bases, soils of mapping unit 1 were low ($1.2\text{--}2.7\text{ cmolkg}^{-1}$) in calcium, magnesium ($0.2\text{--}1.6\text{ cmolkg}^{-1}$) and low to moderate ($0.15\text{--}0.50\text{ cmolkg}^{-1}$) in potassium. Soil unit 2 were very low ($1.40\text{--}1.90\text{ cmolkg}^{-1}$) in calcium, magnesium ($0.06\text{--}0.16\text{ cmolkg}^{-1}$) and potassium ($0.06\text{--}0.10\text{ cmolkg}^{-1}$). Exchangeable sodium was low ($<0.3\text{ cmolkg}^{-1}$) in the entire study area. The low to very low exchangeable cations encountered in the study area might be due to the coastal plain sand parent material which give rise to poorly aggregated coarse textured soils. Nsor and Adesemuyi (2018) posited that soil texture influences availability of basic cations in the soil. Coarse textured soils do not have enough holding sites resulting in high leaching rates. Therefore fertilizers containing these basic cations should be applied in splits instead of once to reduce leaching losses in coarse textured soils.

Cation exchange capacity, CEC was low ($7.5\text{--}14.6\text{ cmolkg}^{-1}$) in all the pedons evaluated. This is suggestive of a low nutrient reserve and holding capacity of soils in the study area. The base saturation percentage was also low ($21.3\text{--}33.4\%$) in the study area, suggestive of an Ultisol soil order. Available phosphorus by Bray I was medium ($8.1\text{--}13.5\text{ mg/kg}$) soil of mapping unit 1 but low ($4.0\text{--}7.0\text{ mgkg}^{-1}$) in unit 2. The low to medium level of phosphorus in the study area might be due to high Iron (Fe) content of the soils which fixes phosphorus in complexes such as Iron phosphate and through crop removal. The low P in soil unit 2 may be due to wild oil palm

plantation land use which removes appreciable quantities of available P from the soil.

Data on available contents of Iron, Zinc, Manganese and Copper in the study area are given in Table 3. Iron(Fe) was medium ($10.1\text{--}31.7\text{ mg/kg}$) in the entire study area. The adequate levels of (Fe) in the study area might be due to the acid conditions of these soils arising from intense leaching of basic cations (Aduayi and Ekong, 1981). Zinc (Zn) was low ($0.4\text{--}2.2\text{ mg/kg}$) in mapping unit 1, but medium to high ($3.2\text{--}6.4\text{ mg/kg}$) in soils of mapping unit 2. Manganese was low ($<5.0\text{ mg/kg}$) in mapping unit 1, but medium ($20.4\text{--}28.1\text{ mg/kg}$) in soils of unit 2. Contents of available copper (Cu) were low ($0.09\text{--}0.31\text{ mg/kg}$) in mapping unit 1 but medium ($1.01\text{--}1.40\text{ mg/kg}$) in soils of unit 2. The low levels of available Zn, Mn and Cu in soil of unit 1 might be due to farm yard manure and crop residues application unlike the soils of unit 2. This observation corroborates Stevenson and Ardakani (1972) who stated that organic matter application ameliorates toxicities of micro nutrients in soils. Micro nutrient elements are essential in the growth and reproduction of all higher plants, deficient or excess levels of micronutrients causes serious decrease in crop yield and under extreme toxic conditions, total crop failure (Cotteinie *et al.*, 1981).

Classification of Soils in the Study Area.

All the soil pedons studied in the study area had kandic soil surface diagnostic horizons, and a base saturation by ammonium acetate method of less than 35 %. Consequently, the soils in the study area can be grouped under the Ultisol soil order (Soil Survey Staff, 2010). The soils in the study area occur under an udic moisture regime, hence at the sub order level of the USDA soil taxonomy, they are classified Udults. All the pedons had a vertically continuous subsurface horizon that underlies coarser textured surface horizons. The minimum thickness of their surface horizons was 20cm with no densic, lithic, paralithic or petroferic contact within 50cm of the mineral surface soil. All the soil units have apparent CEC by $\text{IN NH}_4\text{OAc}$ at pH 7.0 of less than 16 cmol/kg in all horizons. All the pedons had a regular decrease in organic carbon content with increasing soil depth. These soil characteristics met the conditions for kandic sub soil diagnostic horizons and thus qualified the

soils in the study area as Kandiodults at the great group level of soil classification. At the sub-group level, the soils of the study area were classified Arenic Kandiodults due to their sandy or sandy – skeletal particle size class texture throughout a layer extending from the mineral soil surface to the top of their kandic horizon. The World Reference Base (WRB) equivalent of Arenic Kandiodults is Arenic Acrisols.

Land Suitability Evaluation of Soils in the Study

A summary of land characteristics or qualities of the study area is presented in Tables 1-3. The assessment ratings resulting from matching of the land qualities and the requirements of the test crops (fruited vegetable) in Table 4 is presented in Table 5. Detailed discussions of their suitability is presented below

Table 4 : Rating of Land use Requirement for Fruited Vegetables (Cucumber, Eggplant and Pepper)

Land Quality	Unit	S1 (95)	S2 (85)	S3 (60)	N (40)
Climate (c) :					
Temperature	°C	18-25	25-30	30-35	>35/<18
Rainfall	Mm	2500-3500	1800-2500	1000-1500	<1000
Relative Humidity	%	>42	36-42	30-36	<30
Solar Radiation		>478	478-358	358-239	<239
Soil Morpho-Physical Properties (S):					
Slope	%	< 3	3-5	5-10	>10
Soil depth	Cm	>100	80-100	50-80	<50
Soil Texture Class		SiL,SiCL,FSiL,CL	SCL,SC,SL	SiCL, C,LS	FS,S
Drainage		WD-MD	ID	PD	VPD
Fertility (f):					
pH (H ₂ O)		5.0-6.5	4-5	6.5-7.5	>7.5/<4.0
BS	%	>50	35-50	20-35	<20
CEC (NH ₄ OAc)	cmol/kg	>24	>12	<12	<10
Org. C	g/kg	>5	3-5	1-3	<1
TN	g/kg	>2.0	1.5-2.0	1.0-1.5	<1.0
Avail. P	mg/kg	>20	15-20	10-15	<10
Exch. K	cmol/kg	>0.3	0.2-0.3	0.1-0.2	<0.1
Fe	mg/kg	>3.5	2.5-3.5	1.5-2.5	<1.5
Zn	mg/kg	>1.5	1.0-1.5	0.6-1.0	<0.6
Mn	mg/kg	>1.0	0.8-1.0	0.5-0.8	<0.5

Source: Van Diepen *et al.* (1991) . Sys *et al.* (1993)

Key:

Texture: SiL= Silty Loam, SiCL= Silty Clay Loam, FSiL= Fine Silt Loam, CL= Clay Loam, SCL= Sandy Clay Loam, C= Clay, SC =Sandy Clay, SL= Sandy Loam, SiC =Silty Clay, LS= Loamy Sand, FS= Fine Sand, S= Sand.

Drainage: WD= Well drained, MD = Moderately drained, ID = Imperfectly drained, PD =Poorly drained, VPD = Very poorly drained.

Land Suitability Evaluation of the Study Area for Fruited Vegetables (Eggplant, Cucumber and Pepper)

The climatic condition of the study area (temperature, rainfall, relative humidity and effective solar radiation) were moderately (S2) to highly suitable (S1) for fruited vegetables production as values for temperature were between 25-30 °C (S2) rainfall was >2500 mm, (S1) relative humidity > 42 % (S1) and effective solar radiation >478 MJcm⁻² day⁻¹ (S1) Table 4.4 (FAO, 1983). The slope of less than 6 % made all the soil units moderately suitable (S2) for fruited vegetables. Generally, slope of 3-5 %, reported in this study may moderately favour mechanical operations according to the report of Lawal *et al.*

(2012) on the influence of slope on farm mechanization. In terms of soil depth, all the soil units were highly suitable (S1) as soil depths were > 100 cm. The texture of the soil in the study area (Sandy loam, Loamy sand and Sandy clay) made the soils of both unit to be moderately suitable (S2) for the production of fruited vegetables. All soil units were well drained to moderately drained which made them highly suitable (S1) for the cultivation of fruited vegetables. This could be due to the texture of the soil which had low water retention capacity. Oku *et al.*, (2004) made similar observation in their study on physical properties of the flood plain soil of Rainforest Zone of South- South Nigeria.

Table 5: Suitability Class Scores of the Study Area for Selected Fruited Vegetables (Cocumber, Eggplant and Pepper)

Land Qualities	Mapping Unit 1	Mapping Unit 2
Climate (c) :		
Temperature	S2 (85)	S2 (85)
Rainfall	S1 (95)	S1 (95)
Relative Humidity	S1 (95)	S1 (95)
Effective Solar Radiation	S1 (95)	S1(95)
Soil Morpho-physical Properties (s) :		
Slope	S2(85)	S2(85)
Soil Depth	S1 (95)	S1(95)
Texture	S2(85)	S2(85)
Drainage	S1 (95)	S1 (95)
Fertility (f) :		
pH(H ₂ O)	S1(95)	S2(85)
BS	S3(60)	S3 (60)
CEC	S2(85)	S2 (85)
Org. C	S2(85)	S3(60)
TN	S2(85)	S2 (85)
Avail. P	S3 (60)	NI (40)
Exch. K	S2(85)	NI(40)
Fe	S1(95)	S1(95)
Zn	S1(95)	S1(95)
Mn	S1(95)	S1(95)
Aggregate Suitability by Limitation	S3	N1
Productivity Index by Square Root.	20.9%	8.0%
Aggregate Suitability Class	S3f	N1f

In terms of fertility, pH(H₂O) was rated highly suitable (S1) for mapping unit 1 but moderately suitable (S2) for unit 2 hence will require liming. Base saturation (BS) was rated marginally suitable (S3) for both units as values were less than 35% by ammonium acetate method. Total nitrogen was moderately suitable (S2) for both units and might require nitrogen fertilizer application for optimal production of

fruited vegetables. Organic carbon was moderately suitable (S2) for unit 1 but marginally suitable (S3) for unit 2. Available phosphorus, a nutrient element required in large quantity by fruited vegetable for stimulation of blooming, formation of more flowers and seeds (Aduayi and Ekong, 1981) was rated marginal (S3) in unit 1 and currently unsuitable (N1) in mapping unit 2 and may require phosphorus fertilization for

sustainable production of fruited vegetables. Exchangeable K was moderately suitable (S2) in unit 1 but currently unsuitable (N1) in soils of unit 2. Available micronutrients (Fe, Zn and Mn) in the study area were adequate and rated highly suitable (S1) for sustained fruited vegetable production. In terms of overall or aggregate suitability rating, the soils of unit 1 represented

by pedons A, B, C and F were rated marginally suitable (S3) by both parametric and non parametric method due to fertility limitation. Soil of mapping unit 2 represented by pedons D and E as currently unsuitable (N1) for fruited vegetable cultivation on grounds of severe fertility constraints.

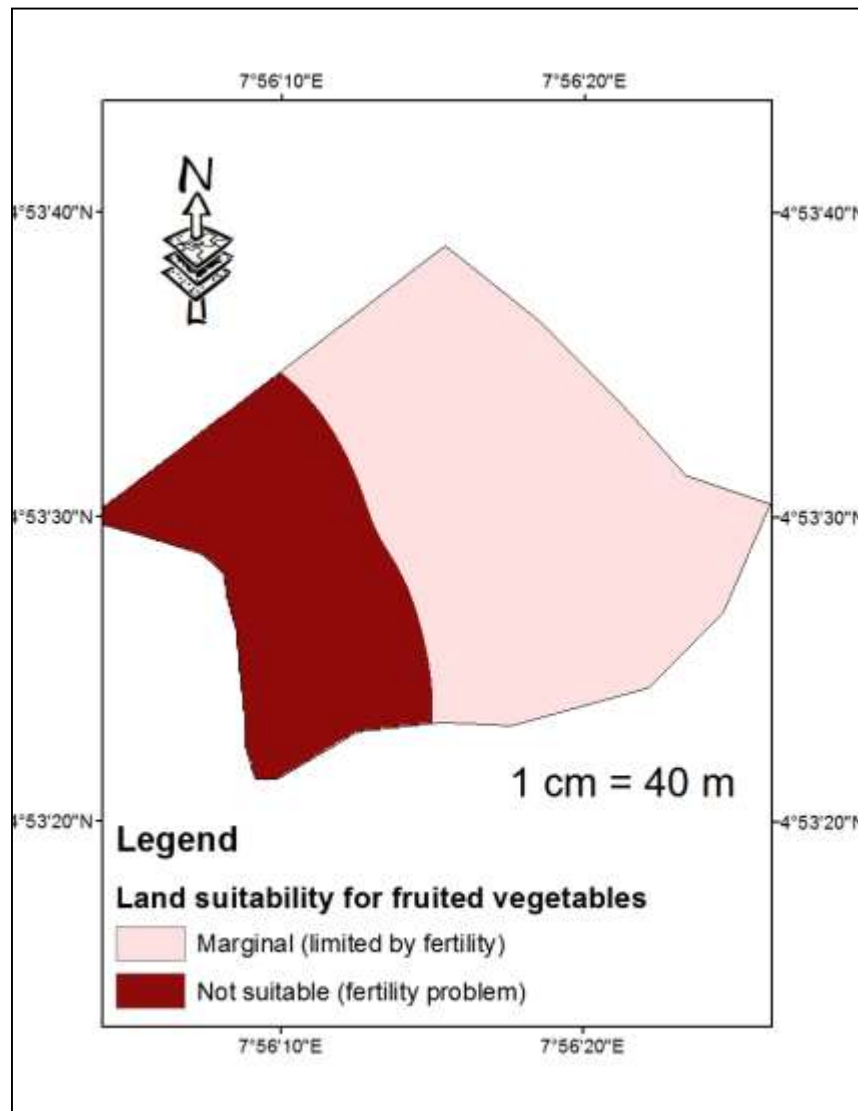


Fig. 2: Land suitability evaluation for the cultivation of fruited vegetables

CONCLUSION

Land biophysical characteristics such as temperature, rainfall, topography soil depth, slope and texture of the study area were favourable for rain-fed cultivation of fruited vegetables. However other factors including drainage and especially fertility parameters varied from marginal to currently not suitable for the test crops under consideration. Available phosphorus and total nitrogen, primary nutrient elements require especially by fruited vegetables for optimum vegetative growth, fruiting and enhancement of disease resistance were grossly inadequate in the study area. Cation exchange capacity (CEC) and base saturation, indexes of the potential of soils to retain and release plant nutrients were marginal to inadequate in both soil mapping units characterized and evaluated.

Both the parametric and non-parametric approaches to suitability evaluation revealed that about 25.1 ha (68.6 %) of the study area, designated mapping unit 1 were marginally suitable (S3) for both fruited vegetables and plantain. However, the remaining 11.5 ha (31.4 %) of the study area representing mapping 2 were currently unsuitable for the test crops.

The study further revealed that fertility (base saturation, CEC, available phosphorus, organic carbon and Exchangeable potassium) was the limitation responsible for the sub-optimum level for the productivity of the land for fruited vegetables. Furthermore, the study revealed that enhanced cultivation of fruited vegetable (cucumber, eggplant and pepper) and plantain is possible with the adoption of intensive soil management practices.

RECOMMENDATIONS

Based on the characterization and suitability evaluation for fruited vegetables and plantain, the following recommendations will optimize the utilization of soils of the study area for the test crops

- Site specific fertilizer protocol with the use of N P K should be developed and applied at the recommended rates for fruited vegetables.
- Sustained application of farm yard manure and crop residue will help boost nitrogen and phosphorus levels in the study area as well as improve the structure of the soils.

- Planting of leguminous cover crops (cowpea, groundnut and melon) and application of other organic residues like empty oil palm fruit bunches should be considered.
- Appropriate Irrigation technologies should be applied to ameliorate the deep water table in the study area and enhance all year round availability of water for cultivation of the test crops.
- Routine application of lime (wood ash etc) will improved the acid condition of these soils.

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