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CONTENTS

Land suitability assessment for okra (*Abelmoscus esculentus L.)* and fluted pumpkin (*Telferia occidentalis, L.*) cultivation in Khana Local Government Area of Rivers State, Southern Nigeria

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ABSTRACT: The study was conducted to evaluate the soils of Khana Local Government Area of Rivers State, Southern Nigeria for the cultivation of okra and fluted pumpkin. Eight mapping units were identified and one profile pit each was dug in each of the mapping. The soil profiles were examined and described horizons by horizon and soil samples were collected from each of the identifiable pedological horizon. The result shows that four soil orders majorly Inceptisols/Cambisols, Entisols/Arenosols, Ultisols/Acrisols, and Alûsols/Lixisols, were identiûed in the study area. The result of the suitability class scores using the non para metric method for the eight pedons evaluated showed that the soils were marginally suitable (S3) for both okra and fluted pumpkin cultivation due to limitation in climate (rainfall) and fertility (low CEC) and soil physical characteristic (depth to water table) in both pedon 4 and 5. Thus, the soils of Khana Local Government LGA can be profitably put into okra and fluted pumpkin cultivation under proper fertility management system and time of planting.

Key words: Fluted pumpkin, mapping, okra, Rivers State, suitability assessment

Relevant information on soil and related properties obtained from soil survey exercise and soil classification can help in better delineation of soil and land suitability for sustainable crop production Amara *et al.* (2016). It is worthy of note that, the performance of any crop is largely dependent on soil properties as well as other environmental related condition such climate and topography (Bargali *et al.,* 1993|). Soil-site suitability assessment help in predicting the performance of crop plants in an area (Arora *et al.,* 2011). According to Amara *et al*. (2016) and FAO (1976), land evaluation is the rating of soil for optimal returns per unit area of land. There are scanty information on soil-site suitability evaluation for okra and fluted pumpkin in Khana Local Government Area of Rivers State, Southern Nigeria. Okra is one of the most popularly cultivated and consumed vegetable in Nigeria and other tropical countries. The fruits are good source of vitamin and minerals in human (Peter and Onweremadu, 2016) and command a high market value because it features daily in the diet of most Nigerians. Okra is a popular fruit vegetable crop grown in most parts of Nigeria especially in Ogoniland (Peter and Onweremadu, 2016). Fluted pumpkin (*Telfairia occidentalis*) is one of the most popular leaf vegetable produced on small scale by peasant farmers in the southern part of Nigeria. It is a tropical vine cultivated as a leaf vegetable and for the edible seeds. It commonly called nyia-ee by the Ogonis, ugu in Ibo and ikong-ubong in Ibibio. It is a good source of dietary fibre that help to maintain blood tissues, and rich in antioxidant that improve blood, bones and teeth production. Pumpkin leaves are high in calcium and a good source of vitamin and mineral. It can be eating raw, but a little cooking bring out the true flavor of the leaf. Despite the economic importance of these two vegetable crops, the non-availability of soil-site suitability studies in the area, militated against their production on sustainable basis. Thus, this study was therefore carried out to provide detailed information on soil-site assessment of agricultural land for okra (*Abelmoscus esculentus L.)* and fluted pumpkin (*Telferia occidentalis, L.*) cultivation in Khana Local Government Area of Rivers State, Southern Nigeria.

MATERIALS AND METHODS

Study Area

Khana Local Government Area occupied 49,631.52

ha of land and it is located within the rainforest zone of southern Nigeria and lies between latitude 4.67172N and longitude 7.34398E (Peter and Umweni, 2020 b). The climate of the study area is characterized by humid tropical climate condition with average annual rainfall distribution that ranged between 2000 -2500 mm/annum and annual temperature ranges from 25 - 28°C with Iso-thermic soil temperature and udic moisture regime (Peter and Umweni, 2020 b). The soils are well drained soils derived from sedimentary rocks weathered into coastal plain sands buried under alluvium at varying degrees at different places in the study area (Peter *et al.*, 2019). According Peter and Ayolagha (2013), Peter and Anthony (2017) and Peter and Umweni (2020a), the natural vegetation of the area mainly comprised of trees and shrubs including *Delinox regia, Chrotaria exelsa, Mahogany, Iroko, Cieba petandra* with grasses such as Guinea grass (*Panicum maximum*) and Elephant grass (*Penisetum purpureum).*

Field survey

A semi detailed soil survey of the study area was carried out on the 49.631.54 hectares of land in the study area using the grid method of soil survey. At every point of intersection cut at 1000 x 500 m apart, auger boring was done at a depth of 0 – 30 cm, 30 – 60 cm, 60 – 90 cm and 90 – 120 cm except where there was obstruction. After auger boring, soils of similar characteristics were grouped forming mapping units. Eight mapping units were identified based on soil colour, texture, drainage, depths and other soil surface characteristics. One profile pit each (2 x 2 x 2 m) was dug in each of the eight mapping units. Geographical coordinates of each of the profile pit was taken using the hand held portable Global Positioning System (GPS) receiver (MODEL GARMIN 12 XL). Different soil horizons of the eight profile pits were described using appropriate soil profile description guidelines of the Soil Survey Manual (Soil survey staff, 2002). Soil samples were collected horizon by horizon, from bottom to top and carefully labeled for laboratory analysis most appropriate for selected soil physical and chemical properties following standard analytical procedures. Core samples were also taken with core samplers for bulk density determination. The soil samples obtained bottom-top from pedogenic horizons were properly air-dried, crushed and sieved to obtain the fine earth fraction and used for laboratory analysis.

Laboratory analysis

Soil particles size distribution was determined using the Bouyoucos hydrometer method, Bulk density determined by the core sampling method (Blake and Hartge, 1986), soil textural class was determined using the soil textural triangle. Soil pH was determined in H_2O using 1:2 soil solution. Organic carbon was determined using the wet combustion method of Walkley, and Black (1934) as described by Van-Ransit *et al.* (1999). Total nitrogen was also determined using the wet oxidation procedure of the Macro Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus was determined following the procedure described by IITA (1999) using the Bray - 1 extraction procedure (Bray and Kurtz, 1945), the amount of phosphorus was determined using spectrophotometer. Exchangeable cations was determined using the method described by Thomas (1982); while exchange Ca and Mg were determined by the Atomic Absorption Spectrometer (AAS) and exchange K and N were measured by the Flame Photometer. Percent base saturation was calculated using the formula:

$$\frac{\text{Summation of exchangeable base}}{\text{ECEC}} \times 100$$

Soil classification

Soils of the study area were classified based on the results from laboratory analytical procedures and morphological attributes of the eight pedons according to soil taxonomy of the United States Department of Agriculture (2014) and correlated with the World Reference Base for Soil Resources (2014)

Soil suitability evaluation procedure

Soil suitability class for okra and pumpkin

cultivation is indicated by its most limiting characteristics across the eight (8) pedons. The potentials and limitations of soils identified in the study site for the cultivation of the two crops of interest were evaluated using NBSS and LUP (1994) criteria. Aggregate suitability class of each pedon was obtained in line with the well-known "Law of the Minimum" in agriculture, which states that crop yield will be determined by the least favourable characteristics and plant nutrient in lowest supply (FAO, 1984). Each limiting characteristic was rated using the Non parametric approach.

RESULTS AND DISCUSSION

Soil classification

According to Peter and Umweni (2020a and 2021), four soil orders majorly Inceptisols/Cambisols, Entisols/Arenosols, Ultisols/Acrisols, and Alûsols/Lixisols, were identified. These soils were further classiûed according to Peter and Umweni (2020 a) as Oxyaquic Dystrudept/Stagnic Endogleyic Cambisol in pedon 1, Typic Udipsamment/Haplic Hypoferralic Arenosol in pedon 2, Oxyaquic Dystrudept/Plinthic Endogleyic Cambisol in pedon 3, Aquic Udipsamment/ Haplic Endostagnic Arenosol in pedon 4, Typic Dystrudept/Haplic Ferralic Cambisol in pedon 5, Typic Kandiudults/Haplic Vetic Acrisol (Hyperdystric) in pedon 6, Oxyaquic Kandiudalf/Gleyic Vetic Lixisol (Arenic, Oxyaquic) in pedon 7 and Fluventic Dystudept/Haplic Fluvic Cambisol (Chromic dystric) in pedon 8.

Soil suitability evaluation for Okra

Suitability classes for okra cultivation in the study area showed that pedon 4 was marginally suitable to okra cultivation in the area due to limitations in climate (rainfall), soil physical characteristics and

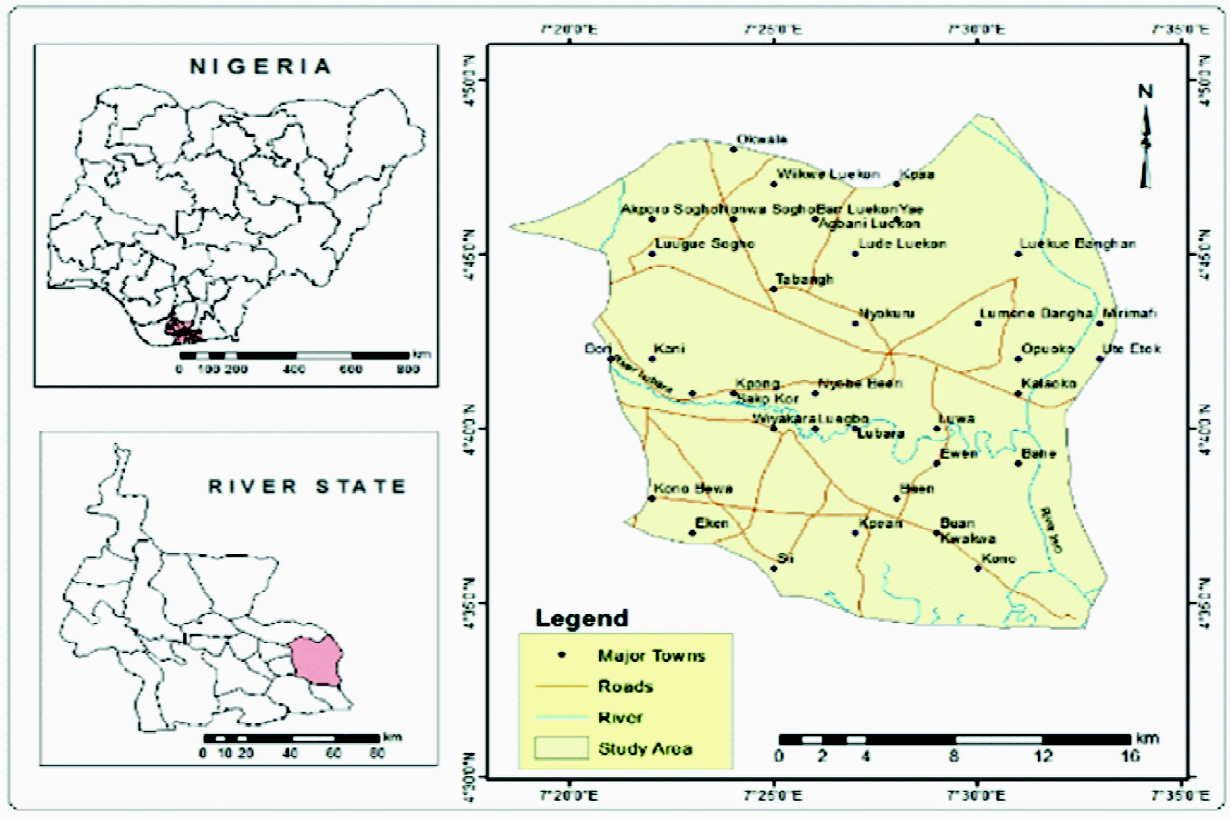

Fig. 1: Map of Khana Local Government Area (Project Site)
Sources: Government of Rivers State, Office of Surveyor General (2014)

Table 1: Soil-site suitability criteria (crop requirements) for Vegetables production

Land quality/site Characteristics	Suitability rating			
	S1	S2	S3	N
Climate (c)				
Mean temp. in growing Season ($_0$c)	25 – 28	29 – 3220 – 24	33 – 3615 – 19	<15>36
Mean annual rainfall (mm)	600 – 750	500 – 600750 1000	450 – 500>1000	-
Length of growing season (Days)	>150	120 -150	90 – 120	-
Topography (t)				
Slope (%)	1 – 3	3 – 5	5 – 10	>10
Wetness (w)				
Soil drainage	Well drained	Moderate	Imperfect	Poor
Soil physical characteristics				
Texture	SL, L, CL, SCL	LS. SiCL,Sic, c (m/k)	C (ss)	S
Coarse fragments (vol. %)	<15	15 – 35	>35	>25
Effective depth (cm)	>75	50 – 75	25 – 50	-
Fertility				
Ph	6.0 – 7.5	5.0 – 5.97.6 – 8.5	<5>8.5	—
CEC (cmol/kg)	>15	10 – 15	<10	-
$CaCO_3$ (%)	Non calcareous	Slightly calcareous	Strongly calcareous	-

Source: NBSS & LUP, 1994

Table 2: Soil- site suitability criteria (crop require) for Vegetables (Fluted Pumpkin (*Telferia occidentalis*))

		Suitability rating				
Land quality/soil-site characteristics		Unit	S1 φ	S2$	S3 φ	N φ
Climate (c)	Mean temperature in growing season	°C	25-28	29-32	33-36	<15
				20-24	15-19	<36
	Total rainfall	Mm	600-750	500-600	450-500	
				750-1000	>1000	
	Rainfall in growing season	Mm	>150	120-150	90-120	
	Length of growing season	Days	>150	120-150	90-120	
Topography (t)	Slope	%	3-Jan	5-Mar	10-May	>10
Wetness (w)	Soil drainage	Class	Well drained	Moderate	Imperfect	Poor
Soil physical	Texture coarse	Class	Sl,l,cl,scl	ls, sicl, sic, sc,	C(ss)	ls,s
properties (s)	fragments	Vol.(%)	<15	c(m/k) 15-35	>35	
	Effective soil depth	Cm	>75	50-75	25-50	<25
	pH	1-2.5	6.0-7.0	5.0-5.9;	<5	
	CEC	cmol(p+)/kg	>15	7.1-8.5	>8.5	
Fertility (f)	$CaC0_3$ in root zone	%		10-15	<10	
Soil toxicity (n)	Salinity (EC saturation extract)	dSm^{-1}	Non-saline	Slightly saline	Strongly saline	
	Sodicity (ESP)	%	Non-saline	Slightly sodic	Strongly sodic	

φ = Highly suitable (IP=100-75%), Moderately Suitable (I), $= (74-50%); = marginally suitable (IP=49-25); = Not suitable (24-0%). Source: Modified from NBSS&LUP, 1994.

fertility. It covers 7,700 hectares of land representing, 15.52 % of the total land area. Pedons 1, 2, 3, 5, 6, 7 and 8 were also marginally suitable (S3) for okra cultivation in the area with major constraints in climate (rainfall) and fertility. It covers an area of 41,932 hectares representing 84.48% of the total land in the study area. Fertility limitation shows that CEC was very low in all the pedons. This contradicted the findings of (Amara *et al.*, 2016) who reported that climate with the exception of total annual rainfall, topography, drainage and soil toxicity were highly suitable for growing vegetables.

Soil suitability evaluation for Fluted pumpkin

The suitability classes for Fluted pumpkin cultivation in the study area also indicated that Pedon 4 was marginally (S3) for pumpkin cultivation in the area with limitations in climate (rainfall), soil physical characteristics and fertility (Amara *et al.*,

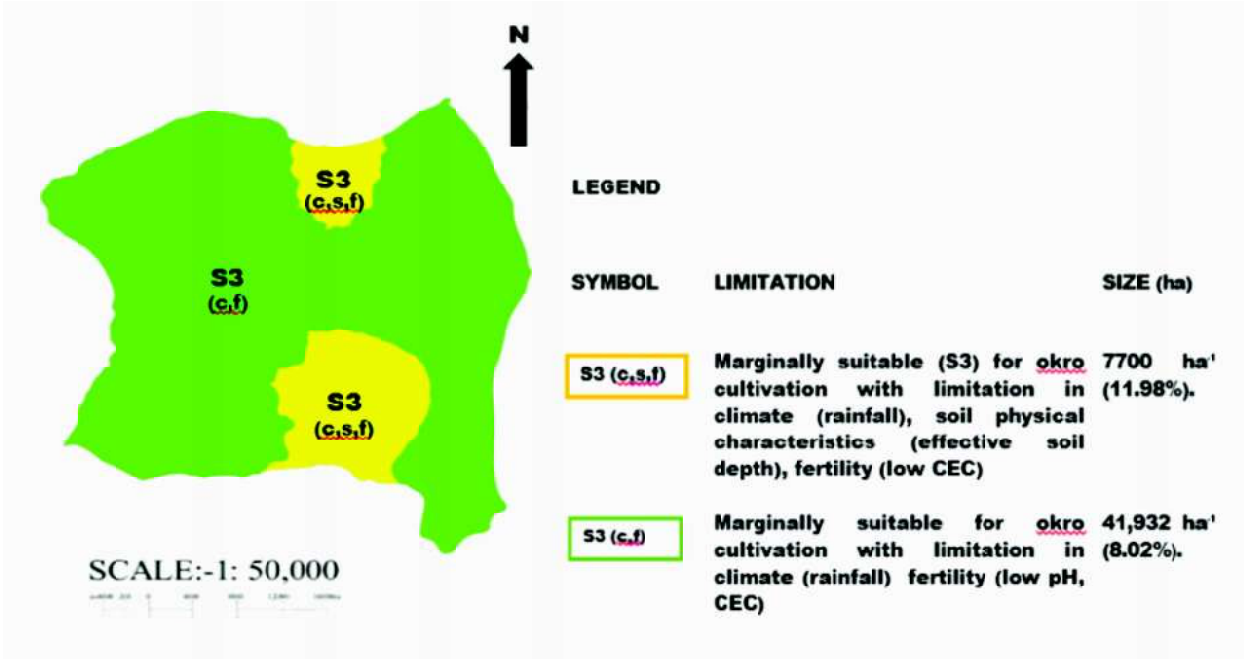

Fig. 2: Land Suitability Map for Okra in Khana LGA.

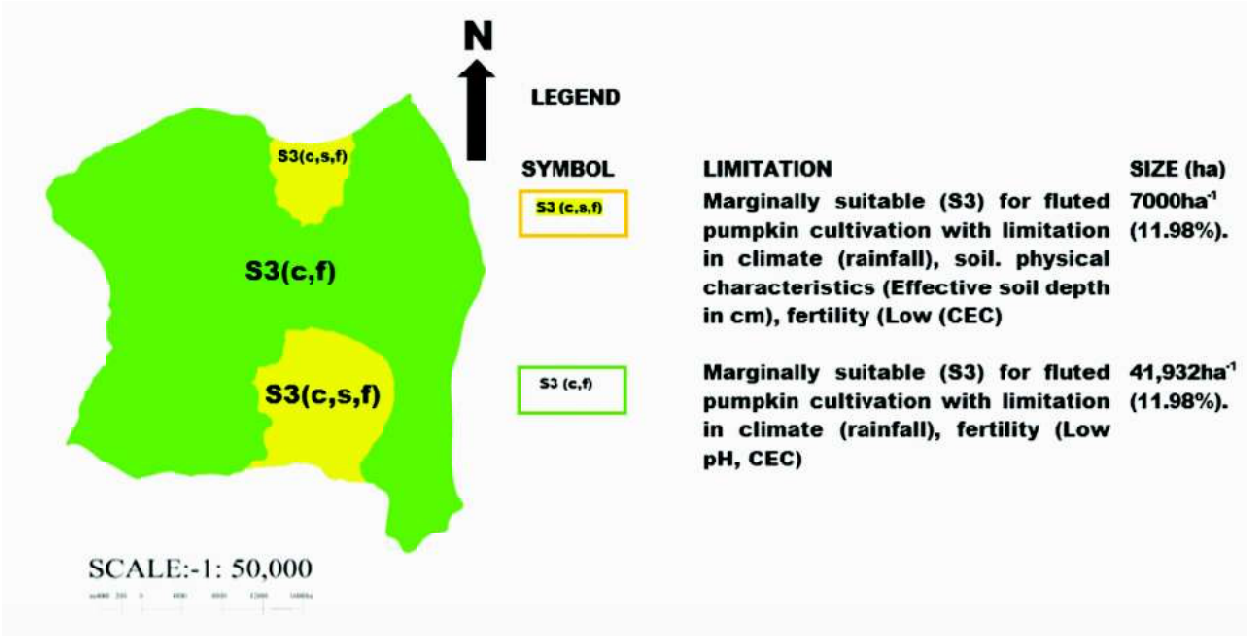

Fig. 3: Land Suitability Map for Fluted pumpkin in Khana LGA

2016). It covers 7,700 hectares of lands representing 15.52 % of the total land area. Pedons 1, 2, 3, 5, 6, 7 and 8 were also marginally suitable (S3) for pumpkin cultivation in the area with constraints in climate (rainfall) and fertility. It covers 41,932 hectares of land, representing 84.48% of the total land in the study area. Fertility limitation shows that CEC was very low in all the pedons. The major limitations for pumpkin cultivation in the area are climate (rainfall) and low fertility. This also agreed with the

Table 3: Summary table for Land Suitability Evaluation for Okra (*Abelmoscus esculentus*) cultivation

Land Requirements/	Pedons and their Suitability Class (s)							
/Land Suitability	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Climate								
Mean temperature in growing season (^{0}C)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)
Total rainfall (mm)	2000 - 2500 (S3)	2000 – 2500 (S3)	2000 - 2500 (S3)	2000 2500 (S3)	2000 - 2500 (S3)	2000 - 2500 (S3)	2000 (S3)	2000 (S3)
Length of growing season (Days)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)
Topography (t)								
Slope (%)	0 - 4 (S1)	0 -4 (S1)	0 - 4 (S1)	0 – 4 (S1)	0 - 4 (S1)	0 - 4 (S1)	0 - 4 (S1)	0 – 4 (S1)
Wetness (W)								
Soil drainage	MD (S2)	WD (S1)	WD (S1)	MD (S2)	MD (S2)	WD (S1)	WD (S1)	WD (S1)
Soil Physical Characteristics (s)								
Texture (Class)	SL (S1)	LS (S2)	SL. (S1)	LS (S2)	LS (S2)	SL (S1)	SL (S1)	LS (S2)
Coarse fragments (vol. %)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)
Effective soil depth (cm)	131 (S1)	200 (S1)	200 (S1)	50 (S3)	120 (S3)	200 (S2)	200 (S1)	200 (S1)
Fertility (f)								
pH(H_2O)	5.5– 6.13 (S2)	5.60 – 6.16 (S2)	5.14 – 6.11 (S2)	5.43 – 6.08 (S2)	4.70 – 5.71(S2)	4.31 – 4.81(S3)	4.70 – 5.90 (S2)	5.67 – 5.83 (S2)
CEC (Cmol/kg)	2.68 – 5.65 (S3)	2.01 – 3.48 (S3)	4.52 – 6.27 (S3)	3.75 – 3.92 (S3)	3.05 – 6.48 (S3)	2.78 – 4.02 (S3)	3.64 – 4.99 (S3)	1.76 – 3.44 (S3)
$CaC0_3$ in root zone (%)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)
Soil toxicity (n)								
Sodicity (ESP) (%)	0.0038 (S1)	0.2 (S1)	0.036 (S1)	0.05	0.21 (S1)	0.51	0.05 (S1)	0.2 (S1)
Aggregate Suitability class	S3 (c, f)	S 3 (c, f)	S3 (c, f)	S3 (c, s, f)	S3 (c, f)	S3 (c, f)	S3 (c, f)	S3 (c, f)
Size (Hectare)	4750	1400	19882	7700	5950	5350	3350	1250
% Coverage	9.57	2.82	40.06	15.52	11.98	10.78	6.75	2.52

Source: Peter (2019) Field Report.

Pedons 1, 2, 3, 5, 6, 7 and 8 (41932 ha) were marginally suitable (S3) for okra cultivation due to limitation in climate (rainfall), Pedon 4 (7700 ha) was also marginally suitable (S3) for okra cultivation due to limitations in climate (rainfall) and wetness (soil depth to water table)

Table 4: Summary table for Land Suitability Evaluation for Fluted Pumpkin (*Telferia occidentalis*) cultivation

Land Requirements/	Pedons and their Suitability Class (s)							
Land Suitability	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Climate								
Mean temperature in growing season (^{0}C)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)	25 – 28 (S1)
Total rainfall (mm)	2000 - 2500 (S3)	2000 – 2500 (S3)	2000 - 2500 (S3)	2000 2500 (S3)	2000 - 2500 (S3)	2000 - 2500 (S3)	2000 (S3)	2000 (S3)
Length of growing season (Days)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)	150 (S1)
Topography (t)								
Slope (%)	0 - 4 (S1)	0 -4 (S1)	0 - 4 (S1)	0 – 4 (S1)	0 - 4 (S1)	0 - 4 (S1)	0 - 4 (S1)	0 – 4 (S1)
Wetness (W)								
Soil drainage	MD (S2)	WD (S1)	WD (S1)	MD (S2)	MD (S2)	WD (S1)	WD (S1)	WD (S1)
Soil Physical Characteristics (s)								
Texture (Class)	SL (S1)	LS (S2)	SL. (S1)	LS (S2)	LS (S2)	SL (S1)	SL (S1)	LS (S2)
Coarse fragments (vol.%)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)
Effective soil depth (cm)	131 (S1)	200 (S1)	200 (S1)	50 (S3)	120 (S2)	200 (S2)	200 (S1)	200 (S1)
Fertility (f)								
pH(H_2O)	5.5– 6.13 (S2)	5.60 – 6.16 (S2)	5.14 – 6.11 (S2)	5.43 – 6.08 (S2)	4.70 – 5.71(S2)	4.31 – 4.81(S3)	4.70 – 5.90 (S2)	5.67 – 5.83 (S2)
CEC (Cmol/kg)	2.68 – 5.65 (S3)	2.01 – 3.48 (S3)	4.52 – 6.27 (S3)	3.75 – 3.92 (S3)	3.05 – 6.48 (S3)	2.78 – 4.02 (S3)	3.64 – 4.99 (S3)	1.76 – 3.44 (S3)
$CaC0_3$ in root zone (%)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)	Nil (S1)
Soil toxicity (n)								
Sodicity (ESP) (%)	0.0038 (S1)	0.2 (S1)	0.036 (S1)	0.05	0.21 (S1)	0.51	0.05 (S1)	0.2 (S1)
Aggregate Suitability class	S3 (c, f)	S 3 (c,f)	S3 (c, f)	S3 (c, s, f)	S3 (c, f)	S3 (c, f)	S3 (c, f)	S3 (c, f)
Size (Hectare)	4750	1400	19882	7700	5950	5350	3350	1250
% Coverage	9.57	2.82	40.06	15.52	11.98	10.78	6.75	2.52

Source: Source: Peter (2019) Field Report.

Pedons 1, 2, 3, 5, 6, 7 and 8 (41932 ha) were marginally suitable (S3) for pumpkin cultivation due to limitation in climate (rainfall), Pedon 4 (7700) was also marginally suitable (S3) for pumpkin cultivation due to limitations in climate (rainfall) and wetness (soil depth to water table)

reports of Nwonuala (2006), that excessive rainfall reduced yield of pumpkin, resulting to leaves, vines and seeds rots. She also opined that, low nutrients level especially low nitrogen level in the soils, could lead to poor leafy and vine growth in fluted pumpkin.

CONCLUSION

The soils of the study area generally have favourable mean annual temperature, soil texture and structure and pH, but high annual rainfall and low CEC. However, with proper timing of planting period and application of both organic and inorganic fertilizers, the soils can be more productive. Thus, currently, the soils are marginally suitable (3) for okra and fluted pumpkin cultivation, but potentially and with adequate inputs and timing of planting, it can be moderately or highly (S2 or S1) suitable over time.

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