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Research Article
Georeferencing and Suitability Evaluation of Some Land in Ogun State Nigeria for Commercial Cassava Production

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Abstract
Background and Objective: The information on the suitability of various types of soils to various types of crops is crucial for planners and agricultural scientists to initiate and encourage farmers to practice cropping systems based on soil potential to various crop categories. A study was carried out to evaluate the suitability evaluation of 3 hectare of land at Agbetu for the production of cassava using parametric model. **Materials and Methods:** Data were obtained by field study and laboratory analyses. A total of 3 ha was surveyed in order to carry out this study using rigid grid survey method and soil samples were collected and described morphologically to determine the mapping units. The 4 profile pits were dug, each in a unit P1, P2, P3 and P4. Soil samples were collected at each pedogenic horizon and prepared for physical, chemical and biological analyses. The laboratory result was subjected to suitability evaluation using parametric method. The land suitability groups: Highly suitable (S1), moderately suitable (S2), marginally suitable and not suitable (N) were used for the rating. **Results:** The soil pH was alkaline. The exchangeable bases were low except magnesium that was moderate in all the profiles. The textural classes of the soils were sandy clay loam, sandy loam, sandy clay, clay loam and clay, but the dominant textural class is sandy clay loam. **Conclusion:** The suitability result showed that the land was highly suitable for cassava production using parametric methods of land suitability evaluation according to the revised frame work.

Key words: Georeference, rigid grid survey method, mapping units, suitability evaluation, parametric approach

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Land users and planners according to Mustafa *et al.*[1] need basic soil information on the potential and suitability of soils for various crops for sustained agricultural production. In this case, the information on the suitability of various types of soils to various types of crops will be crucial for planners and agricultural scientists to initiate and encourage farmers to practice cropping systems based on soil potential to various crop categories. Etuk and Ayuk[2] reported that the United Nations Development Programme (UNDP) in one of the sustainable development goals (SDGs),described agriculture as the main tool for ending extreme poverty, improving food security and nutrition and promoting sustainable agriculture. Food insecurity can be eradicated by sustainable agricultural practices and precision farming. This means that crops and soils irrespective of climatic variations should be provided with favorable conditions for optimum health and productivity. Martínez[3] also emphasized that the concept of sustainable agriculture or farming involves producing quality products in an environmentally, socially acceptable and economically efficient way, ensuring optimum utilization of the available natural resource for efficient agricultural production.

According to Shackelford *et al.*[4] cassava (*Manihot esculenta*), being one of the major sources of Nigerian staple food has many other benefits such as providing income to smallholder farmers serving as a famine reserved crop, a source of industrial raw materials for the production of starch, plywood, alcohol and animal feed. The leaves and shoots, which are relatively high in protein, are often eaten in Asian and African countries reported that cassava is a vital and staple crop for food security and poverty reduction in Africa and Asia. They further reported that cassava provides over 15% of daily calorie intake in Africa. However, cassava production, despite all the technical and financial efforts, has not yet met the demand across the continent.

Food and Agricultural Organization (FAO)[5], stated that the best method of ensuring optimum output of crops, such as cassava from our land resources is their allocation to the use for which they are most suitable by evaluating the land for its suitability. In order to comply with these principles of sustainable agriculture, one has to grow the crops where they suit best and for which 1st and the foremost requirement is to carry out a land suitability analysis according to Ahamed *et al.*[6]. The land evaluation, therefore aims at achieving optimum economic return from the allocation of land resources without land degradation. The objectives of this research were to map and geo-reference the suitable portions of the researched land for proper documentation for cassava production and for future referencing.

MATERIALS AND METHODS

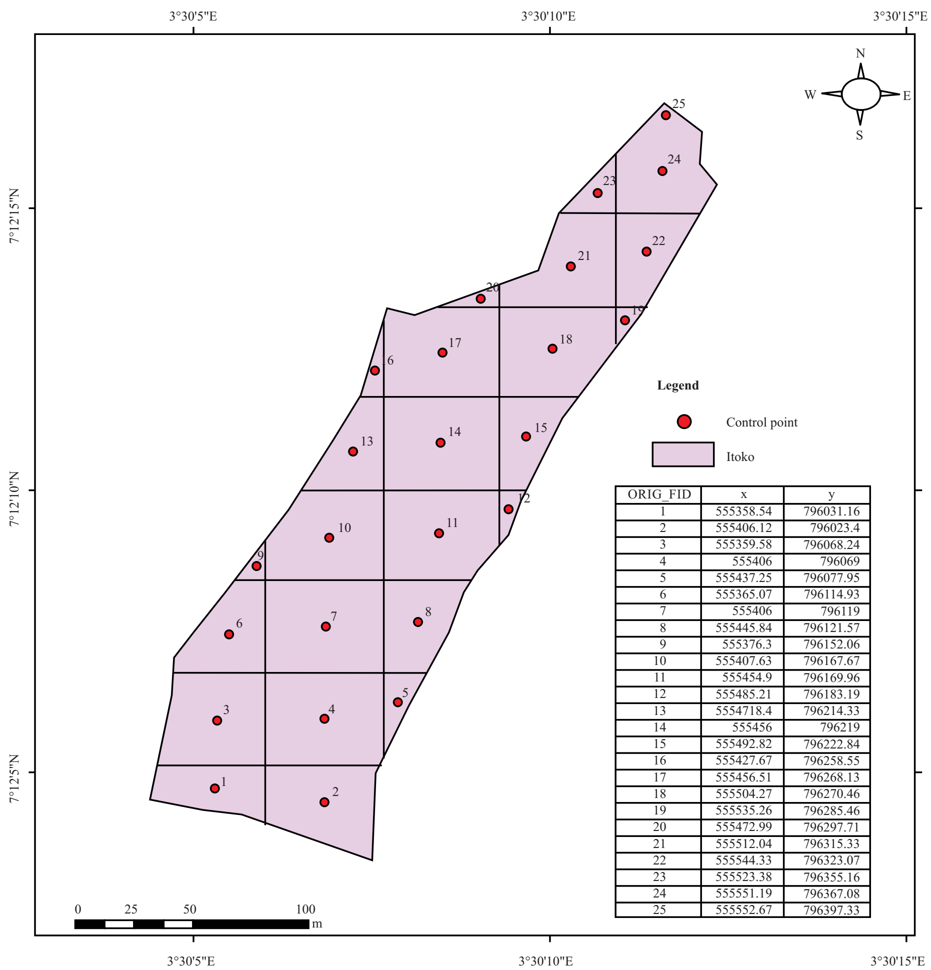
Description of the study area: The study was carried out between February and May, 2022 in Agbetu, Odeda Local Government Area of Ogun State. It is a 3 hectare land. The area is located between Latitudes 7.101 and 7.106°N and Longitudes 3.301 to 3.304°E. The vegetation is derived from savanna, which has been modified by various agricultural practices over time. The climate of Abeokuta falls between the humid and sub-humid tropics with a mean annual rainfall of about 1113 mm, 2 peaks distribution pattern and 5 dry months in the year. Mean temperature ranges between 25-28°C. The soil temperature which is relatively higher than the air temperature is highest at the 5 cm depth (34-35°C) and decreases with the depth from 10 to 50 cm from the surface, though remaining above 30°C. The relative humidity is highest between July and September, ranging from 86 to 88% and lowest between January and February, at 66 to 68% in most years Osinuga *et al.*[7].

Field survey: Field was gridded into a regular polygon (Fig. 1) at an interval of 50×50 m using the Geographic Information System (GIS) and the center coordinates were taken, with the appropriate longitude and latitude. The determined coordinates were loaded into a hand held Global Positioning System (GPS) to locate the positions of the coordinate. Sampling was done at intervals of 15 cm from the top of the soil to a depth of 90 cm using a 1.5 m length soil auger. The morphological properties of the soil were done *in situ*. The determined characteristics were used to partition the soil into mapping units (Table 1). A profile pit was dug in each determined unit. Samples were taken from the pedogenic horizon of each profile according to the FAO (2006) guidelines.

Laboratory analysis: The air-dried soil samples were ground and sieved with a 2 mm mesh sieve and sub-samples were further sieved with a 0.5 mm sieve for the organic carbon and nitrogen determination. The organic carbon was determined using Walkley and Black[8] method. Soil pH in water was determined with the use of a glass electrode pH meter by Mclean[9]. Exchangeable cations were extracted with 1 m NH_4OA_C (pH 7.0), sodium and potassium was determined

Table 1: Mapping unit with coordinates

Profile	Latitudes	Longitudes
1	07.12.285°N	003.30.171°E
2	07.12.243°N	003.30.157°E
3	07.12.217°N	003.30.131°E
4	07.12.153°N	003.30.131°E



ORIG_FID	x	y
1	555358.54	796031.16
2	555406.12	796023.4
3	555359.58	796068.24
4	555406	796069
5	555437.25	796077.95
6	555365.07	796114.93
7	555406	796119
8	555445.84	796121.57
9	555376.3	796152.06
10	555407.63	796167.67
11	555454.9	796169.96
12	555485.21	796183.19
13	5554718.4	796214.33
14	555456	796219
15	555492.82	796222.84
16	555427.67	796258.55
17	555456.51	796268.13
18	555504.27	796270.46
19	555535.26	796285.46
20	555472.99	796297.71
21	555512.04	796315.33
22	555544.33	796323.07
23	555523.38	796355.16
24	555551.19	796367.08
25	555552.67	796397.33

Fig. 1: Sampling points properly geo-referenced with coordinates

using a (Corning 410 flame photometer) and exchangeable Mg and calcium by (Buck Scientific 210VGP model Atomic Absorption Spectrometer) by Klute *et al.*[10]. Available P was extracted using Bray-1 extractant followed by Molybdenum blue colorimetric. Exchangeable acidity was determined by the KCl extraction method by Mclean[9]. Percentage base saturation was determined and effective cation exchange capacity (ECEC) was calculated from the sum of all exchangeable cations. Total nitrogen was determined by the Macro-kjeldahl digestion method of Jackson[11]. The bulk density was determined by the core method. Particle size distribution analysis was determined by the Bouyoucos[12] hydrometer method using the calgon as dispersing agent.

Land suitability evaluation

Parametric approach: For the parametric method, each limiting characteristic was rated as in (Table 2). According to Sys *et al.*[13] the index of productivity (actual and potential) was calculated using the following equation:

$$IP = A \times \sqrt{\underset{(c)}{\frac{B}{100}} \times \underset{(t)}{\frac{C}{100}} \times \underset{(w)}{\frac{D}{100}} \times \underset{(s)}{\frac{E}{100}} \times \underset{(f)}{\frac{F}{100}}}$$

where, IP is index of productivity, A is overall fertility limiting and B, C....F are the lowest characteristic ratings for each land quality group. The 5 land quality groups climate (c), topography (t), soil physical properties (s), wetness (w) and fertility (f) were used in this method of evaluation. Only 1 member in each group was used for calculation purpose because there are usually strong correlations among members of the same group (e.g. texture and structure).

For actual productivity index, all the lowest characteristics ratings for each land quality group were substituted into the index of productivity equation above. However, in the case of potential productivity index, it was assumed that the corrective fertility measure will no longer have fertility constraints. Suitability classes S1, S2, S3 and N are equivalent to IP values of 100-75, 74-50, 49-25 and 24-0, respectively.

Table 2: Climatic and land suitability requirement for cassava

Land qualities and land characteristics	S11 96-100	S12 86-95	S2 61-85	S3 41-60	N1 21-40	N2 0-20
Climate (c)						
Annual rainfall	1200-1400	1500-1200	1100-900	900-500		<500
Mean annual temperature (°C)	22-24	24-26	26-30	30-35		>35
Relative humidity (%)	60-80	50-60	40-50	30-40		<30
Wetness (w)						
Flooding	FO	FO	-	-	-	F1
Drainage	WD	Well drained	Moderately drained	Poorly drained	Very poorly drained	
Soil physical properties (s)						
Soil depth	>75	60-75	40-60	20-40	-	<20
Texture	SCL, L	SL, SiL, Si, SC	LS, LFS, CO, SiC			CM, Si, Cm
Fertility (f)						
Soil pH	5.4-5.7 and 5.7-6.0	5.0-5.4 and 6.0-6.5	4.3-5.0 and 6.5-7.0	4.0-4.3 and 7.0-7.8	-	>7.8
Organic carbon	>20	12-20	08-12	<8	-	
CEC	>24	16-24	15-16	<15	-	
Base saturation (%)	>50	35-50	20-35	<20	-	
Topography (t)						
Slope (%)	0-5	05-12	12-120	12-30		>20

S11 and S12: Highly suitable, S2: Moderately suitable, S3: Marginally suitable, N1: Not suitable, N2: Permanently not suitable, WD: Well drained, SCL: Sandy clay loam, SL: Sandy loam, SiL: Silty loam, Si: Silty, SC: Sandy slay, LS: Loamy sandy and SiC: Silty clay

RESULTS AND DISCUSSION

Morphological, physical and chemical properties of the soil profile: The morphological, physical and chemical properties of the profile soils were shown in Tables 3-5, respectively. The colour varied in all the mapping units. In mapping unit 1, the colour varied from 10YR2/2 very dark brown to 5YR5/8 yellowish red. The colour varied from 10YR2/2 very dark brown to 5YR6/8 reddish yellow in mapping unit 2. In mapping unit 3, the colour varied from 10YR4/4 dark yellowish brown to 5YR3/8 dark reddish brown whereas in mapping unit 4, the colour varied from 5YR3/1 very dark gray to 10R4/6 red. The variations in the morphological properties could be as a result of the drainage pattern on the land. This was in conformity with Pretorius *et al.*[14], reported that colour variations were as a result of drainage pattern and the regional water table. This was also in line with Zhang *et al.*[15] that soil colour is determined by mineral composition, element concentration, organic matter and moisture content. The structure varied from single grain at the O horizon to sub angular blocky in all other horizons. The consistency varied from friable to firm. Coarse materials were not generally present in all the profile pits. They were abundant in soil horizons of some pits especially pit no. 3 and 4. The root concentration varied from very few medium common roots to very fine many coarse roots. The boundaries were abrupt, wavy and some were irregular. Iron and manganese concretions were present in some horizons in profile pits 1, 2 and 4. The presence of iron and manganese minerals is also an indicator for the colour changes according to Jackson[16] which stated that soils with iron tends to be reddish as found in mapping unit 4. Generally the particle size distribution of sand, clay and silt varied from profile to profile. This showed that the pedons have very high sand contents across the profiles. In mapping unit one, the sand content ranged from 78.90 to 94.93% and fluctuated along the profile pit. The clay content ranged from 4.16 to 7.16% and increased with depth along the profile. The silt content however ranged from 0.91 to 4.88% and also varied along the profile.

In mapping unit 2, the sand content ranged from 81.93 to 92.93% and fluctuated along the profile depth. The clay content ranged from 5.13 to 14.13% and varied with depth along the profile. The silt content however ranged from 1.91 to 7.91% and also fluctuated along the profile. In mapping unit three, the sand content ranged from 81.93 to 95.40% and reduced with the profile depth. The clay content however ranged from 3.60 to 14.13% and fluctuated with depth. The silt content however ranged from 0.94 to 4.94% and also fluctuated along the profile.

In mapping unit 4, the sand content ranged from 73.96 to 94.93%. The clay content ranged from 4.07 to 20.13%. The silt content however ranged from 0.94 to 3.97% and also fluctuated along the profile. The high percentage of sand in all the land uses is a good indication of the observable high infiltration rate according to Osinuga *et al.*[7]. The implication of high sand content is the decrease in ECEC and nutrient holding capacity. This was clearly evident in this research work as the ECEC was very low. There was significant variation in the bulk density. The pH values of the land uses ranged from 7.3

Table 3: Morphological properties of the pedons

Pit No.	Depth	Colour	Text	Structure	Consistency	Coarse material	Root conc.	Drainage	Concretions	Bioactive	Boundary
1	0-14	10YR2/2 very dark brown	S	SG	VFr	A	VfM	WD	A	F	Ab
	14-42	5YR4/4 reddish brown	S	SAB	Fr	A	VfMC	WD	A	F	Ab
	42-88	5YR4/6 yellowish red	S	SAB	F	QSCC	VfF	MD	Mn, Fe	A	Ab
	88-133	5YR5/6 yellowish red	SL	SAB	F	QSCF	A	ID	Mn, Fe	A	WC
	133-197	5YR5/8 yellowish red	SL	SAB	VFI	A	A	PD	Mn, Fe	A	
2	0-7	10YR2/2 very dark brown	LS	SG	VFr	A	VfMC	WD	A	F	Ab
	7-37	5YR5/4 reddish brown	S	SAB	Fr	A	VfMC	WD	A	F	Gr
	37-114	5YR4/6 yellowish red	LS	SAB	Fr	A	VfF	MD	A	F	WC
	114-159	5YR5/8 yellowish red	LS	SAB	Fi	QSCC	A	ID	Mn, Fe	A	Gr
	159-198	5YR6/8 reddish yellow	SL	SAB	VFi	QSCF	A	PD	Mn, Fe	A	
3	0-14	10YR4/4 dark yellowish brown	S	SG	L	QSMM	VfMC	WD	A	F	Ab
	14-30	5YR3/6 dark reddish brown	S	SG	Fr	QSMM	VfMC	WD	A	F	CW
	30-110	2.5YR4/8 red	LS	SAB	Fr	QSMF	VfF	ID	A	F	GRI
	110-168	5YR3/6 dark reddish brown	SL	SAB	VFi	A	A	PD	A	A	
4	0-11	5YR3/1 very dark gray	S	SG	VFr	A	VfMC	WD	A	F	CS
	11-26	5YR4/3 reddish brown	S	SAB	Fr	A	VfCM	WD	A	F	CS
	26-79	2.5YR4/6 red	LS	SAB	FI	QSMF	VfF	ID	A	F	GW
	79-138	10R4/8 red	SCL	SAB	FI	QSMF	VfF	ID	Mn, Fe	A	G
	138-173	10R4/6 red	SCL	SAB	VFI	QSMF	A	PD	Mn, Fe	A	

SG: Single grain, SAB: Sub angular blocky, SL: Sandy loamy, LS: Loamy sand, SCL: Sandy clay loam, SC: Sandy clay, S: Sandy, VFr: Very friable, Ab: Abrupt, Gr: Gradual, GW: Gradual and wavy, CS: Clear and smooth, WD: Well drained, PD: Poorly drained, MD: Moderately drained, VfMC: Very few to medium coarse root, VfF: Very few to fine root, Mn and Fe: Manganese and iron concretion

Table 4: Physical properties of the pedons

Profile	Horizon depth	Sand (%)	Silt (%)	Clay (%)	Texture
1	0-14	90.96	4.88	4.16	Sand
1	14-42	94.93	0.91	4.16	Sand
1	42-88	90.93	1.94	4.16	Sand
1	88-133	78.90	1.97	7.13	Sandy loam
1	133-197	81.93	3.94	19.13	Sandy loam
2	0-7	86.96	7.91	14.13	Sandy loam
2	7-37	92.93	1.94	5.13	Loamy sand
2	37-114	87.93	1.91	5.13	Sand
2	114-159	84.96	2.88	10.16	Loamy sand
2	159-198	81.93	3.94	12.16	Loamy sand
3	0-14	95.40	1.00	14.13	Sandy loam
3	14-30	92.93	1.94	3.60	Sand
3	30-110	86.96	0.94	5.13	Sand
3	110-168	81.93	4.94	12.10	Loamy sand
4	0-11	91.96	3.97	13.13	Sandy loam
4	11-26	94.93	0.94	4.07	Sand
4	26-79	88.90	1.97	4.13	Sand
4	79-138	75.90	3.97	9.13	Loamy sand
4	138-173	73.96	3.94	20.13	Sandy clay loam

to 7.8, although this value followed no definite pattern in their distribution down the profiles. The pH showed that the pedons were slightly alkaline. According to Souza *et al.*[17] pH affects nutrient availability by changing the nutrient forms. Phosphorus also is mostly available at a neutral pH. This was evident in most horizons in this research work with neutral pH. The exchangeable bases (Ca, Na, Mg and K) in all the profiles were very low except for Mg which was moderate only at the surface in all the profiles. The low in calcium, potassium and sodium could be a result of leaching as reported by Zhang *et al.*[18]. The exchangeable acidity was generally low with values ranging from 0.4 to 0.8 Cmol kg^{-1}. The organic carbon varied across the profiles. The organic carbon was moderate at the surface in all the profiles except in profile 3 which was low. The total N was only high at the surface in profile 2 while low in all the profiles. This was due to the accumulation of litter fall at the surface as reported by Ajiboye *et al.*[19]. This is an indication that a lot of anthropogenic activities have taken place at the surface. According to Saha and Handique[20] land cover acts as a factor for variation in soil organic carbon as different plants produce different quantity and quality of litter.

Table 5: Chemical properties of the pedons

	Mapping unit														
Depth	pH	OC (%)	TSN (%)	P in soil (mg kg^{-1})	TEA (Cmol kg^{-1})	Ca (Cmol kg^{-1})	Mg (Cmol kg^{-1})	Na (Cmol kg^{-1})	K (Cmol kg^{-1})	ECEC (Cmol kg^{-1})	Bsat (%)	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
0-14	7.7	1.50	0.10	10.58	0.5	2.06	1.51	0.23	0.22	4.53	88.95	0.017	7.17	8.82	1.237
14-42	7.8	0.27	0.01	4.79	0.5	0.84	0.67	0.25	0.06	2.32	78.43	0.142	4.34	5.68	1.650
42-88	7.8	0.27	0.01	3.24	0.6	0.96	0.93	0.21	0.06	2.76	78.30	0.115	1.76	1.45	1.734
88-133	7.8	0.31	0.01	3.10	0.4	1.43	1.25	0.25	0.09	3.43	88.33	0.153	2.30	1.40	1.477
133-197	7.8	1.66	0.11	3.81	0.6	1.25	1.04	0.27	0.08	3.23	81.45	0.098	1.59	2.05	1.387
0-7	7.3	2.97	0.21	21.57	0.5	1.98	1.50	0.36	0.40	4.73	89.44	0.068	8.58	8.20	2.509
7-37	7.6	0.27	0.01	3.24	0.8	1.12	0.83	0.21	0.14	3.10	74.21	0.169	4.21	4.52	2.216
37-114	7.5	1.04	0.07	9.17	0.5	1.38	0.99	0.27	0.12	3.25	84.62	0.159	2.80	1.89	1.903
114-159	7.5	1.85	0.13	8.04	0.5	1.69	0.92	0.23	0.11	3.45	85.49	0.144	4.52	0.92	1.601
159-198	7.4	0.15	0.00	2.82	0.5	1.47	1.13	0.27	0.11	3.47	85.60	0.148	1.69	0.94	1.250
0-14	7.5	0.27	0.01	11.28	0.8	0.92	0.68	0.18	0.08	2.66	69.89	0.118	3.19	1.51	1.787
14-30	7.5	0.69	0.04	5.36	0.5	0.91	0.99	0.20	0.21	2.81	82.18	0.385	6.75	3.71	2.054
30-110	7.3	1.31	0.09	3.10	0.4	1.25	1.01	0.20	0.16	3.02	86.76	0.143	2.58	0.41	1.344
110-168	7.7	0.39	0.02	2.82	0.3	1.67	0.87	0.18	0.13	3.15	90.47	0.134	4.09	0.36	1.489
0-11	7.6	1.23	0.08	8.32	0.6	2.33	1.18	0.23	0.16	4.51	86.70	0.022	9.64	6.67	2.371
11-26	7.6	2.35	0.16	6.49	0.5	1.45	0.79	0.20	0.09	3.03	83.50	0.028	4.87	5.81	1.061
26-79	7.6	1.93	0.13	3.53	0.4	1.25	1.04	0.18	0.12	2.98	86.58	0.129	3.26	1.51	0.515
79-138	7.5	1.31	0.09	0.14	0.4	2.20	1.65	0.23	0.12	4.60	91.31	0.024	3.14	0.53	1.211
138-173	7.6	1.77	0.12	1.55	0.6	1.94	1.99	0.23	0.08	4.84	87.60	0.224	2.56	0.27	0.397

OC: Organic carbon, TSN: Total nitrogen, P: Phosphorus, TEA: Exchangeable acidity, Ca: Calcium, Mg: Magnesium, Na: Sodium, K: Potassium, Bsat: Base saturation and ECEC: Effective cation exchange capacity

Table 6: Suitability class scores and aggregate suitability of the representative pedons for cassava

Profile No.	Annual rainfall (mm)	Mean annual temp (°C)	Topography slope (%)	Net (w) drainage	Soil physical characteristics Texture/ structure	Soil pH	OC (%)	Parametric square root method Actual	Parametric square root method Potential	Linear method Actual	Linear method Potential
P1	S12(95)	S12(95)	S1(100)	S1(100)	S1(95)	S3(95)	S3(85)	S1fs	S1s	S1	S1
P2	S12(95)	S12(95)	S1(100)	S1(100)	S1(100)	S3(100)	S3(85)	S1f	S1s	S1	S1
P3	S12(95)	S12(95)	S1(100)	S1(100)	S1(195)	S3(95)	S3(85)	S1fs	S1s	S1	S1
P4	S12(95)	S12(95)	S1(100)	S1(100)	S1(85)	S3(85)	S3(85)	S1fs	S1s	S1	S1

S1 and S12: Highly suitable, S3: Marginally suitable and OC: Organic carbon

Land suitability evaluation (LSE): According to Sys *et al*.[13] for tropical soils, the matching of the land qualities/characteristics of the pedons with the land requirements of the crop (Table 1) produced the various suitability classes for the various crops given in Table 6. From the matching, using the square root and linear methods of parametric approach, the result showed that the soils are highly suitable for cassava production for both actual and potential status of the soil.

CONCLUSION

Dependence on cassava as a staple food in Nigeria is on the increase and land is now being encroached for the production of cassava without suitably evaluating to ascertain whether the land is suitable for cassava or otherwise. This research evaluated some land for this purpose and the conclusion was that all mapping units geo-referenced were found to be highly suitable for cassava production and therefore safe for commercial purpose.

SIGNIFICANCE STATEMENT

The study was necessary due to the fact that it addressed the improper use of land. A larger percentage of farmers have not yet imbibed the culture of land evaluation for its proper use as most fertile land has rather been used for other interests. The main result submitted- that the researched land was suitable for the use to which it will be subjected to.

RECOMMENDATIONS

Nutrient availability in the soil is the bedrock for any crop to thrive. Although the soil was suitable for commercial production of cassava, the nutrients status of the soil may not be enough to sustain future projection as regard cassava cultivation, it is therefore recommended that perennial suitability evaluation of the land be done to ascertain the actual nutrient status and for the area with low nutrient status, organic materials should be incorporated during tillage operation in order that the organic carbon and the exchangeable bases may be improved.

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