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Land Evaluation for Selected Crops in Some Quartzite Schist Derived Soils in Ibadan, South Western Nigeria

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ABSTRACT

In ensuring the proper use of land in any area, there must be sufficient information on the type and distribution of soil, the limitations and the suitability of soils in that area for the purpose for which it is to be used. This is achieved by carrying out land evaluation which is the end product of soil resource survey. The suitability of the land in the Teaching and Research Farm of the University of Ibadan for sugarcane, groundnut and yam was investigated in this study. A detailed survey was carried out in the TRF. A rigid grid (80×100m) method of survey was adopted in which observation points were predetermined in a GIS environment. Similar examination points were grouped together to form mapping units which were further examined with modal soil profiles. Soil samples collected from genetic soil horizons and surface soils were subjected to analysis for physical and chemical properties using standard laboratory procedures. Soil classification was carried out according to the USDA Soil Taxonomy System and were correlated with the World Reference Base (WRB) and local series classification systems. Suitability evaluation was by Parametric and Non- Parametric methods. Three mapping units were identified in the study area. These were classified as Inceptisols (Cambisols) and Alfisols (Lixisols). The suitability evaluation of the soils for the cultivation of sugarcane indicate that the soils are all marginally suitable (S3) at both actual and potential for sugarcane. The soils ranged from moderately suitable (S2) to marginally suitable (S3) for the actual suitability rating but ranged from highly suitable (S1) to marginally suitable (S3) for the potential suitability. For the cultivation of yam, the soils are marginally suitable (S3) for the actual suitability rating while it ranged from moderately suitable (S2) to marginally suitable (S3) in the potential suitability for yam. Soil fertility, wetness and textural conditions were the identified limitations to the use of the land area for the cultivation of these crops. For the successful cultivation of sugarcane, groundnut and yam in the study area, it is recommended that soil management practices such as the application of fertilizer, organic manures should be adopted to supply deficient nutrients while improved drainage of the soils is also required.

Keywords: land evaluation, soil characteristics, sugarcane, Groundnut, yam, land suitability

INTRODUCTION

Land is an abundant natural resource that makes up the solid surface of the earth and is the most important natural resource of any region or country (Orimoloye and Akinbola, 2013). The FAO (1985) defines land as any delineable area of the earth's terrestrial surface, involving all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil, the terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), near-surface layers and associated ground water and geohydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water shortage or drainage structures, roads, buildings, etc.). Soil is an important component of land and it is essential in sustaining the activities of living organisms and human survival. Soil is normally considered as the fine earth which covers land surfaces as a result of the *insitu* weathering of rock materials or the accumulation of mineral matter transported by water, wind, or ice (Nortcliff *et al.,* 2006). According to FAO, soil can also be defined as a natural body consisting of layers (soil horizons) that are composed of weathered mineral materials, organic material, air and water. The soil can be studied for its physical and chemical properties, it also can be described and mapped with its origin and formation discovered. An understanding of soil properties and processes is important in planning the use of land.

Demand for land for agricultural purpose is increasing globally implying a limitation in land resource (Abah, 2013). This is because of the increasing world population and climate change which has caused changes in the soil and therefore the land. Land evaluation correlates soil survey information, climate, vegetation and other aspects of land with the specific use for which land is evaluated (Manikandan *et al.*, 2013). Land evaluation is a part of the land use planning process. In land evaluation, the suitability of a land for a specific purpose is assessed and classification of the land for that purpose also occurs. In suitability assessment, the limitations of the land for a specific use is also considered. According to FAO 1976, land evaluation is formally defined as 'the assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation. Land evaluation is the process of predicting the use potential of land on the basis of its attributes (Rossiter, 1996). An evaluation of the suitability of land for alternative kinds of use requires a survey to define and map the land units together with the collection of descriptive data of land characteristics and resources (FAO, 2007).

Sugarcane (*Saccharum officinarum*) is a tall perennial grass of the family Poaceae which is propagated primarily by cuttings. Sugarcane is adapted to tropical and sub-tropical regions but it is grown mostly in the Northern part of Nigeria. Sugarcane is grown mostly for the sugar obtained from it but it has other by-products which include ethanol which is used as biofuel, molasses which is a by-product of sugarcane juice extraction. Sugarcane is considered the most important sugar crop in the world as most of the sugar produced are obtained from sugarcane. Groundnut (*Arachis hypogaea*) (also known as peanut) is a legume crop belonging to the family Fabaceae and widely cultivated the tropical and sub-tropical regions of the world. Groundnut is grown mostly in the Northern part of Nigeria. Groundnut products like oil and cake accounted for a significant percentage of total Nigerian export earnings (Ajeigbe *et al.,* 2015). Groundnut has contributed greatly to the development of Nigeria's economy and is popular across Nigeria and evidence of this can be seen in the famous Kano Groundnut Pyramid of the 50's and 60's (Ibrahim *et al.*, 2013, Zhigila, 2014). Yam (*Dioscorea spp*) is an annual crop grown for its tubers which are consumed in various forms. Yam belongs to the family Dioscoreaceae and there are several species belonging to this family and those commonly cultivated and consumed in Nigeria include *Dioscorea rotundata* (white yam), *Dioscorea* *alata* (water yam), *Dioscorea cayenensis* (yellow yam). Yam is grown in tropical regions and is produced mostly in West Africa, where it is a major cash crop, but can also be grown in Latin American and Caribbean countries (Verter, 2015). Yam is important in the socio-cultural activities of Nigeria, but like other crops, there are constraints to yam production in Nigeria such as soil degradation among many others (Verter, 2015, Adeyemo, 2016).

In Nigeria, the production of sugarcane is unsteady and irregular and much is not known about the evaluation of the land and soils of the sugarcane producing regions of the country. Although, Nigeria was once the leading producer of groundnut globally, its production dropped after shift in focus from agriculture to oil. Land evaluation information on groundnut cultivation, like sugarcane, is not sufficient. Nigeria is the largest producer of yam in the world but yam production is declining due to several factors such as declining soil fertility, high labour cost, among others. As much as yam is cultivated in Nigeria, land or soil evaluation is rarely carried out before production commences. There is the need for sufficient information and a soil database for these crops in order to find ways of increasing productivity and improve yield. The objectives of this study are therefore to identify and classify soils of the study area, evaluate the suitability of the soils of the study area for sugarcane, groundnut and yam production.

MATERIALS AND METHODS

Description of the Study Area

This study was carried out at the Teaching and Research Farm of the University of Ibadan which is located at the northern end of Ibadan. The study area occupied a land area of about 15.7 hectares. The area is located within the coordinates of latitude 07.45557° N – 07.855207°N and longitude 03.61202°E – 03.89372° E. The land area is situated close to the Botanical Garden of the University of Ibadan and separated from the Ajibode community by the River Ona. The location and soil map of the study site are as shown in Fig.1

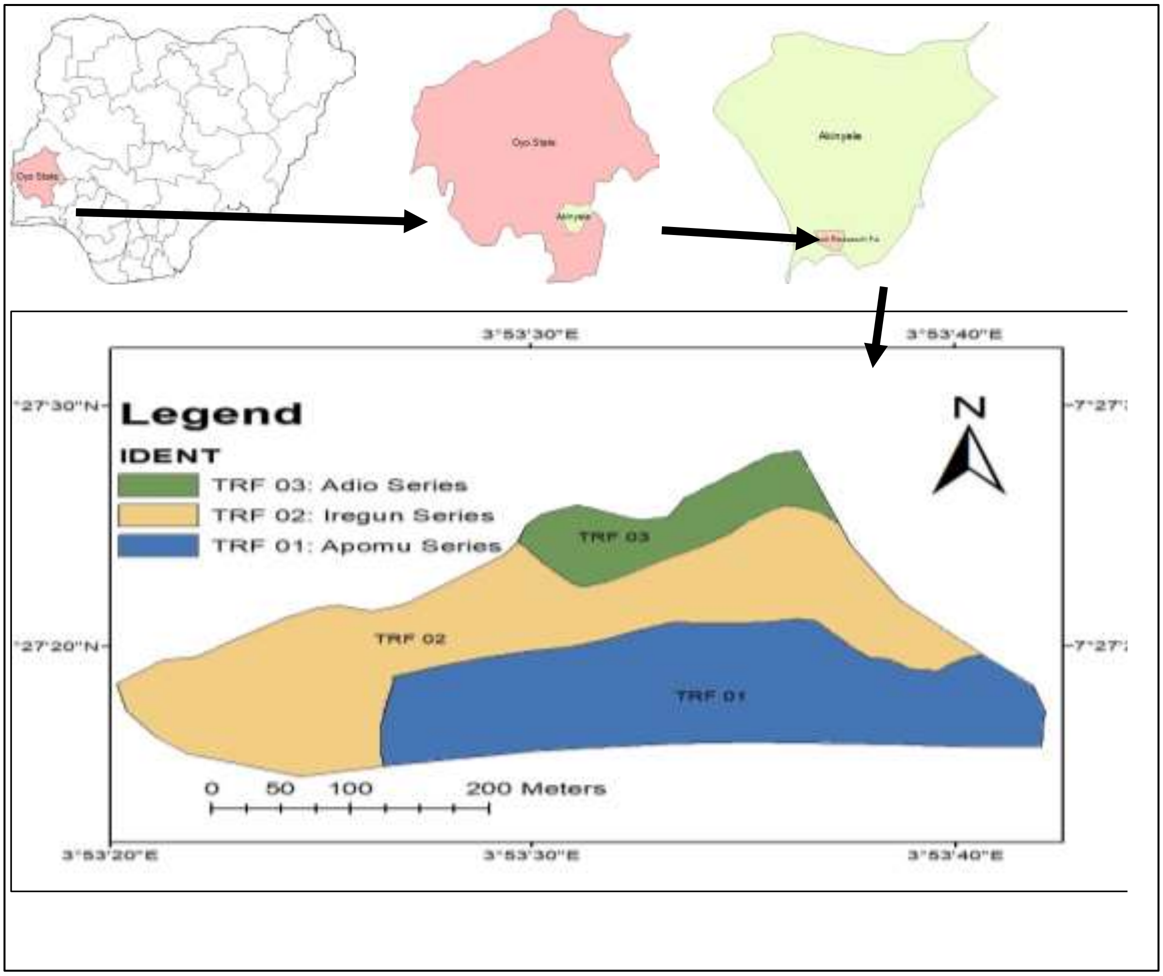

Fig. 1: Location and soil map of the study site

The climate of the area is designated as sub-humid with mean annual rainfall between 1200-1800 mm and two distinct seasons which are the dry season occurs between December and February and rainy season occurs between March and November. The mean annual temperature ranges from 21.9°C to 32.5°C. The study area lies within the northern fringe of the rain forest zone (Orimoloye *et al.*, 2019) with the original rainforest vegetation giving way to a derived savanna due to continuous cultivation. The geology comprises of metamorphic rocks belonging to the pre-Cambrian basement complex and the major rock types found in the area include banded gnesis alternating with strata of quartzite and quartz schist (Orimoloye *et* al., 2019).

Field Survey A rigid grid method of soil survey was used with transects 80m× 80m apart laid. Examination points were predetermined and coordinates were pre-loaded into a Global Positioning System (GPS) device. Identification observations of the soils were made using soil auger at each observation point at depths of 0-30, 30-45, 45-60 and 60-90 cm (where feasible) with soil morphological properties such as texture, colour, consistency examined. Variations in the observed morphological properties in the auger examination points were used to delineate the soils into mapping Units. Each mapping unit was further examined in detail by sinking modal profiles to depths ranging 110cm to 145cm.

Soil Sampling. A total of 3 soil profiles were dug at the Teaching and Research Farm and they were described according to FAO guidelines. Soil genetic horizons were sampled and undisturbed core samples were also collected at the genetic horizons for the determination of some soil physical properties (bulk density).

Composite soil samples were also taken at 4 different land use types (fallow land, organic farm, arable land and non-accessible land), using the soil auger, for total and organic carbon determination. A total of 26 soil samples were collected for laboratory analysis.

Laboratory Analysis: Profile and composite soil samples collected from the field were air dried, crushed and passed through 2 mm plastic and 0.5 mm mesh sieves for physical and chemical analysis. The soils were analyzed for particle size using hydrometer method, pH using glass electrode pH meter, Total Nitrogen by Micro-kjhedahl method, Organic carbon using the chromate wet oxidation method, Available P, exchangeable bases and exchangeable acidity using standard procedures as described in Methods of soil analysis, Part 3 Soil Chemistry (1996). The gravel content (portion of the soil sample greater than 2 mm in diameter) was calculated as a percentage of the total air-dried soil.

Soil Classification: The identified soil types in the study area were classified using the systems recognized internationally which are the USDA Soil Taxonomy (Soil Survey Staff, 2014), the World Reference Base (WRB) System (FAO/IUSS, 2014) and the Local classification system (Smyth and Montgomery, 1962). The taxonomic classifications were done based on the morphological and chemical properties of the soils as observed in the profile pits. The morphological and chemical properties of the soil were found from the field and laboratory data respectively.

Land Evaluation Method: The suitability of the soils of the study area for the cultivation of sugarcane, groundnut and yam was evaluated using the FAO Land Suitability Evaluation according to the revised FAO framework (FAO, 2007). The suitability criteria adopted for each crop, was modified from Sys (1993) as shown in Tables 1, 2 and 3

Table 1: Land requirements for suitability classes for sugarcane

Land qualities	S1 (100)	S2 (85)	S3 (60)	N1 (40)	N2 (25)
Climate (c)					
Annual rainfall (mm)	>1600	1100-1600	800-1100	<800	-
Topography (t)					
Slope (%)	0-2	2-5	5-12	>12	-
Wetness (w)					
Drainage	Well drained	Moderately well drained	Fairly well drained	Poorly drained	poor and not drainable
Soil physical properties (s)					
Texture	C, L, SCL,	SiCL, SL	SiC, LS	C (%	Cm, SiCm,

	SiL, Si, CL, L			clay≥65), G, SC, S, AC	S, cS
Coarse fragments (vol%)	0-3	15-35	35-55	-	>55
Soil depth (cm)	>100	50-100	25-50	<25	-
Soil fertility (f)					
Apparent CEC (cmol/kg)	>24	<16(-)	<16(+)	-	-
Base saturation (%)	>80/50-80	50-35	<35	-	-
Organic carbon (g/kg)	>25	15-10	<10	-	-
	>15	10-6	<6	-	-

Source: (Sys *et al.*, 1993); (Orimoloye *et al.*, 2020) S1= highly suitable, S2= moderately suitable, S3= marginally suitable, N1= temporarily not suitable, N2= permanently not suitable; Cs= structural clay, Cm= massive clay, SiC= silty clay, SiCL= silty clay loam, CL= clay loam, Si= silt; L= loam, SCL= sandy clay loam, SL= sandy loam, LfS= loam fine sand, fS= fine sand, S= sand, G= Gravel soil

Table 2: Land requirements for suitability classes for groundnut

Land qualities	S1 (100)	S2 (85)	S3 (60)	N1 (40)	N2 (25)
Climate (c)					
Annual rainfall	700-1000	500-700	350-500	<350	-
Mean temperature in growing season(°C)	24-30	22-23 31-33	20-21 34-40	<20 >40	<10
Topography (t)					
Slope (%)	<3	3-5	5-10	>10	
Wetness (w)					
Drainage	Well drained	Mod. well drained	Imperfectly drained	Poorly drained	Poor, not drainable
Soil physical characteristics (s)					
Texture	LS,SCL,SL	CL, SCL	S, SC, SiC	C	Cm, SiCm
Coarse fragment (vol %)	<35	35-50	>50	-	-
Soil depth (cm)	>100	75-100	50-75	<50	<25
Soil fertility characteristics (f)					
Apparent CEC (cmol/kg)	>12	6-12	4-6	<4	-
Base saturation (%)	>80	50-80	40-50	<40	-
Organic carbon (g/kg)	>12	8-12	5-8	<5	-

Source: (Sys *et al* ., 1993); (Ahukaemere *et al.*, 2015) and (Meena *et al.*, 2018). S1= highly suitable, S2= moderately suitable, S3= marginally suitable, N1= temporarily not suitable, N2= permanently not suitable; Cs= structural clay, Cm= massive clay, SiC= silty clay, SiCL= silty clay loam, CL= clay loam, Si= silt; L= loam, SCL= sandy clay loam, SL= sandy loam, LfS= loam fine sand, fS= fine sand, S= sand

Table 3: Land requirements for suitability classes for yam

Land qualities	S1 (100)	S2 (85)	S3 (60)	N1 (40)	N2 (25)
Climate (c)					
Mean annual rainfall (mm)	1000-750	750-600	600-550	550-500	<500
Mean annual temperature (°C)	25-35	20-25	15-20	<15	<15
Topography (t)					
Slope (%)	0-5	5-12	12-20	>20	>20
Wetness (w)					
Drainage	Well drained	Moderately drained	Imperfectly drained	Poorly drained	Very poorly drained
Soil physical characteristics (s)					
Texture	L, SCL, CL, SL, SiCL, SiC	Cs, LfS, LS, CS, ,fS	CS, S, Cs	SC, Cm	Cm, S
Soil depth (cm)	>100	100-75	75-50	<50	<50
Soil fertility (f)					
Apparent CEC (cmol/kg)	>16	16-10	<10	<5	<5
Base saturation (%)	>35	>15	15-10	<10	<10
Organic carbon (g/kg)	>15	>8	>5	<3	<3

Source: Eze, 2014, Asadu *et al.*, 2017 and Usman *et al.*, 2020 S1= highly suitable, S2= moderately suitable, S3= marginally suitable, N1= temporarily not suitable, N2= permanently not suitable; Cs= structural clay, Cm= massive clay, SiC= silty clay, SiCL= silty clay loam, CL= clay loam, Si= silt; L= loam, SCL= sandy clay loam, SL= sandy loam, LfS= loam fine sand, fS= fine sand, S= sand

The parametric and non-parametric approach was used to assess the suitability of the mapping units. For the non-parametric approach, the Liebig's law of the minimum is used in which the suitability class of a mapping unit is indicated by its most limiting characteristics.

In the parametric approach, each limiting characteristic was rated using the criteria presented in Tables 3.1 to 3.3 for sugarcane, groundnut and yam respectively. Table 3.4 shows the ratings of limiting factors and suitability index of land quality for parametric suitability evaluation and the Index of Suitability (IS) for each profile pit was calculated using the equation:

$$IP = A \times \sqrt{\frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100}}$$

Where: IP = Index of Productivity; A = Overall lowest characteristic rating; B, C, D, E = The lowest characteristic ratings of each land quality group.

The five land quality groups used in this evaluation are climate (c), soil physical characteristics (s), topography (t), fertility (f) and wetness (w). Only one member in eachgroup was used for calculation purpose because there are usually strong correlations among members of the same group. For actual suitability index, all the lowest characteristic ratings for each land qualities group were substituted into the index of suitability equation above. For potential suitability index, it was assumed that the corrective limitation observed will no longer have such constraints.

Results and Discussion

Three mapping units were identified and described by soil profiles in the study area. The soil map of the study area is presented in Fig. 4.1. The taxonomic classification, morphological properties, physical properties and chemical properties of the soils of the study area are presented in Table 4.1, 4.2, 4.3 and 4.4 respectively. The three soil types were classified at series level as Aponmu, Iregun, and Adio series respectively. The soil type distribution of the study area was observed to have been influenced by the physiographic position. Older soils (Alfisols) occur at the upper slope while younger soils (Inceptisols) occur at the valley bottom and lower slope positions at the site.

The three soil mapping units identified were coded with TRF 01, TRF 02 and TRF 03 respectively. The soils of TRF 01 mapping unit are identified as Ustic Kandihaustalf in the USDA Soil Taxonomy or Haplic Lixisol in the WRB. This mapping unit is situated at an upper slope of the topography. It has a profile thickness of 145cm and the soils were found to be well drained. The parent material of the soil of this mapping unit is Quartzite-schist. The texture of the soil ranges from sandy at the surface horizon and from sandy to sandy loam in the sub-horizon. The very high sand content of the soils could be attributed to their quartzite parent materials. The colour of the soil range from very dark brown (10YR 2/2, moist) at the top to strong red (7.5 YR 5/6, moist) at the lower part of the profile. The pH ranges from 7.33-7.90 which shows that the soils are slightly neutral contrary to the ranges of 4.5-9.1 reported for Oyo by Aizebeokhai *et al*. (2018). The ECEC value at the surface horizon is medium (12.92 cmol/kg), while that of subsurface horizons were lower ranging from 3.99 to 12.08 cmol/kg. The low ECEC may be related to low organic matter content as high organic matter content has been related with high CEC (Lal and Kang, 1982). The base saturation values are generally high, ranging from 83.87-93.97 %. The soils of Mapping Unit TRF 02 were identified as Humic Eutrudept in the USDA Soil Taxonomy or Eutric Cambisol in the WRB. This mapping unit is situated at a lower slope of the topography. It has a profile thickness of 120cm and the soils were fairly well drained. The texture of the soil ranges from sandy at the surface horizon and from loamy sand to sandy at the subsurface horizon. The colour of the soil range from very dark brown (7.5YR 2.5/2, moist) at the top to brown (7.5YR 5/4, moist) at the lower part of the profile. The pH of the soils of this mapping unit range from 7.07 to 8.29. The ECEC value at the surface horizon is very low (5.86 cmol/kg), while the subsurface horizon ECEC values range from very low to low (4.67-7.48 cmol/kg). The base saturation values are generally high, ranging from 86.35- 94.44 %. The textural class of this mapping unit alternated between sandy and loamy sand.

Table 4: The Taxonomic Classification of each mapping unit of soils of the study area

Mapping Unit	USDA Soil Taxonomy(Soil Survey Staff, 2014)	WRB System (FAO/IUSS, 2014)	Local Classification (Smyth and Montgomery, 1962)
TRF 01	Udic Kandihaustalf	Haplic Lixisol	Apomu series
TRF 02	Humic Eutrudept	Eutric Cambisol	Iregun series
TRF 03	Fluvaquentic Endoaquept	Eutric Fluvisol	Adio series

Table 5: Morphological properties of the soils of the study area

Profile No.	Horizon	Depth (cm)	Colour	Mottle	Field texture	structure	consistency	Boundary
TRF 01	OA	0-10	10YR 2/2	-	SL	Crumbs	friable	SC
	A	10-44	7.5YR 4/4	-	S	Crumbs	friable	Wavy
	B	44-55	7.5YR 2.5/3	-	S	Crumbs	friable	SC
	Bt1	55-76	5YR 4/4	-	LS	Crumbs	loose	Diffuse
	Bt2	76-106	5YR 4/4	-	LS	sbk	firm	Diffuse
	Bt3	106-145	7.5YR 5/6	-	LS	sbk	v. firm	-
TRF 02	Ap	0-16	7.5YR 2.5/2	-	S	Crumbs	friable	SC
	AB	16-56	10YR 3/6	-	LS	Crumbs	friable	SC
	Bw1	56-78	7.5YR 5/4	-	LS	Crumbs	loose	Diffuse
	Bw2	78-120	7.5YR 5/4	-	LS	Crumbs	loose	-
TRF 03	A	0-30	10YR 3/3	-	SL	massive	firm	Wavy
	Bw	30-46	10YR 3/4	Many	SC	massive	firm	Wavy
	Aob	46-71	10YR 3/3	-	L	massive	firm	SC
	Bwb	71-110	10YR 4/6	-	S	massive	friable	-

TRF- Teaching and Research Farm, SL=Sandy loam; S= Sandy; LS= Loamy sand; SC= Sandy clay; L= Loam, Sbk= sub angular blocky, SC= Smooth clear.

Mapping Unit TRF 03 was identified as Fluvaquentic Endoaquept in the USDA soil taxonomy and Eutric Fluvisol in the WRB system. The mapping unit is found at a valley bottom of the topography. It has a profile thickness of 110cm and the soils are poorly drained. The parent material of the soil found in this mapping unit is Alluvium. The soil texture ranges from loamy sand at the surface horizon to sandy loam and loamy sand at the subsurface horizon. The colour of the soil range from dark brown (10YR 3/3, moist) at the top to dark yellowish brown (10YR 4/6, moist) at the lower part of the profile. The pH ranges from 6.91- 8.00 and the ECEC value at the surface horizon is medium at 16.99 cmol/kg, while the ECEC values for the subsurface horizons range from low to very low with the lowest ECEC value found at the lowest horizon at (5.52 cmol/kg). The base saturation values are generally high, ranging from 85.51-96.18 %.

Land Suitability Evaluation for Sugarcane: **T**he suitability class scores and classification of the study area for sugarcane with the non-parametric suitability evaluation (actual and potential) and parametric suitability evaluation (actual and potential) are presented in Table 8. For non-parametric (actual) evaluation, mapping units TRF 01 and TRF 03 are both currently not suitable for sugarcane cultivation. Wetness (w) is identified as the limitation for mapping unit TRF 03. It is difficult to ameliorate the identified constraints in the mapping units (wetness (w) is not easily corrected due its cost implication), hence the potential suitability evaluation for these mapping units remain N1 with both mapping units TRF 01 and TRF 03 retaining their limitations of soil physical characteristics (s) and wetness (w).

Table 6: Physical properties of the soils of the study area

Profile No.	Horizon	Depth (cm)	Bulk Density (g/cm3)	Gravel content (%)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural class
TRF 01	OA	0-10	1.09	23.22	896	50	54	S
	A	10-44	1.75	48.34	941	13	46	S
	B	44-55	1.62	45.47	941	2	57	S
	Bt1	55-76	1.72	47.47	934	8	58	S
	Bt2	76-106	1.65	59.50	821	20	159	SL
	Bt3	106-145	1.57	45.65	824	37	139	SL
TRF 02	Ap	0-16	1.36	50.27	914	28	58	S
	AB	16-56	1.54	50.23	850	90	60	LS
	Bw1	56-78	1.91	47.98	901	37	62	S
	Bw2	78-120	1.91	45.14	848	70	82	LS
TRF 03	A	0-30	1.11	66.36	852	88	60	LS
	Bw	30-46	1.17	35.94	801	97	102	SL
	AOb	46-71	1.39	28.87	841	97	62	LS
	Bwb	71-110	1.25	10.88	896	50	54	SL

Mapping unit TRF 02 is marginally suitable for sugarcane cultivation with the soil physical characteristics (s) and wetness (w) identified as the limitations. It is difficult to ameliorate the identified constraints in the mapping unit, hence the potential suitability evaluation for this mapping unit remain S3 and the limitations are retained. The climate of the study site is favourable for sugarcane cultivation. A mean annual rainfall of 1200-1800mm at the study site is ideal for sugarcane cultivation considering the recommended 1100-1600 mm/year for sugarcane cultivation (Sys *et al*., 1993; Orimoloye *et al*., 2020, Riajaya, 2020). The soils of the three mapping units are generally deep enough for sugarcane cultivation, however the depth of TRF03 could be limiting due to possible water logging especially under heavy rainfall and flood prone conditions. The soil texture of the soils of the three mapping units are not ideal for sugarcane cultivation as they range from sandy to sandy loam, sandy to loamy sand and loamy sand to sandy loam respectively and clay-loam and loam soils are considered best for sugarcane production (Mubashir *et al*., 2018). While TRF01 soils were well drained, the TFR02 and TFR03 soils were fairly-well drained and poorly drained respectively. Thus in the case of current aggregate suitability, wetness is the most limiting characteristic in terms of drainage for the study site. therefore rated as marginally suitable for sugarcane production. They could, however, be made suitable through fertilizer application, especially organic amendments, and good residue management practices. The aggregate suitability ratings of the soils from TRF01 were low due to the soil physical characteristics in terms of the texture of the soils. The high sand content of these soils would predispose them to excessive leaching of nutrients and poor moisture retention.

Table 7: Chemical properties of the soils of the study area

Mapping Unit	Horizon	Depth (cm)	pH	OC	TN	Avail P	EA	Ca	Mg	Na	K	ECEC	BS	ESP	Mn	Fe	Cu	Zn
				g/kg		mg/kg		cmol/kg					(%)	(%)	mg/kg			
TRF 01	OA	0-10	7.8	24.42	0.56	96.3	0.4	7.51	3.82	0.27	0.92	12.92	97.29	2.16	73.46	37.64	1.33	32.36
	A	10-44	7.9	7.4	1.96	39.3	1.1	3.14	1.71	0.23	0.64	6.82	83.87	4.02	19.45	15.78	1.73	6.24
	B	44-55	7.3	8.88	2.24	21.7	0.4	2.33	1.00	0.23	0.49	4.45	91.01	5.68	14.98	17.1	1.78	4.06
	Bt1	55-76	7.3	6.66	2.24	11.7	0.4	1.98	0.73	0.24	0.64	3.99	89.97	6.69	11.35	13.85	1.12	2.3
	Bt2	76-106	7.4	7.4	2.24	4.3	0.6	6.70	1.31	0.91	2.56	12.08	95.03	7.93	13.76	17.62	1.99	3.04
	Bt3	106-145	7.4	8.14	1.68	2.0	0.2	6.23	1.32	0.34	1.59	9.68	97.93	3.59	12.48	17.11	1.64	2.37
TRF 02	Ap	0-16	7.1	27.75	2.24	11.4	0.8	2.84	1.33	0.23	0.66	5.86	86.35	4.55	16.97	12.85	1.34	3.33
	AB	16-56	7.4	11.1	1.96	11.1	0.3	2.75	1.03	0.18	0.41	4.67	93.58	4.12	14.32	37.26	1.27	2.73
	Bw1	56-78	8.3	8.88	2.24	13.3	0.4	4.83	1.27	0.20	0.49	7.19	94.44	2.95	19.01	22.69	0.75	8.22
	Bw2	78-120	8.2	8.14	2.24	4.7	0.5	3.15	2.70	0.29	0.84	7.48	93.32	4.15	11.21	9.28	0.85	1.67
TFR 03	A	0-30	8.0	28.12	2.52	15.3	0.9	13.54	1.89	0.23	0.43	16.99	94.70	1.43	111.12	278.35	0.2	94.21
	Bw	30-46	7.3	14.80	1.96	8.7	0.4	8.45	1.14	0.26	0.23	10.48	96.18	2.58	23.76	488.45	7.09	45.13
	Aob	46-71	6.9	16.65	1.40	14.7	0.6	8.21	1.06	0.35	0.90	11.12	94.60	3.33	35.62	201.13	8.9	85.26
	Bwb	71-110	7.1	12.21	1.96	19.8	0.8	3.29	0.69	0.25	0.49	5.52	85.51	5.30	22.03	197.89	4.18	35.56

The soils from TRF01 were Also, supplementary water supply through provision of appropriate irrigation would improve the suitability of the soils from TFR01. The aggregate suitability of TRF02 were also low due to the soil physical characteristics in terms of the texture of the soils and wetness in terms of drainage. Similar to the soils of TRF01, the high sand content can predispose them to leaching and poor moisture retention. The drainage of TRF02 would need to be improved for optimal sugarcane production at the site. The soils from TRF02 were therefore rated as marginally suitable for sugarcane production. Suitability ratings of the soils from TRF03 were low due to the wetness in terms of drainage. Similar to the soils of TRF01 and TRF02, the high sand content can predispose them to leaching and poor moisture retention. The soils of TRF03 are poorly drained and would need to be improved for optimal sugarcane production at the site. The soils from TRF03 were therefore rated as marginally suitable for sugarcane production

Land Suitability Evaluation for Groundnut: The suitability class scores and classification of the study area for groundnut with the non-parametric suitability evaluation (actual and potential) and parametric suitability evaluation (actual and potential) are presented in Table 9. For non-parametric (actual) evaluation, mapping unit TRF 03 is currently not suitable for groundnut cultivation with wetness (w) identified as the limitation. Wetness (w) is not easily ameliorated due to its cost implications, hence the potential suitability evaluation remains (N1) with wetness being the limitation. Mapping units TRF 01 and TRF 02 are marginally suitable for groundnut cultivation with the soil physical characteristics (s) and fertilty (f) being their limitations respectively. The identified constraint for mapping unit TRF 01 is not easily ameliorated, hence the potential suitability evaluation for this mapping unit remains (S3) and the limitation is retained. If the identified constraint for mapping unit TRF 02 is improved upon, the potential suitability evaluation for this mapping unit becomes (S2) with wetness (w) being the limitation which is not easily ameliorated due to cost implications. For parametric (actual) evaluation, mapping unit TRF 03 is marginally suitable (S3) with suitability index of 36.88 (S3), and a corresponding potential suitability index (SIp) of

40.00 (S3). TRF 01 and TRF 02 are moderately suitable (S2) with suitability index of 55.32 (S2) and 51.00 (S2) respectively and a corresponding potential suitability index (SIp) of 60.00 (S2), 85.00 (S1) respectively.

When climatic requirements for groundnut were matched with the land quality of the study area, all the soils were highly suitable. A mean annual rainfall of 1200-1800mm at the study site is ideal for groundnut cultivation considering the recommended 700-1000 mm/year for groundnut cultivation (Meena *et al*., 2018). Soil physical characteristics that were considered for groundnut cultivation were soil depth, texture.

Table 8: Suitability Class Scores and Classification of the study area for Sugarcane

	Mapping Units		
Land qualities	TRF 01	TRF 02	TRF03
Climatic factor (c)			
Annual Rainfall (mm)	S1(100)	S1(100)	S1(100)
Soil physical characteristics (s)			
Soil depth (cm)	S1(100)	S1(100)	S1(100)
Texture	N1(40)	S3(60)	S2(85)
Topography (t)			
Slope (%)	S1(100)	S2(85)	S2(85)
Fertility (f)			
Base saturation (%)	S1(100)	S1(100)	S1(100)
CEC (cmol/kg)	S2(85)	S2(85)	S2(85)
Organic carbon (g/kg)	S2(85)	S1(100)	S1(100)
Wetness (w)			
Drainage	S1(100)	S3(60)	N1(40)
Non parametric			
Actual	$N1_s$	$S3_{sw}$	$N1_w$
Potential	$N1_s$	$S3_{sw}$	$N1_w$
Parametric			
Actual	S3(36.88)	S3(26.34)	S3(31.35)
Potential	S3(40.00)	S3(46.48)	S3(36.88)

S1= highly suitable, S2= moderately suitable, S3= marginally suitable, s= soil physical properties, c=climate, f= fertility

Table 9: Suitability Class Scores and Classification of the study area for Groundnut

	Mapping Units		
Land qualities	TRF 01	TRF 02	TRF03
Climatic factor (c)			
Annual Rainfall (mm)	S1(100)	S1(100)	S1(100)
Mean annual temperature (°C)	S1(100)	S1(100)	S1(100)
Soil physical characteristics (s)			
Soil depth (cm)	S1(100)	S1(100)	S1(100)
Texture	S3(60)	S1(100)	S1(100)
Topography (t)			
Slope (%)	S1(100)	S1(100)	S1(100)
Fertility (f)			
Base saturation (%)	S1(100)	S1(100)	S1(100)
CEC (cmol/kg)	S2(85)	S3(60)	S1(100)
Organic carbon (g/kg)	S1(100)		
Wetness (w)			
Drainage	S1(100)	S2(85)	N1(40)
Non parametric			
Actual	S3s	S3f	N1w
Potential	S3s	S2w	N1w
Parametric			
Actual	S2(55.32)	S2(51.00)	S3(36.88)
Potential	S2(60.00)	S1(85.00)	S3(40.00)

S1= highly suitable, S2= moderately suitable, S3= marginally suitable, s= soil physical properties, c=climate, f= fertility

Soil depth is highly suitable for groundnut cultivation at the three mapping units and soil texture varies from marginally suitable in TRF01, and highly suitable in both TRF02 andTRF03. The texture of the soils of TRF02 and TRF03 (sandy- loamy sand and loamy-sand – sandy-loam) makes the soil highly suitable for groundnut production (Sys *et al.*, 1993). Generally, the slope of 0-2% and 2-6% found in the mapping units in this study are highly suitable for groundnut cultivation (Sys *et al*., 1993; Ahukaemere *et al*., 2015; Meena *et al*., 2018). In terms of soil wetness (drainage), the results of matching the crop requirements with land characteristics shows that soils from TRF01 are highly suitable for groundnut production, soils from TRF02 are moderately suitable while soils from TRF03 are unsuitable for groundnut production. From the results of the current aggregate suitability, soils from TRF01 and TRF02 are marginally suitable for groundnut cultivation while the soils from TRF03 are not suitable for groundnut cultivation. The major land characteristic limiting groundnut cultivation is wetness. The aggregate suitability ratings of the soils from TRF03 were low due to the wetness in terms of drainage. The soils of TRF03 are poorly drained and would need to be improved for optimal groundnut production at the site. The soils from TRF03 were therefore rated as marginally suitable for groundnut production.

4.5 Land Suitability Evaluation for Yam: The suitability class scores and classification of the study area for yam with the non-parametric suitability evaluation (actual and potential) and parametric suitability evaluation (actual and potential) are presented in Table 10. For non-parametric (actual) evaluation, mapping unit TRF 03 is currently not suitable for yam cultivation with wetness (w) identified as the limitation. Wetness (w) is not easily ameliorated due to its cost implications, hence the potential suitability evaluation remains (N1) with wetness being the limitation. Mapping units TRF 01 and TRF 02 are marginally suitable for yam cultivation with the soil physical characteristics (s) and fertilty (f) being the limitations for TRF 01 and fertility (f) being the limitation for TRF 02. If some the identified constraint for mapping unit TRF 01 is ameliorated, the potential suitability evaluation for this mapping unit remains (S3) with soil physical characteristics (s) left as the only limitation which may not be easily ameliorated. If the identified constraint for mapping unit TRF 02 is improved upon, the potential suitability evaluation for this mapping unit becomes (S2) with climate (c), soil physical characteristics (s) and wetness (w) being the limitations which are not easily ameliorated due to cost implications. For parametric (actual) evaluation, mapping units TRF 01, TRF 02 and TRF 03 are marginally suitable (S3) with suitability index of 42.85(S3), 47.02(S3) and 34.00(S3) respectively and a corresponding potential suitability index (SIp) of 55.32 (S2), 72.25(S2) and 36.88(S2) respectively.

When climatic requirements for yam were matched with the land quality of the study area, all the soils were highly suitable. A mean annual rainfall of 1200-1800mm at the study site is ideal for yam cultivation considering the recommended 750-1000 mm/year for groundnut cultivation (Asadu *et al*., 2017). Soil physical characteristics that were considered for yam cultivation are soil depth and texture. Soil depth is highly suitable for yam cultivation at the three mapping units and soil texture varies from marginally suitable in TRF01, moderately suitable in TRF02 and highly suitable in TRF03. The texture of the soils of TRF03 (loamy-sand – sandy-loam) makes the soil highly suitable for yam production (Eze, 2014; Asadu *et al*., 2017; Usman *et al.*, 2020). Generally, the slope of 0-2% and 2-6% found in the mapping units in this study are highly suitable for yam cultivation (Eze. 2014). In terms of soil wetness (drainage), the results of matching the crop requirements with land characteristics shows that soils from TRF01 are highly suitable for yam production, soils from TRF02 are moderately suitable while soils from TRF03 are unsuitable for yam production. From the results of the current aggregate suitability, soils from TRF01 and TRF02 are marginally suitable for yam cultivation while the soils from TRF03 are not suitable for yam cultivation. The major land characteristic limiting yam cultivation are soil texture as an aspect of soil physical characteristics, soil fertility measured by CEC and wetness measured by drainage.

Conclusion: The study site is marginally suitable for sugarcane production, moderately and marginally suitable for groundnut production and marginally suitable for yam production. Wetness is the major limitation to the suitability of the soils of the study area for sugarcane, groundnut and yam production in the study site. Climate is not a constraint to the production of the selected crops in the study site. Soil management practices and corrective measures like application of organic manures, fertilisers can be used to correct the problem of fertility encountered. The problem of poor drainage can be corrected by adding lots of organic matter to the soil which will allow it to drain more easily and hold the appropriate amount of water. Further studies should be carried out in the study area to determine the effects of soil management practices to be employed for sugarcane, groundnut and yam production.

REFERENCES

Abah, R. (2013). Importance of Agricultural Land Use Evaluation in Nigeria: A Review of Literature. Agricultural Journal. 8. 262-275.

Adeyemo, A., Sodiq J.R., and Obaisi, A. (2016). Economic assessment of yam production among yam farmers: a case study of Ekiti state, Nigeria. International Journal of Agriculture and Food Science. volume 6.

Ahukaemere, C., Ekpe, I. and Unachukwu, I.C. (2015). Suitability evaluation of soils derived from dissimilar lithological materials for maize and groundnut production in Owerri agricultural zone, southeastern Nigeria. Malaysian Journal of Soil Science. 19. 73-82.

Aizebeokhai, A., Okenwa, U., Oyeyemi, K., Kayode, O., Adeyemi, G. (2018). Soil characterization using satellite in southwestern Nigeria: Implications for precision agriculture. IOP Conference Series: Earth and Environmental Science. 173. 012027. 10.1088/1755-1315/173/1/012027

Ajeigbe, H.A., Waliyar, F., Echekwu, C.A., Ayuba, K., Motagi, B.N., Eniayeju, D and Inuwa A. 2015. A Farmer's Guide to Groundnut Production in Nigeria. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 36 pp.

Asadu, L. A. *et al.*, (2017). Comparison of the Suitability of Contiguous Fallow-forest Lands for Cassava, Yam, Cocoyam and Sweet Potato Production in Nsukka, Southeastern Nigeria. *Path of Science, [S.l.]*, 3 (1): 1.1-1.12, ISSN 2413-9009.

Eze, N.C. (2014). Soil characterization and land suitability evaluation of Anuka farmland in Nsukka local government area of Enugu state, Nigeria. A dissertation submitte in partial fulfilment of the requirements for the award of the degree of Master of science (M.Sc) in soil science (soil survey, classification and land use management).

FAO, (1976). A framework for land evaluation. Soil Resources Management and Conservation Service Land and Water Development Division. FAO Soil bulletin 52 (72). FAO-UNO, Rome. pp 19

FAO, (1985). Guidelines: Land evaluation for irrigated agriculture. Soils bulletin 55. Food and Agriculture Organization of the United Nations.

FAO, (2007). Land evaluation: towards a revised framework. Land and water discussion paper 6. FAO, Rome.

FAO/IUSS (2014). World reference base for soil resources 2006. 3rd edition, World Soil Resources Reports No 103. FAO, Rome.

Ibrahim, U., Ayinde, B.T., Dauda, H. and Mukhtar, A.A. (2013) Socio-Economic Factors Affecting Groundnut Production in Sabongari Local Government of Kaduna State, Nigeria. International Journal of Food and Agricultural Economy, 1, 41-48.

Lal, R and Kang, B.T. (1982). Management of organic matter in soils of the tropics. In: Soil Management Abstract, 1(2): 152-178

Manikandan, K., Pandian, K., Mariappan, S. and Devi, G.V. (2013). Concepts on land evaluation. e-Journal Earth Science India. 6. 20-26.

Mubashir, J., Raihan, A. and Haroon, S. (2018). Land suitability assessment for sugarcane cultivation in Bijnor district, India using geographic information system and fuzzy analytical hierarchy process. GeoJournal. 83. 10.1007/s10708-017-9788-5.

Nortcliff, S., Hulpke, H., Bannick, C., Terytze, K., Knoop, G., Bredemeier, M., Schulte-Bisping, H., Auerswald, K., Litz, N., & Mayer, R., Stoy, A., Alef, K., Kerndorff, H., Crössmann, G., Eikmann, T., Franzius, V., Grimsky, D., Möhlenbruch, N., Storm, P., Dworshak, U. (2006). Soil, Definition, Function, and Utilization of Soil. 10.1002/14356007.b07_613.pub2.

Orimoloye, J. R. and Akinbola, G. E (2013). Evaluation of some sandstone derived soils of southern Nigeria for rubber (*Hevea brasiliensis*) cultivation. *Nigerian Journal of Soil Science* 23 (2): 252 – 263

Orimoloye, J. R., Adegbiji A. O. and Akinbola G. E. (2019). Soil properties and suitability evaluation for current agricultural land use types in Ibadan, South-West Nigeria. *Journal of Food, Agriculture and Environment.*17 (3 & 4): 54 - 64

.

Orimoloye, J. R., Nkwocha, H. U. and Adamu, I. (2020). Assessment of inland valley soils for sugarcane (*Saccharum officinarum* L.) production in some floodplains in central Nigeria. *Agricultura Tropica Et Subtropica*, 53(2), 81–92, 2020

Riajaya, P.D. (2020). IOP Conference Series: Earth and Environmental Science, Volume 418, 1st International Conference on Sustainable Plantation (1st ICSP 2019) 20–22 August 2019, IPB International Convention Center, Bogor, Indonesia**.**

Rossiter, D. G. (1990).A theoretical framework for land evaluation, Geoderma, Volume 72, Issues 3–4, 1996, Pages 165-190, ISSN 0016-7061. https://www.sciencedirect.com/science/article/pii/0016706196000316)

Smyth, A. J. and Montgomery, R. F. (1962). Soils and land use in central Western Nigeria. Government Press, Ibadan. 265

Soil Survey Staff, (2014). Keys to soil taxonomy (12th Edition). USDA Natural Resources Conservation Service, Washington, D.C

Sys, C. (1985). Land Evaluation. International Training Centre for postgraduate soil Scientists Vol I & II. State University, Ghent

.Sys, C., Van Ranst, E., Debaveye, J., and Beernaert, F. (1993). Land Evaluation Part III: Crop Requirements. Agricultural publication and ITC Ghent.

Verter, N. (2015). An Analysis of Yam Production in Nigeria. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 63. 659-665. 10.11118/actaun201563020659.

Zhigila, D. (2014). Traditional preparations and uses of groundnut in Nigeria. Annals. Food Science and Technology