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Soil Characterization and Suitability Evaluation for Yam (*Dioscorea spp*) Production in the Polytechnic Bali Research Farm, Taraba State, Nigeria

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Abstract
The soil of Teaching and Research farm of the Polytechnic Bali of Taraba State, Nigeria were characterized and evaluated for suitability rating for yam production. Three soil units I, II and III were identified based on the morphological, physical and chemical characteristics of the soil using grid method of soil survey. The soil were very deep (14 cm – 200 cm), well drained with sandy loan surface texture and sandy clay loam subsurface texture. The soil reaction was moderate to slightly acidic (5.1 – 6.3) with moderate to high exchangeable bases (0.21 cmol/kg – 3.85 cmol/kg), medium to high organic carbon (0.5 % - 0.7 %). Low total N (0.12 % - 0.13 %), moderate P (7 mg/kg – 19 mg/kg) and high base saturation (51.6 % - 59.59 %) with moderate to high CEC (15.38 cmol/kg – 19.64 cmol/kg). The soil properties were match with the requirement of yam and the overall suitability rating of the soil were asses based on the factors and limitations. Soil unit I and III were rated non- suitable (N) for yam production due to the stony surface, high slope gradient and several rills while unit II were considered moderately suitable (S2) as result of depth of the soil, texture (sandy loam) and moderate nutrient status of the soil.

Introduction

Soil characterization and fertility evaluations are key in production of crop that identify and qualify the soil containing the essential nutrients needed by the plant for maximum yield Massawe et al., (2017). The process of estimating the potential of land for various alternative use is termed land evaluation. Dent and Young, 1981 and according to FAO frame work for land evaluation stated that the process of assessing land performance for specified purpose involving the execution and interpretation of surveys and study of landforms, soil, vegetation, climate and other aspect of land in other to identify and make a comparison of promising kinds of land use in term applicable to the purpose of evaluation. Obasi et al., (2017). The suitability assessment of land is the estimation of land or soil for crop production which involves a wide range of criteria including climatic factor, soil characterization and landform, identifying land use options and the most suitable managerial solutions for high yield of crops (Belal et al,.2015, El Baroudy et al,.2020). Soil evaluation inform farmer on the suitability of their land for specific kind of use and its limitations which is done by matching the qualities of soil and its characteristic with the requirements of the envisaged use Obasi et al., (2017). Low yield of crop due to lack of correct matching of crops requirements with the soil properties may lead to food losses and poor economic growth. Correct information about the properties of the soil impact greatly in the management of the soil and its suitability rating for crop (Ogbu et al,.2022)

Land suitability assessment is the process of evaluating the suitability of soils for specific kind of use. It deal with matching of crop (Yam) requirement and other environmental factors with the quality of land on the growth and yield of crop. This is aim at increasing the sustainable productivity in the traditional way of using land where a specific portion or location is set aside for a particular crop that performs better in a particular location of the land.(Ufot et al., 2021, Ogbu et al,. 2022). In evaluating the suitability of soil for the production of crops, certain nutrients are required by the plant for maximum yield. (ogbu et al,.2022, Ogunwale et al,.2002) and the need to understand these requirement in the context of limitations imposed by land form and other features that are not part of the soils but may likely impact significantly on the use of the soil. The morphological soil requirement for the production of Yam including a well – drained sandy loam or loamy soils, high temperature of 25^{oc} – 30^{oc}, rainfall of 120 cm – 180 cm per annum spread across the first six months of its growing period, abundant sunshine and pH of 4.5 – 7.7 (Ogbu etal,.2022). and the nutrient requirement indicate that yam respond significantly well under Nitrogen and Potassium fertilizer but respond slightly to phosphorus as a result of a significant removal of P by yam in the soil and partly due to the soil use for yam production are naturally rich in Phosphorus.

Nigeria is the leading producer of yam in West African sub region with 45,004 million tons of yam annually. Yam provide more than 200 dietary calories per day for more than 60 million people in Nigeria. The production of yam is affected by many factors including soil fertility (Bassey E.E, 2017). This crop is the only crop which is usually celebrated during and after harvest, called yam festival (Ugwu, 1996). Yams are also important as sources of pharmaceutical compounds like saponins and sapogenins, which are precursors of cortisone and steroidal hormones (Okonkwo, 1985). Apart from the fertility status of soil and the textural class, yam yield is a function of other factors including depth, soil moisture and porosity. Therefore the objective of this study is to evaluate the suitability of soil in the polytechnic research farm for the production of yam and characterized the soils according to the USDA Soil Taxonomy and the World Reference Base (WRB) for Soil resources

Materials and Methods

Site Location

The study was carried out on the students Teaching and Research Farm of the Department of Agricultural Technology, Federal Polytechnic Bali, Taraba State, Nigeria. The study area is between Latitude 7^0 12'N to 9^0 00N of the equator and Longitude 10^0 00E to 12^0 00E of the meridian, it has a land mass of 10000 km2 and lies within the Guinea savannah ecological zone of Nigeria. This area has been under intensive production before the establishment of the polytechnic in 2008 up to date. The annual rainfall ranges from 750mm to 1100mm with the temperature ranges between 22^0C – 35^0C.

Field Study

The grid method of surveying soil was used in teaching and research farm of the polytechnic. The auger points examined were done at an interval of 100 m along transverse at 100 m apart on the baseline. Because of these investigation, three soil unit were established and two profile pits were excavated in each. The pits were describe according to the guideline for soil profile description (Soil survey staff 2014).

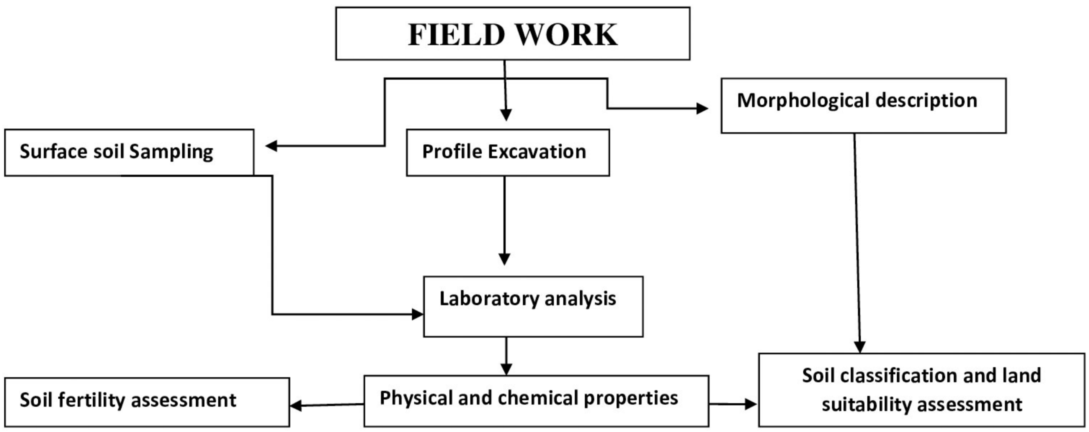

Fig 1: The graphical representation of how soil samples were collected from the field and laboratory analysis carried out.

Laboratory Analysis

Soil samples were air-dried and crushed with pestle and mortar, fine earth separate was obtained by passing the soil samples through a 2 mm sieve which was transported for analysis at the Federal University of Technology Akure, Ondo state, Nigeria for the determination of chemical and physical properties following the standard procedures. Particle size distribution analysis was done using the Hydrometer Method of (Wang *et al*, .2022). The bulk density was determine using the clod method of Liu *et al. (2020*). The (PH) soil reaction determination was carried out using 1: 1 water ration in glass electrode PH meter (Zhou *et al*, 2022) .soil organic carbon was determine using the method of He et al.(2022). The total Nitrogen was calculated by the use of macro kjeldhal digestion method (Hicks et al, 2022), the method describe by Lin et al,.2022, was used to determine the available phosphorus while the exchangeable cations ($Ca2+$,$Mg2+$, $K+$ and $Na+$) were determined using the Ammonium acetate saturation method by Zhao et el,.(2020). The effective Cation Exchange Capacity (ECEC) was calculated by adding total exchangeable Bases and total exchangeable acidity, and % Base

Saturation was calculated by expressing the total exchangeable bases as a function as a function of cation exchange capacity while the percentage base saturation of the soil was calculated by the use of the below formula:

BS (%) = Echangeable bases / Cation Exchange Capacity x 100

Results and Discussion

Morphological Characteristic of the Soil.

The morphological characteristic of soils examined in the study area consist of soil colour, texture, depth, structures, consistency and presence of roots. (Table 1). The soil in (unit I) covered about 30 % of the research farm of the polytechnic with soil depth of > 67 cm containing cataclassic rocks at the surface horizon. The texture of the soil is sandy loam that is well drained and have a dominant hue of 10 YR, form of level to undulating slope. The structure of the soil is moderate sub angular blocky which is friable in consistency and an abundant roots inclusion of the soil. Soils in units II middle slope account for 32 % of the study area. The soil are deep with loamy surface underlain by sandy clay loam subsoil with dark greyish brown colour (7.5 4/6). The structure of the soil were moderate fine sub angular blocky with the presence of mottle at the surface horizon and the soil is well drained having abundant roots inclusion at the surface and is non sticky when wet. The upper slope (soil unit III) covered 38 % of the study area and are characterized with sandy loam surface texture and the structure is generally fine coarse sub angular blocky. The soil are well drained at the surface while the presence of mottle at the subsurface is an indication that this portion is seasonally water logged and the dark brown colour (7.5 Y/R 4/8) surface soil could be as a result of the presence of organic matter as the most influential colouring agent in the surface soil. (Peter et al., 2022). This also collaborate with the findings of Peter and Umweni (2020), Peter et al., 2021) Peter et al., 2022). Who reported that dark soils colouration was as result of the presence of organic matter and the degree of pedogenic activities (illuviation and eluviation in the soil is considered factor in the colouration matrix of each soil, very sticky and plastic when wet.

Table: 1 Morphological properties of soils in the study area

Soil units	soil depth	colour	texture	structure	consistency	Roots
1	0 -14	10YR3/4	SL	1sbk	friable	Abundant root
	14 -28	10YR5/6	LS	2sbk	friable	less root
	28 -49	10YR6/8	SCL	3sbk	friable	no root

	49 -67	10YR6/4	SCL	2abk	friable	no root
	67 -104	10YR5/2	SCL	2abk	friable	no root
	104 -200	7.5YR5/8	SL	sbk	friable	no root
II	0 -19	10YR4/4	SL	1fsbk	friable	Abundant roots
	19 -28	10YR5/6	SL	2fbk	friable	Abundant root
	28 -49	10YR3/2	L	1abk	very friable	no root
	49 -67	10YR5/2	SCL	2fbk	friable	on root
	67 -104	10YR5/3	SCL	2abk	friable	no root
	104 -200	7.5YR4/6	SCL	2abk	friable	no root
III	0 -18	10YR5/6	LS	1abk	friable	Abundant root
	18 -28	10YR4/3	SL	1sbk	friable	Abundant root
	28 -49	10YR6/4	SL	1sbk	friable	less root
	49 -67	10YR4/4	SCL	2abk	friable	no root
	67 -104	7.5YR4/8	CL	2fsbk	no friable	no root
	104 -200	7.5YR4/6	SCL	2fsbk	friable	no root

Remarks: sl = sandy loam, scl = sandy clay loam, ls = loamy sand, l = loamy, s = sandy, 2fsbk =fine sub angular blocky, sbk = sub angular blocky, csbk = coarse sub angular blocky, fbk = fine blocky, 1 = weak, 2 = moderate, 3 = strong.

Physical and Chemical Properties of Soil

Soil texture in unit I and III contains finer texture compare to unit II as indicated in (table 2**).** The clay content ranges from (21 % - 29.7 %). The silt fraction did not show any definite pattern of distribution among the topography position. This is also in line with the findings of Idoga et al, 2005 soil in savannah zone of Nigeria. The chemical properties of soils in the study area are represented in table 3 and 4. The soil reaction (pH) in water ranges from moderately to slightly acidic when compared to the rating by chude et al., (2011). Soil unit I and II had soil pH (H2O) ranges from (5.3 - 6.2) and (5.3 - 6.3) indicating a moderate to slight acidic nature of the soils which are in line with the assertion of Awanish et al, 2014. This is also true of the work done by Danladi et al, .2019 in Bali that the soil is strongly acidic in (KCl). The acidic nature of the soils in the study area could be as a result of parent material, extensive weathering and leaching of the soil. According to Brady and Weil (2010) a pH range of 5.5 to 7.0 is the preferred range for the overall satisfactory availability of plant nutrients in the soils. The exchangeable acidity is less indicating that the acidity cannot be a threat to the soils studied. Soils in unit I, II and III had average organic Carbon of 0.7 %, 0.6 % and 0.5 % respectively table 3. This shows that the level of organic carbon of the soils studied was medium to high which was in agreement with the finding of Danladi et al, .2019. The level of organic Carbon observed at the surface of all the pedons ranges from 1.1 % to 1.4 % compare to the subsurface 0.2 % to 0.5 %. These could be as a result of deposition of organic materials on the soil surface leading to an increase in the level of organic carbon at the surface of soil horizons. The total Nitrogen (0.1 % – 0.13 %). The values were rated very low when compared to the available standard as reported by peter and Aaron (2019). Similar result of low values of Nitrogen was reported by danladi et al (2019) in Bali, Nigeria. The values of total Nitrogen in the soils changes irregularly with the depth, which may be as a result of the influence of continuous farming practices in the area occasioned by the removal of crop residues and burning of the organic matter. Soil available phosphorus (7 mg/kg – 13.1mg/kg). Level of available P in the soils studied were in medium condition when compare to the rating by Esu (1991) which are within the minimum critical level required for the optimum productivity of crops as recorded by petel et al (2021). Total exchangeable bases are slightly low (0.21 cmol/kg – 3.85 cmol/kg) in all the soils as a result of high weathering intensity and low organic C which reduce their ability to hold cations in exchangeable form.(Ogbu et al,.2022) The cation Exchange Capacity (CEC) of the soils were medium to high as indicated in appendix 1 by Esu (1991) rating of < 6 is low, 6 – 12 is medium and > 12 is high. The higher average of CEC (15.38 cmol/kg - 19.64 cmol/kg) table 4 was as a result of the medium to high exchangeable bases and the mineralogical composition of the parent materials. The variation in the value of CEC as observed in all the pedon may also be attributed to the variability in the mineralogy of the parent materials.

Soils in the study locations has the average base saturation value of (51.60 % - 69.90 %) table 4. According to FAO (1999), soils with base saturation of > 50 %

are regarded as fertile soils while those with the value less than (< 50 %) are considered as not fertile. Therefore, soils of the studied area are regarded as fertile soils.

Table: 2. Physical properties of soils in the study area

Horizon	Depth (cm)	Sand (g/kg)	silt (g/kg)	clay (g/kg)	TC	Drainage	BD (g/cm^3)
AP	0 -14	74	10	16	SL	well drain	1.21
AB	14 -28	74	9	17	LS	well drain	1.12
Bt1	28 -49	73	10	17	SCL	well drain	1.52
Bt2	49 -67	49.5	23.4	27.1	SCL	well drain	1.61
Bw1	67 -104	50.5	23.4	26.1	SCL	well drain	1.61
Bw2	104 -200	45.7	26.4	27.9	SCL	well drain	1.63
	Mean	**58.54**	**18.44**	**23.02**			
AP	0 -19	49.5	24.5	26	SL	well drain	1.31
AB	19 -28	40.3	25.2	34.5	SL	well drain	1.31
Bt1	28 -49	41.8	32.5	25.7	L	well drain	1.61
Bt2	49 -67	42.9	29.5	27.6	SCL	well drain	1.64
Bw1	67 -104	42.5	29	28.5	SCL	well drain	1.79
Bw2	104 -200	45.7	26.4	27.9	SCL	well drain	1.73
	Mean	**43.8**	**27.9**	**28.4**			
AP1	0 -18	52.5	26.4	21.1	LS	well drain	1.21
AP2	18 -28	49.5	24.4	26.1	SL	well drain	1.21
AB	28 -49	48.5	23.9	27.6	SL	well drain	1.42
Bt1	49 -67	47.9	22.6	29.5	SCL	well drain	1.41
Bt2	67 -104	49.8	25.5	29.7	CL	well drain	1.52
Bw1	104 -200	47.7	23.3	29	SCL	well drain	1.61
	Mean	**48.98**	**23.9**	**27.2**			

Table 3. Chemical properties of soil in the studied area

Depth	soil pH	OC	TN	Av.P	
(cm)	H2O	KCl	%	%	mgkg-1
0 14	6.2	4.9	1.4	0.1	10.5
14 -28	5.3	5.1	0.8	0.2	9.7
28 -49	5.8	4.7	0.8	0.1	13.1
49 -67	6.1	4.8	0.2	0.1	7.5
67 -104	6.0	5.2	0.3	0.1	7.0
Average	**5.9**	**4.9**	**0.7**	**0.12**	**10**
0 -14	6.1	5.0	1.1	0.2	10.2
14 -28	5.2	4.6	0.9	0.2	10.2
28 -49	5.8	4.7	0.7	0.1	12.8
49 -67	5.9	5.2	0.4	0.1	7.0
67 -104	6.3	4.8	0.1	0.1	6.8
104 -140	5.5	4.9	0.1	0.1	6.9
	5.8	**4.9**	**0.6**	**0.13**	**9.0**
0 -17	5.9	5.1	1.0	0.1	11.5
17 -28	6.0	4.8	0.9	0.1	14.8
28 -54	6.2	5.1	0.5	0.2	13.5
54 -67	5.8	4.7	0.3	0.1	7.3
67 -120	5.8	4.9	0.2	0.1	7.1
120 -190	6.2	4.8	0.2	0.1	7.2
Average	**6.2**	**4.9**	**0.5**	**0.1**	**10.2**

Table 4: Exchangeable Acidity, Exchangeable Bases, Cation Exchange Capacity and Base Saturation of soils in the studied area

Depth	Horizon	Exchangeable	cmol(+) kg^{-1}			PBS %		
(cm)		Acidity	Ca	Mg	K	TEB	CEC	
0 – 14	AP	0.52	3.78	1.75	0.15	6.05	12.15	54.65
14 -28	AB	0.35	4.99	1.20	0.17	6.28	9.30	76.82

28 -49	Bt1	0.49	3.38	2.85	0.21	5.80	10.59	72.71
49 -67	Bt2	0.76	3.25	1.63	0.23	5.76	28.10	73.81
67 -104	Bw1	1.05	3.85	1.77	0.27	6.25	16.75	18.76
	Mean	**0.63**	**3.85**	**1.84**	**0.21**	**6.03**	**15.38**	**59.35**
0 – 14	AP	0.57	3.72	1.73	0.17	6.02	12.13	50.62
14 -28	AB	0.34	4.90	1.22	0.19	6.23	9.32	76.85
28 -49	Bt1	0.44	3.34	2.83	0.24	5.85	10.51	72.71
49 -67	Bt2	0.72	3.21	1.61	0.22	5.73	28.10	70.83
67 -104	Bw1	1.01	3.82	1.74	0.21	6.21	16.74	18.71
104 -200	Bw2	1.12	3.73	1.65	0.24	6.32	13.34	19.87
	Mean	**0.71**	**3.79**	**1.80**	**0.21**	**6.06**	**15.02**	**51.60**
0 – 17	AP	0.52	3.75	1.75	0.15	6.01	11.15	52.65
17 -28	AB	0.35	4.34	1.20	0.17	6.18	10.30	74.82
28 -54	Bt1	0.49	3.28	2.85	0.21	5.60	12.59	69.71
54 -67	Bt2	0.76	3.25	1.63	0.23	5.36	28.10	70.81
67 -120	Bw1	0.67	3.32	1.58	0.24	5.47	28.14	77.76
120 -190	Bw2	0.62	3.23	1.43	0.34	5.28	27.54	73.65
	Mean	**0.57**	**3.53**	**1.74**	**0.22**	**5.65**	**19.64**	**69.90**

Soil Classification

The soils were categorized base on the latest laid down criteria in Key to Soil Taxonomy USDA/ Soil Survey Staff (2020) and World Reference Base for Soil Resources (peter,2018). Soil Classification was done at order, suborder, Great group and Subgroup level using some of the following characteristics of soil including Morphological, Physical and Chemical properties of the soils studied. Most surface pedons of I, II and III in the study area were thin 14 cm to 19 cm having a colour value 3 to 6 with chroma 3 – 5, organic carbon ranged from 0.9 to 1.4 with the percentage base saturation in NH4OAC varied from 59.35 % to 69.90 % table 4. With all these properties in place therefore, the epipedons were regarded as an Ochric epipedon for I and II with Umbric horizon in III. According to WRB, when the organic carbon is (> 0.6 %) with the chroma of 3 and a value of 2 – 3, base saturation of more than (>50 %). Hence, the soil profile in the study area are considered having Mollic Epipedons and III with less organic carbon (< 0.6 %), the value 3 with the 28 cm thickness is placed as an Umbric surface horizon

In I, the subsurface horizon was underlying a coarse textured surface horizon (Sandy Loam), without lithic, paralithic, desic orpeytroferric contact within the 60 cm mineral surface of the soil. The average CEC of the horizon was 15.38 cmol/kg of soil which is (< 16 cmol/kg). Organic carbon decreased irregularly within the profile and the ratio of clay B/A was 1.16 as such, the characteristic identified, has qualified the subsurface horizon to be classified as Kandic horizon. The presence of kandic horizon, the total base saturation of 54.7% (> 35%), and the overlying epipedon of Sandy loam, an increase in clay content along the profile, the soil is placed into the order of ultisols. Location I falls within the suborder Udelts for possessing udic moisture regime, hence the soil is placed in the great – group Kandiudults. In the subgroup, the soil is within the Arenic Kandiudults and Haplic Acrisols for having a texture class sandy loam, loamy sand, and sandy clay loam layer extending from the mineral soil surface to the top of kandic horizon at the depth of 49 – 104 cm by both USDA and FAO Classification System.

The subsurface horizon of location II and III profiles contains a higher percentage of phyllosicate clay than the overlying soil materials that are evidence of clay illuviation the horizons are form below the surface of the soil that contains the textural class of sandy clay loam which qualifies the subsurface horizon to be Argillic horizon. The average percent base saturation of 51.6 % and 69.9 % (> 35 %), the present of argillic horizon and the overlying epipedon of sandy clay loam with an increase in clay content within the profile, the soils are classified in the order of ultisols. Both FPB II and III has a sub- order of Udalfs for having Udic moisture regime. Therefore, the soils are placed as hapludalfs in the Great – group while in the sub –group level, the soils are classifies as typic Hapludalfs by USDA classification and Abruptic Lixisols by FAO system.

The soil in location I are classified as Cambisols at the Reference Soil Groups (RSGs) because of the presence of Cambic Horizon overlaid by Sandy loam. At the subsurface level, location I is classified as Dystric/ Euric Cambisols for having sandy clay loam textural class. II is classified as Luvisols for having an argic horizon within one hundred and fifty centimetre of the soil surface containing textural class of clayed loam. At the lower level, location II is classified as calcic Luvisols for possessing the morphological properties of loamy sand. The unit III profile is qualified to be placed Lixisols for having argic horizon by (RSGs) at the surface of the soil overlaid by sandy loam. At the lower level, it falls within the Argic Lixisols for possessing a subsurface horizon with a distinct higher clay content than the overlying horizon.

Suitability Rating of Soil for Yam Production

The suitability assessment for agricultural is meant to determine the ability of a piece of land to provide optimal ecological requirement of a particular crop growth and productivity which are the function of other factors including soil conditions, the climate and agricultural practices. Soil have being utilized intensively for all purpose at the expense of its suitability capability thereby resulting in land degradation. Therefore it is necessary to carried out soil suitability evaluation in order to ensure that the selected area is suitable and capable of sustaining production of crop. The suitability rating of soil in the polytechnic research farm was done by comparing the quality of the soil with the requirement of yam. Soil characteristic including organic carbon, OC, CEC, available P, total N, exchangeable bases and pH are necessary for yam production and can also be amended where necessary by the farmers and therefore cannot be considered permanent limitation. Soil depth, drainage, slope, porosity, texture, soil fertility and structure are important physical and chemical properties of soil that influence yam growth, development and yield. Soil unit I and III had a stony surface, high slope gradient (4 – 8 %) and several rills. This factors causes tillage problems and reduce plant root penetration and base on these reasons, the soil is said to have major limitation to yam production. Therefore rated as non – suitable (N) for yam production. Other limiting factors consist of low to medium available P, Total N and organic carbon and a higher CEC and Exchangeable base saturation. This implies that the soil in unit II had medium nutrient status hence, moderately suitable for yam production.

The physical, chemical and morphological characteristic of the soil were considered favourable for yam production, growth and yield. Therefore large number of tubers of yam can be obtained from the soils of the study area and also the depth of the soils and thick surface horizon encourage tillage and tuber elongation. Hence are consider moderately suitable (S2) for yam production which account for 38 % of the area and the individual farmer who cultivate yam need management practices by incorporation and application of fertilizer, erosion control as well as other agronomic practises to improve maximum yield of yam. There is virtually no soil that is completely not useful with little human management, these soils are better use for permanent crop production including oil palm, mango, citrus, cocoa, cashew etc. these plants may take longer time to establish and once established, the soil is stabilized.

Soil can be maximally utilized when their properties are perfectly matched with the crop or other land use type, as such, food loss in term of improper soil use can be handled with such practice and more robust economic growth is guarantee. The suitability rating is carried out in line with the factors of land requirement for yam production and the suitability class score as indicated in Appendix 2 and 3

Conclusion

The suitability rating of soils in teaching and research farm of the polytechnic is to ensure that soil are being use appropriately to avoid food loss through wrong use of land for an improved crop productivity in large quantities. The suitability rating indicate that soils in unit I and III are non-suitable (N) for yam production and those in unit II are moderately suitable (S2) for cultivation of yam. The result indicate that the soils is qualified to be classified as Umbric and Kandic horizons, Ochric and mollic epipedon based on USDA criteria system of classification while the World Reference Base for soil resource (WRB), the soil is placed as Luvisols, Lixisol and Cambisols which are sustained for reasonable Agricultural productivity.

Proper soil management practices including incorporation of organic matter, application of inorganic fertilizer, addition of liming materials that will raise the soil pH and appropriate timing of planting are recommended for an optimum production of yam in the study area

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Appendix I

Critical Limit for Interpreting Fertility Levels of Analytical Parameters for Nigeria Soils

Parameters		**Low**		**medium**	**High**	
Ca2	(cmol kg-1	< 2		2 – 5		> 5
Mg2+	(cmol kg-1	< 0.3		0.3 – 1		> 1
K+	(cmol kg-1	< 0.15		0.15 – 0.3		> 0.3
Na+	(cmol kg-1	< 0.1		0.1 – 0.3	> 0.3	
CEC	(cmol kg-1	< 6		6 – 12		> 12
Org C	(g kg-1)	< 10		10 – 15		> 15
Avail. P	(mg kg-1)	< 10	10 – 20		> 20	
B.S (%)		< 50		50 – 80		> 80

Appendix 2: Factor rating and rating values of soil parameters

Soil parameters	**factor rating**							
	100		**80**		**50**		**20**	**10**
pH (1:2.5, soil water)	6.5 – 7.5	7.6-8.3		5.5-6.4		4.5-5.4	<4.4- >85	
EC (dsm^{-1})	0 -2		2.1-4		4.1-6		6.1-8	>8
SOM (g/kg)	>30		20.1-30	10.1-20	5.1-10	0-5		
TN (g/kg)	>3.29		1.71-3.20	0.91-1.70	0.45-0.90	<0.45		
P (mg/kg)	>89		25.1-80	8.1-2.5		2.4-8.0	<2.5	
Ca (cmol $_{(+)/kg}$)	17.6-50	5.76-17.5	1.19-5.75	>50	<1.19			
Mg (cmol (+) kg -1)	>12.5		4.1- 12.5	1.34-4.0	0.42-1.33	<0.42		
K (cmol (+) kg -1)	0.29-0.74	0.75-2.56	0.13-0.28	>2.56	<0.13			
Na (cmol (+) kg -1)	0.0-20		0.21-0.30	0.31-0.70	0.71-2.0	>2.0		
Soil textural class	CL,SCL,SiCL		vfSL,L,SiC,SC,SiC		SL,Fsl	S, LS		

Chemical property: EC, electrical conductivity, SOM, soil organic matter; TN, total nitrogen; C:N, carbon-to-nitrogen ratio; P, phosphorus; Ca, calcium; Mg, magnesium; K, potassium; Na, sodium; CEC, cation exchange capacity; ESP, exchangeable sodium percentage, BS, base saturation; Textural class: CL, clay loam; SCL, sandy clay loam; SiCL, silty clay loam; vfSL, very fine sandy loam; L, loam; SiL, silty loam; Si, silt; C, clay; SC, sandy clay; SL, sandy loam; Source 48,50

Appendix 3: classes and values of soil fertility index

Class	**soil fertility index**	**Descriptions**
S1	> 80	Good fertility
S2	80 – 51	moderate fertility
S3	50- 20	Marginal fertility
N	< 20	Poor fertility

Source: (saglam and Dengiz, 2014)