JOURNAL of
SUSTAINABLE AGRICULTURE
AND THE ENVIRONMENT

E-mail: jsae@mouau.edu.ng. Website: www.mouau.edu.ng.

Agricultural Potential of Soils Derived from Coastal Plain Sand for Oil Palm (*Elaeis guineensis*) Cultivation in Ikwuano Local Government Area, South Eastern Nigeria.

E. A. Adesemuyi[1] and F. O. Adekayode[2]

[1]*Department of Soil Science and Meteorology, Michael Okpara University of Agriculture, Umudike, Nigeria. E-mail: adesemuyi@yahoo.com* (**08034858583**)

[2]*Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria.*

Abstract

The current food requirements of a rapidly increasing population demand that marginal lands such as the coastal plain sands which have been left under-utilized, be brought under intensive agricultural land use to ensure food security. Thus, this study was carried out to characterize and evaluate the agricultural potentials of the coastal plain sands soils of Ikwuano Local Government Area of Abia State, Nigeria for sustainable food production. Four farming communities were used as study sites. Results from the study showed that the soils were predominantly coarse in texture with moderately acid (pH 5.4 –5.6) top soil over strongly acid (pH 4.0 – 5.0) subsoil. The soils were moderate in the following surface soil fertility parameters: organic carbon content (1.00 - 1.40%), total nitrogen (0.15 – 0.21%), cation exchange capacity (11.25 - 13.62 cmol kg-1), exchangeable K (0.30 - 0.55 cmol kg-1), available phosphorus (10.60 - 15.43 mg kg-1) and base saturation (41 - 49%). The results of land suitability evaluation revealed that the land is currently marginally suitable (S3) for oil palm. Major crop production constraints identified were soil physical characteristics (texture) and fertility (basic cations). Management techniques such as application of organic fertilizers to enhance nutrient holding capacity of the soils and supply the deficient basic cations will raise the productivity of the soils. Regular soil testing for proper fertilizer application is also recommended.

Keywords: Agricultural potential, coastal plain sands, oil palm

Introduction

Land evaluation is an essential part of land use planning upon which proper land management can be carried out. According to Dent and Young (1981), land evaluation assesses the potential of land for alternative uses through systematic comparison of the land use requirements (LURs) with land quality/characteristics. FAO (1984) noted that land evaluation is a complex attribute of land which affects its suitability for specific uses in a distinct way. It assesses the present performance of the land, particularly as this affects changes in the use of land and in some cases changes in the land requirement and qualities (FAO, 1976).

Information on the kinds of soils in an area is obtained through soil survey activities.
Land evaluation thus, interprets these vital information from soil survey, identifies the most limiting land qualities/characteristics, enables the formulation of recommendations for improving specific soil constraints and

provides a good basis for advising farmers on the appropriate management practice for optimum production in a particular agro ecological Zone (Udoh, *et al.*, 2013; Bera, *et al.*, 2014). It enriches the user of the relevant information about land resources that are necessary for planning development and taking management decisions (FAO, 1976).

Land evaluation aims at assessing land quality or suitability for a specific land use.
Oluwatosin, *et al* (2006) reported that soil quality assessment is becoming increasingly popular and is now being used as advisory tools for farmers in the USA. This was attributed to the fact that soil varies in quality and this quality changes in response to use and management and that assessment of soil quality is useful for optimizing land use planning as well as addressing environmental problems. Adequate assessment of soil quality with respect to soil functions such as productivity, environmental quality and animal health will help to identify the main limiting factors for the agricultural production and enable land users, land use planners, and agricultural support services to develop crop management that can overcome such constraints, thereby increasing crop yield (Kappo, *et al.*, 2015).
Oluwatosin *et al* (2006) observed high correlation between soil quality assessment and land evaluation, that the two approaches can be used interchangeably, and the choice between them will depend on other peculiar situations.

The coastal plain sands soils, like other 'acid sands' of south-eastern Nigeria are coarse-textured soils that are fragile, acidic, low in native fertility and high level of leaching consequent upon high rainfall amount and high relative humidity (Enweozor *et al.*, 1990). However, due to the very poor agricultural productivity of these coastal plain sands, they are not intensively cultivated by farmers who seem to regard the areas as marginal lands because of lack of knowledge and appropriate technology for managing them for optimum productivity.

Economic growth and prosperity of oil palm are central to long-term poverty alleviation for social and environmental sustainability. The oil palm industry represents one of the most effective avenues for poverty alleviation, food security and ensuring economic stability in Nigeria. The palm oil industry has the prospects of providing employment for millions of unskilled and semi-skilled people. As demonstrated in other economies, with proper focus on production of commodities of large scale commercial values, improvement in the production of oil palm can effectively mitigate the poverty level in Nigeria (PIND, 2011).

Therefore, due to the very low fertility status of these soils, harsh climatic conditions, proneness to leaching and the dense population they support, there is need for special attention to their proper management for agriculture especially, for oil palm production.
The current shortage of food and the increasing food requirements of the rapidly expanding population necessitate that marginal lands such as the coastal plain sands hitherto left under-utilized, be brought under intensive agricultural land use, and commercially oriented permanent farming.

In view of the above, this study was therefore carried out to evaluate the agricultural potential of the coastal plain sand soils of Ikwuano Local Government Area of Abia South-eastern Nigeria in terms of their fertility capability classification and suitability for the cultivation of oil palm *(Elaeis guineensis).*

Materials and Method

The Study Area

Ikwuano Local Government Area is located around latitudes 5^0 24^1 and 5^0 30^1; longitudes 7^0 31^1 and 7^0 37^1) is located in northern Abia State, Nigeria (Fig. 1). The selected study sites are Umuariaga (covering about 4 ha), Amaoba-Ime (2 ha), Ndoro (3 ha) and Okwe (2 ha). The climate of the area is characterized by tropical humid conditions with a mean annual rainfall of 2000 – 2500 mm, a mean annual temperature of 22 -23^0 C and a mean relative humidity of 80 – 90% at the peak of rainy season (NRCRI, Umudike Meteorological Station, 2013). The parent materials in the area are predominantly coastal plain sands underlain by sedimentary rocks and alluvium (Okoye and Lekwa, 1995).

Field Survey and Data Collection

The study sites were reconnoitered using footpath; boundary demarcations, etc with a view to identifying the various physiographic units, land use patterns and vegetation. Based on the reconnaissance survey and the observed features of the land, the grid method of survey was adopted for the field mapping. Auger point investigations were carried out at depths of 0 – 15, 15 – 30 and 30 - 60 along traverses cut at 100 m apart on the baseline. The soils were described in terms of colour, texture and consistence. General observations on vegetation and land use were also made. Following the establishment of the mapping units, a total of four representative soil profiles were dug; one in each of the selected locations. The coordinates and the altitudes of the profiles were obtained using Garmin Etress 10 GPS meter.

Field characterization of the profiles was carried out following the procedure of Soil Survey Staff (2010). Soil samples were obtained from the pedogenic horizons from base of the profile to avoid cross contamination. The samples were preserved in polythene bags, labelled and taken to laboratory for physical and chemical analysis.

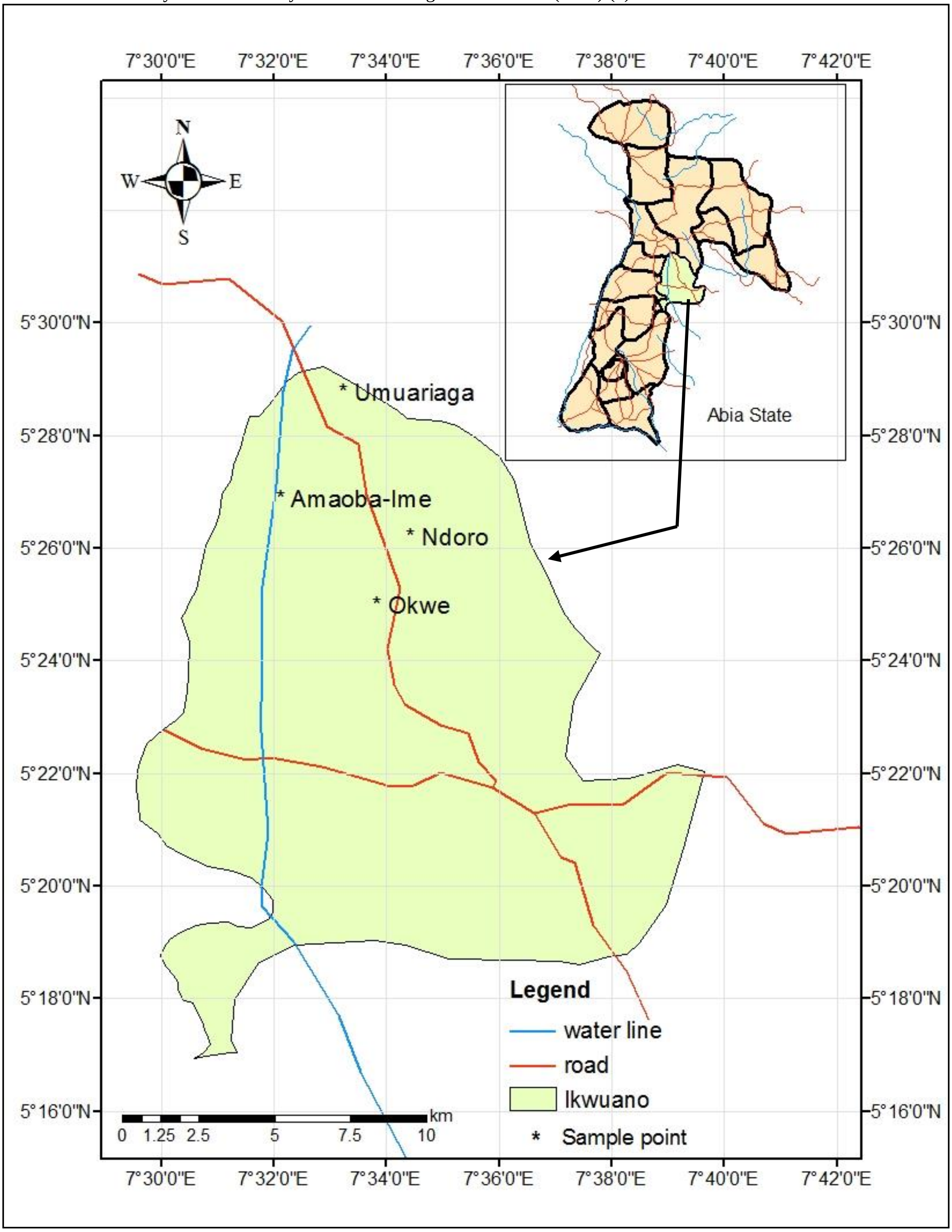

Fig. 1: Map of Ikwuano LGA showing the sampling locations

Laboratory analysis

Soil samples were air-dried under laboratory conditions, and sieved through 2 mm mesh sieve to remove materials greater than 2mm in diameter. The fine earth fractions (< 2 mm) were subjected to routine soil analyses. Following the appropriate standard procedures described by Udo *et al*. (2009), the following parameters were analysed: Particle size distribution (Bouyocous method) using sodium hexa-metaphosphate as dispersant and selenium tablets as catalysts. Soil reaction (pH) was measured potentiometrically in a soil: water suspension (mixed at a ratio 1:2.5 soil: water) using a glass electrode pH meter. Organic carbon was determined from the sieved soil samples (further passed through 0.5 mm sieves) by the dichromate wet oxidation method and converted to organic matter by multiplying by a van Bremner factor of 1.724. Total nitrogen was determined on samples (also passed through 0.5 mm sieve) by the regular mico Kjeldahl method. Available phosphorus was extracted with Bray number 1 solution of HF and HCl and the P in the extract determined spectrophotometrically. The cation exchange capacity (CEC) and exchangeable bases were extracted by saturating soil with neutral 1M KCl and the determined Kjeldahl distillation method for the estimation of CEC of the soils. The bases Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} displaced by NH_4^{+} were measured by Atomic Absorption Spectrometer (AAS). Exchangeable acidity was extracted with 1N KCl and estimated in the extract by titration. Base saturation was obtained by expressing the sum of exchangeable Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} as percentages of the cation exchange capacity. Effective cation exchange capacity (ECEC) was determined as the summation of exchangeable cations (Ca, Mg, K, Na) and exchangeable acidity ($Al^{3+} + H^{+}$).

Land evaluation

The potential and limitations of five land qualities / characteristics (climate, topography, wetness, soil physical characteristics and soil fertility) in determining the suitability of the study area for oil palm, cocoa and cashew cultivation were evaluated using the parametric method of FAO Land Suitability Evaluation (LSE) (FAO 1976) employed by Khiddir (1986), Ogunkunle (1993) and Udoh and Ogunkunle (2012). Each land characteristic with relevance on the land use potential was rated (allocated a numerical value) ranging from 100 (for the highest potential) to 40 or less (for the lowest potential) based on the extent to which the land characteristic meets the requirements of the crop. By this approach, the most limiting (poorest) characteristic of a pedon indicates the suitability class. This aligns with the principle of the ‘‘Leibig’s law of the minimum’’ which states that ‘growth is controlled not by the total amount of resources available but by the most insufficient resource (limiting factor) (FAO, 1984). Then, the index of productivity (current and potential) was calculated from the individual ratings using the lowest rating from each of the land quality group as shown in the equation below:

$$IP = A \, x \sqrt{\frac{B}{100} \, x \, \frac{C}{100} \, x \, \frac{D}{100} \, x \, \frac{E}{100} \, x \, \frac{F}{100}} \quad \ldots\ldots\ldots\ldots 1$$

Where: IP= Index of Productivity

A = Overall lowest characteristic

B, C, D, E, F = the lowest characteristic ratings for each land quality group.

According to Udoh and Ogunkunle (2012), it is assumed that members of the same land quality group are strongly correlated. For instance, texture and structure in soil physical characteristic group are strongly correlated; CEC and base saturation in fertility group are also correlated. Therefore, only one member of each group and the most limiting factor was used to calculate the index of productivity. They also reported that, in calculating the index of potential productivity (IP_p), fertility values such as K mole fraction, Mg: K ratio, and other fertility characteristics, which can easily be corrected by the application of fertilizer(s) are not considered in rating for the fertility land quality group but these are considered when rating for Current/Actual productivity (IP_c).

Results and Discussion

Morphological and physical properties

The moist conditions of soils of Umuariaga mapping unit revealed dark brown (10 YR 3/3) surface over yellowish brown (10 YR 5/6) subsurface colour notations. The soils are deep (> 170 cm), well drained and devoid of concretions. The soils possess weak medium crumb surface structure overlying moderate medium sub-angular endopedons. The friable consistence of the surface soils under moist conditions extend down the endopedons to the depth of 77 cm.

The particle-size distribution showed high sand content across the horizons, though decreasing from 88.00 % in the top-soil to 60.00 % in the sub-soil. Conversely, clay content increased progressively from the top-soil (7.80 %) down the sub-soil (35.50 %) whereas silt was very low and did not follow a particular distribution pattern across the horizons. The bulk density ranged from 1.32 top-soil to 1.64 sub-soil (Table 1).
The friable consistence and the moderate bulk density (top-soil) will enhance good tillage operations and crop root development but the soils may also be prone to leaching of soil nutrients due to coarse nature of the soils (Ojeniyi, 2002).

Amaoba-Ime mapping unit occurred on a relatively gently slopy (3 %) landscape. The unit, when observed under moist condition had dark brown (10 YR3/3) surface colour overlying strong brown (5 YR 4/5) subsurface colour notations. Similar to Umuariaga mapping unit, Amaoba-Ime soils are deep (> 160 cm), well drained and devoid of concretions. The soils possess weak medium crumb epipedons underlain by moderate medium sub-angular structure endopedons. However, the soils under moist condition revealed friable consistence throughout the profile depth.

The texture of the soils in this mapping unit indicated high amount of sand content from the top-soil (88.00 %) to the sub-soil (75.00 %). A relative increase in clay content was observed down the depth with low silt content showing no definite pattern of distribution across the depth. The top soil bulk density (1.33) is ideal for agronomic activities as soils with bulk densities less than 1.65 do not impede root penetration and development (Asadu, *et al.*(1990). However, the friable consistence coupled with the coarse texture of the soils (Table1) may aggravate leaching of soil nutrients.

Ndoro and Okwe mapping units are located on gently slopy (3 % slope gradient) and nearly flat (2 %) terrains respectively. Both are well drained, deep and non concretionary. They had bright soil colour: dark brown (10YR 3/3) colour top-soils over strong brown (7.5YR 4/4) colour sub-soils. The bright soil colour as evident by the chroma (>2) is perhaps indicative of the good internal drainage conditions of the soil. The soils were weak/moderately well structured. The top-soils had weak medium crumb structure, while the sub-soils had moderate medium sub-angular blocky structure (Table1).

The particle-size distribution of these mapping units revealed that clay content positively correlated with depth while sand content was inversely proportional to depth. Silt showed no definite distribution pattern. The trend of distribution of the bulk densities across the depths was similar to that of

Amaoba-Ime mapping unit. The high sand particle fraction observed across the units is indicative of high infiltration rates and low nutrient retention capacity. The implication of this is that the ground supply may not be able to recharge from the ground water table during dry season (Ogban and Ibia, 2006).

Table 1: Some soil morphological and physical characteristics of the study area

Pedon	Horizon	Depth (cm)	Colour (moist)	Slope (%)	Drainage	Structure	Consistence (moist)	Sand (%)	Silt (%)	Clay (%)	Texture	Bulk Density
UMUARIAGA (4 ha)	Ap	0 – 13	10YR3/3, DB	2	Good	1MCr	V.Friable	88.00	4.20	7.80	LS	1.32
	AB	13 – 38	10YR 3/3, DB			2MSbk	Friable	82.50	2.25	15.25	SL	1.54
	Bt1	38 -77	10YR 4/4, YB			2MSbk	Friable	77.80	3.20	19.00	SL	1.58
	Bt2	77 – 128	10YR 5/6, YB			2MSbk	Firm	66.35	4.65	29.00	SCL	1.64
	BC	128 - 180	5YR 5/8, RB			2MSbk	Firm	60.00	4.50	35.50	SC	1.63
					Good							
AMAOBA-IME (2 ha)	Ap	0 – 18	10YR 3/3, DB	3		1MCr	Friable	88.50	6.25	5.25	LS	1.33
	AB	18 – 40	7.5YR 4/4, SB			2MSbk	Friable	84.00	9.50	6.50	LS	1.68
	B1	40 – 86	5YR 4/5, RB			2MSbk	Friable	79.30	6.50	14.20	SL	1.72
	B2	86 - 165	2.5YR 4/6, RB			2MSbk	Friable	75.00	7.60	17.40	SL	1.76
NDORO (3 ha)	Ap	0 – 16	10YR 3/3, DB	3	Good	1MCr	Friable	86.25	7.50	6.25	LS	1.40
	AB	16 – 52	7.5YR 4/4, SB			2MSbk	Friable	81.50	6.00	12.50	SL	1.38
	B1	52 – 86	7.5YR 4/4, SB			2MSbk	Friable	82.25	4.00	13.75	SL	1.54
	Bt	86 - 168	5YR 5/8, RB			2MSbk	Friable	74.00	4.50	21.50	SCL	1.63
OKWE (2 ha)	Ap	0 – 22	7.5YR 4/4, DB	2	Good	1MCr	Friable	84.20	9.30	6.50	LS	1.27
	AB	22 – 57	7.5YR 4/6, DB			2MSbk	Friable	80.55	6.30	13.15	SL	1.45
	Bt1	57 – 95	7.5YR 5/6, SB			2MSbk	Friable	73.44	4.50	22.06	SCL	1.52
	Bt2	95 - 172	7.5YR 5/8, SB			2MSbk	Friable	69.28	4.00	26.72	SCL	1.68

Key: **Colour:** SB =Strong Brown, YB=Yellowish Brown, DB=Dark Brown, RB=Reddish Brown,

Structure: ½=Very weak, 1=Weak, 2=Moderate, 3=Strong. M=Medium, C=Coarse. Cr=Crumb, Bk=Blocky, Sbk=Sub-angular blocky.

Texture: SL=Sandy Loam, SCL = Sandy Clay Loam, SC = Sandy Clay, C = Clay.

Chemical properties

The chemical fertility status of the soils of Umuariaga mapping unit as presented in Table 2 showed strongly acid in reaction (pH 5.0 –5.5) for both the top and sub soils although with slight decreased with depth. Organic carbon contents were moderate1.22 – 1.40% in the surface horizons but with a sharp decrease down the profile. Accumulation of organic matter in the surface layers could be attributed to nutrient recycling by biomass and amount of decomposable materials returned to the soil surfaces through litter fall.

Total nitrogen contents ranged from 0.21 % in the topsoil (with a sharp decrease) to 0.03 % in the sub soils. Light soils are naturally poorly endowed with native nitrogen especially, 'acid sands' of South-eastern Nigeria with inherent low levels of organic matter (Enwezor, *et al.,* 1990), volatilization through high temperature and high levels of leaching consequent upon high rainfall amount and high humidity. Exchangeable bases ranged between moderate (K^+ and Mg^{2+}) and low (Na^+ and Ca^{2+}) in the top soils but with concentrations decreasing slightly with depth. Cation exchange capacity, available phosphorus and base saturation were moderate in the surface with a decrease down the profile.

The chemical fertility status (pH, organic carbon, total N, available P, exchangeable bases, CEC and base saturation) of the other mapping units (Amaoba-Ime, Ndoro and Okwe) followed similar trend with that of Umuariaga (Table 2).

The result shows that the high rainfall experienced in the area coupled high sand particle size fraction of less chemical activeness (Hazelton and Murphy, 2011) are perhaps responsible for the susceptibility of the study areas to leaching (Amusan, *et al*., 1995). This may have resulted in the observed low CEC, low base status, high exchangeable acidity and the overall low nutrient status of the soils across the locations.

Table 2: Some soil chemical characteristics of the study area

Pedon	Horizon	Depth cm	pH (H_2O)	pH (KCl)	**O.C** %	Total N(%)	Av. P mg/kg	K^*	Na^*	Mg^*	Ca^* cmol/kg	Al^{3+}	H^+	CEC	ECEC	Base Sat.(%)
UMUARIAGA	Ap	0 – 13	5.5	4.7	1.40	0.21	13.70	0.45	0.15	2.44	2.61	0.25	0.85	13.62	6.75	41.48
	AB	13 – 38	5.4	4.5	1.22	0.12	10.60	0.55	0.18	1.26	2.10	0.33	1.00	8.80	5.42	46.48
	Bt1	38 -77	5.2	4.4	0.13	0.08	10.05	0.40	0.13	0.95	1.82	0.38	1.25	10.54	4.93	31.31
	Bt2	77 – 128	5.0	4.3	0.40	0.04	9.60	0.11	0.13	1.53	2.46	0.35	0.85	12.00	5.43	35.25
	BC	128 - 180	5.0	4.3	0.20	0.03	8.55	0.14	0.16	0.78	2.15	0.42	0.65	8.00	4.30	40.38
AMAOBA-IME	Ap	0 – 18	5.6	4.7	1.18	0.20	14.80	0.36	0.25	2.11	3.24	0.36	1.12	12.25	7.44	48.65
	AB	18 – 40	5.4	4.6	1.00	0.14	13.55	0.22	0.38	2.30	2.50	0.24	1.00	9.50	6.64	56.84
	B1	40 – 86	5.0	4.3	0.38	0.09	11.50	0.18	0.27	2.10	2.05	0.40	1.24	8.00	6.24	57.50
	B2	86 - 165	4.6	3.8	0.20	0.05	10.75	0.15	0.23	2.00	2.13	0.25	0.68	8.25	5.44	54.67
NDORO	Ap	0 – 16	5.5	4.6	1.35	0.19	12.00	0.32	0.29	2.33	2.38	0.31	0.78	11.55	5.79	46.06
	AB	16 – 52	5.4	4.5	1.10	0.14	12.75	0.50	0.34	1.95	2.10	0.29	0.95	9.00	6.13	54.33
	B	52 – 86	5.4	4.5	0.44	0.08	10.50	0.33	0.18	2.04	1.65	0.29	1.12	7.56	5.61	55.56
	Bt	86 - 168	5.0	4.4	0.25	0.03	9.50	0.18	0.18	1.55	2.00	0.40	0.70	8.80	5.01	44.43
OKWE	Ap	0 – 22	5.5	4.4	1.18	0.16	15.43	0.30	0.28	1.60	2.83	0.10	0.62	11.25	5.73	44.55
	AB	22 – 57	5.3	4.2	0.76	0.07	12.64	0.14	0.29	0.82	2.04	0.10	0.78	5.23	4.17	62.91
	Bt1	57 – 95	4.9	3.5	0.51	0.06	10.50	0.08	0.28	0.80	2.00	0.12	1.32	5.46	4.60	57.88
	Bt2	95 - 172	4.8	3.5	0.42	0.04	12.00	0.04	0.26	0.82	1.60	0.20	1.50	4.88	4.42	55.74

Key: Av. = Available Phosphorus, * = Exchangeable cations

Agricultural potential of soils of the coastal plain sands

***Fertility Capability Classification* (FCC)**

The result of fertility capability classification of the soils in the study area is shown in Table 3. The conversion data used in evaluating the soils as outlined by Sanchez *et al*. (1982) consists of three categorical levels: ‘type’ (texture of plough layer or top 20 cm); substrata type’ (texture of subsoils) and ‘modifiers’ (soil properties or conditions which act as constraints to crop performance). Class designations from the three categorical levels are combined to form a FCC unit. Thus, the soils were classified according to whether a characteristic was present or not. The FCC units of the pedons were determined based on the soil profile characteristics. Each FCC unit lists the ‘type’ and ‘substrata type’ in capital letters, and the modifiers in lower case letters. The result of FCC in Table 3 shows that all the pedons in the study area have the same FCC unit, SLehk. The results show that the soils are generally characterized by uniformly sandy topsoil (S) overlaying loamy sub-soils (L); they have low cation exchange capacity (CEC), represented by e; they have acidic reaction, represented by h; and are deficient in exchangeable potassium, which is represented by k. The FCC results (Table 3) show the kinds of problems presented by the soils for agronomic management of their chemical and physical properties (Sanchez *et al.* 1982).

Table 3: Fertility capability classification of soils derived from the coastal plain sands

Pedon	**Type 1**	**Substrata Type; 2**	**g**	**d**	**k**	**e** (→ **3** ←)	**a**	**h**	**b**	**i**	**FCC**
UMUARIAGA	**S**	**L**	**-**	**-**	**+**	**+**	**-**	**+**	**-**	**-**	**SLehk**
AMAOBA-	**S**	**L**	**-**	**-**	**+**	**+**	**-**	**+**	**-**	**-**	**SLehk**
NDORO	**S**	**L**	**-**	**-**	**+**	**+**	**-**	**+**	**-**	**-**	**SLehk**
OKWE	**S**	**L**	**-**	**-**	**+**	**+**	**-**	**+**	**-**	**-**	**SLehk**

*After Sanchez *et al*. (1982)

Key: S=Sand, L=Loam, C=Clay, k=low K reserves, e=low CEC, h=acidic, b=basic, d=depth, i=low avail..P

1. Type = texture of topsoil;

2. Substrate Type = texture of subsoil

3. Condition modifiers = Crop production constraints (k = exchangeable potassium deficiency; e = low cation exchange capacity; h= acidic reaction;

Land Suitability Evaluation

The suitability evaluation of the coastal plain sand soils was carried out following the parametric square root method of the FAO (1976) framework for land evaluation employed by Udoh and Ogunkunle (2012). The determination of land suitability involved the matching of the Land qualities/characteristics (Tables 1 and 2) with the established land/agronomic requirement (Table 4) of oil palm (Sys, 1985; Ogunkunle, 1993). After matching the land characteristics with the agronomic requirement of the crop, depending on the extent to which the land characteristics satisfied the requirement, each limiting characteristic was rated (Table 5). For the parametric evaluation method, the final (aggregate) suitability class in Table 6 is indicated by the most limiting land quality/characteristics of the pedon (FAO 1976).

The results of matching land requirements for the test crop with land qualities shows that the area is climatically suitable for oil palm being optimal (100% suitable) in terms of annual rainfall and relative humidity and nearly optimal (95% suitable) in terms of mean temperature. Topography and drainage are not very serious limitations to the cultivation of oil palm across the study area. Soil depth as one of the physical characteristics was optimal in the entire area. However, soil texture was the most limiting of the soil physical characteristics. Soil texture for optimum productivity of oil palm should be clay loam, sandy clay loam or loam (Sys 1985), but the texture across the area was loamy sand/sandy loam. This has rendered the entire area only marginally suitable for oil palm cultivation and constitutes a major constraint to its production.

Soil fertility is another serious constraint limiting oil palm, cocoa and cashew cultivation in the area. Although cation exchange capacity (CEC), base saturation and organic carbon were rated sub-optimal (95/85% suitable), K (mole fraction) was grossly inadequate (30 - 40% suitable), thereby rendering the whole area to be currently marginally suitable to non-suitable for oil palm, cocoa and cashew cultivation. But in terms of soil reaction, the entire area was rated optimal (100% suitable) for the cultivation of all the test crops.

Aggregate Suitability for Cultivation of Oil Palm

The individual ratings of the land characteristics for each pedon for oil palm cultivation is shown in Table 5, while Table 6 shows the aggregate suitability classification of each pedon for oil palm.

The use of parametric method of FAO Land Suitability Evaluation (FAO 1976) employed by Ogunkunle (1993), put all the pedons in the study area into marginal suitability class (S3) for oil palm cultivation because of the severity of soil physical characteristic (s) and fertility (f) limitations.

Table 4: Land use requirements for oil palm

Land Quality and characteristics	SI (100 - 95%)	S2 (94 - 85%)	S3 (84 - 40%)	N1 (39 - 20%)	N2 (19- 0%)
Climate (c): Annual rainfall (mm)	> 2000	1450 - 1700	1250 - 1450	< 1250	< 1250
Mean annual temperature. (^{o}C)	25 - 35	22 - 25	20- 22	18 - 20	< 18
Topography (t): Slope (%)	0 - 4	4 - 8	8 - 16	16 - 30	> 30
Wetness (w): Drainage	Imperfect	Moderate	Moderate	Poor, drainable	V/poor, not drainable
Soil Physical Properties (s): Texture	CL, SCL, L	SC, SCL	SL	LS	C, S
Coarse fragments (l%), 0-10cm	3 - 10	10 - 15	15 - 35	35 - 55	> 35
Depth (cm)	> 100	90 - 100	50 - 90	25 - 50	< 25
Fertility (f):					
CEC (cmolkg^{-1})	> 10	8 – 10	6 – 8	< 6	-
Base saturation (%)	> 35	20 - 35	< 20	-	-
pH	5.5 - 6	6 – 6.5	6.5 - 7	< 4 or > 7.0	< 4 or > 7.0
Organic carbon (%), 0-15cm	> 1.2	1.2 - 0.8	< 0.8	-	-
Exch. K (cmolkg^{-1})	> 1.5	1.2 - 1.5	1.2 - 0.5	< 0.5	< 0.2

CL, clay loam; SCL, sandy clay loam; L, loam; LS, loamy sand; C, clay; SC, sandy clay.

Source: Modified Sys (1985)

Table 5: Suitability class scores of the soils of the study area for oil palm cultivation

Land Quality		Pedon			
		Umuariaga	Amaoba-Ime	Ndoro	Okwe
Climate (c)	MAR (mm)	S1(100)	S1(100)	S1(100)	S1(100)
	MAT(^{0}C)	S1(95)	S1(95)	S1(95)	S1(95)
	RH (%)	S1(100)	S1 (100)	S1 (100)	S1 (100)
Topography (t)	Slope (%)	S1(100)	S1(100)	S1(100)	S1(100)
Wetness (w)	Drainage	S1(100)	S1(100)	S1(100)	S1(100)
Soil Physical Characteristics (s)	Texture	S3(60)	S3(60)	S3(60)	S3(60)
	Soil depth (cm)	S1(100)	S1(100)	S1(100)	S1(100)
Fertility (f)	CEC (cmolkg^{-1} clay)	S2 (85)	S2 (85)	S2 (85)	S2 (85)
	Base saturation (%)	S1(95)	S1(95)	S1(95)	S1(95)
	pH	S2(85)	S2(85)	S2(85)	S2(85)
	O C (%) 0 – 15 cm	S2 (95)	S2 (90)	S2 (90)	S2 (90)
	Exch.K (cmolkg^{-1})	S3 (40)	N1 (35)	N1 (35)	N1 (35)
Aggregate	Potential	S2(54)	S2(54)	S2(54)	S2(54)
	Actual (Current)	S3(30)	S3(26)	S3(26)	S3(26)
	Limiting factors	sf	sf	sf	sf

Key: Aggregate suitability class scores: S = 75 - 100; S2 = 50 - 74; S3 = 25 - 49; N1=15 - 24; N2 = 0 - 14;
MAR=Mean annual rainfall (mm); MAT=Mean annual temperature (^{0}C); RH = Relative humidity

Table 6: Suitability classification of the soils derived from coastal plain sand for oil palm, indicating the limiting factors

Pedon	***Potential***	***Current***
UMUARIAGA	S2sf	S3sf
AMABA-IME	S2sf	S3sf
NDORO	S2sf	S3sf
OKWE	S2sf	S3sf

Conclusion and Recommendation

The result of this study is in alignment with other previous works. Enweozor, *et al.* (1990) has shown that the soils of the study area, like other 'acid sands' of South-eastern Nigeria are light-textured soils: fragile, acidic, low in native fertility with high level of leaching consequent upon high rainfall amount and high relative humidity.

They are marginally suitable for oil palm cultivation because of serious fertility and physical characteristic constraints.

To raise the productivity of these soils to optimum and also to sustain productive potential, integrated nutrient management, involving the wise use of organic and inorganic nutrient sources, with regular soil testing to monitor nutrient balances should be adopted.

Judicious use of lime to enhance the availability of the deficient cations may be required as this will raise the base saturation of these soils. Application of crop residues to ensure adequate soil conservation and water retention, application of a reasonable level of organic matter should be maintained at all times by use of farm yard or green manure and split application of mineral fertilizer will help to sustain the productive potential of these soils. This will help to improve the physical structure of the soils and also will serve as major source of plant nutrients.

References

Amusan, A.A., Oyedele, D.J., Adepetu, J.A. and Aina, P.O. (1995). Characterization and classification of soils developed in eolian material in Northern Guinea Savanna of Nigeria. *3rd African Soil Science Society Conference*. Vol.28: 79-87.

Asadu, C.L.A, Akamigbo, F.O.R. Ezumah, H.C. and Nweke, F.I. (1990). The Characteristics of Selected Yam-Growing Soils in South Eastern Nigeria: Physical and Morphological Properties. *Nigerian Agricultural Journal*, 24: 55 – 69.

Bera R., Seal A., Das T. H., Sarkar D. and Chatterjee A. K. (2014). Application of Fertility Capability Classification System in Rice Growing Soils of Damodar Command Area, West Bengal, India. *Journal of Recent Advance in Agriculture*, 2(12): 330-337.

Enweozor, W. O., Ohiri, A.C., Opuwaribo, E.E.and Udo, J.E. (1990). Literature Review on Soil Fertility Investigation in Nigeria, Federal Ministry of Agriculture and National Resources, Lagos.

Dent, D. and Young, A. 1981. Tropical soils and Soil Survey. Cambridge University Press, New York. 468p.

FAO (1976). A framework for Land Evaluation. FAO *Soils Bulletin* 32; FAO, Rome. 87 pp.

Food and Agricultural Organization (1984). Guidlines; Land evaluation of rainfed agriculture. *FAO Soil Bulletin*. 52: 237.

Hezelton P. and B. Murphy (2011). Interpreting soil test results. CSIRO Publisher, Australia. 152pp.

Kappo, A., Rilwani, M., Lawal and Muibi, K. (2015). Land suitability assessment for cocoa cultivation in Ife Central Local Government Area, Osun State. *International Journal of Scientific Engineering and Research (IJSER) www.ijser.in ISSN (Online)*: 2347- 3878, Impact Factor (2014): 3.05. Vol. 3 Issue 4. 139 – 144.

Khiddir, S.M (1986). A Statistical approach on the use of parametric system applied to the FAO framework for land evaluation Ph.D. Thesis. State University of Ghent, Belgium, 141 pp 55.

NRCRI (2013). National Root Crop Research Institute, Meteorological Station, Umudike.

Ogba, P.I. and Ibia, T.O., 2006. Infiltration characteristics and soil physico-chemical properties of wetlands in Akwa-Ibom State, Southeastern Nigeria. *Nigerian Journal of Soil Science* (16): 73-76

Ogunkunle, A.O. (1993). Soils in land suitability evaluation: An example with oil palm in Nigeria. *Soil Use Management. 9(1): 35-40.*

Ojeniyi, S.O. (2002). Soil Management, Natural

Resources and Environment. Adediran Press. 30pp.

Okoye, E.O.U. and Lekwa, G. 1995. Trend in national soil survey, classification and soil correlation in Nigeria. Country report: Contribution at the 17th Soil Correlation Meeting held in Quagadougou, Burkina Faso. 10-17, 1995.

Oluwatosin, G.A., Adeyolanu, O.D., Ogunkunle, A.O. and Idowu, O.J. (2006). From land capability classification to soil quality: And assessment. Tropical and Subtropical Agro Ecosystems, ano/vol.6, numero 002. Universidad Autonoma de Yucatan. 45-55.

PIND (2011). Foundation for Partnership Initiatives in the Niger Delta: A report on Palm Oil Value Chain Analysis in the Niger Delta, Nigeria. 55pp.

Sanchez, P.A, W. Cuto and S.W Buol (1982) The Fertility capability soil classification system, interpretation, applicability and modification. Geoderma, 27: 283- 309.

Soil Survey Staff. 2010. *Keys to Soil Taxonomy*. Washington, D.C.: USDA – NRCS.337 pp.

Sys, C. 1985. Land Evaluation. Part I, II and III. Publication No. 7 of the General Administration of Cooperation Development. Place de Champs Mars 5, boite 57, 1050 Bruxelles. 247 pp.

System. Interpretation, applicability and modification. *Geoderma* 27: 283-309.

Udoh, E.J., Ibia, T.O., Ano, A.O. and Esu, I.E. (2009). Manual of Soil, Plant and Water Analysis. Sibon Books Ltd. Festac Town, Lagos.

Udoh, B.T. and Ogunkunle, A.O. ((2012). Land suitability evaluation for maize (*Zea mays*) Cultivated in a Humid Tropical Area of Southeastern Nigeria.

Udoh, B.T., Esu, I. E, Ibia, T.O., Onweremadu, E.U and Unyienyin, S.E. (2013). Agricultural Potential of the Beach Ridge Soils of the Niger. Delta, Nigeria. *Malaysian Journal of Soil Science Vol. 17: 17-37.*