FUPRE Journal of Scientific and Industrial Research
Vol.4, (3), 2020
ISSN: 2579-1184 (Print) ISSN: 2578-1129 (Online)

Suitability Assessment of Soils for Oil Palm Cultivation in Ofunwengbe, Ovia North East Local Government Area of Edo State, Nigeria

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Abstract

The aim of the study was to determine the suitability of an18 hectare piece of land situated in Ofunwengbe Village Area, Ovia North East Local Government Area of Edo State, Nigeria for oil palm cultivation. Field survey was made along the transverses for physical, morphological and landscape examination. Also, surface and subsurface soil samples were collected in addition to relevant climatic data for suitability and fertility evaluation. The soil samples collected were analyzed in the laboratory using standard methods.The vegetation consists of primary forest, the topography ranged from flat to undulating / sloppy with elevation above the sea level of greater than 100 m. The soil ranged from sandy loam to loamy sand with increase in clay content with depth. The effective soil depth is greater than 90 cm (rooting zone) and the soil is well drained and free from hard pan and impediment. Temperature, sunshine hours, relative humidity and rainfall amount are adequate for oil palm establishment but number of dry months is marginal for oil palm production. The pH of the soils ranged from acid (4.7) to slightly acid (5.9). The percentage organic carbon content was generally low than 0.8% in the entire site. Similarly, the nitrogen content was considerably low in all the examined points, with the values ranging from 0.002% to 0.008%. Available phosphorus content ranged from very low (6.4 mg/kg) to very high (33.92 mg/kg). Exchangeable magnesium was generally high (greater than 0.2 cmol/kg) in all the examined points; hence magnesium is not a limiting factor for oil palm production in the site. However, exchangeable potassium was generally low (less than 2.0 cmol/kg) in all the examined points. Thus, the values fall below the recommended level especially for oil palm cultivation. Effective Cation Exchange Capacity (ECEC) was very low < 10 cmol/kg. This falls below the requirement for oil palm production. The results indicated that the site had good potential for oil palm production. Therefore, in order to improve the condition and raise the productivity of the land to optimum level, planting of cover crops and application of organic residue like empty fruit bunches (efb) should be considered to compensate the soil moisture deficit during the dry month when the production of fresh fruit bunch commence.The soil reaction level (pH) is adequate for nutrient availability. The main fertility constraint is the low effective cation exchange capacity (ECEC), low level of nitrogen (N) and exchangeable potassium (K). These can be augmented by the addition of appropriate fertilizer and proper timing from field establishment to fruit-bearing period.

Keywords: Suitability assessment, oil palm cultivation, Edo State.

1. Introduction

Suitability is a function of crop requirements and land characteristics and it is a measure of how well qualities of land unit match the requirements of a particular form of land use *(FAO, 1976)*.For agriculture, land suitability evaluates the ability of a piece of landto meet the agro-ecological requirements of a given crop for maximum yield *(Abdel Kawy and Abou El-Magd, 2012)*.Land evaluation is very important in this direction as it provides information on the potentials and constraints of land for a defined land use type in terms of crop performance as affected by the physical environment. Soil suitability classification quantifies in broad terms to what extent soil conditions match crop requirements under a defined input and management *(FAO, 1976)*. Assessing the suitability of land enables optimum performance and maximum productivity of crop. In evaluation, the specific crop requirements will be calibrated with the soil parameters *(Dent and Young, 1981)*, so that the identified limiting factors could be managed to suit crop requirements and improve productivity. Land evaluation thus, enables management guidelines in order to promote a more sustainable use of the soil and environmental resources *(Maniyunda et al., 2007)*.The interest of the farmer in the business of producing crops is mainly on how profitable it is to grow a particular crop and what amendments are necessary to optimize the productivity of the soil for the specified crop *(Fasina and Adeyanju, 2006)*. Land evaluation aims at achieving optimum economic return from allocation of land resources without land degradation *(FAO, 1976)*.The oil palm (*Elaeis guineensis*),an economically important tropical crop which produces vegetable oil and is widely used in the production of palmwine, palmkernel cake as a feed stock for feeding livestock, palmoil for consumption and soap making. Oil palm is a rain-fed crop, climate plays an important role in defining the range limits of the crop. However, factors such as soil properties and biotic interactions may prevent plants from colonizing sites that are otherwise suitable. Like other agriculture crops, environmental constraints such as drought,high temperatures and rainfall deficit, could also influence the

productivity of oil palm.Thus,this study was therefore designed to assess the potentials and limitations of soil properties and their suitability for oil palm cultivation in the study area.

2. Materials and Methods

2.1 Locationof the Study

The study area is located within Ovia North East Local Government Areas of Edo State Nigeria. The site is enclosed within Latitude N06^{0}26'49.9'' and E005^{0}30'26.1'' and Longitudes N06^{0}27'.02.5'' and E006^{0}30'.14.2''. The entire study area is approximately 18 hectares. The site is located about 6.5 kilometers North West from BeninCity, Edo State, Nigeria. Figures 1 and 2 respectively.

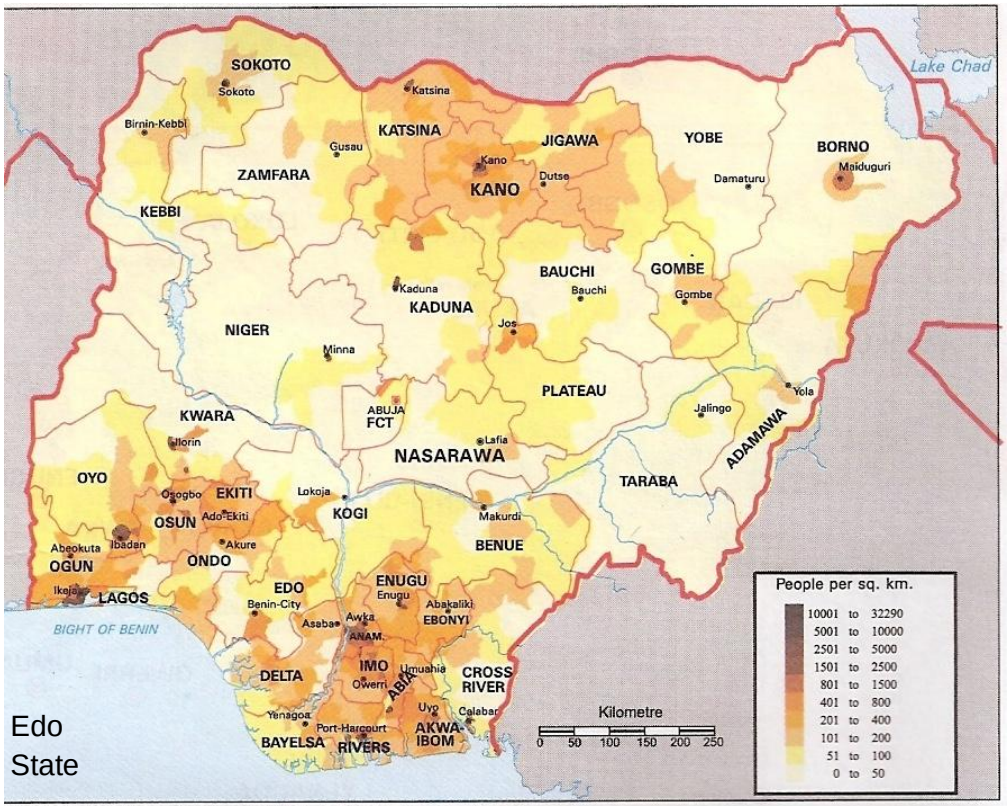

Figure 1: Map of Nigeria Showing Edo State

Figure 2: Map of Edo State showing the Local Government

The site fall within the rainforest regionof Edo StateNigeria, it has a hot and humid tropical climate. The climate is characterized by seasonal rainfall, high temperature and relativehumidity. The environment is noted for two distinct seasons of rainy and dry periods in a year. The Southwest trade wind predominates over the area, usually between March and November, while the Northeast trade wind has greater influence between December and February/March.The major climatic element of importance in

the area in terms of soil formation and agriculture are rainfall, temperature and relative humidity. Theclimatic data were acquired from Nigerian Institute for Oil Palm Research (NIFOR) Benin City which is approximately 25 kilometers from the site.The annual total rainfall for the area is >1,500 mm. with peaks in September/October, The mean air temperature ranged between 28°C to 36°C while the relative humidity ranged between 70 to 80 %.

2.2. Land Evaluation Procedure

The suitability evaluation of the soils in the study area was assessed using the conventional method (FAO, 1976). Soils were placed in their suitability classes by matching their characteristics with the established requirements for oil palm (Table) The parameters used for the land suitability include rainfall, mean annual temperature, slope, wetness, drainage while the soil characteristics were texture, soil pH, depth with fertility indicators: ECEC, organic carbon (organic matter) and available phosphorus.

2.3 Geomorphology and Physiography

The soils in the study area were developed from coastal plain sand and alluvial deposit, relatively flat with gentle slopes> 4 % and depressed graduallywith an elevation of 100 meters above sea level.

2.4 Vegetation / Land-Use

The natural vegetation of the area consists mainly of primary forest which consists of climbers and tall trees ranging from 20 to 30 m with continuous canopy.There were relatively high densities of oil palm trees within the catchment which possessed large kernels and tiny mesocarp suggesting the Dura or other wild varieties, other naturally occurring plant species include citrus, mango, cashew pawpaw etc human activities present in the study area includes clearing, bush burning, fallow/shifting cultivation and lumbering. The land was previously cultivated to Rubber trees as evidenced on the Eastern portion of the site and sporadic distribution across the other portion of the site.

2.5 Laboratory Analysis

The soil samples collected were air dried at room temperature and sieved through a 2 mm sieve. The resulting soil samples were analysed for their physical and chemical properties as follows: Particle size was determined by hydrometer method *(Gee and Boulder, 1986).* Available Phosphorous (P) was determined by Bray P-I method *(Anderson and Ingram, 1993)*. Total Nitrogen (N) was determined by macro-kjedhal method *(Brookes et al., 1985)*. Soil pH was determined in a 1:2 soil to water suspension using a pH meter *(Maclean, 1982)*. Exchangeable bases were extracted using NH_4OAC buffered at pH 7.0 *(Thomas, 1982)*. While Potassium (K) and Sodium (Na) were read from a flame photometer, Exchangeable Calcium (Ca) and Magnesium (Mg) was determined using atomic absorption spectrophotometer. Total Exchangeable acidity ($H^+ + Al^{3+}$) was by titration method *(Anderson and Ingram, 1993)* while effective cations exchange capacity was determined by summation of exchangeable cations and exchangeable acidity *(Tan, 1996).*

3. Results and Discussion

3.1 Soil and climatic requirements for the oil palm

The piece of land for planting of oil palm is determined by the quality of the soil and topography; the land should be levelled or slightly undulating, well-drained with good fertility management. Annual rainfall in the study area is greater than 1500 mm which is below the requirement of 2000 – 2500 as recommended by *Hartley (1998)* and is considered Not suitable (N) for oil palm cultivation in terms of amount and spread (Table: 3). The average temperature is greater than 28^0C and is considered highly suitable (S1) for oil palm cultivation, while the duration of sunshine in the study area is 4 months with an average sunshine duration of less than 5 hours which is below the requirement for the oil palm. In terms of drainage, the entire area is well-drained and fulfil the requirement for oil palm cultivation in terms of drainage (Table 3). The entire site were very deep (> 90 cm) and suitable with respect to soil depth, corresponds with the optimum value according to *Sys (1985)*

3.2 Soil Physical and Chemical Properties

Table 1 shows the chemical properties of soils of the study area. The soils is sandy to loamy sand in texture, which is marginally suitable S3 (Table 3) for oil palm cultivation. The optimum soil texture for oil palm is sandy loam or clay loam *(Hartley, 1988 and Goh, 2000)*. The particle size analysis shows the dominance of sand fraction over the mineral particles and decreases with depth. Clay was next to sand in dominance and increased with soil depth, while silt does not show any definite trend. (Table; 1). This observation, however, corroborates earlier findings by *Raji et al., (2001)* in Northern Nigeria, who reported that clay content increased with increased oil depth. The pH of soil measured in water was slightly acidic with pH value ranged from 4.7 to 5.9 (Table, 2) and rated Highly suitable (S1) (Table 3). However, the pH decreased with depth in all the locations (Table, 1); this might be due to the effect of cultivation and leaching of basic cations down the soil profile. This observation is consistent with *Nwite, et al., (2005)*, who reported a general decrease in pH values in the lower profile. Fertility status of the soils with respect to organic carbon ranged from 0.13 to 0.70 % (Table, 2) and was highest at the surface and decreases with depth in all the location and was rated low or marginally suitable (S3) for suitability class for oil palm (Table, 3).Similarly, the nitrogen content was considerably low in all the examined points, with the values ranging from 0.002 % to 0.008 %(Table, 2) but they were high at the surface as compared to lower depths and were rated low.Available phosphorus content ranged from very low (6.4 mg/kg) to very high 33.9 mg/kg (Table, 2) and this fluctuates irregularly with increased soil depth. (Table 1) and was rated marginally suitable (S3) (Table 3), Exchangeable magnesium was generally high (greater than 0.24 cmol/kg) in all the examined points; this observation is consistent with *Rankine et al., (1999)* who stated that magnesium is not a limiting factor for oil palm production. The low level of N and P in these soils makes the application of inorganic fertilizer necessary to supply basic nutrient elements required by the oil palm. Effective Cation Exchange Capacity (ECEC) was very low < 10 cmol/kg. This falls below the requirement for oil palm production. The low values of ECEC observed in the study area is in line with findings by *Amakhian and*

Osemwota, (2012) who reported low values of ECEC in soils of Southern Guinea Savanna Zone of Nigeria. The low ECEC coupled with low organic matter is indications of inadequate soil fertility status, which can be corrected through management practices that will encourage the incorporation of organic residues so as to maintain favourable soil conditions for sustainable oil palm cultivation.

Conclusion

The studyshows that the site has good potential for oil palm production. Therefore, in order to improve the condition and raise the productivity of the land to an optimum level, planting of cover crops and application of organic residue like empty fruit bunches (EFB) should be considered to compensate the soil moisture deficit during the dry month when the production of fresh fruit bunch commences. Furthermore, appropriate and timely application of fertilizer must be adhered to upon completion of field establishment to enhance maximum productivity of the soils for oil palm on a sustainable basis.

Location /depth (cm)	Particle size distribution			EC µS/cm	Textural class
	Sand %	Silt %	Clay %		
KU_1 0 – 15	85.6	9.9	4.5	1000	S
KU_1 15 -30	84.1	8.9	7.0	1000	LS
KU_2 0 -15	87.1	8.4	4.5	1100	S
KU_2 15- 30	82.6	9.9	7.5	1200	LS
KU_3 0 – 15	84.6	9.4	6.0	50	S
KU_3 15- 30	82.1	9.9	8.0	20	LS
KU_4 0 – 15	88.6	8.4	3.0	60	S
KU_4 15- 30	86.1	9.4	4.5	80	LS
KU_5 0 – 15	89.1	7.9	3.0	50	S
KU_5 15- 30	86.1	7.9	6.0	30	LS
KU_6 0 – 15	86.6	8.4	5.0	2200	S
KU_6 15- 30	81.1	8.4	10.5	30	LS

Table 1: Physical properties of soils in the study area

Key: *EC = electrical conductivity, S = Sandy, LS = Loamy sand*

Table 2: Chemical properties of soils in the study area

Location /depth (cm)	Soil properties										
	pH	O.C %	N %	P Mg/kg	K	Ca	Mg	Na cmol/kg	H	Al	ECEC
KU_1 0–15	5.7	0.67	0.007	13.20	0.15	2.24	0.24	1.19	0.20	ND	4.02
KU_1 15-30	5.6	0.42	0.005	33.92	0.14	2.32	1.36	1.24	0.30	ND	5.36
KU_2 0-15	5.9	0.42	0.005	25.79	0.16	2.40	0.80	1.21	0.20	ND	4.77
KU_2 15-30	5.6	0.29	0.002	6.49	0.15	2.00	1.20	1.24	0.30	ND	4.89
KU_3 0–15	4.6	0.45	0.005	17.22	0.14	2.32	1.20	1.27	1.20	0.30	6.43
KU_3 15-30	4.7	0.42	0.005	16.07	0.12	1.92	0.32	1.22	1.50	0.50	5.58
KU_4 0–15	5.0	0.64	0.006	16.89	0.19	1.84	0.88	1.26	0.90	0.10	5.17
KU_4 15-30	4.9	0.48	0.005	11.06	0.18	2.64	0.08	1.27	1.30	0.60	6.07
KU_5 0–15	4.9	0.38	0.004	24.49	0.11	2.40	0.32	1.24	1.20	0.60	5.87
KU_5 15-30	4.5	0.13	0.002	16.04	0.13	2.40	0.32	1.35	0.60	0.70	6.50
$KU_6$0–15	6.7	0.70	0.008	30.46	0.18	4.00	1.12	1.32	0.2	ND	6.82
KU_6 15- 30	4.7	0.61	0.006	26.28	0.12	2.72	1.52	1.30	1.20	0.40	6.90

Key: *O.C =Organic carbon; N=Total Nitrogen P= Available Phosphorus Ca = Exchangeable Calcium, Mg=ExchangeableMagnesium;*

K = Exchangeable PotassiumNa =Exchangeable Sodium H^+ = Exchangeable Hydrogen; AI $^{3+}$ = Exchangeable Aluminium:

ECEC = Effective Cation Exchange capacity:ND = Not Detected

Table 3: Land soil requirement and suitability rating for oil palm cultivation.

Soil and Climatic characteristics	Units	Soil suitability class	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
		Degree of limitation	None	Slightly	Moderate	Severe
Annual rainfall	Mm/yr	------	200-2500	2500-3000	3000-4000	500
		____	____			
	Mm/yr			1700-2000	1400-1700	1700
Mean Annual Temperature	^{0} C		26 – 29	29 – 32	32- 34	35
Relative humidity	%		75	70 – 75	65 - 70	60
Daily solar radiation	MJ/m2		16 – 17	17- 19	19- 21	21
Wetness (W)						
Drainage		Drainage class	Well drained	Moderately drained	Poorly drained	Very poor drained
Flooding			Never	Minor flooding	Moderate flooding	Severe flooding
Soil depth	(Cm)		100	75 – 100	50 - 75	25
Soil texture		Textural class	SL, L, SiL	CL,SiCL, SC	SCL, LS, SiC, SC	Gravel, S,C.

Fertility status					
(soil reaction,		5.0-6.5	4.5-5.0	4.0-4.5	<4.0
pH)	g/kg^{-1}	0.25	0.15	0.12	0.08
Total Nitrogen	g/kg^{-1}	25	20	15	<8
Available P.	g/kg^{-1}	2.2	1.5	1.2	<0.
Organic C.					

Adapted from *Hartley, (1988) and Goh, (2000)*

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