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Suitability Assessment of Soils of Egbili Obebe in Ibaji Local Government Area of Kogi State for Oil Palm Establishment

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Abstract

Soils of Egbili Obebe in Ibaji Local Government Area of Kogi State were evaluated for suitability for oilpalmcultivation. Suitability of soils for oil palm was assessed using Hartley's Land and soil requirement and suitability ratings for oil palm. Soil texture classes identified were dominated by clay loam.The soils were slightly acidic, with pH ranged from 4.50 to 6.00. The results showed that certain land characteristics such as,mean annual temperature, rainfall, soil depth and drainage were rated highly suitable (S1) to marginal suitable (S2), organic matter, total nitrogen, Available phosphorus and ECEC were generally low and rated as marginally suitable (S3) for oil palm cultivation in the study area. The major limitations that lower the suitability of these soils for oil palm establishment in the area were inadequate rainfall, rooting depth, poor drainage, and low soil fertility status. If these soils can be put to use for oil palm it should be subjected to soil management practices, which may encourage return of organic residue into the soils such as incorporation of legumes and application of farmyard manures. The low level of N 0.35 – 3.5 $gkg^{-1}$and P 2.44 - 37.48 $cmolkg^{-1}$in these soils makes application of inorganic fertilizer necessary to supply basic nutrient element required by the oil palm. Results, however, indicated that over 67% of the entire area assessed is marginally suitable (S3) while 33 % is considered Not suitable (N) for the cultivation of the oil palm. Marginal suitability implies non-optimal yield in oilpalm productivity. Alternatively, soil characteristics that posed a severe limitation to high yielding oil palm cultivation in the study area, it is, therefore, recommended that a more suitable site be adopted for the establishment of the oil palm.

***Keywords**: Suitability, Assessments, Land characteristics, Marginal and oil palm,*

1. Introduction

Suitability of land is assessed considering a rational cropping system, for optimizing use of a piece of land for a specific use *(FAO, 1976; Sys et al., 1991)*. The suitability is a function of crop requirements and land characteristics, and it is a measure of how well the qualities of land unit match the needs of a particular form of land use *(FAO, 1976 and Mustafa et al, 2011)*.In crop production, interest of the farmer is mainly on how profitable it is to grow a specific crop and what amendments are necessary to optimize the productivity of the soil forparticular cultivation*(Fasina and Adeyanju, 2006)*.Thus, solutions to the farmer's problems hinge on the suitability of the land. Land evaluation becomes very important in this direction as it provides information on the potentials and constraints for a defined land-use type in terms of crop performance as affected by the physical environment. These requirements must be understood within the context of limitations imposed by landforms and other features which do not form part of the soil but may have a significant impacct on use that can be made of the soil *(FAO, 1978 and Ande, 2011)*. In Ibaji agro-ecological zone of north central Nigeria, there is abundance of flood plains soils. Farmers have often misused or exploited the natural resources largely due to ignorance of their physical and chemical composition. This is however exacerbated by lack of documentation on these resources. The management of these soils is compounded by the use of plantation sites for arable cultivation. This challenge is captured by *Ohajianya (2006)* who reported poor resource use efficiency. By complmatching the requirements of land use to land qualities, soil management is optimized, and productivity enhanced*(FAO, 1976)*. This provides a sound basis for advising farmers on appropriate management practices.

The oil palm (*Elaeis guineensis jacq*) received its botanical name from jacquin (1963) originated in West Africa. It is commonly grown in Africa in small and large scales. In Nigeria, it grows in the rain forest and derived savannah belt of Nigeria. The oil palm is one of the large palm species; it has a single stem, The leaf is pinnate with the pinnae (leaflets) arranged in two or more planes on each side of the rachis. In each leaf axial, there is an influence primordial male, and female inflorescence develops into a fruit bunch from which monocarp and kernel oils can be extracted *(Corley and Gray, 1976)*. The oil palm root system is typically monocotyledonous anchoring directly under the base of the palm; the primary root system is very superficial below a depth of one meter *(Purvis, 1956)*. The Oil palm busines plays a significant role in the economy of Nigeria. It provides palm oil for direct household consumption and industrial uses as well as palm kernel and palm kernel oil for livestock feed and industrial raw materials. It provides direct employment to about 4 million Nigerian people who are engaged in the production and marketing of the various products of the oil palm- palm oil, palm kernel, palm kernel oil, palm wine, baskets, brooms, etc. At present, Oil palm production is described to be second to that of Soy bean in world vegetable oil production, and the market for oil palm is expected to increase in the future *(Ho et al., 2007; Yusuf, 2007; Coley, 2009)*. This current study was therefore, undertaken to determine the productivity of soils in the study area with respect to the oil palm and to highlight their limiting qualities and management requirements with a view for improved management of the soils supporting Oil palm plantations in flood plain soils of Igbaji Local Govt area of Kogi state Nigeria.

2. Materials and Methods

2.1 Description of the study area

This study was conducted at Egbili Obebe in Ibaji Local Govt area of Kogi state Nigeria.; the area has geographic coordinates as shownin (Table 1) with an elevation of 106.4m above sea level. It covers an area of approximately 8 hectares. Egbili Obebe in Ibaji experiences a bimodal pattern of rainfall that falls between April to October, with peaks in July and September.This is followed by a short period of the dry season, which is usually between November to February. The study area has an average annual rainfall of 1250 -1350mm with a mean monthly relative humidity of between (30 and 93%) and mean temperature of 29.8^{0}C.The type of land use is majorly annual cultivation with small sizes of land for maize, cassava, Yam, Mango and Orange.

Vegetation/Land use

The location of the study areafalls within the Northern Guinea Savanna vegetation belt of Nigeria, characterized by grassland, shrubs, and scattered trees mainly of economic importance,such as oil palm, showing evidence of degrading secondary forest of a guinea savanna.The dominant grasses include *Andropogon gayanus,Tridas procumbens,Imperata cylindrical, Rottoboellia cochinchinensis* etc.The land is cultivated to arable crops such as *Oriza sativa, Manihot species, Arachis hypogea, Dioscorea species, and Zeamays*.

Field investigation

The proposed site was examined solely for the establishment of oil palm plantation;the basic approach was to delineate the area with reasonably homogenous units on the bases of topography, drainage, vegetation, and land use, and other discernable features that could contribute to soil variation. Auger sampled were taken at a depth of 0-15 and 15-30 cm, respectively. Soil samples were collectedand put into labeled polythene bags and taken for laboratory analysis. All sampling points were geo-referenced using a Geographic positioning system (GPS). Geographic Information System (GIS) approach was used in acquiring relevant satellite imageries for computation of land use and cover. The site qualities occurring under the physical environment were computed using the weighted indices system for soil suitability assessment as earlier enumerated. Climatic data were obtained from the Nigeria Meteorological Agency NIMET (location) *****

Soil Laboratory analysis

Soil samples collected at surface and subsurface (0-15 and 15-30 cm) depth were air-dried at room temperature, pulverized and pass through a 2mm sieve and analyzed using standard procedures. Samples were analyzed for physical and chemical properties of the following parameters: Soil pH was determined in 1:1 soil water suspension using a pH meter *(Hendershot et al., 1993),* Particle size distribution was by the Bouyoucs hydrometer method using Calgonas a dispersing agent as described by *Day (1963)*. Organic carbon was analyzed by the dichromate oxidation procedures *(Walkley and Black,1934)* method, Total (N) was determined by Micro-kjeldah method *(Brookes et al., 1985)*, Available phosphorus was determined by Bray-1 method *(Bray and Kurtz, 1945)*, Exchangeable cations were extracted using NH_4OAC buffered at pH7.0 *(Thomas,1982),* Potassium (K) and Sodium (Na) were determined with a flame photometer while Exchangeable calcium (Ca) and Magnesium (Mg) were determined using Atomic Absorption Spectrophotometer (AAS) Perkin Elmer 403.CationsExchange Capacity (CEC) was determined by the summation of the exchangeable cations *(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 ofthe soil and topography; the land should be leveled or slightly undulating, well-drained with good fertility management. Annual rainfall in the study area ranged between 1250 to 1350 mm which is far below the requirement of 2000 – 2500 as recommended by *Hartley, (1998)* and is considered Not suitable (N) for the requirement of the 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 four months with an average sunshine duration of less than 5 hours, which is below the requirement for the oil palm (Table3). In terms of drainage, over 50 % of the entire area is poorly drained and could lead to severe flooding; this observation is consistent with its proximity to the River Niger. This implies that the general water table in the surrounding area is high and saturated in most of the year with high rainfall. This condition is damaging because palms' roots are tolerantof anaerobic soil layer only to a moderate extent. Besides, anaerobic conditions cause a reduction of nitrate ion, part of it is lost as gaseous nitrogen. Nitrogen deficiency is, therefore, a danger.This condition posed a serious limitation to the cultivation of the oil palm in the study area.

Vegetation and land use

About 58.1 % of the area is swampy while 28.64 % is associated with the natural vegetation with few isolated stands of an existing oil palm tree growing in the wild in some portion of the entire area.

Morphological properties:

The field morphological characteristic shows that land was relatively flat and over 50 % of the entire area is poorly drained; this, however, did not fulfill the requirement for oil palm in terms of drainage (Table 3); this limitation could lead to severe flooding in the study area due to its proximity to the River Niger.The texture of the soil is loam clay at the top (0 – 15 cm) and is dominated by clay loam sub-soil (15 -30 cm).

Soil physical and chemical properties:

Table 1 shows the physical and chemical properties of soils in the study area. The soils have a loam clay texture, which is moderately suitable S2 (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 dominance of sand fraction over the mineral particles and decreases with depth. Clay was next to sand in dominance and increased with increasing soil depth, while silt does not show any definite trend. (Table 1). This observation, however,corroboratesearlier findings by*Rajiet al., (2001)* in Northern Nigeria,who reported that clay content increased with increasedoil depth.The pH of soil measured in water was slightly acidic with pH value ranged from 4.50 to 6.00(Table, 2) and rated Highly suitable S1(Table 3), the pH decreased with depthin 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 5.1- 22.4 gkg^{-1}(Table, 2) and was highest at the surface and decreases down the profile in all the locations assessed and rated low or marginally suitable (S3) for suitability class (Table, 3).

The Total Nitrogen (N) content in all locations was generally low ranged from 0.35 – 3.54 gkg^{-1} (Table, 2),but they were high at the surface as compared to lower depths andwere rated low.The available P values ranged from 2.44 – 26.63 to cmol kg^{-1} (Table, 2) and this fluctuates irregularly with increased soil depth. (Table 1) and was rated marginally suitable (S3) (Table 3), the lowlevel of N and P in these soils makes the application of inorganic fertilizer necessary to supply essential nutrient element required by the oil palm. The Effective Cation Exchange Capacity (ECEC) values in the study area were generally low,ranged between 3.02 – 9.19g kg^1(table 1). 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 matteris 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 favorable structure for sustainable oil palm cultivation

Table: 1. Some selected soil physical and chemical properties of soils of the study sites

Coordinates	Depth	pH	O. C	N	P	Ca	Mg	Na	K	H	Al	ECEC	Clay	Silt	Sand
	(cm)		gkg^{-1}					Cmol kg^{-1}						gkg^{-1}	
N 06^0 56.220	0 - 15	5.90	22.4	1.31	3.95`	3.24	0.96	0.23	0.17	0.20	ND	4.8	47	49	904
E006^0 44.837^1	15 -30	5.40	16.6	0.89	17.10	2.72	0.88	0.22	0.13	0.20	ND	4.15	82	21	897
N06^0 56.136	0 - 15	5.70	17.3	1.20	8.57	2.71	1.00	0.25	0.12	0.20	ND	4.28	42	37	921
E006^0 44.779^1	15 - 30	5.60	5.10	0.35	6.59	2.56	0.80	0.21	0.10	0.20	ND	3.87	82	15	903
N06^0 56.011	0 - 15	6.00	13.4	1.10	26.63	2.56	0.52	0.37	0.33	0.30	ND	3.71	33	29	938
E006^0 44.708^1	15 - 30	5.80	10.6	0.79	13.13	2.12	0.44	0.22	0.29	0.20	ND	3.27	57	18	925
N06^0 55.929	0 - 15	5.70	18.2	1.22	37.48	2.32	0.80	0.21	0.16	0.20	ND	3.69	37	35	928
E006^0 44.718^1	15 - 30	5.60	14.7	0.94	19.10	2.08	0.40	0.20	0.14	0.20	ND	3.02	67	27	906
N060 55.754	0 - 15	6.00	9.60	0.71	24.90	3.08	0.68	0.22	0.21	0.20	ND	4.39	37	18	945
E006^0 44.909^1	15 - 30	5.80	9.60	0.64	2.44	2.44	0.60	0.22	0.18	0.20	ND	3.64	42	17	941
N06^0 55.665^1	0 - 15	5.00	15.4	1.33	17.06	1.72	1.24	0.67	0.24	0.80	3.00	5.67	172	27	801
E006^0 4.995^1	15 - 30	4.90	8.00	0.57	4.07	1.56	0.44	0.62	0.13	0.60	4.40	4.81	202	11	787
N06^0 5565^1	0 - 15	4.80	61.6	3.54	9.65	3.65	3.00	0.86	0.72	0.50	1.40	9.19	107	54	839
E006^0 44.995^1	15 –30	4.70	9.60	0.71	5.04	3.44	2.24	0.75	0.45	0.30	2.10	7.88	177	12	811

Table : 2 Showed the descriptive statistics of the physico chemical properties of the soil

Soil properties	Mean ± SD	Minimum	Maximum
pH	5.375 ± 0.532	4.500	6.000
Organic Carbon gkg^{-1}	16.08 ± 12.92	5.1	22.4
Total N gkg^{-1}	1.06 ± 0.71	0.35	3.54
P cmol kg^{-1}	13.292 ± 10.029	2.440	37.48
Ca cmol kg^{-1}	2.381 ± 0.805	0.77	3.65
Mg cmol kg^{-1}	0.978 ± 0.694	0.40	3.00
Na cmol kg^{-1}	0.362 ± 0.225	0.200	0.860
K cmol kg^{-1}	0.234 ± 0.159	0.100	0.720
H cmol kg^{-1}	0.319 ± 0.183	0.200	0.800
Al cmol kg^{-1}	0.354 ± 0.511	0.000	1.47
ECEC cmol kg^{-1}	4.349 ± 3.123	2.75	8.42
Clay gkg^{-1}	89.25 ± 55.63	33	202
Silt gkg^{-1}	25.5 ± 12.66	11	54
Sand gkg^{-1}	885.25 ± 52.5	787	945

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,	SCL, LS,	Gravel,

			SC	SiC, SC	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)*

Conclusion and Recommendation

The results obtained from the various indices of the assessment showed that soil conditions such as shallow rooting depth, high clay content, inherent poor drainage and susceptibility to flooding due to topography and high water table; over 67% of the entire area assessed were marginally suitable (S3) while 33 % is considered Not suitable (N) for the cultivation of the oil palm. Marginal suitability implies non-optimal yield in oil palm productivity. Soil characteristics that posed severe limitations to high yielding oil palm cultivation in the study area, it is recommended that a more suitable site be adopted for the establishment of the oil palm.

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