EVALUATION OF ACID SANDS OF EGBEMA AREA OF IMO STATE, SOUTHEASTERN NIGERIA FOR TWO PLANTATION CROPS.

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ABSTRACT
Soil of Acid sands of Egbema Southeastern Nigeria was evaluated for their suitability for two plantation crops. Two soil profiles were dug in pedon(1) with geographical coordinates (5°45' N) and pedon(2) with geographical coordinates 6° 46' E. The pedons were dug, described and sampled using FAO, 2006. Routine analyses were carried out on the soil data using standard methods. Descriptive statistics, coefficient of variation, and correlation coefficient were carried out on the soil data. Results showed that soils from pedon 1 showed very dark gray (7.5YR 3/1) to Red (2.5YR 4/6) (moist) while soils in pedon 2 showed Dark reddish brown (5YR 2.5/2) to Red (10 YR 4/4)(moist). The texture of the soils ranged from Loamy Sand to Sand in the two pedons studied. The soils in pedon 1 have very weak granular structure to moderate subangular blocky structure while in pedon 2, soils have weak granular to strong subangular blocky structure. Soils in pedon 1 had vertical pores to oblique pores while soils in pedon 2 had many macropores to lateral pores and many oblic pores to very large pores at both the surface and subsurface horizons. Soils in pedon 2 had higher moisture content (MC=Mean =8.33 ± 0.53) higher total porosity (TP= Mean= 48.80 ± 0.385 g kg^{-1}) and higher SiltClayratio(SCR) (SCR= Mean=0.778 ±0.096) compared to soils in pedon 1 (Mean= MC= 6.95 ±0.103; Mean = TP =43.33 ± 0.479g kg and SCR= Mean= 0.33 ± 0.038) . Soil were moderately to slightly acidic. Exchangeable Ca (Ca =Mean=2.72 ± 0.62 cmol kg^{-1})) and exchangeable K (K = Mean = 0.18 $cmolkg^{-1}$ ± 0.05) were significantly higher in soils in pedon 1 compared to exchangeable Ca and exchangeable K in soils in pedon 2 (Ca=mean= 0.93$cmolkg^{-1}$± 0.116 ;K=mean =0.08cmolkg-1 ±0.014). Soil in pedon 1 showed a significant variation in CEC and available P (CEC = Mean= 6.33 ±0.761 $cmolkg^{-1}$; Aval P= Mean= 25.88±3.04 $mgkg^{-1}$) compared to pedon 2 (CEC = Mean= 4.10 ± 0.167 $cmolkg^{-1}$; Aval. P = Mean=14.25±0.995 $mgkg^{-1}$). The result of the suitability scores by the non-parametric method showed that the soil of the study area were marginally suitable on the bases of fertility limitation for Banana and oil palm production. Therefore, good fertility management by the use of organic manures can be used as a measure to improve the organic matter content of the soil.

Keywords: Suitability Evaluation, Acid Sands, Plantation Crops, Coastal Plain Sand.

INTRODUCTION

Soil is an important resource that can be used for agriculture. Its importance is linked to the production of crops and food security (Fasina *et al.,* 2007). In the developing country like Nigeria, the use of land for optimum crop production has been in the increase due to rise in human population (Teka and Haftu, 2012; Liu and Chen, 2006). In other to meet the increasing demand for food, large areas of land has been subjected to excessive cultivation and the productivity of such lands has decreased due to its excessive use, overgrazing and other anthropogenic activities causing its degradation (Cessen, 1986; Lal, 1994). However, good management of land resources is very important for food security and environmental sustainability (Aliyu et al, 2016).

Land suitability is the degree of appropriateness of land for a particular purpose (van Ranst and Debaveye, 1991; Halder, 2013). Land suitability evaluation is aimed at bringing and matching the soil properties with the agronomic requirement of crops in other to determine their suitability for that particular crop (Dent and Young, 1981; Akpan and Udoh, 2016). The result will help to guide the land user and planners the best decision to make in the use of land for optimum crop production (FAO 1976).

In recent years, agricultural lands have benefitted from different land suitability evaluation which has provided enough information on how best lands can be assessed and evaluated for different crops. However, poor understanding of soil suitability for agricultural production has become problem to land users. Aderonke and Gbadegesin .(2013) stated that proper soil data can be used to design good land use systems that will guide land users to adopt good soil management practices for sustainable crop production. This will also help farmers to know the particular crops that can be grown in a particular land and the type of management practices to be used for maximum crop production. Aguilar and Ortiz (1992) used the FAO framework together with parametric require index in explaining land suitability classes (S1, S2, S3, N1 and N2). Udo *et al.* (2011) used both parametric and non parametric method to evaluate soils from alluvial deposit for rice and cocoa cultivation.

Oil palm (Elaeis Guineensis) is one of the world most important vegetable oil contributing more than 30 % in consumption (Hansen, et al, 2015). Laurence et al (2014) reported that due to large demand for palm oil, there has been rapid expansion in the production of oil palm in Nigeria and across the globe. In Nigeria, oil palm serves as a source of food (oil) and palm wine for human consumption, palm kernel cake for feeding of livestock, and palm oil for making soap (Adeniji *et al*., 1991). It serves as a source income and trade along the border districts (Ofosu Budu and Sarpong, 2013).

Banana also is a major export crop that is consumed widely by millions of household. It is a semi-perennial crop that grows throughout the tropics and subtropics under optimum condition with good water supply. Naidu *et al*. (2006) reported site suitability criteria for optimum growth and yield of banana which include the temperature range of 26-30^o C, wind speed less than 10 mph but not greater than 25 mph, effective soil depth greater than 125 cm but not less than 50 cm.

Land quality which is the important attributes of land contains one more of land characteristics that is important for oil palm and banana production (Rajkishor *et al*., 2017) and such land qualities include (topography, soil and climate) are linked to plant requirements (Ritung *et al*., 2007). These land qualities and land characteristics (drainage, texture, soil depth, nutrient retention, (PH, CEC), alkalinity, erosion hazard) when subjected to changes can limit oil palm and banana production (Fischer *et al*., 2008).

Ogbokofia, a small community in Ohaji Egbema is known for its production for arable food. Most of these crops are produced from peasant farmers which have processed and exported them to other states and countries thus bringing revenue to the State and Nigeria at large. However, due to improper use of land and poor soil management practices, they production of these crops have declined in recent years due to decline in soil properties and soil fertility. There has been depletion of humid rainforest due to excessive use of land in the area. These alterations in land use have caused long lasting effects on soil carbon, nutrient contents, soil texture and pH which arise from changes in plant specie composition and association improper management practices in the study area. This study therefore investigated the evaluation of Acid sands of Egbema area of Imo State, Southeastern Nigeria for two plantation crops.

MATERIALS AND METHODS

Study Area

The study was conducted at Ogbokofia in Oloshi Egbema area of Imo State, lying between latitudes 5^{0}30' and 5^{0}50' N and longitudes 6^{0}30'and 6^o 50' with elevation 58 m above sea level (Fig. 1). The soils are derived from Coastal Plain Sand (Benin formation) (Orajaka, 1975). The area in generally flat to nearly flat (it is a plain with few gentle to undulating slopes). It lies within the humid tropical climate with annual rainfall of 2,500 mm. It has a bimodal rainfall pattern with rainfall peaks at the months of July and September. Generally, there are 9 rainy months and 3 dry months although extreme weather events are currently being noticed. The break time in rainfall pattern is termed August break. The annual temperature ranges between 26-30^o C with higher temperature occurring during dry months. The area has a typically rainfall vegetation characterized by multiple plant species. The plant species are arranged in storeys with few plant species towering above others. These ones are called emergent plant species. The lower plant specie tends to have their species over lapping each other forming a blanket. The older forests have open floors (opening) which are dominated by sun hated plants or shade loving plants. Some of the plant species include oil palm, plantain, oil bean, mango, native pear, coconuts, Avocado, ukwa, pawpaw. Common crops include cassava, yam (tree leaf) melon and groundnut. The area is governed by rivers, streams and lakes. The rivers include Imo river, Oguta Lake, Oloshi river, Uramiriukwa and urashi river. The major socio economic activity of the area is small holder Agriculture with a multiple cropping system. Soil fertility regeneration is by bush fallow in which the soils are allowed to rest for sometimes to enable it regain its fertility. However, with increasing population, the fallow period had shortened leading to supplimentation of soil fertility with chemical fertilizer. Land clearing is by slash and burn system and land preparation is majorly flat except in few areas where mounds are made.

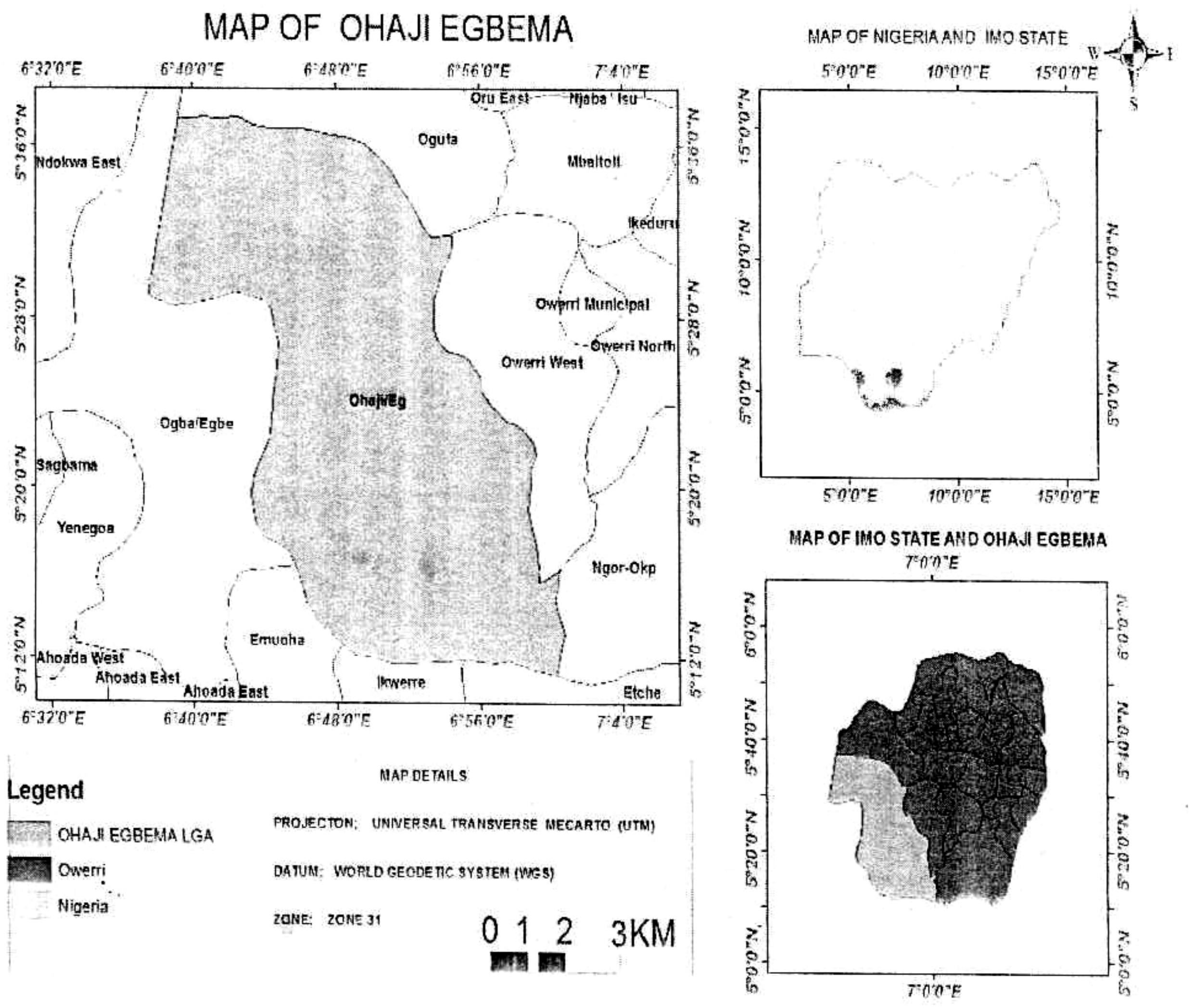

Fig.1: Map of the Study Area

Field Studies

Two sandy sites were selected for the study. Two soil profiles were dug in pedon(1) with geographical coordinates 5^o 45' N (Latitude) and pedon (2) with geographical coordinates 6^o 46' E (Longitude). The profile digging, description and sampling was doing according to FAO (2006). Sampling was based on horizon differentiation and soil samples were collected from the last horizon upwards. Core samples were also collected for bulk density determination. Soil colour was determined insitu using munsell colour chart. The collected soil samples were air-dried and sieved using 2 mm sieve in preparation for laboratory analysis.

Soil Analysis

Particle size distribution was determined by the hydrometer method according to the procedure of Gee and Or (2002). Bulk density was determined by the core sampler method according to Blake and Hartge (1986). Total porosity was calculated from particle density (Pd) and bulk density using the relationship P=100(1-Bd/Pd) where particle density is constant. Soil pH was determined in 1:2.5 soil/water suspension using a glass electrode pH meter. Soil organic carbon was determined using Walkley and Black wet oxidation method (Nelson and Sommer, 1996). Available P was determined using Bray No. 11 method (Olsen and Sommer, 1982). Total Nitrogen was determined using the micro-kjeldahl method (Bremner, 1996). Exchangeable bases (Ca, Mg, K and Na) were extracted using IN ammonium acetate (NH_4OA_C); Ca and Mg were determined by using atomic absorption spectrophotometer while K and Na were determined using flame photometer (Jackson, 1967). Exchangeable acidity was determined by titrating with IN KCl extract (Mclean, 1965). Cation exchange capacity (CEC) was determined using ammonium acetate and leaching at pH, 7.0 (Rhoades, 1982). Effective cation exchange capacity (ECEC) was estimated by summing the exchangeable acidity $Al^{3+} + H^{+}$. Percentage base saturation was calculated using the relationship below

$$BS (\%) = \frac{\text{Exchangeable bases}}{\text{Cation Exchange Capacity}} \times \frac{100}{1}$$

Land Suitability Evaluation

The suitability of soils for banana and oil palm production was evaluated using non parametric method according to Sys. (1985). Soils were first placed in suitability classes by matching their land characteristics with the established requirements for banana and oil palm production. The final suitability classes were determined by the number and intensity of the limitation. The land quality groups were climate (Annual rainfall and mean annual temperature), topography (slopes) wetness, drainage, soil physical characteristics (texture, soil depth) and fertility indicators which include CEC, base saturation, Organic M, Available P, while the suitability classes were S1 (highly suitable), S2 (Moderately Suitable), S3 (Marginally Suitable) and N (Non suitable).

Statistical Analysis

Data collected were subjected to descriptive statistics of Mean, standard deviation. Coefficient of variation was used to determine the variation among soil properties. The coefficient of variation was done according to the procedure of Wilding *et.al* (1994) where Cv ≤ 15% =low variation, CV> 15%≤ 35% =moderate variation, CV>35%= high variation.

RESULTS AND DISCUSSION

Some morphological properties of the soil of the study sites are given in Table 1.The result showed that under moist condition the soils from pedon 1 had very dark gray (7.5YR 3/1) to yellowish Red (5 YR 4/6) at the surface while at the subsurface horizon, the soil colour had Yellowish Red (5 YR 4/6) to Red (2.5 YR 4/6) indicating good drainage and proper aeration in the study site. However, soil from pedon 2 had dark reddish brown (5YR2.5/2) to blank brown (5YR 4/4) indicating the presence of organic carbon content. At the subsurface horizon, soils are Red (Red 10 R 4/4) indicating the presence of unhydrated iron oxide thus denoting good drainage and proper aeration in the soils of the study site. The colour of the soil indicates the influence of the soil forming process on soils of the study sites (Ibange, 2006). The soils of the study sites varied from loamy sand to sand at the surface and subsurface horizons. The soils structures from pedon 1 have very weak granular structure at surface to moderate subangular blocky at the sub surface horizon, while soils from pedon 2 have weak granular to coarse angular blocky structure at the surface to strong subangular blocky at the subsurface horizon. The soils of the study area indicated very friable to friable consistence at the surface horizon and firm consistence at the subsurface horizons. Vertical pores were observed at the surface horizons of pedon 1and oblique pores at the subsurface horizon. However, soils from pedon 2 have many macrospores to lateral pores at the surface horizons and many oblique pores to very large pores at the subsurface horizon.

Table 1: Morphological Properties of Soil of the Study Sites

Horizon	Depths (cm)	Colour (Moist)	Texture	Structure	Consistency	Porosity	Faunal Activity	Root abundance	Inclusion	Boundary
						(Pedon 1)				
Oa	2mm-0	Very dark gray 7.5YR 3/1	LS	Very weak granular	Very friable	Vertical pores.	Prominent	Few fibrous root.	Nil	smooth
A	0-12	Dark brown 7.5YR 3/2	L	Granular	Friable	Vertical pores.	Prominent	Few fibrous root.	-	wavy
AB	12-33	Yellowish Red 5YR 4/6	SL	Sub angular blocky	Firm	Oblique	Nil	Few fibrous root.	-	Diffuse
Bt1	33-65	Yellowish Red 5YR 4/6	LS	Moderate SBK	Firm	Obilque	Nil	Few fibrous root.	-	Wavy
Bt2	65-101	Red 2.5YR 4/6	S	Moderate SBK	Firm	Obilque	Nil	Few fibrous root.	-	Wavy
Bt3	+101	Red 2.5YR 4/6	LS	Moderate SBK	Firm	Obilque	Nil	Few fibrous root.	-	Wavy
						Pedon 2				
A	0-10	Dark,Reddish brown 5YR2.5/2	LS	Weak granular	Very friable	Many macropores	Prominent	Few fine roots	Pottery	Clear
AB	10-29	Dark brown 5YR 4/4	S	Coarse angular blocky	Friable	Lateral Pores	Minimal	Manyfine roots.	Pottery	Clear
Bt1	29-65	Dark brown 5YR 5/6	S	Coarse angular blocky	Firm	Many oblic pores	Nil	Few Large roots	-	Diffuse
Bt2	65-100	Dark Reddish Brown 7.5YR 3/2	SCL	Medium SBK	Firm	Very Large pores	Nil	Many large roots	-	Diffuse
Bt3	+100	Red 10R 4/4	SL	Strong SBK	Firm	Very large	Nil	Few large roots	-	Smooth

Sbk=Subangular blocky, S=Sand, LS=Loamy Sand, SCL=SandyClayLoam

Faunal activities were prominent at the surface horizons of the two sites studied, while in the subsurface of pedon 1 no faunal activity was found. However, in soils from pedon 2 faunal activities were minimal at the AB horizon, while at the subsurface horizon, there was no faunal activity. Furthermore, the root composition in soils from pedon 1were few fibrous root at both surface and subsurface horizons indicating low to absence of oxygen down the horizon. On the other hand, the soils from pedon 2 has few fine roots to many fine roots at the surface horizons and few large roots to many large roots at the subsurface horizons. There were inclusions observed in soils of pedon 2. These inclusions were the presence of broken pots indicating that our ancestors lived there. Soil boundaries were clear and smooth at the surface and diffused at the subsurface horizons of the two sites studied.

The Physical Properties of the soils of the studied sites

Soil physical properties given in Table 2 showed that soils were sandy in the two sites studied. (Sand =Mean= 899.00-924.40). This sandiness could be attributed to parent materials and response to pedogenesis. Clay content was significant higher in pedon 1 (Clay = Mean=81.102± 6.48) compared to pedon 2 (Clay =Mean=42.40±4.774) indicating the distribution of clay particles especially at the subsurface horizon. Bulk Density within the two sites studied did not vary significantly. Moisture content (MC) was significantly higher in pedon 2 (Mean= MC = 8.33±0.53) compared to pedon 1 (Mean=MC=6.95±0.103) possibly due to shady from trees. Sidari et al. (2008) reported that higher amount of insulation governs soil temperature and water availability thus affecting soil properties. Therefore, the canopy formed from pedon 2 reduced the evapo-transpiration which increased the moisture content in the study site. Similarly soils from pedon 2 were significantly higher in Total Porosity (TP) (TP=Mean=48.80±0.385 g kg^{-1}) campared to soils in pedon 1 (TP=Mean=43.33±0.479 g kg^{-1}). This could be due to less disturbance of soils in pedon 2 compared to soils in pedon 1. This result is in line with Onweremadu (2008) who reported high significant variation of total porosity in soils from Oil Palm with mucuna. The low TP in soils from pedon 1 may be attributed to tillage practices and other land uses which may have lowered the total porosity in soils from pedon 1. This is true because tillage breaks down the macroaggregates in the soil through the reduction of biological activities which takes place in plant roots and soil fauna (Wan and El Swaify, 1989).

Table 2: Physical Properties of the studied soils (Mean±Standard deviation)

	Sand	Silt	Clay	SCR	BD	MC	TP
	gkg^{-1}				gcm^{-3}	%	g kg^{-1}
			Pedon 1				
Mean	899.00^{b}	22.20^{b}	81.02^{a}	0.33^{b}	1.37^{a}	6.95^{b}	43.33^{b}
STD	38.297	12.248	38.880	0.229	0.079	0.619	2.875
Std. error	6.380	2.041	6.48	0.038	0.013	0.103	0.479
CV %	4.26	55.17	47.88	69.82	5.77	8.91	5.95
Rank	LV	HV	HV	HV	LV	LV	LV
			Pedon 2				
Mean	924.40^{a}	27.67^{a}	42.40^{b}	0.78^{a}	1.35^{a}	8.33^{a}	48.80^{a}
STD	22.803	15.101	23.87	0.480	0.047	2.65	1.923
Std-error	4.561	3.020	4.774	0.096	0.009	0.53	0.385
CV	2.47	54.58	56.29	61.69	3.48	31.81	3.94
Rank	LV	HV	HV	HV	LV	MV	LV

Means with the same letter are not statistically significant at P<0.05,
STD = Standard Deviation, std error = standard error, CV = Coefficient of variation, LV = low variation, HV=high variation, MV= Mediate variation.

Also SiltyClayRatio(SCR) was significantly higher in soils from pedon 2(SCR=Mean=0.778±0.096) compared to soils from pedon 1(SCR=Mean=0.328±0.038) indicating higher weathering in soils in pedon 2. FAO (1990) reported that SCR<0.20 indicates a low degree of weathering. Therefore, the result of this study showed that SCR was greater than 0.20 from the two sites studied indicating that the soils are highly weathered but more weathered in pedon 2 compared to soils from Pedon 1.

Soil Chemical Properties of soils of the studied sites

Table 3 shows the result of the chemical properties in soils of the study sites. The soils were moderately to slightly acidic. Organic Matter (OM) and Total Nitrogen (TN) did not differ significantly (P<0.05) their values were higher in soils in Pedon 1 (OM=Mean=11.48 ±1.800 gkg^{-1}; TN = Mean=0.57±0.92 gkg^{-1}) compared to soils from pedon 2 (OM= Mean=10.45±0.887 gkg^{-1}; TN= Mean =O.51±0.045 gkg^{-1}). The higher values of OM in soils in pedon 1 were due to high accumulation of litter materials and manure materials such as, used bunches or bunch refuse from the study site. Sharma and Acharya (2000) reported that crop residues increase soil organic carbon in soils. Therefore, the litter materials in the study site increased the Organic Matter (OM) in pedon 1. The higher values of Total Nitrogen (TN) (TN=Mean=0.57±0.092 gkg^{-1}) in pedon 1 and Total Nitrogen (TN) in pedon 2 (TN=Mean=0.51±0.045 gkg^{-1}) is indicative of less mineralization of N. However, soils from pedon 1 showed a significant increase in Available P (Av.P) (Av.P=Mean=25.88±3.004 mg kg^{-1}) compared to soils from pedon 2 (Av.P=Mean=14.25±0.995 mg kg^{-1}) probably due to addition of phosphate fertilities in the study site. The Av.P in soils from pedon 2 was below the critical limit of 15 mg kg^{-1} for soils of Southeastern Nigeria (Ogban *et.al,* 2005). This may be attributed to management and fixation of Phosphorous. Ballard and Fiskell.(1974) reported that P sorption is high in highly weathered tropical soil as a result of the presence of iron and aluminum at the exchange sites, and presence of hydrated oxide, Organic Matter (OM) silt and clay. This has made P more sorbed in the study site. Exchangeable bases varied highly in both pedon1 and pedon 2. Exchangeable Ca and exchangeable K were significantly higher in soils in pedon 1 (Ca=Mean=2.72±0.621cmol kg^{-1}; K=Mean=0.18±0.05cmol kg^{-1}) compared to soils in pedon 1 (Ca=Mean=0.93±0.116cmol kg^{-1}; K=Mean=0.08±0.014cmol kg^{-1}). When compared with the critical limit of 0.31cmol kg for exchangeable K as reported by Unnambah-Opara, (1985), the soils in the study sites, were deficient in exchangeable K and therefore requires the addition of potassiumfertilizer.

Table 3: Chemical Properties of soils of the studied soils

		Exchangeable bases					Exch. Acidity							
	pH	Ca	Mg	Na	K	TEB	H	Al	TEA	CEC	BS	OM	TN	AV.P
	H_2O					$cmolkg^{-1}$					%	gkg^{-1}	gkg^{-1}	$mgkg^{-1}$
							Pedon 1							
Mean	6.33^{a}	2.72^{a}	1.77^{a}	0.14^{a}	0.18^{a}	4.93^{a}	0.77^{a}	0.53^{a}	1.40	6.33^{a}	72.24^{b}	11.48^{a}	0.57^{a}	25.88^{a}
STD	0.404	3.724	1.186	0.227	0.302	4.739	0.794	0.853	1.419	4.565	22.384	10.803	0.553	18.023
Std. error	0.067	0.621	0.198	0.038	0.05	0.789	0.132	0.142	0.237	0.761	3.731	1.800	0.092	3.004
CV (%)	6.38	>100	67.06	>100	>100	96.13	>100	>100	>100	72.12	30.99	94.10	97.02	69.64
Rank	LV	HV	HV	HV	HV	HV	HV	HV	HV	HV	MV	HV	HV	HV
							Pedon 2							
Mean	6.45^{a}	0.93^{b}	1.92^{a}	0.21^{a}	0.08^{b}	3.15^{b}	0.46^{a}	0.44^{a}	0.92^{b}	4.10^{b}	75.56^{a}	10.45^{a}	0.51^{a}	14.25^{b}
STD	0.568	0.581	1.003	0.042	0.068	0.944	0.357	0.645	0.424	0.834	10.543	4.433	0.225	4.973
Std. error	0.114	0.116	0.201	0.008	0.014	0.189	0.071	0.129	0.085	0.167	2.107	0.887	0.045	0.995
CV (%)	8.81	62.47	52.24	0.20	0.85	29.97	77.61	>100	46.09	20.34	13.95	42.42	44.12	34.898
Rank	LV	HV	HV	LV	LV	MV	HV	HV	HV	MV	LV	HV	HV	MV

Means with the same letter are not significant at $P< 0.05$, STD = Standard deviation, Std error = Standard error, CV = Coefficient of variation, LV = Low variation, HV = High variation, MV = moderate variation.

Also, Cation Exchange Capacity (CEC) and Base Saturation (BS) showed significant difference in both pedon 1 and pedon 2 .Cation Exchange Capacity (CEC) was significantly higher in pedon 1 (CEC=Mean=6.33±0.761cmol kg ^{1}) compared to pedon 2 (CEC=Mean=4.10±0.167cmol kg ^{1}). Base saturation was significantly higher in pedon 2 (BS=Mean=75.56±2.107cmol kg ^{1}) and lower in pedon 1 (BS=Mean=72.24±3.731cmol kg ^{1}).

Land Suitability Evaluation

The results of the land suitability evaluation in Tables 4, 5, 6 and 7 showed that when the land characteristics of the study area were matched with the established requirements for banana and oil palm, (Sys, 1985), annual rainfall and mean annual temperature scored 95 % (S1) respectively in all the land units. The suitability class was highly suitable(S1) indicating that the soil was highly suitable for banana and oil palm production with no limitations and therefore do not limit growth and yield of banana and oil palm. Also, matching the requirement for banana and oil palm plantation with the drainage and topography of the study area, it indicated that the drainage condition in both pedon 1 and 2 were optimal (95 %) showing that the study sites were well drained. The topography in both pedons was also optimal, pedon (1) (95 %) and pedon (2) (100 %). This is an indication that the drainage condition and the sloppy nature of the soils of the study area are highly suitable (S1) for banana and oil palm production. Furthermore, the soil physical properties and fertility status considered for both banana and oil palm production were soil depth, texture, pH (H_2 O), CEC, base saturation and organic matter. The soil depth was optimal (95 %) and highly suitable (S1). Also, most of the fertility parameters namely; pH (H_2 O), (95 %), base saturation (95 %) and organic matter (95 %) were all optimal and highly suitable (S1) with no limitation for banana and oil palm production.

Table 4: Suitability Characteristics of the Study Area

Land qualities	Land characteristics	Pedon 1	Pedon 2
Climate (C)	Mean annual Rainfall (mm)	2,500	2,500
	Mean annual Temperature (^{0}C)	26-30	26-30
Wetness (W)	Drainage	well drained	well drained
Topography (t)	Slope (%)	0-1	0-1
Soil physical properties.	Soil Depth (cm)	>100	>100
	Texture	LS LS,SCL,S	
Fertility (F)	pH ($H_2$0)	6.33	6.45
	CEC (cmol kg^{-1})	6.33	4.10
	BS (%)	72.24	75.56
	Om (g kg^{-1})	11.48	10.45

LS = Loamy Sand, SCL = Sandy Clay Loam, Sbk = Subangula blocky, CEC = Cation Exchange Capacity, BS= Base Saturation, Om = Organic Matter.

Table 5: Soil Requirement for Banana Production

Classes	Climate		Slope	Drainage	Soil characteristics					Saline (ds/m) Alkaline (%)
						Fertility				
	Ann.Rain (mm)	Mean (°C) Ann.Tem	%		Texture	CEC Clay	BS	pH H_20	OC	
S1	>1500	18-22	0-2	Moderately Good	SiCI, CI, SiL, SCL	16-24	35->50	5.8-7.5	>24	0-2 0-4
S2	1250-1500	16-18	2-4	Imperfect	SCL	16(-)	20-35	4.2-5.6 7.5-8.0	2.4- 1.5	2-4 4-8
S3	1000-1250	14-16	4-6	Poor	SL,LS	16(+)	<20	5.2-4.5 8.0-8.2	1.5-0.8	4-6 8-12
N	<1000	<14	>6	Poor	FS,S,CS	-	-		<0.8	>6 >16

S1= suitable, s2 = moderately suitable, s3 = marginally suitable, n=not suitable, (n1= not suitable(improveable), n2 = not suitable (permanent), sicl = Silty clay loam, cl= Clay loam, Sil=silt loam, sc= Sandy clay, sl=sandy loam, l=loam, fs= fine sand, cs=coarse sand, s=sand.
Source: Soil Requirement for Banana plantain Modified from Sys. (1985).

Table 6: Soil Requirement for Oil Palm Modified From Sys. (1985)

Land Qualities	**100** **$S1_1$**	**95** **$S1_2$**	**85** **S2**	**60** **S3**	**40** **N1**	**25** **N2**
Climatic (C):						
Annual Rainfall (mm)	>2000	1700-2000	1450-1700	1300-1450	1300-1250	<1250
Length of growing season (months)	<1	1-2	2-3	3-4	3-4	<4
Mean Annual temp. (^oC)	>25	22-25	20-22	18-20	16-18	<16
Relative humidity (%)	>75	70-75	65-70	62-65	60-62	<60
Topography (T):						
Slope (%)	0-4	4-8	8-16	16-30	>30	>30
Wetness (w):						
Flooding	F0	F0	F1	F2	F2	F3
Drainage	Somewhat	mod. Well Poorly drained	mod. Well	Poor drain	Poor drainable	Poor, very poor not drainable
Soil physical properties (s):						
Texture	CL, SCL L	CL SCL L	SCL	SCL-LM	Any	C. Cx. any
Structure	Blocky	Blocky				
Soil Depth (cm)	>125	>100	>75	>50	>55	<50
Fertility (f):						
CEC (cmol/kg-1Clay)	>16	Any	<10	<10	<5	<5
Base Saturation (%)	>35	35-20	20-15	15-10	<10	<10
Organic matter (%C) (0-15cm)	>1.5	0.8-1.5	<0.8	<0.5	<0.3	<0.2

Table 7: Suitability Class Scores of the soils of the study sites

Land qualities	Land characteristics	Pedon 1	Pedon 2.
Climate (C)	Mean annual Rainfall (mm)	S1 (95-100)	S1 (95)
	Mean annual Temperature (^{0}C)	S1 (100)	S1 (100)
Wetness (W)	Drainage	S1 (95)	S1 (95)
Topography (t)	Slope (%)	S1 (95)	S1 (100)
Soil physical properties.	Soil Depth (cm)	S1 (95)	S1 (95)
	Texture	S3 (60)	S3 (60)
Fertility (F)	PH (H_20)	S1 (95)	S1 (95)
	CEC (cmolkg^{-1})	S3 (60)	S3 (60)
	BS (%)	S1 (95)	S1 (95)
	Om (gkg^{-1})	S1 (95)	S1 (95)

Suitability class range = S1=95-100, S2=85, S3=60, NI =40, N2 = 25. Optimal)
(Nearly optimal) (Marginal) (Sub optimal).

However, texture such as sandiness of the soil and low cation exchange capacity (CEC) were the major constraints being marginally suitable (S3) scoring 60% each in the entire study area. This indicates that study area has severe limitations to produce good yield for banana and oil palm due to sandiness of the area (texture) and low ability of the soils to retain nutrients. Therefore, increase in Organic Matter (OM) is necessary to sustain soil fertility.

CONCLUSION

The soils of the study area are marginally suitable for banana and oil palm production. The major constraints in banana and oil palm production are the limitations from texture and cation exchange capacity (CEC). Therefore, the soil of the study area should be put into good fertility management by incorporating organic matter to the soil such that the marginally suitable (S3) would become moderately suitable.

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