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Research Paper

LAND EVALUATION AND MANAGEMENT OF AN UTILISOL FOR FRUIT CROPS PRODUCTION IN SOUTH SOUTHERN NIGERIA

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Abstract

About 60ha farm in an utisol in South Southern Nigeria was suitability Evaluated for fruit crop production (Plantain/Banana, pineapple mango, citrus, pawpaw and pear) is on nearly flat to flat land with agro-ecological features adequate for most tropical fruit crops. Soil constraints are topsoil coarse texture, poor structure, extreme acidity, low basic cation content and CEC. Current soil chemical properties are the most critical soil fertility limitations which rate Pedons 1 and 3 as moderately suitable [S2f] and marginally suitable [S3f] for citrus, pineapple, plantain/banana while Pedon 4 is not suitable [NSf]. For mango, pear, guava and indigenous tree fruits, Pedons 2 and 4 are moderately suitable [S2f] and marginally suitable [S3f] respectively. Only pawpaw has climatic limitations, for marginally suitable [S3c, S3cf] and not suitable [NScf] ratings in the pedons. Mulching and manuring to maintain soil organic matter at high levels should optimize soil reaction and so make liming unnecessary for citrus, guava, mango and pawpaw. Split application of appropriate N, K and Mg fertilizers and complementary manure – fertilizer use are recommendations for attaining potential suitability rating in the site.

Key words: Ultisols, Suitability, Evaluation, Fruits, Citrus, Suitable, Not suitable.

INTRODUCTION

Establishment of tree crops, in plantations, mimics the natural rainforest vegetation and is perhaps the only sustainable land use for the humid tropical environment characterized by inherently poor soil resources (Ataga *et al*, 1981; Opeke, 1987; Aruleba and Ajayi 2012). Thus, tree fruits are regular features of cropping systems in Onne

Eleme Local Government Area in the upland zone of River State, in the farm of semi-wild volunteer plants protected during bush clearing and the regularly cultivated species. The latter consist of (1) Indigenous fruit trees: African mango (Iruingia gubonensis), native pear (Dacryodes edulis), star apple (chrysophyclum albidum), African breadfruit (Treculia africana), etc and exotic tropical and subtropical species: mango (mangifer indica), pawpaw (carica papaya), plantain/banana (musa sp), pineapple (Ananas cornosus), guava (Psidium guajava), Avocado pear (Persa amerizana) oranges (citrus sp) etc. These feature as the cultivated tree plant component of the intensively – managed multistory homestead garden / compound farm production system and the intercropping system with staple food and cash crops in the (distant) farms (Ohigbo, 1983; NRCRI, 1986; Aruleba and Ajayi 2012).

Cultivation of these crops appears the first logical land use option for the 60.7 hectare (ha) farm at Onne proposed as a rural development project by NAFCON Limited, to demonstrate the effectiveness of urea-based nitrogenous fertilizers. This development would aim at sustainable land use, and so require that evolution of the land resources be carried out, through soil survey and characterisation. Data obtained from studies on land forms, soils, vegetation, land use and various aspects of the land would be interpreted to produce soil type and land capacity maps (Fagbami and Ogunkunle, 2000; Aruleba 2004). Thus, it would be possible to predict the relationships that determine the use to which the land is best put, identify the inherent limitation and how to mitigate them and so attain potential suitability. This paper uses data of physiography and climatic features, soil morphological and physico-chemical of the soils to assess the inherent capability of the NAFCON farm, and the extent to which appropriate management recommendations can alleviate the current limitation and so raise the sustainability for fruit crops.

MATERIAL AND METHODS

Land suitability evaluation involved meteorological data, physiolographic measurements in the farm and surroundings, morphological description of four pedons, physical and chemical characteristics of samples taken from the horizon. The method of land evaluation was that developed by FAO (1976) and modified for tropical soils and crops by Sys (1985).
Site qualities were matched with identified individual requirement
which are known to exert significant influences on yields in the crops (Table1). Aggregate suitability for each pedon as indicated by the most limiting site quality, was determined at the actual and potential levels of suitability for Avocado pear, citrus, guava, mango, pawpaw, pineapple, plantain/banana and the three most important indigenous tree fruits: African mango, native pear and African star apple. The actual refers to suitability for pear desired land use in its present condition, without any improvement on the land. The potential is suitability for the desired use at some future date, after substantial improvement must have been made on the modifiable properties of the land.

Scores were given to the quality of each pedon and suitability calculated as index of productivity, as follows:

$$1P = A \times \sqrt{B/100 \times C/100 \ldots\ldots\ldots F/100}$$ (sys, 1985).

Where A= overall lowest characteristic rating.
B,C……F are lowest characteristic ratings for each land quality group: land quality group are C= climate, t= topography, s= soil physical characteristics, w= wetness, and f= fertility.
Suitabilities classes are S1= Highly suitable, S2= Moderately suitable, S3= Marginally suitable, NS= Not suitable, corresponding to 85-100, 60-85, 40-60 and <40% respectively.

RESULTS AND DISCUSSION

The sites topography is undulating and nearly flat to flat (0-2% gradient) with deep (>180cm) and well drained pedons, (Table 2) and so highly suitable (S1) when matched with requirement for fruit crops. The excessive annual rainfall (>2400mm) and number of dry months compared with citrus and pawpaw requirements should rate the site as not suitable. The crops are widespread in the LGA, through not deliberately cultivated in orchards, but as few plantings or protected seedling, in compound farms or outlying farms. Pawpaw is found in habitat provided by refuse dumps / sites on the outskirts of town and villages. The common citrus species is sweet orange, which in the absence of low temperature needed for the break of golden yellow colour retains shades of green at ripening and so termed Nigerian Green Orange (Adelaja and Olaniyan, 2000).

The surface layer coarse texture (sandy loam-clay loam) and poor aggregate stabilities, indicated by weak, fine, granular / struictureless and loose structure, are typical of soils developed on coastal plain sands (CPS) parent materials (FMANR, 1990; Ogban *et al*,2001). The

low clay content is responsible for low available water capacity and poor water retention, while non-capillary porosity is high. These cause rapid gravitational flow and low water storage (Ogban, *et a,.* 2005). Fruit crops are usually established by slash-and-mulch system under which the inadequate soil physical quality (coarse-textured nature and poor structure) does not pose problems. That the site is rated as highly suitable (S1). Slaking and surface sealing, problems that occur with frequent cultivation under slash-and-burn, short bush-fallow, and high tillage-induced. compaction and erosion are eliminated. Slash-and-burn, excessive drainage and aeration after tillage under the high rainfall and temperature requires provide intensely oxidizing environment for rapid breakdown of organic matter. (Ogban, *et al,*2005).

Extreme acidity (pH 3.8-4.5; 3.8-4.3 in the 0-15 and 15-30cm layer respectively) is due to very low-low basic cation content. The CPS parent materials, are deficient in weatherable minerals, white the intensive weathering and leaching by humid tropical condition leave hematite-stained quartz in the sand fraction and the silt dominated by quartz, kaolinite and iron-oxides (FMANR, 1990). These conditions require the exchange complex of basic cations and their replacement by H and AI ions, such that the soils exhibit extreme acidity and low CEC. Low levels of exchangeable cations and CEC rate the pedons as highly suitable (S1) to not suitable (NS) depending on the crop.

Soil organic carbon is moderate to high, with only pedon1 rated as moderately suitable (S2) for plantain / banana, citrus and pineapple. The values exceed averages reported for some soils developed in CPS in Rivers State (Enwezor *et al,*1981) and Akwa Ibom State (Ogban and Edem, 2005). The re-established vegetation of small woody trees and shrubs add substantial letter which has low decomposition under the complete canopy cover while small holder farming activities ceased on the site.

Aggregate suitability under the present situation, varies between highly suitable (S1) in Pedon 3 for all crops (except pawpaw) to NSf in Pedon 4 for plantain / banana, pineapple and citrus and NScf in Pedon 4 for pawpaw. The inclusion of soil pH as a land quality requirement worsened the site for the production of these crops except in Pedon 2 and 4 which retain marginally suitable (S3f)and not suitable (NSf) rating for plantain / banana and pineapple, and Pedon 4 at not suitable (NSf, NScf) for citrus and pawpaw.

CONCLUSIONS AND RECOMMENDATIONS:

Land development should involve slashing and stumping of the small-sized woody trees and shrubs. If mechanical clearing is unavoidable, the bulldozer blade should be kept at a level that does not disrupt or scrape the surface layer of soil. Only pineapple may require further tillage for planting on that beds. Deep ploughing, to mix the fine-textured subsoil with the coarse topsoil, and making the beds alone, the contour will reduce runoff and erosion. Mulching (plant residuce management) manuring and cover cropping are recommended, to control maintain soil organic matter at high levels.

These crops are adapted to the high rainfall zone where soils are inherently acidic. So, low soil pH, per se, is not a limitation but the deficiency in basic cations as the main cause of acidity, would affect the crops. In the circumstances, liming is not a recommended practice for plantain / banana and pineapple. Fruit crops have large K requirements, which can be met with the application of muriate of potash (Mop, 60% K20) and appropriate compound fertilizer, such as NPK 12-12-17+2Mg0. With these recommendation, the potential suitability rating improve to highly suitable (S1) except for pawpaw with marginal suitability (S3c).

Although, N and P status are not soil qualities directly considered in land suitability evaluation, their management is released from organic matter mineralization that may not satisfy the needs of crops and prospect of high nitrate leaching losses explain the widespread N deficiency in the area. Thus, application of N fertilizer (urea, convenient compound fertilizers-NPK 27-13-13, 20-10-10, 12-12-17+12 Mg0) and complementing manure-fertilizer use would be the rule. Thus, the optimal rates must be evaluated.

Available P is high in these soils, based on 25mg.kg soil^{-1} high soil fertility class (FMANR, 1990). Since responses to P and P requirements of fruit crops are low (Denton *et al*, 2000), P fertilizer use would not be a priority.

Plantain / banana, pineapple and pawpaw productivity declines as the orchards age. So, after harvesting 2-3 ratoon crops, the pineapple plants are removed and the orchard allowed to revert to fallow. After harvesting the mother plant, 1-2 suckers should be maintained in each plantain / banana mat. The prospects of orchard reliabilitation, by replanting hygienically produced suckers and also to re-align the stands can be exploited. These practices that sustain orchard productivity also prevent a building of insect pests, nematodes and pathogens.

Table 1: **Land quality requirements for production of major fruit crops.**

	Plantain / Banana				**Pineapple**				**Mango**			
Land Qualities	S1	S2	S3	NS	S1	S2	S3	NS	S1	S2	S3	NS
Climate (c)												
Rainfall (mm)	2000 +	1450-2000	1250-1450	<1200	2000 +	1450 - 2000	800-1450	<800	1700 - 2000 +	1450 - 1700	1000 - 1450	<700
Dry season length	1-2	2-4	4-5	>5	1-2	2-4	4-6	>6	2-3	3-4	4-6	>6
Temp.^{0}c	25-32	22-25	20-22	<20	25-30	20-25	15-20	<15->14	25-32	20-25	18-22	<18
Wetness (w)												
Drainage	Well	Moderate	-	Imperfect	Well	Mod-erate	-	Imper Fect	Well	-	-	Moderate
Flooding	F0	F1	-	F2	F0	F1	-	F2	F0	-	-	F1
Topography (t)												
Slope, %	0-8	8-16	16-30	30-50	0-8	8-30	30-50	>50	0-8	8-16	16-30	>30
Soil physical characteristics (s)												
Soil depth (cm)	>100	50-100	20-50	<20	>100	50-100	20-50	<20	>100	70-100	50-70	<50
Texture	SL,SCL CL	LS	S	C	SL,SCL CL	LS	S	C	LS,SL,SCL,CL	SC	S,LC	c
Soil fertility (f)												
CEC, cmol.kg^{-1} clay	>16	12-16	10-12	<10	>16	12-16	10-12	<10	>16	10-16	5-10	<5
Base Saturation %	>35	20-35	10-20	<10	>35	20-35	10-20	<10	>35	20-35	-	<20
Organic matter	>1.8	1.2-1.8	0.8-1.2	<0.8	>1.8	1.2-1.8	0.6-1.2	<0.6	>1.2	0.8-1.2	0.4-0.8	<0.4
Soil pH	5.0-6.0	6.0-6.9	4.0-5.0	<4.0	5.5-6.0	4.0-5.5	6.0-6.9	<4.0	6.7	5.6	4-5	<4
	Citrus				**Pawpaw**				**Avocado Pear**			
	S1	S2	S3	NS	S1	S2	S3	NS	S1	S2	S3	NS
Climate (c)												
Rainfall (mm)	1700 - 2000 +	1250-1700	800-1200	<800	1250 - 1450	1450 - 1700	1700 - 2000 +	<700	1700 - 2000 +	1450 - 1700	1250 - 1450	<1200
Dry season	2-3	3-5	5-7	>7	4-5	3-4	1-3	>7	2-3	3-4	4-5	>5

length												
Temp.^{0}c	25-37	20-25	15-20	<13->42	25-32	22-25	20-22	<20	25-32	20-25	20-22	<20
Wetness (w)												
Drainage	Well	-	-	Mod-erate	Well	Mod-erate	-	-	well	Mod-erate	-	-
Flooding	F0	-	-	F1	F0	F1	-	-	F0	F1	-	-
Soil physical characteristics (s)												
Soil depth (cm)	>100	70-100	50-70	<50	>100	50-100	20-50	<20	>100	75-100	50-75	<50
Texture	SL,SCL CL	LS	S	C	SL,SCL CL	LS	S	C	LS,SL,SCL,CL	SC	S,LC	c
Soil fertility (f)												
CEC, cmol.kg $^{-1}$ clay	>16	10-16	-	<10	>16	12-16	8-12	<8	>16	8-16	4-8	<4
Base Saturation %	>35	20-35	-	<20	>35	20-35	-	<20	>35	-	-	-
Organic matter	>1.8	1.2-1.8	0.8-1.2	<0.8	>1.8	1.2-1.8	0.8-1.2	<0.8	0.8-1.2	0.4-0.8	-	<0.4
pH	5.5-6.5	6.5-7.0	4.5-5.5	-	5-6	6-7	4.5-5.0	<4.5->7.0	6.7	5.5-6.0	4.5-5.5	<4.0
Topography (t)												
Slope, %	0-16	16-30	30-50	>50	0-4	4-16	16-30	>30	0-8	8-30	30-50	>50

	Guava				**Irungia, Star apple, Native pear**			
	S1	S2	S3	NS	S1	S2	S3	NS
Climate (c)								
Rainfall (mm)	2000+	1450-2000	800-1450	<700	2000+	1450-2000	800-1450	<800
Dry season length	1-2	2-4	4-6	>6	1-2	2-4	4-6	>6
Temperature	25-32	20-25	10-20	<16	32-36	25-32	22-25	<22
Topography (t)								
Slope, %	0-16	16-30	30-50	>50	0-8	8-30	30-50	>50
Wetness (w)								
Drainage	Well	Moderate	-	Imperfect	Well	Moderate	-	-
Flooding	F0	1	-	F2	F0	F1	-	-
Soil physical characteristics								
Texture	CL,SCL SL	LS	C,S,	-	SL,SCL CL,L	SC	LS,S	C
Soil depth	>100	70-100	50-70	>50	>100	70-100	50-70	<50
Soil fertility (f)								
CEC cmol.kg clay^{-1}	>16	8-16	4-8	<4	>16	8-16	4-8	<4
Base saturation, %	>35	-	-	-	>35	-	-	-
Organic matter	>1.2	0.8-1.2	0.4-0.8	<0.4	0.8-1.2	0.4-0.8	0.2-0.4	<0.2
pH	5.5-6.0	6.0-7.0	4.4-5.5	<4.0->7.0	5.0-6.0	4.0-5.0	6.0-7.0	<4.0->7.0

S1=Highly suitable, S2= Moderately suitable, S3= Marginal suitable, NS= Not suitable, F0=No flooding, F1= 1-2 month Flooding in 10 years, F2= not more than 2-3 months flooding in 5 out of 10 years, F3= flooding 2 months almost every year; CS= clayey sand, CL= clay laom, SC= sandy clay, SCL= sandy clay loam, SL= sandy loam, LS= loamy sand, S= sand C= Clay.

Table 2: **Site characteristics in the NAFCON Ltd farm at Onne.**

	Pedons			
Characteristics	1	2	3	4
Climate (c)				
Annual rainfall (mm)	2400	2400	2400	2400
No of dry months	1-2	1-2	1-2	1-2
Absolute min. temp ºc	23.3	23.3	23.3	23.3
Maximum temp, ºc	30.4	30.4	30.4	30.4
Relative humility, %	75-89	75-89	75-89	75-89
Topography (t)				
Slope,%	0-2	0-2	0-2	0-2
Wetness (w)				
Drainage	Well drained	Well drained	Well drained	Well drained
Flooding	F0	F0	F0	F0
Soil physical characteristics (s)				
Texture	SL	CL	SL	SCL
Depth, (cm)	180	180	180	180
Soil fertility (f)				
CEC umol.kg soil^{-1}	2.15	3.68	2.41	1.36
Base saturation, %	49	76	68	55
Exch. Ca, cmol.kg soil^{-1}	0.24	1.27	0.56	0.09
Exch. Mg, cmol.kg soil^{-1}	0.16	0.84	0.36	0.06
Exch. K, cmol.kg soil^{-1}	0.18	0.15	0.18	0.11
Exch. Na, cmol.kg soil^{-1}	0.48	0.47	0.53	0.49
Total acidity, cmol.kg soil^{-1}	1.09	0.85	0.78	0.61
Organic matter, %	3.69	5.14	3.03	3.55
Total N, %	0.12	0.25	0.14	0.29
Available P, cmol.kg soil^{-1}	26.2	27.3	29.0	32.8
pH	4.3	4.4	4.5	4.0

F0= No flooding, SL= Sandy loam, CL= Clay loam, SCL= Sandy clay loam
ESP= Exchangeable sodium percentage

Table 3: **Aggregate suitability of soil for production of fruit crops.**

	Plantain/Banana				Pineapple				Mango				Citrus			
Pedons	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Characteristic																
Soil fertility (f)																
CEC cmol.kg^{-1}clay	S1	S3	S1	NS	S1	S3	S1	NS	S1	S2	S1	S3	S1	S2	S1	NS
Organic matter	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
* pH	S3	S3	S3	S3	S2	S2	S2	S2	S3	S3	S3	S3	NS	NS	S3	NS
Actual suitability	S1	S3f	S1	NSf	S1	S3f	S1	NSf	S1	S2f	S1	S3f	S1	S2f	S1	NSf
* Actual suitability	S3f	S3f	S3f	NSf	S2f	S3f	S2f	NSf	S3f	S3f	S3f	S3f	NSf	NSf	S3f	NSf
Potential suitability	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1

	Pawpaw				**Pear**				**Guava**				**Indigenous tree fruits**			
Climate (c)																
Rainfall (mm)	S3	S3	S3	S3												
Dry months	S3	S3	S3	S3												
Soil fertility (f)																
CEC, cmol.kg clay^{-1}	S1	S3	S1	NS	S1	S2	S1	S3	S1	S2	S1	S3	S1	S2	S1	S3
Organic matter	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
pH	NS	NS	S3	NS	NS	NS	S3	NS	NS	NS	S3	NS	S2	S2	S2	S2
Actual suitability	S3c	S3cf	S3c	NScf	S1	S2f	S1	S3f	S1	S2f	S1	S3f	S1	S2f	S1	S3f
* Actual suitability	NScf	NScf	S3cf	NScf	NSf	NSf	S3f	NSf	NSf	NSf	S3f	NSf	S2f	S2f	S2f	S3f

* Suitability included soil pH as a land quality.
Ratings not included for some qualities that are highly suitable (S1).
S1= Highly suitable, S2= Moderately suitable, S3= Marginal suitable,
NS= not suitable.

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