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Suitability Assessment of a Farm at Onne, Rivers State for Leaf and Fruit Vegetable Crops

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Abstract: The nearly level to level and undulating topography of the 60.7 ha Farm of NAFCON Limited at Onne, Rivers State offers potentials for mechanized land development. The >2400 mm annual rainfall is well distributed to allow 2-3 cycles of leaf and fruit vegetables. The identified soil constraints are surface layer coarse texture, extreme, low content of basic cations and CEC. Based on requirement set for okro, pepper, eggplant, melon (egusi) amaranth and fluted pumpkin, actual level of suitability of four pedons are marginal (S3sf) to moderate (S2f). The site is not suitable (NSscf) for wet season tomato but can be marginally Suitable (S3sf) in late season production. Soil management recommendation are conservation tillage, practices which increase and maintain organic matter, liming, split application of appropriate fertilizers and implementing manure fertilizer use.

Key words: Ultisoils, Land evaluation, fruit and leaf vegetables, suitable not suitable

INTRODUCTION

Dietary vegetable products fit into the description of new, high quality and cheap sources of protein, energy, vitamins and minerals (Ologunde *et al*., 1992; Gubben and Deaton, 2004) that have great potentials for feeding the rising human population associated with rapid urbanization and industrial growth in Nigeria. The number and sizes of towns/cities are growing and the inhabitants need to be supplied with sufficient quantities of nutritious food.

This is a dawating challenge and source of scare, as the present unsatisfactory nutritional status, based on high level consumption of street food, processed food and snacks (junk or fast food) rich in fat, sugar and salt, eaten just to fill the stomach rather than feed in a balanced way is already taking a toll on the inhabitants' health.

The nutrition crisis is indicated by severe protein-energy malnutrition, vitamin A, iron and micronutrient deficiency specially in children, pregnant women and lactating mothers and high levels of obesity, diabetes and cardio-vascular diseases in adults. Thus, the awareness is on the increase that inclusion of enough vegetables in the diets would prevent these illnesses. This is generating a huge demand, that provides incentives for farmers to step up production and increasingly turn vegetables into cash crops.

Indigenous species intercropped with staple food crops in smallholder outlying fields and in mixtures with fruit trees in compound farms (homestead gardens) are the main forms of vegetable production systems in Nigeria (Okigbo, 1983). Rising demand for vegetable in the quest for better living standards and decline in arable land available for cultivation per capita are accelerating the change to science-based production systems. Thus, okro (*Abelmoschus esculentus*), chillies and peppers (*Capsicum* sp.) eggplant (*Solanum gilo, Simelongena*), amananth (*Amananthus cruentus*, *A hybridus*), melon (egusi), *Citarillus lanatus*), fluted pumpkin (telfaina occidentialis) etc would be grown using methods, resumes allocation and scale of operations similar o arable crops, during the wet and dry seasons to generate important commodities of local trade and sources of rural income. Therefore, a range of substance to commercial indigenous and exotic vegetable enterprises is possible in the 60.7 ha farm at Onne as a rural development project proposed by National Fertilizer Company of Nigeria Limited (NAFCON) to demonstrate the effectiveness of urea based nitrogenous fertilizers on crops.

Onne is in Elewe Local Government Area, in the upland zone of Rivers State. The land resources are used in traditional small holder arable crops farming, characterized by interrupting and interplanting of staple food crops with several fruit and leaf vegetable species, (NRCRI, 1986).

The potentials offered by the humid tropical agro-ecological features in the NAFCON Farm, (especially the long rainy season, can be exploited for 2-3 production cycles of short duration fruit and leaf vegetables annually, with output targeted at the market created by

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Port-Harcourt rising urban and sub-urban population. One requirement for success is the suitability assessment of the land, or part of it, for the vegetable enterprises in terms of inherent capacity by identifying site constraints and appropriate mitigation measures so as to attain probitable production (Fagbami and Ogunkunle, 2000).

Land capability evaluation to identify suitability of some environments for specific crops involves matching the site characteristics with the ideal requirements and condition set for soils and crops (Sys, 1985). Unfortunately, the requirements for tropical fruit and leafy vegetables were not included in the original format. Thus, little or no suitability evaluation has been described for soils and environment in Nigeria in relation to fruit and leafy vegetables as an extension of the benign neglect suffered by horticultural crop research and development over the years. Except the recent work by Aruleba and Fasina 2066 which was majorly on evaluation of valley bottom soil for vegetable production in Southern Nigeria.

This study proposes a set of criteria for the crops and considers the aspect of land quality assessment that would guide the utilization of the NAFCON Farm for rainfed tropical fruit and leaf vegetables production, with a view to identifying the appropriate crop and soil management options for sustained productivity.

MATERIALS AND METHODS

Study area and soils: Landscape, land use and vegetation features of the 60.7 ha NAFCON Farm, adjoining the Fertilizers Plant Complex at Onne (longitude 7°031E, latitude 40511N) was described at 100 m intervals along regular grid traverses and auger borings described to 150 cm depth. Four profiles were dug up to 180 cm and described according to FAO (1976). Metrological data were obtained from the IITA High Rainfall Station, Onne. The soils are very dark grayish brown to dark brown sandy loams to clay loams with weak, fine and loose structure overlying yellowish brown to brownish yellow sandy loams to clay loams developed on coastal plain sands or 'acid sands' (unconsolidated sandy sediments) (FDALR, 1990) and classified as Typic Kandinadult or Dystric Nitosol, with local reference as Bori series (Ayodele, 2006).

Land suitability evaluation: The method used is that developed by FAO (1976) and adapted to tropical soils and major crops by Sys (1985). Site characteristics were matched with the respective crops' requirements and aggregate suitability of the profiles indicated by the most limiting quality, determined for actual and potential levels of use.

RESULTS AND DISCUSSION

Table 1 shows the site features while the proposed climatic and soil quality requirement for the vegetable crops are shown in Table 2 and 3. the nearly flat to flat topography, at 0-2% gradient, is highly suitable for the crops. The soil profiles are very deep (>150 cm), well-drained and not flooded. These physiographic features are adequate, offering huge potentials for mechanized tillage operations. Annual rainfall, at >2400 mm is excessive, but the distribution over 150 rainy days assures 2-3 production cycles of leaf vegetables, okro and melon (egusi).

The 0-30cm layer is coarse textured (sandy loam-clay laom) with poor structure (weak, fine, granular/loose to medium sub-angular blocky) and adequate for these vegetables with shallow root systems. Apparent CEC varies from not suitable to highly suitable, in relation to extreme acidity (low pit) and very low to low cation content (Table 4). The parent materials are coastal plain sands deficient in weatherable minerals, which intensive weathering and regime of excessive rainfall that causes strong leaching have deprived of basic cations (Enwezor *et al*., 1981). This low CEC reflects the equally low clay content and its mineralogical consumption of Low-Activity Clays (LACs) and iron oxide minerals (Nemetite and goethite) (Juo, 1981).

Soil organic matter and total Nitrogen (N) are moderate to high. The organic matter level is particularly significant as its mineralization should substantially increase amount to available N. However, despite these availability, indices, N deficiency is widespread due to

Table 1: Features of the NAFCON Ltd. Farm at Onne, Rivers State

	Profiles			
Characteristics	1	2	3	4
Climate ©				
Annual rainfall (mm)	2400	2400	2400	2400
No. of dry months	2	2	2	2
Absolute minimum temperature (0c)	23.3	23.3	23.3	23.3
Relative humidity (%)	75-89	75.89	75.89	75.89
Topography (t)				
Slope (gradient,%)	0-2	0-2	0-2	0-2
Wetness (w)				
Drainage	Well drained	Well drained	Well drained	Well drained
Flooding	Nil	Nil	Nil	Nil
Soil physical characteristics (s)				
Texture	SL	CL	SL	SLC
Depth (cm)	180	180	180	180
Fertility (f)				
Apparent CEC (cmol.kg + day)	16.5	11.9	26.8	6.8
Base saturation(%)	49.0	76.0	68.0	55.0
Organic mater (organic carbon in 0-15cm layer)(%)	1.6	3.0	1.8	2.1

SL= Sandy Loam, Cl = Clay Loam, SCL= Sandy Clay Loam

Table 2: Climatic requirements for tropical leaf and fruit vegetable

	Tomato				Okro, capsicum, egg plant melon (egusi)			
Characteristics	S1	S2	S3	NS	S1	S2	S3	NS
Rainfall, (mm)	850-1250	1250-1450	-1450-1700	<500 <1700	1250-1750	850-1250	>1700 2000+	<850
Number of dry months	4-5	3-4	2-3	>5<2	3-4	4-5	2-3	>5
Absolute temperature during growth period, (°C)	20-27	15-20	-	-	30-35	25-30	20-25	<20
Relative humidity during development stage, %	60-70	70-75	70-80	>80	70-80	60-70	80-85	<60
	Amananth				Talfairia (fluted pumpkin)			
	S1	S2	S3	NS	S1	S2	S3	NS
Rainfall, (mm)	1700-2000+	1250-1700	850--1250	<850	1450-1700-	1250-1450	1700 2000+	<1250
Number of dry months	<3	3-4	4-5	>5	3-4	4-5	2-3	>5
Absolute temperature during growth period,(°C)	25-30	22-25	15-22	<15	30-35	25-30	20-25	<20
Relative humidity during development stage, (%)	75-85	70-75	60-70	<60	5-80	70-75	80-85	<60

Table 3: Land quality requirements for tropical leaf and fruit vegetables

Land quality features	S1	S2	S3	NS
Topography (t)				
Slope, %	0-4	4-8	8-16	>16
Wetness (w)	Well drained	Moderately,	Poorly drained	Poor drained
Drainage	Drained,	drained not Imperfect,	drainable	acric
Flooding potentials	F0	F1	F2	F3
Soil physical characteristics				
Texture	CL, SL, CL, SIL,	SL, LFS, LS	LCS, FS S, CS, C	SIC, SC, L, SCL
Depth (cm)	>75	50-75	20-50	<20
Soil fertility (f)				
Apparent CEC, (cmol. Kg-^{1} day)	>24	16-24	8-16	<8
Base saturation, (%)	>35	20-35	<20	-
Organic matter (organic carbon in 0-15cm) %	>1.2	0.8-1.2	0.4-0.8	<0.4
PH	5.5-6.5	6.5-7.0	4.5-5.5	<4.0>7.5

S1 = Highly Suitable, 85 – 100%; S2= moderately Suitable, 60-85%; S3= marginally Suitable, 40-60%; NS = Not Suitable, < 40%. FO = No Flooding, F1 = 1 – 2 months Flooding in >10 yeas; F2 = Not more than 2-3 months flooding in 5 out of 10 years, F3 = flooding 2 months almost every year. C = Clay, Cl = Clay loam, CS = Coarse Sand, FS = Fairly Sandy, L = Loam, LCS = Loamy Coarse Sand, LFS = Loamy Fine Sand, LS = Loamy Sand, S = Sand, SC = Sandy Clay, SCL = Sandy Clay Loam, SIC = Silty Clay, SIC = Silty Clay Loam, SIL = Silty Loam, SL = Sandy Loam

Table 4: Some Chemical characteristics in the 0-30cm layer of soils in the NAFCON Ltd. Farm at Onne, Rivers State

Soil property	Mean	Range of values
PH	4.11	3.80-4.30
Organic matter (%)	2.45	1.59-3.90
Total N, (%)	0.14	0.09-0.20
Exchangeable Ca, (cmol.kg^{-1} soil).	38	0.09-0.92
Exchangeable Ca mg, (cmol.kg^{-1} soil)	0.25	0.06-0.61
Exchangeable k, cmol.kg	0.14	0.11-0.61
Exchangeable Na, (cmol.kg^{-1} soil)	0.48	0.45-0.51
Total acidity (cmol.kg^{-1} soil)	0.85	0.61-1.01
Effective CEC (cmol.kg^{-1} soil)	2.09	0.33-3.00
Base saturation,(%)	56.5	46.8-68.5
Available P, (mg.kg^{-1} soil)	28.0	22.7-30.7

Effective CEC = Sum of basic cations and acidity

nitrate leaching losses that increase in the light-textured surface soil as the wet season, characterized by excessive rainfall, progresses.

Available Phosphorous (P) is in the high futility class, established for soils and acid sands, but extreme acidity and toxic Aluminum (AL) can interfere with P availability and curtail its uptake (FMANR, 1990).

Constrains to sustainable vegetable production and land suitability classes in the NAFCON Ltd. Farm: Table 5 shows the climatic and soil quality features that would limit production based on the differences between site characteristics and the requirements set for fruits and leaf vegetable crops.Soil physical quality is moderately Suitable (S2) in profiles 1 and 3, but adequate water supply from a long rainy season should compensate for low water retention and rapid infiltration in the coarse-textured soils. This excessive rainfall regime would engender high nutrient leaching losses, because retention capacity is low in coarse-textured soils. The associated high relative humidity, overcast weather and low sunshine hours would encourage rapid multiplication of pathogens which predispose the crops to severe disease pressure. Low diurnal range of temperature distorts the physiological processes essential for fruit development, especially in tomato.

Low CEC is a fertility limitation on account of the deficiency in basic cations. Soil PH, a potential fertility

Table 5: Aggregate suitability of soils in the NAFCON Ltd. Farm, Onne, for leaf and fruit vegetable crop production

	Tomato				Okro, Eggplant, Capsium melon (egusi)			
Pedons climate ©	1	2	3	4	1	2	3	4
Rainfall	NS	NS	NS	NS	S3	S3	S3	S3
Dry season length	NS	NS	NS	NS	S3	S3	S3	S3
Temperature	NS	NS	NS	NS	S1	S1	S1	S1
Relative humidity	NS	NS	NS	NS	S3	S3	S3	S3
Soil physical characteristic (s)								
Texture	S2	S3	S1	NS	S2	S3	S1	NSNS
Soil fertility (f)								
Apparent CEC	S2	S3	S1	NS	S2	S3	S1	NS NS
*PH	NS	NS	NS	NS	NS	NS	NS	
Actual productivity	NSCfs	NScfs	NScfs	NScfs	NScfs	NScfs	NScfs	
*Actual productivity	NSCfs	NScfs	NScfs	NScfs	NScfs	NScfs	NScfs	
Potential productivity	NSc	NSc	NSc	S3c	S3c	S3c	S3c	
Topography, wetness, Profile, depth are highly Suitable (SI)								
	Amaranth				Telfairia (Fluted pumpkin)			
Pedons	1	2	3	4	1	2	3	4
Soil physical characteristic (s)								
Texture	S2	S1	S2	S1	S2	S1	S2	S1
Soil fertility (f)								
Apparent CEC	S2	S1	S2	S1	S2	S1	S2	S1
*PH	S2	S3	S1	NS	S2	S1	S2	S1
Climate, topography, wetness, profile depth, base saturation at highly suitable (SI)								
Actual productivity	S2fs	S3f	S2sf	Nsf	S2sf	S3f	S2s	Nsf
*Actual productivity	S2fs	S3f	S2sf	Nsf	S2sf	S3f	S2s	Nsf
Potential productivity	S2s	S1	S2s	S1	S2s	S1	S2s	S1

•Suitability assessment with inclusion of soil pH

index that should be adequately managed was excluded by Sys (1985) on land suitability assessment. Its inclusion scores the pedons as Not Suitable (NS) for all crops except Telfairia, because of the low PH values.

Organic matter level is adequate, but the soils' highly Suitable (SI) rating is to the extent that land development does not disturb (pulverize) or scrape the topsoil. When burning accompanies land clearing, surface litter and plant debris are burnt off while intense heat can completely destroy the humidified organic matter (Van Reuter and Janssen, 1993). Mechanized tillage, the preferred practice, has been indicted for land degradation, due to rapid depletion of organic matter and attendant loss of soil quality (Lal, 1984; Eneji, 1997). The high proportion of sands and lack of banding materials, notably organic colloids in-between them cause sand particles to lie in close contact for the soil to became compacted. Lal *et al.* (1986) noted that features of this compaction: Rapid internal drainage, that transfer, rise in soil and air temperature, soil loss though run off and erosion, nutrient leaching would worsen under continuous mechanical tillage.

On the aggregate, no pedon is suitable for tomato (NScf) while three pedons are marginally Suitable (S3cf) for okro, melon (egusi), eggplant and peppers. Two pedons are moderately Suitable (S2sf, S2s) one each is marginally Suitable (S3f) and Not Suitable (NSf) for amaranth and telfairia. The inclusion of soil PH did not alter the rating for tomato (NScf, NScfs), reduced site suitability for okro, egg plant, melon (egusi) and amaranth, while telfona being adapted to the high rainfall belt and so acid-tolerant and retained the rating in all pedons.

Management recommendations for optimum of vegetable crops: Vegetables are planted on flat, ploughed and harrowed land.Deep ploughing to mix the fine-textured subsoil with the surface layer, rides or beds made along the contour to reduce runoff and erosion, raise plant roots above surface ponds that may remain in the furrows after heavy downpours are recommended.

Mulching and manuring, the increase soil organic matter, prevent deterioration of the poor aggregate stability, reduce surface soil temperature and lessen rampant of raindrop splashes are appropriate recommendations. The practices would prevent rapid water loss by evaporation that creates droughty condition between the rainy periods and so maintain favourable soil moisture conditions which enhance germination of direct-seeded crops.

Application of appropriate liming materials (limestone, dolomite) and P sources (rock phosphate, single super phosphate) that contain soluble Ca is necessary to neutralize extreme acidity by displacing excess Al and so increase Ca, Mg and P availability and reduce Na saturation. Manures produce a similar effect, such that their regular application makes routine liming unnecessary. N and K needs are met with application of appropriate NPK fertilizers. Urea would be split-applied,

banded and covered with soil to prevent lose in runoff, reduce leaching losses that exacertate N deficiency and minimize buildup of residual acidit (FMANR, 1990). Thus complementary application of manure-N fertilizer and compound fertilizer (NPK 27-13-13, 20-10010) etc holds promise. With these soil management recommendations, the pedone obtain highly Suitable (SI) potential productivity for amaranth and telfeirla, marginally Suitable (S3c) for okro, eggplant, egusi and pepper and Not Suitable (NSC) for tomato.

Crop management options relate to avoiding periods of the season when the site is unsuitable for optimum productivity. Thus, tomato is expected to be successful as a late or dry season crop, but this has not been so. Galling due to infestation by females of the nematode (Meloidogyne incognate) causes pants top be dwarfed, while complication with Pseudomonas solanecearum infection increases tomato wilt, to cause complete crop loss (Zuofa and Onuegbu, 1998). All-year-round cultivation is possible for amaranth, to be harvested by uprooting and repeated culting and early maturing, day-neutral okro. The okro planted in August-early October would produce fresh fruits and seed while early and late season production of okro, amaranth, telfairia is most profitable, if a reliable source of water for supplementing irrigation can be assured.

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