EVALUATION OF KUDU LAND OF NIGER STATE FOR MANGO (*Mangifera indica*) PRODUCTION

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ABSTRACT

Suitability of Kudu land, in the sandstone-derived terrain of savanna ecological zone in Niger State, Nigeria, for mango production was assessed. A 500 ha parcel of land originally earmarked for mango production was assessed using rigid-grid method of soil survey. Aggregate actual suitability rating put three out of the five mapping units 88% of the total land area as marginally suitable while the remaining part of the land was non-suitable for mango production. Soil fertility, in terms of calcium mole fraction constitutes limitation in about 86.4% of the land and this proportion of the land was rated moderately suitable under aggregate potential suitability. Drainage and pH constitute major limitations which constitute about 13.6% of the land and aggregate potential suitability rated this as non-suitable. Climate, electrical conductivity indices and soil physical characteristics were conducive for the production of mango. Management practices such as drainage and liming of the waterlogged parcels as well as fertility enhancement measures are recommended to elevate the current status of the land for mango production.

INTRODUCTION

Land evaluation is the assessment of land qualities for alternative uses. It involves the interpretation and execution of surveys and studies of landforms, soil, vegetation, climate and other aspects of land in order to identify and compare kinds of land use in terms applicable to the objectives of the evaluations. It is based on the fundamental principle that different kinds of land use have different requirements. Braimoh (2000) differentiate between soil classification and land evaluation by saying that two soils which fall in to the same taxonomic unit might qualify for different land evaluation units.

Many systems of land evaluation are known to exist. These include the (JSD/V land capability classification system (Klinkeberge and Montgomery, 1961); United Kingdom land classification system (Mackney, 1974); Sask'atchewan soil rating system, (Moss. 1972): land evaluation system for Malaysia (Wonu, 2014) and FAO framework for land evaluation (FAO, 2006). Different similar criteria were used in all the above land evaluation systems. Land suitability evaluation has been appraised and used by some scientists in Nigeria (Ogunkunle, 2014; Onasanya and Ogunkunle, 2018 and Fasina, 2008). The purpose which the land is required to serve is always the basis of the evaluation system, this is the case of sandstone-derived terrain in the southeastern part of land in Niger State of Nigeria. Five hundred hectares (ha) of land (500ha) in Kudu was assessed for its suitable for this purpose by the standards of Yates (2007). A large proportion of this land is sandy and might pose problems of excessive drainage and low retention of applied fertilizer (Ogunwale *et al.,* 2002). It is therefore necessary that an alternative crop that is equally profitable should substitute for mango and this crop should thrives well under a variety of climate and soil conditions. It grows best on loamy sandy soils with good drainage, Mango production is an economically viable venture that is becoming more popular around this ecological zone. The objective of this study is to evaluate the suitability of the soils of the study area for mango production, and also to determine the management practices or measure that will sustain the continuous production of this crop at a profitable level of the land.

MATERIALS AND METHODS

The site:

The site lies approximately between latitudes 9^0 12N and. 9^0 13N and longitudes 5^0 11' E and $5^0$12'E. The plot of land is about 5.6 km to the and lies between Kudu and Batagi village (Ogunwale *et al.,* 2002) Kudu is situated above river Niger and lying about 10km north East of in Niger state Nigeria, the main features of pronounced wet land dry seasons and steady high annual temperatures (28-32^{0}C).

The site falls within the Southern Guinea Savanna vegetation zone and the parent material is sandstone, Ogunwale *et al*. 2002).

Field studies

A total of 500ha of' land originally earmarked for mango production was assessed for this study and a rigid grid system of soil survey was adopted. A baseline was cut from Sabo Tunga end of' the land to Batagi end. Measuring 2.5 kilometers (km), Transects. Each measuring 2 km long were cut at regular intervals of' 500 hectares along the base line. Minipits were dug at intervals along each transect, Soil observations for texture, colour. Soil depth, gravel content, structure, artifacts, and organic materials were observed. Consistence and root population were made at depths of 0 -15. 15-30 centimeters of each minipit. Soils with similar properties were identified and grouped together. For each of such groups, a representative spot was chosen where profile pit was dug. Five profile pits were dug, described, sampled and the samples were analyzed routinely in the laboratory.

Laboratory studies

Soil samples that were air-dried. Crushed and sieved to pass through 2 mm sieve were analyzed in the laboratory. Particle size Distribution was determined by the hydrometer method (Bouyoucos, 1962). Soil pH was in 1:1 soil-water suspension using a pH meter. Organic carbon was by the chromate wet oxidation method (Jackson. 1958). Exchangeable cations were extracted with neutral normal solution using soil: extractant ratio magnesium in the extract were determined by the versenate titration method. Potassium and sodium were determined by flame photometry.

Total acidity was extracted With KCI solution and the extract titrated against 0. IN until a pink colour that persists was obtained. The effective cation exchange capacity was the summation of basic cations and total acidity (Juo *et al.,* 1976).

Land evaluation procedure

'The method of Sys (1985) as modified by Ogunkunle (2014) was adopted, with modifications in the scorings of data for classes and in the rating of land qualities. Calcium mole fraction and available P were used, there were also in the calculation of current index of productivity, modifications in the scoring for fertility indices such as CEC, calcium mole fraction as well as pH for the suitability evaluation of the soils. Modifications were made to suit sandstone-derived terrains in savanna zone, which evidently support mango stands in spite of their low fertility and annual bush burning.

The suitability classes were established by matching the characteristics of each pedon (land qualities) as contained in Tables I and 2 with land requirements for mango production (Table 3). Following the 'law of minimum', the most limiting factor determined the class of the pedon. Table 4 presents the ratings for each of the limiting characteristics. Only one characteristic from each group of characteristics (Table 5) was used for placing the pedons in their respective land suitability classes following the recommendations of FAO (2006). The groups of land qualities used for evaluation are climate (c), topography (t), soil physical properties (s), wetness (w) chemical fertility (f) and salinity and alkalinity (n).

Index of productivity (IP) was calculated for each pedon using the equation:

Where: A is the overall lowest characteristic rating

B, C—F are the lowest characteristic ratings for each land quality group.

Potential index of productivity (IPc) and current (actual) index of productivity (II c) were calculated for all the pedons from the raw data. The IPc was calculated with calcium mole fraction (exchangeable Ca as a fraction of cation exchange capacity) and available phosphorous (Bray PI) not being part of the T group; while calcium mole fraction was included in the T group for the calculation of IPc. The use of Calcium mole fraction and available phosphorus in the calculation of IPc is based on the fact that the proximate composition of the dried kernel of mango is 2.5% of minerals made up mainly of calcium, phosphorus and iron (Awopetu, 2001).

RESULTS AND DISCUSSION

Soil Classification:

Pedons l, Il, Ill and V were classified as Typic Ustipsament of the Soil Survey Staff (2004) and locally as Batagi series, while pedon IV classifies as Vertic Ustropept of the Soil Survey Staff (2004) and locally as Bachigi series, Ogunwale *et al.,* (2002).

Climate:

The climate of the studied area is quite favourable for the production of mango. The duration of rainfall is about seven months in the year. The mean annual temperature and the length of dry season reasonably meet requirements given by Santsen (2002) for mango production.

Topography:

The site is almost flat (slopes ranging from <1 to 2%), hence the slope gradient is suitable. The drainage in all the sites except that of pedon IV is also suitable. Pedon IV is situated in an area of impeded drainage, hence, its non-suitable for mango production.

Soil Physical properties:

Awopetu (2001) recommended a soil depth of I80cm for a good crop of mango. By this standard all the pedons are deep enough.

The texture of all the pedons is equally suitable for mango production, except pedon IV which is clayey in nature (Table l).

Potential Soil Fertility:

Ogunkunle (2014), identified cation exchange capacity, base saturation and organic matter content which are the Chemical properties that are not easily altered as constituting potential soil futility. The pedon IV was the highest, followed by that of pedon I. There was no limitation in any of the pedons for base saturation (Tables 2 and 5 compared to 3) but the pH was a limiting factor in pedon IV, Organic matter values were low to moderate in pedons I, Il, Ill and V, and high in pedon IV. Therefore, interms of potential fertility, pedon IV seems to be better than other pedons except in terms of its pH, Table 3 compared to 5).

Special ratings of limiting characteristics were used for Mango because stray Mango stands were found doing well on the land studied.

Table 1: Morphological characteristic and classification of Kudu soils

Taxonomic Units	Horizon	Horizon Thickness	Colour (Moist)	Months +++
Typic Ustipsament	A	33	10YR3/3	a
(Batagi Series)	B	>150	7.5YR4/6	c2d5YR5/6
Typic Ustipsament	A	32	10YR(3/1)	a
(Batagi Series)	B	>162	10YR(5/4)	a
Typic Ustipsament	A	37	10YR(4/3)	a
(Batagi Series)	B	>154	10YR(5/4)	c2d5YR5/8
			10YR6/6	
Vertic Ustropept	A	18	2.5YR(3/2)	a
(Batagi Series)	B	>100	10YR(6/2)	c2d5YR6/8
Typic Ustipsament	A	68	10YR(4/6)	a
(Batagi Series)	B	>155	10YR(6/6)	c2d5YR5/6

+++ 1 = fine; 2 = medium; 3 = coarse; f = few; d = distinct; a = absent; p = prominent; m = many; c = common

Table 2: Morphological characteristic and classification of Kudu soils

Taxonomic Units	Horizon	Texture ++	Consistence +	Structure +	Drainage **
Typic Ustipsament	A	S	M.Fr	1.M.Sab	IV
(Batagi Series)	B	LS	M.Fr	1.M.C	IV
Typic Ustipsament	A	S	M.Fr	1.M.Sab	IV
(Batagi Series)	B	LS	M.Fr	1.M.C	IV
Typic Ustipsament	A	S	M.Fr	1.M.Sab	IV
(Batagi Series)	B	LS	M.Fr	1.M.C	IV
Vertic Ustropept	A	SCL	M.SS	2.C.Sab	II
(Batagi Series)	B	C	M.Fr	3,C,Sab	II
Typic Ustipsament	A	S	M.Fr	1,M,Cr	IV
	B	S	M,Fr	1,M,Sab	IV
(Batagi Series)					

++ S = sand; LS = Loamy sand; SCL = Sandy clay loam; C = clay, + M = moist; Fr = Friable; Fi = Firm; SS = Slightly Sticky, 1 = Weak; 2 = moderate; 3 = well developed; M = medium; C = Coarse; Cr = Crumbs; Sab = Sub angular blocky, ** II = Poorly drained; IV = well drained.

Table 3: Land qualities/ Characteristics soils at Kudu

Pedon	Annual Rainfall (mm)	Length of dry season (days)	Mean atmos Temp (^{0}C)	Slope (%)	Drain age	Soil Depth	Coarse Fragment (A-horizon)
I	I.III	150	>29	1-3	Good	>150	Nil
II	I.III	150	>29	<2	Good	>162	Nil
III	I.III	150	>29	>2	Good	>154	Nil
IV	I.III	150	>29	>1	Good	>100	Nil
V	I.III	150	>29	>2	Good	>150	Nil

Table 4: Land qualities/ Characteristics soils at Kudu

Pedon	Ex. Ca (cmol/kg)	Ca Mole Fraction	ECEC (cmol/kg)	Avail P (mg/kg)	BS (%)	pH in H_2O
I	1-4	0.4-0.7	2-7	19-50	92-97	5.6-6.3
II	1-3	0.4-0.8	2-5	35-64	92-95	5.5-6.0
III	1-3	0.4-0.7	2-5	29-57	90-95	6.1-6.4
IV	9-11	0.7-0.8	11-14	16-20	83-91	4.5-4.9
V	1-25	0.4-0.6	2-5	32-57	91-95	6.2-6.5

Table 5: Land Requirements for suitability classes for mango cultivation (Modified from Sys, 1985)

Land Qualities	Suitability Classes					
	S11	S12	S2	S3	N1	N2
Climate (C):	(95-100%)	(80-94%)	(60-79%)	(40-59%)	(20-39%)	(10-19%)
Annual rainfall (mm)	>1000	800-1000	600-800	500-600	400-500	<400
Length of rainy Season (months)	>5	4-5	3-4	2-3		<2
Mean ann max. temp. (^{0}C)	>29	27-29	24-27	22-24		<22
Ave. daily min. temp. (^{0}C)	>20	18-20	16-18	14-16		<14
Mean annual temp. (^{0}C)	>25	22-25	20-22	18-20		<18
Relative humidity (^{0}C)	>75	70-75	65-70	60-65		<60
Topography (t):						
Slope (%)	<4	4-8	8-12	12-16	>16	-
Wetness (w):						
Flooding	Fo	Fo	F1	F2	-	F3
Drainage	well drained	well drained	well drained	imperfect	poor	v. poor
Soil Physical Properties (s):						
Texture	LS	SL	L	SCL	CL	C
Structure	Crumb	Crumb	Sab	Sab	Columnar	Columnar
Vol. of coarse Frag. (0-30cm)	3-10	10-15	15-35	35-55	>55	-
Depth (cm)	>150	120-150	100-120	50-100	25-50	<25
Soil Fertility (f):						
CEC (cmol/kg) (0-30cm)	>6.0	5-5.9	4-4.9	3-3.9	2-2.9	<2.0
Base Saturation (LH) (%)	>70	60-70	40-60	20-40	10-20	<10
pH	6.5-7	6.0-6.5	5.5-6.0	5.0-5.5	4.5-5.0	<4.5>7.5
Org. Carbon %(0-30cm)	>2.0	1.5-2.0	1.25-1.5	1.0-1.25	<1.0	<1.0
Ca (mole fraction)	0.6-7.0	0.5-0.6	0.4-0.5	0.3-0.4	0.2-0.3	<0.2
Avail. P (mg/kg) (0-30cm)	>20	16-20	12-16	8-12	4-8	<4
Salinity and Alkalinity (ds/m)(n)	<1	1-2	2-3	3-4	4-8	>8

S = sand; SL = sandy loam; L = loam; SCL = Sandy clay loam; CL = clay loam; C = clay; Sab = subangular blocky; LH = Lower horizons.

Again, mango can perform well in soils with low fertility provided that the annual rainfall is at least 900mm and drainage is good (Samson, 1982).

Mango plant is capable of building up nutrients in the surface soil after proper canopy establishment because of leaf litters that fall on the ground, decay and decomposed over a long period of time.

Current Soil Fertility

This puts into consideration, those properties that are easily altered (e.g. exchangeable calcium (Ca), Ca mole fraction and available P in addition to those considered for potential soil fertility. Exchange calcium as well as Ca mole fraction are limiting in pedons l, Il, Ill and V with that of pedon V most limiting while they were adequate in pedon IV. Available P is not limiting in any of the pedons but lower in value in pedon IV. It can therefore be said that pedon I is the most suitable in terms soil fertility (both potential and actual).

Climate does not constitute any limitation to mango production at Kudu study area.The topography of the area is also favourable except in pedon IV where the structure as well as the texture of the soil is not favourable because of the clayey texture and poor drainage which make topography sub-optimal. The situation is however, not the same with the fertility aspect as pedon IV was the most suitable of the five pedons except for its pH that is acidic and which makes it sub optimal.

Suitability Ratings
Table 6 presents the ratings individual land characteristics as well as their aggregate ratings (both potential and current).

Table 6: Ratings of Limiting Characteristics

Limitation	Rating (%)	Class
None	100-95	S1
Very slight	94-80	S1
Slight	79-60	S2
Moderate	59-40	S3
Severe	39-20	N1
Very severe	19-0	N2

Table 7: Suitability scores of representatives pedons of the Kudu

	Soil Types				
Climate (c)	**Pedons I**	**II**	**III**	**IV**	**V**
Annual rainfall	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)
Length of rainy season	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)
Mean annual temperature	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)
Average sunshine hr.	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)
Relative humidity	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)
Topography (t)					
Slope (%)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)
Wetness (w)					
Drainage	S_1 (100)	S_1 (100)	S_1 (100)	N_1 (100)	S_1 (100)
Soil physical characteristics (s)					
Texture	S_2 (85)	S_2 (85)	S_2 (85)	S_2 (85)	S_2 (85)
Structure	S_2 (85)	S_2 (85)	S_2 (85)	S_3 (85)	S_2 (85)
Vol. of course fragments	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)	S_1 (95)
Soil depth	S_1 (100)	S_1 (100)	S_1 (100)	N_1 (35)	S_1 (100)
Soil Fertility (f)					
Effective CEC	S_1 (100)	S_2 (75)	S_2 (75)	S_1 (100)	S_2 (75)
Base saturation	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)
pH	S_{12} (90)	S_2 (75)	S_{12} (90)	N_1 (35)	S_1 (100)
Organic matter	S_{12} (90)	S_2 (75)	S_2 (90)	S_{11} (100)	S_2 (75)
Avail. P	S_1 (100)	S_1 (100)	S_1 (100)	S_{12} (85)	S_1 (100)
Calcium mole fraction	S_3 (55)	S_3 (55)	S_3 (55)	S_2 (75)	N_1 (30)
Salinity/Alkalinity (n)					
Electrical conductivity	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)	S_1 (100)
Aggregate suitability (%)					
Potential	76.7	65.7	67.4	13.6	67.4
Actual	49.4	49.4	49.4	29.0	27.0

The potential suitability classification rated pedon I as the best scoring 76%. Followed by pedons III and V scoring 67.4%; pedon II scored 65.7% while pedon IV was the worst scoring 13.6%. Pedons l, ll, III and V (86.4% of the total land area) were therefore rated as moderately suitable while, pedon IV (13.6% the total land area) was rated as non-suitable in term of soil fertility, most especially calcium mole fraction, was a limitation for pedons l, Il, Ill, and V. Fertility enhancement measures such as fertilizer application, organic manuring and efficient residue management methods should be ensured to enhance the fertility status of this land, in terms of drainage in accordance, was the major limitation of pedon IV. Infact, pedon IV would have been the best soil if not for drainage problem. This shows that a single factor may impose major influence on the suitability rating of soils. The suitability status of this parcel of land (pedon IV) can greatly be its drainage but when is improved by use of drainage tiles or by channelization. Pedons I, II, III, IV which belong to the same taxonomic class of typic utispalment, were found to belong to the same suitability class S2. The aggregate actual suitability ratings were low. They were 49.4, 49.4, 49.4, 29,0 and 27.0 for pedons I, II, III, IV and V respectively. These values indicate that actual suitability ratings of pedons I, II and III (78% of the total land area) make them marginally suitable and others (22% of the total land area) are unsuitable.

CONCLUSION

The actual suitability ratings put pedons l, land area as marginally suitable while, pedons IV and V (22% of the total land area) are non-suitable. It was observed that most especially in terms of calcium mole fraction was the limiting factor in pedons I, Il. III and V while drainage was the most severe limitation in pedon IV. The results show that a single limiting factor can have a great effect on the suitability rating of a piece of land. Management practices that will enhance fertility such as fertilizer application and good residue management techniques are recommended for pedons I & II. Good drainage and adequate leaching are recommended for pedon IV. These management practices can enhance the suitability status of mango production on a sustainable basis. Modifications in the ratings of land qualities may be necessary for terrains where specific crops grow and thrive but for which fertility data suggest otherwise, thus, culminating in wrong evaluation.

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