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Suitability Assessment of Calcareous Parent Material Derived Soils for Mango and Guava Production in Yamaltu-Deba Local Government Area, Gombe State Nigeria

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Abstract **– This study was conducted to evaluate the suitability of soils in Kanti, Dadin kowa, Baure and Kwadon areas of Yamaltu-Deba Local Government Area of Gombe State, for the production of tree crops. A Profile pit was sunk at each of the selected study areas. The soils were described for their physico-chemical properties. All soil samples collected were analysed using standard Laboratory procedures. The results revealed that the soil texture ranged from Sandy Clay loam (SCL), Sandy Loam (SL) to Clay (C). The soil pH ranged from 5.10- 7.79 (strongly acidic to alkaline in reaction), and low in organic carbon. Cation Exchange Capacity (CEC), was found to be low for Kanti and Dadin kowa sites, but high for Baure and Kwadon. The actual suitability of the studied sites, for both crops was found to be substantially Non Suitable (NS) due to certain non-permanent constraints that can be corrected. Management practices such as, irrigation, application of organic manure, plant residue (Mulching), will be required for sustainable tree crop production.**

Keywords **– Assessment, Guava, Mango, Mulching, Suitability.**

I. INTRODUCTION

Suitability of land is assessed considering rational cropping systems, for optimizing use of a piece of land for a specific use [1, 2]. The suitability is a function of crop requirements and land characteristics and it is a measure of how well qualities of land unit match the requirements of a particular form of land use [1]. A major step towards sufficiency in food production is effective and proper use of land for the purposes for which they are most suitable. Ineffective and unplanned use of agricultural land is a major constraint to agricultural production in developing countries of the world [3].

Therefore an effective agricultural planning and use of agricultural lands involves soil survey and land evaluation, using methods such as Suitability and irrigation capability classification [4].

Although tree crops grow freely in Nigeria, there is need for land evaluation and soil assessment to ensure productive use and management of land for profitable crop production.

Tree crops are perennial in nature and have longer contacts with the soil environment, some for as long as 30 years and above. Also the above association could lead to massive nutrient loss from the soil through harvest in areas where soil nutrient is not supplemented [5].

Establishment of tree crops, in plantations, mimics the natural rainforest vegetation and is perhaps the only sustainable land use for the humid tropical environment characterised by inherently poor soil resources [6, 7]. Therefore establishment of orchards on non-suitable soils with so many constraints may be counterproductive on the long run.

Several research works have been conducted on the suitability of soils in the study area for arable and some tree crops, although majority of this research do not give prime attention to Mango and Guava production. It is against this backdrop that this research work was initiated to serve as baseline data, hence provide information on soil properties and characteristics of the study areas. Therefore, this paper tend to use obtained data on climatic features and soil physico-chemical properties of the study areas to assess the inherent capability/suitability and the extent to which appropriate management recommendations can alleviate the current limitations in the production of Mango and Guava.

II. MATERIALS AND METHODS

The Study Area

The study was conducted in Yamaltu-Deba Local Government Area, Gombe state, Nigeria, situated about 609.5m above the sea level [8]. It is in northern guinea savanna agro-ecological zone of Nigeria [9]. Its geomorphology comprises of gently undulating plains and sediments.

The climate is characterised by two distinct wet and dry seasons, with annual rainfall ranging from 700- 1,250mm. The mean annual temperature ranges between 30-32^{0}C, and a relative humidity of 17-19%.

Soil Sampling and Techniques

One pedon/profile pit was dug at each of the selected sites (Kanti, Dadin kowa, Baure and Kwadon) in Yamaltu-Deba local Government Area, according to [10]. Soil samples were then taken from each identified genetic horizons of the dug profile pits. The collected soil samples were then stored in a properly labelled polyethene bags and taken to the laboratory for analysis. In the laboratory each sample was separately air dried, ground using a porcelain pestle and mortar and passed through a 2mm sieve. The sieved samples were then used for all laboratory analysis.

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Laboratory Analysis

The processed soil samples were analysed for some physico-chemical properties following standard procedures as described by [11]. Particle size distribution was determined by the Hydrometre method [12]. The soil pH was determined in 1:1 soil/water suspension, using a glass electrode pH metre, while organic carbon and nitrogen in the soil was determined by the wet combustion method of [13]. The cation exchange capacity (CEC) was estimated using the NH4OAC saturation (pH7) method, while the leachate was used to determine the exchangeable bases.

Land Evaluation

Climatic, soil and water requirements for Mango and Guava, and the assessment of land for horticultural tree crops were based on information prescribed by [4, 14, 15 and 16]. Land characteristics were used to match crop requirement and based on this soils were classified as highly suitable S1, Moderately suitable S2, Marginally suitable S3 or Non suitable NS.

Data Analysis

Data obtained were analysed using simple descriptive statistic as described by [17].

III. Results and Discussion

Table 1. Climate and soil requirements of Mango and Guava production

Requirements	Suitability Ratings							
	Mango				Guava			
	S1	S2	S3	NS	S1	S2	S3	NS
Climate								
Rainfall (mm)	1700-2000	1450-1700	1000-1450	<700	2000+	1450-2000	800-1450	<700
Temperature (^{o}C)	25-32	20-25	18-22	<18	25-32	20-25	10-20	<16
Land quality								
Soil depth (cm)	>100	70-100	50-70	<50	>100	70-100	50-70	<50
Soil Texture	LS,SL,SCL,CL	SC	S,LC	C	SCL,SL,CL	LS	S,C	-
Slope (%)	0-8	8-16	16-30	>30	0-16	16-30	30-50	>50
Altitude	600	600-500	500-400	<400	600	600-500	500-400	<400
Drainage	Well	Well	Well	Moderate	Well	Moderate	Moderate	Imperfect
pH	6.0-7.0	5-6	4-5	<4/>7	5.5-6.0	6.0-7.0	4.4-5.5	<4/>7
OCgkg^{-1}	>1.2	0.8-1.2	0.4-0.8	<0.4	>1.2	0.8-1.2	0.4-0.8	<0.4
CEC (cmol kg^{-1})	>16	10-16	5-10	<5	>16	8-16	4-8	<4

Modified from: FAO, 1976; Aruleba and Ayodele, 2015

SL: Sandy Loam, LS: Loamy Sand, SCL: Sandy Clay Loam, S: Sand, C: Clay, OC: Organic Carbon, TN: Total Nitrogen, CEC: Cation Exchange Capacity

Climatic requirements necessary for tree crop production include rainfall, temperature, humidity etc, while soil requirements may include effective soil depth, slope, drainage and soil chemical properties. Table1. Shows the climatic and land qualities requirements for Mango and Guava production. The annual rainfall and temperature for the selected study areas (Table2) ranges between 700-1250mm and 30-32^{0}C respectively, upon matching with Mango and Guava requirements (Table 1.), the sites were rated Marginally suitable (S3) and highly suitable (S1) for Mango and Guava production respectively.

Table 2. Climatic and Land qualities of study areas

	Kanti	D/Kowa	Baure	Kwadon
Climate				
Rainfall (mm)	700 – 1250	700 – 1250	700 – 1250	700 - 1250
Temperature (^{o}C)	30 – 32	30 – 32	30 – 32	30 - 32
Land quality				
Soil depth (cm)	>149	150	146	135
Depth to water				
table (cm)	>149	>150	>146	>135
Soil texture	SL	SCL	C	C
Slope %	0 - 4	0 – 4	0 – 4	0 - 4
Altitude	609.5	609.5	609.5	609.5
Drainage	Well	Well	Well	Well
pH	5.10	5.9	7.79	7.09
OCgkg^{-1}	0.21	0.68	5.56	8.76
CEC (cmolkg^{-1})	3.72	4.5	33.24	35.89

The sites topography is undulating and nearly flat (0-4% gradient), with deep (> 100cm) and well drained pedons (Table 2) and so highly suitable (S1), when matched with requirements for both Mango and Guava production. Poor

drainage affects gaseous exchange in soils and consequently poor plant performance [18].

The soil texture (Table 2) was found to be Sandy loam and Sandy Clay loam for Kanti and Dadin kowa locations respectively, and classed as highly suitable (S1), while the soils of Baure and Kwadon were clayey in nature and rated as Non suitable (NS) for Mango and marginally suitable (S3) for Guava production.

The soils from Kanti and Dadin kowa were found to be generally acidic, with soil pH at Kanti to be 5.10 (Strongly acidic), and that of Dadin kowa was 5.90 (moderately acidic), which rates the soils from the two sites to be moderately suitable (S2)and highly suitable (S1) for Mango and Guava production respectively, while soil pH of Baure and Kwadon were found to be 7.79 and 7.09 (alkaline) respectively, which can be attributed to the high level of basic cations [18], and the last two sites are Non suitable (NS) for both Mango and Guava production.

Soil organic carbon from all the pedons was found to be low as per [19], rating scale for levels of analytical parameters, with Baure and Kwadon highly suitable (S1) for the production of both Mango and Guava, while Dadin kowa and Kanti were found to be marginally suitable (S3) and Non suitable (NS) for the production of both crops respectively. However, soil nutrient deficiencies are not permanent constraints, as the can be corrected with proper soil fertility management programme, especially for Dadin kowa and Kanti sites. Organic manure and chemical fertilizer application can help to improve the soil fertility.

The cation exchange capacity (CEC) of the studied soils were found to be low for Kanti and Dadin kowa with values of 3.72 and 4.50 cmol/kg respectively, and were rated as Non suitable (NS) for both crops at Kanti, while Guava production was found to be Non suitable (NS) and Marginally suitable (S3) at Kanti and Dadin kowa respectively. Baure and kwadon recorded CEC values of 33.24 and 35.89 cmol/kg respectively, which is high as per [19] rating scale, and therefore highly suitable (S1) for the production of both Mango and Guava.

Table 3. Aggregate Suitability of Climatic and Land Qualities of study areas for production of Mango and Guava

	Mango				Guava			
	KN	DK	BR	KW	KN	DK	BR	KW
Climate								
Rainfall (mm)	S3	S3	S3	S3	S3	S3	S3	S3
Temperature (°C)	S1	S1	S1	S1	S1	S1	S1	S1
Land quality								
Soil depth (cm)	S1	S1	S1	S1	S1	S1	S1	S1
Depth to water table (cm)	S1	S1	S1	S1	S1	S1	S1	S1
Soil texture	S1	S1	NS	NS	S1	S1	S3	S3
Slope %	S1	S1	S1	S1	S1	S1	S1	S1
Altitude	S1	S1	S1	S1	S1	S1	S1	S1
Drainage	S1	S1	S1	S1	S1	S1	S1	S1
pH	S2	S2	NS	NS	S1	S1	NS	NS
OCgkg^{-1}	NS	S3	S1	S1	NS	S3	S1	S1
CEC (cmolkg^{-1})	NS	NS	S1	S1	NS	S3	S1	S1
Actual suitability	NS	NS	NS	NS	NS	S3	NS	NS
Potential suitability	S1	S1	S1	S1	S1	S1	S1	S1

KN= Kanti, DK= Dadin Kowa, BR= Baure, KW= Kwadon

IV. Conclusion and Recommendations

As a result of some non-permanent constraints, the actual suitability of the studied sites for both crops was found to be substantially Non suitable (NS) due to few parameters like soil texture, soil organic carbon, pH and CEC, which are non-permanent constraint as they can be corrected with proper soil fertility management programme. But, generally the potential suitability of the studied sites can be said to be highly suitable (S1) for the production of both crops.

The addition of organic manure and plant residues (mulching), will go a long way in improving the soil texture, soil organic carbon, lowering the soil pH and CEC, in addition supplemental application of water during dry periods is very necessary.

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