

## SOIL REACTIONS, BASE SATURATION AND SUITABILITY ASSESSMENT OF SOME SOILS TO CERTAIN CROPS IN BAUCHI STATE, NIGERIA

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### ABSTRACT

*This study was conducted in the year 2005 to 2007 to characterize the soils for the purpose of assigning its suitability to certain crops in South Western Bauchi State, Nigeria. Soil pH was determined both in water and 0.01M CaCl<sub>2</sub> solution at 1:1 soil: water and 1:2 soil solution ratios respectively using a glass electrode pH meter. Base saturation of soils was calculated using exchangeable bases and CEC in percentage. Where statistical differences were obtained they were separated using DMRT as described by Steel and Torrie, 1981. The results obtained indicated that the texture soils ranged from loam to sandy loam and were slightly acidic (mean pH in water = 6.2; in CaCl<sub>2</sub> = 5.4) in reaction. While base saturation (range = 41.6% - 94.5%) was high. The soils were rated marginally to moderately suitable for all the crops considered. The limiting conditions for crops considered was CEC rating S3. Consequently, the soils are of low fertility and hence, the need for appropriate fertilizer application, involving organic manuring and adequate inorganic fertilizer additions for sustainable crop production.*

**KEYWORDS:** Characteristics, classification, acidity and soil

### INTRODUCTION

Soil fertility, according to Brady (1974) is defined as the inherent capacity of a soil to supply nutrients to plants in adequate and in suitable proportions. It is the quality that enables a soil to provide adequate nutrients in a proper balance for specified plant growth, other factors such as light, moisture, temperature and the physical condition of the soil being favourable. If the required amounts of nutrients are not available in the soil, the crop yield remains low, and in most cases, farming becomes uneconomical/economically ineffective.

Essential nutrients, particularly primary macronutrients: N, P, and K as well as Ca and Mg, are the major determinants of soil fertility (Singh, 1999). Due to repeated cultivation and removal of plant nutrients, most cultivated soils have been depleted of the reserved nutrients and therefore unable to produce good yield. Some soils tend to be acidic or alkaline in nature due to improper balance of elements and fail to support growth of crops. The study intends to characterize the soils of the study area in view of its suitability assessment to certain crops.

### MATERIALS AND METHODS

The study area is located in the South Western part of Bauchi State, latitudes 9° 40' and 10° 18'N, and longitudes 8° 58' and 9° 50' E. (Fig. I and II). The entire State lies on the high plains with elevation exceeding 500m above sea level. (Kowal and Knabe 1972). Most of the area is fairly flat although the plains are dotted 'with inselbergs in some regions. Along the edge of the area there are the foothills of the Jos Plateau and to the west, these climb some 1000m directly to the plateau. There are heavy runoffs after rains due to soil characteristics.

Five local government areas namely; Bauchi, Dass, T/Balewa, Bogoro and Toro were

selected for the study. Five composite soil samples were collected from each at 0 - 15cm, and 15 - 30cm depths of the local governments identified making a total of 50 soil samples. The samples were dried, ground and sieved through a 2mm sieve. The sieved soil samples were stored in polythene bags and used for all laboratory analyses using the following procedures.

Soil pH was determined in both Water and 0.01 CaCl<sub>2</sub> solution at 1:1 water and 1:2 Soil: Solution ratios respectively using a glass electrode pH meter. Base Saturation (BS) percentage was computed using data on CEC and exchangeable bases using the following formula:

$$BS(\%) = \frac{\text{Total exchangeable bases}}{CEC} \times 100$$

The critical limits for interpreting levels of analytical parameters adopted by Esu (1991) were used for the soil fertility rating. For the purpose of agricultural potential of the soils, the critical limit given by FAO (1976) were employed to assess the suitability class of soils to different crops considered. Where S1 = suitability, S2 = moderately suitable, S3 = marginally suitable and N = Not suitable.

The potential of the soil samples for agricultural production was evaluated using the land suitability assessment. The suitability of the soils for different crops (maize, groundnut, sorghum, onion and rice) was assessed using two methods, viz: the method based on matching the land use requirements with land qualities using the limiting condition principle (the least favourable assessment found limiting was taken as the land suitability class) and the principle of arithmetic modeling [each factor was assigned a suitability class assigned value ranging from 1.0 for "S1" to 0.0 "n" (FAO, 1983)].

Some soil properties such as pH, texture and Base saturation were employed to assess the soil samples for the different crops considered.

Data so obtained were statistically analysed in a nested design using the *Minitab* software F-test. Means that were significantly different were separated using the Duncan's Multiple Range Test (DMRT) as described by Steel and Torrie (1981).

### RESULTS

Table 1 shows the soil pH values both in water and in calcium chloride and the percent base saturation. The results show that pH in water (pH<sub>w</sub>) ranged from 5.9 to 6.3 in Bauchi, 5.9 to 6.9 at Dass, 5.8 to 6.5 at T/Balewa, 5.9 to 6.4 at Bogoro and 5.9 to 6.5 at Toro. The soil pH both in water and CaCl<sub>2</sub> were significantly higher in T/Balewa soil than all locations. While Bogoro soils had higher pH in CaCl<sub>2</sub> than Bauchi soils which was also higher significantly than Dass and Toro soils with the same value of 5.2. The base saturation (BS) ranged from 87.0 to 96.6%, 93.1 to 96.9, 81.6 to 96.6%, 71.9 to 92.5% and 31.0 to 53.9% at Bauchi, Dass, T/Balewa, Bogoro and Toro soils respectively. Toro soil was significantly lower in BS than all the soils of other locations.

Table 2 shows the soil pH values both in water and in Calcium Chloride and percent Base Saturation of the soils of the study areas. Depth wise, the pH values ranged from 6.2 and 5.4 for water and CaCl<sub>2</sub> respectively. It appeared that the pH apparently increased with depth, but in both water and calcium chloride did not vary significantly ( $p = 0.05$ ) between the depths of 0 - 15 and 15 - 30cm. The base saturation percentage of soils from Bauchi, Dass and T/Balewa did not vary significantly ( $p = 0.05$ ) while that of Bogoro and Toro varied significantly with depths.

The soil characteristics presented in Tables 2 to 4 were used in assessing the suitability of the soils of the studied area. The requirements and limits of land characteristics for the crops considered as given in Table 2 and 3 were adapted from FAO (1976). Table 3 and 4 shows suitability classification rating of the soils to different crops. It indicates that the soil was suitable (S1) for all crops considered except rice and sugarcane for which it was marginally suitable (S3). Low organic carbon and CEC content were the dominant factors responsible for lowering the overall crop suitability rating of soil from all five local government of South Western Bauchi state Nigeria.

Table 1: Soil pH and base saturation of the soils

Location	Ph		BS (%)
	(in water)	(in CaCl <sub>2</sub> )	
Bauchi	6.1b	5.4c	91.2a
Dass	6.1b	5.2d	94.5a
T/Balewa	6.2a	5.7a	88.3a
Bogoro	6.1b	5.5b	80.8a
Toro	6.1b	5.2d	41.6b
SE±	0.026	0.041	2.31

Means followed by the same letter(s) within column are not significantly different  $p < 0.05$  (DMRT).

Table 2: Soil pH and base saturation as influenced by soils depth

Location	Depth (cm)	pH		BS (%)
		(in water)	(in CaCl <sub>2</sub> )	
Bauchi	0 - 15	6.1a	5.4a	90.5a
	15 - 30	6.1a	5.4a	93.5a
Dass	0 - 15	6.0a	5.2a	92.5a
	15 - 30	6.1a	5.2a	96.4a
T/Balewa	0 - 15	6.2a	5.7a	89.1a
	15 - 30	6.3a	5.7a	87.6a
Bogoro	0 - 15	6.1a	5.5a	74.9b
	15 - 30	6.1a	5.5a	86.8a
Toro	0 - 15	6.1a	5.2a	37.8b
	15 - 30	6.1a	5.2a	49.5a
SE±		0.04	0.06	1.70

Means followed by the same letter(s) within column are not significantly different  $p < 0.05$  (DMRT).

Table 3. Suitability classification of some Soils to Maize, Rice, Groundnut and Sorghum crops in South Western Bauchi, Nigeria using limiting condition Principle.

Soil Property	Location				
	Bauchi	Dass	T/Balewa	Bogoro	Toro
<b>Maize</b>					
Texture	s3	s1	s1	s1	s1
pH (in water)	s1	s1	s1	s1	s1
CEC (cmol(+))kg <sup>-1</sup>	s3	s1	s1	s1	s1
Base Saturation	s1	s1	s1	s1	s1
Suitability	S3	S1	S1	S1	S1
<b>Rice</b>					
Texture	s2	s2	s2	s2	s2
pH (in water)	s1	s1	s1	s1	s1
CEC (cmol(+))kg <sup>-1</sup>	n	n	n	n	n
Base Saturation	s1	s1	s1	s1	s1
Suitability	n	n	n	n	n
<b>Groundnut</b>					
Texture	s1	s1	s1	s1	s1
pH (in water)	s1	s1	s1	s1	s1
CEC (cmol(+))kg <sup>-1</sup>	s3	s3	s3	s3	s3
Suitability	S3	S3	S3	S3	S3
<b>Sorghum</b>					
Texture	s1	s1	s1	s1	s1
pH (in water)	s1	s1	s1	s3	s3
CEC (cmol(+))kg <sup>-1</sup>	s3	s3	s3	s3	s3
Suitability	S3	S3	S3	S3	S3

Rating: s1 = Suitable, s2 = Moderately suitable, s3 = Marginally suitable,  
 N = Not suitable.

Table 4. Suitability classification of some Soils to Maize, Rice Groundnut and Sorghum crops in South Western Bauchi, Nigeria using Arithmetic Modelling Methods.

Soil Property	Location				
	Bauchi	Dass	T/Balewa	Bogoro	Toro
<b>Maize</b>					
Texture	0.5	1.0	1.0	1.0	1.0
pH (in water)	1.0	1.0	1.0	1.0	1.0
CEC (cmol(+))kg <sup>-1</sup>	0.5	1.0	1.0	1.0	1.0
Base Saturation	1.0	1.0	1.0	1.0	1.0
Suitability	0.5	1.0	1.0	1.0	1.0
<b>Rice</b>					
Texture	0.8	0.8	0.8	0.8	0.8
pH (in water)	1.0	1.0	1.0	1.0	1.0
CEC (cmol(+))kg <sup>-1</sup>	0.0	0.0	0.0	0.0	0.0
Base Saturation	1.0	1.0	1.0	1.0	0.8
Suitability	0.0	0.0	0.0	0.0	0.0
<b>Groundnut</b>					
Texture	1.0	1.0	1.0	1.0	1.0
pH (in water)	1.0	1.0	1.0	1.0	1.0
CEC (cmol(+))kg <sup>-1</sup>	0.5	0.5	0.5	0.5	0.5
Suitability	0.5	0.5	0.5	0.5	0.5
<b>Sorghum</b>					
Texture	1.0	1.0	1.0	1.0	1.0
pH (in water)	1.0	1.0	1.0	0.5	0.5
CEC (cmol(+))kg <sup>-1</sup>	0.5	0.5	0.5	0.5	0.5
Suitability	0.5	0.5	0.5	0.5	0.5

0.5 = Marginally suitable 0.8 = Moderately suitable 1.0 = Suitable  
 0.0 = Not suitable

#### DISCUSSION

Results show that pH in water (pH<sub>w</sub>) ranged from 5.9 - 6.3 at Bauchi down to Toro (5.9 to 6.5) (Table 1). The soils are therefore classed as moderately to slightly acidic at all locations considered. The low acidity level of the soils may

be attributed to low level of leaching of bases and annual deposition of small quantity of lime materials present in the hamattan dust (Jones and Wild, 1975; which encroach the area seasonally from the sahara desert.

The percentage base saturation ranged from 87.0 to 96.6 at Bauchi, 93.1 to 96.9 at Dass, 81.6 to 96.6 at T/Balewa, 71.9 to 92.5 at Bogoro and 31.0 – 53.9 at Toro respectively (Table 1). The BS percentage was low at Toro while higher at Bauchi, Dass, T/Balewa and Bogoro. The low content of the exchangeable cationic bases associated with low pH however, could have led to the low base saturation recorded in the soils. Most of the soils showed a high base saturation and this may also be due to low CEC value of the soils of the study areas.

The pH values ranged from 6.1 to 6.2 (mean = 6.2) and 5.2 to 5.7 (mean = 5.4) for pH in water and in  $\text{CaCl}_2$  to 0 – 15 and 15 – 30cm respectively. The values of pH decreased with increase in depth. This could be due to the effect of nutrient biocycling. Also it could be partly attributed to low rainfall, burning and slow removal of bases due to low cropping intensity (Beets, 1990). It may also be due to leaching of exchangeable bases, especially  $\text{Ca}^{2+}$ , and its replacement by  $\text{Al}^{3+}$  (Jones and Wild, 1975). In the surface soil the value of pH was slightly acidic and high in value than sub-surface and decreased irregularly with depth. These decreasing pH values with profile depth could be due to the effect of nutrient biocycling (Ogunwale *et al.*, 2002). In terms of base saturation, 0 – 15cm seems to be higher with values ranging between 49% and 96% than the 15 – 30cm with values ranging between 38% and 91%. This could also be attributed to the effect of nutrient biocycling.

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The suitability classification rating given in Table 3 and 4 show that the soil at South Western Bauchi state was suitable (S1 for all crops considered except sorghum at Bogoro and Toro and rice and sugarcane at all local government areas for which it was moderately suitable (S2). This conforms with to the result adopted for Nigerian sudan savanna fadama soils for selected crops by Mustapha *et al.* (2005). Low organic carbon and CEC content were the dominant factors responsible for lowering the overall crop suitability ratings of soil at five local government areas. An improvement in the level of organic carbon and CEC may enhance suitability rating.

#### CONCLUSION

The study concludes that, the soils of the study area were classified as poor in fertility for most arable crops. The pH indicates a slightly acidic soil reaction with values ranged from 5.18 – 6.23 in water. The base saturation percentage for all the soils was high with values ranged between 41.6 to 94.5%. The continuous production led to degradation of soil. Also the constant usage of land for intensive cultivation made the land to be scarce and depletion of its natural resources. Increased population with a consequently increased pressure on land use may have resulted into the degraded nutrients of the depleted nutrients in the soil. The use of inorganic fertilizer is recommended as it could improve the soil fertility and productivity.

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