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FERTILITY STATUS OF SOME SELECTED SOILS IN THE SAVANNAH REGION OF NORTHERN NIGERIA

Mustapha, A. A.[1*], Abdu, N.[2] and Mafara M.[1]

[1]*Department of Soil Science, Bayero University Kano, Kano, Nigeria,* [2]*Department of Soil Science, Ahmadu Bello University, Zaria*
**corresponding author aamustapha.ssc@buk.edu.ng. +2348034751783*

Abstact
The fertility status of some soils in the savannah was evaluated. Soil was sampled from four locations within the savannah regions (Jakara, Bunkure, Ombi and Duduguru). In each location, ten representative soil samples were collected at a depth (0 – 20cm). A total of forty samples were collected. The samples were subjected to standard laboratory analytical methods to determine the physico – chemical properties of the soil orders, various standard fertility ratings and guides were used to interpret the results obtained. Jump was used for statistical analyses Most of the soils were dominated by the sandy loam texture. The results show that the soils of Bunkure, Ombi and Duduguru were very strongly acidic in KCl (4.62, 4.77 and 4.76 respectively) and strongly acidic and moderately acidic in water (5.37, 5.20 and 5.64 respectively). The soils of Jakara were moderately acidic (5.83) and slightly acidic (6.16) in KCl and water respectively. Organic carbon, total nitrogen and potassium were found to be low across all the locations. Low to moderate content of available P was observed in all the locations with the exception of Jakara (98.56 mg). The results of the CEC were low across all the locations. The use of soil cover and organic amendments /fertilizer is suggested to improve soil productivity as well as practices that will increase pH of the soil.
KEYWORDS: Fertility; soil properties and savannah soils

Introduction

The Nigerian tropical savannah comprises of the Guinea, Sudan and Sahel Savannah and it is characteristics of the central and northern part of Nigeria. The climate is well marked with single peak rainy season usually in August and a distinct dry season. Annual mean temperature is 18^0C (Eludoyin *et al.,* 2014). Arable land is abundant with great potentials for food production (grains, legumes and tuber to a lesser extent), however the total yield in the region are low in comparison to world yield (FAOSTAT. 2012). Hence, food production in this region remains largely on an extensive scale whereby lands are continuously cultivated with little inputs with consequent effects on soil productivity.

The chemical properties of the soil are a result of the factors of soil formation and the various processes of soil change. Soil minerals are disintegrated and decomposed during weathering, which results into the release of individual ions into the soil pool and this nutrient may also be lost through drainage (Brady and Weil, 2010). Soil nutrient supply is usually influenced by the type of mineral particles and hence by parent materials as well as by the organic properties of the soil with most soils in the savannah been classified as having low inherent nutrient status(Voncir *et al.,* 2006). Soil restoration and fertility management is a key factor for productive and sustainable agriculture with this partially achieved in Nigeria through bush fallow system, organic manures and integrated soil fertility management (Vanlauwe *et al.,* 2002). The rising population has shorten the fallow period, and manure quantities often do not meet the demand alongside the high labour requirement for and integrated soil fertility management which most farmers find a problem especially during the farming season. In addition, blanket approach is usually used in fertilizer recommendations without consideration of soil properties and characteristics which may lead to in appropriate fertilizer use thus causing nutrient imbalance and thereby impacting negatively soil fertility and productivity. Therefore, to increase and sustain soil productivity in order to increase food production as to meet the demands by the growing population, maximization of land resources is a key and hence determination of the inherent fertility status of the soils in order to better increase soil productivity.

Materials and Methods

Location of Study Site

The study was conducted in Kano state and Nasarawa State. Average annual rainfall in Kano state is 657.3 mm and a prolonged dry season, with abundant short grasses and fewer trees. Nasarawa state has an average annual rainfall of 1314mm with scattered trees and tall grasses. Agricultural activities are dominant in both states.

Soil Sampling and Preparation

Soil was sampled from four locations in the savannah with their respective coordinates recorded with an hand held Global Positioning System (GPS as follows; Duduguru on $08^0$25'11.4"- $08^0$25'19.1" N and $08^0$34'11.4" - $08^0$34'21.2" E, Ombi between latitude $08^0$33'25" - $08^0$32'14.7" N and longitude $08^0$32'00" - $08^0$32'50.7" E, Bunkure $11^0$46'05.2" - $11^0$42'17.2" N and $08^0$31'46.2" - $08^0$31'49.4" E, Jakara $12^0$02'07.9" - $12^0$02'08.8" N. Soils were sampled at a distance of 1 km in each location with the exception of Jakara at a depth of 0 – 20 cm. the soils in Jakara were sampled at a distance of 1m. Ten samples were collected from each location, making it a total of 40 samples. Samples were air dried and prepared for analysis.

Laboratory Methods

The principles of Bouyoucous-hydrometer method was used in the determination of particle size distribution, following the dispersion of the soil with calgon solution (Bouyoucous, 1962). Cation exchange capacity (CEC) was determined by leaching the soil with 1M ammonium acetate (NH_4OAC) buffered at pH 7 as outlined by (Rhodes, 1982). Soil pH was measured in both water and KCl_2 at a soil: water and soil KCl_2 ratio of 1:2.5 using a glass electrode pH meter. Organic carbon (OC) content of the soil was determined using the wet oxidation method (Nelson and Sommers 1982). Total N was determined using the micro- Kjeldahl digestion method of Bremmer, (1996) while Available P was extracted using the Bray 1 method (Bray and Kurtz 1945).

Data Analysis

Descriptive statistics was used to summarize the data for soil properties across the different locations using JMP Statistical package

Results and Discussion

Particle Size Distribution

Table 1 shows the result of the sand, silt clay and silt: clay of the soils of Bunkure, Jakara, Ombi and Duduguru. High variation in the soil particle size fraction was recorded among the different locations. The highest sand content of 81. 08% was observed in the soils Ombi while the lowest

content of 47.48% was observed in the soils of Duduguru. Clay and silt content was observed to be highest in the soils Duduguru (22.36% and 30.16% respectively) and Jakara (19.16%17.16% respectively). The results shows that clay: silt fraction was in the order Ombi (10.02) >Bunkure (1.34) > Jakara (1.24) >Duduguru (0.78).The amount of sand observed in the soils of Bunkure and Jakara was high and the textural class was determined to be sandy-loam. The high fraction of sand in these soils was attributed to the interplay of factors of soil formation (Salako *et al.,* 2006). Akinbola *et al.*(2009) and Voncir *et al.* (2006)also suggested that surface wind erosion may be responsible for the dominance of sand fraction. The dominance of sand may also be linked to the granitic origin of the soils (Voncir *et al.,* 2006). The results obtained was in tandem with the reports of Shehu *et al.* (2015).
Malgwi *et al*. (2013)suggested that the appreciable amount of clay found in Duduguru soils may be attributed geological processes and biological activities such as clay migration through illuviation and eluviation. Similar results was reported by (Nyandansobi *et al*., 2017).

Table 1: The Particle Size Distribution and Clay: Silt of Bunkure, Jakara, Ombi and Duduguru

Location	Sand (%)	Clay (%)	Silt (%)	Clay: Silt
Bunkure				
Range	58.88 – 76.88	14.56 -22.56	8.56 -22.56	0.82- 1.93
Mean	68.28	17.56	14.16	1.34
Standard deviation	5.74	2.54	4.40	0.39
Jakara				
Range	36.88 -78.88	14.56 -28.56	6.56-36.56	0.73 -2.22
Mean	63.68	19.16	17.16	1.27
Standard deviation	13.44	4.90	8.80	0.41
Ombi				
Range	70.88- 84.88	12.56 -16.56	0.56 -16.56	0.76 -29.57
Mean	81.08	13.96	4.96	10.02
Standard deviation	4.26	1.65	4.88	11.94
Duduguru				
Range	38.88 -54.88	14.56 -14.56	20.56 -46.56	0.31 -1.24
Mean	47.48	22.36	30.16	0.78
Standard deviation	4.33	4.47	7.35	0.31

The high clay and silt content may be due to dust deposited by harmattan winds(Sharu *et al*., 2013).The average Clay: silt ratio was observed to be 1.34 and 1.27 for the soils of Bunkure and Jakara respectively. The soils of Ombi were observed to have the highest Clay: silt ratio of 10.02 while Duduguru had the lowest mean of 0.78. Generally, Clay: silt ratio > 0.15 is an indication of young parent materials. All the locations were observed to be greater than 0.15, thus, depicting the presence of weatherable minerals (Brady and Weil, 2010; Ibrahim *et al*., 2016).

pH and Electrical Conductivity

The pH and Electrical conductivity of the soils of Bunkure, Jakara, Ombi and Duduguru are as presented in Table 2. The results show that the soils of Bunkure, Ombi and Duduguru were very strongly acidic in KCl (4.62, 4.77 and 4.76 respectively) and strongly acidic and moderately acidicin water (5.37, 5.20 and 5.64 respectively). The soils of Jakara are moderately acidic (5.83) and slightly acidic (6.16) in KCl and water respectively. The pH observed in these soils may likely be an inherited property from the parent material (Voncir *et al*., 2006). It may also be as a result of application of acid forming fertilizers which has been found to accelerate acidity in soils (Tanko, 2018). The mean EC observed across all the locations was found to be low indicating the non -saline status of these soils (Ibrahim *et al*., 2016; Sharu *et al*., 2013).

Organic Carbon, N, P and K

The organic carbon, total nitrogen, available P and Total P are as shown in Table 3. The organic carbon content observed across all locations was low (< 1). The low amount of organic carbon has been related to continuous cropping, overgrazing, bush burning and soil cover removal; these results in the loss of organic materials that could have been added to the soil has well as well as promoting the rapid decomposition and mineralization of organic materials (Ibrahim *et al*., 2016; Voncir *et al*., 2006). The amount of nitrogen observed across all location was also low which may

Table 2: pH and Electrical Conductivity of Bunkure, Jakara, Ombi and Duduguru

Location	pH(water)	pH(KCl)	EC (Dsm^{-2})
Bunkure			
Range	4.31 -6.98	3.84 5.79	0.01 -0.04
Mean	5.37	4.62	0.02
Standard deviation	0.80	0.59	0.01
Jakara			
Range	5.60 – 6.61	5.48 -6.20	0.08 -0.60
Mean	6.16	5.83	0.28
Standard deviation	0.36	0.28	0.14
Ombi			
Range	4.84 -5.76	4.36 -5.24	0.01 -0.15
Mean	5.20	4.77	0.03
Standard deviation	0.30	0.27	0.04
Duduguru			
Range	4.72 -6.83	4.01 -5.91	0.01 -0.11
Mean	5.64	4.76	0.03
Standard deviation	0.51	0.32	0.03

be due to the low organic carbon content, crop removal and low density of soil cover (Ibrahim *et al.,* 2016; Voncir *et al.,* 2006). The content of available P was low in Bunkure and Duduguru (<10 mg kg^{-1}), medium in Ombi (10.01 mg kg^{-1}) and high in soils of Jakara (98.56 mg kg^{-1}). The low to medium content of available P observed could probably be related to the poor amount of organic carbon and continuous mining of soil P without adequate replacement (Ibrahim *et al.,* 2016; Voncir *et al.,* 2006). The high amount of available P observed in the soils of Jakara may probably be due to wastewater irrigation in vegetable production resulting in an overload of the topsoil with P (Mukhtar and Samndi, 2016). The observed K was low in all soils with the exception of the soils of Ombi (0.40 cmol (+) kg^{-1}).

Table 3: Organic carbon, N, P and K of Bunkure, Jakara, Ombi and Duduguru

Location	Organic carbon (gkg^{-1})	N (%)	Available P ($mgkg^{-1}$)	K (Cmol (+)kg^{-1})
Bunkure				
Range	0.06 -0.46	0.03 -0.11	0.62 -6.57	0.07 -0.25
Mean	0.22	0.07	3.98	0.12
Standard deviation	0.15	0.02	1.60	0.05
Jakara				
Range	0.06 -1.06	0.07 -0.11	80.85 -133.98	0.04 -0.24
Mean	0.43	0.08	98.56	0.09
Standard deviation	0.30	0.01	18.13	0.06
Ombi				
Range	0.10 -0.46	0.03 -0.07	2.72 – 38.50	0.04 -0.69
Mean	0.28	0.05	10.07	0.40
Standard deviation	0.11	0.02	13.50	0.20
Duduguru				
Range	0.66 -1.06	0.04 -0.28	2.41-12.58	0.08 -0.45
Mean	0.91	0.11	5.69	0.15
Standard deviation	0.12	0.08	3.71	0.11

CEC and Exchange Acidity

The CEC and EA were low across all the locations as shown in Table 4. The low CEC observed in all the soils across the different locations may be as a result of the intense weathering undergone by the soils, parent materials as well as low activity clays. It may also be related to the low amount of organic carbon in these soils which may have an influence on cation content of the soil(Ibrahim *et al*., 2016; Sharu *et al*., 2013; Shehu *et al*., 2015).

Table 4: CEC and EA of Bunkure, Jakara, Ombi and Duduguru

Location	CEC (cm0l(+)kg^{-1})	EA (cm0l(+)kg^{-1})
Bunkure		
Range	1.17 -4.13	0.08- 0.25
Mean	3.02	0.17
Standard deviation	1.07	0.04
Jakara		
Range	0.56-4.30	0.08 – 0.42
Mean	1.73	0.29
Standard deviation	0.48	0.14
Ombi		
Range	7.48 -19.47	0.25
Mean	12.71	0.25
Standard deviation	4.87	0.00
Duduguru		
Range	4.33 -18.12	0.08 -0.33
Mean	8.71	0.20
Standard deviation	3.73	0.07

Conclusion and Recommendations

Generally all the soils observed were sandy-loam textured with low amounts of organic carbon, total nitrogen and low to high contents of available P. The poor status of most of the soils has been linked to continuous cropping, removal of soil cover as well as overgrazing. Hence, practices that will improve the soil conditions such as use of organic amendments and soil cover should be encouraged.

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