EVALUATION OF SOIL FERTILITY AND SALINITY STATUS OF NATIONAL OPEN UNIVERSITY OF NIGERIA, (NOUN) RESEARCH FARM.

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ABSTRACT
An assessment was carried out on the current fertility and salinity status of the Faculty of Agricultural Sciences, National Open University of Nigeria, research farm. 20 soil samples were taken from 0-15 and 15-30cm depths in different locations. A laboratory test analysis was conducted and result obtained indicated that the soil contents of organic carbon (1.03-1.89), total N (0.02-0.98), available P (8.00-14-31), Ca (2.00-3.27cmol (+) kg^{-1}) were low while available K (0.16-0.5cmol (+) Kg^{-1}) was high. The values of Mg (0.75-1.63cmol$^{(+)}$ kg^{-1}), and CEC (3.13-5.23cmol $^{(+)}$ kg^{-1}) varied from low to moderate while P^H (5.24-5.65), Ec (0.01-0.05ms/cm-1) and Esp (2.49-5.41%) indicated no salinity risk at present. The extremely moderately acidic reaction and low nutrient status of this soil may result in acid-soil infertility. The simultaneous application of inorganic fertilizers and organic manure will help Improved the fertility.

Keywords: Soil Fertility, Salinity, Organic carbon, Total nitrogen, Available phosphorus, CEC, Exchangeable Base, Base saturation.

INTRODUCTION
Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Earth's body of soil, called the pedosphere, has four important functions:as a medium for plant growth, as a means of water storage, supply and purificationas a modifier of Earth's atmosphere, as a habitat for organisms. All of these functions, in their turn, modify the soil and its properties.Soil is also commonly referred to as earth or dirt; some scientific definitions distinguish dirt from soil by restricting the former term specifically to displaced soil.
The pedosphere interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere. The term pedolith, used commonly to refer to the soil, translates to ground stone in the sense fundamental stone, from the ancient Greek ground, earth. Soil consists of a solid phase of minerals and organic matter (the soil matrix), as well as a porous phase that holds gases (the soil atmosphere) and water (the soil solution). Accordingly, soil scientists can envisage soils as a three-state system of solids, liquids, and gases. Soil is a product of several factors: the influence of climate, relief (elevation, orientation, and slope of terrain), organisms, and the soil's parent materials (original minerals) interacting over time. It continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and stronginternal connectedness, soil ecologists regard soil as an ecosystem. (Ponge,2015)
Soil salinity is a measure of the minerals and salts that can be dissolved in water. In most cases, the following mineral ions are found in soil-water extract listed in order of importance:
$Na^+, Cl^-, Ca^{++}, SO_4^{=}, HCO_3^-, K^+, Mg^{++}, NO_3^-$.
Increased soil salinity has progressive and often profound effects on the structure, water movement, and microbial and plant diversity of soils. Soil salinity is measured by using electrical conductivity (EC) measurements of a water-saturated soil paste extract. (Artiola and Crimmins,2019).Soil fertility refers to the ability of soil to sustain agricultural plant growth, i.e. to provide plant habitat and result in sustained and consistent yields of high quality. A fertile soil has the following properties:The ability to supply essential plant nutrients and water in adequate amounts and proportions for plant growth and reproduction; and the absence of toxic substances which may inhibit plant growth.
The following properties contribute to soil fertility in most situations:Sufficient soil depth for adequate root growth and water retention;Good internal drainage, allowing sufficient aeration for optimal root growth (although some plants, such as rice, tolerate waterlogging);Topsoil or horizon O is with sufficient soil organic matter for healthy soil structure and soil moisture retention;Soil pH in the range 5.5 to 7.0 (suitable for most plants but some prefer or tolerate more acid or alkaline conditions); Adequate concentrations of essential plant nutrients in plant-available forms; and Presence of a rangeof microorganisms that support plant growth. (Wikipedia," soil fertility", 2016)
In lands used for agriculture and other human activities, maintenance of soil fertility typically requires the use of soil conservation practices. This is because soil erosion and other forms of soil degradation generally result in a decline in quality with respect to one or more of the aspects indicated above.
It has been estimated that 60% of cultivated soils suffer from growth-limiting problems, with both deficiencies and toxicities of mineral nutrients occurring globally (Cakmak 2002). A crucial aspect

of plant nutrition is therefore to preserve the fertility of soils so that they can deliver nutrients at the right time and in the right quantity for growing plants (Johnston and Bruulsema 2014; Withers et al. 2018). Nutrient supply and plant growth are very frequently constrained by adverse soil conditions affecting parameters such as soil pH and redox state, which impact the Phyto-availability of mineral nutrients and the concentrations of toxic elements in the soil solution (White and Greenwood 2013). Assessing the size of the Phyto-available pool of nutrients is a fundamental challenge in plant nutrition (Tandy et al. 2012; Mason et al. 2013). It is, however, not only soil properties that determine the capability of soils to deliver nutrients. Soils also need to sustain root growth so that the growing plants can capture a sufficient proportion of the available nutrients (White et al. 2013ab). In this context, interaction with the soil microbiome, including mycorrhizae, is important (Richardson et al. 2017; Campos et al. 2018; Svenningsen et al. 2018).

MATERIALS AND METHODS

The study Area

The research was conducted in 2017 at the Faculty of Agricultural Sciences, National Open University of Nigeria research farm located at 4km off Kaduna-Zaria expressway, Rigachikun, Kaduna State, in the northern Guinea savannah zone of Nigeria (altitude: 722 m above sea level, latitude 10.6321° N, and longitude 7.4706° E, this part of the Savannah region has an annual rainfall ranging from 850 – 870mm per annum with annual mean temperature of 38^0 C – 43^0C, with relative humidity of 40% - 51.3% respectively. The Southern part ofthe research farm is hilly and will be characterized by rough topography that is not suitable for crop production.

Sampling and Samples Preparation

A total of 20 samples were collected each at the depth of 0 – 15cm and 15-30cm. The samples were taken to laboratory and air-dried, ground using porcelain pestle and motar. The grounded soil samples were sieved using a 2mm sieve and the fine earth fraction was collected and kept for analysis. Chemical analyses were carried out in the laboratory on each of the prepared soil samples following standard laboratory procedures.

Data Analysis

Soil pH was determined in 1:2 soil/water using a caramel glass electrode pH meter (Smith 1983). Available phosphorus was extracted by Bray 1Method as provided by Bray and Kute (1984). The concentration in samples was determined calorimetrically with a spectrophotometer at 882mm. Organic carbon and organic matter were determined by wet oxidation method by Juo (1979). The exchangeable bases were determined using ammonium saturation method (Chapman, 1956). The bases, Ca and Mg were read on the atomic absorption spectrophotometer while Na and K on the flame emission photometre at appropriate wavelength. Exchangeable acidity was extracted with 1ml KCl solution and determined by titrating with standard microkjehdal method.Electrical conductivity (Ec) wasdetermined in 1:5 soil/water extract on a conductivity meter, the value was multiplied by a factor (6.4) to obtain the Ec of saturation extract (London, 1991). Exchangeable sodium percentage (ESP) was calculated using the formula:

$$Esp.\% = \frac{Na}{CEC} X \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$PBS = \frac{Na+Ca+Mg+K}{CEC} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

RESULTS

Determination of Fertility Status

The distribution of organic carbon in the various locations and within the depth is presented in (Tab.1). According to the classification by Esu (Tab 4) organic carbon was "Low" ranging from 1.03% as the lowest and 1.89% as the highest. One important factor noticed is that the value changes from the Northern part of the research farm to the Southern which indicates differences in fertility rate. The distribution of total N according to the classification by ESu was "Low" ranging from 0.02% as the lowest and 0.98% as the highest. The amount of the total N changes from North to South. Distribution of available phosphorous (P) in the various locations and within the depth (Table 1).

Table 1. Organic carbon Total N and Available phosphorus content of the research farm

Locations	*Depth (cm)*	*OC (%)*	*Total N (%)*	*Available(P)ppm*
A_1	5cm	1.89	0.10	10.26
A_2	15-30cm	1.40	0.96	9.30
B_1	0-15cm	1.58	0.98	8.65
B_2	15-30cm	1.08	0.03	8.00
C_1	0-15cm	1.03	0.03	13.20
C_2	15-30cm	1.84	0.93	8.00
D_1	0-15cm	1.59	0.04	12.00
D_2	15-30cm	1.43	0.02	12.02
E_1	0-15cm	1.64	0.95	14.31
E_2	15-30cm	1.56	0.05	14.25

According to the classification by Esu available phosphorus was "moderate". The highest value obtained was 14.31 ppm and the lowest value was 8.00 ppm. The value of available phosphorus differs with different locations.

Determination of CEC, Exchangeable Bases and Base Saturation Status

The distribution of CEC between location and within depth is shown in (Table 2) According to the classification by Esu (1999)(Table 4) CEC was medium ranging from 3.13 cmol $^{(+)}$ kg^{-1} to a maximum of 5.23 cmol $^{(+)}$ kg^{-1} within the depth of 0-15cm, CEC ranged from 3.57 – 5.23 cmol $^{(+)}$ kg^{-1}. CEC varied between locations but not within depth.

Table 2. Some exchangeable characteristics of the research farm

Locations	CEC	K	Na cmol$^{(+)}$ kg^{-1}	Ca	Mg	BS%
A_1	4.08	0.26	0.18	2.73	0.91	100
A_2	3.13	0.21	0.16	2.01	0.75	100
B_1	3.82	0.22	0.16	2.30	1.14	100
B_2	4.88	0.35	0.21	3.10	1.22	100
C_1	3.57	0.21	0.18	2.31	0.87	100
C_2	3.33	0.22	0.19	2.00	0.92	100
D_1	5.23	0.20	0.13	3.27	1.63	100
D_2	4.96	0.16	0.15	3.08	1.52	98.99
E_1	4.14	0.20	0.19	2.92	0.83	100
E_2	4.34	0.20	0.15	2.40	1.07	88.01

The distribution of exchangeable bases (Ca, K, and Na) according to the classification by Esu (1999). (Table 4) were "Low" except Mg which was high and ranged from 0.75 – 1.63 cmol $^{(+)}$ kg^{-1}. CEC did not significantly vary both between locations and within depth. (Tab. 2). However,the distribution of Base saturation between locations according to the classification by Esu (1999). (Tab.4). Base saturation was "high" ranging from 88.01% - 100% Base saturation did not significantly vary both between locations and within depths.

Determination of Salinitystatus

The distribution of the pH ranged from a minimum of 5.2 to a maximum of 5.6 which is considered as acidic. Within the depth of 0-15cm, pH ranged from 5.2-5.6 and 5.3-5.7 in 15-30cm depth. The EC value between ranged from 0.01ms/cm^{-1} - 0.05 ms/cm^{-1}within the depth of 0-15cm, Ec values ranged from 0.01 ms/cm^{-1} - 0.05 ms/cm^{-1} while in the depth of 15-30cm, Ec ranged from 0.01 ms/cm^{-1} to 0.03 ms/cm^{-1}. The distribution of ESP between locations ranged from 2.49% to 5.04%within the depth of 0-15cm, ESP ranged from 3.02% to 5.71%.

Table 3. Salinity parameters – pH in water EC and ESP

Locations	pH (In water)	EC(ms/cm^{-1})	ESP (%)
A_1	5.6	0.05	4.41
A_2	5.6	0.02	5.11
B_1	5.3	0.01	4.19
B_2	5.6	0.03	4.30
C_1	5.3	0.01	5.04
C_2	5.6	0.01	5.71
D_1	5.2	0.01	2.49
D_2	5.3	0.03	3.02
E_1	5.4	0.04	4.59
E_2	5.5	0.03	3.46

Table 4. ***Rating for soil fertility in the Nigerian savanna as adopted by Esu (1999) From Hill and Rachem (1973)***

Parameters	Low	Medium	High
Organic carbon (gkg^{-1})	<10	10-15	>15
Total Nitrogen (gkg^{-1})	<1.5	1.5-2.0	>2.0
Available P (mgkg^{-1})	<10	10-20	>20
Available K (cmol$^{(+)}$kg^{-1})	<0.15	0.15-0.30	>0.30
Exch Ca (cmol$^{(+)}$kg^{-1})	<2	2-5	>5
Exch mg (cmol$^{(+)}$kg^{-1})	<0.3	0.3-1.0	>1.0
CEC (cmol$^{(+)}$kg^{-1})	<6	6-12	>12

DISCUSSION

Soils being the natural medium for plant growth are vital for life on earth through their roles in the production capacity/capability. The fertility of a soil refers to its status with respect to the amount and availability of essential nutrient elements for plant growth. Nutrient availability is one of the prime factors determining crop yield and investigations of the nutritional requirement of food crops have been the subject of immense studies. Organic matter plays a key role and occupies a central position in the provision of some of these essential plant nutrients (Brady and Neil, 1999) and stabilizing the soil environment (Mustapha et al, 2001). Of the many nutrients required by crop plants, the macro-nutrients N.P.K, Ca and Mg are the major nutrients that determine soil fertility.

Organic carbon is an index of organic matter and plant nutrient content in soils. Data in Table 1 shows the content of organic matter in the soils varied narrowly within the range. The organic carbon at the different depths (0-15) and 15-30cm) was low at the different locations. This implies low organic matter content in the soil. The organic carbon decreased irregularly with depth. The content of organic carbon did not vary significantly among the locations. The total values of N obtained in all the locations indicated low level. Total N, just like organic C, was low ranging from 0.02% to 0.98%. Like the organic carbon, it also decreases with increase in soil depth, but did not vary significantly among location and depth, suggesting that it is associated with organic matter content. The low N content of this soil could be probably due to the continuous leaching as a result of seasonal rainfall and anaerobic conditions during the rainfall. Rending and Taylor (1989) reported that N mineralization under anaerobic conditions doesn't proceed pass the ammonium stage which is subsequently lost as a gas to the atmosphere, because of their moderately low N content, these soils are very likely to respond to N fertilization. Similarly, if crop rotation involving legumes is to be adopted, the productivity of the soils can be maintained on sustainable basis.The available p content of this soil is moderate ranging from 8.65ppm -13.20 ppm. Available p content did not vary significantly among the locations but varied with depth.

The result in table 2 shows that the distribution of the exchangeable bases was low except for Mg which was high and ranged from 0.75-1.63cmol $^{(+)}$ kg^{-1}. Table 2 shows that the CEC value ranges from 3.13 cmol $^{(+)}$ kg^{-1} to 5.23 cmol $^{(+)}$ kg^{-1}. The cation exchange capacity of this soils is low, thereby requiring appropriate soil management steps to be employed, if fertilizers are to be beneficial to crops otherwise the applied nutrients would be lost through leaching. Results in table 2 shows that the values of calcium and magnesium varied. Both Ca and Mg did not vary significantly among the locations and within depth. The value of Ca was low which corresponds to the values reported for semi arid soils. Mg was the dominant base in the soil. Similar observations have been made in the past for West Africa Savannah soils in general (Kowal and Knabe, (1972). Sodium also did not significantly vary with depth and among locations.

Table 3: shows value for soil pH, EC, and ESP, which is considered acidic. The EC values are generally low ranging from 0.01 – 0.05ms/cm$^{-1.}$ This value suggested that there is no salinity risk to this soil since none of these values is up to 4 mmhos/cm. The ESP values also ranged from 2.49% to 4.59%. All of the ESP, EC and pH did not vary significantly both among location and within depth.

CONCLUSION

A study was conducted to determine the fertility and salinity, status of the research Farmof Faculty of Agricultural Sciences, National Open University in Kaduna. The results obtained indicate that the content of Organic Carbon (1.03 – 1.87%) total N (0.02 – 0.98%) available P (8.70 – 14.31), Ca (2.01 – 3.27 Cmol $^{(+)}$ Kg^{-1}), Na (0.13 – 0.19 Cmol $^{(+)}$ Kg^{-1}),K (0.20 – 0.35 Cmol $^{(+)}$ Kg^{-1}) and EC (0.01 – 0.05mScm^{-1})were low. The content of CEC was medium (3.13 – 5.23 Cmol $^{(+)}$ Kg^{-1}). The P^{H} (5.2 – 5.67) indicate acidity. The low EC however is an indication of no salinity risk. Therefore, an adequate soil management measures should be employed to avoid further deterioration and enhance crop production. Therefore, is important to avoid bush burning, that destroys crop residue and loss of important plant nutrient that would have been incorporated into the soil. Application of inorganic fertilizers, organic manure and liming would improve soil P^{H}.

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