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Evaluating Soil Fertility Potentials of Some Soils of Bali Local Government, Taraba State, Nigeria.

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Abstract
A field experiment was carried out to evaluate the soil fertility potentials of some soils in Bali Local Government area of Taraba State, Nigeria. Soil samples were collected from different wards which were Bali A and B using cropping system as criteria for the collection of soil samples. Six (6) soil profile pits were dug in each of the ward and twelve (12) auguring points with the distance of 2.5km away from the pit. The soil samples were analysed to determine their physical and chemical properties. The result of the analyses concluded that the soils were deep soils (> 1.5km) and they were generally sandy loam textured. The soils were also yellowish brown to reddish in colour which indicated the presence of iron three (Fe 111) and iron two (Fe 11) oxide as a result of iron oxidation with the mean value of soil bulk density 1.53 and 1.55 gcm^3 for the pedon and the soil samples, respectively. The mean value of soil porosity was 45% for the all collected soil samples. In the chemical properties of the soil, it showed that the pH of the soils were moderately acidic to neutral with low to moderate EC values in pedon and soil samples, respectively. The means of the organic carbon and the net nitrogen were 10 /kg and 7 mg/kg, respectively. The average of available P were 4.8 mg/ kg and o.94 for pedon and the soil samples, respectively. ESP, exchangeable acidity and exchangeable bases were low, but ECEC was moderate to high in all the soil samples. The soils of the wards are deep, moderately structured and well drained with, low to medium organic carbon, N, P and K contents indicated medium fertility levels and could be maintained and sustained through monitoring and balanced integrated nutrient management using both synthetic and organic fertilizers

Keywords: Evaluating, Soil, Fertility and Potentials,

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I. Introduction

One of the essential tools to evaluate the strength of any country in the world is her ability to feed her population which depends on land resource, and this is related to soil fertility. The productivity of a farming system is fundamentally determined by the soil fertility. Soil fertility is the ability of the soil to supply nutrient to the soil in an adequate amount without a harmful too high or low concentration of any of the nutrient when a proper soil management is given. In a situation where the nutrients are in adequate to support that ability, chemical fertilizers are applied to support that (Swift & Palm., 2000).). The rate at which the population is very high while the rate of food production is very low. As times goes on as a result of geometric way of population increase, many people are going to die starvation unless modern farming system is practise. And one of the principles of it is soil management which includes the determination of the soil fertility (IFPRI, 2013). In the world in general, the decline in soil fertility creates the most important concern to policy makers (Cray & Moran, 2003).According to Neo-Malthusian hypothesis, the decline of soil fertility happens when there is a fast population growth and lack of proper management of land resources. Nevertheless, different methodology suggests that population growth, under positive situation can reduce the incidence of soil erosion to a certain level and amplify or intensify soil fertility (Tiffen & Mort more, 1994: Fair head & Leach, 1995: Leach & Fair head, 2000a). Soil fertility increases the yields and investment of farmers who strongly depend on farming either commercial or subsistent farming. .Other results of soil importance fertility are increased food policy by maximizing the production and deflation of food prices. The most positive consideration of soil fertility is to reduce redundancy in youth and other interested people in farming sector and increase wealth. (World Bank, 1994).

To sustain soil fertility potentials of some soils farmers need to apply high level of NPK fertilizer. However, local farmer do not carry out soil analysis to determine the fertilizer dosages, but they just apply the chemical fertilizer haphazardly and this does not give the expected yields (Casanova et al. 2013). There are many methods which can be practice which can be applied to give a maximum satisfaction in managing soil fertility. Cash crops can be rotated with leguminous crops like groundnut, beans, Bambara nut and so on. This practice maintains the soil fertility to a maximum level (Altieri 1995). Addition of more organic matter which are incorporated into the soil and nitrogen content of the organic matter is mineralized by the action of microorganisms (Lampkin 1990). Mychorrhizal, fungi also helps in the management, it is the association of fungus with higher plants in which the higher plants supply glucose to fungus while fungus supplies the nutrients to plants by its long hypae . This management practice helps in increasing soil fertility in three ways, by capturing the leached nutrients by the fungus, lessening soil bone disease and formation of soil structures (Bethlenfalvy & Lindeman 1992: Mader et al, 2000). Other factors that are very important in assessing the fertility of the soil are: Chemical properties of the soil such as soil P^H, cation exchange capacity, soil salinity, and organic matter content of the soil. Physical properties of the soil such as soil bulk density, soil structure and soil texture. Biological properties of the soil which depend on the number and quality of the macro and micro-organisms involved in the decomposition of organic matter (Pravin et, al 2013).This research was carried out to assess the soil fertility potential of some soils in Bali Local Governments, in taraba State, Nigeria. This paper will focus on some physical and chemical properties of the soil in the evaluation of the soil fertility potentials of soils of the mentioned area. The research will be conducted in Bali A and B. The soil sample will be collected using soil augar and Bouyoucos method of soil particle size analysis will be used. After the results are obtained, they be discussed and compared with the work of other researchers.

II. Material And Methods

Location and Extent of the Study Area.

The field experiment was carried out in Bali local government area of Taraba State covering different districts in the local government; Bali A and Bali B. Bali local government is located in the Sudan Savannah region of North East Nigeria and lies between latitudes 716520.90N' and longitudes 868589.97E with an elevation of 204m above sea level. (Adebayo and Tukur, 1992). The average annual rainfall for the state is 1500mm./ year.

Soil Sampling Collection

A soil spiral Auger was used to collect the soil samples in each of the two selected wards. Six area for the digging of soil profile pits were sited and dug in each of the wards with a dimension of 1.5m x 2m x 2m. Soil samples were collected from different identified horizons. Surface (0-20) and sub-surface (20-50) and they were also collected at a distance of 2.5 km away to left and right of each site of the pit. , pit samples were twelve in both Bali A and in Bali B. A total of twenty four (24) profile soil samples and twenty four (24) Auger soil samples were collected. The soil collected were air dried, gently crushed with pestle and mortar, sieved, labeled and taken to the laboratory for physical and chemical analysis.

Laboratory Analysis

Particle size distribution was determined using Bouyoucos hydrometer method as described by (Jaiswal, 2004) and the soil color was determined using Munsell color chart both in the dry and wet state. Soil pH and EC were measured in 1:2 soil to water ratio using pH and Digital Conductivity Meters respectively. Calcium and Magnesium were determined using titrimetric method with 1N Ammonium acetate (Black, 1965). Potassium and Sodium were determined using Flame Photometer. Titrimetric Method was used to determine Aluminum and Hydrogen ions as described by Jaiswal (2004). The organic carbon of the soils were determined using Walkley and Black, Potassium dichromate wet oxidation method as described by Jaiswal (2004).The Bray 1 method (Black, 1965) was used for the determination of available phosphorus content of the soil. Total exchangeable bases (TEB) were calculated by the summation of sodium, potassium, calcium and magnesium. The exchangeable sodium percentage (ESP) content was obtained by calculating and dividing the exchangeable sodium content of the soil by the TEB (soil) and was expressed in percentage. Summation method as described by IITA (1984) was followed to obtain the ECEC. Base saturation was calculated by dividing the sum of TEB by the effective cation exchange capacity (ECEC) and was expressed in percentage (Black, 1965).Soil data were analyzed using statistics 8.0 software.

III. Result And Discussion

After the completion of the field experiment on the evaluation of soil fertility potentials of some soils of Bali Local Government area of Taraba State, the following results were obtained and presented in the tables below.

On the chemical properties of the soil of Bali A, there was variation of soil pH between the pit and within the pit from pit 1, 2, 3, 4, 5 and 6 pit. This variations in soil PH might be as a result of different farming activities such as over cultivation, leaching, bush burning, bush fallow, decomposition of organic matter, high or low application of synthetic fertilizer (ammonium fertilizer) and the nature of parent material from which the soil is formed (granite or basalt) (Usman, 2005). According to this researcher, the oxidation of ammonia decreases the soil P^H. Also, when over cover cultivation is seriously practised in a certain area, the basic ions such as K, Mg, and Ca and so on, they are absorbed by the plants and they are replaced by the acidic ion (H+) which decreases the soil PH (acidity). Marschaner, 1986, Brady and Weil, 2008, are of the opinion that leaching is one of the causes of soil acidity because as nutrients are absorbed by the root, they are replaced by hydrogen ions there by causing the acidity of the soil. When soils are bush burnt, it leads to the destruction of soil structure that has an influence on the ability of the soil to hold nutrients. When this happens, nutrients are lost and be replaced by hydrogen ion which causes soil acidity (Bech et., al, 1999).

The electrical conductivity (Ec) varied from the length of the soil and from pit to pit. This difference might be as a result of different amount of salt compound such $CaCO_3$, NaCl, $MgCO_3$ and so on, cause soil salinity. Different level of evaporation of water from the pit, irrigation of salt affected water to the soil and salty parent material from which the soil is formed are the causes of high electrical conductivity values which increase the soil acidity (Adamu et, al, 2014).According to Beck et., al, (1999) , soil will be non-saline if the Ec value is < $0.4dm^{-1}$ and it will therefore suitable for crop production. According to this, none of the pit was saline except pit where the soil sample was collected from 20 --- 40cm.

The availability of nitrogen (N), its concentration varied from pit to pit and within the pit.This difference might be as a result of the amount of organic matter between and within the pit. Also, the type of micro-organisms and the extent of mineralization (Greenland, 1958). According to the report of Raj et.,al, (2000), nitrogen concentration in the soil has a positive correlation with the amount and type of organic matter and the application of synthetic and man-made fertilizer.

The availability of phosphorus as shown in table 1, differed between and within the pit and the highest concentration was recorded in pit 4.The presence of it might signify that the soil was formed from the apatite parent material but application of phosphate fertilizer might also attribute that (Hassan et., al ,2013). The presence of exchangeable bases was seen in all the pit. Their concentration in the pit might depend on the farming activities of the area and the presence or absence of the parent material from which the bases are obtained and the type of fertilizer applied (Lampkin 1990).

On the chemical properties of Bali B soil, the results showed that the Ph concentration of the pit varied when comparing the result of the upper and the lower portion of the pit. Also, variation existed from pit to pit as shown in table 2. This variation might be attributed to leaching, acidic parent materials, over cultivation and so on (Usman, 2005). In table 2, the upper portion of pit 1 was slightly acidic while the lower portion is acidic. This difference within the pit and between the pits might be connected to the above reasons. According to (Sanchez, 1976), every part of the soil horizon has an equal chance of having the higher or lower acidity provided the reaction taking place in that portion can cause either acidity or alkalinity as shown in some of the pits where the lower part of the pit had a lower PH than the portion of the upper pit as shown in table 2.

The electrical conductivity (Ec) differed from the length of the soil and from pit to pit as indicated in table 2. This difference might be suspected to be as a result of different quantity of salt compound such $CaCO_3$, NaCl, KCl and so on, are the causes of soil salinity. High rate of evaporation of water from the pit, use of salt affected water as an irrigation water and parent materials that contain salt can lead to the formation of high electrical conductivity values which decrease the soil PH (Kogel- Knabner et, al, 2010).According to Salazar et., al, (2009), soil will be non-saline if the Ec value is < $0.4dm^{-1}$ and it will therefore suitable for crop production. According to this, none of the pit was saline because all the values were < $0.4dm^{-1}$ and so the land where the pits were dug are suitable for crop production. The availability of nitrogen (N), and phosphorus as shown in table 2, their concentration was not equal from pit to pit and within the pit. The factors that might likely bring this difference might be as a result of over cultivation, formation of insoluble compound by the phosphorus and the mineralization process and the amount of organic matter between and within the pit The presence of phosphorus in the pit might indicate that apatite might be the soil parent materials. (Greenland, 1958).

The presence of exchangeable bases was observed all the pit, their concentration in the pit might depend on the farming activities of the area and the presence or absence of the parent material from which the bases are obtained and the type of fertilizer applied (Lampkin 19).

On the physical properties of Bali A, there was an individual difference BD between the pit and within the pit from pit 1, 2, 3, 4, 5 and 6 pit. This variation might be as a result of different type of soil or different amount of organic matter in the area (Holltz and Kovac (1981). In table 3, the BD of the lower part of the pits were higher than the lower part of the pit. This is because of more soil compaction in the lower part of the pit and more farming activities and organic matter in the upper part (Brady and Weil (2008). The water holding capacity (WHC) of Bali A soil, the capacity varied from pit to pit and from length to length. This difference occurred as a result of different level of soil compaction that determined the level of bulk density and the water holding capacity. Generally the higher the soil compaction, the higher the bulk density and the higher the holding capacity of the soil (Irmiya, 2005).On the porosity of Bali A soil, there were some variation between and within the pits. The variation was a consequence of different of soil compaction. Where there was high bulk density, the porosity will be low and where there was low bulk density, the porosity will be high (Nwaka et., al, 1999).

On the physical properties of Bali B of table 4, there was a variation in BD between the pit and within the pit from pit 1, 2, 3, 4, 5 and 6 pit. This variation might be as a result of different amount of soil or different amount of organic matter and compaction in the area (soil survey staff, 2014). In table 4, the BD of the lower part of the pits were higher than the lower part of the pit. This is because of more soil compaction in the lower part of the pit and more farming activities and organic matter in the upper part (Brady and Weil (2008). On the water holding capacity (WHC) of Bali B soil, the capacity varied from pit to pit and from length to length. This difference occurred as a result of different level of soil compaction that determined the level of bulk density and the water holding capacity. Generally the higher the soil compaction, the higher the bulk density and the higher the holding capacity of the soil (Irmiya, 2005).On the porosity of Bali A soil, there were some variation between and within the pits. The variation was a consequence of different of soil compaction. Where there was high bulk density, the porosity will be low and where there was low bulk density, the porosity will be high (Nwaka et., al, 1999

Table 1: Chemical properties of Bali A soil

Pit	Range(cm)	PH	EC	Available Nitrogen	Available Phosphorus	Available Potassium	Available Sodium	Available Magnesium
1	0-20	5.5	0.01	1.13	43.4	0.32	0.26	0.72
	20-40	6.72	0.018	1.18	38.5	0.34	0.31	0.85
2	0-20	4.31	0.017	1.14	39.4	0.45	0.24	0.83
	20-40	5.45	0.016	1.64	40.5	0.43	0.32	0.86
3	0-20	6.28	0.015	1.52	35.6	0.42	0.23	0.75
	20-40	6.64	0.014	1.34	42.7	0.39	0.25	0.84
4	0-20	6.77	0.016	1.45	45.4	0.37	0.36	0.81
	20-40	6.55	0.017	1.67	36.3	0.38	0.45	0.79
5	0-20	7.36	0.018	1.75	33.8	0.42	0.27	0.76
	20-40	8.24	0.019	1.48	38.6	0.43	0.28	0.87
6	0-20	9.41	0.016	1.56	37.5	0.35	0.33	0.83
	20-40	7.61	6.017	1.65	34.6	0.31	0.32	0.82

EC =Electrical Conductivity

Table 2: Chemical properties of Bali B soil

Pit	Range	PH	EC	Available Nitrogen	Available Phosphorus	Available Potassium	Available Sodium	Available Magnesium
1	0-20	6.1	0.018	1.14	45.3	0.42	0.25	0.73
	20-40	5.1	0.017	1.17	39.4	0.31	0.32	0.81
2	0-20	4.6	0.019	1.15	40.5	0.41	0.25	0.82
	20-40	5.32	0.015	1.71	30.6	0.42	0.33	0.85
3	0-20	5.83	0.016	1.49	34.3	0.40	0.24	0.78
	20-40	6.31	0.015	1.35	36.4	0.44	0.26	0.80
4	0-20	5.62	0.017	1.46	40.2	0.38	0.37	0.83
	20-40	4.3	0.019	1.57	58.1	0.32	0.38	0.69
5	0-20	6.35	0.019	1.57	35.7	0.36	0.28	0.79
	20-40	7.45	0.018	1.48	39.3	0.41	0.29	0.84
6	0-20	8.36	0.016	1.65	36.4	0.32	0.37	0.81
	20-40	7.45	0.017	1.53	35.3	0.42	0.36	0.83

EC = Electrical Conductivity

Table 3: Physical properties of Bali A soil

Pit	Range(cm)	BD(g/cm^3)	WHC (%)	Porosity (%)
1	0-20	1.5	5.34	50
	20-40	1.6	6.4	40
2	0-20	1.4	5.45	30
	20-40	1.5	7.11	35
3	0-20	1.3	4.61	32
	20-40	1.4	5.38	30
4	0-20	1.4	8.33	34
	20-40	1.5	40.22	51
5	0-20	1.7	12.55	43
	20-40	1.6	13.45	20
6	0-20	1.5	7.61	37
	20-40	1.3	7.98	32

Physical properties of Bali B soil.

Pit	Range (cm)	BD BD(g/cm^3)	WHC (%)	Porosity (%)
1	0-20	1.4	6.22	30
	20-40	1.5	7.55	35
2	0-20	1.6	8.11	40
	20-40	1.5	10.35	35
3	0-20	1.4	12.30	30
	20-40	1.3	20.11	33
4	0-20	1.6	9.21	26
	20-40	1.4	11.53	31
5	0-20	1.7	12.21	22
	20-40	1.5	13.35	34
6	0-20	1.4	10.62	30
	20-40	1.3	12.93	31

IV. Conclusion

The soils are deep with moderate texture and structure for smooth growth and development of crop plants. Similarly, pH and all other critical soil fertility indices are favorable for crop production. Thus, the soils are of medium fertility and careful soil monitoring and improved management through balanced fertilization may maintain and sustain soil fertility and enhance soil productivity in the area.

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