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Evaluation of Fertility Status of Soil for Sustainable Productivity of Crops in Bali North Central Taraba State, Nigeria

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Abstract:- The evaluation of the fertility status of an agricultural field is an essential parameter in terms of sustainable productivity of crops. Macro and micro nutrient elements govern the fertility of soils and control the growth, development and yield of crops. This study was aim at determining the fertility status of soil in the study area. Sixty (60) surface soil samples (0 – 15 cm) were tested for their status /level of pH, E.C, Organic carbon, available N, P, K, S and available Zn, Fe, Cu and Mn using standard laboratory procedure. The level of soil pH, E.C and organic carbon ranged from 4.7 – 5.1 (strongly acidic), 0.35 – 0.95 dsm^{-1} and 0.86% - 1.14% respectively. The status of organic carbon in the soils was rated medium while the available N status is low (82 %) only few (18 %) of the soils in JT and GB were in medium of N content. Both available P and K were medium in status with the range of 6.17 kg/ha – 23.85 kg/ha and mean values of 333 kg/ha while S was within the critical range of 7.9 mg/kg – 9.5 mg/kg available S status. The available micro element status in the soil was high ranges between 3495.6 mg/kg - 6033.6 mg/kg for Fe, 18.32 mg/kg – 66.66 mg/kg for Zn, 157.5 mg/kg – 302.4 mg/kg for Mn and 1.54 mg/kg – 7.28 mg/kg for Cu respectively. The high level of these elements was as a result of pH of the soil which was found to be strongly acidic.

Keywords:- *Macro Nutrients, Fertility Status, Micro Elements, Sustainable.*

I. INTRODUCTION

The productive and health of plants is the function of adequate supply of plant nutrients and the amount of these nutrients required by plants differs among plant species, yield potential, soil properties, environment and management. (John *et al*, 2012).Determining the concentration of plant nutrient availability in soil is significantly important if agricultural land is to remain conducive in crop production sustainably in an acceptable level by farmers (Brady & Weil, 2004). Various techniques are employed in assessing soil fertility including soil testing which is widely used in the world (Havlin *et al.*, 2010). The testing of soils provide information on the availability of plant nutrients which form the basis for fertilizer recommendations that increase crop yield and maintained the fertility of soil for a longer period (Khadka. *et al*,2016) The ability of soil to provide or supply essential nutrient required by plant is termed soil fertility. Plants are in need of 14 essential mineral elements as their nutrient obtainable from the soil for healthy growth and development (white and Brown, 2010). These elements are directly involved in the nutrition of plant (Arnon and Stort, 1939). Knowledge of the amount of a particular nutrient element is fundamental in crop production so as to supply those deficient in the soil for optimal yield. A decrease in productivity of crop is often cause by low phytoavailability of nutrient elements and excesses of some potentially toxic mineral including Na, Cl, B, Fe and Al in soil solution resulting in limited yield White and Brown, (2010).

➢ *Chemical Constituents of Fertile Soil*

The soil reaction (pH) is an important parameter of soil that affects the availability of nutrient in soil (Brady & Weil, 2004) as decrease in pH (acidic condition), increases the solubility of micronutrient elements including Mn, Cu, Fe, Al and Zn with the exception of Mo that decreases when the pH decreases Alloway and Ayres, (1990). Soils with low pH may reduce the nutrient needs of crops including Maize, Rice, Wheat vegetables etc. Organic matter is an important source of plant essential nutrients after their decomposition by microorganisms. It supplies plant nutrient, improve the soil structure, water infiltration and retention, feeds soil micro-flora and fauna, and the retention and cycling of applied fertilizer. (Khadka. *et al*, 2016). Nitrogen is taken up by plants in greatest quantity next to carbon, oxygen and hydrogen for crop production, but in the tropical zones, it is one of the most deficient elements (Mesfin, 1998). The nitrogen content ranged from 0.04 to 0.09% with a mean value of 0.08% indicates medium content in soil. Phosphorus is a key nutrient element to agriculture in term of productivity and yield of crops. A research work revealed an increase in dry matter and seed yield of sesame crop at optimum level of P (Okpara *et al*., 2007, Malik *et al*., 2003). In a similar study by Okpara *et al*., (2007) in Adamawa state University Mubi, Nigeria reported an increased in seed yield of 86 % at the available P level of 22.5 kg/ha. The growth of both cultivated and uncultivated plants is limited by availability of P in the soils (Foth and Ellis, 1997). The available phosphorus (P_2O_5) concentration of 0.78 to 145.51 ppm of any soil shows a higher content that support sustainable growth and development of crop. And the extractable potassium (K_2O) content ranging from 21.6 to 369.6 ppm is medium in soil ((Khadka. et al, 2016).

➢ *Impact of Phosphorus to Plant and Soil*

Phosphorus plays a number of important roles in plants, It is a major component of nucleic acids and involves in plant reproduction which result in quality production of grains. It is essential in biological energy transfer processes that are important to life and growth. Sufficient level of phosphorus in soil results in higher grain production, improved crop quality, greater stalk strength, increased root growth, and early maturity crops (Chaplot *et al.* (1992). The availability of Phosphorus to crops can be accurately determined by testing the soil because it cannot be lost into the atmosphere and hardly does it leach beyond the reach of plant roots. In soil, phosphorus act as micronutrient in that the concentration of phosphate in soil solution is low and the phosphorus is immobile in soil which is vital

➢ *Physical Evaluation of Soil Fertility*

The physical parameter affecting soil sustainability is the texture .sand; silt and clay which are the three components of soil texture that influences nutrient absorption, microbial activities, infiltration and retention of water, aeration, tillage and irrigation practice (Gupta, 2004). The colour of soil reflects the translocation and transformation that takes place in soil as a result of biological, chemical and physical attributes (Ponnamperuma & Deturck, 1993).

➢ *Determinants of Fertile Soils*

Soil with high base saturations is considered more fertile because many of the bases that contribute to it are plant nutrients (Olusola O, 2012). The amount and type of clay and organic matter content in the soil determine the quality of Cation Exchange Capacity in the soil. Higher amount of clay and organic matter in the soil means higher C E C (Olusola O, 2012). Clay particles have a major influence on a soil's capacity to store plant nutrients. This is as a result of its strong negative charges. Plant nutrients in soil solution have positive charges. These cations are attracted to and held by the clay particles. Physical, chemical and biological properties are the main components of soil fertility (Abbott and Murphy 2003). On decomposition, organic matter introduces essential plant nutrients in to the soil; it provides humus which improves the water Holding Capacity (W.H.C.) and cation Exchange Capacity (C.E.C) of the soil. Organic matter provides food for microbes in the soil and boosts their beneficial activities such as fixation of nutrients like Nitrogen (Preston, 2003).

The productive capacity of any soil depends on availability of plant nutrient elements resulting in less utilization of external farm inputs e.g. fertilizers to increase the level of nutrient for crop yield. The answer to the question why a particular kind of life is in a specific place has yielded a list of responsible factors such as rainfall, temperatures, soil fertility status e t c. These factors can be summed up and realized that the availability and quantity of food is the major determinant of any life process and its pattern. The availability of food and its quantity in turn depends on the different crops that could be successfully grown on the soil and according to the differences in fertility status of soil on which it is growing. (John *et al.*, 2012) Thus, the ability of the soil to support life forms plays a major role in human existence. Farmers' uses synthetic fertilizers without actually analyzing the soil to identify which of these available nutrient elements are deficient in the soil. Inadequate data on the chemical properties of soils in Bali brought about inappropriate supply of farm inputs such as fertilizers, herbicides and pesticides that impact negatively on our environment and causes soil acidity leading to a decrease in crop production, as the native soil supplies of nutrient decreases with increasing intensity of cropping. Therefore, the aim and objectives of this work is to determine the pH, level of organic matter content and the concentration of available macro and micro nutrient elements composition of soil supporting crop production in Bali.

The hypothesis is that, there is significantly statistically difference in mean concentration of the macro nutrient elements in soil of different locations in the study area.

II. MATERIAL AND METHODS

➢ *Study Area*

The study was carried out in Bali North Central part of Taraba State between Latitude 7° 12'N to 9°. 00N of the equator and Longitude 10° 00E to 12° 00E of the meridian (Atlas, 2006) it has a land mass of 10000km2 and lies within the Guinea Savanna ecological Zone of Nigeria. The annual rainfall ranges from 750mm to 1100mm, the Temperature ranges between 22℃-35℃. The Soil is dominantly of ferruginous tropical type that lies on Sandy parent materials (Dada et al, 2006)

➢ *Soil Sampling*

The surface soil samples were collected from six villages where the study was conducted including: Garba chede (GD), Maihula (MH), Sabondale (SD), Gazabu (GB), Jatau (JT) and Suntai (ST). In each of these villages, (10) ten soil samples were collected using stratified sampling method with soil auger at the depth of (0-15 cm) diagonally in quadrants

➢ *Analysis of Soil Samples*

The soil samples collected from the study area were dried and crushed using pastel and mortal, and the grinded soil samples was passed through 2 mm sieve which was used for the evaluation of macro and micro nutrient and determination of soil reaction using the standard laboratory methods at the federal university of technology, Akure, Nigeria. The pH of the soil was determined using glass electrode pH Meter (Jackson, 1973), the EC, bulk density and texture were determined following the standard method adopted by (Chopra and Kanwar, 2005). The organic carbon and available N (0.32% alkaline $KMnO_4$), Available P (0.5 M $NaHCO_3$), Potassium 1 N Neutral Ammonium Acetate extractable) were evaluated using the adopted methods by (page et al, 1982) and the available micro nutrients (Fe, Zn, Mn and Cu) were determined by DTPA

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extractable methods (Lindsay & Norvel, 1978). Table 1 is used in rating the soil samples base on the nutrients status.

➤ *Statistical Analysis*

- *The Soil Parameters Obtained from the Descriptive Statistics*

The data obtained from the soil analysis were subjected for normality and homogeneity of variance on IBM SPSS. Using one way analysis of variance (ANOVA) to test for the sufficiency of macro and micro nutrient element content in the soil and the fertility status ratting by (Awanish et al., 2014) as indicated in table 1 was adopted for rating the prevalence of macro and micro nutrients availability in soil of the study area.

Parameters	Low	Medium	High
OC (%)	0.25 -0.50	0.50 – 0.75	> 0.75
Avail N (kg/ha)	< 280	280 – 560	> 560
Avail P (kg/ha)	< 12.5	12.5 – 25	> 25
Avail K (kg/ha)	< 135	135 – 335	> 335
Cu (ppm)	< 0.2	0.2 – 0.4	> 0.4
Zn (ppm)	< 0.6	0.6 – 1.2	> 1.2
Fe (ppm)	< 4.5	4.5 – 9	> 9
Mn (ppm)	< 3.5	3.5 – 7	> 7

Classification for pH values

Strongly Acidic	Moderately acidic	slightly acidic	Neutral
< 5.5	5.5 – 6.0	6.0 – 6.5	6.5 -7.5

Total soluble salt classification

No effect	critical for germination	critical for salt sensitive crops	injury to the crop
< 1.0	1.0 – 2.0	2.0 – 3.0	> 3.5

Table 1:- Soil Test Values used for Rating the Fertility Status of Soil
(Source: Awanish et al,.2014)

III. RESULTS AND DISCUSSIONS

Location	No of samples	Avail kg/ha	Avail P kg/ha	Avail K kg/ha	S	Oc %	Om %
GD	10	145	6.17	261	9.3	0.86	1.49
MH	10	226.3	17.46	309.9	8.1	0.68	1.17
SD	10	264.4	23.85	426	9.4	1.11	1.98
GB	10	300	10.49	279	7.9	0.86	1.46
JT	10	368.5	12.37	316	8.6	1.23	2.31
ST	10	235.9	23.14	406	9.5	1.14	1.72

Table 2:- Macro Nutrient Elements Status in Soil of Bali, Taraba

The level of macro nutrient elements in the soil is affected by the low soil pH which decreases the availability of these elements as indicated in table 2 above. The pH of soil in location GD, MH and SD are 4.9, 5.1, and 4.8 respectively in table 3 which is strongly – medium acidic could be responsible for the low status of available N, available P and S in soil of the study area table 2

Location	pH	Ec	sand	Silt	Clay	Fe	Cu	Mn	Zn
GD	4.9	0.40	45.7	26.4	27.9	6033.6	3.26	230.4	53.58
MH	5.1	0.39	40.3	25.2	34.5	3681.8	7.28	302.4	23.72
SD	4.8	0.35	39.8	24.7	29.5	4560.8	4.86	164	60.3
GB	4.7	0.37	40.9	23.9	27.6	4681.4	1.54	237.8	34.7
JT	4.8	0.42	41.8	22.3	25.4	5100	2.18	157.6	18.32
ST	4.9	0.95	42.5	21.4	26.1	3495.6	3.46	259.6	66.66

Table 3: Physic –Chemical Properties and Micro Nutrient Status of Soil in Bali, Taraba.

The micro nutrient elements status in soil is sufficiently available for enhanced productivity of agricultural products table 3. The pH level of the soil (strongly acidic) 4.7 -5.1 has impacted positively on the availability of Iron, Manganese, Copper and Zinc as shown in table 3 above. The electrical conductivity (EC) of the soil is normal (0.35 – 0.95 dsm^{-1}) . This is due to the leaching of salt below the soil horizon of sandy loam textural class of the study area.

Soil properties	Range	Mean	SD
EC (dsm^{-1})	0.35 -0.45	0.40	0.04
pH 1:2.5 soil water	4.7 – 5.1	4.9	0.14
OC %	0.86 – 1.14	0.98	0.21
OM %	1.17 – 2.31	1.69	0.21
Available N kg/ha	145 – 368.6	256.7	75.2
Available P kg/ha	6.17 – 23.85	15.58	7.13
Available K kg/ha	261 – 408	333	68.1
Available Zn mg/kg	18.32 – 66.66	42.88	20.10
Available Cu mg/kg	1.54 – 7.28	3.76	2.06
Available Mn mg/kg	157.5 – 302.4	225.3	55.9
Available Fe mg/kg	3495.6 – 6033.6	4592.2	935.5

Table 4:- Prominent Soil Characteristics of the Study Area

The mean and the standard deviation of the micro nutrient elements of soil of the study area as indicated in table 4 above are: 42.88 ± 20.1, 3.76 ± 2.06, 225.3 ± 55.9 and 4592.2 ± 935.5 for Zn, Cu, Mn and Fe respectively which are sufficiently available for production of crop. This is in line with the research work of (Awanish et al., 2014) carried out on Vertisol soil of Kabeerdham District of Chhattisgarh, in India.

IV. DISCUSSION

➢ *Macro Nutrient Elements Status of Soils Under Studied Area*

- *Soil Reaction*

The soil pH of the study area ranged from 4.7 – 5.1, Table 4. Following the pH values of: < 5.5 = strongly acidic, 5.5 – 6.0 = moderately acidic, 6.0 – 6.5 = slightly acidic and 6.5 – 7.5 = neutral as indicated in Table 1 by (Awanish et al 2014). Based on the above, all the soil in the study area is strongly acidic. This is also in agreement with the categorization by Lando (1991) < 5.5 = low, most of the soils in the study area had pH below the satisfactory range of some crops including sesame production of 5.5 – 7.0 Ashri (1998). The strongly acidic nature of the soils in the study area could be as a result of the parent material and the extensive weathering and leaching of the soil.

- *Organic Carbon*

The organic carbon content analyzed in the soil samples ranged from 0.86% - 1.14% as indicated in table 4. The rating of organic carbon in soil as shown in table 1 revealed that: 0.25 % - 0.50 % = low, 0.50 % – 0.75 % = medium and > 0.75% = high. In view of the above, the organic carbon status of soils in the study area is in medium to high Oc content.

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- *Available Phosphorus*

The available phosphorus content in the soil varies from 6.17 kg/ha – 23.85 kg/ha with mean and standard deviation of 15.58 kg/ha ± 7.13 kg/ha table 4. In view of the rating suggested by (Awanish et al 2014) in table 1, revealed that available status in soils of study area is medium (12.5 kg/ha – 25 kg/ha). Location GD and GB of the study area were low in available P content of 6.17 kg/ha and 10.49 kg/ha while location MH, SD, JT and ST had the P values of 17.46 kg , 23.85 kg, 12.37 kg/ha and 23.14 kg/ha respectively. This shows that the level of available P in the soils were medium Table 2. The results of this studies agreed with categorization of available phosphorus by Landon (1991) as 15 kg/ha – 20 kg/ha = medium. The low level of available P content in GD and GB locations of the study area is as result of low pH values of 4.9 and 4.7 tables 3 which are strongly acidic. This is in line with the work of (Tisdale *et al* 1993) that the availability of P is low in acid soil which could be the same reasons for the medium status of available P in the study area, as the pH of 6 – 7 is adequate for P availability in the soil.

- *Available Nitrogen*

The values for available N as indicated in Table 4 ranged from 145 kg/ha – 368.6kg/ha with an average of 256.7 kg/ha. Based on the rating suggested by Awanish *et al* (2014) as shown in table 1, the available N level in soil of the study area is low. Similar result was established by Rajeshwar et al (2009) that soils of Krishna district were found to be low in available N (133 kg/ha to 188 kg/ha). Few soils about 18% in location GB and JT of the study area were in medium categories of 280 kg/ha – 560 kg/ha as shown in table 2. Thus, the use of nitrogen fertilizer is recommended in soils of Bali Local Council in order increase productivity and yield of crops.

- *Available Potassium*

The concentration of available K in soils of the study area ranged between 261 kg/ha and 408 kg/ha with the mean value of 333 kg/ha. According to Awanish et al 2014 categorization in table 1, most of the soil from the locations, (80 %) were found to be medium in available K status in the soils (135 kg/ha – 335 kg/ha) while the remaining (20 %) of the soils samples from location SD (426 kg/ha) and ST (406 kg/ha) available N content table 2 were high (> 335 kg/ha) as indicated in table 1. This may be due to the presence of Potassium rich clay minerals like kaolinite and illite Awanish et al (2014) in those locations of the study area.

- *Available Sulphur*

The data for available sulphur in the study area ranged from 7.9 mg/kg – 9.5 mg/kg Table 2. Based on the categorization established by Landon (1991), soils of the study area are within the critical range of 6 – 12 mg/kg therefore, sulphur status in soils of the study area is adequately sufficient to support crop production.

- *Micronutrient Elements Status*

- *Iron*

Th**e** available Fe content in the soil of the study area range from 3495.6 mg/kg - 6033.6 mg/kg (table 4). As shown in the table 3, all the soil in different location of the study area have higher available Fe content than the critical levels of 4.5 mg/kg reported by (Awanish *et al*.,2014) and Tandon (1995). This is an indication that the soils have sufficient level of Fe that can support the growth and development of plant. The low pH of the soil could be the reason of high Fe content in soils of the study area.

- *Zinc*

The concentration of available Zn (table 3) in soil at different villages of the study area is high above the normal critical values proposed by Landon (1991) and (Awanish *et al*. 2014) of 1 mg/kg. The level of Zn in soil under study range from 18.32 mg/kg – 66.66 mg/kg (table) which is far above the categorization of Zinc content in soil by (Tisdale *et al* 1993) for low, medium and high as 0 – 2.5, 2,6 – 4.5 and > 4.5 respectively.

- *Manganese*

The status of Mn in soils under studies 157.5 mg/kg – 302.4 mg/kg (table 4). All the six villages under the studied area had higher Mn content in soil which are far greater than the critical range of : 0 – 0.5 as low, 0.6 – 1.0 as medium and > 1.0 as high categorized by Tisdale *et a*l.(1993) and Awanish *et al* 2014) as indicated in (table 1). The high amount of Mn in soils of studied area is associated with the low pH which increases the solubility of Mn minerals in soils according to (Allowayss and Ayres, 1990).

- *Copper*

The amount of Cu ranged from 1.54 mg/kg – 7.28 mg/kg (table 4). These values is greater than the critical level of 0.3 – 0.4 establish by (Awanish *et al* 2014) and Tandon 1995). Thus, Cu is sufficiently available in soils under studied area for the support in agricultural productivity of
Crop plant

- *Texture of the Soil*

The mean values of sand, silt and clay fractions were 41.8 %, 18.5 % and 39.7 % respectively, as indicated in table 3 above. Showing that, the textural properties of the soil is sandy loam texture. This suggests that the soil is well drained and in medium texture which can support the performance of most crops including sesame, groundnut, maize, soy beans, yam, cowpea etc.as reported by Carlson (2008) that majority of crops can thrive better on sandy loam soils provided the moisture is adequate.

V. CONCLUSION

Based on the results obtained from the study, we concluded that soils of the study area are strongly acidic, normal salt content safe for crop production. The organic carbon status of the soil is medium and the available N amount exhibited low to medium status in the soil while available P and K levels in the soils were in medium categories. The concentrations of available Mn, Fe, Zn and Cu in all the soil samples analyzed were high which could be as a result of the strongly acidic nature of the soils in the study area. We therefore recommend that agricultural lime be applied on the soil so as to raise the soil pH to required level of 5.5 – 7.8 for crop productivity. Nitrogen and organic fertilizers are required to be applied on the soil to increase crop yield sustainably.

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