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Changes in Some Soil Physico-Chemical Properties of Lithosols under Different Levels of Nitrogen and Cowdung Fertilizers in Mubi Area, North-Eastern of Nigeria

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Abstract - The research work was conducted to evaluate the changes in some lithosols soil physico-chemical properties under different levels of nitrogen and cowdung fertilizers in Mubi area, North-eastern of Nigeria. The Treatments comprised of five rates of N (0, 30, 60, 90 and 120 kg ha-^{1}) and two levels of cowdung (0 and 5 ton ha-^{1}). These treatments were combined and arranged in an experiment laid out in Complete Randomized Design and replicated three times. Data were collected on some soil chemical properties and were subjected to analysis of variance. Correlation analysis was also carried out to assess relationship between measured parameters. The results showed that Differences in soil Available Phosphorus and Exchangeable Potassium concentration decreased in all the treatments except at 60 kg N ha-^{1} by 30.23% for Exch. K while percent O.C, O.M, Ec and pH generally increased except for pH which slightly decreased at 60 kg N ha-^{1} than at 120 kg N ha-^{1} + 5 kg cowdung ha-^{1} respectively. Significant positive correlation exists between leaf area and plant height with correlation value of r = 0.723 at (P < 0.1%), K content with P uptake, r = 0.042 (P >5%) and between pH with O.M content r = 0.442 at (P > 5%), while significantly negative correlation occurred between P content with leaf area r = -0.374 at (P > 5 %), and O.M with O.C content r = -0.612 at (P < 0.1%). It is therefore assessed that combined application of organic and inorganic fertilizers produced more effect on maize growth and retained nutrient availability in the soil than sole application of each nutrient sources or none. Thus, 120 kg N ha^{-1} + 5 kg cowdung ha^{-1} should be adopted for maintaining soil physic-chemical properties and optimum growth of maize in the area.

Key words - Nutrients, Maize growth, Soil Physico-chemical properties, Fertilizers, Soil fertility

I. Introduction

Sustainable agricultural production requires a good knowledge of the changes soils undergo under different land uses in relation to the management options that can be adopted [1].This is because soil fertility is not a stable property, but rather a dynamic one. Fertility status of a soil is a natural inherent resources bestowed within the layers of soil which are governed and regulated under various Physico-chemical processes eventually subjecting the soil in to stage of depletion from its inherent fertility nature. Generally, there are various factors influencing soil nutrient losses Reference [2] stated the basic factors causing soil nutrient losses which are: soil erosion, crop removal, human activities, leaching and losses in gaseous forms. In addition, Reference [3] reported that, one of the major problems affecting food production in Africa is the rapid depletion of nutrients in smallholder farms. Similarly, soil chemical properties deterioration indices obtained from studies conducted in Ethiopia showed that pH, EC, CEC were higher in continuously cultivated fields than in other land uses. The reasons adduced for this observation included higher organic matter content, crop removal and tillage practice [1]

In Nigeria, despite the importance and increased in the total production of maize, yield per hectare is still relatively low [4]. This is because Nigerian savannah soils are characterized by low organic matter content, low CEC, low water holding capacity and low fertility [5].This might be as a consequence of dynamic changes in physico-chemical properties of the soil which is not clear and understandable to the most peasant farmers.

Soil fertility depletion through chemical and physical changes might be also inflicted due to inadequate or sole use of either organic or inorganic fertilizers coupled with poor management system by the smallholder farmers. However, because of high cost of mineral fertilizer coupled with availability problem, there is need for alternative sources. Reference [6] also conceived that the use of organic fertilizer may go a long way in providing solution to low crop yield . Organic manures check erosion, leaching of nutrients, evaporation losses and remain longer in soil and releases nutrients slowly making it available to plants ([7]; [8]; [9]). According to Reference [10] imbalanced use of inorganic fertilizer without application of farmyard manure (FYM) as well as knowing the requirements of crops and fertility status of soil causes deterioration in soil structure and depletion of soil fertility. In addition, soil organic matter (SOM) is central to soil function and quality. Soil carbon (C) sequestration in agricultural soil has been suggested as a strategy to improve soil quality [11]. The amelioration of soil physicochemical properties by increasing soil organic carbon (SOC) has been proposed for increasing crop yields [12]. Thus, an understanding of the spatial variability of the soil properties is important in planning and development of site-specific management options by making use of geostatistical techniques and mineralization ([13], [14], and [15]). It is highly imperative to study changes in some soil physico-chemical properties under different levels of organic and inorganic fertilizers with the aim of finding workable solutions to soil nutrients depletion and sustainability that will realize optimum food production for the growing population. Therefore, the objective of this study was to evaluate changes in some soil physicochemical properties of lithosols under the different levels of nitrogen and cowdung fertilizers in Mubi area, North-eastern part of Nigeria

II. Materials And Methods

2.1 Description of the Study Area

Mubi area lies between latitudes 9°30' and 11° north of the equator and longitudes 13° 00’ and 13°45' east of the Greenwich Meridian at an altitude of 696 m above sea level. It is situated in the northern savannah ecological zone of Nigeria. It has a land area of 4,728.77 km^2 and a population of 759,045 people in 2003 [6]. The climate of the study area is characterized by alternating dry (November to March) and wet (April to October) seasons. The mean annual rainfall ranges from 700 mm to 1,050 mm. The seasonal maximum temperature of 37.0°C occurs in April and minimum of 12.7°C in January. Maximum relative humidity is 90% and minimum is 50% (Adebayo, 2004).The vegetation is of typical Sudan savannah type, which implies grassland interposed by shrubs and few trees mostly acacia (*Acacia albida*), locust-beans (*Parkia biglobosa*) and Eucalyptus trees (*Eucalyptus spp*) among others (Adebayo, 2004, Tekwa and Usman, 2006). Studies have revealed that the soils of Mubi area fall under the category of lithosols ([16]; [17]). Lithosols constitutes one of the upper categories of the Food and Agricultural Organization (FAO) and United Nations Economic, Scientific, and Cultural Organization (UNESCO) soil classification system. They refer to soils with rock-basements within shallow depths from the soil surface as shallowness and stoniness of the surface soil depths, and are usually characterized by orchard-type vegetation due to limitations in inherent fertility [18]. Mubi soils have also been classified as Alfisols based on the United States Department of Agriculture (USDA) classification system and the soils are generally of low fertility status to support heavy nutrient requiring plants [19].

2.2 Soil sampling and sample preparation.

To obtain more relatively significant changes in soil properties, soil sampling in the plough horizon (0±20 cm depth) was conducted and collected from a fallow land in order to avoid residual effects of fertilizers and persistent of pesticide and herbicides in the soil which may affects the result. The bulk-purposive sampling method was adopted. The samples collected were neatly packed in polythene bags and transported to the laboratory for analysis. The soil samples were air-dried, crushed and sieved to remove materials larger than 2 mm with the aid of 2-mm sieve.

2.3 Laboratory Analysis

Particle size distribution analysis was determined using Bouyocous Hydrometer Method [20]. Soil reaction (pH) was determined using the pH meter method (soil/water ratio of 1:2.5), while the electrical conductivity (EC) was determined in a soil/water extract using an EC meter [21]. Organic carbon was determined by dichromate digestion

[22], from where organic matter was calculated. Available Phosphorus (P) was extracted by Bray No. 1 method [23]. Similarly, Available Potassium (K) was determined by flame photometer using routine analytical methods [24]. Water holding capacity (WHC) was determined by gravimetric method [20]. Exchangeable Acidity (EA) was extracted with 1 Normal KCl and the percentage base saturation (PBS) was calculated as the sum of the bases [total exchangeable bases, (TEB)] divided by CEC and expressed as percent using the routine analytical methods by [24].

2.4 Experimental design

A potted experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi (Latitude 9^0 30 and 11^0 N and Longitude 13^0 and 13^0 $45^{'}$ E). To evaluate changes in some lithosol soil physico-chemical properties as affected by nitrogen fertilizer and cowdung under irrigated maize growth in Mubi area. Treatments consisted of five rates of nitrogen (0, 30, 60, 90, and 120 kg ha-^{1}) and two levels of cowdung (0, and 5 ton ha^{-1}). The treatments were combined factorially produced ten treatments and laid out in a Complete Randomized Design and replicated three times. Cowdung manure was imposed and mixed thoroughly with the soil weighed 2 kg prior to sowing in each pot. The physico-chemical properties of the soil were determined before mixing it with cowdung. Perforated plastic pots of 49 cm diameter and 17 cm depth was filled with the mixed soil to its bream leaving a space for watering. Fertilizer containing NPK 15:15:15 was applied to provide the recommended K and some part of N and P. Thereafter, Urea and Single Super-Phosphate (SSP) were used to make up the remaining N and P, respectively. The SSP that was used to make up the recommended P was applied together with NPK at sowing. The remaining N from urea was applied 7 days after sowing. The quantity of fertilizers and cowdung manure needed for each pot was calculated using furrow-slice method [25]. After germination, the seedlings were thinned to two plants per pot, watering was done early in the morning and soil moisture meter was used to observe and maintain the moisture content of the soil to avoid leaching of nutrients and kept the soil water content at field capacity. Weeding was carried out manually. Data were collected on maize growth parameters at 8 weeks after sowing (soil nutrients mining phase by plant at expense of their vegetative growth) such as plant height, number of leaves and leaf area per plant respectively. The physico-chemical properties of the soil samples used were analyzed in the laboratory to determine the changes occurred after the experiment.

Quantity of fertilizer applied in the pot experiment was calculated using furrows slide method:

$$Formula \quad = \frac{R \text{ x } W \text{ x } 100}{2{,}000{,}000 \text{ x } C}$$

Where:

R = rate of fertilizer to be applied (kg ha^{-1})

W = weight of soil used (kg)

C = concentration of element in fertilizer (%)

2,000,000 = assumed weight of soil per ha per (0 – 15cm) plough layer depth (kg)

2.5 Data Analysis

All the data collected were subjected to analysis of variance (ANOVA) using [26].Means showing significant F-Test were separated using DMRT and Correlation test analysis were also carried out respectively.

III. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Physico-Chemical Properties of the Soil before the experiment

Table 1 shows the initial characterization of the soil used for the experiment. The percentage sand, silt and clay were found to be 56%, 24% and 20%, respectively, classified as sandy clay loam. The soil pH was 6.99 (neutral) where the Electrical Conductivity (Ec) was 57.60 µs/cm.The available P was 45 ppm, soil organic carbon content and organic matter were 0.88% and 1.52%, respectively, both rated as very high. The water holding capacity (WHC) of the soil was moderate (20.651%). The soil has an Exchangeable acidity (EA) of 0.8 with Exchangeable Potassium 1.15 cmol kg^{-1} . Thus, the soil might support plant growth under effective organic and inorganic fertilizer management.

3.1.2 Effects of Nitrogen and Cowdung Fertilizers on the Growth Characters of Maize

a. *Plant height*

The data on plant height At 8 WAS was given in Table 2. The treatment 120 kg N ha^{-1} produced the highest plant height of 71.877 cm which was statistically followed by 30 Kg N ha^{-1} + 5 kg cowdung ha^{-1} with about 70.463 cm respectively. Similarly the trend slightly changed at 90 Kg N ha^{-1} with a recorded value of 69.253 cm. Plant heights was lowest (33.597 cm) at control then lagged with 5 kg Cowdung ha^{-1} at plant height of 42.230 cm. There was significant differences at 0.1% level of probability on effect of nitrogen and cowdung at 8 WAS on maize growth respectively.

b. *Number of Leaves per Plant*

From the table 2, it was revealed that application of nitrogen and cowdung fertilizers did not show any significant effects on number of leaves per plant. However, all the treatments had a statistical number of 9.000 maximum numbers of leaves except that of control and 5 kg Cowdung ha^{-1} which recorded the lowest number of leaves per plant of 6.000 and 8.000 respectively.

c. *Leaf Area per Plant*

In Table 2 below, at 8 WAS, 120 kg N ha^{-1}+ 5 ton cowdung ha^{-1} had the maximum leaf area per plant (205.38 cm^2). The trend changes statistically at 90 kg N ha^{-1} + 5 cowdung ha^{-1} and 120 kg N ha^{-1} with corresponding values of 200.240 cm^2 and 198.920 cm^2 . Conversely, the lowest leaf area was recorded at control (101.180 cm^2) then tailed by 5 cowdung ha^{-1} (146.160) correspondingly.

3.1.3 Soil Analysis after the Experiment

Physico-chemical properties of the experimental soil after the experiment were shown in Table 3. There were no significant differences between treatments on chemical properties of the experimental soil after the experiment. However, there were insignificant increased of soil pH in all the treatments except in 60 N kg ha $^{-1}$ and 120 kg N ha^{-1}+ 5 ton cowdung ha^{-1} . The trends remain the same at exchangeable Potassium except at 30 kg N ha^{-1}+ 5 ton cowdung ha^{-1} where the value increased to about 3.440 cmol (+) kg^{-1} respectively. Similarly, the value of organic carbon increased insignificantly from 0.88 % to about 0.99 % in all treatments.

3.1.4 Correlation analysis

The correlation matrix describing the relationship between growth parameters of maize as well as some chemical properties as influenced by nitrogen and cowdung fertilizers was shown in Table 4, plant height had positive and significant correlation with leaf area (r =0.723) while leaf area showed significant negative correlation with P uptake (r= -0.374). P content had significant positive relationship with K uptake (r =0.04). Organic carbon had significant negative relationship with OM (r= -0.612) while OM had significant positive correlation with PH (r= 0.442) However, number of leaf, $_{P}$H, K and Ec had no significant relationship with other parameters.

Table 1: Selected Physico-Chemical Properties of the Experimental Soil before the experiment.

Parameter	*Value*
% Sand	56
% Silt	24
% Clay	20
Textural Class	Sandy Clay Loam
pH (H_2O) 1:1	6.99
Ec (H_2O) 1:1	57.60
Total N (g Kg-^{1})	*ND

Available Phosphorus (ppm)	45
Organic Carbon (%)	0.88
Organic Matter (%)	1.52
Water Holding Capacity (%)	20.65
Exchangeable Acidity ($H^+ + A1^{3+}$)	0.8
Exchangeable Potassium (cmol (+) kg^{-1}	1.15

Source: Field study. *ND: Not determin

Table 2: Effect of Nitrogen and Cowdung fertilizers on Plant Height, Leaf Area, and Number of Leaf of Maize at 8 WAS

Treatments	***PH cm***	***LA cm²***	***NL***
Control	33.597^b	101.180^c	6.000
5 kg Cowdung ha^{-1}	42.230^b	146.160^b	8.000
30 Kg N ha^{-1}	64.750^a	173.670^ab	9.700
60 Kg N ha^{-1}	59.673^a	188.340^a	9.400
90 Kg N ha^{-1}	69.253^a	188.290^a	9.600
120 Kg N ha^{-1}	71.877^a	198.920^a	9.700
30 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	70.463^a	173.720^{ab}	9.700
60 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	64.640^a	193.000^a	9.400
90 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	65.453^a	200.240^a	9.500
120 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	59.420^a	205.380^a	9.800
SE (±)	4.739	9.439	1.387
Level of Significance	***	***	NS

Source: Field study.

*** = Significant at 0.1% level of probability. NS =Not significant .SE = Standard Error.

WAS =Weeks after Sowing

Table 3: Some Selected Physico-Chemical Properties of the Soil after the Experiment

Fertilizer	*Parameters*					
	P Ppm Mg Kg^{-1}	*K Cmol Kg^{-1}*	*OC %*	*OM %*	*PH (H_2O)1:1*	*EC (H_2O)1:1*
Control	20.370	0.757	0.966	1.669	7.440	129.100
5 kg cowdung ha^{-1}	6.770	0.620	0.942	1.628	7.100	149.93
30 Kg N ha^{-1}	7.747	0.537	0.962	1.514	7.377	143.900
60 Kg N ha^{-1}	5.497	4.480	0.948	1.641	6.910	126.930
90 Kg N ha^{-1}	4.993	0.487	0.942	1.501	7.146	150.400
120 Kg N ha^{-1}	12.087	0.423	0.955	1.651	7.273	143.130
30 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	10.197	3.440	0.955	1.651	7.370	121.540
60 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	5.757	0.513	0.942	1.628	7.077	125.200
90 Kg N ha^{-1} + 5 kg cowdung ha^{-1}	10.733	0.477	0.937	1.651	7.397	130.330
120 Kg N ha^{-1} +5 kg cowdung ha^{-1}	8.333	0.420	0.100	1.743	6.883	158.630
SE (±)	3.419	0.908	0.850	0.810	0.371	21.732
Level of Significance	NS	NS	NS	NS	NS	NS

Source: Field study.

Table 4: Correlation matrix between some Growth parameters and Some Selected Soil Chemical Properties

	LN	*PH*	*LA*	*P*	*K*	*OC*	*OM*	*pH*	*EC*
LN	1.000								
PH	0.092	1.000							
LA	0.037	0.723***	1.000						
P	0.050	-0.342	-0.374*	1.000					
K	-0.035	0.181	-0.038	0.042*	1.000				
OC	-0.032	-0.117	-0.142	-0.193	-0.041	1.000			
OM	0.087	0.070	0.033	0.182	-0.052	-0.612***	1.000		
pH	0.032	0.159	-0.197	0.053	-0.029	-0.107	0.442*	1.000	

EC	0.084	0.055	-0.050	-0.099	-0.035	0.017	0.098	0.271	1.000

Source: Field study.

3.2 DISCUSSION

The significant effect of treatments on the plant height of maize might be due to the influence of nitrogen and cowdung fertilizers in promoting cell division and elongation. This result agreed with the reports of [10] that stem height of maize was influenced positively by the application of organic and inorganic sources of nitrogenous fertilizers. The insignificant differences in number of leaves observed might probably because assimilates observed were translocate to the fruit development at that stage. The highly significant effects on leave area per plant with the treatments might be or not connected to the increased in the number of leaves. This is in line with the assertion of [27] that there was significantly improved leave area with the combined used of organic and inorganic fertilizers than sole use of each sources.

The non-significant effect of treatment on some soil chemical properties at the end of the experiment might be due to the quantity of soil used as well as the confining of the soil within the pot. Thus, movement of nutrients were restricted.

The significant relationship between plant height and leave area per plant is an indication that as plant height increased, it increased number of leaves per plant thereby increasing leaf area per plant. Conversely, the significant negative correlation between Leave area per plant and Available Phousphorous may be an indication that, as the leave area per plant increased the Available Phouphorous content decreased through absorption and translocation to other parts of the plant resulting to increase in straw strength mostly in cereals. Thus, Phosphorus is essential and necessary in cell division and for meristematic growth in apical plant tissues [28]. Positive relationship between AP and K uptake might have indicated the response of soluble P and K in the soil as the AP content increases K uptake also increased. Though reference [29] stated that respond to P and K cannot be fully explained in most soils. Organic carbon had a negative relationship with organic matter content. This may be due to the increased in the decomposition of the carbonaceous materials in the soil which might have resulted in an increased in the OM content as was explained by [30]. On the other hand, the positive relationship between OM with the soil pH might be an indication that soil pH is influenced by the rate and content of organic matter in the soil. Reference [28] explained that organic matter facilitates soil buffering effect that regulates soil reactions ($_P$H values).

IV. CONCLUSION

The incorporation of nitrogen and cowdung fertilizers in lithosol soil for optimum growth and production of maize was necessary, because it improves nutrient availability to crop and maintained some soil chemical properties. This study has found out that combined application of organic and inorganic fertilizers result in high crop growth rate than sole application. Therefore, the application of 120 kg N ha^{-1} + 5 kg cowdung ha^{-1} produced the highest effects on the growth parameters measured and maintained little glaring changes in some soil chemical properties through sustaining and retaining nutrient depletion in the soil. Thus, soil management through application of organic and inorganic fertilizers is therefore recommended for the area and similar soil environments.

V. SUGGESTION FOR FURTHER RESEARCH.

It is further suggested that field experiment for such similar research should be conducted in order to obtained absolute dependable data for the farmers' utilization towards optimum food production for the growing population in region.

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REFERENCES

[1] Awe G. O, Nurudeen O. O, Omotoso S. O, Amiola A. A, Ojeniyi D and Tutuola1 T. Soil physico-chemical properties changes under different crops in Ado Ekiti, Nigeria. *Asian Soil Research Journal 2018. 1(2): 1-15,; article no.asrj.41183*

[2] Roy, R. N., Finak, A., Blair, G. J. and Tandon, H. L. S. *Plant Nutrition for food securities*. A guide for integrated nutrient management. 1st Edition by discovers publishing House New Delhi-11002. 2007. Pp. 83-84.

[3] Gopal, C. D. *Fundamentals of Agronomiy*. Published by Oxford IBH publishing Co. Put Led New Delhi: 110 001 ISBN 81-204-01416. 2002. Pp. 16.

[4] Apraku, B. B., Fakorede, M. A. B., Onedrago, M., Carsky, R. J. and Menkir, C. Maize Revolution in West and Central Africa, West and Central African Collaborative. *Maize Research Network; Ibadan, 2003 pp. 225.*

[5] Lombin, G. Fertilizer requirements of the major cereal crop in the Nigerian Savanna. 1987. In Sobulo, R. A., Yayock, J. Y., Ezeduwa, Salako, E. A., Ejga, N. O. O., Anojuhu, C. C., Ologide, L. O. Onwugbow, C. K. and Udegbe, C. I. (eds); Towards Efficiency of Fertilizer Use and Development in Nigeria. *Proceeding of the National Fertilizer Seminar, held at Port-Harcourt October 28 – 30 (1987) by Federal Procurement and Distribution Department of the Federal Ministry of Agriculture, Water Resources and Rural Development. 1987. Pp. 106 – 126.*

[6] Tunku, P.. Comparative Effects of Inorganic and Organic Fertilizers on the Performance of Okra (Abelmoschusesculentus (L.)MOENCH).2012. In Jibrin, J. M., Hussaini, M. A., Auwalu, B. M., Essiet, E. U., Muhammad, I. R., Mohammed, S. G., Daneji, M. I., Garba, Y. and Pantami, S. A. (eds); Agricultural Transformation in a Deregulated Economy: Prospects and Challenges. *Proceeding of the 46th Annual Conference of the Agricultural Society of Nigeria at Convocation Arena New Campus, BUK, Kano, Nigeria, and November 5th – 9th, 2012. Pp. 890 – 891.*

[7] Malival, P. L. *Agronomy at a Glance*.Agrotech Publishing Academy, Udaipur. 2001. Pp: 3 – 15.

[8] Food Agriculture Organization. (FAO). Fertilizer Use by Crops in Pakistan. 2004 Pp: 4 – 24. *In Pakistan Journal of Life and Social Sciences. 2009. 7 (2): 108 – 111.*

[9] Das, P. C. .*Manures and Fertilizers*.2nd Ed. Kalyani Publishers, New Delhi. 2005, Pp: 75 – 76.

[10] Shah, S. T. H., Zamir, M. S., Waseem, M., Asghar, A., Tahir, M. and Waleed, B. K. Growth and yield response of maize (Zea mays L.) to organic and inorganic sources of nitrogen. *Pakistan Journal of Life Social Science.* 2009. *7 (2): 108 – 111.*

[11] Bhattacharyya R, Prakash V, Kundu S, Srivastva AK, Gupta HS. Soil aggregation and organic matter in a sandy clay loam soil of the Indian Himalayas under different tillage and crop regimes. *Agr Ecosyst Environ. 2009; 132: 126±134.*

[12] AlagoÈz Z, Yilmaz E. Effects of different sources of organic matter on soil aggregate formation and stability: A laboratory study on Lithic Rhodoxeralf form Turkey. *Soil Till Res. 2009; 103: 419±424.*

[13] Bekele A, Hudnall WH. Spatial variability of soil chemical properties of a prairie forest transition in Louisiana. *Plant and Soil. 2006;280:7-21.*

[14] Aina, P.O. Soil changes resulting from long term management practices in Western Nigeria. *Soil Science Society of American Journal. 1979; H3:173-177.*

[15] Lal R. Soil surface management in the tropics for intensive land use and sustained production. *Advances in Soil Science. 1986;5:1-100.*

[16] Adebayo, A. A. *Mubi Region: A Geographical Synthesis* (1st Eds). Paraclete Publishers, Yola – Nigeria. 2004. Pp. 32 – 38.

[17] Tekwa, I. J. and Usman, B. H. Estimation of Soil Loss by Gully Erosion in Mubi, Adamawa State, Nigeria. *Journal of the Environment.* 2006. *1, 1:35 – 43.*Published by School of Environmental Sciences, Modibbo Adama University of Technology, Yola-Nigeria.

[18] Nwaka, G. I. C., Alhassan, A. B. and Kunduri, A. M. A Study of Soils Derived from Basalt in North-eastern Nigeria 11. Physico-chemical Characteristics and Fertility Status. *Journal of Arid Agriculture.* 1999. *9: 89 – 98, Maiduguri, Nigeria.*

[19] Tekwa, I. J., Shehu, H. E. and Maunde, S. M., Soil Nutrient Status and Productivity Potentials of Lithosols in Mubi Area, North-eastern Nigeria. *Agricultural and Biology Journal of North America,* 2011. *2 (6): 887 – 896.*

[20] Trout, T. J., Gareia-Castilas, I. G. and Hyart, W. E. *Soil Water Engineering, Field and Laboratory Manual.* M/S Eurasia, New Delhi, India. 1987

[21] Page, A. L., Miller, R. H. and Keeney, D. R. *Methods of Soils Analysis, Part 2,* Agronomy No. 9, American Society of Agronomy, Madison, Wisconsin, USA. 1982. Pp-4-9

[22] Walkey, A. and Black, C. An Examination of Destjareff Method for Determining Soil Organic Matter with Chromatic Acid Titration Method. *Soil Science Society of American Journal* 1934. *37: 29 – 38.*

[23] Bray, R. H. and Kurts, L. T. *Determination of Total Organic and Available Phosphorus in Soils.* Soil Science 1945, 59, 39 – 45.

[24] I. I. T. A. *Selected Methods for Soil and Plant Analysis.* Manual Series No. 1, International Institute of Tropical Agriculture (I.I.T.A.), Ibadan, Nigeria. 1979.

[25] Babaji, B. A., Ali, R. I., Yahya, R. A., Mahali, M. A. and Shavifai, A. I. Nitrogen and Phosphorus Nutrition of Sesame (Sesamum indicum L.) at Savanna Nigeria.*Proceeding of the 31st Annual Conference of the Soil Society of Nigeria.* 2006 *pp329 – 336.*

[26] SAS. Statistical Application for the Sciences Institute, Inc., NC, USA. 2005

[27] Amujoyegbe, B. J., Opabode, J. T. and Olayinka, A. Effect of Organic and Inorganic Fertilizer on Yield and Chlorophyll Content of Maize (*Zea mays* L.) and *Sorghum bicolour* (L.) (Moench) *African Journal of Biotechnology,* 2007 *Vol. 6 (16), pp. 1869 – 1873.*

[28] Sadiq, A.A and Tekwa I.J. *Soil ferlity and management practices in Mubi region*. Published by Life-line Press, Nigeria. ISBN 978-978-959-589-1 2018. Pp.99 and 116.

[29] Cooke, G. W. *Fertilizing for Maximum Yield.* Published by English Language Book Society and Grandar London. ISBN 0 246 – 119047 1982, pp. 90 – 92.

[30] Das, D.K.(2010).*Introductory Soil Science.* By Kalanyi Publshers New Delhi -110 002 Pp 75-76