International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 3, Number 2, June 2018
http://www.casirmediapublishing.com

EFFECT OF ORGANIC AND INORGANIC AMENDMENTS ON SOIL PRODUCTIVITY AND YIELD OF MAZE (*Zeamays* L) ON AN ULTISOL IN ABAKALIKI, SOUTH EAST NIGERIA

J. E. Orji
Department of Soil Science and Environmental
Ebonyi State University, Abakaliki
Email: nacfarms@gmail.com

ABSTRACT

The agronomic potential of organic and inorganic fertilizers as soil amendments was evaluated. The objective was to determine their effect on soil physicochemical properties and grain yield. The experiment was carried out at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The field was laid out in randomized complete block design (RCBD) comprising NPK 15:15:15 (NPK) poultry droppings (PD), cow dung (CD), unburnt rice husk (UBRH) and control (C) replicated four times. The amendments were applied at the rate of 0.3tha^{-1}, 5t ha $^{-1}$5t ha $^{-1}$ and 5t ha $^{-1}$ for NPK, PD, CD and UBRH respectively. The test crop used was Oba super II (Maize variety). Results of the study showed that bulk density, total porosity, saturated hydraulic conductivity, water retention aggregate stability were significantly ($P<0.05$) higher in poultry droppings (PD) amended plots compared to control (C). Soil pH, total N, effective Cation exchange capacity, exchangeable acidity and percent base saturation were significantly ($P<0.05$) higher in plots amended with poultry droppings (PD) compared to control (C). Results also showed that the plot amended with PD had the highest grain yield of maize. The yield increase in amended plots was in the order of PD>NPK>CD>UBRH>C. Therefore, poultry droppings applied at the rate of 5t ha^{-} could be recommended for the rural farmers for improved soil productivity in Abakaliki south east Nigeria.

Keywords: *Organic, inorganic, amended, soil nutrient, maize, yield.*

INTRODUCTION

Soil remains the fundamental resource for agricultural production and the most important possession and input for farmers who use the soil as a medium for plant growth. Naturally, its continued cultivation brings about loss of nutrients. The tropical soils have a wide range of limiting factors for agricultural use; these include nutrient deficiencies, acidity, lower water storage and poor physical attributes occasioned by losses of organic matter due to rapid oxidation, high temperature and heavy precipitation (Nnoke, 2001; Bell and Seng, 2005). The soil undergoes serious structural deterioration due to the heavy rains. The impacts of the drops separate the fine soil particles and the organic matter from the sand, and the soil pores get chogged. This condition accentuated by long periods of cultivation without addition of amendments trigger leaching, run-off and erosion (Rouw, 2005). Since soil fertility is a major factor in determining soil productivity, fertilization will be required to correct and maintain the nutrient balances in the soil in order to increase its productivity and yield of crops. Agronomists have long recognized the benefit of maintaining and increasing soil organic matter which enhances soil fertility, water retention and crop production (Mbah and Mbagwu, 2003). According to Igwe (2005), good soil management options can help in rehabilitation of soils that are badly degraded. Fertilizers according to Abd El-Aziz (2007) are source of plant nutrients that can be added to the soil to supply its natural fertility. John *et al.* (2004) also reported that inorganic fertilizers are the most important sources of Nitrogen (N) and adequate supply of Nitrogen is associated with high photosynthetic activity, vigorous vegetation growth and dark green colour of leaves. It has been considered by previous researches that the concentrations of soil nutrients (e.g. organic C,N,P and K) are good indicators of soil quality and productivity because of their favourable effects on the physical, chemical and biological properties of soil (Cao *et al.,* 2011).

The use of organic sources such as animal manure has received much attention. Many researchers have reported significant improvements in physicochemical properties of soil and improved yield of crops in animal manure treated soils (Sridhar and Adeoye, 2003, Moyin and Atoyosoye, 2002). The fertility of soil provided by organic matter from manures had effects on flowering date, teaseling time, silking time hence the maturity and the crop yield (Martins and Vleic, 2001). The use of animal waste in productivity restoration is not only important as soil improvement programme but also essential for man's health that derives his sustenance from it (Moyin and Atoyosoye, 2002). Therefore, for a soil to remain fertile and productive especially in the tropics there is need for the application of organic and inorganic fertilizer which will help to boost crop yields. Organic manures are derived from organic matter i.e. from plants and animals and their products example farm yard manure while inorganic manures are manures that are man-made or manufactured artificially e.g muriate of potash (Nnoke, 2005). Abakaliki in Ebonyi Southeast Nigeria, most farmers cultivate the soil for crop production without serious attention to the soil nutrient maintenance using available organic and inorganic fertilizers for sustainable agriculture, even the few who make use of the amendments apply them without specific recommendation on the best rate of application due to insufficient research works. The objective of this study was to investigate the effects of organic and inorganic amendments on soil properties and maize yield with a view to making recommendations on the best amendment and rate of application to adopt for maize production.

MATERIALS AND METHODS

Site Description

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki in Ebonyi state, South Eastern Nigeria. The area is located at latitude 06°4N and Longitude 08°65'E in the derived Savannah Zone of Nigeria. The rainfall pattern of the area is bimodal (April to July) and (September to November) with a short spell in August popularly called "August break" The annual rainfall of the area is between 1800-2000mm. The mean annual temperature ranges from 27 to 31°C throughout the year the relative humidity is high during rainy season reaching 80% (ODNRI, 1989) and declines to 65% in dry season. The soil is underlain by sedimentary rock derived from successive marine deposit. According to FDALR (1985), Abakailiki agricultural zone lies within Asu River and is associated with brown olive shale's, fine grained sandstone and mudstone. The soil is unconsolidated to 1m depth belonging to the order ultisol classified as typical Haplustult (FDALR, 1985).

Field Methods

The total land area of 588m^2 was used for the research. The site was cleared of existing vegetation manually and debris removed. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates and five treatments which gave a total of twenty experimental plots. The plots measured 3m x 4m and separated by 0.5m space were prepared manually. The soil amendments used and their rate of application were as follows; NPK 15:15:15 at 0.3t ha$^{=1}$ (0.6kg/plot), poultry droppings at 5t ha^{-1}(10kg/plot), cow dung at 5t ha^{-1} (10kg/plot), Unburnt rice husk at 5t ha^{-1} (10kg/plot) the unamended/Control. The organic manures (poultry dropping and cow dung) collected from Animal science department of Ebonyi State University Abakaliki and Urbunt rice husk collected from the Abakaliki Rice mill were spread on the beds and later incorporated into the soil during tillage. The inorganic manure (NKP 15:15:15) purchased locally in Abakaliki was applied using top dressing method. The test crop, Oba supper II variety of maize (*Zea mays* L.) was purchased from Ebonyi State Agricultural Development programme (EBADEP). The maize grains were planted at a spacing 25cm x 75m inter and intra row respectively and two maize grains planted per hill. This was thinned down to one plant per hill ten days after germination to give a total plant population of 53, 333 plants per hectare. Weeding was done manually at three weeks interval till harvest.

Soil Sampling

A composite soil sample was collected with soil auger at 0 to 20cm depth while core samples were collected at 0cm to 10cm depth from the site before cultivation and treatment application for pre-planting analysis. After planting, core and anger samples were further collected from each plot at 0 to 10cm and 0 to 20cm depths respectively.

Laboratory Methods

Core samples were used to determine physical properties of soil. Composited samples were used to analyse for dispersion ratio and aggregate stability. The particle size analysis was carried out by pipette method (Gee and Orr, 1994). Bulk density was determined by Blake and Hartge (1986) and total porosity was calculated from bulk density data as follows:

$$Tp = \frac{(1\text{-}Bd)}{Pd} \times \frac{100}{1}$$

(Where Tp = Total porosity, Bd = Bulk density and Pd= particle density assumed to be $2.70gcm^{-3}$) (Obi, 2000) Hydraulic conductivity was determined using constant head method (Stolt, 1997). Soil water retention capacity was determined using gravimetric method (Obi, 2000) Dispersion ratio was calculated from particle size analysis data using the formula,

$$\%\ DR = \frac{\text{Water dispersion}}{\text{Calgon dispersion}} \times \frac{100}{1}$$

Aggregate stability was determined using the method described by kemper and Rosenau (1986). The auger samples were composited, air dried at room temperature, ground and sieved through a 2mm sieve. Soil pH was determined in soil/water suspension ratio of 1:2.5 and values read with Peech pH meter (1965). Nitrogen was determined by semi-macro kjeldahl method (Bremmer and mulvancy, 1982). Organic Carbon determination was by Nelson and Sommers (1982). Available phosphorus determination was by using Bray 2 method as described in Page *et al.* (1982). Effective cation exchange capacity was determined by summation method of:

ECEC = TEB + TEA

where ECEC = effective Cation exchange capacity, TEB = total exchangeable bases and TEA – total exchangeable acidity

Exchangeable acidity was determined in KCl through displacement method.

Grain Yield

Harvesting of Cobs was done at maturity, dried, threshed, weighed and the grain yield adjusted to 14% moisture content.

DATA ANALYSIS

Data collected from the experiment were subjected to statistical analysis using Analysis of Variance (ANOVA) for Randomized complete Block Design (RCBD) and significant means were separated using fishers least significant Difference (F-LSD 0.05) according to Steel and Torrie (1980).

Table 1 Mean value of soil properties before planting

Parameters	Values
Sand (kg^{-1})	750
Silt (kg^{-1})	140
Clay (kg^{-1})	90
pH (H_2O)	49
Available phosphorus ($Mgkg^{-1}$)	23.6
Nitrogen (%)	0.11
Organic Carbon (%)	1.07
Calcium (mol. kg^{-1})	41
Magnesium ($molkg^{-1}$)	2.8
Potassium (mo kg^{-1})	0.32
Sodium ($molkg^{-1}$)	0.29
Base saturation (%)	85
Exchangeable acidity ($cmolkg^{-1}$)	3.8
%OM	2.51

Table 2 Nutrient composition of the organic amendments

Nutrient	PD	CD	UBRH
Organic matter (%)	2.8.60	13.60	6.80
Organic Carbon (%)	16.00	8.50	3.50
Nitrogen (%(	2.10	1.50	1.40
Available phosphorus ($mgkg^{-1}$)	2.16	0.75	0.70
Calcium(%)	6.20	4.30	3.20
Magnesium(%)	2.00	2.00	1.30
Potassium(%)	3.40	0.60	0.40
Sodium(%)	0.70	0.32	0.24
C.N	8.0	45	2.5

[PD –Poultry, Dropping, CD - Cow Dung, UBRH - Urbunt Rice husk, C.N - Carbon – Nitrogen ratio

RESULT AND DISCUSSION

Table 1 shows the result of pre-planting analysis. The soil was sandy loam in texture with pH of 4.9 which means that the soil was acidic (USDA-SCS, 1974).The soil OC, OM and N were 1.07%, 2.51% and 0.11g/kg respectively. Available phosphorous (23.6mgkg^{-1}) was high (Landon, 1991). The percentage base saturation recorded high value of 90% and exchange able calcium and magnesium dominated the exchange complex of the soil. The result shows that organic carbon content of the soil was low (Metson, 1967) Table 2 shows the nutrient composition of the organic manure used as amendments. The nutrient composition of inorganic fertilizer NPK 15:15:15was known. The result shows that both the organic and inorganic amendments contained all the nutrients needed by plants. Generally the result shows that nutrient concentration was higher in the amendments than in the soil. The organic amendments contained N, P, and K and other nutrients (table 2) but the inorganic amendment contained N, P and K.

Effect of the organic and inorganic amendments on soil properties

The physical properties of soil after amendments are shown in Table 3. The textural class of the soil was sandy loam. According to Obi (2000) texture was a permanent property of soil and did not change after cultivation. The high content of sand (750g/kg^{-1}) could be attributed to parent material. Sand content of the soil in south eastern region is characteristics of sand formed on unconsolidated coasted plain and sand stones from Asu River (FDALR, 1987). Texture has good relationship with nutrient storage, water retention and porosity (Foth and Turk, 1972). Bulk density values of the amended plots were significantly ($P<0.05$) lower relative to the control. The lowest bulk density (1.41gcm^{-3}) was found in plots amended with PD which may be attributed to large quantity of organic matter and carbon in poultry dropping which helps in opening the soil. This is in line with the observations of Abiven *et al.* (2007) Bulk density of a soil is a measure of soil compaction and lower bulk density may result in easy penetration of roots, hence increase in the feeding area of plant which will result in higher soil productivity (Abu-Hamdeh *et al.,* 2006, Anikwe and Nwobodo, 2002). The higher bulk density recorded in control could be due to the low organic matter (OM) and Carbon (OC) observed in the soil. The highest total porosity (46.9%) was obtained in plots amended with PD followed by CD, NPK and UBRH (39.1%, 38.7% and 34.2%) respectively. The value was significantly higher than other amended plots and control. (Mbah and Mbagwu (2006) observed that animal waste application increased total porosity of soil. PD amended plots gave significantly ($P<0.005$) higher ($1.09cmh^{-1}$) hydraulic conductivity than other amendments. Similarly, Poultry droppings amendment showed a significant ($P<0.05$) higher effect on total porosity, hydraulic conductivity, water retention and aggregate stability compared to other amendments. The higher hydraulic conductivity in plots with amendments could be attributed to low bulk density and high total porosity that improved hydraulic conductivity. This corroborates with findings of Anikwe (2000), Adesodun and Ojeniyi (2005) and Wagner *et al.* (2007). The highest value of 49.40% for percentage water retention recorded by PD and higher values relative to control recorded by CD, NPK and UBRH amended plots agrees with the initial findings of Obi and Ebo (1995) that stated that increased moisture content may be attributed to the colloidal content of organic manure which increases water holding capacity. Higher values recorded in percentage aggregate stability showed significant ($p<0.05$) effect on soil amended with PD, CD, NPK and UBRH compared to the control. This agrees with earlier reports of Martens (2000), Anikwe (2000) and Abiven *et al.* (2007) that addition of organic and inorganic fertilizers increases biological activities and aggregate stability of the soil. Percentage dispersion ratio showed no significant difference among the amendments at ($P<0.05$). Table 4 shows chemical properties of the soil after amendment. The pH according to the result ranged between 5.1-6.0 indicating that the plots remained acidic (USDA-SCS, 1974). The pH of the organic and inorganic amendments was significantly ($P<0.05$) higher than that of the control. The highest pH value (6.0) was recorded by PD compared to the other amendments. Generally, there was increase in the pH values of all the treatments. The total N values in the amended plots were generally higher (Poultry droppings 0.14%, NPK 0.14%, cow dung 0.12% and unburnt rice husk 0.11%) than in the control (0.10%). NPK and PD amendments significantly ($p<0.05$) increased total nitrogen relative to C, CD and UBRH amendments. NPK and Poultry droppings have high total N that increased soil productivity than other amendments. This agrees with the observations of John *et al.* (2004) Abd El-Aziz (2007) and Moyin and Atoyosoye, (2002). Percentage organic carbon (OC) and available phosphorus (P) of organic and inorganic amendments were not significantly ($P<0.05$) different from control.

However, their values recorded respectively higher when compared with the control plots. This was in line with the findings of Abd El-Aziz

(2007) that fertilizers are source of plant nutrients that can be added to the soil to supply its natural fertility and Awodun *et al.* (2007) that high percent organic carbon and available phosphorus were obtained from animal waste amendment. Table 4 also showed that values of ECEC ranged between 8.51-11.13 cmolkg^{-1}, exchangeable acidity (EA) ranged between 0.88-1.20 molkg^{-1} whereas percentage base saturation (BS) ranged between 85-92% respectively. ECEC (11.15 cmolkg^{-1}) and BS (92%) were significantly ($P<0.05$) higher in poultry dropping amendment than in other amended plots. The decreasing order of ECEC values was PD>NPK>CD>UBRH>C.
Nonga (2001) reported that application of poultry droppings increased significantly effective cation exchange and percentage base saturation respectively. Significantly ($P<0.05$) higher exchangeable acidity was recorded in NPK (1.20 Cmolkg^{-1}) and control (1.01Cmolkg^{-1}) amended plots compared to other amendments. The high exchangeable acidity (EA) in NPK and control plots could be attributed to the chemical composition of the inorganic fertilizer and high presence of Al^{3+} in soil of the amended plots. This was in line with the observation of Nwite *et al.* (2013) that certain types of fertilizers could encourage soil acidity (low pH). Low values of exchangeable acidity recorded by poultry droppings (0.88 cmolkg^{-1}) agrees with the findings of Adeniran (2003) who reported that animal wastes decreased exchangeable acidity by removal of Al^{3+} from soil exchange site. Poultry droppings)PD) compared to other amendments recorded better pH, percent Organic Carbon, total nitrogen, available phosphorus, effective cation exchange and base saturation.

Grain Yield of Maize

Significantly ($P<0.05$) grain yield of maize was affected by the amendments (Table 5). The result shows that the highest yield of maize grain was obtained in the plots amended with poultry droppings. NPK also recorded higher values of maize grain yield compared to other amendments. The increasing order of grain yield was C<UBRH<CD<NPK<PD corresponding to 0.8, 1.5, 1.6, 1.8, 2.1. The increased maize grain yield could be attributed to higher nutrient content in the various amendments especially poultry droppings released to the soil for maximum productivity. Martins and Vleic (2001) reported that that the fertility of the soil provided by organic matter from manures had affects on flowering date, teaseling time, silking time hence maturity and the crop yield.

Table 3 Physical properties of soil after amendments

Treatment	BD (vm^{-3})	TP (%)	SHC (cm/hr)	WR(%)	AS(%)	(DR(%)
Control (C)	1.89	29.6	0.82	31.24	11.44	0.77
NPK 15:15:15 (NPK)	1.62	38.7	1.02	41.88	14.82	0.83
Poultry Droppings (PD)	1.41	46.9	1.09	49.40	19.05	0.84
Cow Dung (CD)	1.61	39.1	1.08	44.03	15.05	0.80
Unburnt Rice Husk (UBRH)	1.77	34.2	0.87	42.10	12.17	0.78
F-LSD (0.05)	0.0689	4.5277	0.3157	4.5079	3.5213	NS

BD-Bulk density, TP-total porosity SAC-saturated hydraulic conductivity, WR-water retention, AS Aggregate stability, DR-dispersion ratio

Table 4.Chemical properties of soil after the amendments

Treatment	O.C (%)	T.N(%)	P (mgkg^{-1})	pH(H_2O)	ECEC (cmolkg^{-1})	EA (cmolkg^{-1})	BS(%)
C	1.05	0.10	25.60	5.0	8.51	1.20	85
NPK	1.62	0.12	29.65	5.6	9.45	1.01	91
PD	1.76	0.14	28.30	6.0	11.15	0.88	92
CD	1.40	0.11	28.18	5.7	9.76	0.90	90
UBRH	1.52	0.11	27.79	5.5	10.06	0.90	90
F-LSD(0.05)	Ns	0.02	NS	0.1	0.91	0.11	2.0

OC-organic carbon, TN-total Nitrogen, P- Available phosphorus, ECEC-effective cation exchange capacity, BS-Base saturation.

Table 5 Grain Yield of Maize

Treatment	Grain Yield of maize (tha^{-1})
Control (C)	0.8
NPK 15:15:15 (NPK)	1.8
Poultry Droppings (PD)	2.1
Cow Dung (CD)	1.6
Unburnt Rice Husk (UBRH)	1.5
F-LSD (0.05)	0.2

CONCLUSION

Results from this study show that application organic and inorganic amendments in appropriate levels improved soil productivity and increased maize yield. The amendments significantly improved the soil properties. Comparatively, poultry droppings at 5tha^{-1} improved soil productivity and increased grain yield more than other amendments. Therefore, poultry droppings (PD) could be recommended to farmers for increasing soil productivity and grain yield of maize in Abakaliki, Southeastern Nigeria.

REFERENCES

Abd El-Aziz, N G (2007). Stimulatory Effect of NPK Fertilizer and Benzyla Denine on Growth and Chemical Constituents of Codiaeum Variagatum L. plant. Am Eura Sian J. *Agric. Enr. Sci, 2: 711-719*

Abiven, S., Menasseri S., Angers D. A., Leterme P. (2007). Dynamics of Aggregrate Stability and Biological Binding Agents during Decomposition of Organic Materials. *European Journal of Soil Science,* 58: 239-247.

Abu-Hamdeh, N. H., Abo-Qudais S. A., Othman A. M. (2006) Effect of Soil Aggregate Size, Infiltration and Erosion Characteristics. *European Journal of Soil Science,* 57: 609-616.

Anikwe, M. A. N. (2000). Amelioration of Heavy Clay Loam Soil with Rice Husk Dust and its Effect on Soil Physical Properties and Maize Yield. *Biores, Technol. 74: 169-173.*

Anikwe, M. A. N., Nwobodo K. C. A. (2002). Long Term Effect Municipal Waste Disposal on Soil Properties and Production of Sites used for Urban Agriculture in Abakaliki, Nigeria. *Biores Technol. 93(3): 241-250.*

Bell, R. W., Seng, V. *(2005*). The Management of the Agro-Ecosystems Associated with Sandy Soils. IN FAO Proceedings: Management of Tropical Sand Soils for Sustainable Agriculture. 27th - 2nd Dec, 2005, Khon Kaen, Thailand.

Bierman, P. (2000). Nutrient Cycling and Maintaining Soil Fertility. The Ohio State University Centre at Pikleton. Swr-3- 15pp.

Doran, J. W and Mielke, L. N. (1984). A Rapid-Low Cost Method for Determining of Soil Bulk Density. *Soil Sci. Am. J. 48:717-71.*

FDALR (1985). Reconnaissance Soil Survey of Eastern Nigeria Soils Report 1985; 133

Gee, G. W. and Orr, D. (1994). Particle Size Analysis in Method of Soil Analysis Part 4-Physical Methods. Soil Sci. Am. Book Ser. 5 Edited by: Dane, J. H, Topp, G. C., S. S A, Madison, W.I 2002: 255-293pp

IGwe, C. A. (2005). Soil Physical Properties under Different Management Systems and Organic Matter Effects on Soil Moisture along Soil Catena in South Eastern Nigeria. *Tropical and sub tropical agro ecosystems, 5:52-66.*

John, L. W., Jamer, D. B., Samuel, L. T., Warner L. W. (2004). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. Pearson Education, India PP 106-153.

Kemper, W. D., Rosenau (1986). Aggregate and Size Distribution. In: Klute, A (ed). Methods of Soil Analysis Part 1 Physical and Mineralogical Method 2nd (ed) ASA, SSA Madison WIUSA 425-440pp.

Landon, J. R. (eds) (1991). Booker, Tropical Soil Manual: A Handbook for Survey and Agricultural Land Evaluation in Tropics and Subtropics. John Wiley and Sons. Inc. Third Avenue, New York, USA, p. 474.

Martens, D. A. (2000). "Manage and Crop Residue Influence on Soil Aggregate Stability" *J. Quart. 29:23-727.*

Martins, C. H. T., Viek P. L. G. (2001). The Management of Organic Matter on Tropical Soil, What are Priorities? Nutrient Recycling in Agro-ecosystem 61-1-16pp.

Mbah, C. N., Mbagwu J. S. C. (2003). Changes in Structural Stability and Water Retention of a Sandy Clay Loam Amended with Organic Wastes. *Journal of Sci of Agric. Food Techn. and the Environment 3:* 16-21.

Metson, A. (1967). Methods of Chemical Analysis for Soil Survey Samples. New Zeal and DSK. Soil Bull. 12 Government Printer, Washington, New Zealand.

Moyin, J. E. I., Atoyosoye B. (2002). Utilization of Agricultural Wastes for the Growth of Leaf and Soil Chemical composition of Accia Seedling in the Nursery. Part Mark *J. Trop. Agric. Sci.* 25:53-62

Nnoke, F. N. (2001). Essentials of Pedology and Edaphology. Fedico Ventures, Abakaliki.

Nnoke, F. N. (2005). Concise Soil Handbook. Published by Innarok Syndicate, Abakliki.

Nonga, D. L. M. (2001). Comparative Effectiveness of Animal Manure on Soil Chemical Properties, Yield and Growth of (*Amaranthuscruntus. L.) Agric. J. Soil Technol.* 1:14-21.

Nwite, J. N., Okolo C. C., Ezeaku P. I. (2013). Evaluation of the Productivity of Soil Amended with Different Animal Wastes in an Acid Ultisol at Abakaliki Southeast Nigeria. Academic *J. Scientific Research and Essays.* Vol. 8 (36) pp 1720-1724.

Obi, M. E. (2000). Soil physics A Compendium of Lectures Published by Atlantic Publishers Nsukka.

Obi, M. E. and Ebo, P. O. (1995). The Effect of the Organic and Inorganic Amendments on the Soil Physical Properties and Maize Production in Severely Degraded Sand Soil in Southeastern Nigeria. *Bio Resources Tech 51:111-123.*

Ofomata, G. E. K. (1957). Nigeria in Maps, Eastern States. In Ofomata, G. E. K. (Ed) Ethopa Pub. House, Benin City pp 45-46

Pagae, A. L., Miller, R. H., Keeeney, D. R. (1982). Methods of Soil Analysis. Part 2 American Society of Agronomy, Madison, pp. 539-579.

Peech, M. (165). Hydrogen Long Activity. *IIn.* Black CE (eds) Methods of Soil Analysis Part II. Am. Soc. Agron. 9:9-14 926.

Rouw, A. (2005). Long-term Topsoil Changes under Pear Millet Production in the Sahel. In FAO Proceedings: Management of Tropical Sand Soils for Sustainable Agriculture . 27th-2nd Dec, 2005, Khon Kaen, Thailand

Steel, RGD and Torrie JH (1980). Prinicples and procedures of statistics, a bio Metrical Approach 2nd Edition, McGair Hill Block Co. Inc New York 3 pp.

Stolt J (ed) (1997). Manual of Soil Physical Measurement Version 3. Wageningen DLO Starting Centre Techn. DOC 37 pp.