EFFECTS OF RICE (*ORYZA SATIVA*) CULTIVATION ON NDOKWA GRASSLAND SOILS

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Abstract

This study examines the effects of rice cultivation on Ndokwa grassland soils;. Soil samples were collected at three locations where rice is presently cultivated in the study area. Five plots of 20m x 20m were randomly selected from each location for assessment. A similar observation was made for uncultivated plots which served as control to this study. The samples were collected with the aid of field instruments. The samples collected were analyzed for physical, chemical properties and heavy metal. The results revealed that the total mean values of sand, silt, clay, bulk density, total porosity, pH, organic carbon ,total nitrogen, available phosphorus, CEC and lead were 85.63%, 7.25%, 7.12%, 1.02g./cm^3, 61.55%, 4.3%, 2.33%, 0.18%, 7.25%, 3.2 and 0.009 respectively for cultivated plots. While 81.2%, 8.2%, 7.9%, 0.79g/cm^3, 69.91%, 4.9, 2.33, 0.18, 5.96, 4.7, and 0.003 respectively for uncultivated plots. While the elements of chromium, cadmium and nickel were below detection level for both plots. The result also revealed that variations exist between areas under rice cultivation and uncultivated areas, this indicate a reduction in the values of these soil physical and chemical properties, implies a deteriorating state of the soil of the Ndokwa grassland. Therefore it is recommended that the farmers should adopt the use of soil amendments, liming, tillage and incorporation of rice straw as soil management measures to improve the soil fertility.

Soil is the medium for plant growth and for many of the processes that constitute man's real life support system, including energy flow and cycling of matter (Areola 1990). The physical, chemical and biological characteristics of the soil determine such essential qualities of land as for example, it's ability to supply water and nourishment to plants and animals, and to provide mechanical support and construction materials for all living things, including man. While rice is an annual crop and is one of the world's most important cereals, serving as a staple food for most countries. The plant has a hollow stem, which is jointed and reaches a height of 3m to 2.5m; it has a branching (tittering) habit. Its roots are thin and shallow and the leaves made up of long sheathing base and long narrow leaf blade with a well defined midrib (Omoruyi, et al 2003). The mature grain is elongated and is enclosed in the hull or husk. We have the upland rice that can withstand dry conditions and the swamp rice that needs irrigation. Rice is propagated by seeds, and it requires an annual rainfall of 1,270mm to 2,000mm. The crop requires high mean temperature of 18^{oc} to 27^{0}C with no cold season (Omoruyi, et al 2003).

Continuous cultivation is responsible for reduction in soil nutrient status and low yield, Nye and Greenland (1960) observed a decline in calcium and nitrogen following the cultivation of the Guinea Savannah for 6 years. This was later confirmed by Aweto (1998) and Asadu and Nweke (2001) who asserted that soil organic matter and pH content in cultivated soil decline with increasing years of cultivation, they therefore call for studies in cultivated soil in similar grassland, but they however suggest good soil management to the soil to improve it fertility. .

In Ndokwa area, because of limited land availability, farming activities have started to encroach onto the Ndokwa grassland. Rice cultivation began at Ogbele-Ogume, about 32 years ago (Okpor, 2002). Other grassland patches where rice is now being cultivated include Utagba-Uno and Ossissa. Over the years, the farmers complain that the yield rice in the area has been decreasing. This low yield has been attributed to a marked fall in the nutrient content of the soil and environmental problem by some farmers in the area. Thus this study is aimed at evaluating the effects of rice cultivation on the physical and chemical properties of soils of Ndokwa grassland.

Study Area

The study area is located in South – Eastern part of Delta State in the South South zone of Nigeria. It lies between latitude 5^0 45' N 6^0 01' N and longitude 6^0 06'E to 6^0 20' E. It is bounded by river Niger on the east, Isoko North Local government area in the South, Ughelli North and Ethiope East Local Government Areas in the west and Ika North and South, Aniocha South and Oshimili South Local Government Areas to the North see (fig 1).

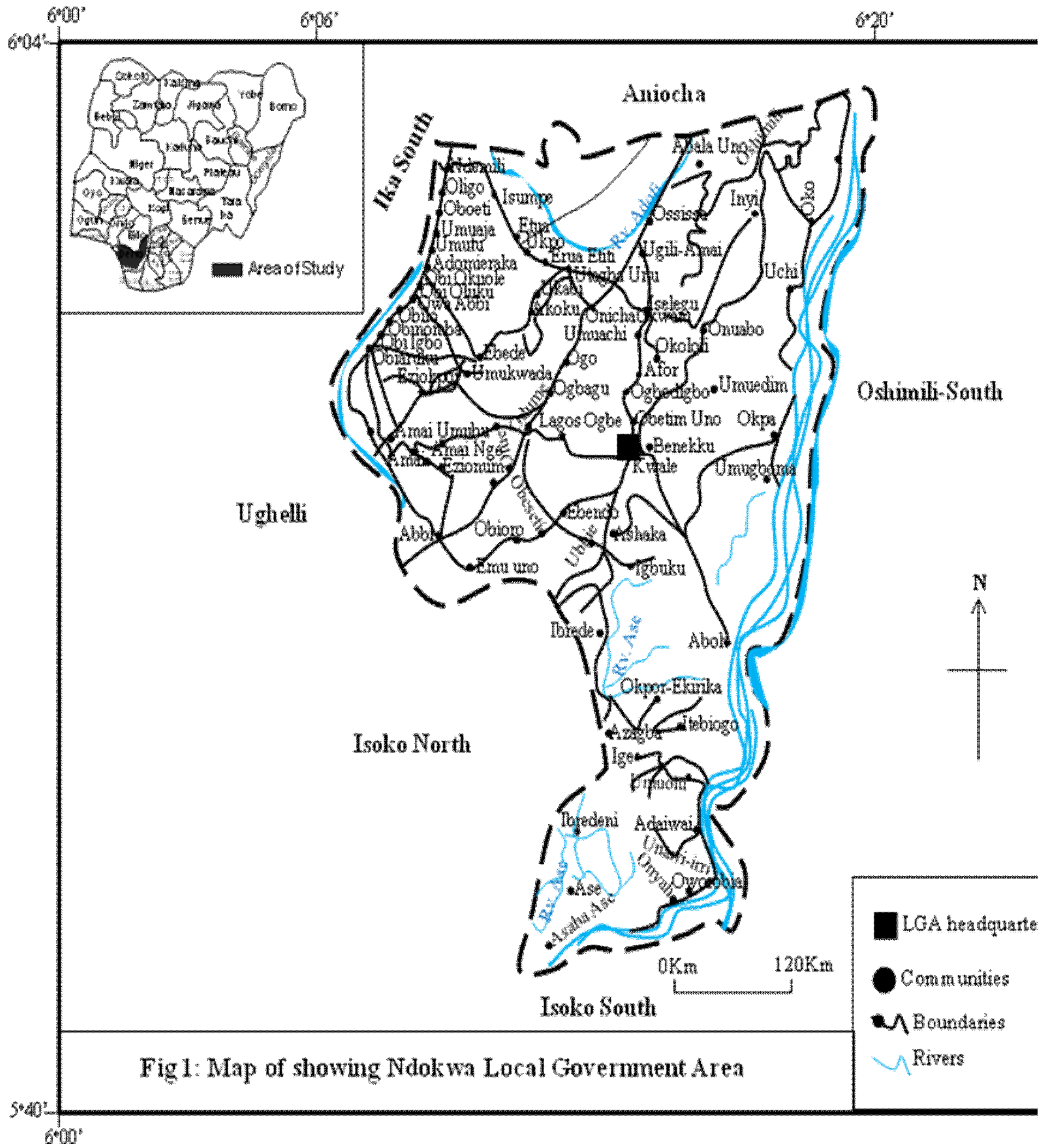


Fig 1: Map of showing Ndokwa Local Government Area

Ndokwa lies in the coastal plain of Southern Nigeria. The area is gently undulating plain without even a single hill rising above the general land surface. The mean elevation of the area is generally below 50 metres above sea level which favour the growth of rice (Okpor, 2002).

The study area is part of Niger Delta and it is underlain by sedimentary rocks, consisting mainly of yellow and white sand with pebbles. Clay and sandy clay occur in lenses (Reyment 1964). Three geological formations of Benin, Agbada and Akata formations occur in the area and they lie one below the other. The soil found in the area is sandy. The soil is mainly tropical ferralitic soils

(Oxisols) formed from unconsolidated sediments (Aweto, 1987). The soils are deeply weathered, severely leached, and friable and they lack distinct and well defined horizons. The soils have low silt and clay content, low cation exchange capacity and consequently low pH (Okpor, 2002).

The mean annual rainfall over much of the study area is up to 2540mm. September is the wettest month with a mean of 485.39mm. January is the driest month with a mean of 32.27mm. The relative humidity of the air is high throughout the year. Humidity during the wet season is about 80% and range from 60% to 70% during the dry season. The mean annual temperature is about 27^oc (Okpor, 2002). The natural vegetation of Ndokwa is the tropical rainforest. The plant community is basically of evergreen species that yield hardwood e.g *Entaudrophragma Spp, Melicia excelsa, Khaya Ivorensis, Lovoa trchiliodes* etc. Grassland vegetation is also found in many areas in Ndokwa, mainly in patches.

Materials and Methods

The study adopts a field survey of rice farmland in the area, where the three locations of grassland patches in the study area was each divided into five divisions for the purpose of sample selection. In each of the divisions, soil samples were selected randomly in a quadrat of 20m x 20m at an equidistance point of 10 meters within a predetermined depth of 0- 10cm from the top soil, being the threshold of rice cultivation (Omoruyi et al, 2003). A similar observation was made in the adjacent uncultivated plots that served as control. At Ogbele-Ogume, Utagba-Uno and Ossissa where rice is cultivated were each demarcated into five strata, making a total of 15 soil samples from the rice cultivated plots, a similar division was made for the three locations of the adjacent uncultivated grassland which serves a control, and making another 15 soil samples. In all a total of 30 soil samples were collected for the grassland for investigation. The soil sampled collected were placed in a polythene bag and labelled before taken to the laboratory for further processing and analysis.

Soil bulk density was estimated from samples collected from the cultivated and uncultivated plots collected from the 0-10cm layer from the top soil separately that were determined on cores (Black, 1965), The soil samples were immediately weighed before transportation to the laboratory for oven drying at 105^oc for 24 hours and re-weighed. Bulk density was then calculated as oven-dry mass (mg) per volume (m^3). Total porosity values were calculated from the bulk density figures using an assumed particle density value of $2.65cm^3$ (Vomocil, 1965). With the exception of samples collected for density determination, all other soil samples were air-dried at room temperature, passed through a 2mm sieve and analyzed for particle size composition by hydrometer method (Bouyoucos, 1926), and Organic carbon by chromic acid digestion method (Walkey and Black, 1934). To analyse for Total Nitrogen, regular micro-kjeldahl method was. Available phosphorus was derived by Bray PI method. Soil pH was determined potential metrically in distilled water, using a soil ratio of 1:1 (Bates, 1964).
Soil sample data collected from rice cultivated plots were compared with those of uncultivated for significant differences using a paired t-test, with the view of assessing the effects of rice cultivation on soil properties.

Results and Discussion

The results of the soil samples collected from rice cultivated and uncultivated area of Ndokwa grassland are presented in Table 1-4 and discussed below

Table 1: Soil Characteristics of Rice Cultivated Area of the Ndokwa Grassland

Soil Properties	Ogble.Ogume	Utagba-Uno	Ossissa	Cultivated	Uncultivated
	Mean Range	Mean Range	Mean Range	Mean	Mean
Sand (%)	88.28 ± 86.2-90.2	85.4 ± 83.2-86.2	83.2 ± 78.2-88.2	85.63	81.2
Silt (%)	5.56 ± 4.4-7.4	7.0 ± 3.5-9.4	9.2 ± 5.4-12.4	7.25	8.2
Clay (%)	6.16 ± 4.4-7.4	7.6 ± 3.4-10.4	7.6 ± 2.4-10.4	7.12	7.9
Bulk Density (g/cm^3)	1.04 ± 0.98-1.10	1.00 ± 0.98-1.03	1.02 ± 0.97-1.10	1.02	0.79
Total Porosity (%)	60.91 ± 58.5-63.2	62.34± 61.1-63-2	61.4 ±58.5-63.4	61.56	69.91
Soil pH (in water)	4.2 ± 3.9-4.5	4.6 ± 3.9-5,2	4.12 ± 3.8-4.5	4.3	4.9
Organic Carbon (%)	1.67 ± 0.53-3.12	1.5 ± 0.84-2.84	1.55 ± 0.16-3.47	1.54	2.33
Total Nitrogen (%)	0.23 ± 0.15-0.29	0.28 ± 0.17-0.36	0.27 ±0.12-0.39	0.26	0.18
Available Phos (ug/g)	4.58 ±2.20-7.28	7.80 ± 3.78-11.22	5.53 ± 3.70-8.45	5.97	5.96
CEC (me/g)	3.99 ± 2.80-6.36	2.81 ±0.88-4.82	2.79 ± 0.84-4.82	3.2	4.7
HEAVY MEATLS					
Chromium (mg/1)	-	-	-	-	-
Cadmium (mg/1)	_	_	_	_	_
Nickel (mg/1)	_	_	_	_	_
Lead (mg/1)	0.0108±0.007-.015	0.0078 ± 0.005-0.011	0.008 ± 0.006-0.011	0.009	0.003

Table 2: Uncultivated

Soil Properties	Ogble.Ogume	Utagba-Uno	Ossissa	Grand Mean
Soil Properties	Mean Range	Mean Range	Mean Range	Mean
Sand (%)	84.4 ± 76.2-91.2	77.8 ±70.2-88.2	81.4 ± 72.2-87.2	81.2
Salt (%)	7 ± 4.4-9.4	8 ± 6.4-9.4	9.6 ± 3.4-22.4	8.2
Clay (%)	8.6 ± 4.4-14.4	8.2 ± 5.4-10.4	7 ± 3.4-10.4	7.9
Bulk Density (g/cm^3)	0.789 ± 0.74-0.82	0.81 ±0.79-0.84	0.769 ± 0.76-0.85	**0.79**
Total Porosity (%)	70.26 ± 69.1-72.1	69.51± 68.3-70.2	69.96 ± 67.9-71.3	69.91
Soil Ph (in water)	4.8 ± 4.7- 5.0	4.9 ±4.7-5.1	4.96 ± 4.8-5.3	4.9
Organic Carbon (%)	3.34 ±1.82-6.37	1.7 ±0.72-3.20	1.95 ± 0.44-2.88	2.33
Total Nitrogen(%)	0.214 ± 0.18-0.33	0.164 ±0.11-0.31	0.172 ±0.09-0.17	0.18
Available Phos (ug/g)	6.80 ±4.42-13.20	4.58 ± 4.8-11.4	6.49 ± 3.21-8.70	5.96
CEC (me/g)	5.17 ± 3.10-.34	4.58 ±1.82-8.40	4.21± 2.10-6.74	4.7
HEAVY MEATLS				
Chromium (mg/1)	-	-	-	-
Cadium (mg/1)	_	_	_	_
Nickel (mg/1)	_	_	_	_
Lead (mg/1)	0.0036 ± 0.003-0.004	.0028 ± 0.001-0.004	.0018 ± 0.001-0.003	0.003

In table 1 and 2, the total mean values of sand, silt and clay are 85.63%, 7.25% and 7.12% respectively for rice cultivated plots, while those for uncultivated plots are 81.25, 8.2% and 7.9% respectively. This distribution shows that soils under uncultivated and cultivated plots are predominantly sandy and texturally homogenous since the difference is not statistically significant

(<0.05) (see table 3). This is expected since the soils are derived from the same parent materials (Aweto, 1998)

As shown in tables 1 and 2, the total mean values of bulk density and total porosity in cultivated plots are 1.02 g/cm^3 and 61.56% respectively, while those of uncultivated plots are 0.79 g/cm^3 and 69.91% respectively.

The difference in values between cultivated and uncultivated plots with respect to bulk density was proven to be statistically significant (<0.05) (see table 3), while total porosity has a significant difference (>0.05) (see table 3). This shows that soils under uncultivated plots have a better physical status than those under cultivated plots, because they are less dense or compact and more porous. This is presumably because uncultivated plots have grasses that grows in tussocks, have greater coverage than the cultivated plots (Okpor, 2002). Statistically, significant difference exists between the pH of cultivated and uncultivated plots (see table 3).

Table 3: Student T- Table Value of Soil Parameters and Heavy Metals Concentration

Parameters for comparison	**Calculated student t – Value**	**Table value of T – Test at 5% level**	**Remarks**
Sand	-2.25 * *	2.05	No Sign diff exist
Silt	2.03 * *	"	No Sign diff exist
Clay	0.75 *	"	No Sign diff exist
Bulk density	-17.82* *	"	No Sign diff exist
Total porosity	16.14*	"	Sign diff exist
Soil pH	6.11*	"	No Sign diff exist
Organic carbon	1.67*	"	Sign diff exist
Total Nitrogen	2.76*	"	Sign diff exist
Available Phosphorus	1.17 * *	"	Sign diff exist
Cation Exchange capacity (CEC)	4.9 *	"	Sign diff exist
METAL		"	
Lead	0.007* *	"	No Sign diff exist

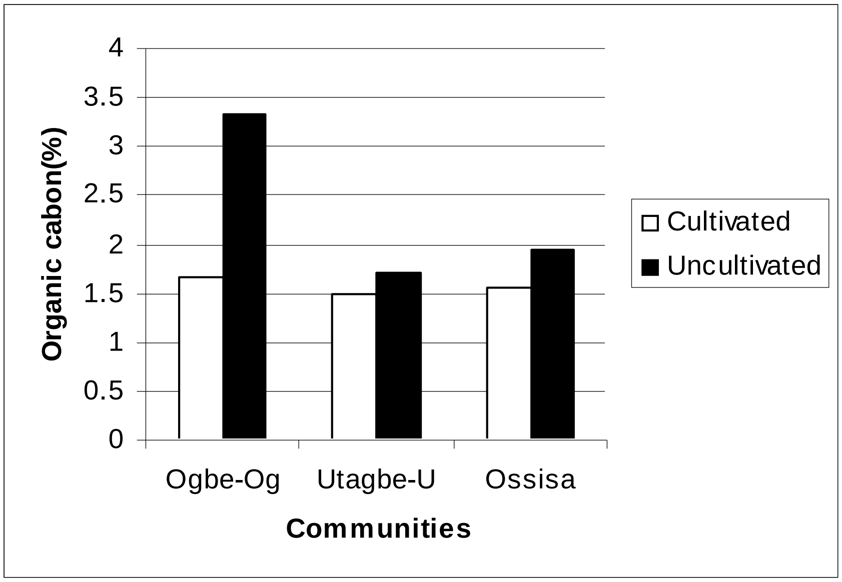
Note: ** Not significant at 5% level
* Significant at 5% level

Negative sign (-) means that mean value for the parameters is greater in rice cultivated plots than in uncultivated plots.

The total mean values of pH in both plots as shown in table 1 and 2 are 4.3 and 4.9. The pH value observed in uncultivated plots suggest that rice crop makes a great demand on soil nutrients such as calcium and magnesium than the grass species of uncultivated plots (Bongfen, 1983). The loss of bases in the soil through either leaching or uptake by plants, results in soil acidity. Generally, the soils from both plots are acidic because they are below 5 (see table 1 and 2). The acidity of the soil is attributed to heavy annual rainfall resulting in depletion of the cations. Significant difference however exist amongst the plots (>0.05), indicating a better soil fertity in the uncultivated than the cultivated (see table 1, 2 and 3)

Tables 1 and 2, also shows that the total mean values of organic carbon for cultivated plots of 1.57% is lower than that of uncultivated plots of 2.33%, however the total mean organic carbon is highest in Ogbe- Ogume and lowest in Ossissa (3.4% and 1.95) (See fig. 2). Statistically, there is significant difference between them (>0.05). The greater cover of the uncultivated plots could not have made much impact with regards to addition of more organic matter to the soil because of occasional burning of the grassland during the dry season, while rice straws are left to decay into the soil in cultivated plots at each cultivation, Organic matter accumulates more in the first 20cm of surface soil. And it is conventionally to aim at soil organic matter of between 1.5 to 5% to maintain soil fertility (Aduayi 1981).

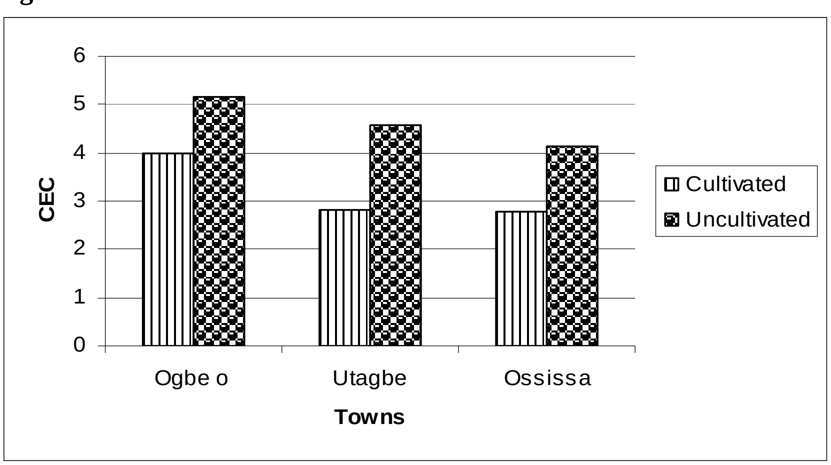
Fig. 2: Total Mean Values of Organic Carbon



Total mean value for total nitrogen of cultivated plots is 0.26% is greater than the value of uncultivated plots of 0.18%. Statistically, a significant difference exist (>0.05). The differences arise probably because the grass species make greater demands on nitrogen than rice plant. Bongfen (1983) observed that nitrogen content of weed was significantly higher than that of rice straw. In another vein, as shown in tables 1 and 2 and 3, the total mean values for available phosphorus (in ug per gramme of soil) of cultivated plots of 5.97 is slightly lower than that of uncultivated plot which is 7.25, but the difference is not statistically significant (< 0. 05). This indicates that rice cultivation does not have much adverse effect on grassland soils.

Total mean value of action exchange capacity for cultivated plots of rice is 3.2 and this is lower than that of uncultivated plots of 4.7. The difference between two plots with respect to cation exchange capacity was proven to be statistically significant (> 0.05). (See table 3). The reason for the lower value of cultivated plots can be attributed to the fact that a substantial part of the nutrients in inorganic fertilizers applied to the soil will be leached away during cropping (Okpor, 2002).

Fig. 3 CEC of the Ndokwa Grassland Soil



However CEC in Ogbe Ogume is highe than those of Utagbe-Uno and Ossissa (3.99me/g, 2.81, 2.7me/g and 9me/g respectively) (see fig. 3).

Tables 1 and 2 shows that the total mean values of chromium, cadmium and nickel were below detection level for both plots, and the reasons for the inability of these metals to be detected, can be attributed to the fact that oil related activities like exploitation, exploration, spillage etc, have not occurred in the area from which samples were collected. While the concentration level of lead in cultivated plots has a total mean value of 0.009 and a total mean value of 0.003 for uncultivated plots (see tables 1 and 2). The occurrence of lead in the area may be as a result of other human activities other than oil related activities. Lead may occur in effluence from lead and battery manufactures or even from domestic waste containing lead materials. Table 3 shows that the differences that exist between the two plots is not statistically significant (<0.05). It implies that the concentration level of lead in Ndokwa grassland soils is low and has no adverse effect on the soil nutrient status.

Conclusion

This study has revealed that continuous rice cultivation in the Ndokwa grassland area has depleted the soil fertility, and this effect Is more in Utagbe-Uno and lowest in Ogbe Ogume, which is attributed to continuous cropping and poor soil management practice. Thus, is recommended that the introduction of soil management measures like the use of soil amendments, liming, zero or minimum tillage and incorporation of rice straw to enhance nitrogen balance in the soil will enhance the fertility of the soil should be practiced by the farmers to enhanced the soil fertility and improve the yield of rice in the area..

References

Aduayi, E. A. (1981). Nutrient composition of the white yam (Dioscorea Rotundata) leaves sampled influenced by Nitrogen fertilization *comm. Soil science and plant analysis* 10, 927- 939

Areola, O. O. (1990). The good earth inaugural lecture delivered at the University of Ibadan, on April 19th 1990 *Inauguaral Lecture* series No. 31 Ibadan Nigeria, Johnm of Printers.

Aweto, A.O. (1987). Vegetation and soil of the Savanna Nigeria *Catena* 14. 177 – 188

Aweto, A. O. (1998). Physical and nutrient status of soils under rubber (Hevea Brasiliensis) of different ages in South Western Nigeria. *Agricultural systems* 23: 63 – 72

Bates, R. C. (1964). *Determination of Ph: Theory and practice* New York, John Wiley and Sons.

Black, C. A. (1965). Estimation of bulk density in soils. Analysis. *American society of agronomy* 24: 374 – 390.

Bongfen, G. S. (1983). *The characteristics of soils under permanent and shifting cultivation in Ndu area of Cameron Grassland* M.Sc thesis, Geography Dept, University of Ibadan, Nigeria.

Bouyoucos, G. J. (1926). Estimation of colloidal materials in Soil. *Soil science 64:362*

Okpor, O. M. (2002). *Evaluation of fertility of hydromorphic soils, under yam (Dioscorea Rotandata) cultivation in the lower Niger Valley*. M. Sc dissertation, Dept of geography University of Ibadan 23.57

Omoruyi, S. A; Orhue, U. X; Akerobo, A. A. & Aghimien, C.I. (2003). *Introduction to agricultural science* Benin City, Idodo Umeh publishers ltd.

Reyment, R. A. (1964). Geological formations in Nigerian coasts. *Agricultural system* 14: 374-390.