Available online at http://www.ajol.info/index.php/njbas/index
Nigerian Journal of Basic and Applied Science (2011), 19 (1): 155- 161 ISSN 0794-5698

Ipomea asarifolia (Desr), A Potential Cover Crop for Soil Fertility Improvement in The Sudan Savanna Region, Nigeria.

*[1]A.A. Abdullahi, [2]S.A. Ibrahim, [1]S. Yusuf, [1]M. Audu, [3]N. Abdu, [1]S.S. Noma and [4]H. Shuaibu
[1]Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto, Nigeria.
[2]Crop Production Programme, Abubakar Tafawa Balewa University, Bauchi, Nigeria.
[3]Soil Sceince Department, Ahmadu Bello University, Zaria, Nigeria.
[4]Department of Agricultural Economics and Extension, Usmanu Danfodiyo University, Sokoto, Nigeria.
[*Corresponding Author: E mail: aanchau@yahoo.com; GSM: 08039735066.]

ABSTRACT: The effect of *Ipomea asarifolia* on physico - chemical properties of the soils at Usmanu Danfodiyo University, Sokoto main campus, in the Sudan Savanna of Nigeria was investigated. The study determined the effect of the plant on some physical and chemical properties of soils, found out the nutrient retention ability of the plant in the soils and the variation of the effect with distance within the plantsô canopy. A total of 48 samples were collected from four different sites within Usmanu Danfodiyo University main Campus; VC complex area, University stadium area, Behind new library area and opposite IBB centre area and four distances from the plant (control, plant base, 0.5 m and 1 m from the plant base). Samples were collected for use in a randomized complete block design (RCBD) experiment with three replicates. Soil pH, Organic C, CEC, total N, available P, K, Ca and Mg concentrations were determined, particle size analysis was also carried out. The results were subjected to analysis of variance (ANOVA), where significant F values were obtained, the means were separated by Duncan multiple range tests (DMRT). The difference among the sites and the distances were found to be statistically significant ($P < 0.01$) for the chemical properties determined. The soils of the University stadium area had the highest CEC and total N; 4.28 g kg^{-1} and 0.41 g kg^{-1} respectively, while the soils of the IBB centre area had the least organic carbon, CEC, and available phosphorus; 3.23 g kg^{-1}, 2.00 cmol kg^{-1}, 9.00 mg kg^{-1} respectively, with the effect almost following the order; University stadium area > VC complex area > New library area > IBB centre area. On the other hand, the effect on all the parameters was found to decrease with distance from the plant with the base of the plant having the highest organic C, CEC, total N, available P and exchangeable K, Ca and Mg; 6.83 g kg^{-1}, 5.00 cmol kg^{-1}, 0.42 g kg^{-1}, 10.82 mg kg^{-1} and 0.26, 0.50 and 0.97 cmol kg^{-1} respectively, while the control soils had the least values; 3.46 g kg^{-1}, 4.00 cmol kg^{-1}, 0.12 g kg^{-1}, 7.43 mg kg^{-1}, 0.21, 0.38, and 0.45 cmol kg^{-1} respectively. The effect was attributed to the accumulation of organic matter around the plant and its ability to prevent erosion by both water and wind thus retaining nutrients making it a suitable cover crop for soil fertility improvement.
Key words: *Ipomea asarifolia*, Cover crop, soil chemical properties, soil fertility

INTRODUCTION

Vegetation is a storehouse of abundant and readily available nutrients for crop production. Therefore, vegetation management forms an important component of farm practices for sustainable crop production, especially in the humid and sub-humid tropics where there is pressure on arable land (Olaitan and Lombin, 1988). Farmers in tropical Africa have practiced shifting cultivation with long fallow periods, which led to improved soil conditions, accumulation of organic matter and restoration of soil fertility (Olaitan and Lombin, 1988). However, the traditional shifting cultivation or bush fallowing is fast being replaced by continuous intensive cultivation because population and other economic pressures such as industrial development and infrastructural constructions have increased the demand for land considerably (Olaitan and Lombin, 1988).

Under this condition, the soil is subjected to degradation and loss of fertility due to such processes as wind and water erosion leading to serious nutrients depletion, thus becoming less and less capable of supporting a protective canopy of vegetation, as a results, ñislandsò of soil fertility are found only under shrubs and other vegetation types, while soils between them become increasingly thin and infertile (Brady and Weil, 1999).

The use of cover crop as an alternative means of maintaining soil fertility could therefore, be a good option. These crops are not harvested, but rather allowed to provide vegetation cover for the soil and then either harvested and left on the surface as mulch or tilled with the soil as green manure, instead of leaving the soil bare during off seasons (Tisdale and Lombin, 1993).

Cover crops can provide soil protection between growing seasons (off season) for annual crops and continously for widely spaced perennial crops, such as orchards and vine yards and as well as permanently protect the soil between rows (Brady and Weil, 1999). The advantages of the cover crops could not be over emphasized, they provide habitat for wild life and beneficial insects, protect the soil from erosive forces of wind and rain, add organic matter, and if leguminous, even increase available nitrogen in the soil through fixation from the atmosphere. They also reduce nutrient losses through run-off, especially in the tropics in two ways; the action of cover crop in reducing the formation of surface crust, leading to high infiltration rate and filtering out of the sediments containing nutrients and maintaining them even if run-off occurs. They also reduce nutrient leaching below the rooting zone, especially nitrogen in form of nitrate (NO_3^-) by immobilizing them through root uptake during the growing season which mineralizes on decomposition in the following year, in contrast to what is obtainable in the bare soil. Cover crops have the potentiality of binding the soil together and futher reducing the loss of nutrient through erosion, leaching, volatilization e.t.c. (Olaintan and Lombin, 1988) through the maintenance of an extensive root system as quickly as possible once the main crop has ceased growth (Havlin *et al.,* 2005). Cover cops are also important for their ability to block weeds, and maintain soil moisture (Mazza, 2006).

Ipomea asarifolia (Desr.) which belongs to the family convolvulaceae in the dicotyledonous class of angiosperm has been observed as one of the common weeds growing in Usmanu Danfodiyo University main campus. It has the largest population compared to other weeds and therefore, the most prominent; especially with its annual to perennial pattern of growth coupled with its ability to be easily established under different soil conditions (poorly drained, well drained and extremely dry) thus covering a large portion of the soils, which leads to an interest on it. There are all tendencies for it to modify the soil microclimate for a good period of time and thus affect the physico-chemical properties of the soils. Earlier studies on the plant established its ability to prevent erosion by water and wind, acting as a cover crop and develop large quantities of organic matter in the soils through their leaf litters and roots (Aliero and Anka, 2001; Yakubu and Singh, 2001) which might lead to the retention of nutrients. It is imperative therefore; to study the effect of the plant on soil properties with a view to establishing itôs suitability for adoption as a cover crop to be utilized for improvement of soil fertility in the region.

The study was conducted to determine the effect of *I. asarifolia* on nutrients retention and other important chemical properties of soils, with the specific objectives of determing the effect of the plant on selected chemical properties, the extent of nutrients retention and the variation of these effects with distance from the base of the canopies in soils of Usmanu Danfodiyo University main campus.

MATERIALS AND METHODS

The Study Area

The study was conducted in Usmanu Danfodiyo University, Sokoto main campus, located about ten kilometers North of Sokoto town. Sokoto is located in the northern western part of Nigeria at latitude 13° 01ôN and longitude 5° 15ôE, it is 308 m above sea level and lies within the Sudan Savanna belt (Reuben, 1981). The climate is hot semi-arid type Aw in the Koppean classification (Sombroek and Zonneveld, 1971). The area experiences a long dry season from October to May and a short rainy season from June to September. The dry season consist of a cold dry spell (Hamattan) roughly from November to January, followed by a hot dry spell from February to April (Singh and Babaji, 1989). Rainfall in the area is erratic in nature and small in quantity with an annual mean of 724 mm for a period of six years (1998-2003) and of uneven distribution with a peak in August (Noma, 2005). Temperature during the year fluctuates roughly between 45°C maximum and 15°C minimum (Arnborg, 1988).

Soil Sample Collection, Preparation and Analysis

Soil samples were collected from four (4) different sites, observed to have the highest concentration of the plant within the study area in September, 2007. At each site, three (3) plants were selected randomly to represent the plant population and samples were collected at three different distances from each plant ccontrol (bare land, without any vegetation), plant base, 0.5 m and 1m from base making a 4 x 4 factorial experiment replicated three times in randomized complete block design (RCBD). The control samples were collected, at 20 m away from the site in each case. A total of 48 samples were collected using auger at a depth of 0 - 15 cm. The samples were air dried, grinded using stainless steel mill, sieved through 2 mm sieve and then stored for subsequent analysis.

Soil pH was determined with a pH meter using 1:1 soil water ratio (Bates, 1954), organic C by the dichromate oxidation method as described by Nelson and Sommers (1982), total N by the microkjedahl method (Jackson, 1962), available P by Bray No.1 method (Bray and Kurtz, 1945), CEC by ammonium acetate saturation method (Chapman, 1965), exchangeable bases by extraction with 1 N ammonium acetate at pH 7 (Kundsen *et al.*, 1982), K and Na were determined by Flame Photometry while Mg and Ca were determined using EDTA method from the leachate and particle size analysis was carried out using Bouyoucos hydrometer method as described by Gee and Bouder (1986).

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) to compare the different sites and distances, where F test values were significant, treatment means were separated using New Duncan multiple range test (DMRT). All statistical analyses were performed using (SAS, 1998). Enrichment factors relative to the control for all the parameters measured were calculated as done by Saa *et al.* (1994).

RESULTS AND DISCUSSION

The effect of *I. asarifolia* (Desr.) on soil chemical properties at Usmanu Danfodiyo University main campus is presented in Table 1. The effect of the plant on soil pH, organic C, CEC, available P, exchangeable K, Ca and Mg concentrations were found to be significant ($P < 0.01$) among the different sites, however total N concentration was not significantly ($P > 0.05$) different among the areas. The soil pH ranged between 7.05 and 8.08, the lowest pH value was obtained in the soil of the University stadium area, indicating a possible higher effect of decomposition of organic matter than the other sites, coincidentally, the plants are less disturbed than in the other areas. The same university stadium area was found to have the highest CEC, total N, exchangeable Ca and Mg concentrations of 4.80 cmol kg^{-1}, 0.41 g kg^{-1}, 0.48 cmol $kg^{-1}$and 0.83 cmol kg^{-1} respectively. The soils of the VC complex area had the highest organic C (6.42 g kg^{-1}) closely followed by that of the soils in the university stadium area (5.46 g kg^{-1}) which were statistically similar. Likewise, the highest available P concentration was recorded in the soils of the new library complex (10.30 mg kg^{-1}) also closely followed by that of the soils of the university stadium (9.72 g kg^{-1}) and the VC complex area (9.55 g kg^{-1}) which are also statistically similar. On the other hand, the least organic C, CEC, available P and exchangeable K were observed in the soils of the IBB center area with reletively lower concentration of the plant and its regular disturibution. The non significance in total N concentrations among the different sites may be attributed to volatilization losses due to high temperature (Brady and Weil, 1999). The advantage of some sites, like the university stadium area over others like the IBB centre in most of the parameters determined could be attributed to possible longer period of establishment of the plant, leading to higher concentration of the plant resulting to a higher effect, coupled with less tendency of disturbance to the plant by other activities taking place in the campus such as buildings, planting of ornamental plants, utilization of the lands as roads e.t.c..

The variation of the effects of the plant on organic C, CEC and total N, available P, exchangeable K, Ca and Mg concentrations among the different distances from the plant were statistically significant ($P < 0.01$) with the concentration of the properties decreasing with distance fron the plant with the control having the least, indicating a clear effect of the plant. All the parameters were observed to be highest at the base of the plant; 6.83 g kg^{-1}, 5.00 cmol kg^{-1}, 0.42 g kg^{-1}, 10.82 mg kg^{-1}, 0.26 cmol kg^{-1}, 0.50 cmol kg^{-1} and 0.97 cmol kg^{-1} for organic C, CEC, total N, available P, exchangeable K, Ca and Mg respectively. The interaction between the site and distance was also significant ($P > 0.05$). However, only a slight indication of decrease in pH was observed at the base of the plant. The enrichment factors calculated by the ratio of a particular propertyôs concentration at any distance within the plant canopy to its concentration at the control for the base of the plant, 0.5 m from the plant and 1m from the plant respectively were as follows: organic C; 1.93, 1.94 and 1.54, for CEC; 1.25, 1.05 and 1.05, for total N; 3.20, 1.00 and 1.00, for available P were 1.46, 1.39 and 1.34, for exchangeable K; 1.23, 1.19 and 1.14, for exchangeable Ca; 1.32, 1.29 and 1.18 and for exchangeable Mg; 2.16, 1.53 and 1.18 respectively (Figure 1). The effects could vividly be seen to decrease dramatically with distance away from the plant, with the control having the lowest organic C, CEC, total N, available P, exchangeable P, Ca and Mg of 3.46 g kg^{-1}, 4.00 cmol kg^{-1}, 0.12 g kg^{-1}, 7.43 mg kg^{-1}, 0.21, 0.38 and 0.45 cmol kg^{-1} respectively. The observed effects could be attributed to the ability of the plant to provide additional organic matter to the soil through the shedding of leaf litter, decay of the roots, stems and other parts of the plant and enhancing its decomposition by modifying the microclimate for more efficient microbial activities, retention of nutrients by preventing their loss through run-off, leaching e.t.c. and its role of preventing erosion by both water and wind thus retaining the rich top soil, among others, thus acting as an effective cover crop through its shoot network which provide a nearly complete cover on the soil as observed by several authors (Aliero and Anka, 2001; Yakubu and Singh, 2001; Mazza, 2006; Havlin *et al.,* 2005). This indicates that the plant could be used as a cover crop for maintaining soil fertility.

Even though, there was no change in soil texture observed as a result of the effect of the plant, an indication of higher silt and clay contents of the soils at the base of the plants relative to futher distance and soils in areas affected by the plant relative the to control which had higher sand contents (Table 2). This is not unconnected with the need for an effect of a very long period of time or large amount of organic matter in order to have a change in soil texture.

Table 1. Effect of *I. asarifolia* (Desr.) on chemical properties of soils atUsmanu Danfodiyo University, Sokoto main campus

Treatments	pH	OC g kg^{-1}	CEC cmol kg^{-1}	Variables Total N g kg^{-1}	Avail. P mg kg^{-1}	Exch. K cmol kg^{-1}	Exch. Ca cmol kg^{-1}	Exch. Mg g kg^{-1}
Sites								
VCC	8.02a	6.42ab	4.60a	0.12b	9.55b	0.26a	0.48a	0.49b
USA	7.05b	5.46b	4.80a	0.41a	9.72b	0.23c	0.48a	0.83a
BNL	8.08a	7.19a	4.00b	0.12b	10.30a	0.25ab	0.38b	0.50b
IBBC	7.28b	3.23c	2.00b	0.12b	9.00c	0.21c	0.49a	0.81a
Significance	**	**	**	*	**	**	**	**
Distance								
Control	7.74	3.46c	4.00b	0.12b	7.43d	0.21c	0.38c	0.45c
Plant base	7.54	6.83a	5.00a	0.42a	10.82a	0.26a	0.50a	0.97a
0.5m from base	7.55	6.71a	4.20b	0.12b	10.36b	0.25ab	0.49ab	0.69b
1 m from base	7.59	5.31b	4.20b	0.12b	9.96c	0.24b	0.45b	0.53bc
Significance	NS	**	**	*	**	**	**	**
SE	0.08	0.34	0.01	0.07	0.14	0.01	0.02	0.06
CV (%	3.82	12.21	9.62	11.36	4.95	11.08	11.61	3.57

VCC= Vice Chancellor Complex; USA= University stadium area; IBBC= IBB centre; BNL = Behind new library
Means within a treatment group at a column followed by the same letter(s) are not significantly diffrent ($P > 0.05$), * Significant at 5%, ** Significant at 1%, CV - Coefficient of variation.

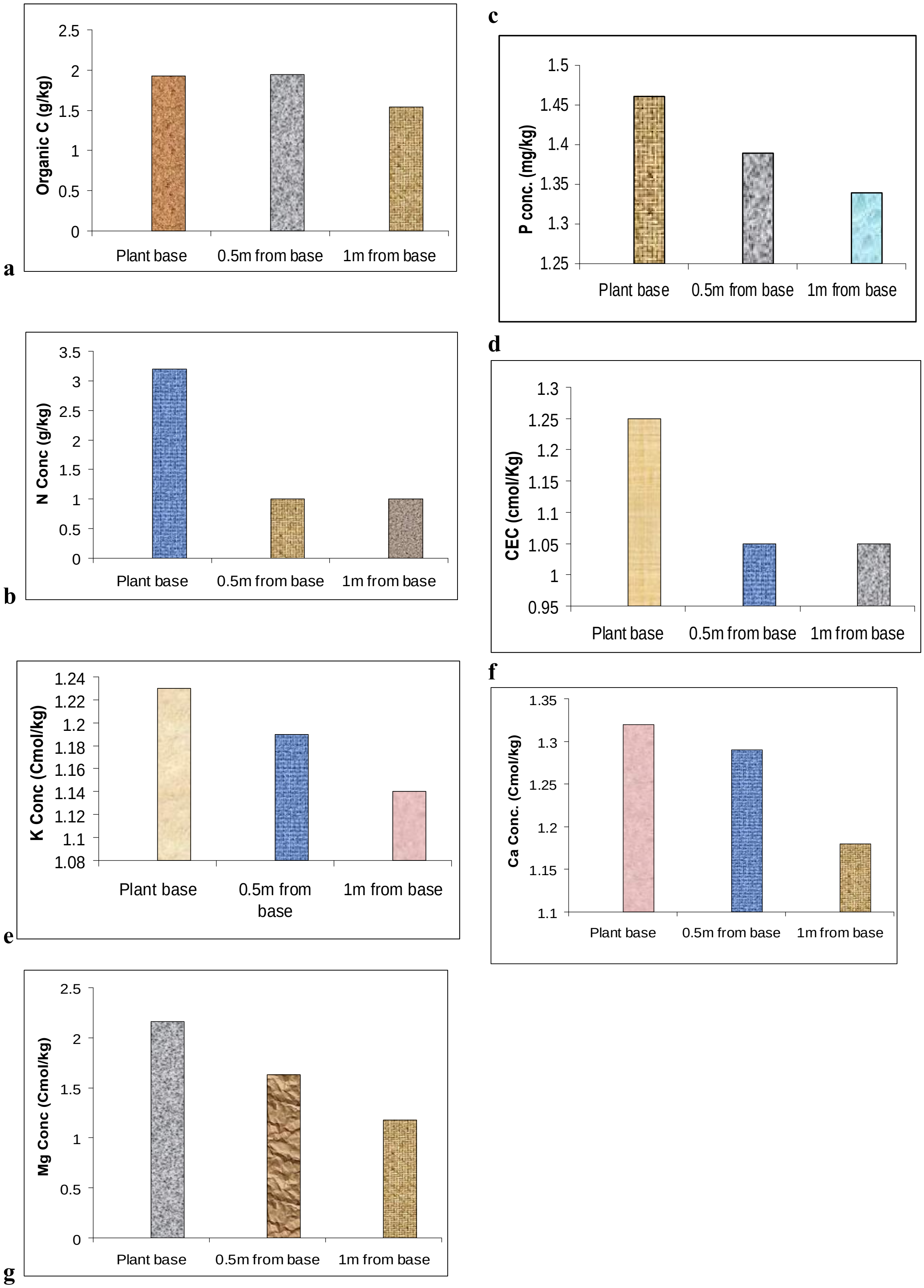

Figure 1: Enrichment factor of the various chemical properties in the soils of Usmanu Danfodiyo University, Sokoto main campus due to the effect of *I. asarifolia* (Desr). (a) Organic carbon (b) Total nitrogen concentration (c) Available phosphorus concentration (d) Cation exchange capacity (e) Exchangeable K (f) Exchangeable Ca and (g) Exchangeable Mg.

Table 2 Effects of *I. asarifolia* (Desr) on the particle size distribution of the soils of Usmanu Danfodiyo University, Sokoto main campus.

Treatments	Sand (%)	Silt (%)	Clay (%)	Textural
S_1D_0	93.40	3.80	2.80	Sandy
S_1D_1	93.10	1.50	5.40	Sandy
S_1D_2	94.50	2.00	3.50	Sandy
S_1D_3	94.10	2.40	3.50	Sandy
S_2D_0	96.80	3.00	0.20	Sandy
S_2D_1	94.10	1.80	4.10	Sandy
S_2D_2	94.50	1.40	4.10	Sandy
S_2D_3	94.80	1.10	4.10	Sandy
S_3D_0	97.20	2.40	0.40	Sandy
S_3D_1	94.80	2.40	2.80	Sandy
S_3D_2	94.80	2.40	2.80	Sandy
S_3D_3	94.50	2.70	2.80	Sandy
S_4D_0	96.80	2.70	0.50	Sandy
S_4D_1	94.10	2.80	4.10	Sandy
S_4D_2	93.50	2.40	4.10	Sandy
S_4D_3	93.40	2.50	4.10	Sandy

Sites: S_1(VC Complex Area), S_2 (University Stadium Area), S_3 (Behind new Library Area) and S_4 (Opposite IBB Centre Area). **Distances:** D_0 (Control), D_1, D_2 and D_3 (plant base, 0.5 m and 1 m from plant base, respectively

CONCLUSION

The study confirms the possible effect of *I. asarifolia* (Desr) as a potential cover crop for maintaining soil fertility, through its ability to retain plant nutrients and improve other chemical properties of soils, in the study area. The various areas vary in chemical properties in the order; University stadium area > VC complex area > New library area > IBB centre area. The concentration of all the chemical properties favourable to soil fertility decreased dramatically with distance from the plant, with the least in the control (bare land), hence it could be recommended for adoption as a cover crop, especially for erosion control and nutrients retention. Further studies are suggested to fully establish the usefulness of the plant as a suitable cover crop in the region which should include the analysis of the nutrient composition of the plant and possible adverse effect of its resin content. There is also the need to know the amount of nutrients retained and the extent of the modification of the chemical properties by the plant for known period of time when well established.

ACKNOWLEDGEMENT

The authors wish to acknowledge the contributions of Professor B. L. Aliero of the botany section of Usmanu Danfodiyo University towards the success of the study, Dr Ajit Singh who helped in the statistical analyses and Mal. Ahmad Modi, the laboratory Technician who helped immensely in it conduct of the laboratory analyses.

REFERENCES

Aliero, B.L. and Anka. S.A.B. (2001). *Biological Soil Conservation a Field Guide* . The University press Ltd., Usmanu Danfodiyo University, Sokoto. pp: 46 - 50.

Arnborg, T. (1988). *Where Savanna Turn into Desert*. Rural Development Studies No.24, Swedish University of Agricultural Science, Uppsala.

Bates, R.C (1954). *Electrometric pH determination*. Jounwiley and sons Inc. New York pp 35-38

Brady, N.C. and Weil. R.R. (1999). *The Nature and Properties of Soils.* 12th ed. Prntice - Hall Inc. Simon and Scuster A.Viacon company Upper Saddle River, New Jersey.

Bray, R.H. and Kurtz, L.T. (1945). Determination of total and available forms of phosphorus in soils. *Soil Sci.,* **59:** 39 - 45.

Chapman, H.D. (1965). Cation Exchange Capacity. In: *Methods of Soil Analysis*, part II,Agronomy No.9; Black , C.A. (ed) Am. Soc. of Agronomy Madison, Wisconsin, pp 891-901.

Gee, G.W. and Bouder, J.W. (1986). Particle size analysis. In: Aklate (ed.) *Methods of Soil Analysis*, 2nd ed. No.9 ASA. Inc. SSSA Madison, Washington D.C. pp: 383 - 409.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (2005). *Soil Fertility and Fertilizers: An introduction to nutrient management.*7th ed. Pearson Education Inc., Upper Saddle River, New Jercy. pp.515

Jackson, M. L (1962). Soil Chemical Analysis. International Institute for Tropical

Agriculture (IITA). Manual Series No.1, 70p

Kundsen, D., Peterson, G.A. and Prett, P.F. (1982). Lithium, Sodium, Potassium. In: A. L. Page, R. A. Miller, D. R. Keeney (eds.) *Methods of Soil Analysis*, Part 2 Afron. Amer. Soc. Agron. Inc. Madison Wisconsin, 5-246.

Mazza, C. (2006). Cranell gardening resources using organic matter in the garden. http://www.gardening.cornell.edu/Factsheets/orgmatter (Accessed 2/12/2006).

Nelson, D.W. and Sommers, L.E. (1982). Total carbon, organic carbon and organic matter.p:530-577. In: A. L. page et al (ed). Methods of soil Analysis. Part 2. 2nd ed. Manogr. 9 ASA and SSSA Madison, W.

Noma, S.S. (2005). Properties, Genesis and Classification of Sokoto - Rima Floodplains at Sokoto, Nigeria. PhD Thesis, Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto (Unpublished).

Olaitan, S.O. and Lambin, G. (1988). In: Onazi A.C. (ed). *Introduction to tropical soil science.* Macmillan publishers Ltd. London and Basingstoke. 124 pp.

Reuben, K.U. (1981). *Geographical Regions of Nigeria.* Heinemann, London, pp. 38-90.

Saa, A.,M., Trasar-Cepeda, C., Soto, B., Gilsotres, F. and Diaz-Fierros, F. (1994). Forms of Phosphorus in the sediments eroded from burnt soils. *J. Environ. Qual.* **23:** 739-746.

Singh, B.R. and Babaji, G.A. (1989). Characteristics of Soils in Dundaye District I. The Soils of the University Dry Land Farm. *Niger. J. Basic Appl. Sci.* **3:**7-16.

Sombroek, W.G. and Zonneveld, I.S. (1971). Ancient Dune Fields and Flunatile Deposits in the Rima-Sokoto River Basin (NW Nigeria). Soil Survey Paper No. 5 Soil Survey Institute Wageningen. 109 pp.

Yakubu, M. and Singh, B.R. (2001). Erosion losses of soil and nutrient from Dry land Farm in Sokoto, *Niger. J. Agric. Environ.* **2(1)**:142-149