Asian Journal of Agricultural Sciences 3(2): 58-62, 2011
ISSN: 2041-3890

Received: April 12, 2010 Accepted: May 04, 2010 Published: March 15, 2010

Soil Dynamics under Continous Monocropping of Maize (*Zea mays*) on a Forest Alfisol in South-Western Nigeria

[1]O.S. Eludoyin and [2]C.C. Wokocha
[1]Department of Geography and Environmental Management,
[2]Department of Crop and Soil Science, University of Port Harcourt, Port Harcourt, Nigeria

Abstract: The present study evaluated the impacts of maize cultivation on soil properties under the continuous monocropping system of farming in South-western Nigeria. Soil samples were collected from both cultivated maize plot and less disturbed secondary forest, both lying contiguous to each other. Laboratory analysis was carried out to determine the levels of particle size composition, porosity, bulk density; and concentrations of Cations Exchange Capacity (CEC), Exchangeable Sodium (Na), Exchangeable Calcium (Ca), Exchangeable Magnesium (Mg), Available Phosphorous (P), Soil pH, Exchangeable Acidity, Organic Carbon (C) and Nitrogen (N). The mean of each of these soil properties was used for comparison and t-test was also used to determine the significant difference that exists in each soil property. The result shows that the level of C, N and porosity were higher in soils under forest than soils under maize. However, there was no significant difference in Exchangeable Acidity, Mg, Soil pH and Ca in the two land use types. Nevertheless, the concentrations of Na and K were higher in the cultivated soils while P and Ca were lower in the cultivated soils. The particle size composition was predominantly sandy. Planting of cover crops, mixed cropping and mulching among others were suggested as ways to minimize erosion and leaching so that fertility can be restored and maintained.

Key words: Alfisol, forets, maize, monocropping, soil dynamics, south-western

INTRODUCTION

The geometric increase in population in the developing region necessitated several means of survival, which include agriculture in order to safeguard against food shortage and malnutrition. This development has however made agricultural practices to be shifted from the traditional extensive system of shifting cultivation to continuous farming (Aweto, 1981a), and this could be in form of intercropping or monocropping. Whichever is the form, crops are grown year in year out on the same plot.

It is therefore important to know that during cropping, there is lowering of soil fertility and this can be highly observed in continuous cropping because the soil is exposed for long and unprotected from damaging climatic influences. Finck (1973) viewed that the reduced yields in variable lands in the tropics, which become apparent, even after a year or two of cultivation is caused by a lowering of soil fertility and thus poses many constraints on intensive food crop production in tropical Africa (Lal, 1987) suggesting that if adequate care is not taken, tropical soil will be subjected to degradation and the natural purpose the fertile land suppose to supply will be defeated. Nye and Greenland (1960) observed that calcium declined from 1.57 to 1.15 me/100 g and nitrogen declined from 0.06 to 0.05% following a forest clearing for two years in Trinidad. Similarly, Aweto *et al*. (1992) observed that continuous intercropping of cassava and maize appeared to have a greater harmful effect on soil in terms of soil organic, total nitrogen and available phosphorous while Dalal and Mayer (1986a) also reported that soil C and soil N were greatly reduced in the cereal-belt of Southern Queensland following land clearing. Maize (*zea mays*) is a staple and popular food for the populace of Nigeria and mostly intercropped with crops like cassava, vegetables, and yams to mention a few in peasants farming due to the decrease in virgin land in the South western part of Nigeria. Nevertheless, maize plantation still exists in some commercial farms. Considering various effects caused by crops on soil properties, it is also important and advisable to assess the soil quality under the continuous monocropping of maize so as to promptly step up the restoration measures if the soil is degraded. Many studies on agronomy of food crops have been carried out and these include Kowal and Kassam (1978), Aweto *et al*. (1992), Lal (1987), Dalal and Mayer (1986a) and Nye and Greenland (1960) to mention a few but most of the studies carried out on maize and soil quality were under intercropping system of peasant farming. Therefore, this study evaluates both the physical and chemical properties of soil under the continuous monocropping of maize.

MATERIALS AND METHODS

Study area: The study was carried out at International Agriculture for Research and Training (IAR&T) Ibadan, Nigeria whereby maize is planted on a plot of land every

Corresponding Author: O.S. Eludoyin, Department of Geography and Environmental Management, University of Port Harcourt, Port Harcourt, Nigeria

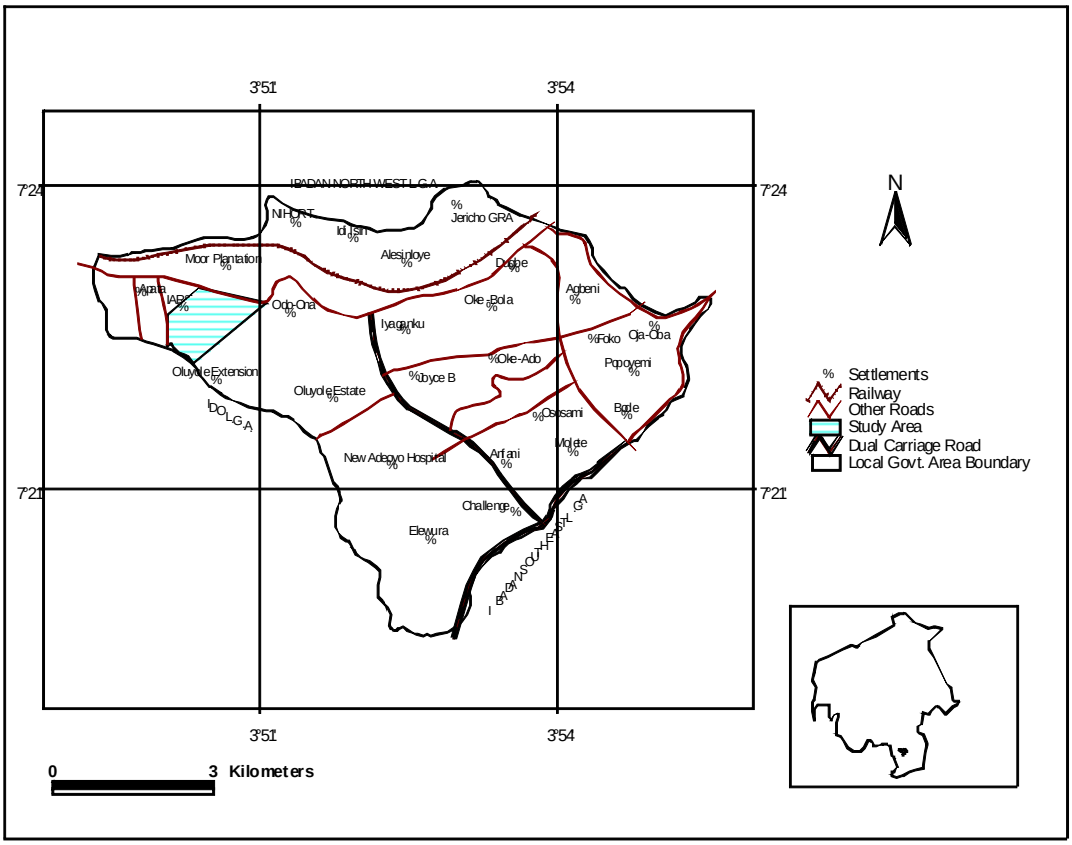

Fig. 1: Map of Ibadan South West LGA showing the study area, Inset: Map of Oyo State showing Ibadan South West local govt. area

year for experimental purpose (Fig. 1). This is a commercial farm practiced on a large scale and almost all farm operations are done with the use of machines. Ibadan is located relatively between latitudes 7º 25′ and 7º 45′ N; and longitudes 3º 40′ and 3º 70′ E. The area is made up of series of hills and plains. The hills are made up of quartzite ridges and they occur widely in this area (Faniran, 1978). The gneissic inselberg dominates the northeastern corner of Ibadan. The plains form the most extensive landform in Ibadan with elevation ranging between 180 and 210 m above sea level. The entire area is well drained by small and large rivers, which are seasonal. These include Ogunpa, Kudeti, Ona River and their tributaries. The climatic condition of the area is characterized by wet and dry periods with most rains falling during the rainy season from March to October. Average annual rainfall over the area is about 2100 mm, which shows marked monthly pattern, the highest being recorded in July and September. Temperatures (minimum and maximum) are generally high throughout the year. Average temperature in the area is 27ºC. Relative humidity is also relatively to the influence of the dominant tropical maritime air mass. Soils of the area belong to the ferruginous tropical soil. The climax vegetation is the tropical rainforest characterized by high species diversity and marked stratified grasses that form the under storey layers in this forest. The main human activity in the area is farming.

Methodology: The study was carried out at International Agriculture for Research and Training (IAR&T) Ibadan, Nigeria in 2004 whereby two plots of maize (cultivated plot) and less disturbed secondary forest (uncultivated plot or control plot) were selected. Soil samples were collected randomly from twenty sample points in each of the land use type. Both plots are within the same climatic region, relief, parent material and soil types. This makes comparison of soil properties between the two land use types possible. Thus any difference observed between the soils under cultivated plot and uncultivated plot will be accounted for by differences in nature of the plant cover.

The soil samples were collected from 0-15 cm depth of the topsoil with bucket auger into well-labeled polythene bags and brought into the laboratory for various analyses. The soil samples were air-dried and carefully sieved with 2 mm diameter mesh after which standard laboratory techniques were used to determine some physical and chemical properties of the soil. Soil samples

were analyzed for particle size composition using the hydrometer method (Bouyoucos, 1926); bulk density and total porosity using core method (Blake, 1965)

Exchangeable bases which include Calcium (Ca), Potassium (K) and Sodium (Na) were determined by flame photometry, and exchangeable magnesium by atomic absorption spectrophotometer. Cation Exchange Capacity (CEC) was determined using summation method (Chapman, 1965) and total Nitrogen (N) was determined by Kjeldahl steam distillation. Available Phosphorous (P) was extracted with Bray P solution (Murphy and Riley method) and measured calometrically (Bray and Kurtz, 1945). Soil pH was measured potentiometrically in 0.01 M calcium chloride solution. Organic Carbon (C) was determined using the chromic acid digestion method (Walkey and Black, 1934). The method of statistical analysis adopted was pair-wise t-test, otherwise known as paired comparison as described by Snedecor and Cochran (1967). It was used to determine the significant differences that exist in the soil properties between maize and forest plots. The means of the soil properties or parameters examined for each of the maize and forest plots were calculated.

RESULTS AND DISCUSSION

Effects of monocropping of maize on physical properties of soil: The result of the analysis of sand particles level in soils under maize was 77.36% while forest was 71.4%. Silt level in cultivated soil was 10.6 and 15.4% in forest soils. The mean value of clay particles was higher in forest plot than maize plot (Table 1 and Fig. 2). However, the mean value of porosity under forest soils was 46.50% while 43.60% under maize cultivation. The analysis shows that porosity level of soil in both plots was similar. Furthermore, the bulk density analysis reveals that bulk density was higher in the cultivated site than the control plot (Table 1 and Fig. 2). The t-test shows that there was significant difference in all physical properties between the two land use types under study except total porosity (Table 1).

Effects of monocropping of maize on chemical properties of soil: The result of the analysis shows that organic carbon in soil under maize cultivation had mean value of 0.96% compared to 2.02% under forest soils. There was no significant difference in the soil pH between the two land use types. Total nitrogen, available phosphorous and exchangeable magnesium were higher in soil under forest than the soil under maize cultivation while exchangeable sodium, exchangeable potassium, exchangeable acidity and cation exchange capacity were higher in soil under maize cultivation (Table 2 and Fig. 3). This present study shows that only total nitrogen, exchangeable sodium and organic carbon varied significantly (Table 2).

Table 1: Physical properties of soil under both maize and forest plots

Soil property	Maize plot	Forest plot	Calculated t-values
Sand (%)	77.36	71.40	2.84*
Silt (%)	10.60	15.40	3.50*
Clay (%)	11.64	12.10	3.50*
Porosity (%)	39.62	46.50	1.64NS
Bulk Density (%)	1.49	1.39	3.24*

Author's Fieldwork, 2004; *: Significant difference at 5% confidence level; NS = Not Significant at 5% confidence level

Table 2: Chemical properties of soil under both cassava and forest plots

Soil property	Maize plot	Forest plot	Calculated t-values
Soil pH	7.24	7.26	1.64NS
Total Nitrogen (%)	0.20	0.39	3.90*
Available Phosphorous (ppm)	11.97	12.59	1.97NS
Exchangeable Calcium (me/100 g)	3.28	3.44	0.66NS
Exchangeable Magnesium (me/100 g)	1.20	1.27	0.99NS
Exchangeable Sodium (me/100 g)	2.05	1.66	2.39*
Exchangeable Potassium (me/100 g)	1.43	1.28	1.21NS
Exchangeable Acidity (me/100 g)	0.22	0.21	0.32NS
Cation Exchange Capacity (me/100 g)	8.28	7.86	0.79NS
Organic Carbon (%)	0.96	2.02	4.95*

Author's Fieldwork, 2004; *: Significant difference at 5% confidence level; NS = No Significant difference at 5% confidence level

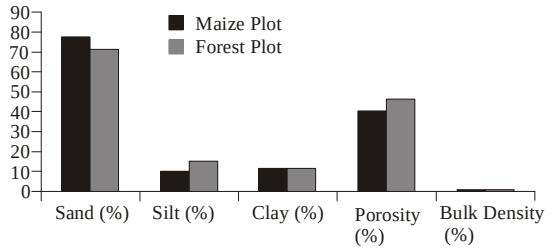

Fig. 2: Chart showing the physical properties of soil under both maize and forest plots

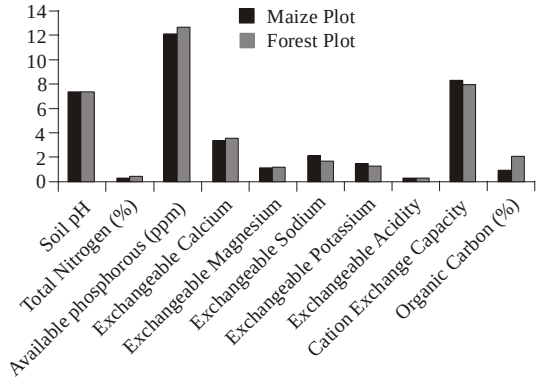

Fig. 3: Chart showing the chemical properties of soil under both maize and forest plots

DISCUSSION

The result shows that the distribution of particle size composition reveals that the two plots were predominantly sandy but texturally homogenous having derived from pre-Cambrian granites of basement complex origin. The higher sand particles observed in maize land use type may be presumably due to erosion caused by the

long period of intensive cultivation while the lower proportion of silt particles under cultivated plots suggested that cultivation of crops especially under continuous monocropping reduces silt particles in soil. This may also be attributed to erosion, which removes finer particles of soil due less vegetative cover that could reduce the impact of raindrops on soil in the cultivated plots. The clay particle, which had insignificant variation between the two land use types, suggested that the soils are similar with respect to textural composition since the soils are derived from the same parent materials. Bulk density was higher in the cultivated site; however the result corresponds with the observation of Dalal (1982) that bulk density increases with increase in the period of cultivation. This otherwise shows that as cultivation causes decline in the organic matter, the bulk density increases.

The analysis of organic carbon is related to Woodruff (1949) view that says whenever virgin soils are brought under cultivation and cropping, organic carbon content generally declines because the amount of organic materials returned to the soil decreases sharply. The lower organic matter content of maize cultivation compared to forest was therefore due to site clearance before cultivation which would have disrupted the rate of organic matter decomposition (Nye and Greenland, 1960; Areola, 1984; Agboola, 1985), and this would have given chance for erosion and leaching to degrade the soil. Meanwhile the soil pH analysis is similar to the findings of Aweto *et al*. (1992) in the study of the effects of cassava intercropped with maize on a forest alfisol in south western Nigeria.

The lower concentration of total nitrogen in the maize plot reflected the organic matter dimunition as organic matter has a direct influence on it (Aweto, 1981b). This could be attributed to the leaching of nitrogen in its soluble form as it (leaching) is accelerated by clearing of vegetation and higher percentage of sand content. Kowal and Kassam (1978) stressed that the nitrogen status of the soil is closely associated with the soil organic matter as it (organic matter) is the major source of soil nutrients. This nutrient decline is also due to nutrient removal while harvesting maize because the crop stores large quantities of nitrogen (Cooke, 1982). Furthermore, calcium concentration was revealed to be higher among all other exchangeable bases in the study area; thus, this conforms with the observation made by Aweto *et al*. (1992) that calcium concentration was the highest of other exchangeable bases on a forest alfisol in South western Nigeria. It is however glaring that magnesium concentration was higher in the forest plot than maize plot. This may be attributed to organic matter dimunition and more so, more magnesium would be undoubtedly utilized by cultivated crops and some may be washed off by surface erosion following the exposure of forest by burning and tree felling (Adejuwon and Ekanade, 1975). The level of sodium concentration which was higher in the cultivated soil may be presumably due to selective mobilization of sodium by certain forest species while the higher concentration of potassium in maize land use type suggest that forest makes more demand on potassium than monocropping of maize.

CONCLUSION

The impact of continuous monocropping of maize can be clearly observed from the result of the analysis. Despite the importance of maize as a major food crops that can meet up and sustain the growing population, it still degrades both the physical and chemical properties of soil and the soil quality is impaired and degraded. It is therefore concluded that monocropping of maize reduces the soil nutrient especially the organic matter which is the basis of the nutrient status of the soil.

RECOMMENDATION

It is important at this juncture to suggest some ways to reduce the problem of soil quality degradation caused by maize cultivation which could assist in restoring, managing and maintaining the soil fertility. The heavy rainfall in the study area is a major factor causing soil erosion and even leaching of essential nutrients; therefore planting of cover crops would check erosion and also prevent leaching. The relatively low organic matter content discovered in the study area can be improved by mulching so that the soil can be cultivated for many years with good yield. Mulching would help to maintain fertility of the soil because of its ability to reduce run-off intensity and effects of direct insolation. It would also help to make soil more structurally stable and inhibit the growth of weed. Finally, mixed cropping should be adopted. This would allow growing of different crops on the same plot of land at the same time especially leguminous plants, which can help in fixing atmospheric nitrogen.

REFERENCES

Adejuwon, J.O. and O. Ekanade, 1975. Soil changes associated with forest/savanna boundary. Nigerian Geogr. J., 27(1-2).

Agboola, A.A., 1985. The relationship between soil pH, soil organic matter, available hosphorous, exchangeable potassium and nine elements in maize tissues. J. Soil Sci., 115: 367-375.

Areola, O.O., 1984. The characteristics and Fertility status of the old cocoa farms in Ibadan Region, Nigeria. Malays. J. Trop. Geogr., 10: 1-11.

Aweto, O.A., 1981a. Fallowing and soil, soil fertility restoration in South Western Nigeria. Malays. J. Trop. Geogr., 3: 1-7.

Aweto, A.O., 1981b. Total nitrogen status of soils under bush fallow in the forest zone of South Western Nigeria. J. Soil Sci., 32: 639-642.

Aweto, A.O., O. Obe and O.O. Ayanniyi, 1992. Effects of Shifting Cultivation and Continuous Cultivation of Cassava (manihot esculenta) intercropped with maize on a Forest Alfisol in South Western Nigeria. J. Agr. Sci., Cambridge, 118: 195-198.

Blake, G.R., 1965. Bulk Density. In: Black, C.A. (Ed.), Methods of Soil Analysis. Vol. 1, A.S.A. Madison, Wisconsin.

Bray, R. and L.T. Kurtz, 1945. Determination of total organic and available forms of phosphorous in soils. Soil Sci., 59: 39-45.

Bouyoucos, G.J., 1926. Estimation of the colloidal material in soils. Soil Sci., 64: 362.

Chapman, H.D., 1965. Cation Exchange Capacity in Methods of Soils Analysis. In: Black, C.A. (Ed.), Madison: American Society of Agronomy, pp: 891-901.

Cooke, G.W., 1982. Fertilizing for Maximum Yield. 3rd Edn., Granada Publishing Ltd., London.

Dalal, R.C., 1982. Organic matter content in relation to the period of cultivation and crop yields in some sub-tropical soils. 12th International Congress. Soil Sci., 6: 59.

Dalal, R.C. and R.S. Mayer, 1986a. Long-term trends in fertility of soils under continuous cultivation and cereal cropping in South Western Queensland, I overall changes in soil properties and trends in winter cereal yields. Aust. J. Soil Res., 24: 265-279.

Faniran, A., 1978. Essentials of Soil Study. Heinemann, Ibadan.

Finck, A., 1973. The fertility of tropical soils under the influence of agricultural land use. Appl. Sci. Dev., 1: 7-31.

Kowal, J.M. and A.H. Kassam, 1978. Agricultural Ecology of Savanna. A Study of West Africa, Clarendon Press, Oxford, UK.

Lal, R., 1987. Managing the soils of Sub Saharan Africa. Science, 4(236): 1069-1076.

Nye, P.H. and D.J. Greenland, 1960. The soil under shifting cultivation. Plant Soil, 21: 101-112.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods. 6th Edn., Iowa State University Press, USA.

Walkey, A.B. and I.A. Black, 1934. An examination of the detjareff method for determining soil organic matter and a proposed modification to the chromic acid titration method. Soil Sci., 37: 29-38.

Woodruff, C.M., 1949. Estimating the nitrogen delivery of soil from the organic matter determination as reflected by sanborn field. Soil Sci., 14: 208.