

SPATIAL AND DEPTH VARIATION OF SOIL PHYSICO-CHEMICAL PROPERTIES OF TWO LAND USE SYSTEMS IN UMUDIKE, ABIA STATE, NIGERIA

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Abstract

The effects of two land use systems, oil palm plantation and arable cropping (maize, melon and cassava mixtures) on soil physicochemical properties were evaluated along the axis of horizontal spacing and depth variability in Umudike, Abia State. Soil samples were collected at three depths; 0-20, 20-40 and 40-60cm respectively using soil auger, from five locations 10m apart within a hectare area. The samples were collected in three replicate each from the two different land uses and an adjacent area of land was sampled and used as control. The samples were analyzed in the laboratory using standard procedures. The data obtained were subjected to analysis of variance (ANOVA) and means were separated using Fisher's least significant difference at five percent probability level. The study showed that the different land uses produced differences in soil physical and chemical properties across the fields and the values for these properties decreased with depth of the soil. However, the texture of the soil (sandy loam) was the same in both land use studied. Soil properties investigated such as organic carbon content of the arable cropped land varied, with OC value for the arable land classed as medium (1.54-1.70) compared to that of oil palm plantation which was high (2.01-2.06). The soil pH of arable cropped farmland varied from strongly acidic to moderately acidic (4.70-5.21) while oil palm farm was moderately acidic (5.13-5.33). The effect of depth of sampling indicated that soil chemical properties varied with depth indicating that beyond 40cm depth nutrient elements decreased as you move down the profile limiting plant nutrient absorption and proper crop growth and yield. Therefore spatial and depth variability in soils should be taken into consideration during soil testing to enable efficient prediction of the quantity of input (fertilizer or organic manure) required for uniform and maximum plant growth and yield.

Keywords: Land use, spatial variability, arable land, organic carbon and depth variability

Introduction

Agricultural land use pattern has several effects on the physical, chemical and biological properties of soil (Enwezor, 2001). Land use defines the arrangement of activities and inputs undertaken in a certain land cover type to produce change or maintain it (FAO, 1997). According to Vink (1975), land use also defines any permanent or cyclic human interactions to satisfy human needs from complex natural and artificial resource which constitute land. It is a resultant interplay of available land resources with cultural, social and economic conditions of the past and present development when two or more land use types occur on the same soil (Akamigbo and Asadu, 2001). Land use information is used to develop solutions such as salinity and water quality, and has been categorized into major kind as rain fed agriculture and into primary or compound kinds in which more than one kind of land use is practical within an area (FAO, 2002). There are indications that effects of different land use and management practices on soil properties vary in significant and degree depending on the method of the application of the management practice (FAO 1997) the soil type, previous history and geomorphic position. The capacity of the soil to support plant and animal life, water availability, soil erodibility and responses of soil to changes in the environment depends on

the structural indices of the soil. Soil erosion has always accompanied certain land use and soil management practices (Parker and Charles, 1983),

The use of lands must be planned and soils properly managed if it is to continue to support crops and give the maximum yield because land use affects soil fertility and productivity. These manifest as changes in soil properties such as nutrient content (N, P, K, Ca, Mg, S, etc.), pH, organic matter, cation exchange capacity and structure. Research reports (Aluko and Fagbemi (2000), Akinrinde and Obligbesan (2000), and Akamigbo and Asadu 2001) generally observed marked influences on morphological, physical and chemical properties of soils which resulted to accelerated pedogenic processes and a decline in fertility of soil under traditional than forest land use. It has been observed that as the fertility of the soil declines, soil structure weakens and the soil becomes susceptible to erosion (Adetunji, 2005). Soil degradation occurs mainly as deterioration of physical properties by compaction or surface crusting or as deterioration of chemical properties by acidification or salt accumulation. Nwajiuba (1999) reported that agricultural production system in Nigeria relies on traditional soil fertility regeneration methods such as, crop rotation, monocropping, fallow management and shifting cultivation for many years and attributed this to increased land degradation, soil infertility status of soil. Other farming practices such as burning also reduce the soil nutrient which cultivation takes from the soil or the crops will not yield well and will be damaging the world's most valuable resources.

Fertile lands have changed to their present barren state through improper land use (Chepil and Woodruff, 1963) and in parts of Nigeria; many hectares of arable land have become gullied due to destructive anthropogenic activities (Akamigbo, 1993). Different management practice can affect the soil aggregate stability as an index of soil structure status and soil quality (Ezyz and Dexter, 2009). In comparison with forest soils, continuously cultivated soils have lower organic matter content and unstable aggregates. In order to suggest appropriate land use system, it is essential to qualify the changes that occur in soil properties under different land use system. The distribution of these properties at different slope positions in turn affects crop yield. However, there are indications that affect different land use and management practices on soil properties vary in significant and degree depending on the methods of application of the management practices, the soil type previous history and geomorphic position. Hydraulic conductivity, soil organic matter exchangeable cations are among such properties as these enhance the soil ability to resist erosion and maintain productivity (Kay, 1999). Cultivation loosens the soil temporally and this generally results in the reduction of organic matter and soil compaction which affects soil structural indices. In soil under in situ conditions, particles of clay, silt and sand are combined in a number of different ways and held together by forces resulting in aggregate formation and stabilization (Piccolo and Mbagwu, 1999). The specific objective of the study was to study the spatial and depth variation of the soil physical and chemical properties in two land use systems (oil palm plantation and arable cropping) in south eastern Nigeria.

Materials and Methods

The study was conducted at Michael Okpara University of Agriculture Umudike (MOUUAU). Soil samples were collected from two different land uses, oil palm plantation, arable land use (mixed cropping of cassava, melon and maize). The area is located at latitude 05° 29'N and longitude 07° 33'E. It has a mean annual rainfall of 2238mm with maximum and minimum temperature of 32°C and 23°C respectively and relative humidity of 63- 80% (Meteorological Station NRCRI, Umudike. 2005).

Sampling Procedure

Soil samples were collected using soil auger from a hectare area of land. The samples were collected from three depths, 0-20cm (top soil), 20-40cm and 40-60cm (subsoil) from the two different land uses. In each land use, samples were collected in five (5) locations with three replicates each. Samples were also collected from adjacent area of land as control and were replicated three times. The soil samples were air-dried and passed through a 2mm mesh sieve before laboratory analysis.

Laboratory Analysis

The soil properties analyzed were; soil particle size, determined using hydrometer method (Day, 1965). Exchangeable acidity of the soil was determined by titration method following the procedures as described by MClean (1965). The available phosphorus was determined by Bray and Kurtz (1945) No.2 method. Organic carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1934). Total soil nitrogen was determined by the macro-Kjeldahl method, and the soil pH was determined in 1:2.5 soil-water suspension. Cation exchange capacity (CEC) was determined by leaching with Ammonium acetate, distillation using Kjeldahl apparatus and titrated as described by Eno *et al.* (2009).

Statistical Analysis

The results from laboratory analysis were subjected to analysis of variance using a split plot in an RCBD, with soil depth as the main plot treatment and land use as sub plot treatment. Means separation was carried out by Fisher's least significant difference (F_{LSD}) at 5% probability.

Results and Discussion

The results presented in Tables 1 and 2 are the mean values for soil physico - chemical properties for the land use systems. From the result the soil pH, organic matter, total nitrogen, exchangeable acidity, and cation exchange capacity for the oil palm plantation were significantly higher than those in the arable/ mixed cropping land use. The soil reaction varied from strongly acidic (4.70) in the arable farm land to moderately acidic (5.33) in oil palm plantation. The two land use types generally have moderate concentrations of cations as reported by Agbede (2009). A comparison of selected properties for the two land use systems, (Table 3) indicated that there were no significant differences in the textural classes as both were sandy loam textured soils, however, oil palm plantation differs significantly from arable farm land in pH level, organic carbon content, total nitrogen, available phosphorous, exchangeable acidity and cation exchange capacity. Generally other soil properties were high in the arable cropped farmland and moderate in oil palm plantation, this observation agrees with the report of Akamigbo (1998) who also obtained higher values for soil properties in plantation land use system compared to arable crop land use. A study of spatial and depth variability in of soil properties (Table 4,5 and 6) indicated that properties such as pH, organic carbon, total nitrogen, available phosphorus, exchangeable acidity and cation exchange capacity varied significantly across the fields (10 meters apart) as well as down the depth. While pH levels increased down the depth, other properties showed an inverse relationship as you go deeper into the subsoil. This is attributable to the leaching of soil nutrients (especially basic cations) down the depth resulting in more acidic top layer of the soils (Brady and Weil 2007). The correlation matrix of selected physico-chemical properties of soil of oil palm and arable farm (Table 7) showed significant ($p < 0.05$) correlation between clay, sand, organic matter and total nitrogen. Cation exchange capacity correlated positively with clay, silt, total nitrogen, available phosphorus and exchangeable acidity while cation exchange capacity correlated negatively with sand, pH, organic matter. However, there were significant ($p > 0.05$) relationship between cation exchange capacity with pH, available phosphorus and exchangeable acidity.

Conclusion

The study showed that there were spatial and depth variation in soil physico-chemical properties for the soil under study. This variation shown to be significantly ($p < 0.05$) affected by land use. The different land uses showed increases the values of soil physical and chemical properties across the horizontal distances in the fields and decreased in values down the depth of the soil. The trend in variation was the same in both oil palm plantation and the arable farm land. However, texture was the same (sandy loam) in both farm lands but all other properties investigated including cation exchange capacity were higher in oil palm plantation than the arable farm land. Based on the result of this research work, it is recommended that crops/ plants with rooting depth below 40cm may not do well in these soils as beyond 40cm depth of the soil the nutrient elements decreased, such that plants may not be able to absorb enough for proper growth and yield. Also proper soil testing of a field soil and along horizontal distances of about 10 meters would enable efficient prediction of the quantity of inputs (fertilizer or organic manure) required for uniform and maximum growth and yield.

References

- Adetunji M.T. (2005) Comparative effects of organic and inorganic fertilizer on soil chemicals properties. Annual conference, soil sc.. Nig. Ibadan, Oyo State. Pp 56-60.
- Agbede O.O. (2009). Understand soil and plant nutrition. Salmon publishers, Nigeria, pp: 58-79.
- Akamigbo F.O.R (1998). Influence of parent materials on the soil of south eastern Nigeria. East Africa Agriculture and Forestry Journal 5(48):81-91.
- Akamigbo F.O.R and Asadu C.L.A (2001). Influence of parent materials on the soil of south eastern Nigeria. East Africa Agriculture and Forestry Journal 48:81-91.
- Akamigbo FOR (1993) Chemical and mineralogical properties of soil in southeastern Nigeria in relation to aggregate stability. Geoderma 93:111-123.
- Akinrinde, E.A and Obigbesan G.O.(2000). Evaluation of fertility status of selected soil for crop production in five ecological areas of Nigeria. Proc. 26th Annual Conf. Soil Sci. Soc. Nig Ibadan, Oyo State. Pp 279 -288
- Aluko, A.P and J.A Fagbenor, Akinrinde & Obligbesan (2000). The role of tree species and land use systems in organic matter and nutrient availability in degraded Ultisol of Onne, Southeastern Nigeria. Proc. Annual Conf, Soil Sci Soc. Nig. Ibadan, Oyo State. Pp 89-292
- Angers, D.A (1992) Changes in soil aggregation and organic carbon under corn and alfalfa. Soil Sc. Soc. Am. J. 56:1244-1249
- Brady, N. and Weil (2007). The nature and properties of soils (14th edition) by prentice hall, Inc New Jersey Pp 214-520
- Bray, R.H and Kurtz, L.T (1945) Determination of total organic and available forms of p in soil Sc. 56:39-45
- Chepil W.S. Woodruff N.P. (1963) The physics of wind erosion and it control. Advances in agronomy 13:211-302.
- Day (1965). Soil textural analysis. Particle fractionation and particles size analysis. P. 545-567.
- Eno, J.U. Trenchard, O. Ibia, Joseph, A. O. Anthony, O. A. and Ivara, E. E. (2009). Manual of Soil Plant and Water Analysis. Pp 183.
- Enwezor W.O, (2001). A review of Soil Fertilizer use in crops in Southeastern Zone of Nigeria (in five volumes). Produced by the Fed. Min. Agric and Nat. Re. Lagos.
- Ezyz and Dexter (2009), Crop rotation impact on soil quality (ed): A Klute American society of agronomy and soil science society.
- Food Agricultural Organization (FAO, 1997) Land use categories recognized in FAO'S world census of agriculture.

- Food Agricultural Organization (FAO, 2002). Land and agriculture: a compendium of recent sustainable development initiatives in the field of agriculture and land management. 57pp.
- Kay, B.D (1999) Mineral Soil surface crusts and wind water erosion soil structure in handbook of Soil Science: Effects of tillage practices on aggregate size distribution
- Mclean, E.O. (1965). Methods of soil analysis. Soil science laboratory manual part III . NRCRI (2005) Nation Root Crop Research Institute Umudike. Bulletin.
- Nwajiuba C.U. (1999) Prospects of the use of agricultural wastes in soil fertility regeneration in Nigeria” paper accepted for presentation at the conf. on energy and agree towards the third minimum Greece.
- Parker C.J. and C.J. Charles (1983).The effects of recent land use changes on red Podzoliz soils near Syndey N.S.W. Australia catena. 10:61-76.
- Piccolo and Mbagwu (1999) Water repellency of aggregate size fractions of a volcanic ash soil. (Eds) Soil Science Journal pp. 4-7.
- Vink (1975) Land use in advancing agriculture. (Ed) Pp. 122-134.
- Wakley A and Black C.A. (1934). An examination of the digijareff method for determining soil organic carbon in soil an proposed modification of the chronic acid titration method. Soil sci. 37:29.38.