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Influence of Landuse on Soil Properties of Three Mapping Units in Southwestern Nigeria-Implications for Sustainable Soil Management

A.S. Fasina, F.O. Omolayo, O.S. Ajayi and A.A. Falodun
Department of Crop, Soil and Environmental Science, University of Ado-Ekiti, Nigeria

Abstract: The influence of landuse on 19 soil properties is described using four mapping units from granitic parent materials in southwestern Nigeria. The three mapping units seem to be homogenous with respect to % sand, soil pH and Base saturation (Cvs of 5.53, 5.16 and 7.95%). The different landuse types (Yam, maize and Natural fallow) have been found to cause variation in topsoil properties within the three mapping units studied. F- test showed that three soil properties (% clay, Soil colour and Soil consistence) were effective and significant ($p<0.05$) in separating the mapping units. Three soil properties (Exch Na, K and texture) were significantly different ($p<0.05$) within mapping unit A when the effect of the three landuse types were examined. When two pairs was considered (Yam + Fallow, Maize and Fallow) on soil mapping unit A four soil properties (soil pH, Exch, Ca, K, Na) were found to be significantly different ($p<0.05$). Landuse types on the same mapping unit differ significantly in most of the chemical properties. Since result of agronomic trials are commonly measured by crop yields, which in turn depend on soil fertility, this high level of soil variability has implications for experiment all and productive agriculture. The result of this study emphasis the need for caution in assuming uniformity of soil properties between soil previously or currently used for different crops inspire of the fact that they occurred on the same mapping unit. From this study, it is recommended that for the production of different crops on the same unit, their soil must be managed separately based on adequate soil test.

Key words: Soil properties, mapping units, sustainable, soil management, Nigeria

INTRODUCTION

There is an increasing need for information on soils as a means to produce food. Variation in soil properties due to use and management and their consequence to the production capacity have been the subject of research in the past for a range a climatic and edaphic conditions (Fasina, 2004; Castro, 1995; Alves, 1992; Costigan *et al.*, 1983; Aiboni, 2001).

An assessment of variation in soil properties associated with land use and management activities is vital for the selection and establishment of appropriate sustainable practices under different agro systems. Variations in properties of soil have also been found to influence soil management and crop production. Fasina (2002) reported that with 18 soil properties in regression in 1990, 92.51% of the variation in yield of maize was explained white for 1991 the same 18 soil properties explained 87.29% in maize variation. He further stated that the two most relevant soil properties that contributed significantly to the yield of maize were Ex Ca and organic Carbon for the two years study.

The more uniform the soils within each experimental plot, the more reliable is the result the trial. Moorman and Kang (1978) stated that conducting agricultural experiment in lands with considerable soil variation as a result of past land use activities is most commonly cause for frustration of agricultural workers. This is because results from field experiment subject to considerable soil variation are often discarded if expected differences between treatments are not statistically significant. Besides, soils or plot of similar pedons/ mapping units have been known to respond differently to the same use or management due to just one factor that may be obscure to soil classification. Study on influence on land use activities on soil properties across landscapes prior to cropping would have revealed such differences. Also the specificity of the crop yield prediction depends upon the homogeneity of the soil unit which serves as basis for prediction. It was in view of this that the present experiment was set up to assess the influence of different land use activities on soil properties in cultivated and cultivated mapping units.

Corresponding Author: A.S. Fasina, Department of Crop, Soil and Environmental Science, University of Ado-Ekiti, Nigeria

Therefore, the main objective of the study is to examine the influence of land use on soil properties on cultivated and uncultivated mapping units derived from granitic parent material in southwestern Nigeria. This is with a view to study the implication that influence of land use activities would have on soil management and crop production.

MATERIALS AND METHODS

Environmental setting: The research was carried out within the University of Ado-Ekiti Teaching and research Farm, Ekiti State in southwestern Nigeria. The area lies between latitude 7°31N and 7°4°N and longitude 5° 31 and 5°2° and covers an area of 2.88 hectares. It has a humid tropical climate characterized by distinct dry and wet seasons with moderate mean annual rainfall of about 1367 mm. Rainfall is seasonal with two peaks. Temperature in this area is almost uniform throughout the year with very little deviations from the mean annual temperature of 27°C. February and March are the hottest months with mean temperature of 28 and 29°C, respectively. The geology of the area is dominated by crystalline rock, which form part of the basement complex of southwestern Nigeria. The soils are mostly of granitic parent material.

Description of land use types: Three land use types occurring within a distance of between 100-1000 m to each other on the same or different mapping units were used.

Maize (zea mays): The plot was bulldozed since 1987 for arable maize cultivation for the past 19 years, the land has been under intensive maize-cowpea cultivation with heavy use of inorganic fertilizer especially NPK-15-15-15 and Urea.

Cassava (manihot spp): The cassava plot has been used for cassava cultivation since 1987 with no fertilizer use.

Fallow plots: The land had been under fallow for 4 years. It was reverted back to fallow after it has been used for the cultivation of arable crops like pepper, okro and maize.

Soil survey and soil sampling: The soil of the area has been mapped by Babalola and Fasina (2006) and the soils have been classified. Three mapping units have earlier being identified on the field (mapping units A, B and C). An almost flat area of 50×30 m was selected under each land use type and 10 plots were demarcated for sampling. It means ten surface (0-15 cm) samples were collected each from yam, maize and fallow plots from mu A, ten each from yam and fallow plots in mu B and Ten only from fallow plot in mu C. Altogether 60 surface soil samples were collected randomly from each of the three major land use types encountered on the three different mapping units. For the soil samples collected, notes were taken of soil colour, soil texture, structure, consistence, stoniness, mottles, cutans and concretions.

Laboratory analysis: Before analysis, the soil samples were air dried, grinded with pestle and mortal and sieve to separate the fine earth fraction from coarse fragment. The gravel content was determined as the percentage of particles with diameter >2 mm. This involved the determination of the total percentage gravel content it contains. The gravel content was then expressed as a percentage of the total weight of the sample. All other soil properties were analysed following the guidelines of IITA (1979).

Statistical analysis: The variability of soil properties within and between the different mapping units and land use types was measured by estimating mean (x), standard deviation (sd) and coefficient of variation (cv). The F-test and T-test were used to test for significant differences of soil properties between and within land use types and mapping units.

RESULTS AND DISCUSSION

Variation in soil properties within the different land use types as located on different mapping units: Table 1 and 2 show the coefficient of variation (cv) for soil properties within and between land use types and mapping units. These results confirm the high values of within series variation in chemical properties as also reported by several other workers (Kang, 1978; Zebarth *et al*., 2002; Ogunkunle, 1993; Fasina, 2002, 2005).

Soils within land use types are more uniform in properties which are more permanent such as textural properties (e.g. % sand) which is one of the soil properties used for soil mapping, while properties which are ephemeral and which are related to management (e.g. Available p, Total N, Exchangeable Cations, (ECEC) are more variable (Table 1). Soil pH, Base Saturation and % Sand are consistently the least variable properties irrespective of land use types. This is in line with the findings of most precious workers (Fasina, 2001, 2003, 2005; Ogunkunle and Ataga, 1985). The CV values obtained for total sand (Table 1 and 2) indicates that the whole area seams to be homogenous with respect to sand content. This is a true reflection of the nature of the parent materials from which the soils have been formed. The observed differences in the variability of physical

Table 1: Variation in soil properties within land use types and mapping units

	Cultivated				Uncultwated							
	A (Yam)		B (Yam)		A (Maize)		A (Fallow)		B (Fallow)		C (Fallow)	
Soil property	X	CV	X	Cv	X	CV	X	CV	X	CV	X	CV
PH	6.24	1.61	6.21	3.04	6.13	3.04	6.05	1.41	6.06	1.38	5.81	13.68
%sand	76	1.86	78	6.85	80	3.41	77	8.79	76	0.98	77	3.40
%Silt	16	12.50	14	24.16	13	17.28	15	18.13	18	6.48	17	16.63
% Clay	8	17.68	8	7.68	7.60	11.77	8	39.12	6	13.98	6	13.98
% Gravel	33.85	25.17	17.12	66.26	45.91	17.65	45.96	29.66	24.48	27.50	35.34	40.72
Total N	0.23	38.28	0.15	62.18	0.22	33.61	0.33	55.96	0.20	56.79	0.25	39.20
Avail P	8.09	31.72	4.33	14.79	4.93	45.08	10.46	99.96	4.05	39.99	4.64	39.20
Ca	4.70	9.51	4.06	21.50	4.30	42.53	3.82	13.27	5.16	14.45	4.56	58.03
Mg	4.49	18.61	4.06	38.58	5.32	64.92	6.48	37.85	4.84	44.85	4.34	42.79
Nat	0.33	14.32	0.36	22.87	0.42	11.02	0.44	14.92	0.38	11.01	0.35	7.54
K^+	0.18	33.19	0.24	37.61	0.32	24.370	0.34	30.49	0.23	31.16	0.20	12.62
Exdiacidity	1.44	24.85	1.92	45.17	1.68	63.89	2.16	54.93	1.60	63.74	1.52	39.03
Organic carbon	0.46	0.30	0.44	0.72	0.40	0.51						
ECEC	11.08	9.09	10.63	17.41	9.88	27.90	13.24	26.76	12.16	18.60	10.91	33.81
%B.S	86.94	3.99	81.40	11.62	66.74	12.09	84.16	6.95	86.46	10.38	84.29	9.65
Colour	4.0	0	4.0	0	3.40	16.11	3.20	26.14	3.40	16.11	40.	17.68
Structure	4.60	29.17	4.4	20.33	3.80	11.77	4.20	26.08	4.0	0	4.40	20.33
Texture	9.0	0	8.2	21.82	6.60	33.20	6.60	33.20	8.2	21.82	6.60	33.20

Key: A, B, C, Mapping units

Table 2: Estimate of variability between mapping units of some properties for the whole area

Soil property	CV%
PH	5.16
% Sand	5.53
% Silt	18.06
% Clay	22.11
% Gravel	32.46
Total N	52.66
Avail P	76.39
Ex Ca	31.68
Mg	43.87
Na^+	17.36
K+	39.04
Ex. acidity	46.68
ECEC	24.16
% BS	7.95
Colour	16.58
Structure	20.51
Texture	26.70

properties for the whole area as a whole can be attributed to differences in the gravel content and slope which is a major factor of soil formation around the study area. Fasina (1986) found out that parent materials could also vary regularly over short distances. Possible causes of this were identified by Ogunkunle to include rock weathering, biological action, micro relief, erosion (wash) and deposition. There are large differences in the variation of soil properties within the different landuse types. (Table 1). The high level of variation observed for the chemical properties could be due to variation imposed by management practices (bush burning, cultivation, fertilizer application and grazing within the land use types Zebart *et al.* (2002) also, provided further evidence that human induced changes in soil can fundamentally alter the pattern of soil distribution in the landscape, even over relatively short time scales.

Grouping of soil properties by coefficient of variation (CV%) according to Wilding and Drees (1983) shows that fallow plots seems to be more homogenous than others (Table 1) followed by Yam (A), Maize (A), Yam (B) in that order. This result suggests that leaving the land to fallow not only improves soil fertility but also decreases soil variability and this is desirable for both practical and experimental agriculture. The change in the magnitude and variance of the chemical properties is a clear indication of how susceptible this type of soil is to the cultivation and agricultural use of the four land use types. McBratney (1984) presented a thorough discussion on the benefits and advantages of soil variation and pointed out that taking into account the traditional agricultural oriented point of view, soil heterogeneity is perceived as negative. However, it may be advantageous for sustainable soil use in that it produces stability and resilience. Cattle *et al.* (1994) found a virgin brown earth from Australia to exhibit more diversity that the adjoining cultivated one. Addiscot (1992) also suggested that diversity in soil properties might be advantageous for sustainable cropping.

Paz-Ganzalez *et al.* (2000) reported that allowing a land to fallow after long term agricultural soil use seems to have a tendency to homogenize the topsoil and this is most evident for attributes such as organic matter, total N and ECEC.

Table 3: Variance ratio test of soil properties studied for the whole area.

Soil property	F-Value
PH	12.1NS
% Sand	94.9NS
% Silt	40.6NS
% Clay	21.17NS
% Gravel	0.53**
Total N	64.0NS
Avail P	25.8NS
Ca	65.8NS
Mg	41.2NS
Na^+	65.8NS
K+	23.1NS
Exch Acidity	18.INS
ECEC	72.INS
% BS	7.5INS
Colour	4.62**
Structure	41.7NS
Texture	48.8NS
Consistence (Wet)	2.67**

Table 4: Summary of Number of soil properties significantly different between Land use pairs in all mapping units

Land use pair	No of properties that are different	
	Mapping unit A	
Y-M	07	pH, ExCa, Ex Na, ExK texture Structure, consistence (Moist), EK
Y-F	05	pH, ExCa, Ex Na, Ex K, texture
M-F-Y	01	pH
M-F	05	pH, ExCa, Ex Na, Ex K, Soil Structure
	Mapping unit B	
Y-F	01	Soil colour
Y-F-M	All mapping units combined	
Y-F-M	03	% Gravel, soil colour, soil consistence

Influence of land use types on soil properties in cultivated and uncultivated fields: The different land use types caused large differences in the chemical properties of the soil (Table 1-4). Land use types influenced the soil properties differently in spite of the same mapping unit. Three soil properties (soil colour, % gravel, soil consistence (wet) was significantly different when all the three mapping units are pooled together. The significant differences in these three properties are among the properties indicates that the separation of soil into different mapping units was very accurate since these three properties are among the properties are among the properties considered for separating soils into different mapping units during field work.

The non-significant differences between the mapping units in variability of exchangeable cations (Ca, Mg, K and Na) and some other chemical properties can be explained from the view expressed by Beckett and Webster (1971) that variability in these properties are largely affected by management practices. The significant difference in % gravel may have serious management implication for crop production as it has been reported by Babalola and Lal (1997) that subsurface gravel horizon has effect on root growth and crop production.

When one consider the influence of the three land use types (Yam, maize and fallow) in mapping units A and B (Table 4) and Soil colour are significantly different. This may be a serious soil management problem in crop production as it has been reported that pH influences nutrient availability (Agboola and Corey, 1973) and that exchangeable, bases, available P and total nitrogen have high and positive correlation with organic matter (Agboola and Corey, 1973; Fasina, 2001, 2003; Ogunkunle and Egbagbara, 1992). It simply means that the soils under the different land use types must be managed separately in spite of the fact that they were located on the same mapping unit or soil type.

There are few indications of the variability that the users of soil maps will accept.

Klingebiel and Montgomery suggested that the yield of different series (averaged over farm and years) within individual land capacity units, intended to guide land use planning at the farmer's level, should not vary by more than 25%.

The significant difference obtained for soil colour between the mapping units is due to the fact that all the soils in the landscape as a whole are formed under different pedogenic processes, different topographic position and under different land use and management practices.All these tend to impose their variability on the soils in terms of colour.

Table 4 shows the number of soil properties that differed within Land use pairs on the same mapping unit. It was observed from Table 4 that seven soil roperties (pH, ExNa, K, texture, structure, soil colour and consistence moist) out of nineteen soil properties were statistically significant between yam and maize located on the same mapping unit A alone. For Yam and fallow, it was only five properties (pH, Ca, Na, K+ and texture) that were statistically significant. Between maize and fallow located on the same mapping unit A, five soil properties were statistically significant. When the influence of all the three land use types (Maize, fallow and Yam) was examined when both three are located on the same mapping unit, pH was the only soil property that was significant. The implication of all these results is that land use types located on the same mapping unit differ in these properties It simply mean that such soils on which these land use types are located cannot be taken as uniform for agricultural experiment and production.

With soil pH being very significantly different (Table 4), it is not surprising that some chemical nutrients are also significantly different. This is because pH affects nutrient availability (e.g., fixation of some micronutrients at low pH). For soil texture, this may be as a result of land preparation for maze (mechanization) which was different from that of Yam, (manual) and Fallow field.

For future land use it may be difficult to merge some of the plots because of the high degree of soil variability (Table 4). The results emphasize the need for canton in assuming uniformity of soil properties between area previously or currently used for different crops or crop combination even of they occur on the same mapping unit or soil type. When there is need to merge plots as a result of increased demand for land to utilize, they can be grouped according to the number of significantly different soil properties.

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