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ORIGINAL ARTICLE

Soil Characteristics of Cassava Growing Ferralsols and Ferruginous Soils in Kwara State, Nigeria

E.O. Oriola*, O.R. Babatunde, and A.A. Salami

Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria

Correspondence:
*lolaoriola@gmail.com,

Abstract
Population pressure on land has led to reduced fallow periods, more intensive land-use and increasing problems of soil infertility in Kwara State, Nigeria. As a result, depletion of soil fertility is a serious issue due to little or no external addition of plant nutrients to the soil. Present study was conducted to examine the variation in cassava yield on ferralsols and ferruginous soils in Kwara State, Nigeria. Primary and secondary data were used in this study. Stratified sampling technique using quadrats was used to collect soil samples. The data collected were subjected to statistical analysis. Results showed that organic matter content, nitrogen, cation exchange capacity and available phosphorus were higher in ferruginous soils than ferralsols. The results of the t-test indicated that the clay content between two soils ($p>0.036$) was significantly different in top soils and but not significantly different ($p>0.233$) in sub soils. While the silt content between two soil indicated a highly significant difference ($p>0.028$) for both topsoil and ($p>0.001$) subsoil, the sand content indicated no significant difference ($p<0.734$) for topsoil and ($p>0.674$) subsoil. The study was limited to soil characteristics under ferralsols and ferruginous in Kwara State, Nigeria. It is suggested to conduct a study on soils properties with a view to identifying areas that could be better managed to improve the productivity of crops.

Keywords: *Cassava Yield, Ferrasols, Ferruginous Soils, Kwara State, Nigeria, Variation*

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1. Introduction

Soil varies from one place to another and this variation depends on soil forming factors. Cambardella and Karlen (1999) reported that soil properties vary spatially from a field to a larger regional scale due to both intrinsic (soil forming factors) and extrinsic factors (soil management practices, fertilization, and crop rotation). At any time, chemical properties have been said to be more variable than physical and biological properties (Brahy et al. 2000).

In Kwara State, severity of agents of soil depletion varies from one geographical location to another and this also accounts for differences in soil fertility gradient across the State. Soil parent rock and microbial activities influence on the nature and fertility level of soil in a particular location (Aghatise 1992). The difference in soil type in the State will result to variation in crop yield. Variability in crop yields and crop quality is often related to the spatial variability in soil quality indicators.

The spatial variation in the soil properties affecting plant growth has in some cases been directly linked to changes caused by soil translocation through tillage (Schumacher et al. 1999; Kosmas et al. 2001). There is limited information on dynamics of soil chemical properties, the translocation of these properties and the effects on crop production in particular (Oriola 2004). In absence of good understanding of the types and patterns of soil occurrences, there could be no adequate and practicable soil management technique (Oriola 1995).

At present, a wide range of traditional cassava foods such as garri, fufu, starch, lafun, abacha, among others are produced for human consumption (Kormawa et al. 2003). The root crop has gained industrial importance with uses in producing ethanol, cassava flour in bread production, glucose syrup etc. Large processing plants in Nigeria which require larger quantities of cassava are collected small as amounts in an extent of large area. Therefore, these processing plants have low output. Hence, it is a necessity to examine the soils as this will help to identify those areas or variables that could be better managed to improve the productivity of cassava in the State.

The aim of this study was to examine soil characteristics of cassava growing ferralsols and ferruginous soils in Kwara State, Nigeria. Specifically, the study objectives were to: examine the nature of the physical and chemical properties of ferralsols and ferruginous soils under cassava cultivation; and determine the differences between ferralsols and ferruginous soils under cassava cultivation in the study area.

Study Area

Kwara State is geographically located at the southern border of River Niger and in the southern guinea savanna. It lies between latitude 8^0 and 10^0 04'' North of the Equator and Longitude 2^0 45'' and 6^0 12'' East of Greenwich Meridian (Fig. 1). The State has an elongated shape running from west to east and covering an area of about 32,500 km^2 (Longman 2000). It has River Niger as its natural boundary along its Northern and Eastern margins. Kwara State can be divided ino two physiographic regions: the western upland and the Niger trough. The elevation on the western side varies from 273 m to 333 m above sea level while on the eastern side varies from 273 m to 364 m (Oyebanji 1993). Lower Niger River drains the trough area.

Cropping patterns are influenced by hydrologic regimes of inland valleys. Cassava is a favourite dry season crop grown in inland valleys in West and Central Africa (Lahai and Ekanayake 2009) as the result of its adaptation to different edapho-climatic conditions (Adejini et al. 2011).

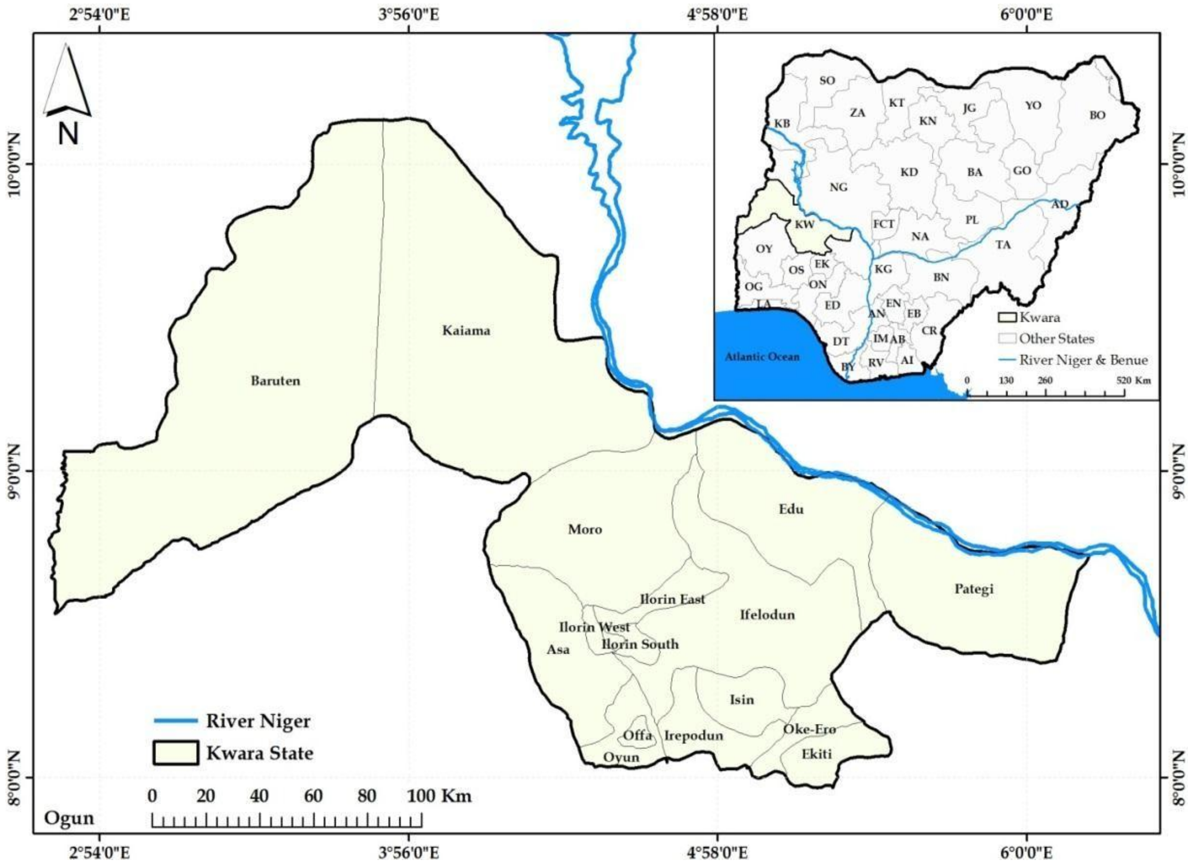

Figure 1: The Study Area, Kwara State, Nigeria

Kwara State lies within a region described as tropical climate and it is characterized by dual rainfall maxima and has tropical wet and dry climate (Olanrewaju 2009). Both seasons last for about six months. The study area has an annual rainfall range of 1000 mm to 1500 mm. The rainy season begins towards the end of March and lasts until early September, and then the dry season begins in early October and ends in early March (Ifabiyi and Omoyosoye 2011). The larger proportion of the area in the state belongs to dry sub-humid while the Northwestern fringe belongs to semi-arid climatic regions on the Thornthwaite weather climatic scheme (Olaniran 1988). Temperature is uniformly high and ranges from 25^0C to 30^0C throughout the wet season except in July to August when the clouding of the sky prevents direct insolation while the range in dry season is 33^0C to 34^0C (Olanrewaju 2009). Cassava requires a warm, moist climate with average temperatures of 25^0C to 29^0C, and a well-distributed annual rainfall of 1,100-2,000 mm for optimum growth (Onwume 1978; Silvestre 1989).

Vegetation and climate of an area can determine at a certain extent the development of soil in the area. Kwara State is located in the Southern guinea savanna vegetation zone which is characterized by the presence of fire tolerant woody shrubs and trees that are about 12 m high with grass of about 1.5 to 2.5 m. Guinea savanna is found towards the northern part of the state. Trees and grasses decrease in height northwestwards. Deciduous trees like baobab (*Adansonia digitata*), silk cotton (*Ceiba pentandra*), locust bean (*Parkia biglobosa*) and sheabutter (*Vitellaria* paradoxa) are among the various woody materials in the state. Forest land clearing is carried out to reach more sunlight to the ground and to avoid weed growth and undergrowth to minimize them compete with cassava.

Geology can influence the development of soils. The geology of Kwara State is of crystalline Precambrian basement complex rocks (metamorphic and igneous rocks) and sedimentary rock along the Niger River bank. The metamorphic rocks include biotite gnesiss, banded gnesiss, quartzite augitegneiss and granitic gnesiss. The intrusive rock includes pegmatite and vein quartz (Smyth and Montagomery 1962; Lawal 1997; Olaniyan 2003). A large proportion of the land area in the State is characterized by ferruginous tropical soils on crystalline acid rocks. The highly weathered red and yellowish-brown soils known as ferralsols on loose sandy soil guinea savanna are found in some parts of the state. The soils that predominates the bank of river Niger are the alluvial and hydromorphic soils (Fig. 2).

The soils in Kwara State support cultivation of cassava, maize, rice, guinea corn, sweet potato, millet etc. In practice, cassava is grown on a wide range of soils, provided the soil texture is friable enough to allow the development of the tubers. Although, cassava is tolerant to infertile soils and drought, continuous cultivation without efficient management can result in serious nutrient depletion of the soil and a complete crop failure (Papa et al. 2013). A typical characteristic of Kwara State is agriculture as the basis for economic activities. The vast savannah grassland that characterize the vegetation of the State is highly conducive for the production of food crops such cassava, sweet potatoes, yam, and guinea corn etc.

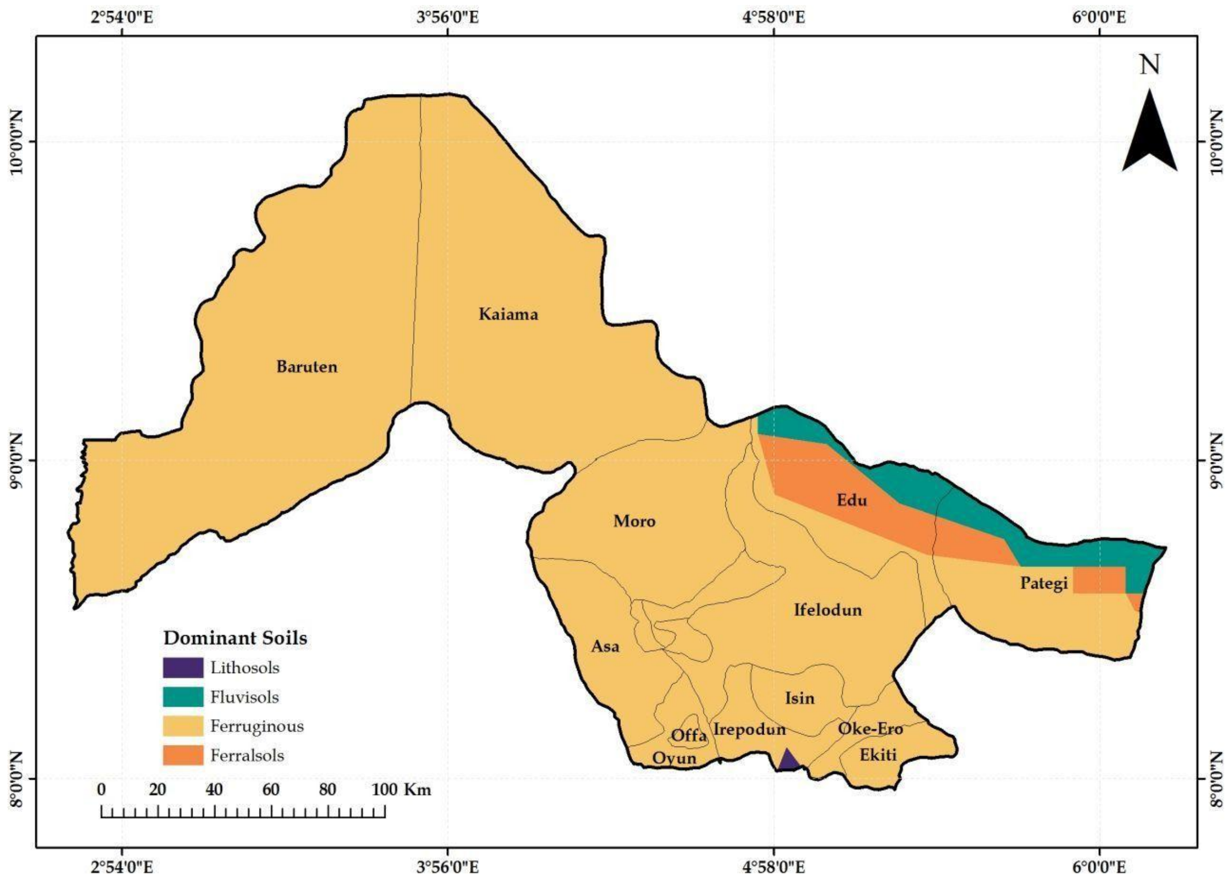

Figure 2: The Dominant Soils of the Study Area

2. Materials and Methods

The data required for this study were as follows: the content of soil physical and chemical properties in the study area; the size of the farmland; and soil map of the study area. These data were obtained from both primary and secondary sources. Primary data were collected from the field. The fields were cultivated cassava farmlands under ferralsols and ferruginous soils. Soil map of the study area was acquired from the Food and Agricultural Organization. Data were collected through reconnaissance survey and field observation. A reconnaissance survey was carried out to identify large cassava cultivated farmlands under ferralsols and ferruginous soils. Permission for digging and sampling was obtained.

A stratified sampling technique using quadrants (grids cells) was applied to collect the soil samples. This technique has been used in different studies (Oriola 2004; Oriola and Bamidele 2012). Hence, this study adopted 50 m x 50 m sample quadrats, the representative sample of the quadrat was obtained by selecting 5 representative cores from each 50 m x 50 m quadrant. The two fields sampled measure 50,000 m^2 each. Therefore, each of the field was demarcated using 250 m x 200 m which was subdivided into 20 quadrats measuring 50 m x 50 m (2,500 m^2). Furthermore, there was a subdivision of the 50 m x 50 m quadrats using grids measuring 25 m x 25 m from which representative cores were collected (Fig. 3). Therefore, soil auger was used to collect 5 representative cores along a zigzag transect at the depths of 0-30 cm (topsoil) and 30-60 cm (subsoil) (Baker et al. 2007; Olowolafe and Olushola 2013). The 5 representative fractions were thoroughly mixed to obtain 1 composite sample representing each 50 m x 50 m quadrat. Hence, a total of ten composite samples for the predetermined depth of 0-30 cm and 30-60 cm were obtained from the fields of ferralsols and ferruginous soils under cassava cultivation. A total of 40 samples, that is, 20 each for the top soil and subsoil.

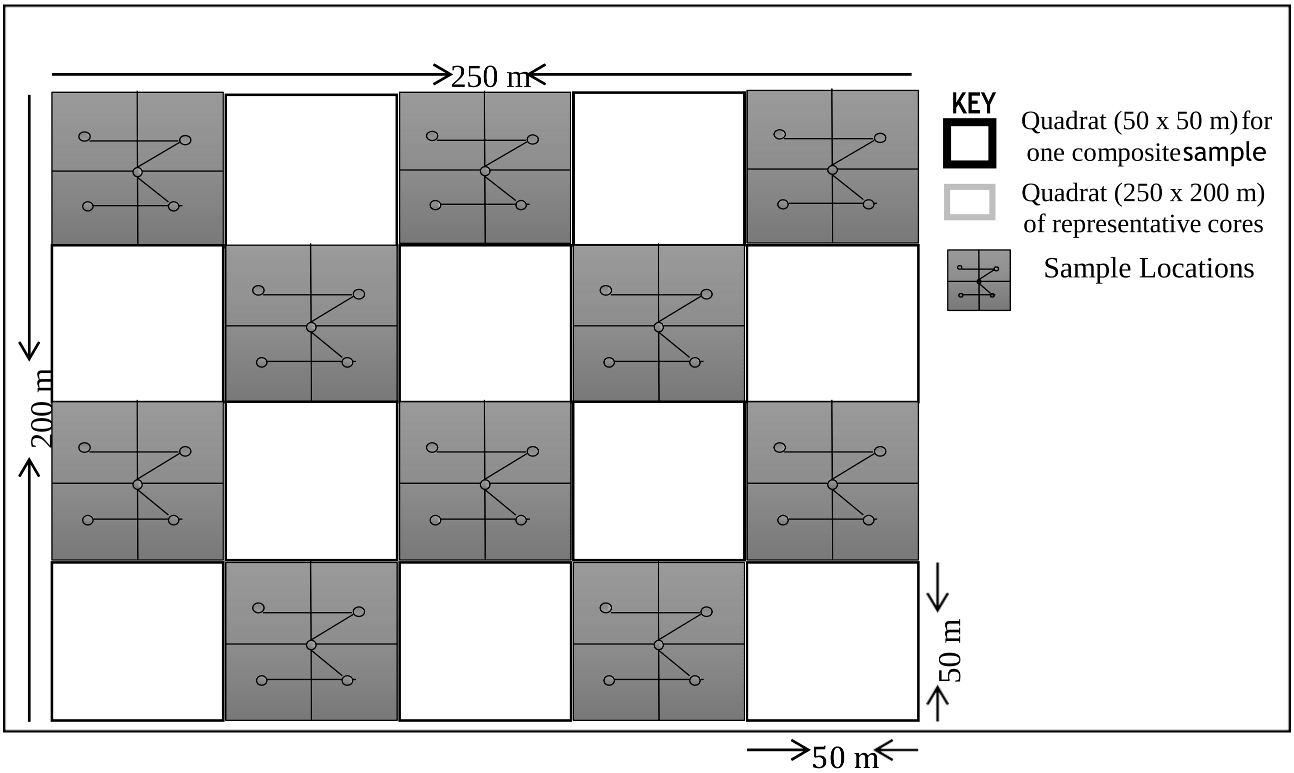

Figure 3: Soil Sample Quadrats and Transects

Physical and chemical properties of ferrasols and ferruginous soils was considered in this study. The soil samples were air dried and ground to pass through a 2.0 mm sieve before laboratory analysis was carried out. The soil properties such as available Ca^{2+}, Mg^{2+}, Na^{+},K^{+}, available phosphorus, cation exchange capacity, base saturation, organic matter content, and total nitrogen were determined. Those are chemical properties that directly influence fertility status and productivity of soil (Brady and Wail 1999; Oriola 2004). Particle size distribution was also analyzed as it is a soil physical property that influences the availability of certain chemical properties in the soil (Musa 2015).

Descriptive statistics (Mean, percentage, standard deviation) and inferential statistics (student's t-test) were employed. Student's t-Test has been used by many authors such as Tshiunza et al. (1999), Oriola and Hammed (2012), and Olowolafe and Olushola (2013) in the study of soil differences between soils and cassava yield. The formula is as follows:

$$t = \frac{|X - Y|}{\sqrt{\frac{sx^2}{N_x} + \frac{sy^2}{N_y}}}$$

Where:

t= student's t-test;

X= sample for X;

Y= sample for Y;

sx^2= a square of the standard deviation of X;

sy^2= a square of the standard deviation of Y;

N_x= sample size of X; and

N_y = sample size of Y.

3. Results and Discussion

Table 1 shows the laboratory results of physical and chemical properties of ferralsols under cassava cultivation while table 2 shows the laboratory results of physical and chemical properties of ferruginous soils under cassava cultivation in the study area.

Table 1: Physical and Chemical Properties of Ferralsols

S/N	I.D	pH (H_2O)	% Total Organic Carbon	% Total Nitrogen	Available Phosphorus mg/kg	Ca	Mg	K Cmol/kg	Na	% Clay	% Silt	% Sand	CEC Cmol/kg
1	A 0 – 30	6.40	0.08	0.01	3.28	2.85	0.86	0.16	0.27	7.40	11.40	81.20	2.29
2	A 30 – 60	6.10	0.71	0.07	0.84	2.17	0.74	0.19	0.20	6.00	11.40	82.60	2.15
3	B 0 – 30	6.30	1.00	0.10	0.19	2.68	0.84	0.21	0.31	8.70	17.40	73.90	5.07
4	B 30 – 60	6.00	0.50	0.05	0.28	2.22	9.82	0.20	0.23	6.80	17.00	76.20	3.56
5	C 0 – 30	6.30	1.20	0.11	0.69	2.47	0.73	0.23	0.36	8.00	15.40	76.60	5.68
6	C 30 – 60	6.10	0.85	0.09	0.84	1.98	0.08	0.17	0.28	10.70	15.40	74.60	4.62
7	D 0 – 30	6.10	1.55	0.16	1.22	2.68	0.86	0.20	0.33	9.00	17.00	74.00	6.74
8	D 30 – 60	6.00	1.10	0.11	0.75	2.03	0.78	0.14	0.28	10.00	15.40	74.60	5.38
9	E 0 – 30	6.20	1.36	0.14	1.86	2.84	0.87	0.27	0.30	6.00	11.40	82.60	6.16
10	E 30 – 60	6.00	1.00	0.10	1.13	1.87	0.63	0.19	0.19	8.00	15.00	77.00	5.07
11	F 0 – 30	6.70	1.68	0.17	2.20	2.96	0.88	0.26	0.29	9.00	17.00	74.00	7.13
12	F 30 – 60	6.00	1.17	0.12	1.87	1.81	0.61	0.23	0.20	8.00	15.00	77.00	5.59
13	G 0 – 30	5.90	1.47	0.15	1.64	2.68	0.96	0.31	0.34	10.00	15.40	74.60	6.50
14	G 30 – 60	5.70	1.22	0.13	1.17	2.53	0.74	0.27	0.28	8.00	15.40	76.60	5.73
15	H 0 – 30	5.80	1.51	0.16	1.32	2.74	0.86	0.37	0.27	10.00	17.40	72.60	6.62
16	H 30 – 60	5.60	1.19	0.12	0.86	2.63	0.61	0.29	0.21	9.00	19.40	71.60	5.65
17	I 0 – 30	6.60	1.35	0.14	1.42	2.86	0.09	0.36	0.30	4.00	17.40	78.60	6.13
18	I 30 – 60	6.30	1.12	0.12	0.80	2.37	0.65	0.25	0.26	4.00	19.40	76.60	5.44
19	J 0 – 30	6.40	1.30	0.13	1.76	2.89	0.81	0.30	0.40	6.00	17.40	76.60	5.98
20	J 30 – 60	6.20	1.04	0.11	1.14	2.74	0.67	0.22	0.31	4.00	19.40	76.60	5.19

Table 2: Physical and Chemical Properties of Ferruginous Soils

S/N	I.D	pH (H$_2$0)	% Total Organic Carbon	% Total Nitrogen	Available Phosphorus mg/kg	Ca	Mg	K Cmol/kg	Na	% Clay	% Silt	% Sand	CEC Cmol/kg
1	A 0 – 30	5.50	2.16	0.22	2.09	1.84	0.49	0.07	0.38	6.00	11.40	82.60	8.58
2	A 30 – 60	6.20	1.88	0.19	4.55	1.79	0.53	0.14	0.27	8.00	15.40	76.60	7.74
3	B 0 – 30	5.80	2.83	0.29	10.75	4.01	1.19	0.16	0.34	8.00	19.40	72.60	10.61
4	B 30 – 60	5.70	2.08	0.21	3.10	2.42	1.86	0.14	0.26	14.00	19.40	66.60	8.34
5	C 0 – 30	6.00	2.86	0.29	6.49	2.52	1.38	0.19	0.41	8.00	19.40	72.60	10.70
6	C 30 – 60	5.90	2.16	0.22	3.03	3.61	0.81	0.18	0.28	10.00	15.40	74.60	8.58
7	D 0 – 30	5.70	2.43	0.25	6.28	2.08	0.46	0.33	0.36	10.00	15.40	74.60	9.40
8	D 30 – 60	5.40	1.76	0.18	2.38	1.58	0.45	0.13	0.29	10.00	17.40	72.60	7.37
9	E 0 – 30	5.30	1.96	0.20	2.24	2.00	0.59	0.22	0.40	8.00	17.40	74.60	7.98
10	E 30 – 60	5.10	1.53	0.15	3.25	1.80	0.30	0.09	0.33	10.00	17.40	72.60	6.70
11	F 0 – 30	5.60	2.20	0.22	1.52	1.56	0.87	0.17	0.46	0.00	21.40	78.60	8.70
12	F 30 – 60	5.90	2.16	0.22	2.17	1.06	0.67	0.08	0.40	0.00	19.40	80.60	8.58
13	G 0 – 30	5.00	1.53	0.15	5.41	3.74	0.35	0.08	0.43	6.00	13.40	80.60	6.68
14	G 30 – 60	4.70	1.76	0.18	1.01	1.70	0.18	0.06	0.40	2.00	17.40	80.60	7.37
15	H 0 – 30	5.10	1.69	0.17	3.97	3.37	0.32	0.11	0.42	0.00	19.40	80.60	7.16
16	H 30 – 60	5.00	1.29	0.13	4.47	2.58	0.34	0.07	0.34	0.00	19.40	80.60	5.95
17	I 0 – 30	6.20	2.12	0.22	19.91	1.97	0.98	0.14	0.38	0.00	21.40	78.60	8.46
18	I 30 – 60	6.70	2.21	0.21	22.87	2.80	1.04	0.11	0.29	0.00	23.40	76.60	8.73
19	J 0 – 30	5.30	2.14	0.23	8.23	1.84	0.78	0.14	0.31	0.00	25.40	74.60	8.52
20	J 30 – 60	5.30	2.31	0.24	6.71	1.55	0.66	0.08	0.25	0.00	25.40	74.60	9.04

The result of the laboratory analysis showed that the textures of the soil was predominantly sandy loamy, with high sand fraction for both topsoil and subsoil in ferralsols and ferruginous soils, with mean silt contents below 26%, the soil has weak surface aggregation data (Tables 1 and 2). Both soils have low clay contents which were below 11%. Clay content ranging from 21% to 33% is low (Chihikezie et al. 2010). Fine soil fraction and sandy nature of soils in tropical savanna influences most of the nutrient properties of the soil and at the same time their capacity to retain water for plant growth (Abiodun 2015).

The soil pH varied from 5.80 to 6.70 (topsoil) and 5.60 to 6.40 (subsoil) for ferralsols while for the ferruginous soils, it ranged from 5.00 to 6.20 (topsoil) and 4.70 to 6.70 (subsoil) respectively. The decrease in soil pH is in agreement with the findings of Ogeh (2013) of which it was reported that soil pH decreases with increase in the number of times the soil was cultivated. The decrease in pH value is a result of higher uptake of cations by the crop without a reasonable replacement. Moderately acid conditions are reported to be favourable to many tropical crops including cassava (Howeler 1996).

The soils are dominated by calcium ranging from 1.56 Cmol/kg to 4.01 Cmol/kg and 1.06 Cmol/kg to 3.61 Cmol/kg for topsoil and subsoil respectively. The data show that cover Ca contents in subsoil in comparison with both ferralsols and ferruginous soils. High calcium values are an indication that the soils have a high affinity for calcium, and also that calcium is more strongly bound to exchangeable sites than those of other cautions (Isa 2004). The values of magnesium ranges from 0.09 Cmol/kg to 0.98 Cmol/kg for topsoil of both soils have the higher values. The level of Magnesium falls within the average standard of 0.5Cmol/kg to 1.5Cmol/kg (Max et al. 1999). Magnesium showed an inconsistent pattern of distribution within the field. For most Nigerian soils, low level of calcium, magnesium and potassium have been attributed to leaching of nutrients as the result of high rainfall.

Sodium values ranged from 0.19 Cmol/kg to 0.46 Cmol/kg for both soils. The value of sodium ranging from 0.2Cmol/kg to 0.5Cmol/kg is appropriate to support crop production (Blakemore et al. 1987). Potassium values range from 0.06Cmol/kg to 0.37Cmol/kg. In soils, the level of potassium less than 0.4Cmol/kg is considered to be low (Max et al. 1999). The values of potassium in both soils were low compared to Calcium and magnesium levels. The uptake of potassium might be affected by the quantities of calcium and magnesium present in the ferrasols and ferruginous soils. This is in line with the report of Isa (2004) where it was found that availability of potassium to plants can be limited by the presence of excessive quantities of exchangeable calcium and magnesium in the soil.

Organic matter ranged from 0.08% to 2.86% for ferralsols and 0.50% to 2.31% for topsoil and subsoil respectively. The observed values of organic matter content agreed with the findings of Abua and Atu (2010) where it was reported that such level of organic matter content could sustain intensive cassava production and other agronomic crops in the ecological zone. They further added that this low level of organic matter content might be attributed to intensive land use via cropping and natural settings.

Total nitrogen contents were low, ranging from 0.01% to 0.24 for ferralsols and 0.05% to 0.29% for ferruginous soils top and subsoil respectively. This is also agreed with the findings of Abua and Atu (2010) of which it was reported that low level of total nitrogen below 0.45 percent established for productive soils in the zone could not sustain intensive crop production. This low level of total nitrogen could be attributed to rapid microbial activities, crop removal, and leaching of nitrates in the soil of the prescribed study area. Available phosphorus value was high ranging from 0.19mg/kg to 19.91mg/kg and 0.28mg/kg to 22.87mg/kg for top and subsoil respectively. Phosphorus value less than 10mg/kg is considered to be low (Max et al. 1999). The two soils types are rich in phosphorus mineral. Cation exchange capacity hardly exceeds 10Cmol/kg. The value of cation exchange capacity in sandy or low in organic matter soils ranging from 5Cmol/kg to 12Cmol/kg is considered to be low (Blakemore et al. 1987). The cation exchange capacity was generally low in both soils. This range of values less than 10Cmol/kg indicates that the soils are inherently infertile to sustain an intensive crop.

Table 3 shows the t-test summary of variations in soil properties under Ferralsols and Ferruginous soils. The results show that there was significant difference ($p>0.036$) for topsoil and no significant difference ($p>0.233$) for subsoil between the two soils for their clay contents, a highly significant difference of ($p>0.028$) for topsoil and ($p>0.001$) for subsoil between their silt contents and no significant difference ($p<0.734$) for topsoil and ($p>0.674$) for subsoil between their sand contents. The chemical properties of the two types of soil are discussed hereafter.

3.1. Soil pH

Table 3 shows that soil pH was generally higher in ferralsols than that of ferruginous soils. Both soils are slightly acidic, the acidity is higher in ferruginous than that of ferralsols. The t-test presented in the table below shows that differences in pH (H_2O) between the two soils in their topsoil ($p>0.000$) and subsoil ($p>0.022$) were highly significant. The mean value of pH (H_2O) of ferrasols is 6.27% (topsoil) and 6% (subsoil) while that of ferruginous soil is 5.55% (topsoil) and 5.59% (subsoil) respectively. The ferruginous soil is more acidic. Such soil condition can induce phosphate fixation and reduce the ability of microorganisms to fix atmospheric nitrogen and induce phosphate fixation (Abua and Ate 2010). Ferralsols have increased pH value. Effects include increase in exchangeable Ca and Mg as shown in table 4.3, may have caused part of the acidity to neutralize, thereby increasing pH. The pH value obtained in this study agrees with the findings of Agbede (2008) as it falls within the range of 4.5 to 7.5. Higher levels and availability of some other nutrients like phosphorus, exchangeable calcium, magnesium and potassium in ferralsols may have been contributed by the higher pH conditions as reported by Olowolafe and Olushola (2013) who worked on effects of corralling on the properties of an inceptisol in Vom area, Jos Plateau,Nigeria.

Table 3: The T-Test Summary of Variations in Soil Properties under Ferrasols and Ferruginous Soils

<table>
<tr><th rowspan="3">Soil Property</th><th rowspan="3">Soil Layer</th><th rowspan="3">Soil Type</th><th colspan="2">Paired Samples Statistics</th><th colspan="2">Paired Samples Test
Paired Differences</th><th rowspan="3">Test
P- Value</th></tr>
<tr><th>Mean</th><th>Std. Deviation</th><th>Means</th><th>Std. Deviation</th></tr>
<tr></tr>
<tr><td rowspan="4">pH (H_2O)</td><td rowspan="2">Top</td><td>Ferrasols</td><td>6.27</td><td>0.28304</td><td rowspan="2">0.72</td><td rowspan="2">0.30111</td><td rowspan="2">0.000*</td></tr>
<tr><td>Ferruginous</td><td>5.55</td><td>0.38658</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>6</td><td>0.21082</td><td rowspan="2">0.41</td><td rowspan="2">0.46774</td><td rowspan="2">0.022*</td></tr>
<tr><td>Ferruginous</td><td>5.59</td><td>0.60636</td></tr>
<tr><td rowspan="4">% Total Organic Carbon</td><td rowspan="2">Top</td><td>Ferrasols</td><td>1.25</td><td>0.45331</td><td rowspan="2">-0.942</td><td rowspan="2">0.69094</td><td rowspan="2">0.002*</td></tr>
<tr><td>Ferruginous</td><td>2.192</td><td>0.42985</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>0.99</td><td>0.23452</td><td rowspan="2">-0.924</td><td rowspan="2">0.4525</td><td rowspan="2">0.000*</td></tr>
<tr><td>Ferruginous</td><td>1.914</td><td>0.32972</td></tr>
<tr><td rowspan="4">% Total Nitrogen</td><td rowspan="2">Top</td><td>Ferrasols</td><td>0.127</td><td>0.04668</td><td rowspan="2">-0.097</td><td rowspan="2">0.07394</td><td rowspan="2">0.002*</td></tr>
<tr><td>Ferruginous</td><td>0.224</td><td>0.04526</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>0.102</td><td>0.0253</td><td rowspan="2">-0.091</td><td rowspan="2">0.04606</td><td rowspan="2">0.000*</td></tr>
<tr><td>Ferruginous</td><td>0.193</td><td>0.03401</td></tr>
<tr><td rowspan="4">Available Phosphorus mg/kg</td><td rowspan="2">Top</td><td>Ferrasols</td><td>1.558</td><td>0.83871</td><td rowspan="2">-5.131</td><td rowspan="2">5.91124</td><td rowspan="2">0.023*</td></tr>
<tr><td>Ferruginous</td><td>6.689</td><td>5.4829</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>0.968</td><td>0.40876</td><td rowspan="2">-4.386</td><td rowspan="2">6.43386</td><td rowspan="2">0.059</td></tr>
<tr><td>Ferruginous</td><td>5.354</td><td>6.34944</td></tr>
<tr><td rowspan="4">Ca</td><td rowspan="2">Top</td><td>Ferrasols</td><td>2.765</td><td>0.14331</td><td rowspan="2">0.272</td><td rowspan="2">0.97139</td><td rowspan="2">0.399</td></tr>
<tr><td>Ferruginous</td><td>2.493</td><td>0.88422</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>2.235</td><td>0.32346</td><td rowspan="2">0.146</td><td rowspan="2">0.79515</td><td rowspan="2">0.576</td></tr>
<tr><td>Ferruginous</td><td>2.089</td><td>0.75294</td></tr>
<tr><td rowspan="4">Mg</td><td rowspan="2">Top</td><td>Ferrasols</td><td>0.776</td><td>0.2478</td><td rowspan="2">0.035</td><td rowspan="2">0.5126</td><td rowspan="2">0.834</td></tr>
<tr><td>Ferruginous</td><td>0.741</td><td>0.36211</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>1.533</td><td>2.91841</td><td rowspan="2">0.849</td><td rowspan="2">2.52742</td><td rowspan="2">0.316</td></tr>
<tr><td>Ferruginous</td><td>0.684</td><td>0.48587</td></tr>
<tr><td rowspan="4">K Cmol/kg</td><td rowspan="2">Top</td><td>Ferrasols</td><td>0.267</td><td>0.06897</td><td rowspan="2">0.106</td><td rowspan="2">0.11635</td><td rowspan="2">0.018*</td></tr>
<tr><td>Ferruginous</td><td>0.161</td><td>0.07549</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>0.215</td><td>0.04625</td><td rowspan="2">0.107</td><td rowspan="2">0.07889</td><td rowspan="2">0.002*</td></tr>
<tr><td>Ferruginous</td><td>0.108</td><td>0.03853</td></tr>
<tr><td rowspan="4">Na</td><td rowspan="2">Top</td><td>Ferrasols</td><td>0.317</td><td>0.04111</td><td rowspan="2">-0.072</td><td rowspan="2">0.07345</td><td rowspan="2">0.013*</td></tr>
<tr><td>Ferruginous</td><td>0.389</td><td>0.04458</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>0.244</td><td>0.043</td><td rowspan="2">-0.067</td><td rowspan="2">0.07917</td><td rowspan="2">0.025*</td></tr>
<tr><td>Ferruginous</td><td>0.311</td><td>0.05466</td></tr>
<tr><td rowspan="4">% Clay</td><td rowspan="2">Top</td><td>Ferrasols</td><td>7.81</td><td>1.95758</td><td rowspan="2">3.21</td><td rowspan="2">4.12861</td><td rowspan="2">0.036*</td></tr>
<tr><td>Ferruginous</td><td>4.6</td><td>4.11501</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>7.45</td><td>2.27804</td><td rowspan="2">2.05</td><td rowspan="2">5.06957</td><td rowspan="2">0.233</td></tr>
<tr><td>Ferruginous</td><td>5.4</td><td>5.50151</td></tr>
<tr><td rowspan="4">Silt</td><td rowspan="2">Top</td><td>Ferrasols</td><td>15.72</td><td>2.40592</td><td rowspan="2">-2.68</td><td rowspan="2">3.23344</td><td rowspan="2">0.028*</td></tr>
<tr><td>Ferruginous</td><td>18.4</td><td>4.13656</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>16.28</td><td>2.56333</td><td rowspan="2">-2.72</td><td rowspan="2">1.91183</td><td rowspan="2">0.001*</td></tr>
<tr><td>Ferruginous</td><td>19</td><td>3.23866</td></tr>
<tr><td rowspan="4">% Sand</td><td rowspan="2">Top</td><td>Ferrasols</td><td>76.47</td><td>3.36322</td><td rowspan="2">-0.53</td><td rowspan="2">4.78842</td><td rowspan="2">0.734</td></tr>
<tr><td>Ferruginous</td><td>77</td><td>3.62706</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>76.34</td><td>2.76494</td><td rowspan="2">0.74</td><td rowspan="2">5.37488</td><td rowspan="2">0.674</td></tr>
<tr><td>Ferruginous</td><td>75.6</td><td>4.44722</td></tr>
<tr><td rowspan="4">CEC</td><td rowspan="2">Top</td><td>Ferrasols</td><td>5.83</td><td>1.37211</td><td rowspan="2">-2.849</td><td rowspan="2">2.09087</td><td rowspan="2">0.002*</td></tr>
<tr><td>Ferruginous</td><td>8.679</td><td>1.29994</td></tr>
<tr><td rowspan="2">Sub</td><td>Ferrasols</td><td>4.838</td><td>1.14312</td><td rowspan="2">-3.002</td><td rowspan="2">1.62075</td><td rowspan="2">0.002*</td></tr>
<tr><td>Ferruginous</td><td>7.84</td><td>0.99447</td></tr>
</table>

*Significant at 0.05 level

3.2. *Phosphorus*

There was a highly significant difference between the two types of soil in their available phosphorus contents. Soil pH is one of the factors that influence the availability of phosphorus (Landon 1991; Brady and Weil 1996). At pH levels between 6.0 and 8.0, phosphorus becomes more available, decreasing in availability at lower pH values (<6.0) where the element is liable to be fixed by Al^{3+}, Fe^{3+} and Mn oxides (Olowolafe and Olushola 2013). The mean value of phosphorus in ferralsol is 1.558 mg/kg (topsoil) and 0.968 mg/kg (subsoil) and the remain value of *P* of ferruginous soils is 6.689 mg/kg and 5.354 mg/kg top and sub soil respectively. Ferruginous soils have higher contents of phosphorus than ferralsols. The low contents of phosphorus in ferralsols might have been due to the general reaction characteristics of phosphorus element which is fixation of phosphorus by soil oxides (Ogeh 2013).

In this study, there was a significant difference ($p>0.023$) for topsoil of ferralsols and ferruginous soils in their contents of phosphorus. The subsoil of both soils showed no significant difference ($p<0.059$) in their contents of phosphorus (Table 3). Availability of phosphorus in soil is a complex issue that is dependent on pH, certain minerals and microbial activity (Les 2006). Increased phosphorus level in ferruginous soils might be as a result of the higher level of organic matter in ferruginous soil, because organic matter is also a factor that influences contents of phosphorus (Olowolafe and Olushola 2013).

3.3. *Exchangeable Bases*

Exchangeable calcium and magnesium were significantly higher in ferrasols. The mean value of calcium in ferralsols was 2.765meq/100g (topsoil) and 2.235meq/100g (subsoil) while that of ferruginous soils was 2.493meq/100g (topsoil) and 2.089meq/100g (subsoil) respectively. There was no significant difference ($p<0.339$) and ($p<0.576$) in calcium content between the two soils in their topsoil and subsoil respectively. The higher content of the exchangeable calcium in both soils may be partly attributed to the higher acidic pH levels of the soils. At high soil pH levels, the solubility of plant nutrients is induced. Soil pH does affect nutrient availability in soils and nutrient uptake by plants which was observed by Agboola and Corey (1973). In both ferralsols and ferruginous soils, the mean value of calcium was higher. Exchangeable Calcium was higher than exchangeable Magnesium and potassium because Calcium was more strongly bound to the exchangeable sites than those of Magnesium and potassium (Beckett 1965).

The magnesium contents of the two soils have no significant difference ($p<0.834$) and ($p<0.316$) in their topsoil and subsoil respectively. The individual concentrations and ratios of the exchangeable bases affect the availability of one another. There was a significant difference ($p>0.018$) and ($p>0.002$) in potassium content between the two soils in their topsoil and subsoil respectively. A very important observation is that the exchangeable bases have their higher values in the surface soils than those in the subsoil particularly in theferralsols.

The Sodium content of the two soils were significantly different at (p>0.013) and (p>0.025) in their topsoil and subsoil respectively. The mean value of cation exchange capacity in ferralsols was 5.83 Cmol/Kg (topsoil) and 4.84 Cmol/Kg (subsoil) while that of ferruginous soils was 8.78 Cmol/Kg and 7.84 Cmol/Kg respectively. The cation exchange capacity (CEC) of ferruginous soils was higher than that of ferralsols. Table 3 shows that the difference between the cation exchange capacity of the two soils were highly significant (p>0.00) and (p>0.00) in their top and subsoil respectively. The increased CEC of ferruginous soils can be attributed to the high organic matter content of the soils.

4. Conclusion

Findings of this study showed that there was a significant difference between the physical and chemical characteristics of the selected soils in the study area. The results of the t-test indicated that there was a significant difference (p>0.036) of topsoil clay content but no significant difference (p>0.233) of subsoil clay content between two soils. Further topsoil and subsoil silt contents between two soil types were also significant. However, no significance difference was observed in sand content in both topsoil and subsoil between two soil types. Soil fertility variables such as organic matter content, nitrogen, cation exchange capacity and available phosphorus are higher in ferruginous soils than those of ferralsols. Therefore, cultivation of cassava should be promoted in ferruginous soils to obtain better harvest.

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