# CHARACTERIZATION OF SOILS OF ISHIAGU, EBONYI STATE SOUTHEASTHERN NIGERIA FOR SUSTAINABLE CASSAVA/UPLAND RICE INTERCROPPING SYSTEM

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## ABSTRACT
Characterization of soils is helpful in the appraisal of soil productivity. Soils of Ishiagu,Ivo Local Government Area of Ebonyi State Nigeria, were characterized for sustainable cassava/upland rice intercropping system. Profile pits were dug and studied, soil samples from pedogenetic horizons were analytically examined for particle size distribution, pH, organic carbon, total Nitrogen, available phosphorous, exchangeable cations and cation exchange capacity. Based on morphological and analytical information the soils were classified according to USDA Soil Taxonomy and correlated with FAO/UNESCO Soil Map of the World Legend. The implication of the analytical data are discussed and recommendations given as to the options to be adopted in managing the soils for sustainable cassava/upland rice intercropping system.

Keywords: Characterization, soils of Ishiagu, cassava/upland rice intercropping

## INTRODUCTION
Characterization of soils is helpful in the appraisal of soil productivity (Mbagwu *et.al.*, 1983). The quest for wise use of soils calls for their characterization as a pre-requisite to proper land suitability evaluation for various competing uses of land, and knowledge of the soil properties is very essential as this can affect crop yield and influence potential management for sustainable productivity. In Southeastern Nigeria, increasing demographic pressure and ecological problem, particularly soil erosion in addition to oil spillage accelerated rural urban industrialization and diminished available agricultural land. Thus fallow periods are reduced and the productivity of the available land lowered (Asawalam and Chukwu 2000). The above highlighted problems make crop intensification on the available piece of land in this region imperative. This intensification can include cassava and upland rice intercropping system. The two major crops widely cultivated and consumed in Nigeria, which are among the crops in the Agricultural Transformation Agenda of the Federal Government of Nigeria.

Nigeria is the largest producer of cassava in the world. The crop plays a major role in the economy of the country, as it supplies more than half the calorie intake of her inhabitants (Abam *et al.*, 2006). It is also the most widely grown root crop across Nigeria, most especially the Southeast agro- ecological zone. Cassava has diversities of uses. It is principally used as human food where it provides the major source of dietary energy for well over 200 million people in Africa (Dorosh, 1988). Cassava chips, pellets and leaves are important in animal feed industry (Hutagalung *et al.*,1973, Tewe *et al.*, 1997). Onwueme (1978) reported that cassava starch is used in glucose, textiles and confectionery industries. Besides the use of cassava as food and in industry, it is a major source of cash income for household. In this regard it generates cash income for the largest number of household in comparison with other staple thereby contributing to poverty alleviation (FMANR, 1997). Increase in the production of cassava is of strategic interest to people of this region to cushion the effects of population pressure, enhance poverty reduction sustainable food and nutrition security and income generation

(Nkanleu and Goekowski, 2006).
Rice is an important staple crop in Nigeria and indeed most countries in the World. It is the sixth major crop in cultivable area after sorghum(*Sorghum bicolor*), millet (*Pennisetum spp*), cowpea (*Vigna ungiculata*), maize (*Zea mays*) and cassava (*Manihot spp*) (Ukwungwu, 2000). It is estimated that 4.6 million ha of land could be put into rice cultivation in the country, but only an estimated 1.9 million ha are currently utilized (Ukwungwu, 2000). This potential notwithstanding, production of rice has not kept pace with the rapid growth in population, though there had been a gradual increase in the production of the commodity over the past years. Its consumption rate is as well on the increase. Consequently, (Oladiran, 2010) estimated that Nigeria imported about 22 billon kg of rice in 2010 to meet local requirements. Therefore, making sustained research on effort towards increasing local production is very important. This can be done through cassava upland rice intercropping system. It should be noted that Nigeria's leading role in World's production rate of cassava is not as a result of yield, but due to vast land subjected to i'ts cultivation

Cassava and upland rice are important and are commercially produced solely in most parts of Southeastern Nigeria agro - ecological zone. The major constraints to the production of these crops in Tropical Africa generally include soil and agronomic factors, pests and diseases, weeds as well as socio-economic factors (IITA 1990). Among all these, soil factors are the major contributor to any crop yield including cassava and rice. This is because ideal soil factors supply enough plant nutrients, which are essential for the growth, development and maturity of crops. Thus, soil information is imperative to the sustainable production of these crops. Consequently, their production depends very much on climate, soil, topography and availability of water, that are the most important categories of environmental information required for judging soil productivity. Also, in different parts of Nigeria, soil characterization has been done for cassava and upland rice production solely, but none has been done on the intercrops (Onyekwere *et al.*, 2013). Good land management must start with soil characterization to generate basic information for land evaluation. Therefore, the objective of this study was to generate information that will help in characterizing soils of Ishiagu, Ivo LGA of Ebonyi State Southeastern Nigeria for cassava/upland rice intercropping system.

## MATERIALS AND METHODS

### Study area

The study area is Ishiagu Ivo Local Government Area (LGA) of Ebonyi State Southeastern Nigeria. The area falls within the derived Savannah zone and lies between latitudes 5° 50' and 5° 61 N and longitudes 7° 39' to 7° 48' E. The climate of the study area is characterized by distinct wet and dry seasons. The former, which lasts for about seven months starts immensely from April to October, with a short break in the month of August popularly known as August break. The dry season stretches mainly from march through November. Peters and Ekwe-Ozor (1982) remarked that a condition of great uniformity is experienced in the area throughout the year with a mean annual temperature between 22 and 31°C the mean Annual rainfall ranged from, 570.0 to 2,395.60mm, and relative humidity varied from 61 to 80 % (Tables 1 ). The vegetation in the study area consists of derived Savanna. The prevailing condition in the area has compelled people towards adapting farming systems that are comparatively advantageous and adapted to their environment. The soil is derived from tertiary Imo formation (shale) the sampling locations were selected based on information obtained from the geology of South Eastern Nigeria.The Meteorological data of the study area are shown in Table 1.

Table 1: Ten years meteorological data of the study area

| Year | Temperature (°C) | | Rainfall (mm) | | Rel humidity (%) | | Sunshine |
|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Days | Amount | 1500 | 900 | Hours |
| 1999 | 22.67 | 31.1 | 159 | 2701.3 | 63 | 79 | 4.6 |
| 2000 | 23.25 | 31.92 | 138 | 1680.6 | 66 | 77 | 4.2 |
| 2001 | 22.33 | 31.33 | 137 | 2351.4 | 64 | 79 | 4.5 |
| 2002 | 22.67 | 31.25 | 137 | 2351.4 | 64 | 79 | 4.4 |
| 2003 | 22.83 | 31.75 | 134 | 2256.5 | 66 | 79 | 4.1 |
| 2004 | 22.42 | 31.92 | 123 | 1911.4 | 63 | 78 | 4.1 |
| 2005 | 22.5 | 32.08 | 147 | 2064.8 | 67 | 80 | 4.3 |
| 2006 | 22.75 | 31.5 | 122 | 2038.3 | 66 | 81 | 4.9 |
| 2007 | 22.42 | 31.67 | 142 | 2416.7 | 62 | 76 | 4.1 |
| 2008 | 22.58 | 31.5 | 141 | 2395.6 | 61 | 76 | 4.7 |

Source: Federal College of Agriculture Ishiagu Meteorological Unit.

**Field work**

500 hectares of land which were measured with the aid of Global Positioning System (GPS) Receiver Garmin Ltd Kansas, USA, were surveyed in the study (Ishiagu). The overall micro-relief of the surveyed arear consists of slightly undulating to gently sloping terrain of not more than 4% gradient. A detailed soil survey using the rigid grid format was conducted. Transverses were cut along a properly aligned base line at 200 m intervals while auger borings were made at 25cm interval to a depth of 100cm, and morphological (colour, texture, structure, consistency and inclusions (Soil descriptions) were made, following which three different soil units were delineated. Then profile pit measuring 2 m x 1m x 2 m or to any impenetretable layer was sited in each delineated soil unit. The morphological characteristics of each of the soil profile pits were described, according to the guidelines for profile pit description outlined in soil survey manual (Soil Survey Staff 2010). The Pedons were cleaned and demarcated based on depths of genetic horizons and sampled horizon by horizon starting from bottom to avoid contamination. Samples were taken to the Soil Science Laboratory of the National Root Crops Research Institute (NRCRI), Umudike, for physicochemical analysis. All the soil samples collected from the soil profile pits were air dried, ground and sieved using a 2 mm sieve preparatory for laboratory analysis, samples for total N, and organic C were passed through a 0.5 mm sieve.

**Laboratory Analysis**

The chemical properties of the soils were determined according to standard laboratory procedures as contained in the method of soil analysis by Udoh *et al.*, (2009). Soil pH: Soil pH ($H_2O$) was determined in 1:1 soil/water suspensions using a glass electrode. Organic carbon: Organic carbon was determined by Walkley and black titration method. Total nitrogen: Total nitrogen was determined by Macro - Kjeldahl method. Available phosphorous: Available phosphorus was determined using Bray P -2 extract of Bray and Kurtz method. Exchangeable Cations: Exchangeable bases were extracted using IN NH4OAc at pH 7 and determined by the EDTA titration method and Ca, K and Na by flame photometry method and Mg by EDTA titration, using Molybdenum blue Colorometry. Soil particle size analysis were determined by standard Laboratory procedures as contained in the method of soil analysis by Udoh et al., (2009), using Bouyocos hydrometer method From the result of the laboratory analyses and the field morphological characteristics of the pedons encountered. The soils were classified following the USDA Soil Taxonomy(Soil Survey Staff, 2006), into order, suborder, great group and subgroups categories and correlated with FAO/UNESCO Legend World Reference Base for Soil Resources (WRB) System (FAO/IUSS 2006)

**RESULTS AND DISCUSSIONS**

**Morphological properties**

The field morphological characteristics of the studied pedons are shown in Table 2

**Soil colour**: The soil colour of the pedons described under moist condition indicated that the colour ranged from red (2.5YR4/2) to brown (10 YR 5/3) at the upper horizons and yellowish red (5YR 5/8) to dark yellowish brown (10 YR 4/4) at the sub soils, with soils from pedon 3 showing redoximorphic features at Ap horizon (Soil Survey Staff 2006), with colour value of 4 and chroma range of 2

**Table 2: Field Morphological Description of Pedons derived from the study area**

| Horizon | Depth | Matrix Colour | Texture | Structure | Consistency (Moist) | Boundary | Other Feature |
|---|---|---|---|---|---|---|---|
| Pedon | 1 | | | | | | |
| Ap | 0-12 | Yellowish red (5YR4/6) | SCL | 3mccr | Frm | Ws | m2rts |
| Bt1 | Dec-45 | Yellowish red(5YR 5/8) | C | 1msg | Fr | Ws | m2rts |
| Bt2 | 45-95 | Red(2.5YR 5/8) | C | 2msbk | Frmt | Ws | f2rts |
| Bc | 95-115 | Red (2.5YR5/8) | C | 2msbk | Frm | - | m2rts, 3 |
| Pedon | 2 | | | | | | |
| AB | 0-15 | Red(2.5YR 4/2) | SCL | 1fsg | Vfr | Cw | m1rts |
| Bt1 | 15-36 | Red(2.5YR 4/6) | C | 3mcr | Frm | Gw | m1rts |
| Bt2 | 36-68 | Red(2.5YR 3/8) | C | 1fcr | Fm | Cw | f1rts |
| Bc | 68-98 | Red(2.5YR3/6) | C | 3fcr | frm | W | f1rts |
| C | 98-120 | Red(2.5YR4/6) | C | 1mcr | frm | - | f1rts |
| Pedon | 3 | | | | | | |
| Ap | 0-18 | Brown(10 YR 5/3) | C | 1fsbk | Frm | Gw | m1rts |
| AB | 18-40 | Dark yellowish brown(10 YR 4/4) | CL | 1fsg | Fr | Gw | m1rts |
| Bt1 | 40-62 | Dark yellowish brown(10 YR 4/4) | CL | 1fsbk | Frm | Cw | m1rts |
| C | 62-93 | Dark yellowish brown(10 YR 4/4) | C | 1msbk | Frm | - | f1rts |

Meaning of Notation and [illegible] Boundary: a = abrupt, b = broken, c = clear, d = diffuse, s = smooth, w = wavy, I = irregular. When a dash (-) is present the property is not recorded. Structure: sbk = sub angular blockly, sg = single grained, c = coarse, cr = crumb, f = fine, m = medium, 1 = weak, 2 = moderate, 3 = strong Consistency: Sfm = slightly firm, frm = firm, vfr = very friable, fr = friable Texture: s = sand, SCL = sandy clay loam, SL = sandy loam, LS = loamy sandy Remarks: rts = roots, m = many, c = common, f = few, 1 = fine, 2 = medium, 3 = coarse, Fe-mn = manganiferrous concretion, Qtz = quartz fragments, Fe = iron nodules, chcl = Charcoal)

**Texture:** Soil texture at the upper horizons of pedons studied ranged from sandy clay to clay, and the sub soils had a similar textural range:
Structure: Soil structure at the upper horizons of pedons studied ranged from weak fine single grained structure to strong moderate crumb structure, while the sub soils had the same structural range

**Consistency** (moist): Soil consistency at the upper horizons of pedons studied ranged from very friable to firm while the sub soils had a similar consistency.
**Soil depth**: The soils were very deep in all the pedons studied

**Physical properties**
The physical properties of the pedons studied are shown in Table 3

**Particle size distribution**
**Sand:** The sand fraction of the pedons studied ranged from 8 to 50.8 %. There was no definite pattern of distribution with depth in all the pedons. The upper horizons had an average value of 44 87%
**Silt**: The silt fraction of the pedons studied ranged from 13.20 to 23.40%. There was no definite pattern of distribution with depth in all the pedons. The upper horizon had a mean value of 19.67%
**Clay**: The clay fraction of the pedon studied ranged from 28.80 to 70.80%. There was no definite pattern of distribution with depth in all the pedons. The upper horizons had an average value of 35.47%

(Silt + Clay) % : The (Silt + Clay) % of the pedons studied ranged from 49.20 to 92.00 %.There was no definite pattern of distribution with depth, with the upper horizon having a mean value of 55.13%. The results of the (silt+clay)% obtained from pedons studied corroborated the findings of Ezenwa (1987) and Onyekwere *et al.*,( 2009), who worked on soils derived from coastal plain sands and shale parent materials respectively.

**Silt/Clay ratio**: The values of silt/clay ratio of the pedons studied ranged from 0.18 to 0.71.There was no definite pattern of distribution with depth in all the pedons, with the upper horizon having a mean value of .0.58 all the soils apart from Pedon 2 Bt1 horizon, are young soils derived from young parent materials with high degree of weathering Asmoa (1983) ,reported that soils with silt/clay ratio less than 0.25 indicates low degree of weathering. It can be further observed that most of the primary minerals have been transformed into clay – size secondary minerals in some of the horizons with silt/clay ratio less than 0.50 in the soils

**Textual classification**: The textual classification of the upper horizons in all the pedons studied ranged from sandy clay loam to clay. Generally, it agrees with optimum criterion of light medium loam sandy soils (Onyekwere *et al.*, 2009) required for unhindered anchorage and bulking of roots and tubers including cassava and for easy harvest apart from pedon 3. The soils can as well retain enough moisture for rice production, giving the indication that these soils are ideal for both cassava and upland rice production

Table 3: Physical Properties of the Pedons studied

| Horizon | Depth | Particle Sand | Size (%) Silt | Clay | Clay + Silt (%) | Silt/Clay Ratio | Texture Class |
|---|---|---|---|---|---|---|---|
| | | | Pedon | 1 | | | |
| Ap | 0-12 | 48 | 19.2 | 32.8 | 52 | 0.59 | SCL |
| Bt1 | Dec-45 | 23..80 | 15.4 | 60.8 | 76.2 | 0.25 | C |
| Bt2 | 45-95 | 8 | 21.2 | 70.8 | 92 | 0.3 | C |
| Bc | 95-115 | 17..20 | 22 | 60.8 | 82.8 | 0.36 | C |
| | | | Pedon | 2 | | | |
| AB | 0-15 | 50.8 | 20.4 | 28.8 | 49.2 | 0.71 | SCL |
| Bt1 | 15-36 | 15 | 13.2 | 72.2 | 85.4 | 0.18 | C |
| Bt2 | 36-68 | 9.6 | 19.6 | 70.8 | 90.4 | 0.28 | C |
| Bc | 68-98 | 9 | 20.2 | 70.8 | 91 | 0.29 | C |
| C | 98-120 | 9.4 | 22.6 | 68 | 90.6 | 0.33 | C |
| | | | Pedon | 3 | | | |
| Ap | 0-18 | 35.8 | 19.4 | 44.8 | 64.2 | 0.43 | C |
| AB | 18-40 | 36.8 | 23.4 | 39.8 | 63.2 | 0.59 | C |
| Bt1 | 40-62 | 27 | 16.2 | 56.8 | 73 | 0.29 | C |
| C | 62-93 | 39.4 | 20.8 | 39.8 | 60.6 | 0.52 | CL |

The primary nutrients : The primary nutrient properties of the pedons studied are shown in Table 4

**Total nitrogen:** The total Nitrogen content of the soils ranged from 0.01 to 0.34 % and the values decreased down the depth.

**Available phosphorus**: The available phosphorus content of the soils ranged from 1.40 to 5.43 mgkg', apart from the upper slope, the values of other pedons decreased down the depth.

**Exchangeable potassium**: The exchangeable K content of the soils, ranged from 0.05 to 0.77 cmol (+) kg' and the values decreased with depth only in pedon 2, whereas the remaining pedons did not maintain any definite pattern of distribution along the depth.

The result of the primary nutrients of the pedons revealed that yield increase of cassava and upland rice will be observed upon the application of NPK fertilizer in arrears covered by pedons 1 and 2 and only N and P fertilizer in pedon 3

Table 4: Primary nutrients of the pedons studied

| Horizon | Depth (cm) | Total N (%) | Available P (mgkg$^{-1}$) | Exchangeable K Cmol (+) kg$^{-1}$ |
|---|---|---|---|---|
| | | Pedon | 2 | |
| Ap | 0-12 | 0.28 | 5.43 | 0.3 |
| Bt1 | 12-45 | 0.14 | 1.4 | 0.05 |
| Bt2 | 45-95 | 0.02 | 3.68 | 0.06 |
| Bc | 95-115 | 0.02 | 2.28 | 0.06 |
| | | Pedon | 2 | |
| AB | 0-15 | 0.31 | 5.08 | 0.45 |
| Bt1 | 15-36 | 0.14 | 3.15 | 0.08 |
| Bt2 | 36-68 | 0.04 | 3.33 | 0.06 |
| Bc | 68-98 | 0.03 | 1.75 | 0.05 |
| C | 98-120 | 0.01 | 1.3 | 0.05 |
| | | Pedon 3 | | |
| Ap | 0-18 | 0.34 | 5.08 | 0.77 |
| AB | 18-40 | 0.27 | 5.08 | 0.18 |
| Bt1 | 40-62 | 0.08 | 3.15 | 0.24 |
| C | 62-93 | 0.01 | 2.63 | 0.28 |

**Selected chemical properties**
Selected chemical properties of the pedons studied are presented in Table 5

**Soil Reaction:** The soil reaction expressed as pH ($H_2O$) of the pedons studied was strongly acidic, with a range of 4.5 to 5.1. There was no definite pattern of changes in pH down with depth and in all the pedons studied, with the upper horizons having an average pH value of 5.1. Soil acidity will not pose a problem in the production of the intercrops, as both crops are acid tolerant.

**Organic carbon**: The organic carbon content of the studied varied from very low to moderate that is from 0.19 to 2.68 %r, the values decreased down the depth in all the pedons studied. The values of the upper horizons ranged from 2.14 to 2.68 %., with an average value of 2.34%. Maintenance of a satisfactory organic matter status is essential to the production of most of the Nitrogen and half of the Phosphorus taken up by unfertilized crops (Von Uxekull 1986), including cassava and rice

**Exchangeable Bases (Ca, Mg and Na)**

**Exchangeable calcium**: The exchangeable Ca, content of pedons studied ranged from 0.68 to 2.80 cmol (+) kg$^{-1}$ with the values of the upper horizons ranging from 0.68 to 2.13 cmol (+) kg$^{-1}$ with a mean value of 1.77 cmol (+) kg$^{-1}$
**Exchangeable magnesium**: The exchangeable Mg content of pedons studied ranged from 0.29 to 1.83 cmol (+)kg$^{-1}$. The values of the surface horizons ranged from 0.67 to 0.83 cmol (+)kg$^{-1}$, with a mean value of 0.76 cmol (+)kg$^{-1}$
**Exchangeable sodium**: The exchangeable Na content of pedons studied ranged from 0.05 to 0.14 cmol (+) kg$^{-1}$, with the values of the upper horizons ranging from 0.09 to 0.14 cmol (+) kg$^{-1}$ having a mean value of 0.11 cmol (+) kg$^{-1}$ The low level of exchangeable bases apart from Mg in the soils is as a result of soil loss through soil erosion Mbagwu (1988) reported that soil loss through soil erosion had resulted in the deficiencies of exchangeable bases in soil
**Effective cation exchange capacity (ECEC)**: The ECEC values of the pedons studied ranged

from 4.36 to 10.83 cmol (+) $kg^{-1}$, with the values of the upper horizons ranging from 4.36 to 10.01 cmol (+) $kg^{-1}$ having a mean value of 6.89 cmol (+) $kg^{-1}$. This result indicated that the Effective Cation Exchange Capacity of the soils is low. The low ECEC and nutrient reserves of the soils have been attributed to the fact that soils of Southeastern Nigeria are strongly weathered have little or no content of weather able rock in sand and silt fraction and have predominantly kaolinite in their clay fractions (FPDD 1989).

**Table 5: Selected chemical properties of the pedon studied**

| Horizon | Depth (cm) | pH | OC (%) | Ca | Mg | Na | Exch.Acidity | CEC | ECEC | Base Sat. (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | -------- | -------- | ------ Cmolkg$^{-1}$ | -------- | -------- | -------- | |
| Pedon 1 | | | | | | | | | | |
| Ap | 0-12 | 5.0 | 2.14 | 2.13 | 0.67 | 0.09 | 3.1 | 8.67 | 6.29 | 50.7 |
| Bt1 | 12-45 | 4.8 | 0.93 | 0.96 | 1.26 | 0.05 | 4 | 7.97 | 6.32 | 36.7 |
| Bt2 | 45-95 | 5.0 | 0.3 | 1.35 | 0.87 | 0.05 | 3.5 | 7.85 | 5.83 | 40 |
| Bc | 95-115 | 5.1 | 0.19 | 1.74 | 1.54 | 0.08 | 2.1 | 7.66 | 5.52 | 62 |
| Pedon 2 | | | | | | | | | | |
| AB | 0-15 | 4.8 | 2.21 | 0.68 | 0.82 | 0.11 | 2.3 | 6.19 | 4.36 | 47.2 |
| Bt1 | 15-36 | 4.8 | 0.75 | 0.96 | 0.68 | 0.09 | 3.1 | 7.98 | 4.91 | 36.9 |
| Bt2 | 36-68 | 5.2 | 0.39 | 1.16 | 0.87 | 0.09 | 2.7 | 7 | 4.88 | 44.7 |
| Bc | 68-98 | 4.7 | 0.24 | 0.77 | 1.49 | 0.08 | 2.7 | 7.35 | 4.09 | 34 |
| C | 98-120 | 4.6 | 0.23 | 0.19 | 1.26 | 0.1 | 4.7 | 9.15 | 6.3 | 25 |
| Pedon 3 | | | | | | | | | | |
| Ap | 0-18 | 4.6 | 2.68 | 2.8 | 0.8 | 0.14 | 5.5 | 13.7 | 10.01 | 45.1 |
| AB | 18-40 | 4.5 | 1.23 | 1.54 | 0.29 | 0.1 | 6.3 | 11.12 | 8.41 | 25.1 |
| Bt1 | 40-62 | 4.7 | 0.74 | 1.16 | 1.83 | 0.1 | 6.1 | 11.03 | 9.43 | 35.3 |
| C | 62-93 | 4.7 | 0.75 | 1.11 | 0.72 | 0.12 | 8.6 | 13.96 | 10.83 | 20.6 |

**Base saturation**: Base saturation values of the pedons studied ranged from 20.6 to 62 %, with the values of the upper horizons ranging from 45.10 to 50.70% having a mean value of 47.67%. This result indicated that the base saturation of the soils ranged from low to high. The high level is a reflection that the exchangeable bases have dominance over the exchangeable acidity of the soils.

**Classification of the soils:** Taxonomic classification of the pedons studied are presented in Table 6.

The soils were classified according to the USDA soil Taxonomy (Soil Survey Staff 2010), and correlated with the World Reference Base (WRB) for Soil Resources (FAO/IUSS. 2006) Legend. In classifying these soils certain criteria were considered. These include the nature of the epipedon, the type of illuviation, or diagnostic master horizon, the cation exchange capacity, the percentage base saturation, the soil organic carbon content, the presence or absence of concretions ( plinthites durapan), the presence or absence of cutans, the soil drainage characteristics, the soil temperature and moisture regime and the colour of the soils

Taxonomic classifications of pedons studied, indicated that all the pedons are formed under ustic moisture regime the moisture control section is dry as long as 90 cumulative days but less than 180 cumulative days in a normal year. There is evidence of argillic, horizons, and presence of B horizons not well developed contain base saturation more than 35 % in most of the horizons so the three pedons were therefore classified as Alfisols. Pedons 1 and 3 finally met the requirement for classification as Ultic Haplustalf under the subgroup level, due to the presence of argilic horizon and base saturation less than 70 % while pedon 2 met the requirement for classification as Rhodustalf based on the presence of Hue of 2.5 in all the horizons . In the WRB Legend all the soils of the pedons were classified as Dystric Lixisol for pedons 1 and 3 and Rhodic Lixisol for pedon 2

**Table 6: Taxonomic Classification of pedons studied**

| Pedon | USDA | WRB |
|---|---|---|
| Pedon1 | Ultic Haplustalf | Dystric Lixisol |
| Pedon 2 | Rhodustalfs | Rhodic Lixisol |
| Pedon 3 | Ultic Haplustalf | Dystric Lixisol |

## CONCLUSION

From the study it was revealed that the soils were deep, well drained, loamy sandy clay loam to clay, red (2.5YR4/2) to dark yellowish brown, acidic, with low to moderate nitrogen, low to high exchangeable K, low available P, and low to moderate organic carbon contents. The textual classifications of the soils were conducive for the production of cassava and upland rice intercrops. The soils were classified as Ultic Haplustalf pedon 1, Rhodustalfs pedon 2 and Ultic Haplustalf under USDA soil Taxanomy and as Dystric Lixisol for pedons 1 and 3 and Rhodic Lixisol for pedon 2 under WRB system. Incorporation of organic materials and application of NPK fertilizer is needed to boast cassava upland rice yield in the soils of the area studied.

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