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Variability of Characteristics and Productive Potential of Some Pedons on the Basement Complex of Southwestern Nigeria

G. E. Akinbola[1], M. O. Adigun[2*] and O. H. Ajimoh[1]

[1]Department of Agronomy, University of Ibadan, Ibadan, Nigeria.
[2]Olabisi Onabanjo University, College of Agricultural Sciences, Department of Crop Production, Yewa Campus, Ayetoro. Ogun State, Nigeria.

Authors' contributions

This work was carried out by author OHA under the supervision of author GEA. Identification and characterization of pedons were done by author GEA. Authors OHA and MOA assisted in the area of statistical analysis. Authors GEA and MOA painstakingly go through the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study is to assess variability of land quality and soil characteristics of some of the pedons on the basement complex of southwestern Nigeria. Variation in soil properties and their relationship with crop production must be studied and understood to ensure sustainability of soil. Soil characteristics can vary significantly across most fields used for crop production. Interaction among the parent materials, topography, vegetation, tillage, fertilization, make variation across fields the norm rather than the exception. Some

**Corresponding author: E-mail: micadigun@yahoo.com;*

soil chemical parameters of pedons on two locations (Alaho-Olokutaand Ajibode) were assessed.
Coefficient of variation was used to evaluate the level of variability of the parameters. The coefficient of variability for pH (Top and Subsoil) for both sites was <15%; for site 1 top soil most of the pH falls below 15%, likewise for site 2 except Balogun series with CV 22.94%. Total N and Organic carbon were extremely variable among the pedons and between the two sites. Organic C in site 1(167, 160, 125, 90.35, 235, 20.9, 134 and 107, 96.41, 40.0, 53, 89, 120, 78%), site 2(102, 105, 133, 71.39, 164, 11.1 and 111, 48.4, 68.26%) respectively.
In site 1, potassium has the least variability while in site 2 it was moderately variable except for Balogun series. ECEC, topsoil and subsoil; (15.78, 14.19, 10.04, 12.55, 19.78, 35.14 and 13.16, 5.15, 5.16, 2.05, 7.94, 3.60, 12.10, 3.69%) was least for site 1, it varied for site 2 topsoil and subsoil ranges from least to moderately variable (25.5, 4.7, 4.6, 7.1, 18.6, 21.9, 15.2, 0.01, 7.5, 4.4, 26.5 and 16.6%) respectively. Results from this investigation showed that the key knowledge of soil chemical and physical properties could influence organic and inorganic fertilizer application at the appropriate time to ensure sustainable crop production on the soils.

Keywords: Productive potentials; pedons; basement complex; series; topsoil; subsoil.

1. INTRODUCTION

A major problem facing agricultural production in the world is not just to increase the food but to produce at a sustainable rate. In order to attain this goal, variability of soil properties within in the landscape coupled with the factors which influences them should be studied and understood.

Land qualities and characteristics are used for land evaluation. Land evaluation brings into consideration all the component of land that will influence its utilization [1,2].

According to [2,1], land qualities are complex attributes of land that could act in a clearly distinct manner from the action of most other in their influence on the suitability of land for specific use. Land qualities are essential for indicating the suitability of a particular improvement for execution within any relevant and foreseable land utilization types [3].

Comparatively land characteristics are measurable properties or attributes of land such as slope angle, rainfall, soil texture, biomass of the vegetation etc, [4]. These characteristics and qualities could vary in both space and time spatially and seasonally [5].

Land characteristics can be classified under two groups: continuous characteristics (which can have a wide range of values e.g. % clay, % organic matter) and class characteristics (which characterized by either a specific narrow range of values e.g. texture class or by a symbol e.g. horizon designation and mapping units [6]. These characteristics could be used for land evaluation as array of values with which group of land characteristics could be used to allocate land to a particular utilization type.

Land utilization type (LUT) is regarded as any use of land defined in greater detail than a major kind of land use. Such a definition depends on the crop management level and technical knowledge of crop production activities and the socio-economic background of the land user. The type of use considered are limited to those which appear to be relevant under general physical, economic and social condition prevailing in an area. These kinds of land use serve as the subject of land evaluation.

Utilization of land varies. Based on utilization of land for crop production, the major factor influencing variability include rainfall, temperature, slope, drainage, topography, farming activities [4]. Out of these factors, climatic factors vary between locations that are separated by long distances.

Variability of soil properties could be described as manifest inconsistency that exist in the properties and characteristics of a land either within or between ecology. Soil variability can either be small, scattered, or distinct.

Soil is perceived differently in different professions based on the use to which they put the soil. But relevant to this study are quality and characteristics that define soil as a medium for sustainable agricultural productivity. According to [7] soil as a pedon is a three dimensional body occupying the uppermost part of the earth crust (a pedon is the smallest unit of soil) and have properties different from the underlying rock material.

Variability governed by the factors of soil formation which are in turn conditioned by lithology, climate, relief through time. Variability of soil when studied at both micro and macro scale helps in grouping the soil in such a way that high degree of variability in the tropics makes it difficult for a mapping unit to exhibit high degree of purity. Thus, it results to easy predictability of potential management and agrotechnology transfer [7,2,3].

1.1 Types of Variability

Soil variability could be broadly grouped into spatial, temporal and vertical, but spatial variability is always larger. Spatial variability is variation, which occurs with distance, while temporal variability is seasonal variations.

Soil properties however vary in vertical and lateral directions and these variations follow systematic change [1] and could be at the level of single field or mapping unit of large scale map (micro variability) or within landform variability or with considerably distance and distinctly different units (macrovariability) [6]. There are number of factors that may cause variation in soil properties and these include topography, parent materials, climate and biological activities.

Some studies on variability of soil properties has been presented by many researchers using different statistical method like ANOVA which is normally used on a small number of randomly collected sub samples [3]. Geo-statistic has also been used which is a valuable tool for analyzing spatial variability, between point observation and ascertaining the interpolating values with a specified error using a minimum number of observation. Using geo-statistic allows an individual soil property to belong totally, partially, or not at all to a particular class [6]. These variabilities could be either be at the scale of single field or mapping unit of a large-scale map or within kind form variability [8].

2. MATERIALS AND METHODS

2.1 The Study Sites

The study site 1 is situated along the old Ibadan- Lagos road, between Alaho and Olokuta village in the Oluyole Local Government area of Oyo state, Nigeria. The site is about eleven

(11km) kilometers south-west of Idi-Ayunre, the Local Government Headquarters. It is approximately 88.954ha in size. The land is bounded in the West by the old Ibadan-Lagos road; in the South by the road running West-East leading from Alaho Community Grammar School to Olokuta village, which is found at the southern tip of the site. The Northern boundary is made up of the earthen road running West-East from old Ibadan-Lagos road to Alajao village. Part of the North-Eastern boundary is also made up of a tributary of River Ona which took its source almost midway of the western boundary, flowing eastward to join River Ona outside the site. The road leading from Alajao village to Olokuta village forms the east and south-east boundaries of the site.

The study site 2 is located at the Northern portion of University of Ibadan campus, encompassing the Ajibode resettlement Area. It is approximately 470.17ha in size apart from the 105.61ha of the resettlement area. The International Institute of Tropical Agriculture (IITA), bounds it in the North. In the South boundary is River Ona and the University’s Botanical garden. To the East is the tarred road separating the site from NISER, while to the West is Apete town.

According to the Federal Survey Topographic Map of 1964 produced at a scale of 1:50,000, site 1 is enclosed within the Ibadan S.E Sheet 261 S.E, while Ajibode is of Ibadan N.E Sheet 261. The two sites are defined with longitudes 3º51’-3º52’E and 3º44’-4º0’E and latitudes 7º9’-7º11’N and 7º30’-7º30’N of the equator.

2.2 Climate of the Study Area

Ibadan is located in the forest savanna-transitory zone of the south-western Nigeria. The annual rainfall is about 1200mm with raining season occurring between April and November. The temperature is generally high with the average annual minimum temperature being 21.9ºC and the maximum is 32.5ºC. The mean monthly temperature ranges between 24ºC and 28ºC. However, extreme daily minimum and maximum temperature of 30ºC respectively have been recorded in Ibadan [3]. Humidity is high in the early hours of the day but sharply decrease in the afternoon. The mean value at 6a.m is 92.98%, while it is 61.4% at 4.00pm. Lower values are recorded in dry season than in west season. As a result of this, the sites like most parts of Ibadan and its environs can be said to be experiencing a hot and humid climate. The area experiences two distinct climatic seasons in a year- the rainy and dry seasons. The seasons are dictated by the prevalence of two major air-masses or wind currents.

According to the [1] classification, the sites fall within the tropical areas with short dry season, in which the deeper soil layers remain permanently moist because of high total annual rainfall. According to [1], the climate of the area can be classified as semi-deciduous forest, experiencing between 1200 and 2000mm of rainfall annually in a tropical environment.

2.3 Vegetation of the Study Area

The sites are endowed with forest communities, young fallow and savannah communities and cultivated arable lands. The forest communities are closely associated, and are found mainly at the crests and upper slopes on the catena. The distribution of the vegetation communities is equally influenced by the soil. The heavy soils readily support forest vegetation while the lighter soils bear more of the grassy vegetation.

2.4 Rainfall

Rainfall in the area is strongly influenced by the movement of the Inter Tropical Discontinuity (ITD). The rainy season lasts for at least nine months (February-October), while the dry season lasts for most of the years from end of November to early February (3 months).

2.5 Soil Survey and Mapping

A detailed soil survey of the site was conducted [1] to identify, characterize, classify and map of the soil types of both sites. Transect were made at intervals of 30m, existing roads and foot path were also used in gaining access to the land.

The morphological characteristic of the soil depth intervals of 0-15cm, 15-30cm, 30-60cm, 60-90cm and 90-120cm using the Dutch soil huger were examine and recorded. Eight(8) mapping units were identified and classified from site 1, these are Egbeda series (EG1 and EG2), Olorunda (OL1 and OL2), Makun (MK2), Oba (OB), Apomu (AP), Jago (JA), and six (6) from site 2, these include Iwo (IW), Iregun (IR), Balogun (BA), Egbeda (EG), Matako (MT) and Ibadan (IB) series respectively, with their % area coverage and names Table 1. The samples collected were air dried, crushed and sieved.

The chemical and physical properties of the soils were determined. These include soil pH in water [9]. Total Nitrogen was determined by the kjeldahl method, Organic carbon content and Bulk density of the soil was also determined by the core method, while particle size distribution was determined by the hydrometer method [10], Extractable micronutrients (Fe, Mn, Zn, Cu) content were also determined using standard analytical methods.

2.6 Soil Classification and Evaluation

The soil types were identified, characterized and classified [1], using two internationally recognized systems: USDA soil Taxonomy and FAO-UNESCO soil classification system. The soils were also classified at the series (local) level on the basement complex with the percentage coverage of each, Table 1.

2.7 Statistical Analysis

The data obtained were analyzed by calculating the mean of the properties for each pedon, standard deviation was also determined and co-efficient of variation (%) was calculated in other to know if variations do exist between the pedons. The level of variation was grouped into 3 according to [2]:

Least variation <15%, Moderately variable 15-35% and Extremely variable >35%.

3. RESULTS

3.1 Mapping Units and Soil Classification

Table 1 depicts the mapping units, their area coverage and soil classification of all the pedons of the sites with local and international names. For site 1, Egbeda normal variation (EG1) is dark reddish brown sandy clay, with argillic horizon, lacking plinthic properties, Egbeda red variation (EG2) is dark reddish brown sandy loam over dusky red sandy clay with kandic horizon, without plinthic properties. Olorunda normal variation (OL1) is a reddish brown sandy loam pedon over yellowish red sandy clay loam with tendency of becoming plinthic at depth, while (OL2) Olorunda concretionary is with a dark brown sand loam over yellowish red sandy clay loam with tendency of becoming plinthic at depth, Makun (MK2) is reddish brown loamy sand, over gravelly and concretionary weak red sandy loam with high tendency for plinthic formation, Oba (OB) is dark grayish brown loamy sand, over yellowish red, mottled sandy loam, lacking plinthic properties, Apomu (AP) has a dark grayish brown loamy sand, over brown mottled sandy loam with Fe/Mn concretions at depth and Jago (JA) series is with a very dark grayish brown loamy sand, over brown mottled sandy loam, with Fe/Mn and ferruginous concretions at depth.

Site 2 has six different pedons, these includes Iwo series (IW) with a dark brown sand, loose crumbs over variegated colored, firm and sticky sandy loam, Iregun (IR) is a dark grey loose crumby sand over yellowish red firm, sticky sub angular blocky sandy loam, Balogun (BA) series has a very dark grey loose crumby loamy sand over variegated colored, stony firm sticky sandy loam, Matako (MT) is a dark brown loose crumby sand over variegated coloured, stony, very firm, and sticky clay, Ibadan (IB) series has a dark brown fine sandy loam, light yellowish brown with a weak medium subangular blocky, sandy clay loam and Egbeda (EG) series has a dark brown, friable, moderate subangular block loamy sand over variegated coloured, stony, very firm and sticky clay.

3.2 Co-efficient of Variation of the Pedons in Site 1 (Topsoil)

Table 2a shows the variation of the topsoil for site 1, thus the assumptions that soils are uniform in their properties, which formed the use of blanket fertilizer recommendation, is not valid.

Soil pH for the topsoil range from least to moderately (5.2, 7.6, 28.78, 4.28, 12.30, 29.81, 6.0, 2.01) respectively, 6 pedons was consistently least variable. Total Nitrogen, Organic carbon and Avail. P were highly variable and the values are (167,160, 125, 90.35, 235.7, 20.29, 86, 29, and 156, 165, 120, 177, 188, 16,789) % respectively. The physical properties silt, clay and gravel varied, from least to moderately variable, sand varied from moderately to extremely variable, (65.65, 55.40, 101.63, 100, 54.24, 61.53 and 20.43) % except for Jago series which is moderately variable with CV (20.43%).

3.3 Co-efficient of Variation of the Pedons in Site 1(Subsoil)

Table 2b indicates the complexity of co-efficient of variation of land quality and characteristics of the pedons in site 1 (subsoil). Generally, low co-efficient of variation were observed for pH in water among all the 8 pedons, this observation has been reported in several other works [11,12,5,1]. The values are 1.10, 1.74, 2.01, 3.00, 3.36, 5.15, 6.00 and 12.56% respectively. High variation was observed for Total N except for OL2, MK2 and JA that are least and moderately variable (6.30, 27 and 29) %. The highest of all was 134%, which belongs to OBA series. Least variable was observed in terms of K and this is as a result of mobility of K in the soil. Organic carbon which is the main factor of production, Apomu series was the only pedon with least variable, all the others are extremely variable and the values are from 40%, 53%, 78%, 89%, 96.13%, 107%, and 120% , for ECEC least variable was recorded (13.16, 5.15, 5.16, 2.05, 7.94, 3.60, 12.10 and 3.69 %), this is from Egbeda to Jago series respectively. In term of physical properties for sand content Egbeda is moderately variable with 19.13% the rest are least variable with the highest value of

13.30% follow by 8.96% which is for Olorunda 2, least to extremely variable was recorded for silt, the values are 17.34, 14.42, 59.43, 15.97, 33.33, 51.60, 22.82 and 34.80%, moderately variable was observed for clay content except for Egbeda that is extremely variable with 35.48%.

3.4 Co-efficient of Variation of the Pedons in Site 2 (Top and Subsoil)

Table 3a and b also indicates the complexity of co-efficient of variation productive potential and characteristics of the pedons in site 2 (topsoil and subsoil).

Generally, low co-efficient of variations were observed for pH in water out of the 6 pedons, Balogun series was moderately variable with CV 22.94% for top soil, same trend for subsoil except for Balogun with CV 36.44%. This observation has been reported in several other works [11,5,1]. The values are 4.8, 3.0, 22.94, 2.81, 14.7, 11.3% topsoil and 2.3, 7.7, 36.4, 3.24, 0.5, and 0.0% for subsoil respectively. High variation was observed for Total N (117, 100, 132, 74.4, 171.3, 50) % except for Ibadan (IB) that is moderately variable (20.29%). The highest of all was 117% for topsoil and 100% for subsoil, which belongs to Matako and Iregun Series. Moderately and least variable was observed in terms of K except Balogun. Egbeda, Ibadan, Iragun series were least variable and this could be as a result of mobility of K in the soil. Organic carbon which is the main factor of production, 5 pedon out of all the series for topsoil were extremely variable except for Ibadan series which is least variable with CV 11.1% and the values are from 156%, 102%, 105%, 133%, 71.3%, 164%, for ECEC it was at least to moderately variable for both top and subsoil with CV (25.5, 4.8, 4.6, 7.1, 18.6, 21.9, 13.4, 12.6, 12.4, 19.2 and 12.5%), this is Iwo to Ibadan series respectively. In term of physical properties for sand content (topsoil) Egbeda is extremely variable with 52.2%, the rest are least variable with the highest value of 11.82% followed by 9.57% which is for Iwo and Balogun series. Same trend goes for the subsoil. Egbeda series has 116%, the rest are least varied. For topsoil clay content were extremely variable except for Matako series which is moderately variable with CV value of 31.7% for subsoil, it range from least to moderately variably with (6.9, 17.9, 30.9, 8.4, 13.4, and 10.6%), the highest CV value is for Balogun series.

Table 1. Mapping units of the two sites with the area covered and name

	Mapping unit	Area covered %	SSS 2003	FAO UNESCO 1990
Site 1	Egbeda (EG1)	15	Kanhaplic rhodustalf	Rhodic ferrasol
	Egbeda (EG2)	20	Kanhaplic rhodustalf	Rhodic ferrasol
	Olorunda (OL1)	20	Typic kanhapludalf	Ferric lixisol
	Olorunda (OL2)	10	Typic kanhapludalf	Ferric lixisol
	Oba (OB)	20	Arenic kandiudalf	Ferric lixisol
	Apomu (AP)	3	Typic psammaquent	Ferralic arenosol
	Jago (JA)	5	Typic psammaquent	Eutic fluvisol
	Makun (MK2)	25	Typic ferrudalf	Chronic luvisol
Site 2	Iwo (IW)	40	Arenic kandiudalf	Ferric lixisol
	Egbeda (EG1)	10	Kanhaplic rhodustalf	Rhodic ferrasol
	Iregun (IR)	15	Typic kanhapludalf	Haplic lixisols
	Ibadan (IB)	25	Arenic kandiudalf	Ferric lixisol
	Balogun (BA)	5	Vitrandic hapludalfs	Ferric lixisol
	Matako (MA)	5	Typic psammaquent	Luvic arenosol

Table 2a. Some statistics of land quality and characteristics of the pedons at site 1 (Topsoil)

Properties	EG1			EG2			OL1			OL2		
	$\bar{X}$	SD	CV (%)	$\bar{X}$	SD	CV (%)	$\bar{X}$	SD	CV (%)	$\bar{X}$	SD	CV (%)
pH (H_20)	6.6	0.34	5.2a	6.2	0.47	7.6a	5.9	1.69	28.7b	6.35	0.27	4.28a
Total N (gkg $-^1$)	0.03	0.05	167c	0.05	0.08	160c	0.12	0.19	125c	0.07	0.06	90.35c
Organic C (gkg $-^1$)	0.27	0.42	156c	0.46	0.75	165c	0.97	1.50	155c	0.67	0.08	120c
Avail. P (mgkg $-^1$)	15.52	16.95	109c	20.94	3.43	16.3b	35.18	14.45	41.08c	12.31	4.81	39.08c
Ca (cmolkg $-^1$)	5.44	0.50	9.21a	5.00	0.66	13.2a	4.29	0.47	11.18a	4.64	0.48	10.51a
Mg (cmolkg $-^1$)	4.07	1.19	29.25b	4.03	0.71	17.67b	3.71	0.44	11.98a	4.02	0.60	14.97a
K (cmolkg $-^1$)	1.20	0.23	19.54b	1.15	0.23	20.39b	1.12	0.13	11.81a	1.2	0.19	16.24b
Na (cmolkg $-^1$)	0.98	0.14	14.43a	0.83	0.12	14.48b	0.81	0.11	13.80a	1.09	0.19	17.43b
Al (cmolkg $-^1$)	0.12	0.24	200c	0.00	0.00	00.00a	0.00	0.00	00.00a	0.00	0.00	0.00a
ECEC (cmolkg $-^1$)	12.25	1.93	15.78b	11.42	1.62	14.19a	10.32	1.03	10.04a	11.39	1.43	12.55a
Exc. acidity (cmolkg $-^1$)	0.58	0.07	12.06a	048	0.05	11.41a	0.44	0.08	18.18b	0.45	0.06	14.05a
Fe (mgkg $-^1$)	250	45.15	18.06b	218	56.73	26.02b	203	53.25	26.22b	245	59.23	24.8b
Mn (mgkg $-^1$)	188	23.99	12.76a	168	336	200c	138	33.37	24.18b	160	41.08	25.68b
Cu (mgkg $-^1$)	7.4	1.34	18.03b	6.7	1.09	16.32b	7.3	1.54	20.98b	8.5	1.50	17.65b
Zn (mgkg $-^1$)	82.42	19.790	24.01b	67.9	20.12	29.61b	71.49	18.26	25.55b	86.3	25.18	29.18b
Sand g/kg	789	65.42	8.29a	832	40.28	4.84a	795	14.67	14.42a	584	198	34.02b
Silt g/kg	235	370	157c	51.2	10.35	20.22b	51.6	28.33	54.90c	103	17.18	17.26b
Clay g/kg	137	46.9	34.23c	116	40.09	34.56b	153	105.2	68.75c	314	204.6	65.18c
Gravel %	37.2	45.0	120.0c	36.4	42.3	116c	13.4	35.2	262c	16.9	25.9	175c

CV % a: least variable <15%; b: moderately variable 15-35% ; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the rows

Table 2a. continued………………

Properties	MK2			OB		
	$\bar{X}$	SD	CV (%)	$\bar{X}$	SD	CV (%)
pH (H_20)	6.6	0.82	12.30a	0.15	0.04	29.18b
Total N (gkg $^{-1}$)	0.03	0.07	233c	0.15	0.05	20.29b
Organic C(gkg $^{-1}$)	0.28	0.49	177c	1.61	0.27	188.00c
Avail. P (mgkg $^{-1}$)	25.2	22.67	90.00c	10.83	4.24	39.20c
Ca (cmolkg $^{-1}$)	4.88	0.96	19.68b	1.8	1.20	66.17c
Mg (cmolkg $^{-1}$)	3.99	0.88	20.05b	0.62	0.46	74.1c
K (cmolkg $^{-1}$)	1.2	0.26	22.44b	0.87	0.18	21.81b
Na (cmolkg $^{-1}$)	1.09	0.26	23.85b	0.67	0.08	11.94a
Al (cmolkg $^{-1}$)	0.00	0.00	00.00a	00.00	00.00	00.00a
ECEC (cmolkg $^{-1}$)	11.6	2.29	19.78b	4.44	1.56	34.14c
Exc. Acidity (cmolkg $^{-1}$)	0.44	0.12	27.84b	0.49	0.07	15.81b
Fe (mgkg $^{-1}$)	215	36.85	17.14b	145	38.15	26.31b
Mn (mgkg $^{-1}$)	158	30.78	19.48b	149	26.97	18.10b
Cu (mgkg $^{-1}$)	8.2	2.00	1.22a	8.0	0.63	7.88a
Zn (mgkg $^{-1}$)	87.4	24.07	27.54b	90.0	13.06	14.51a
Sand g/kg	851	33.46	3.93a	659	85.47	12.97a
Silt g/kg	55.6	5.17	9.31b	173	39.32	22.73b
Clay g/kg	93.3	31.55	22.82b	151	61.20	40.45b
Gravel %	50.0	20.3	40.6c	22.0	13.8	63.0c

Properties	AP			JA		
	$\bar{X}$	SD	CV (%)	$\bar{X}$	SD	CV(%)
pH (H_20)	6.90	0.4	6.00a	5.98	0.12	2.10a
Total N (gkg $^{-1}$)	0.07	0.06	86.00c	0.14	0.04	29.00b
Organic C(gkg $^{-1}$)	8.12	9.41	16.00a	7.98	6.20	78.00a
Avail. P (mgkg $^{-1}$)	15.64	12.56	80.31c	11.00	1.28	11.64
Ca (cmolkg $^{-1}$)	4.71	0.39	8.20a	4.08	0.20	3.33a
Mg (cmolkg $^{-1}$)	3.44	0.80	24.00b	3.33	0.17	0.99a
K (cmolkg $^{-1}$)	0.99	0.04	4.04a	0.99	0.07	7.14a
Na (cmolkg $^{-1}$)	0.87	0.08	9.62a	0.92	0.14	15.37b
Al (cmolkg $^{-1}$)	00.00	0.00	00.00a	00.00	00.00	00.00a
ECEC (cmolkg $^{-1}$)	11.00	1.33	12.10a	9.76	0.36	3.69a
Exc. Acidity (cmolkg $^{-1}$)	1.78	1.29	72.70c	0.43	0.14	3.29a
Fe (mgkg $^{-1}$)	173	23.54	13.61a	121	14.81	15.37b
Mn (mgkg $^{-1}$)	108	10.82	10.02a	89	6.89	7.74a
Cu (mgkg $^{-1}$)	3.2	0.65	20.31b	9.33	0.98	10.50a
Zn (mgkg $^{-1}$)	16	4.82	30.13b	9.33	0.98	10.50a
Sand g/kg	830	26.08	3.14a	810	19.14	2.37a
Silt g/kg	48	10.95	22.82b	55	19.14	34.80b
Clay g/kg	122	26.83	21.99b	134	36.51	27.24b
Gravel %	10.5	6.46	61.53c	17.33	3.54	20.43b

CV % a: least variable <15%; b: moderately variable 15-35%; c: extremely variable >35%, represent the % variation along the rows

Table 2b. Somestatistics of land quality and characteristics of the pedons at site 1 (Subsoil)

Properties	EG1			EG2			OL1			OL2		
	$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)	X	SD	CV(%)	X	SD	CV(%)
pH (H_20)	5.40	0.18	12.5a	5.96	0.06	1.1a	5.55	0.28	5.0a	5.98	0.17	2.8a
Total N (gkg $^{-1}$)	0.30	0.17	87.00c	0.13	0.11	88.00c	0.13	0.11	85.00c	0.16	0.01	6.30a
Organic C (gkg $^{-1}$)	13.10	13.95	107.00c	11.40	10.99	96.41c	8.17	3.24	40.00c	12.17	6.48	53.00c
Avail. P (mgkg $^{-1}$)	8.17	7.93	97.00c	7.77	2.11	27.18b	21.50	25.16	117.0c	8.47	3.22	38.07c
Ca (cmolkg $^{-1}$)	40..	0.24	6.00a	4.03	0.40	9.93a	3.98	0.60	15.00a	4.28	0.57	13.32a
Mg (cmolkg $^{-1}$)	3.15	0.22	7.09a	3.74	0.33	8.87a	3.54	0.55	15.54b	3.73	0.36	9.67a
K (cmolkg $^{-1}$)	1.05	0.06	6.02a	0.96	0.06	6.67a	0.97	0.08	8.25a	0.96	0.11	11.16a
Na (cmolkg $^{-1}$)	0.87	1.13	14.94a	0.98	0.12	12.25a	0.80	0.07	8.84a	0.91	0.11	12.08a
Al (cmolkg $^{-1}$)	0.12	0.27	225.00c	0.00	0.00	0.00a	0.00	0.00	0.00a	0.00	0.00	0.00a
ECEC (cmolkg $^{-1}$)	11.42	1.50	13.16a	10.10	0.52	5.15a	9.69	0.50	5.16a	10.25	0.21	2.05a
Exc. Acidity (cmolkg $^{-1}$)	2.02	1.13	55.94c	0.38	0.09	23.68a	0.41	0.03	7.32a	0.36	0.32	88.89c
Fe (mgkg $^{-1}$)	140	17.21	13.72a	170.2	8.48	4.98b	108.10	9.36	8.66a	164	30.38	12.08a
Mn (mgkg $^{-1}$)	93	12.41	13.34a	122	26.10	21.39b	98.4	25.73	26.15b	92.00	7.21	7.89a
Cu (mgkg $^{-1}$)	3.3	0.45	14.06a	2.6	0.55	21.15b	9.8	2.09	21.33b	13.00	2.10	16.15b
Zn (mgkg $^{-1}$)	11.2	1.81	16.20a	9	2.57	29.00b	98	2.09	21.33b	16.15	13.0	16.15b
Sand g/kg	596	11.4	19.13b	592	78.74	13.30a	614	50.20	8.18a	730	65.42	8.96a
Silt g/kg	96	16.73	17.34b	116	16.73	14.42a	108	64.18	59.43c	560	8.94	15.97a
Clay g/kg	308	109.30	35.48c	288	84.85	29.46b	278	93.16	33.51b	214	67.82	31.69b
Gravel %	37.22	17.98	48.31c	36.42	21.84	59.97c	13.46	13.6	101.6c	16.98	15.0	88.92c

CV % a: least variable <15%; b: moderately variable 15-35% ; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the rows

Table 2b. continued……………

Properties	MK2			OB			OL1			OL2		
	$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)	X	SD	CV(%)	X	SD	CV(%)
pH (H_20)	6.32	0.11	1.74a	6.25	0.21	3.36a	6.90	0.4	6.00a	5.98	0.12	2.01a
Total N (gkg $^{-1}$)	0.11	0.14	27.00b	0.27	0.36	134.0c	0.07	0.06	86.00c	0.14	0.04	29.00b
Organic C (gkg $^{-1}$)	14.96	13.38	89.00c	12.30	14.73	120.0c	8.12	9.41	16.00a	7.98	6.20	78.00c
Avail. P (mgkg $^{-1}$)	10.18	2.60	26.00b	11.10	7.96	71.71c	15.64	12.56	80.31c	11.00	1.28	11.64a
Ca (cmolkg $^{-1}$)	3.23	0.17	53.60c	4.51	0.52	11.53a	4.71	0.39	8.20a	4.08	0.20	3.33a
Mg (cmolkg $^{-1}$)	3.38	1.47	13.91a	3.56	0.39	11.00a	3.44	0.80	24.00b	3.33	0.17	0.99a
K (cmolkg $^{-1}$)	0.95	0.10	10.53a	1.05	0.07	6.67a	0.99	0.04	4.04a	0.99	0.07	7.14a
Na (cmolkg $^{-1}$)	0.86	0.04	5.20a	0.96	0.07	7.37a	0.87	0.0	9.62a	0.92	0.14	15.37b
Al (cmolkg $^{-1}$)	0.00	0.00	0.00a	0.00	0.00	0.00a	0.00	0.00	0.00a	0.00	0.00	0.00a
ECEC (cmolkg $^{-1}$)	8.73	0.69	7.94a	10.39	0.37	3.60a	11.00	1.33	12.10a	9.76	0.36	3.69a
Exc. Acidity (cmolkg $^{-1}$)	0.42	0.32	76.19c	0.30	0.14	47.14c	1.78	1.29	72.70c	0.43	0.14	3.29a
Fe (mgkg $^{-1}$)	100	3.02	5.20a	153.20	37.39	7.37a	173	23.54	13.61a	121	14.81	15.37a
Mn (mgkg $^{-1}$)	103	4.05	3.93a	128.2	13.19	10.29a	108	10.82	10.02a	89	6.89	7.74a
Cu (mgkg $^{-1}$)	13.2	0.87	6.60a	5.60	4.47	78.86c	3.2	0.65	20.31b	9.33	0.98	10.50a
Zn (mgkg $^{-1}$)	13.2	0.87	6.60a	11	0.92	8.38a	16	4.82	30.13c	9.33	0.98	10.50a
Sand g/kg	799	23.09	2.89a	792	38.81	4.90a	830	26.08	3.14a	810	19.14	2.37a
Silt g/kg	60	20.00	33.33c	52	26.83	51.60c	48	10.95	22.82b	55	19.14	34.80c
Clay g/kg	141	41.64	29.53b	156	53.05	34.01b	122	26.83	21.99b	134	36.51	27.24c
Gravel %	50.9	20.67	40.62c	21.71	13.7	62.05c	10.5	6.46	61.53c	17.33	3.54	20.43c

CV % a: least variable <15%; b: moderately variable 15-35% ; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the rows

Table 3a. Some statistics of land quality and characteristics of the Pedons at Site 2 (topsoil)

Properties	IW			IR			BA		
	$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)	X	SD	CV(%)
pH (H_20)	6.84	0.33	4.8a	6.6	0.2	3.0a	5.7	1.30	22.94b
Total N (gkg $-^1$)	0.06	0.07	117c	0.11	0.11	100.00c	0.19	0.25	132.00c
Organic C (gkg $-^1$)	0.56	0.63	102c	1.04	1.1	105.00c	1.88	2.49	133.00c
Avail. P (mgkg $-^1$)	11.2	6.82	60.8c	22.1	3.76	17.05b	20.37	11.10	54.50c
Ca (cmolkg $-^1$)	5.34	0.63	11.8a	4.5	0.03	0.70a	4.17	0.36	8.64a
Mg (cmolkg $-^1$)	4.15	2.20	53.0c	3.34	3.1	2.99a	3.49	0.2	5.73a
K (cmolkg $-^1$)	1.16	0.27	23.2b	0.92	0.14	15.37b	1.03	0.05	5.31a
Na (cmolkg $-^1$)	1.02	0.18	17.6b	0.77	0.06	8.52a	0.70	0.04	13.80a
Al (cmolkg $-^1$)	0.00	0.00	0.00a	0.00	0.00	0.00a	0.00	0.00	0.00a
ECEC (cmolkg $-^1$)	216	20.39	0.1a	176	6.92	3.94a	171	28.49	16.64b
Exc. Acidity (cmolkg $-^1$)	175	16.94	9.6a	135	22.80	16.89b	119	97.76	82.15c
Fe (mgkg $-^1$)	7.11	1.06	15.0a	5.7	0.2	3.51a	5.87	0.37	6.37a
Mn (mgkg $-^1$)	79.31	28.8	36.3a	56.5	21.00	37.16b	60.90	1.00	1.64a
Cu (mgkg $-^1$)	12.23	3.12	25.5b	10.15	0.48	4.73a	9.85	0.45	4.65a
Zn (mgkg $-^1$)	0.6	0.11	0.2a	0.51	0.02	3.92a	o.45	0.17	39.12c
Sand g/kg	833	98.9	11.8a	863	28.2	3.2a	894	95.5	9.57a
Silt g/kg	70	42.4	60.6c	58	2.8	4,8a	54	50.9	94.28c
Clay g/kg	97	56.5	58.3c	79	25.4	32.2b	52.5	34.64	66.0c
Gravel %	8.9	2.3	26.2b	12.4	0.64	10.24a	41.7	7.48	17.94b

CV % a: least variable <15%; b: moderately variable 15-35%; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the rows

Table 3a. continued……………

	EG			MT			IB		
	X	**SD**	**CV(%)**	**X**	**SD**	**CV(%)**	**X**	**SD**	**CV(%)**
pH (H_20)	6.16	0.17	2.81a	6.9	1.0	14.7a	5.8	0.6	113a
Total N (gkg $^{-1}$)	0.12	0.08	74.5c	0.04	0.1	171.3c	0.2	0.1	50.00c
Organic C (gkg $^{-1}$)	1.20	0.85	71.39c	0.40	0.6	164.9c	1.8	0.2	11.1a
Avail. P (mgkg $^{-1}$)	10.7	7.04	65.8c	259.6	30.8	104.3c	13.6	4.5	33.6b
Ca (cmolkg $^{-1}$)	4.73	0.29	6.16a	5.2	1.0	20.2b	2.6	1.2	46.1c
Mg (cmolkg $^{-1}$)	4.0	0.4	0.1a	4.3	0.7	16.2b	1.0	0.2	20.0b
K (cmolkg $^{-1}$)	1.2	0.1	8.3a	1.3	0.2	15.6b	0.8	0.1	12.5a
Na (cmolkg $^{-1}$)	1.1	0.1	15.7b	1.2	0.2	19.2b	0.6	0.1	16.6b
Al (cmolkg $^{-1}$)	0.00	0.00	0.00a	0.00	0.00	0.00a	0.00	0.00	0.00a
ECEC (cmolkg $^{-1}$)	293	38.5	13.1a	228	42.2	18.5b	170	40.8	24.1b
Exc. Acidity (cmolkg $^{-1}$)	190	32.9	17.3b	162	40.7	25.1b	149	17.1	11.4a
Fe (mgkg $^{-1}$)	9.6	0.2	2.6a	8.8	0.6	6.9a	8.3	0.6	8.1a
Mn (mgkg $^{-1}$)	104	5.9	5.6a	228	79.9	35.1c	90.9	19.6	21.5b
Cu (mgkg $^{-1}$)	12	0.8	7.1a	12.6	2.3	18.6b	5.6	1.2	21.9b
Zn (mgkg $^{-1}$)	0.39	0.03	9.9a	0.4	0.2	50.00c	0.4	0.1	25.0b
Sand g/kg	591	309	52.2c	873	6.32	0.72a	698	31.8	4.5a
Silt g/kg	105	19.14	18.2b	528	4.89	9.2a	153	30.5	19.9b
Clay g/kg	303	321	106c	74.3	23.6	31.7b	114	70.2	61.6c
Gravel %	35.8	36.8	102c	7.6	6.63	87.2c	15.6	5.6	35.9c

CV % a: least variable <15%; b: moderately variable 15-35%; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the rows

Table 3b. Some statistics of land quality and characteristics of the Pedons at site 2 (subsoil)

	IW			IR			BA		
	X	**SD**	**CV(%)**	**X**	**SD**	**CV(%)**	**X**	**SD**	**CV(%)**
pH (H_20)	6.47	0.15	2.32a	5.9	0.45	7.7a	6.04	2.20	36.44
Total N (gkg $-^1$)	0.01	0.004	44.72c	0.01	0.01	100.00c	0.07	0.06	88.06c
Organic C (gkg $-^1$)	0.06	0.04	0.75a	0.08	0.08	111.00c	0.35	0.05	14.38a
Avail. P (mgkg $-^1$)	18.43	1.60	8.69a	21.0	3.77	17.97b	11.71	5.78	49.43c
Ca (cmolkg $-^1$)	5.51	0.52	9.43a	5.33	0.69	13.02a	4.28	0.65	15.40b
Mg (cmolkg $-^1$)	4.02	20.63	15.72b	4.49	0.49	10.97a	3.86	0.53	13.83a
K (cmolkg $-^1$)	1.22	0.25	20.97b	1.31	0.07	5.39a	1.17	0.14	12,23a
Na (cmolkg $-^1$)	0.96	0.16	16.79b	0.88	0.14	16.27b	0.88	0.08	9.16a
Al (cmolkg $-^1$)	0.00	0.00	0.00a	0.00	0.00	00.00a	0.00	0.00	0.00a
ECEC (cmolkg $-^1$)	272	44.41	16.32b	246	58.67	23.85b	123	60.26	27.02b
Exc. acidity (cmolkg $-^1$)	196	27.29	13.92a	189	16.85	8.92a	150	40.77	27.18b
Fe (mgkg $-^1$)	7.69	16.85	21.97b	7.38	1.41	19.21b	8.31	1.04	12.62a
Mn (mgkg $-^1$)	84.48	18.76	22.21b	75.59	19.26	25.48b	78.54	21.90	27.89b
Cu (mgkg $-^1$)	12.26	1.64	13.40a	12.27	1.55	12.65a	10.63	1.32	12.49a
Zn (mgkg $-^1$)	0.55	0.08	15.21b	0.43	0.04	1.01a	0.42	0.03	7.52a
Sand g/kg	759	2.1	0.2a	812	3.53	0.4a	729	25.5	3.5a
Silt g/kg	345	476	137c	48	10.58	22.0b	50	17.3	34.6b
Clay g/kg	164	11.43	6.9a	140	25.16	317.97b	220	68.0	30.9b
Gravel %	36.1	10.22	28.3b	16.5	5.61	34.0b	40.3	16.2	40.3a

CV % a: least variable <15%; b: moderately variable 15-35%; SD: Standard deviation, X: mean; c: extremely variable >35%, represent the % variation along the row

4. DISCUSSION

Soil properties manifest both short and long range variability and are multivariate in nature. [11,13].

Tables 2a,b and 3a,b shows the variation of soil properties of the study sites, thus the assumption that soils are uniform in their properties, which formed the use of blanket fertilizer recommendation is invalid [14]. Stated that variability within a single field can be large. This has implication for crop production since soil variability will lead to crop variation, which is undesirable for agricultural experiment.

The low CV% obtained for pH is assumed to be as a result of the non-zero origin of scale as reported by [4]. This could also be supported by the work of [2,3], where he stated that the least variable soil properties are hue and value of soil color, pH and thickness of the A horizon.

Soil pH was consistently the least variable for both sides (CV<15%). Total Nitrogen, Organic carbon and Avail. P were highly variable for both sides in terms of top and subsoil (CV>35%).

The silt, clay and gravel content of subsoil for site 1 are extremely variable while sand is moderately variable. This has also been reported by [9]. However for site 2, silt, clay and gravel varied from least to moderately variable, for sand (topsoil and subsoil) it is least variable (CV<15%).

For silt, clay, Total N and Organic carbon that are highly variable for both sites (<35%), this suggest that they could be managed together to some extent. Comparing the degree of variability of properties among the pedons. From (Tables 2a,b and 3a,b), it was discovered that the value of each of the properties differed between the pedons. Some of the chemical property like K are least variable (CV<15) for site 1 subsoil, while it varied for site 2. Organic carbon which is the main factor of production is the most variable in the study area either sub or topsoil. This observation has also been reported by [9]. In his experiment it was showed that co-efficient of variation for the soil physical properties range from 9-10%, with sand content having a CV that decrease with an increase in clay content. It was also pointed out that skewness would be the most frequent departure from normality. So CV value >100% may be symptomatic of skew distribution.

Silt falls within the range of 15-35% for site 1 subsoil which is referred to as moderately variable [3]. Also reported that some physical and chemical properties fall between a CV value <15%, others extreme, such as available P, Organic carbon and Total N.

However, soils should therefore be managed based on their potential and capability. The work of previous workers e.g. [7,2] has substantiated this assertion.

5. CONCLUSION AND RECOMMENDATIONS

The variation that exists among the pedons indicate that the soils are not uniform (>35%), because variations in soil are the major determinants of crop yield.

Soil pH was consistently the least variable property irrespective of the soil type, while other chemical properties fell within the tolerable limit of variability (CV<35%). However, no single property was consistently highly variable irrespective of the series, except in the case of Total N and Organic Carbon in most of the series, and are highly variable. Gravel content is highly variable irrespective of the series.

In general, the degree of variability for some of the properties as estimated by CV compares well with those obtained by earlier workers. Grouping of soil properties according to degree of variability using CV values also agreed with published data. The variability of some properties such as organic carbon, total nitrogen and available phosphorus are likely to have been markedly influenced by land use and management practices.

Due to inherent variability associated with the soil of the sites, it is therefore possible to group the soil properties together based on their level of variability.

From this finding it is suggested that:

1 Application of fertilizer and allocation of land use with the key knowledge of soil chemical and physical properties for making agronomic decisions is often of great importance.
2 Sustainable management practices that will reduce variability should be put into consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Akinbola GE. Baseline ecological survey of the permanent site of the proposed Emmanuel University, Alaho, Ibadan; 2006.
2. Ogunkunle AO. Spatial variability of some chemical properties in two Ultisol mapping units in Southern-Nigeria. Soil Survey and Land Evaluation. 1993;6(1):26-33.
3. Ogunkunle AO. Variation of some soil properties along two toposequences on Quartile Schist and Banded Gnesis in Southwestern Nigeria. Geo Journal. 1993;30(4):399-402.
4. Sys C. Land evaluation. International training center for postgraduate. Soil scientists. State University Ghent. 1985;1,2,3.
5. Richard GO, Darwin WA, John WBS. The distribution of selected soil properties in relation to land scape morphology in forest Gray Luvisol soils. Can Soil Sci. 1993;73:166-172.
6. Bouma J. Land qualities in space and time. In: J. Bouma and A. K. Bregt (eds.), land qualities in space and time. Proc. ISSS symp. Wageningan. Pudoc, Wageningen. 1989;3-31.
7. Dahiya S, Ritcher J, Malik RS. Soil spatial variability. A review inters J Trop agric. 1984;11:1-102.
8. Hullegalle NR, Ndi FN. Contributory factors to soil spatial variability in an Ultisol-commun. Soil Sci Plant Anal. 1993;24(11 and 12):1409-79.
9. Mausbach MJ, Brosher RD, Nettleton WD. Variability of measured properties in morphological matched pedons. Soil Sci Soc Am J. 1980;44:358-363.

10. Bouyoucos GT. The hydrometer as a new method for the mechanical analysis of soils. Soil Sci. 1990;343-353.
11. Tsegaye T, Hill RL. Intensive tillage effects on spatial variability of soil physical properties. Soil Sci. 1998;163:143-154.
12. Shukla MK, Lal R, Ebinger M. Principal component analysis for predicting biomass and corn yield under different land uses. Soil Sci. 2004;169:215-224.
13. Russol D, Bresler E. Soil hydraulic properties as stochastic process: 1. an analysis of field spatial variability. Soil Sci Soc Am J. 1981;45:682-687.
14. Nelsen DR, Bigger JW, Erh KT. Spatial variability of field measured soil water properties. Hilgardia. 1973;42:215-259.

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