

Attributes and Fertility Ranking of Lade Soils in the Southern Guinea Savanna of Nigeria

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Abstract

A major constraint restraining agricultural production in Nigeria is the scarcity of gen on soil property. The concomitant improper land use results in land degradation and dwindled agrarian efficiency. Consequently, this study seeks to assess the physicochemical attributes and classify and rank Lade soils according to fertility potential. The free survey was conducted to collect representative soil data. Six (6) profile pits designated L1 to L6 were dug to characterize the mapping units using soil samples obtained from horizons in respective profiles for the study of physical and chemical characteristics employing standard laboratory techniques. Profile description and soil classification at the Great Group level followed USDA guidelines. Fertility Capability Classification system was used to evaluate the soils for arable cropping. Soil was indicative of a relatively high structural index ($>9\%$), strong to slightly acidic ($4.0 - 6.3$). Organic carbon ($8.02 - 9.24 \text{ g kg}^{-1}$), available P ($9.66 - 25.76 \text{ mg kg}^{-1}$) and total N ($0.09 - 0.34 \text{ g kg}^{-1}$) were mostly moderate. Extractable bases ranged from high to very high while soil color diverse from dark yellowish brown (10YR 4/4) on the surface to reddish brown (2.5YR 4/3) in the subsoils. Soils L1 - L6 were classified as Endoaqualfs, Kandiusalfs, Haplustalfs, Haplustalfs, Plinthustalfs and Kandiusalfs, respectively. Potential suitability for arable crop place pedons L1 and L3 in class S2 (moderately suitable), whereas other pedons were rated as S3 (marginally suitable). The study gives an insight into the judicious use of inorganic fertilizer combined with good residue management and drainage for fertility improvement of the soil.

Keywords: Characterization, Fertility capability classification, nutrient status, sandstone, soil taxonomy

Introduction

Bungling practices on land as natural renewal resources with its attendant consequence on productivity and sustainability is one of the challenges facing most developing countries. To avoid the downward slide to the attainment of Sustainable Development Goals 1 and 12 targeted towards poverty eradication and resource degradation, viable paths that would guarantee sustainable production systems for better livelihoods in response to indigenous conditions (Filho *et al.*, 2020) are pertinent. These development paths would necessitate the careful alteration of resource use techniques, as well as the implementation of a set of activities that ensure food security and input efficiency (Nash *et al.*, 2020). Soil, being a natural resource and medium for cultivation, must consequently be thoroughly investigated in order to be utilized to its full potential.

Numerous research has been carried out to determine the appropriateness of Nigerian soils for agricultural cultivation. Joshua, Kunda, Anyanwu, and Jajere (2013) employed a GIS and multi-criteria decision analysis (MCDA) to identify potential agricultural production places in the Greater Karu Urban Area, Nasarawa State and concluded that suitability ranged from moderate to high across the areas studied. According to Maniyunda and Gwari (2014), none of the Haplustalfs assessed for maize and groundnut production in Nigeria's sub-humid environment were well adapted. Using maize and peanuts as test crops, Ahukaemere, Ekpr, and Unachukwu (2015) achieved similar results in Owerri, Southeastern Nigeria. Abegunde, Adediji, and Tope-Ajayi (2015) and Ajiboye and Olaniyan (2016) showed low to medium soil suitability levels for maize agriculture in Oyo State and oil palm plantation output in the Etung Local Government area.

According to the preceding, while increasing productivity in resource use is crucial to ensuring adequate food security and environmental sustainability, the minor increase in crop production in Nigeria has been attributed to an increase in hectares dedicated to crop cultivation rather than the maximum yield of each farmland. According to the Food and Agriculture Organization (FAOSTAT, 2012), agricultural production farming in Kaduna state decreased by around 20% between

1991 and 2000 and 2001 and 2010. Furthermore, the potential yield of crops employing enhanced seedlings in Nigeria is insufficient when compared to that of industrialized countries (Izuogu *et al.*, 2023; Oyekale, 2014). The land has been utilized arbitrarily at the expense of its flexibility and capability, resulting in land degradation as well as changes in the land's natural biotic conservatory balances. Land use is frequently not related to its potential capacity as a function of its use type, particularly in Nigeria (Olayide, 2021; Senjobi & Ogunkunle, 2010). As a result, the following research issues will be addressed in this study:

1. What is the current state of selected soil physicochemical properties?
2. What are the soil categories in the research area?

The inventory of land resources is still required for proper exploitation and management of a country's natural resource base. Precise inventories have become essential for assessing a country's current natural resources. As a result, the study area's effort is to optimize land usage using the most practicable and rational methods toward ensuring sustainable output while maintaining fragile ecosystems. This research provides useful information on the physical and chemical aspects of soil classification, the likelihood of flooding and/or drought, and the land use best suited for the area. The goal of this study was to define, categorize, and estimate the intrinsic fertility status of selected soils in Kwara state's Patigi Local Government Area.

Materials and Method

Soil survey

A comprehensive soil survey was conducted in Patigi Local Government Area (LGA), Kwara State, identifying six distinct soil types (Figure 1). Soil classification adhered to USDA guidelines (Soil *et al.*, 2017, 2022). Integrating Lade toposheets, Landsat imagery, and Google imagery, this study generated a detailed soil map delineating habitation, roads, drainage lines, water bodies, land use/land cover, and landforms. Soil boundaries were defined using soil phases and referenced against soil profile location maps and landform maps. ArcGIS analysis yielded six mapping units (L1-

Soil map of the study area showing four soil types: Endoaqualfs (brown), Kandustalfs (orange), Haplustalfs (light green), and Fluventic (dark blue). The map includes a scale bar (0 to 2 Kilometers), a north arrow, and coordinates (5°35'0"E to 5°40'0"E and 102°50'0"N to 102°55'0"N). A legend indicates the Study Area is 13,096.26 ha. Sources listed include Esri, HERE, DeLorme, Intermap, and others.

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Laboratory analysis

Soil samples from the profile horizons were air-dried, sieved to 2 mm, and submitted to physical and chemical analysis as described in Table 1. The effective CEC was calculated by adding the NH₄OAc bases and the KCl exchangeable Al and H. Total exchangeable bases were expressed as a proportion of ECEC to calculate base saturation (Adegbite et al., 2019).

Table 1. Soil Analysis Methods.

Parameter	Method
pH	glass electrode pH meter (Thomas, 1996)
Total nitrogen	Bremner (1990) developed the total nitrogen micro-Kjeldahl digesting method
Available Phosphorus	Bray 1 extraction technique is available, followed by molybdenum blue colorimetry (Frank et al., 1998)
Organic carbon	Walkley and Black technique (dichromate wet oxidation) (Nelson & Sommers, 1996)
Exchangeable cations (potassium, calcium, sodium, and magnesium)	Extraction with 1 N ammonium acetate. A flame photometer was used to measure K and Na in the extract, while an Atomic Absorption Spectrophotometer (Model: Buck 205; Brand: Buck Scientific; Country of manufacture: USA) was used to measure Ca and Mg
Exchangeable Acidity	Extraction with 1 N potassium chloride, followed by 0.01 N NaOH titrimetry with phenolphthalein indicator
Electrical conductivity	Saturated paste method (Okalebo et al., 2000)

Classification of fertility capability

Fertility capability classification (FCC) was performed using the approach indicated in Sanchez, Water, & Buol (1982) and Sanchez, Palm, & Buol (2003) by taking into account both surface and subsurface physical and chemical soil parameters. The FCC system is divided into three categories: i) 'Type,' which refers to the texture of the top 20 cm of surface soil: sandy top soils (S), loamy top soils (L), clayey top soils (C), and organic top soils (O), and ii) "substrata type" which denotes sub-soil texture between 20 and 50 cm depth: sandy sub-soils (S), loamy sub-soils

(L), clayey sub-soils (C), and rock or other hard root-restricting layers (R) and iii) "modifiers" that represent soil physical and chemical features which include dry soil moisture (d), low CEC (e), acidity (h), low K reserves (k), slope (%), among others. By linking this classification method to mapping units, the area's FCC was determined.

Results and Discussions

Physical qualities of the study selected soil

The physical features of the soils used in the study are presented in Table 2. The particle size distribution revealed no evidence of aggregates larger than 2 mm (gravel) in the soil. The soil's sand concentration ranged from 470 to 870 g kg⁻¹, with the fifth (L5) and sixth (L6) profiles exhibiting the lowest and highest sand content, respectively. Across the six profile pits, the sand content of the soil decreased with increasing depth, while the silt and clay contents generally did not follow a consistent pattern. Horizon 2 in Pedon 1, with the highest clay content (210 g kg⁻¹), recorded the most moisture, while Horizon 1 had the lowest moisture content (1.246%) of the four horizons in the pedon. It also had the least clay component at 130 g kg⁻¹, with the majority of its make-up being sand at 870 g kg⁻¹. All of the horizons in Pedon 2 had moisture content that ranged from low to moderate.

Table 2. Physical Properties of the Soils Studied.

Profile ID.	Soil depth (cm)	Sand (g kg-1)	Silt (g kg-1)	Clay (g kg-1)	Silt/clay ratio	Color	texture	Moisture content
L1	0-23	650	220	130	1.69	10YR3/4 (Brown)	Sandy loam	1.246
	23- 34	550	240	210	1.14	10YR5/4 (Yellowish brown)	Sandy clay loam	4.199
	34-53	550	260	190	1.37	10YR7/2 (light grey)	Sandy loam	1.612
	53-120	530	320	150	2.13	10YR5/1 (Grey)	Sandy loam	3.520

Table 2 Continued. Physical Properties of the Soils Studied.

Profile ID.	Soil depth (cm)	Sand (g kg-1)	Silt (g kg-1)	Clay (g kg-1)	Silt/clay ratio	Color	texture	Moisture content
L2	0-17	810	80	110	0.73	7.5YR4/4 (Brown)	Sandy loam	0.392
	17-64	790	80	130	0.62	5YR5/8 (Yellowish red)	Sandy loam	0.466
	64-120	750	200	50	4.00	5YR6/8 (Reddish yellow)	Sandy loam	1.375
L3	0-20	850	100	50	2.00	7.5YR3/3 (Dark brown)	Loamy sand	2.696
	20-60	710	140	150	0.93	10R4/8 (Red)	Sandy loam	0.756
	60-125	550	140	310	0.45	10R5/8 (Red)	Sandy clay loam	1.371
L4	0-15	850	40	110	0.36	5YR3/2 (Dark reddish brown)	Loamy sand	0.418
	15-60	750	120	130	0.92	2.5YR5/8 (Red)	Sandy loam	0.453
	60-150	730	120	150	0.80	2.5YR4/8 (Red)	Sandy loam	0.978
L5	0-20	770	160	70	2.29	10YR4/4 (Dark yellowish brown)	Sandy loam	0.623
	20-49	650	220	130	1.69	2.5YR3/4 (Dark yellowish brown)	Sandy loam	2.373
	49-80	710	80	210	0.38	2.5YR4/6 (Red)	Sandy clay loam	4.140
	80-110	470	120	410	0.29	2.5YR4/6 (Red)	Sandy clay	2.846

Table 2 Continued. Physical Properties of the Soils Studied.

Profile ID.	Soil depth (cm)	Sand (g kg-1)	Silt (g kg-1)	Clay (g kg-1)	Silt/clay ratio	Color	texture	Moisture content
L6	0-12	850	100	50	2.00	5YR2.5/1 (Black)	Loamy sand	0.035
	12-35	850	100	50	2.00	5YR4/3 (Reddish brown)	Loamy sand	0.998
	35-60	870	80	50	1.60	2.5YR4/4 (Reddish brown)	Loamy sand	0.259
	60-80	850	100	50	2.00	5YR5/6 (Yellowish red)	Loamy sand	0.929
	80-125	750	120	130	0.92	5YR5/6 (Yellowish red)	Sandy loam	1.156

The outcome of the particle size distribution shows the existence of lithological discontinuities owing to the deposition of materials of contradictory texture and origin in the course of soil development. This could further be ascertained from the asymmetrical distribution of clay and stratification, which is evident in the dissimilar times of deposition of dregs. As a result of the coarse texture across pedons, less water was retained for pedogenesis, and the initial soil-forming processes were less active in these soils.

The reduced clay concentration of the surface soil in comparison to the subsurface horizons could indicate more intense chemical weathering in the subsurface soil, which is indicative of "old" soils with little weathering. Soils having a silt/clay ratio greater than 0.15 were suggestive of "old" soils (Wambeke, 2006), while silt/clay ratios greater than 0.25 are evidence of a low degree of weathering. Furthermore, the comparatively high sandy nature could be linked to the parent material and a reflection of the features of the Patigi acid sands, as proposed by Idris, Olaniyan, Affinnih, & Ajala (2017).

Pedon 1 (L 1) soils are often deep and well-drained, with brown to yellowish brown to light grey sandy clay loam surfaces overlain by grey sub-angular blocky structure soil. Water retention was relatively active in the surface horizon (0 - 34 cm), as evident from the soil color: brown to yellowish brown. However, hydromorphic mottles were noticeably observed in the subsurface horizons (34 -120 cm), which symbolizes the entire saturation throughout the rainy season.

Pedon 2 consists of brown to yellowish to reddish yellow sandy loam with no lithological discontinuity along the soil profile. Because of the coarse texture of this pedon, less water was retained for pedogenesis, and the first soil-forming processes are less active in these soils. At the subsurface, the soil texture of Pedon 3 (L3) ranged from loamy sand to sandy loam and sandy clay loam. The color of the soil ranged from dark brown at the top to crimson in the subsurface. The color changes were caused by the relatively high organic compounds at the surface and the subsurface oxidation of Fe^{2+} to Fe^{3+} . L4 had subsurface loamy sand to sandy loam, implying moderately coarse to coarse textured soil, whereas L5 had sandy loam (coarse texture) to fine textured, sandy clay loam, and sandy clay soils at lower depths. The subsurface of Pedon 6 transformed from loamy sand to sandy loam as a result of the generally high sand content, which varied from 750 to 870 g kg^{-1} . Except for horizons L3 and L5, all of the horizons were sub-angular blocky.

Chemical characteristics of soils used in the study

Results of chemical attributes and descriptive statistical analysis conducted to examine the chemical properties of the soils are presented in Table 3. The soil reaction (pH) in water and salt solution ranged from strongly acid (4.8) to moderately acid (6.0) in L1, strongly acid (4.0-4.8) in L2, moderately acid (5.8-6.2) in L3, strongly acid (4.6) to moderately acid (5.8) in L4, slightly acid (6.2-6.3) in L5, and strongly acid (4.2-5.7) in L6. The pH of the soils ranged from 4.0 to 6.3, increasing or decreasing with depth. This low pH could be attributed to weathering as well as excessive leaching of basic cations due to the relatively loose nature of the soil. This finding corroborates the submission of Yitbarek, Jembere, and Kerebeh (2018), who opined that most plants perform favorably

between pH 5.5 and 6.8. Subsequently, the pH of the soils in the research area may be deemed inadequate for most agricultural development.

Electrical conductivity, which indicates salinity, was generally low, ranging from 10 to 210 mhos cm^{-1} . Total nitrogen content ranged from 0.09 g kg^{-1} to 0.68 g kg^{-1} , indicating that it was very low to high. The comparatively low nitrogen level could be attributed to its soil solubility and mobility, as well as susceptibility to leaching, particularly in the medium to coarse soils tested. Phosphorus availability was typically high, with values exceeding the ten ppm criterion except for L1 (34 - 53 cm) 7.98, L2 (0- 17 cm) 9.87, and L6 (35 - 60 cm) 9.87. 9.66 mg kg^{-1} soil. The exchangeable acidity, which connotes the ability of the soil to resist a change in pH, varied from 0.00 to 6.52 cmol kg^{-1} , indicating a stable soil reaction in light of erratic environmental conditions.

Organic colloid components of the soils varied greatly depending on location and depth, ranging from 13.79% to 15.93%. However, organic matter distribution was typically uneven in the six (6) pedons, which may be attributed to the research area's vegetation and anthropogenic activities. Data on exchangeable bases identified magnesium and calcium as the dominant cations on soil exchange sites. The results for exchangeable calcium, magnesium, potassium, and sodium were 1.19 to 2.33 cmol kg^{-1} , 2.86 to 3.96 cmol kg^{-1} , 0.15 to 0.97 cmol kg^{-1} , and 1.04 to 0.63 cmol kg^{-1} , respectively.

Irrefutably, all the soils of the six mapping units are from the same parent material; dissimilarities in terrain, vegetation, biological conditions, and anthropogenic activities such as land use changes and agriculture have been responsible for the variability in soil property. This is in tandem with the work of Liu *et al.* (2020), who opined the same submission.

Soil classification

Soils were studied at the Great Group level following the USDA keys to soil taxonomy (Soil et al., 2022) and classified (Table 4).

Table 3. Chemical Properties and Descriptive Statistics of the Soils used in the Study.

Pedon	Hor. Desig	Depth cm	pH H ₂ O 1:1	pH KCl 1:1	EC mmhos cm ⁻¹	TN g kg ⁻¹	AP mg kg ⁻¹	EA cmol kg ⁻¹	OC %	OM %	Exchangeable bases (cmol kg ⁻¹)					
											Ca ²⁺	K ⁺	Na ⁺	Mg ²⁺	%BS	ECEC
L1	A	0-23	6.0	4.9	42	0.11	11.62	4.76	8.46	14.58	2.04	0.68	0.74	3.13	58.02	11.34
	B	23- 34	4.8	4.5	70	0.14	25.76	0.32	8.34	14.38	2.30	0.36	0.70	3.19	95.34	6.86
	C	34-53	5.4	4.1	42	0.19	7.98	1.06	8.10	13.96	2.05	0.39	0.81	3.19	85.91	7.50
	D	53-120	5.8	3.5	94	0.19	11.06	0.32	8.30	14.31	5.11	0.97	0.57	3.34	96.90	10.32
L2	A	0-17	4.4	4.5	76	0.68	9.87	0.60	8.24	14.20	1.10	0.43	0.98	3.96	91.51	7.07
	B	17-64	4.0	4.0	10	0.14	25.06	0.32	8.02	13.83	0.76	0.32	0.92	2.86	93.82	5.18
	C	64-120	4.3	0.5	18	0.42	10.22	0.00	9.24	15.93	1.48	0.63	0.63	3.22	96.75	6.15
L3	A	0-20	5.8	8.5	98	0.25	24.01	0.28	8.20	14.14	1.74	0.35	0.37	3.00	95.11	5.73
	B	20-60	6.2	8.2	62	0.11	14.98	0.88	8.58	14.79	1.62	0.63	0.93	3.10	87.71	7.16
	C	60-125	6.1	7.1	66	0.17	22.68	1.03	8.20	14.14	2.33	0.51	0.73	3.25	86.89	7.84
L4	A	0-15	5.8	3.1	84	0.17	22.61	0.32	8.42	14.52	2.14	0.26	0.67	3.10	95.07	6.49
	B	15-60	4.8	3.0	66	0.25	15.89	0.32	8.28	14.27	2.28	0.74	0.74	3.09	95.54	7.17
	C	60-150	4.6	1.7	72	0.34	21.63	0.56	8.20	14.14	1.17	0.28	0.68	3.14	90.37	5.82
L5	A	0-20	6.3	6.3	68	0.14	10.5	3.72	8.36	14.41	2.67	0.37	0.68	3.10	64.72	10.55
	B	20-49	6.2	6.0	70	0.14	22.54	1.32	8.40	14.48	2.31	0.41	0.67	3.25	83.43	7.96
	C	49-80	6.2	5.6	70	0.22	14.49	0.80	8.54	14.72	4.30	0.32	0.70	3.37	91.57	9.49
	D	80-110	6.2	5.3	56	0.09	22.12	0.92	8.46	14.59	3.87	0.35	0.73	3.37	90.02	9.22
L6	A	0-12	4.5	10.0	206	0.14	15.61	0.52	8.64	14.90	3.94	0.58	0.70	3.28	94.23	9.02
	B	12-35	4.2	9.9	64	0.22	22.12	1.16	8.22	14.17	1.64	0.15	0.66	3.17	82.88	6.78
	C	35-60	5.2	9.2	210	0.17	9.66	6.52	8.00	13.79	1.19	0.16	0.67	3.12	44.04	11.65
	D	60-80	5.5	9.0	90	0.17	23.24	0.00	8.28	14.27	1.31	0.19	0.72	3.19	96.43	5.60

Table 3 Continued. Chemical Properties and Descriptive Statistics of the Soils used in the Study.

Pedon	Hor. Desig	Depth cm	pH H ₂ O 1:1	pH KCl 1:1	EC mmhos cm ⁻¹	TN g kg ⁻¹	AP mg kg ⁻¹	EA cmol kg ⁻¹	OC %	OM %	Exchangeable bases (cmol kg ⁻¹)				%BS	ECEC
											Ca ²⁺	K ⁺	Na ⁺	Mg ²⁺		
Mean			5.36	6.12	77.27	0.21	17.04	1.24	8.34	14.38	2.23	0.44	0.73	3.21	86.21	7.86
min			4.00	3.00	10.00	0.09	7.98	0.00	8.00	13.79	0.76	0.15	0.37	2.86	44.04	5.18
max				10.0	210.0											
			6.30	0	0	0.68	25.76	6.52	9.24	15.93	5.11	0.97	1.04	3.96	96.9	11.65
SD±			0.77	2.31	47.38	0.13	6.10	1.64	0.27	0.46	1.13	0.21	0.14	0.20	13.73	1.89

Legend: EC= Electrical conductivity; TN = Total nitrogen; AP= Available phosphorus; EA= Exchangeable acidity; OC= Organic carbon; OM= Base saturation; ECEC= Effective cation exchange capacity

Table 4. Soil classification of identified mapping units at Lade, Patigi Local Government Area of Kwara State, Nigeria.

Pedon designation	Characteristics	Classification
L1	Poorly drained soil with an argillic horizon, >50% base saturation, the lower boundary of all Ap layers, and depth of 40 cm possess redoximorphic features, ≤ 2 chromas on faces of peds attributable to 50% redox reduction as well as accumulation within peds	Endoaquals
L2	A well-drained, high base saturation (>50%), ustic moisture regime soil with kandic horizon, absence of densic. Lithic, paralithic, or petroferic contact within 150 cm mineral component soil surface, without clay migration with an increase in depth of > 20% with respect to the maximum clay fraction within 150 cm depth.	Kadiustalfs
L3	Well-drained, high base saturation (>50%), ustic moisture regime soil with an argillic horizon, absence of dense lithic, paralytic, or petroferic contact within 150 cm mineral component soil surface, no diagnostic characteristics for other Ustalfs.	Haplustalfs
L4	Well-drained, high base saturation (>50%), ustic moisture regime soil with an argillic horizon, absence of densic. Lithic, paralithic, or petroferic contact within 150 cm mineral component of the soil surface, no diagnostic characteristics for other Ustalfs.	Haplustalfs
L5	Has an argillic horizon, high base saturation of >50% in all horizons, ustic soil moisture regime, and > one continuous plinthite phase in horizons within 150 cm mineral component of the soil surface.	Plinthustalfs
L6	A well-drained, high base saturation (>50%), ustic moisture regime soil with kandic horizon, absence of densic. Lithic, paralithic, or petroferic contact within 150 cm mineral component soil surface, without clay migration with an increase in depth of > 20% with respect to the maximum clay fraction within 150 cm depth.	Kadiustalfs

Fertility capability

Fertility ranking for the mapping units was recognized by applying the type, sub-strata type, and water within 50 cm modifiers using the surface (0–20 cm) and subsurface (20–50 cm) soil properties and nine modifiers identified are presented in Table 5. Pedons 1, 2, and 3 soils: SLgdehik(3–5), SSdeaiKn(3-5), and SSdeahik(3-5), respectively, have more limitations/condition modifiers than the other three pedons, with pedon 6 having the least – Sldak(3-5) which is due to land utilization. Pedon 1, 2, and 3 belong to Uplands, which are generally rainfed, while Pedon 6 is a lowland, normally cultivated with rice. Consequently, good management practices, besides the addition of organic manures through plowing, as well as the rice roots and straw left over after harvest into the soils during hydromorphism.

Table 5. Type/substrata, condition modifiers, and final fertility capability ranking at Lade, Patigi Local Government area of Kwara State, Nigeria.

Soil classification	Type/ substrata	Checklist									Modifiers	Slope (%)	FCC unit
		g	D	E	a	h	I	k	n	S, Ci			
Endoaquals	SL	+	+	+	-	+	+	+	-	+	gdehikS,Ci	3-5	SLgdehik(3-5)
Kadiustalfs	SS	=	+	+	+	-	+	+	+	+	deaiknS,Ci	3-5	SSdeaikn(3-5)
Haplustalfs	SS	-	+	+	+	+	+	+	-	+	deahikS,Ci	3-5	SSdeahik(3-5)
Haplustalfs	SS	-	+	+	+	+	-	+	-	+	deahkS,Ci	3-5	SSdeahkS,Ci(3-5)
Plinthustalfs	SS	-	+	+	=	+	+	-	-	+	dehiS,Ci	3.5	SSdehiS,Ci(3-5)
Kadiustalfs	SL	-	+	-	+	-	-	+	-	+	dakS,Ci	3-5	SLdak(3-5)

Legend: + = present/exist/applicable; - = Not present/non-existence/not applicable

Type: S = sandy top soils within surface or 20cm depth (loamy sands and sands according to USDA definition)

Substrata: S =sandy subsoil; texture as in type; L = loamy subsoil; less than 35% clay but no loamy sand or sand;

Conditioners/modifiers: g = gley; d = d = potential germination and seeding mortality problems caused by planting during the dry season and sporadic rainfall at the onset of the rainy season; e = low cation exchange capacity; a = chemical limitations of subsoil water availability to Al-sensitive plants; h = acid: pH in 1:1 water between 5.0 and 6.0; i = high phosphorus fixation: hues of 7.5YR or redder and granular structure within the surface or 20cm of soil surface; k = low K reserve: exchangeable potassium less than 2% of summation of bases; if bases less than ten meq/100g soil; n = natric: greater than 15% sodium saturation of cation exchange capacity within 50cm of the soil surface; S, Ci = low water holding capacity.

Conclusion and Recommendations

The soils were classified as Aqualfs, Kandistalfs, Haplustalfs, and Plinthustalfs. Potential suitability put pedons 1 and 3 in class S2 (moderately suitable), while pedons 2, 4, 5, and 6 were rated as S3 (marginally suitable). Argillic horizon was common to all the soils. Available P was a limitation in two (2) pedons (1 and 3), while low K reserve was a limitation in all pedons except L5 and will therefore need K fertilization, especially for K- sensitive crops. The silt/clay ratio in the soils was greater than 0.25, which is indicative of "old" soils with a low degree of weathering.

Soil fertility classification relies mostly on the topsoil and subsoil properties and, hence, is a panacea for sustainable crop production. The protection of land and soil resources for their health and productivity requires a proper understanding of the land resources and limitations as well as the allocation of specific land units to uses that are not adversely affected by the limitations posed by the land area. The FCC units identified in the southern Guinea Savanna acreage of Lade show that sandy and/or loamy were the type and substrate type.

Nine major condition modifiers were identified, which inferred the adoption of the best appropriate soil and water conservation methods along with good agronomic management practices at the farm level centered on the confines and abilities of the land units, thus boosting production and efficiency of crops apart from plummeting land degradation and soil erosion in addition to enhancing soil health. The present study has inferences on reviewing the prevailing connections amid condition modifiers definition with soil diagnostic horizon properties so that it will be advantageous for better understanding besides the transformation of reworking soil taxonomic data into real-world applicability of soil fertility capability units.

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Literature Cited

- Abegunde, L., Adedeji, O. & Tope-Ajayi, O. (2015). Land suitability analysis for maize production in Egbeda local government area of Oyo state using GIS techniques. *International Journal of Environmental and Ecological Engineering*, 9(3).
- Adegbite K. A., Okafor, M. E., Adekiya, A. O., Alori, E. T. & Adebisi, O. T. V. (2019). Characterization and classification of soils of a toposequence in a derived savanna agroecological zone of Nigeria. *Open Agric J.* 13: 44-55. DOI: 10.2174/1874331501913010044
- Ahukaemere, C. M., Ekpr, I. I. & Unachukwu, I. C. (2015). Suitability evaluation of soils derived from dissimilar lithological materials for maize and groundnut production in Owerri agricultural zone, southern Nigeria. *Malaysian Journal of Soil Science*, 19, 73-82
- Ajiboye G. A. & Olaniyan J. O (2016). Characteristics and suitability evaluation of the “white soils” of Etung local government area for oil palm and plantain production. *Agrosearch* 16(2): 25-40
- Bremner, J. M. (1960). Determination of nitrogen in soil by the Kjeldahl method. *Journal of Agricultural Science*. 55: 11-31.
- Buol, S. W. & Couto, W. (1981). Soil fertility capability assessment for use in the humid tropics. In *Characterization of soils in relation to their management for crop production: Examples from the humid tropics*, ed. D. J. Greenland, 254–61. London: Clarendon Press.

- Chandrakala, M., Srinivasan, R., Anil Kumar, K. S., Sujatha, K., Hegde, R. & Singh, S. K. (2019). Land suitability evaluation for major crops adapted to the tropical humid region of Kerala, India. *International Journal of Chemical Studies* 7 (4):2446–53.
- FAOSTAT (2012) Food and Agriculture Organization of the United Nations Data. Statistical Databases. <http://faostat.fao.org/default.aspx?lang=en>. Retrieved 20th April, 2024
- Filho, W. L., Wolf, F., Salvia, A. L., Beynaghi, A., Shulla, K., Kovaleva, M. & Vasconcelos, C. R.P. (2020). Heading towards an unsustainable world: some of the implications of not achieving the SDGs. A review. *Discover sustainability* 1: 2. <https://doi.org/10.1007/s43621-020-00002-x>
- Frank, K., Beegle, D. & Denning, J. (1998). Phosphorus. In: Brown, J.R. (Ed.), Recommended chemical soil test procedures for the North Central Region, North Central Regional Research Publication No. 221 (revised) Missouri Agric. Exp. Stn., Columbia, MO, pp. 21-26.
- Gee, W. G & Or, D. (2002). Particle-size analysis. In: *Methods of Soil Analysis*, Book series: 5. Part 4; Dane, J. and G. C. Topp (Eds.), Soil Science Society of America, USA, p. 255-293.
- Idris, A. D., Olaniyan, J. O., Affinnih, K. O. & Ajala, O. N. (2017). Forms and distribution of potassium in red laterite soils of Patigi in north-central Nigeria. *Bulgarian Journal of Soil Science* 2(1): 42-52
- Izuogu, C. U., Orji, J. C., Chinaka, I. C., Ankrumah, E. & Njoku, J. (2023). A REVIEW OF THE Nigerian seed system. *Selekcija I Semearstvo* 29(2). <https://doi.org/10.5937/SelSem2302039I>

- Joshua, J. K., Kunda, J., Anyanwu, N. & Jajere, A. (2013). Land suitability analysis for agricultural planning using GIS and multi-criteria decision analysis approach in Greater Karu Urban Area, Nasarawa State, Nigeria.
- Liu, R., Pan, Y., Liang, S., Bao, H., Jiang, Y., Tu, H., Nong, J., & Huang, W. (2020). Variations in soil physico-chemical properties along slope position gradient in secondary vegetation of the hilly region, Guilin, Southwest China. *Sustainability*. 12. 1303. 10.3390/su12041303.
- Maniyunda, L. M. & Gwari, M. G. (2014). Soil suitability assessment of Haplustalfs for maize and groundnut in a sub-humid environment of Nigeria. *International Journal of Development and Sustainability*. ISSN: 2168*8662 – www.isdnet.com/ijds 3(2), 393-403.
- Nash, L. N., Blythe, L. J., Cvitanovic, C., Fulton, E. A., Halpern, B. S., Milner-Gulland, E. J., Addison, P. F. E, Pecl, G. T., Watson, R. A. & Blanchard, J. L. (2020). To achieve a sustainable blue future, progress assessments must include interdependencies between the sustainable development goals. *One earth* 2((2). <https://doi.org/10.1016/j.oneear.2020.01.008>
- Nelson, D.W. & Sommers, L.E. (1992). Total carbon, organic carbon, and organic matter. In: Page, A. L., Miller, R.H. and Keeney; D.R. (Eds.). *Methods of Soil Analysis*. Part 2. ASA, Madison, WI, USA, pp. 539-580
- Okalebo J. R., Gathua, K. W., & Woomer, P. L. (2000). Laboratory methods of soil and plant analysis: a working manual. Nairobi: TSBF–KARI–UNESCO.

- Olayide, O. E. (2021). Nigeria – land, climate, energy, agriculture and development: a study in the Sudano-Sahel initiative for regional development, jobs, and food security, ZEF Working paper series, NO. 201, University of Bonn, Center for Development Research ((ZEF), Bonn. <https://hdl.handle.net/10419/246470>
- Oyekale, K. O. (2014). Growing an effective seed management system: a case study of Nigeria. *Journal of Agricultural and Environmental Sciences* 3 (2): 345–354.
- Pédro, G. (1983). Structuring of some basic pedological processes. *Geoderma*, 31: 289–299.
- Sanchez, P. A., Palm, C. A. & Buol, S. W. (2003). Fertility capability classification: A tool to assess soil quality in the tropics. *Geoderma* 114:57–185.
- Sanchez, P. A., Water, C., & Buol, S. A. (1982). The fertility capability soil classification system, interpretation, applicability, and modification. *Geoderma* 27 (4):283–309. doi:10.1016/0016-7061(82)90019-2.
- Senjobi, B. A. & Ogunkunle, O. A. (2010). Effect of land use on soil degradation and soil productivity decline on alfisols and ultisols in Ogun state in southwestern Nigeria. *Agriculture Conspectus Scientificus* 75(1): 9-19
- Soil Survey Staff. (2017). Soil Survey Manual. Soil Science Division Staff. United States Department of Agriculture. Handbook No. 18. Issued March 2017.
- Soil Survey Staff. (2022). Keys to Soil Taxonomy, 13th edition. USDA Natural Resources Conservation Service.

- Thomas, G. W. (1996). Soil pH and soil acidity. In J. M. Bigham (ed.). *Methods of soil analysis: Part 3- chemical methods*. Soil Science Society of America Book Series No. 5 Soil Science Society of America and American Society of Agronomy, Madison, WI. Pp 475–490.
- Walkley, A. & Black, I. A. (1934). Determination of organic matter in soil. *Soil Science* 37, 549-556 Walkley, A. J., and C. A. Black. 1934. An estimation of Deglgare methods for determining soil organic matter and a proposed modification of the chromic acid titration methods. *Soil Science* 37 (1):29–38. <https://doi.org/10.1097/00010694-193401000-00003>
- Wambeke, A. (2006). Criteria for classifying tropical soils by age. *Journal of Soil Science*. 13. 124–132. 10.1111/j.1365-2389.1962.tb00689.x.
- Yitbarek, T., Jembere, A. & Kerebeh. H. (2018). Characterization and classification of soils of Wolkite University research sites, Ethiopia. *Eurasian Journal of Soil Science* 7:292–99.