Study of Selected Rice (Oryza sativa) Producing Soil Characteristics of Wukari, North-Eastern Nigeria

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Abstract

The study examining the soil's characteristics for sustainable rice (Oryza sativa) production. The soils featured a sandy clay loam, loamy sand, and sandy loam texture. They were also deep and well-drained. Their pH values ranged from 5.00 to 5.70, indicating that they were generally somewhat acidic in response. The majority of the crops in the study area can be produced sustainably within this pH range. The pH of the soil often controls the availability and unavailability of the majority of nutrient components in agricultural productivity. It also controls how these nutrients are absorbed for a steady crop supply. Additionally, the soils' nutritional (OC, OM, TN & P) concentration was poor. While exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) were limiting variables in the research area, the percentage base saturation was high. A moderately suitable (S2) unit I and marginally suitable (S3) units II rating for rice cultivation was found in the suitability assessment of a few chosen Wukari soils. For increased rice yield in the area under study, significant soil amendment or management techniques specifically, the use of organic or inorganic fertilizer and planting timing have been suggested.

Keywords: soil characteristics, profile, morphology, rice-production

Introduction

Rice has been one of the main staples and important source of carbohydrates in the diet of Nigerians across all socioeconomic strata. The increased demand for rice leads to its importation. Because small-scale farmers cultivate the crop there, according to FAO (2014), Nigeria is one of the top importers of rice worldwide. The inability to meet the increasing demand for rice worldwide has been caused by several factors, including smallholder land holding, reliance on rain-fed agriculture, low irrigation development, poor planting material, low fertilizer application, inadequate storage facilities, and a weak agricultural extension system, even though global rice production has increased over the past 20 years (FAO, 2014).

This could be partially explained by the recent crop failures that have persisted, which have been caused by a lack of knowledge about the characteristics of the soil. This knowledge is crucial for the sustainable and intelligent usage of the soil. Inadequate agricultural productivity, which results from mismatching land properties with crop requirements, can also cause food loss and hence, affect economic growth. A deep awareness of the soil's

characteristics will make managing it and determining whether a given crop is a good fit much easier. This soil information can be obtained by evaluating the land's suitability. Evaluating land involves estimating its potential for different applications (FAO, 1914). A land appraisal has been helping farmers to understand the limitations and potential of their land for specific uses. Evaluation, therefore, requires establishing the required crop requirements and modifying them for the terrain and soil conditions (Dent and Young, 1981). The identified limiting variables could be adjusted to better suit the needs of various crops and boost agricultural productivity. The aim of this study is to determine which soils of Wukari Local Government Area are appropriate for rice production.

Materials and Methods

The Study Area

The study was conducted in northern Jootar (coordinate: N07045.385' E0090 45.953'), which is in Northeastern Nigeria and falls under Taraba State's Wukari Local Government Area. The region has an average temperature of 29.38ºC and 135.2 mm of precipitation annually. Within the Southern Guinea Savannah Zone is the Wukari Local Government Area. Tiv, Jukun, Hausa, Ibo, and Idoma are among the people who have settled in the area; they are primarily traders. Basement and sedimentary rocks, which differ in character throughout the local government, underlie the region's geology. Afia, Jootar, and nearby local government areas including Takum, Logo, and Katsina Ala are home to the majority of the basement complex rocks, which are composed of old igneous and metamorphic rocks.

Field Work

In the field, auger point investigations were conducted at 100-meter intervals using the grid method of soil survey. Based on physiographic and vegetation changes, two soil units were distinguished. Each unit had a profile pit sunk in it, for a total of two pits. Soil samples were taken from the profile pits and documented using the criteria for describing soil profiles (Soil Survey Staff, 2017). The gathered soil samples were meticulously labeled for examination in a lab.

Sample Preparation and Laboratory Analysis

The grid method of soil surveying was used in the study area. Auger point investigations were performed at 100-meter intervals along traverses that were cut on the baseline. Two soil units were identified as a result of these investigations, and one profile pit was sunk for each unit, for a total of two profile pits. The pits were described using the instructions for defining soil profiles that the soil survey crew (2014) gave. Samples were gathered, properly labeled, and transported to a lab for chemical and physical analysis. Standard laboratory procedures were used to analyze the physical and chemical characteristics of the soil samples collected from the field. The bulk soil samples collected from the field were left to air dry for a week. The soil samples were crushed gently and then sieved through a 2 mm sieve for laboratory analysis.

Particle size distribution was determined using the Buoyoucos hydrometer method by Day (1965) with sodium hexameta-phosphate as the dispersing agent; soil pH was measured using a pH meter in water using a 1:1 soil/water ratio; total soil nitrogen was determined using the Kjeldahl method (Bremner and Mulvancy, 1982); extractable P was determined using the Bray-1 method (Murphy and Riley, 1962); base saturation was calculated by

dividing TEB by ECEC and multiplying the result by 100%; and CEC was measured using the procedures described in IITA (2015).

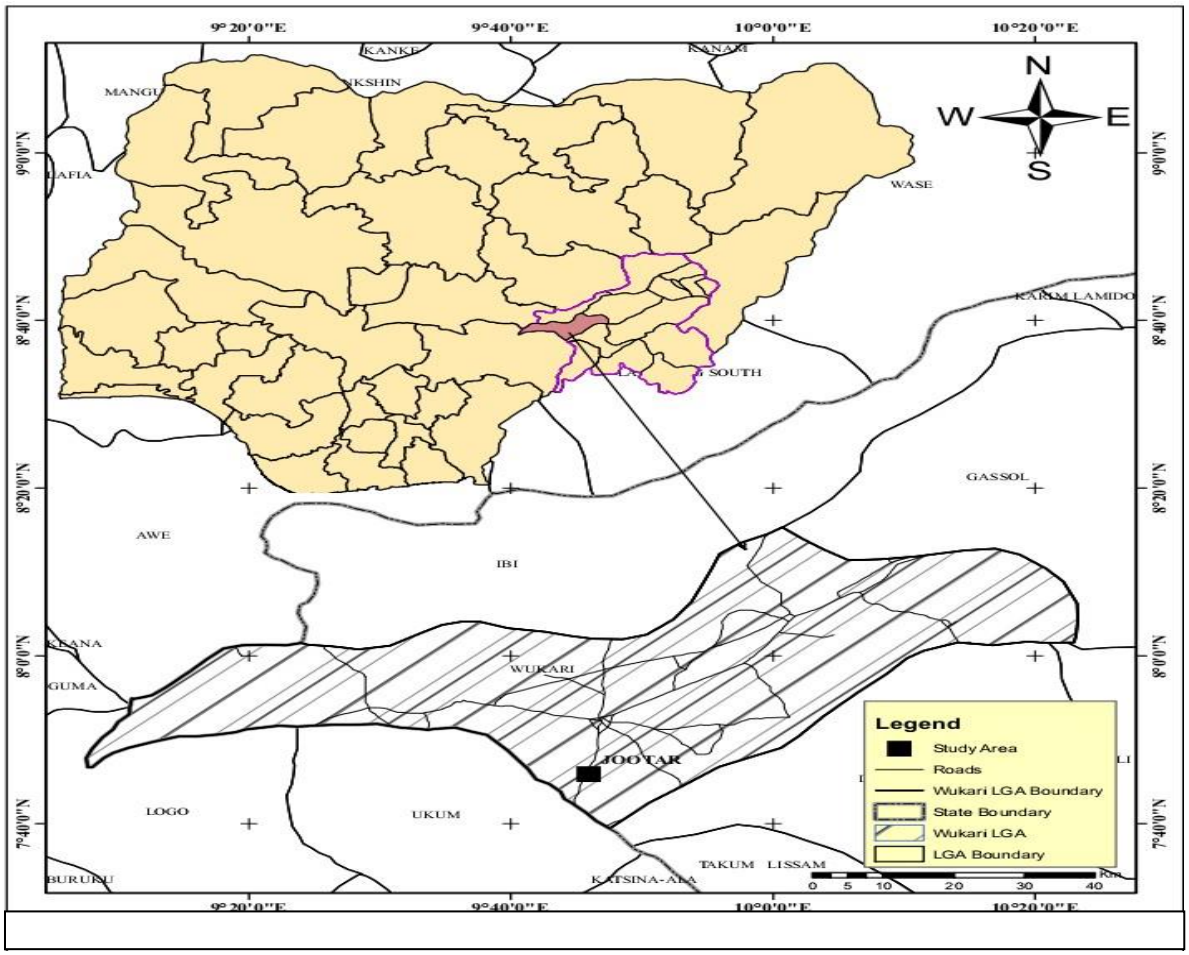


Figure 1. *Map of Wukari LGA showing Location of study area, (source: GIScore, (2023))*

Result and Discussion

Morphological properties of the soils

Table 1 provides information about the morphological features of the study area. In general, the soils had a slope gradient of roughly 0-2% and were relatively deep (120 cm) and almost flat. The soils had good drainage. The research area's common soil structures included: • Moderate and strong medium subangular blocky, which were present in the subsurface horizons of all the soil profiles examined; • Weak and moderate medium granular and weak fine granular, which characterized the profiles' surface horizons (Table 1).

Soil genesis and agricultural productivity depend on the natural aggregation of soil particles. The pace at which water and nutrients move from the surface soil to the roots at the subsurface soil, as well as numerous other processes including infiltration, percolation, excess water drainage, aeration, and water holding capacity, are all significantly impacted by a soil's structure. Therefore, thorough study is necessary to manage plants properly, which promotes plant growth and productivity. The composition of the soil structure in that area can be explained by the relatively high clay content and moderate amount of organic matter in the studied area, which promote soil particle aggregation in the A horizon. A well-aggregated soil has a good crumb structure (Idoga, 1985; Ufot, 2012). Because it results in structural weakness, plant nutrients are usually limited in soils with low organic matter content (Akinyemi and Vivian, 2001).

Table 1. *Morphological properties of the study Area*

Horizon	Depth	Color (moist)	Mottle	Texture	Structure	Consistency	Root	Drainage	Boundary
Pedon 1 Profile 1: (Coordinate = N07^{0}57'185', E09^{0}45'990 elevation = 595)									
Ap	0 -25	5YR6/8 (reddish yellow)	Nil	SCL	1MGR	Friable	CF – FM	Well Drained	CS
AB	25 – 55	10YR6/4 (Pale red Yellow)	Nil	SCL	1MGR	Friable	MFV, MF, MM	Well Drained	CW
Bt_1	55 – 80	7.5YR4/5 (Strong Brown)	Nil	LS	2MSBK	Firm	CF, FM	Well Drained	CS
Bt_2	80 -100	2YR6/8 (Light red)	Nil	SL	3MSBK	Very Firm	FF, FC	Well Drained	CW
Bt_3	100 -120	5YR4/4 reddish brown	Present	LS	1MSBK	Firm	Vff	Well Drained	CS
Pedon 1 Profile 2: (Coordinate = N07^{0}57' 212', E09^{0}45.984 elevation = 597m)									
Ap	0 -25	7.5YR5/8 (strong Brown)	Nil	LS	1FGR	Firm	Cf, fm	Well Drained	CS
AB	25 – 55	5YR6/8 (light reddish Brown)	Nil	LS	2MGR	Friable	Vff, vfm	Well Drained	CW
BA	55 – 80	2.5YR 6/4 Reddish brown	Nil	LS	3MSBK	Very Firm	Cf, cm	Well Drained	CW
B_1	80 -100	5YR 6/4 Light reddish brown	Nil	LS	1MGR	Friable	Ff	Well Drained	CW
B_2	100 -120	10YR6/4 pale red	Nil	LS	2MSBK	Friable	Mff, mfm	Well Drained	CW

Ls=Loamy Sand, SL = Sandy Loam, SBK = Sub Angular Blocky, LC = Loamy Clay, S = Sand, C = Common M = Many, F = Few, VF = Very Few, 1 = Fine, 2=Medium, 3=Coarse, R=Roots, CS=Clear and smooth, St = Structure, SCL Sandy Clay Loam, SBA = Sub-angular, GL = Granular, CB = Crumby

The surface horizons of the research area's soils exhibit a range of colors. Complete decomposition of organic matter (oxygen rich soil) was indicated by the soils' reddish yellow (5YR 6/4 moist), reddish brown (2.5YR 6/4 moist), and strong brown (7.5YR4/5 and 7.5YR5/8) colors. The light reddish-brown color (5YR 6/4 and 2.5YR 6/4 moist) on the surface horizon may be related to the humified nature of the soil organic matter, but the pale red yellow (10R6/4 moist) color may be caused by the presence of unhydrated iron oxide, most likely hematite.

Physical Properties of the soils

The flow of solutes, water, heat, and air through soil is made possible by its physical properties. They include the soil's color, texture, and structure. The behavior and applications of the soil depend on these properties. The soils of the study area were primarily sandy loam in both profiles, with profile 1's surface strata showing sandy clay loam. Both profiles had sandy loam subsurface horizons. These might be ascribed to the study area's parent materials (Table 2). The percentage of sand fractions in the particle size distribution (PSD) rose with depth in profile 1 and was dispersed unevenly in profile 2 (Table 2). All of the profiles had an uneven distribution of silt and clay concentrations with depth. The minor topographic variances may be the cause of the relative PSD disparities between the units.

The most prevalent particle size fraction in both surface and subsurface horizons across all profiles was the % sand fraction. The nature of the parent materials, the ongoing weathering of the rocks, and the downward flow of the clay through the soil mass are the main causes of the high sand component found in most savannah soils. Due to their high sand content, the soil is extremely susceptible to erosion since raindrops and flowing water can quickly separate them. The lower subsurface soils' colluvial or saprolitic origin may also be the cause of the high sand content in some subsurface strata (Yau et al., 2015). Since sand makes up a significant amount of the soil, it readily separates when rain or flowing water strikes it, leaving the land particularly vulnerable to erosion. Similar findings were found by Yakubu (2006) in the soils of Sokoto State.

Table 2. *Physical properties of the soils*

Horizon	Depth (cm)	Silt %	Clay %	Sand %	SCR	TC	BD (gcm-3)	PO%	Moisture Contents %
Pedon 1. Profile 1: coordinate N07^{0}45.385’ E09^0 45.953’ Elevation 507									
Ap	0 -25	20.40	20.00	59.60	1.02	SCL	2.01	24.00	31.55
AB	25 – 55	10.40	22.00	67.60	0.47	SCL	2.17	18.00	15.35
Bt_1	55 – 80	20.40	4.00	75.60	5.10	SCL	2.12	20.00	15.27
Bt_2	80 -100	14.40	2.00	83.60	7.20	LS	2.15	19.00	15.75
Bt_3	100 -120	14.40	4.00	63.60	3.60	LS	1.57	34.00	50.07
Pedon 2 profile 2 coordinate N07^{0}45.600’ E09^0 45.064’ Elevation 495									
Ap	0 -25	14.40	4.00	81.60	3.60	LS	1.54	42.00	50.00
AB	25 – 55	12.40	4.00	83.60	3.10	LS	1.99	25.00	9.26
BA	55 – 80	12.40	2.00	85.60	6.20	LS	2.06	22.00	19.44
B_1	80 -100	12.40	4.00	83.60	3.10	LS	2.08	22.00	15.84
B_2	100 -120	18.40	2.00	79.60	9.20	LS	1.45	45.00	57.54

SCR = Silt clay ratio, TC = Textural Class, BD = Bulk density, PO = Porosity, SCL = Sandy clay Loam, SL = Sandy Loam

Pedon 1

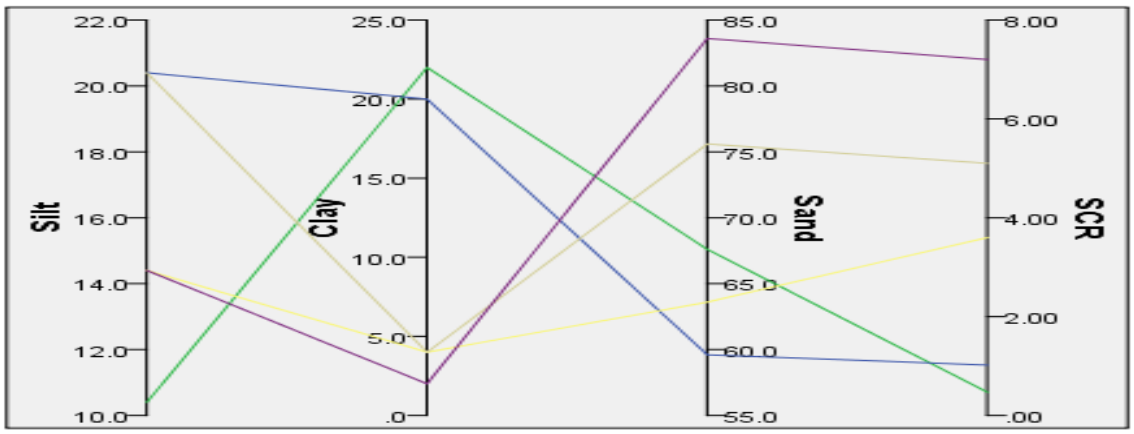


Figure 2. *Relationship between Sand, Silt and Clay*

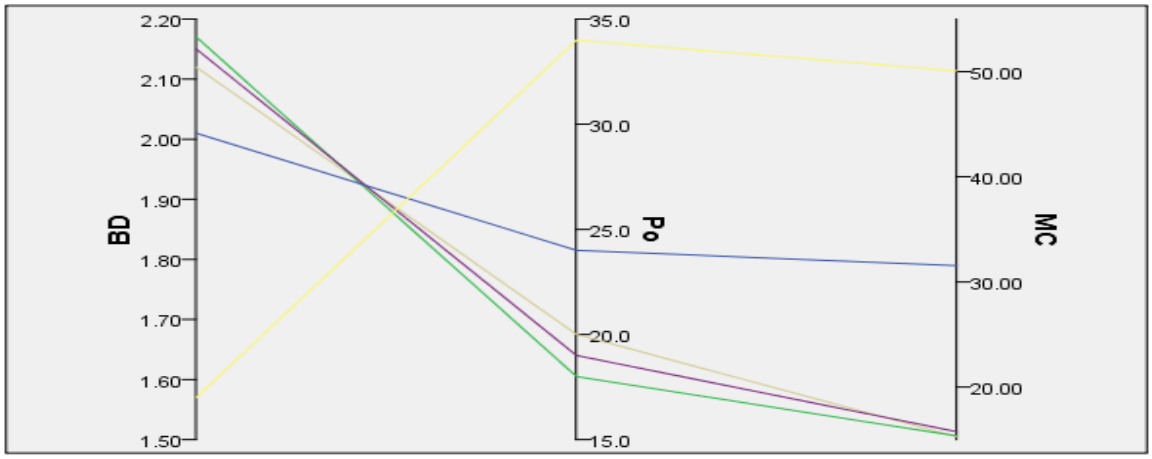


Figure 3. *Relationship between bulk density, porosity and moisture content*

Pedon 2

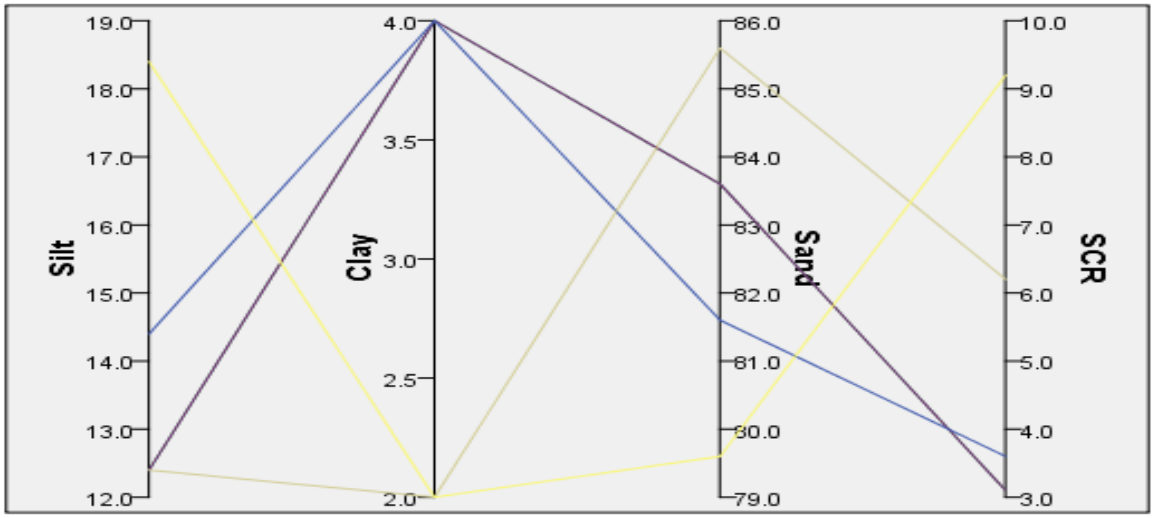


Figure 4. *Relationship between Sand, Silt Clay and Silt/Clay*

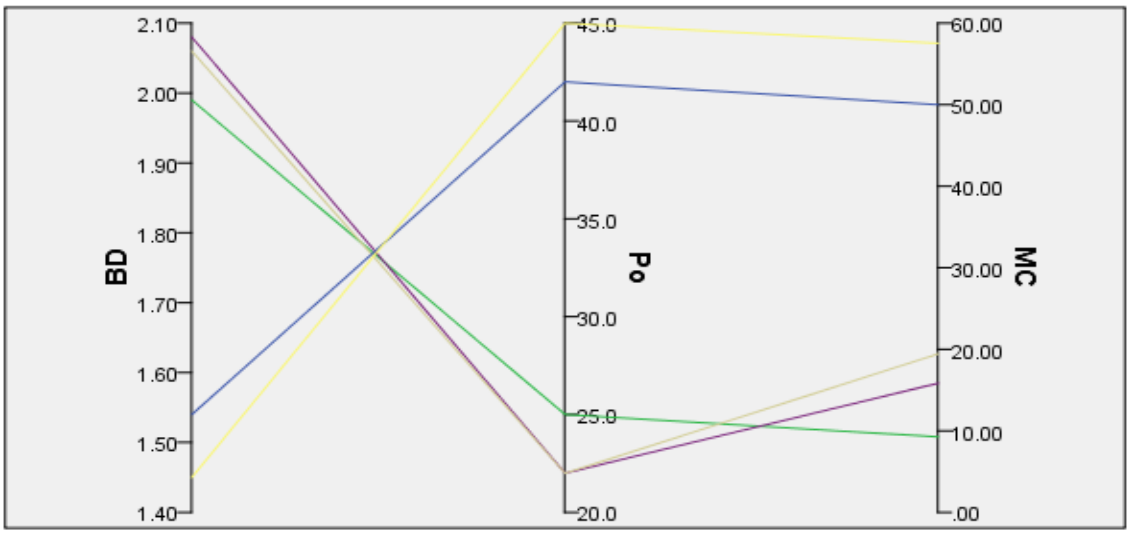


Figure 5. *Relationship between Bulk density, Porosity and Moisture content*

Chemical properties of the soils

Table 3 displays the soils' chemical characteristics. According to the findings, the study area's soils had a somewhat acidic reaction. In H20, the pH values ranged from 5.00 to 5.70. In profile 1, the pH values rose with depth, whereas in profile 2, they fell. The moderate soil reaction may be caused by the direct deposition of crop and vegetable residues on the soil surface, followed by their breakdown to release basic cations into the soil (Usman et al., 2019). Usman et al. (2019) and Ugwu et al. (2001) suggest that profile 1's higher pH at the surface than beneath could be due to nutrient biocycling and high percentage base saturation at the surface horizon. According to Idoga and Ogbu (2012), leaching of bases and frequent crop harvesting are to blame for the decrease in soil pH with depth observed in Pedon 1. The breakdown of plant matter can also produce a variety of organic acids that lower the pH of the soil. Esu (2005) has highlighted that one of the main causes of the pH values declining with depth is the return of bases to the surface due to the pumping effect of the vegetation/crops.

The range of the organic carbon content was 0.99% to 0.3%. In every profile, the proportion of organic carbon content lacked a clear distribution pattern with depth (Table 3). In contrast to Agboola and Ayodele's (1985) assessments, which state that <0.4 = very low, 0.5-1.0 = low, 1.2-1.4 = moderate, 1.5-2.5 = high, and >2.5 = very high, the soils' organic carbon content was evaluated as low. The low organic carbon content may be caused by a number of causes, including grazing, bush burning (Kang, 1993), a long cropping season, a high rate of erosive degradation, harvested crop wastes that are not replaced, and poor management techniques (Landon, 1991). Total nitrogen levels were classified as low and varied from 0.34 to 0.67%. In both profiles, the distribution pattern of the total N values was irregular. There was a favorable correlation between the amount and distribution of organic carbon and total nitrogen. The reason for this is that the two naturally occur in comparatively constant ratios (Ayolagha and Opene, 2012). Moreover, denitrification and volatilization, which cause N loss, may also be to blame for the area's low N levels. Generally speaking, the low amount of nitrogen in the soil can be attributed to a variety of factors, including leaching, gaseous loss, release from plant tissues, surface runoffs, vegetation, human activity, and original soil pH.

According to Christensen (2001), the accessible phosphorus (P) content was classified low since it ranged from 2.97 to 9.35 mg/kg. He stated that < 3 mgkg-I = very low, 3-7 mgkg-1 = low, 7-20 mgkg-1 = moderate, and >20 mgkg-1 = extremely high. However, the low findings support Brady and Ray's (2014) assertion that most native soil has a low total P content, with the majority of that P existing in forms that are not very useful to plants. The floodplain's low level of organic carbon may potentially be the cause of the low available P. Similar to total N and organic carbon, the available P varied with soil depth, demonstrating the interdependence of the three. The low organic C to P ratio in the surface strata suggests that the majority of the P present was in organic form. Although wood ash can provide P, 50–80% of P in savannah soils comes from organic carbon (Ogieva, 2018).

Ca>Na>K>Mg was the descending order of the exchangeable bases. In every profile, the other total exchangeable bases—aside from magnesium—lacked a clear pattern of distribution with depth. There was a range of 4.23 to 5.25 cmolkg-1 of exchangeable Ca. While the sodium concentration ranged from 0.72 to 0.81 cmolkg-1, the potassium value varied from 0.07 to 1.90 cmolkg-1. All of the soil units had low levels of exchangeable bases (Mg, K, and Na) save from Ca. The low exchangeable bases of these soils may be caused by a variety of factors, including the type of parent materials beneath them, the extent of weathering, leaching, low activity clay, the very low amount of organic matter, erosion and surface runoff, and the lateral translocation of bases. Furthermore, the soil's capacity to draw in and retain cations in exchangeable forms was diminished by the low levels of organic matter and clay (Krasilinikoff et al., 2002). These findings supported Sanchez's (1976) theory that the soils of tropical savannah rapidly deteriorate due to continuous cropping. In the exchange complex, calcium was the most prevalent cation, with values ranging from 4.23 to 5.25 cmolkg-1. The predominance of calcium over other cations in these soils may also be due to the presence of calcium at exchange sites in soil that has a specific affinity for calcium, the fact that calcium is less readily lost from exchange sites, or the fact that it has a higher displacement ability than other cations in cation exchange reactions.

The range of the CEC values was 5.49 to 6.56 cmolkg-1. When compared to Esu's (1991) grade of <6 = low, 6-12 = moderate, and >12 = high, the CEC distributions were generally scored low to moderate and varied with depth in all profiles. Keep in mind that one of the best practical soil tests for estimating plant nutrient requirements is the soil's ability to retain cations. The amount of each cation element that will react with or displace it from the soil exchange sites determines its unique equivalent weight (Ufot, 2012; Brady and Ray, 2014). The low CEC values, however, suggested that the soils' capacity to hold onto plant nutrients was limited, necessitating proper soil management. The silicate clay minerals (Kaolinite), which are thought to be the predominant clay type in depressed soils, may be the cause of the soils' low CEC (Hassan et al., 2011). Adding organic carbon is one of the finest ways to increase the CEC of the soil. By enhancing the soil's ability to retain cations, these methods will increase the soil's capacity to retain nutrients for crop growth and optimal output. In comparison to the classifications suggested by FMANR (1990), which are as follows: <20% = very low, 20-40%, low = 40-60%, moderate = 60-80% = high, and >80% = very high, the percentage base saturation values of the soil (61.04 to 86.49%) were evaluated as moderately to very high. In every profile, the base saturation (BS) distributions did not match depth. The impact of harmattan dust, which is known to contain a high proportion of cations, especially Ca, and the active breakdown of plant litter, which releases cations into the

soil surface, could be the cause of this (Idoga, 2002). The high B.S. (61.04 to 86.49%) is probably caused by the alluvial nature of the weathered minerals in the soil profiles, which release nutrients into the soil, as well as their insufficient leaching caused by many dry months and seasonal high-water tables.

Table 3. *Chemical Properties of the study area*

Horizon	Depth (cm)	pH (H2O)	OC	OM	TN (Mg/kg)	AVP	Ca	Mg (%)	K	Na	TEA	CEC (Cmol/kg)	BS (%)
Pedon 1. Profile 1: coordinate N07^{0}45.385' E09^0 45.953' Elevation 507													
Ap	0 -25	5.25	0.21	0.36	0.53	5.94	4.26	0.0001	0.07	0.81	0.50	6.51	82.88
AB	25 – 55	5.15	0.03	0.05	0.67	9.35	4.33	0.0001	0.10	0.78	0.20	5.49	83.11
Bt_1	55 – 80	5.10	0.10	0.17	0.67	5.15	4.23	0.0001	0.11	0.81	40.00	6.56	82.14
Bt_2	80 -100	5.05	0.07	0.12	0.45	3.47	4.23	0.0001	0.12	0.80	0.20	6.49	82.14
Bt_3	100 -120	5.00	0.10	0.17	0.56	6.10	5.24	0.0001	0.11	0.81	0.10	6.49	85.07
Pedon 2 profile 2 coordinate N07^{0}45.600' E09^0 45.064' Elevation 495													
Ap	0 – 25	5.05	0.17	0.29	0.53	5.77	5.23	0.0001	0.12	0.80	0.15	6.50	85.04
AB	25 – 55	5.40	0.72	1.24	0.34	7.22	4.23	0.0001	1.90	0.80	0.25	5.54	61.04
BA	55 – 80	5.50	0.99	1.71	0.34	2.97	4.27	0.0001	0.09	0.81	0.20	6.34	82.59
B_1	80 – 100	5.60	0.48	0.83	0.36	8.34	5.25	0.0001	0.10	0.81	0.30	6.44	85.23
B_2	100 -120	5.70	0.75	1.23	0.39S	3.75	5.25	0.0001	0.10	0.72	0.40	6.56	86.49

OC = Organic Carbon, OM = organic Matter, TN = Total Nitrogen, CEC= Cation Exchange Capacity, AVP = Available Phosphorus K = Potassium, Na = Sodium, TEA = Total Exchangeable Acidity, Ca = Calcium, Mg = Magnesium.

Pedon 1

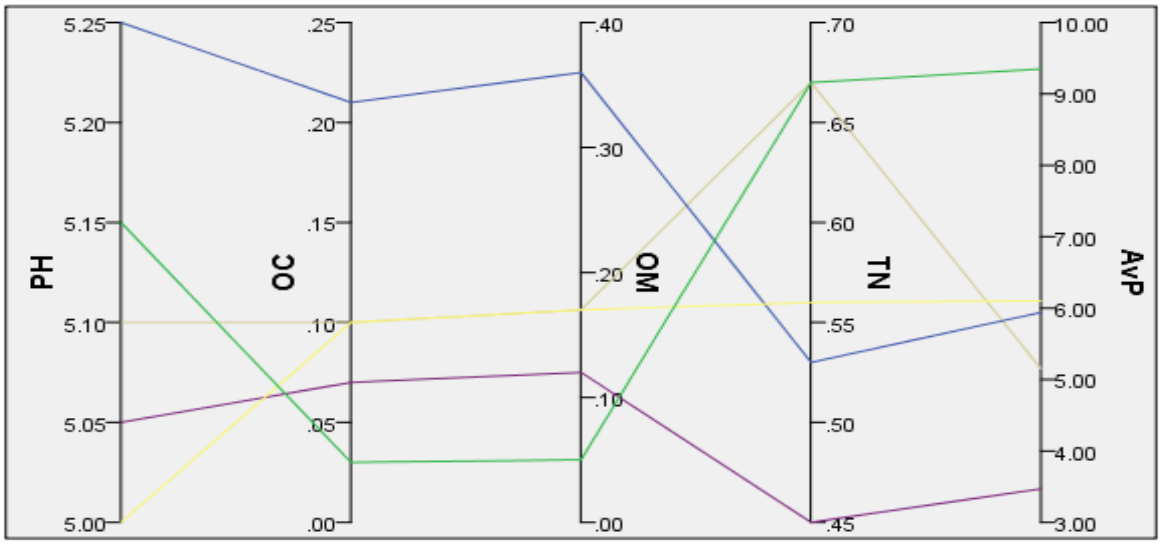


Figure 6. *Relationship between Soil pH, OC and Macro element*

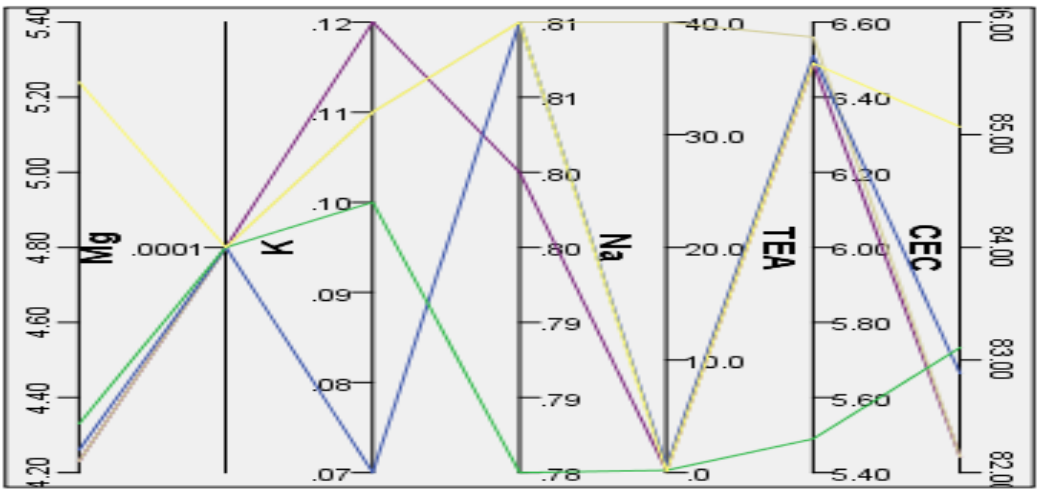


Figure 7. *Relationship between Basic Cations*

Pedon 2

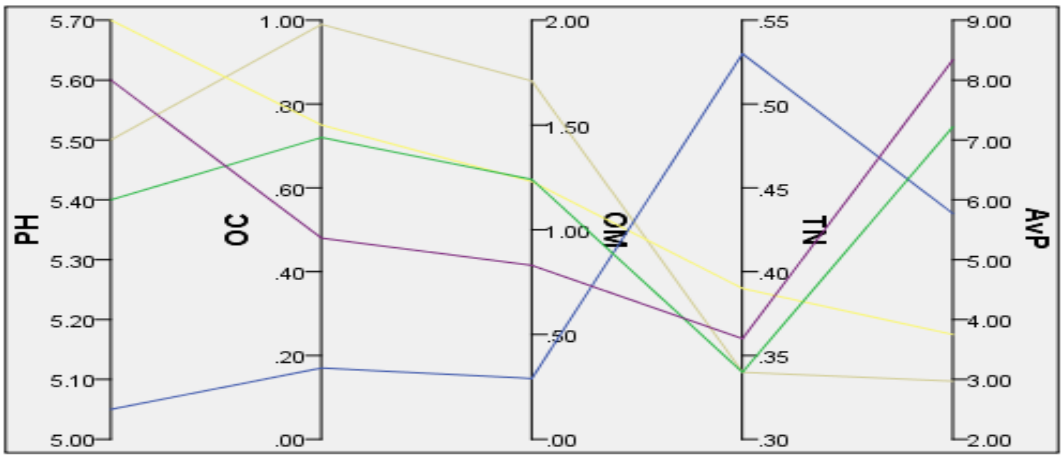


Figure 8. *Relationship between Soil pH, OC, OM, TN and AvP*

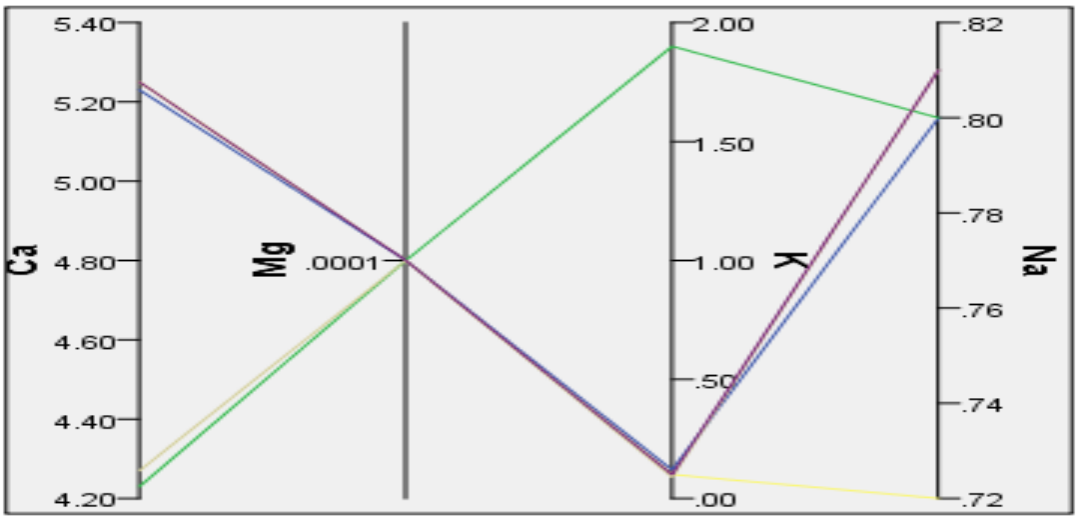


Figure 9. *Relationship between Basic cation*

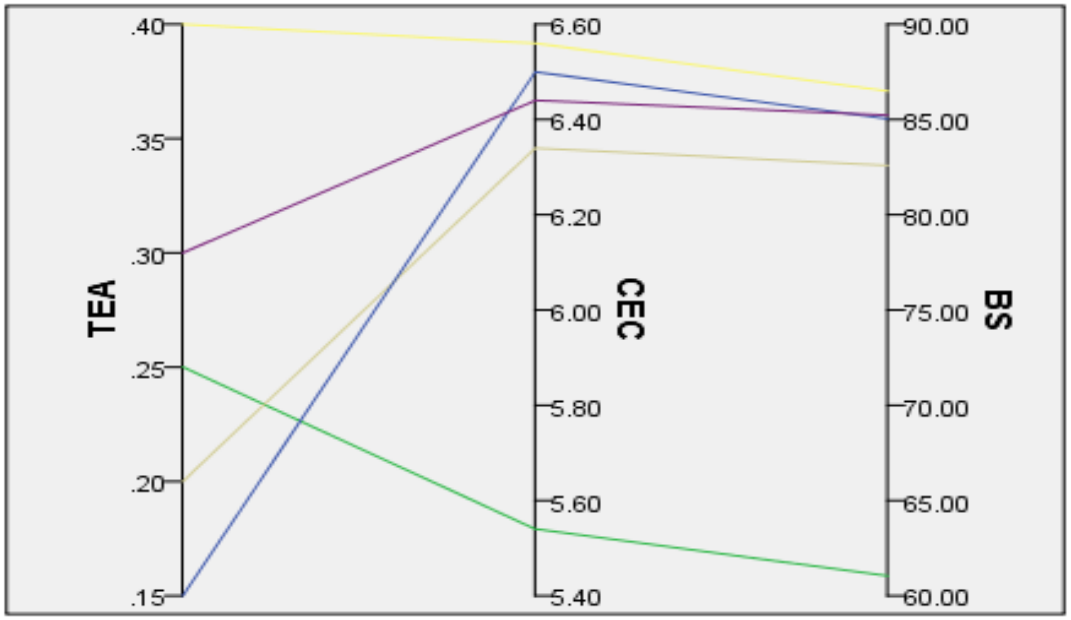


Figure 10. *Relationship between TEA, CEC and BS*

Table 4. *Soil Quality Rating for Wetland Rice*

Land quality	Factor	Factor Rating			
		S1	S2	S3	N
Temperature	Mean air Temp (^{0}C)	25–30	21–24	18–20	<18
			31–32	33-35	>35
Moisture	Mean Annual Rainfall (mm)	1200–2000	1000–1200	800–1000	<800
Growing period		500–800	400–500	300–400	<300
Air Humidity	Mean RH (%)	80	75–79	70–74	<70
Condition for					
1. Harvesting	Rainfall≤ 80*mm*/days	–	1–9	10	>10
2. Ripening	Air Temp (^{0}C)	–	18-19	–	<18
		20–29	30–32	33–40	<40
O_2 Availability	Drainage (class)	Poor	Somewhat poor,	Mod	Well
			Very poor	Well	Excessive
Rooting condition	Root depth (cm)	30–60	20–30	20–10	<10
	Stones & Gravel (%)	<5	5–15	15–35	>35
	Soil texture class	sand–clay	-	-	
Erosion	Slope (%)	<2	2–5	6–8	>8
Hazard	Observed erosion	None	None	None	None
Nutrient	Soil reaction ($_p$H)		5–5.9	4.3–4.9	<4.3
Available		6–7	7.1–7.9	8–8.3	>8.3
Salts	Soil salinity EC	<3	3–5	5.1–7.2	>7.2

Table 5. *Suitability Class Scores of the Pedons in the Study Area for Wetland Rice*

Land quality and characteristics	Soil Mapping Unit	
	1	**2**
Temperature	S_1	S_1
Moisture	S_2	S_3
Humidity	S_1	S_1
O_2 avail	S_2	S_3
Rooting depth	S_2	S_3
Gravels	S_1	S_1
Texture	S_1	S_3
Erosion	S_1	S_2
Nutrient	S_2	S_3
Salt	No data	
Suitability rating	S_2	S_2

Land Suitability Classification of the Study Area

The process of determining whether a piece of land is suitable for a certain purpose is known as land suitability evaluation (Ufot, 2012; Brady and Weil, 2014). The FAO (2016) states that land suitability grading entails matching crop needs with land characteristics. It is the suitability of particular soil characteristics for a particular type of land use. By contrasting the soil's characteristics with rice's needs, the appropriateness rating of a few chosen Wukari soils was determined. It was discovered that the chemical properties of the soils, including pH, organic carbon, CEC, exchangeable bases, exchange acidity, available P, and total N, were either favorable to rice production or could be changed by individual farmers, thus they cannot be regarded as long-term restrictions.

Water availability during the growth season is one of the rice crop's most critical needs (Idoga, 2005). Therefore, the most significant constraint on rainfed rice production is water. The key physical attributes that affect water retention include soil depth, drainage, slope, porosity, texture, and structure. Low-lying soil units I and II had a slope of 1% to 2%. They make it possible for water from the surroundings to accumulate, which results in aquic soil conditions. Water retention for plant usage is positively impacted by the soil's high clay content and sound structural development. Additionally, the grayed color (2.5Y) of these soils indicates that the ground/perched water table had a significant influence on them. Flooding and subterranean seepage are two further sources of water for the soils in the study area besides rainfall. The area's low nutrient status was indicated by the comparatively low levels of soil organic matter, total N, accessible P, CEC, and exchangeable bases (Table 3).

Because of their nutritional status and water availability, the soils in unit I were deemed to be fairly appropriate (S2) for growing rice. Approximately 66% of the research area is made up of the region's reasonably suitable soils. Unit II soils had complete saturation with the high-water level and were located at the lowest elevation in the region. The low-lying or depressional terrain and the soil's high clay composition prevent the soils from losing water as quickly as they did. The ustic moisture regime, low nutritional status, high porosity from the sandy character, and limited water-holding capacity were the main constraints for unit II soils. For a portion of the rice cropping season, water retention is positively impacted by the soil's good structural development and moderate clay concentration. Thus, it is classified as

S3 (Table 5), which is only marginally appropriate for rice production and may need irrigation during a one- to two-month drought and the application of organic or inorganic fertilizer. Approximately 12% of the research area is made up of the area's moderately suitable soils. This suggests that minimal human intervention is required by the one farmer who cultivates the entire wetland in order to achieve the highest possible rice harvest.

Conclusion

The suitability rating of selected Wukari soils for rice production indicated a moderately suitable (S2) in unit 1 and marginally suitable (S3) units II. Management practices such as organic matter incorporation, fertilizer application and time of planting have been recommended for improved rice productivity in the area studied.

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