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Suitability Assessment of Some Soils for Cultivation of Maize Along a Toposequence, in Mokwa Southern Guinea Savannah Ecological Zone of Nigeria

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Abstract
The establishment of an institution of higher learning and related infrastructures in Mokwa community has resulted in the influx of human beings leading to serious pressure on soil and land resources. An experiment was conducted in 2017 to investigate the suitability of some soils along a toposequence for the cultivation of Maize (Zea mays) in College of Agriculture Mokwa teaching and research farm. Maize is a major crop cultivated in this farming community. Three sites were chosen along a toposequence for this study and they were the crest (CS) middle slope (SM) and valley bottom (VB). A four-hectare plot was demarcated for CS and MS respectively while three hectares were for VB. At the Centre of each plot soil samples were obtained with aid of an auger from 0-120cm depth at intervals of 15 meters. The soil samples collected were bagged separately, labeled and taken to the laboratory for routine analysis. At the laboratory samples were treated and analyzed for the following physical and chemical properties, particle size, bulk density, percentage moisture content, pH, percentage organic matter, organic carbon, total N, Available P, exchangeable bases (K, C, A, Mg and Na) CEC and ECEC. Soil depth, slope, and drainage were assessed in the field while climatic data were obtained from the meteorological station of the college. Using the parametric and limitation approach, all land features were highly suitable except slope which was a limitation. The low values of physical and chemical properties make these soils currently not suitable for the cultivation of maize. However, amendment with organic and mineral fertilizer is recommended for continuous cultivation of maize on these soils along with good agronomic practices that will reduce run off to some certain level.

Keyword: Mokwa, suitability assessment, soils, Maize

Introduction
Mokwa is located in the Southern guinea savanna belt of Nigeria. It is a fast growing metropolitan. This is as a result of three factors. It is a gate way town between North and South. It is head quarter of Mokwa Local government area. This growth is reflected in the continuous influx of human beings to the city and the surrounding communities. This is therefore continue to mount pressure on the fixed land and soil resources. This is evidenced in the drastic alteration of the general landscape as well as socio-cultural and economic life of the people. The original forest vegetation has completely disappeared. Bush fallow period meant for the restoration of soil fertility has plummeted fifteen years to three or five years. Erosion and flooding are now common features during the rainy season. It is obvious that land and soil resources, cannot be indiscriminately used as before. There must be a conscious effort to see that land and soil resources are allocated to use for which they best suited.

According to Aluko., *et al.* (2017), any piece of land without determination of its suitability has a serious consequence and that inadequate soil information of the degree to the extent of its suitability constitute a set back to the achievement of global security particularly in developing economies such as Nigeria. Solteni, *et al*. (2013) defined land suitability as the

suitability of a given type of land to support a defined land use either in its current state or after improvement.

Maize is a member of the grass family (poaceae) with the botanical name *Zea mays.* It is the most common and often cultivated plant globally, occurring in most of west and south Africa countries including Asia countries Mokwa is a major Maize producing community in Niger State. It is an important crop in the farming activities of the people as it features prominently in most of the festival and other ceremonies in the area. Maize production in Mokwa account for about 45% of the total Maize production in Niger state (Benjamin. *et al.*, 2017). Omofowma and Kadir (2017) noted that the crop majorly serves as a staple food to the people of the area, as well as a means for income generation. Despite the important role the crop plays in the cultural and the socioeconomic life of citizens, the general lack of information on land and soil resources that support the cultivation of the crop in the areas is not fully discovered. The study was therefore undertaken to generate information on the suitability of selected soils along a toposequence for the cultivation of Maize in Mokwa and its surrounding communities.

Material and Methods

Location

Experimental site was the Teaching and Research farm, College of Agriculture, Mokwa. It is located at Latitude 6.14ºE and longitude 6.74ºN. The climate is dominated by the humid tropical type. Temperature is high throughout the year with an average of 27 ºC. Rainfall last for between six to seven months of the year, while the annual rainfall range is between 1,200 mm-1600 mm. (Remison, 1998). Humidity is high during the rainy season and could be as high as 80%.

The cold and dry hamattan wind which was a seasonal climatic event, has been reduced to just a spell of about two to three months. The terrain is dominated by what Segynola (2011) referred to as the Esan. Plateau elevation above its surrounding is responsible for the existence of numerous incised the valley, with their characteristic dry valley, bottoms. The plateau is a watershed from which such rivers as Kunko and Ejegi derive their source **(**Umar, 2010). These valley bottom soils contrasts those of the nearby basement complex of Northern Nigeria that have seasonal flowing streams and hydromorphic characteristics.

Soil Sample Collection/Soil Analyses

Three sites were chosen for soil sample collection. These were the crest (CS), middle slope (MS) and valley bottom (VB). The study area covered about 10 hactres of land within the Teaching and Research farm of Niger state college of agriculture mokwa. At each site auger borings were made at interval of 15cm from surface to 120 cm. Samples were bagged separately labeled and taken to laboratory for analysis The following physical and chemical properties were assessed according to the method described by Udo *et al* (2009). The pH was determined by using glass electrode in a 1:1 soil water suspension. Organic carbon was determined by Walk – Black method and pH was determined by wet oxidation method as described by Udo, *et al.* (2009). Exchangeable bases and exchangeable acidity were determined by titration method of McClean as described by Udo *et a*l. (2009). The effective cation exchange capacity. (ECEC) was determined as total exchangeable bases plus exchangeable acidity. The percentage base saturation was calculated as the percentages of exchangeable bases divided by effective cation exchange capacity. Total nitrogen (N) was determined using Kjedah distillation methods of Bremner as modified by Udo *et al.* (2009). Land features which included, current land utilization types, soil surface colour, slope, and drainage were assessed in the field, while climatic data for rainfall, humidity and temperature were obtained at the Meterological Station, College of Agriculture, Mokwa.

Results and Disicussion

The results of the selected morphological and physical properties of the study area are presented in table1**.**Then textural class for surface soil (0- 15cm were all sandy loam for all the sites, while subsurface soil were loamy sand. At a depth greater then 180cm, the texture was sandy clay loam for all the sites, the sandy loam nature of surface soil which cut across all the sites, was due to clay loss in elluviation or the nature of parent material to lower horizons. There was an increasing clay content with increase in depth for all the sites and this agrees with the findings, of Nsor and Adesemuyi (2016). This clay illuviation from upper horizons to lower horizons. The range of values for bulk density were 0.85 $gm^{-3}$for valley bottom soils (VB) to 1.39gm $^{-3}$for middle slope (MS) in table 2,this is expected since valley bottom soils recorded the highest value for percentage organic matter (2.326) compared to the other sites (table 3) The value recorded for all the sites were lower than the critical value (1.345-1.85gcm^3) in which root restriction can occur (Soil survey of Staff, 1996) therefore, bulk density was not the limitation. All silt/ clay ratio values were values below unitary, indicating highly weathered soils. The mean values for percentage organic matter (table 3) were 1.613, 1.803 and 2.326, for the crest (CS), middle slope (MS) and valley bottom (VB) respectively/. The crest always witnesses material loss including plant and animal litters due to gravity or run off. Materials that are lost from the crest and middle slope end up as sediment in valley bottom soils hence this is shown in table 4 and they were 6.2,5.1and 4.4 for crest, middle slope and valley bottom respectively, indicating strongly acidic for CS. The concentration of H was highest for VB, (table 4) compare to the rest, which must have accounted for the observed pH status of VB soil. Mineralization of organic matter is said to produce weak acid (Brady and Weil, 2002). This in turn releases H ions into the soil solution environment there by accelerating the acidity of the soil. Valley bottom soils (VB) recorded highest value of percentage organic matter and must have accounted for the observed p^H value for the sites were acidic. Ahukaemere, *et,al* (2016) pointed out that soils of southern Nigeria are generally classified as acidic soil. They have low pH values recorded for VB falls within the range where most nutrients are not available to plant. However, Maize plant has been shown to tolerate a pH range that is as low as the value recorded for VB soils (Isitekhale, *et al*, 2014). The observed values for chemical properties were low for all the sites. Udo, *et al*, (2011) reported that the soils of Northern Nigeria are generally low in nutrients especially, P, N, O,M, and K. this could be attributed to their status as highly weathered soils.

Table 1: Some soil physical properties of the study sites

Landscape Position	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Silt/Clay Ratio	Bulk Density (Mg m^{-3})	Total Porosity (%)
Crest	0–15	12.0	3.0	86.0	0.035	1.08	59
	15–30	13.0	3.0	84.0	0.035	1.32	50
	30–45	15.0	2.0	83.0	0.024	1.08	59
	45–90	29.0	1.0	70.0	0.014	1.24	53
	90–180	34.0	1.0	65.0	0.015	1.32	50
Middle Slope	0–15	15.0	1.0	84.0	0.012	1.01	62
	15–30	24.0	1.0	75.0	0.013	1.39	48
	30–60	32.0	2.6	65.4	0.040	1.08	59
	60–85	33.0	1.0	66.0	0.015	1.16	56
	85–120	34.8	1.6	63.6	0.025	1.24	53
	120–180	34.6	1.4	64.0	0.022	1.16	56
Valley Bottom	0–15	15.0	1.0	84.0	0.012	0.85	68
	15–25	16.4	1.6	82.0	0.020	1.08	59
	25–40	15.2	1.8	83.0	0.022	1.01	62
	40–80	16.4	1.6	82.0	0.020	1.24	53
	>180	16.0	1.0	83.0	0.012	0.93	65

Table 2: Land quality and suitability (Non-parametric) classification for Maize for all the sites

Land Characteristics	Pedon 1 (Crest)	Pedon 2 (Middle Slope)	Pedon 3 (Valley Bottom)
Months of dry season	2–3 (S1)	2–3 (S1)	2–3 (S1)
Annual rainfall (mm)	1500–2000 (S1)	1500–2000 (S1)	1500–2000 (S1)
Maximum temperature (°C)	32 (S1)	32 (S1)	32 (S1)
Minimum temperature (°C)	27 (S1)	27 (S1)	27 (S1)
Relative humidity (%)	85–95 (S1)	85–95 (S1)	85–95 (S1)
Soil depth (cm)	>80 (S1)	>80 (S1)	>80 (S1)
Texture	SL (S1)	SL (S1)	SL (S1)
Drainage	Well drained (S1)	Well drained (S1)	Well drained (S1)
Soil pH	6.2 (S2)	6.2 (S2)	6.2 (S2)
Organic matter (%)	1.613 (S1)	1.613 (S1)	1.613 (S1)
Available P (mg kg^{-1})	2.2 (S3)	2.2 (S3)	2.2 (S3)
Exchangeable K (cmol kg^{-1})	0.005 (S3)	0.005 (S3)	0.005 (S3)
Exchangeable Ca (cmol kg^{-1})	1.021 (S3)	1.021 (S3)	1.021 (S3)
Exchangeable Mg (cmol kg^{-1})	0.681 (S3)	0.681 (S3)	0.681 (S3)

Suitability Assessment

The Procedure that was adopted for this work was according to Sys (1985) Here the properties of the soil in each site was matched with the requirements of the land utilization type, represent here by Maize (Zea mays), to assign a suitability class to it. The result of the suitability class of the site for the utilization is the class indicated by the characteristic with the lowest rating. In this approach, if a soil property optimum for a crop, then it is said that there is no limitation, on the other hand if characteristics is unfavorable for the crop, there is said to be a limitation. Land characteristics and qualities of the study sites are shown on table 5, while the assessment rating resulting from the matching of land qualities and the requirements of the crop (Maize) under consideration is shown in table 6.All the land qualities that is, annual rainfall, mean annual temperatures, humidity, drainage and soil depth were all favorable for the cultivation of the crop and fall under suitability class S1. Remission (1998) also reported that climatic condition (rainfall, temperature and % humidity) to be favorable for the establishment of rainfed agriculture for most crops in this region. It should also be noted that our findings reveal that in the valley bottom the soils were poorly drained. These are incised valleys on an undulating plateau (Sogynola, 2011) created the existence of double slopes i.e the wall of valley, and the valley floor, which also dips towards to head streams whose originated in the plateau. The only limitation was slope, where the value for crest was 11% while middle slope (MS) and valley bottom (VB) have 6% and 3 respectively. These values put the soil of CR and MS in suitability class (S3) while for VB it was class (S1). Slope is therefore a limitation for the soils of CR and MS.

When considering soil depth, all the sites were highly suitable (S1) as no impediment was encountered during profile pit excavation from the surface to 120cm. With regards to chemical properties, the soils of CR and MS were not suitable (NS) but marginally suitable for VB. Low values of exchangeable bases, K, Ca, Mg and Na for all the sites places these soils not suitable (NS) for the cultivation of the crop. Values for percentage Nitrogen and Available Phosphorus were also low for all the sites, making the soils of all the sites to fall under suitability class (NS). Olaleye, *et al.* (2002) also reported that the major limitation to Maize cultivation on rain fed soils to be low exchangeable cation, available P and organic carbon.

Conclusion

In this investigation some soils along a toposequence in College of Agriculture teaching and research farm (CAM), were assessed for their suitability for the cultivation of Maize (Zea mays). The crop is a major arable crop and a staple food crop for the majority of the inhabitants of Mokwa and beyond. Our findings revealed that all land characteristics such as soil depth and drainage were favourable and highly suitable, while slope was a major hindrance. The levels of all chemical properties were found to be low and are unsuitable for the cultivation of the crop. The sandy nature of the soils coupled with high degree of slopes will expose these soils to erosion, except valley bottom, but if proper soil conservation and ideal agronomic practices is put in place it will reduce risk of runoff . The organic matter level was adequate for

continuous cultivation of Maize on these soils, but organic and inorganic fertilizers should be applied on continuous basis for sustainability.

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