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Variation in Cassava Yield Cultivated on Ferralsols and Ferruginous Soils in Kwara State, Nigeria

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ABSTRACT

Depleting soil fertility is a severe issue of cassava production, which is the chief source of dietary food energy for most people living in the lowland tropics and much of the sub-humid tropics of West and Central Africa. This study examined variation in cassava yield cultivated on ferralsols and ferruginous soils for five years from 2011 to 2015 in Kwara State, Nigeria. Primary and secondary data were used, and the collected data were analyzed using descriptive and inferential statistical methods. This study showed cassava yield under ferruginous soils was significantly higher than that of ferralsols ($p<0.05$). The mean values of total organic carbon, nitrogen and phosphorus content in the topsoil of ferralsols were 1.25, 0.127 and 1.558, respectively, while that of ferruginous soil were 2.192, 0.224 and 6.689, respectively. Further, the results showed that the values of nitrogen and potassium contents of ferralsols and ferruginous soils were remained within the range to support the optimum yield of cassava tuber. Findings also revealed that there could be a probable increase in the cassava yield production and a decrease in soil nutrients if farmers continue cultivating on both soils. This study recommends better practices of cassava cultivation on ferruginous soils, enlightenment on the appropriate soil management, and applying fertilizers to meet the increasing demand for cassava.

KEYWORDS: *Cassava Yield, Ferralsols, Ferruginous Soils, Kwara State, Variation, Nigeria*

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1 INTRODUCTION

Natural resource degradation in terms of soil fertility decline, erosion and species extinction through inappropriate agricultural practices are testimonies to the fact that current land-use systems are often far from sustainable. Due to its diverse functions, soil occupies a central position in the landscape balance. Series of changes such as addition, losses, modification and alterations continually occur in soil because of its dynamic system. These changes directly affect the soils' composition, properties and potential (Oriola, Babatunde & Salami, 2019; Akinbode, 1986).

Essential plant nutrient elements of the soil are the most affected elements of land in continuous agriculture without appropriate management. The change in the nutrient elements in the soil could significantly affect plant growth. However, variability of soil properties can also occur due to cultivation, land use, and erosion. Anikwe et al. (1999) reported that the spatial variability of soil properties influences crop production across a field. The yield level is the focus of farmers in any production system (Adak et al. 2014). Thus, the food and cash income gained from farming is directly related to yield.

Cassava (*Manihot esculenta*) is a carbohydrate food source for over 500 million Africans (Food and Agricultural Organization 2003). It is mostly used for human consumption, from boiling the fresh tuber to processing it into cassava flour. Cassava tubers are an essential source of carbohydrates, while the leaves, eaten as a vegetable, are a good source of protein and vitamins. Cassava is a major food crop in Nigeria (Oriola et al. 2019; Ogbe et al. 2007). It is strategically valued for its role in food security, poverty alleviation and as a source of raw materials for agro-allied industries in Nigeria with massive potential for the export market (Egesi et al. 2007). With the ability to tolerate drought and give reasonable yield in soils of low fertility (Salami & Tilakasiri 2020; Tilakasiri et al. 2017), cassava plays a vital role in the food security of many Nigerians (Ezedinma et al. 2006). In rural areas, poor households' consumption of cassava is tripled that of non-poor households. When dried, cassava is both conservable and transportable over long distances.

The soils in Kwara State support cassava cultivation, maize, rice, guinea corn, sweet potato, millet etc. (Oriola et al. 2019), while cassava is mainly used as food, animal feed and cash crop. In Nigeria, a large number of traditional cassava foods, such as garri, fufu, starch, lafun, abacha, etc., are produced for the consumption of humans (Oriola et al. 2019). Cassava has gained industrial recognition in producing ethanol, cassava flour in bread production, glucose syrup production etc. However, the population pressure on land has led to reduced fallow periods, more intensive land use and increased problems of soil infertility (Salami & Tilakasiri 2020). With little or no external addition of plant nutrients, depletion impoverishes the soil, resulting in declining yields and soil degradation (Salami & Sangoyomi 2013). Previous studies have been concentrated on soil properties, soil fertility, soil management practices, and cassava varieties growing and cultivated on different soil types in Nigeria and other parts of the world (Oriola et al. 2019; Adak et al. 2014; Ivan 2014; Oriola & Hammed 2012; Adejini et al. 2011; Lahai & Ekanayake 2009; Ogbe et al. 2007; Ezedinma et al. 2006; Agbaje & Akinlosotu 2004; Howeler 1991). Few or limited studies have been conducted on cassava cultivated on Ferrasols and Ferruginous soil in Kwara State, Nigeria. Therefore, it is necessary to fill in the gap by examining the cassava yield cultivated on different soils in Kwara State, Nigeria, to improve cassava's productivity.

The study aimed to examine the yield of cassava cultivated on ferralsols and ferruginous soils in Kwara State, Nigeria. Specifically, the study objectives were to assess the yield of cassava cultivated under ferralsols and ferruginous soils; determine the implications of long-term cassava cultivation on the soil

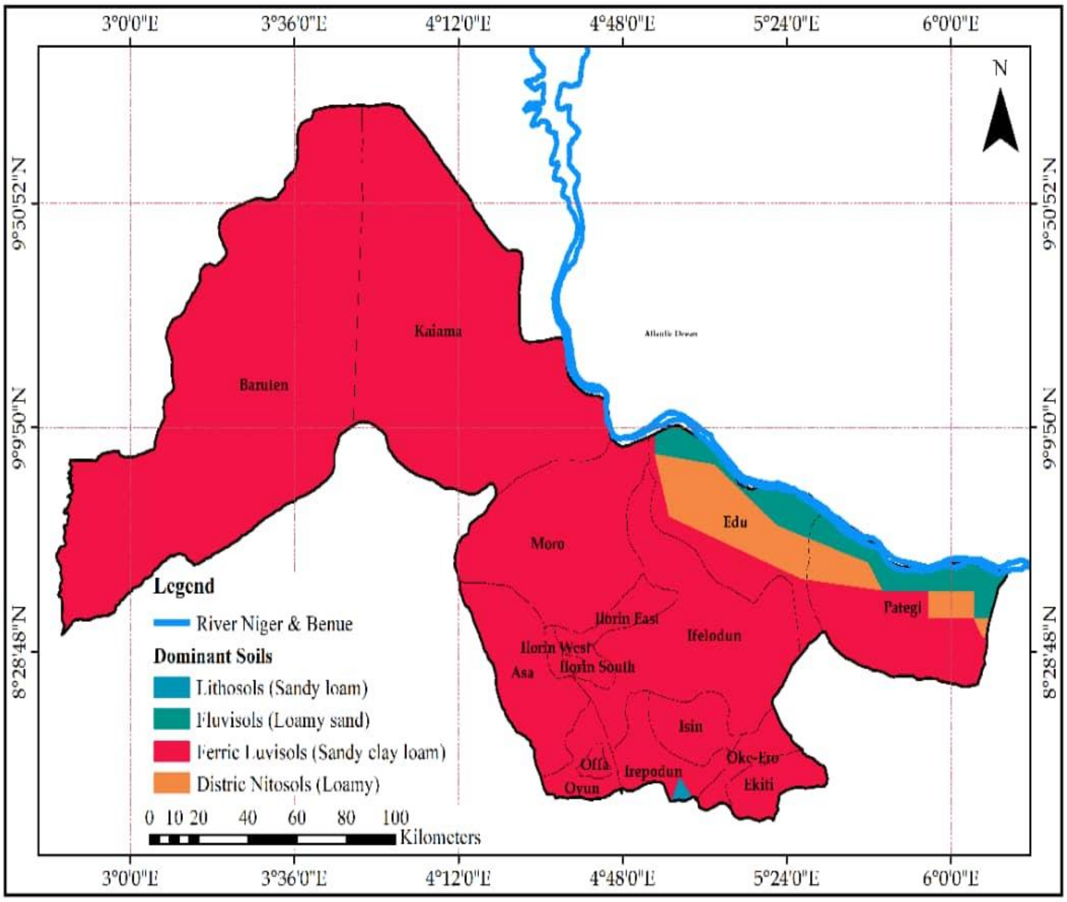

Figure 1: Dominant Soils in Kwara State, Nigeria

properties; and assess the yield increase of cassava in meeting the demand for the product in the study area.

2 RESEARCH METHODOLOGY / MATERIALS AND METHODS

2.1 Geographical Characteristics of the Study Area

Kwara State is located at the southern border of River Niger and in the southern guinea savanna. It lies between latitude 8° and 10° 04" North of the Equator and Longitude 2° 45° and 6° 12" East of Greenwich Meridian (Fig. 1). The State has an elongated shape running from west to east and covering an area of about 32,500 km^2 (Oriola et al. 2019; Longman 2000). It has River Niger as its natural boundary along its Northern and eastern margins. Cropping patterns are influenced by hydrologic regimes of inland valleys (Oriola et al. 2019).

Cassava is a favourite dry season crop grown in inland valleys in West and Central Africa (Lahai & Ekanayake 2009) due to its adaptation to different edapho-climatic conditions (Adejini et al. 2011). The study area is characterized by the tropical wet and dry climates and dual rainfall maxima (Olanrewaju 2009). The more significant proportion of the study area belongs to dry sub-humid, while the Northwestern fringe belongs to semi-arid climatic regions on the Thornthwaite weather climatic scheme (Olaniran 1988). Vegetation, climate and geology of an area can determine, at a certain extent, the soil development in the area. A typical characteristic of Kwara State is agriculture as the basis for economic activities. The vast savannah grassland that characterizes the vegetation of the State is highly conducive to producing food crops such as cassava, sweet potatoes, yam, guinea corn etc. (Oriola et al. 2019).

2.2 Collection of Cassava Yield Data

The data on the size of the farmland, cassava yield under ferralsols (oxisols) and ferruginous soils (ultisols) over five years (2011-2015), and soil map of the study area were used in this study. Data were collected through reconnaissance survey, field observation and interview schedule. An oral interview was scheduled with farmers who possess the farmlands to obtain cassava yield. During the study periods, the two soil types were used for practising commercial cassava cultivation. The yield was collected from the farmers using the oral interview method. The yield measurement was toned per hectare. A 100kg bag of cassava was converted into ton. Crop rotation was not practised within the period of the study. People were hired to weed the farmlands with hoes and cutlasses. The selected area of the farmlands was situated in non-erosion-prone areas. The two farmlands have the same management practices.

2.3 Sampling Method

The two farmlands selected for the study were demarcated into three sections, with various cassava cultivated in each section. The two farmlands were over 20 hectares. From each of the two soil types, TME-419 cultivated sections measuring 50,000 m^2 (5 hectares) were selected for the study. A stratified sampling method using quadrants (grids cells) was used to collect the soil samples of topsoil and subsoil within the 20 squares. This method has been used in different studies (Oriola et al. 2019; Oriola & Bamidele 2012; Oriola 2004). Hence, 50 m x 50 m sample quadrats were adopted. The representative sample of the quadrat was obtained by selecting 5 representative cores from each 50 m x 50 m quadrant. The two fields sampled measure 50,000 m^2 each. Therefore, each field was demarcated using 250 m x 200 m, subdivided into 20 quadrats measuring 50 m x 50 m (2,500 m^2). Furthermore, there was a subdivision of the 50 m x 50 m quadrats using grids measuring 25 m x 25 m from which representative cores were collected (Oriola et al. 2019). This method has also been previously used by Olowolafe & Olushola (2013), and Baker et al. (2007). Hence, a total of 40 samples, that is, 20 from each topsoil and subsoil. Both soil types cultivated the same cassava varieties, namely TME-419, TMS-130555 and TMS-4(2)-1425. Only the yield of TME 419 was studied as it is a commonly cultivated variety with high demand by the people in Kwara State, Nigeria.

2.4 Statistical Analysis

Collected data were analyzed using descriptive and inferential statistical techniques. The descriptive techniques used were mean scores, percentages and standard deviation, while the inferential method employed was the student's t-test. The student's t-test was used for differences between soils and cassava yield, and Statistical Package for the Social Sciences (SPSS) version 23.0 was used for the analyses. Student's t-test has been used for similar research in previous studies (Oriola & Hammed 2012; Olowolafe & Olushola 2013; Tshiunza et al. 1999). The formula for a student's t-test is given below:

$$t = \frac{|X - Y|}{\sqrt{\frac{sx^2}{N_x} + \frac{sy^2}{N_y}}}$$

Where,

t= student's t-test,
X= yield of cassava growing on ferralsols,
Y= yield of cassava growing on ferruginous soils,
sx^2= a square of the standard deviation of yield of cassava growing on ferralsols,
sy^2= a square of the standard deviation of yield of cassava growing on ferruginous soils,
N_x= sample size of cassava growing on ferralsols, and
N_y = sample size of cassava growing on ferruginous soils.

3 RESULTS & DISCUSSION

Figure 2 shows the difference in cassava yield (TME-419) under ferralsols and ferruginous soils over 5 years (2011-2015). Based on the information gathered, each farmland of cassava cultivation under ferralsols and ferruginous soils measured 50,000 square meters under the same management practices, and three different cassava varieties were cultivated on each soil. Cassava yield productions on ferruginous and ferralsols under the studied period (2011 – 2015) were not of the exact quantities.

This study showed that the quantities and tonnes of cassava yield production under ferruginous soils were more than that of ferralsols (Fig. 2). The differences in cassava yield cultivated on ferralsols and ferruginous soil types in tonnes/ha were 8 (2011), 4 (2012), 10 (2013), 3 (2014) and 6 (2015), respectively. This is due to more nutrient available in ferruginous soils which are essential for optimum yield of cassava tuber, than the ferralsols (Oriola et al. 2019).

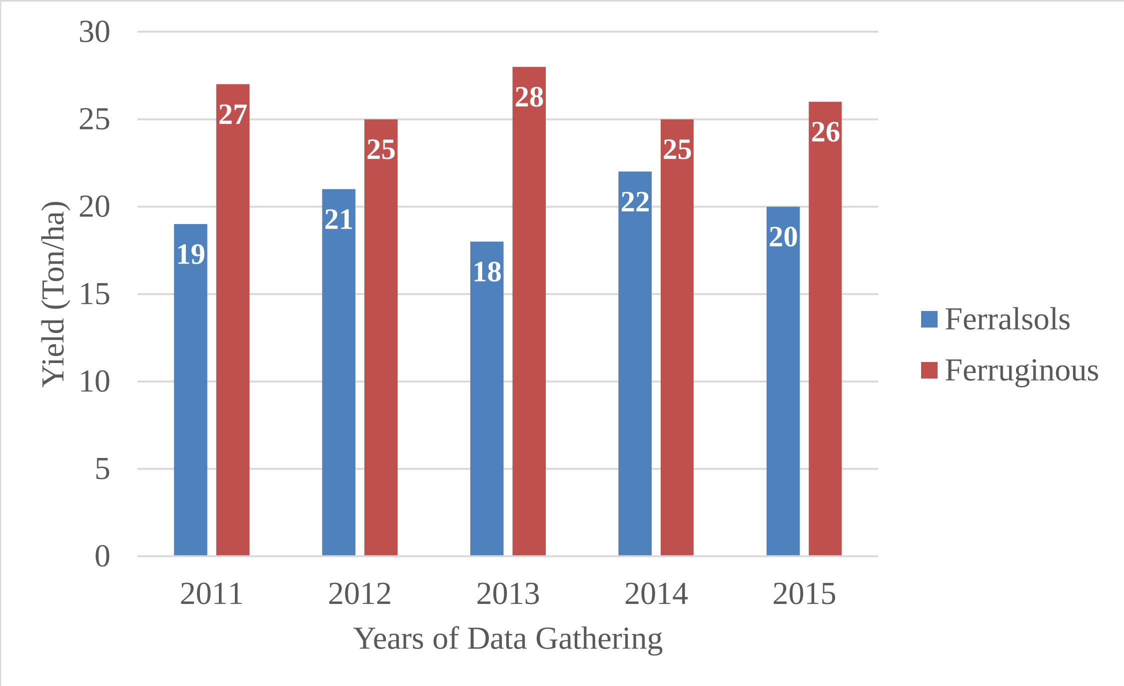

Figure 2: Cassava Yield under Ferralsols and Ferruginous Soils for a Period of 5 Years (2011-2015**)**

The major nutrients required by cassava for optimum growth and yield are nitrogen (N) and potassium k (Howeler 1991). Organic matter exerts a proportional increase in tuber content as it plays a significant role in yield (Abua and Atu 2011). Based on the existing similar research conducted on the physio-chemical properties of soil in Kwara State, Nigeria (Table 1), the mean values of organic matter, nitrogen (N) and potassium

(K) on ferralsols were 1.25% (topsoil) and 0.99% (subsoil), 0.127% (topsoil) and 0.102% (subsoil), and 0.267% (topsoil) 0.215% (subsoil), respectively. Considering the mean values of organic matter, N and K on ferruginous were 2.192% (topsoil) and 1.914% (subsoil), 0.224 % (topsoil) and 0.193% (subsoil) and 0.161% (topsoil) and 0.108% (subsoil), respectively (Oriola et al. 2019).

Table 1: The T-Test Summary of Variations in Soil Properties under Ferralsols and Ferruginous Soils

Soil Properties	Soil Layers	Soil Type	Paired Samples Statistics		Paired Samples Test Paired Differences		T-Test *P- Value*
			Means	Std. Deviation	Means	Std. Deviation	
PH (H_20)	Top	Ferralsols	6.27	0.28304	0.72	0.30111	0.000*
		Ferruginous	5.55	0.38658			
	Sub	Ferralsols	6	0.21082	0.41	0.46774	0.022*
		Ferruginous	5.59	0.60636			
% Total Organic Carbon	Top	Ferralsols	1.25	0.45331	-0.942	0.69094	0.002*
		Ferruginous	2.192	0.42985			
	Sub	Ferralsols	0.99	0.23452	-0.924	0.4525	0.000*
		Ferruginous	1.914	0.32972			
% Total Nitrogen	Top	Ferralsols	0.127	0.04668	-0.097	0.07394	0.002*
		Ferruginous	0.224	0.04526			
	Sub	Ferralsols	0.102	0.0253	-0.091	0.04606	0.000*
		Ferruginous	0.193	0.03401			
Available Phosphorus mg/kg	Top	Ferralsols	1.558	0.83871	-5.131	5.91124	0.023*
		Ferruginous	6.689	5.4829			
	Sub	Ferralsols	0.968	0.40876	-4.386	6.43386	0.059
		Ferruginous	5.354	6.34944			
Ca	Top	Ferralsols	2.765	0.14331	0.272	0.97139	0.399
		Ferruginous	2.493	0.88422			
	Sub	Ferralsols	2.235	0.32346	0.146	0.79515	0.576
		Ferruginous	2.089	0.75294			
Mg	Top	Ferralsols	0.776	0.2478	0.035	0.5126	0.834
		Ferruginous	0.741	0.36211			
	Sub	Ferralsols	1.533	2.91841	0.849	2.52742	0.316
		Ferruginous	0.684	0.48587			
K Cmol/kg	Top	Ferralsols	0.267	0.06897	0.106	0.11635	0.018*
		Ferruginous	0.161	0.07549			
	Sub	Ferralsols	0.215	0.04625	0.107	0.07889	0.002*
		Ferruginous	0.108	0.03853			
Na	Top	Ferralsols	0.317	0.04111	-0.072	0.07345	0.013*
		Ferruginous	0.389	0.04458			
	Sub	Ferralsols	0.244	0.043	-0.067	0.07917	0.025*
		Ferruginous	0.311	0.05466			
% Clay	Top	Ferralsols	7.81	1.95758	3.21	4.12861	0.036*
		Ferruginous	4.6	4.11501			
	Sub	Ferralsols	7.45	2.27804	2.05	5.06957	0.233
		Ferruginous	5.4	5.50151			
% Silt	Top	Ferralsols	15.72	2.40592	-2.68	3.23344	0.028*
		Ferruginous	18.4	4.13656			
	Sub	Ferralsols	16.28	2.56333	-2.72	1.91183	0.001*
		Ferruginous	19	3.23866			
% Sand	Top	Ferralsols	76.47	3.36322	-0.53	4.78842	0.734
		Ferruginous	77	3.62706			
	Sub	Ferralsols	76.34	2.76494	0.74	5.37488	0.674
		Ferruginous	75.6	4.44722			
CEC	Top	Ferralsols	5.83	1.37211	-2.849	2.09087	0.002*
		Ferruginous	8.679	1.29994			
	Sub	Ferralsols	4.838	1.14312	-3.002	1.62075	0.002*
		Ferruginous	7.84	0.99447			

*Significant at $p<0.05$
Source: Oriola et al. (2019)

The result of the t-test presented in Table 2 showed a significant difference between the yield of cassava on the two soil types ($p<0.05$). In contrast, the value of pH ($p=0.000$ for topsoil and $p= 0.022$ for subsoil) further influenced cassava tuber yield (Table 1). The two soil types have the potential for acidity. The findings of this study corroborate with the study of Andrezza et al. (2021) where the pH values further influenced cassava tuber yield positively, provided that there is improved liming and fertilization. The mean value of N in ferralsols is 0.127 (topsoil) and 0.102 (subsoil), while that of Ferruginous soil is 0.224 (topsoil), which implies that the organic carbon content is higher in ferruginous soil than in ferralsols. Andrezza et al. (2021) reported that organic fertilization serves as a soil conditioner and provides nutrients for the crop, promoting soil structure improvement and aeration. CEC for both soil types is below the value of 3.6, as reported by Cruz et al. (2017). It was stated that any value above 3.6 reduces the assimilation of carbon, stomatal conductance, transpiration, and the instantaneous water use efficiency in cassava cultivation. The phosphorus contents of the two soil types are low. This is in agreement with the findings of Aliyu et al. (2019), arguing that, problems relating to low concentration of phosphorus can be addressed through efficient association with arbuscular mycorrhizal fungal inoculants in cassava. Calcium (Ca) and magnesium (Mg) contents are higher in ferralsols than ferruginous soils. The implication is that there is high tuber yield due to low mineralization at a low pH value. An increase in base saturation (Ca:Mg; Mg:K and C:N) ratios decreases the tube yield. This explains why the yield of cassava on ferralsols is lower than that of ferruginous soils.

Table 2: Summary of the t-test of Cassava Tuber Yield Cultivated under Ferralsols and Ferruginous Soils over a Period of Five Years (2011-2015)

Paired Samples Test									
		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Ferruginous Soils - Ferralsols	6.2	2.864	1.281	2.644	9.756	4.841	4	0.008

To have an optimum tuber yield, soils with low N (<0.10% total N) and K (<0.15 Cmol/kg) will require an additional fertilizer (Agbaje & Akinlosotu 2004). The t-test result demonstrated that the value of N and K contents of ferralsols and ferruginous soils are still within the range to support the optimum yield of cassava tuber. In tropical areas, the continuous use of soil without recourse to conservation practices often constrained the soil ecosystems beyond their natural capacity leading to a reduction in soil productivity and sustainability (Jongruaysup et al. 2003) as the soil has lost its major nutrients probably due to continuous cropping of cassava which would have led to the depletion of major nutrients especially N and K and will require fertilizer supplement to give stable yield (Kang & Okeke 1991).

Regarding the long-term implications of cassava yield production in the study area, this study revealed that there would be an increase in cassava yield production and a decrease in soil nutrients if farmers continued cultivating on both soils. Furthermore, the soil properties could support crop cultivation for a very long time with fertilizer application. Continuous cropping without good management practices in the study area could lead to severe soil degradation and complete crop failure.

Cassava performance is affected by the interaction of several factors. This supports the findings that soil fertility is the essential limiting factor of agricultural production in the tropics (Asadu et al. 2007). The results of this study revealed the relevance of organic matter, nitrogen and potassium to the variation in cassava yield. Fertilizer addition significantly influences cassava tuber yield. The combined application of 60 kg of N – 60 kg of P – 0 kg of K per ha is suggested for high cassava tuber yields in the short term (Ivan 2014). Ferruginous soils have the potential to yield more cassava tuber than the ferralsols. Adequate fertilizer application in the right proportion will help increase the yield on both soils in meeting the increasing demand for cassava products.

4 CONCLUSION & RECOMMENDATIONS

The differences in soil types result from variation in crop yield and its quality. Variation in cassava yield cultivated on ferralsols and ferruginous soils for five years (2011-2015) in Kwara State, Nigeria, has been examined. The findings of this study revealed that cassava yield productions on ferruginous and ferralsols under the studied period (2011 – 2015) were not of the exact quantities, and the difference between the yield of cassava on the two soil types was highly significant ($p<0.05$). Also, the continuous cropping of cassava has led to the depletion of major nutrients, especially N and K and will require fertilizer supplements to give a stable yield. Therefore, the long-term implication is that there would be an increase in cassava yield production and a decrease in soil nutrients if farmers continue cultivating on both soils with good management practices. In addition, the yield of cassava in the study area has been increasing in meeting the demand for the product because ferruginous soils can yield more cassava tuber than the ferralsols, and farmers cultivate on ferruginous soil than ferralsols. Based on the findings of this research, this study concludes that the cultivation of cassava should be highly practised on ferruginous soils, appropriate management techniques should be encouraged on ferralsols for high cassava tuber yield productions, and enlightenment on soil management as well as the application of an appropriate and adequate amount of fertilizer.

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REFERENCES

Adak, T, Kumar, K, Singha, A, Shukla, SK & Singh, VK 2014, 'Assessing soil characteristics and guava orchard productivity as influenced by organic and inorganic substrates', *The Journal of Animal and Plant Sciences*, vol. 24, no. 4, pp. 1157-1165.

Adejini, OT, Odo, PE & Ibrahim, B 2011, 'Genetic Relationships and selection indices for cassava root yield in Adamawa State, Nigeria', *African Journal of Agric. Resources,* vol. 6, pp. 2931-2934.

Agbaje, GO & Akinlosotu, TA 2004, 'Influence of NPK fertilizer on tuber yield of early and late-planted cassava in a forest alfisol of South-Western Nigeria', *African Journal of Biotechnology*, vol. 3, no. 10, pp. 547-551.

Akinbode, A 1986, Soil conservation and agricultural reforms: imperatives for rural development in Nigeria. In: Adeniyi, E.O. and Bello-Imam, I.B. (Eds): *Development and the Environment: Proceedings of a National Conference.* Nigerian Institute of Social and Economic Research, Ibadan, Nigeria.

Aliyu, IA, Yusuf, AA, Uyovbisere, EO, Masso, C & Sanders, IR 2019, '*Effect of co-application of phosphorus fertilizer and in vitro-produced mycorrhizal fungal inoculants on yield and leaf nutrient concentration of cassava*', Retrieved May 27, 2022 from https://doi.org/10.1371/journal.pone.0218969

Andrezza, GC, Luciano, SS, Francisco, AX, Alide, MW, Evellyn, FS & Marcela, RB 2021, 'Characterization of soils cultivated with cassava under different management', *Brazilian Journal of Agricultural and Environmental Engineering*, vol. 25, no. 11, pp. 764-771.

Anikwe, MAN & Obi, ME 1999, 'Evaluation of an index model for quantifying the productivity of soils in South-Eastern Nigeria using maize as a test crop', *Journal of Agriculture and Environment*, vol. 1, pp. 80-89.

Egesi, C, Okogbenin, E, Mbanaso, E & Fregene, M 2007, 'Induced mutations and marker-aided breeding for the improvement of root quality traits in cassava', *NRCRI, Umudike Annual Report 2007*, pp. 22-23.

Ezedinma, Cl, Okafor, C, Asumugha, GN & Nweke, F 2006, Trends in farm labour productivity and implications for cassava industrialization in Nigeria. *Proceeding of the 40th Annual Conference of The Agricultural Society Of Nigeria Held At NRCRI Umudike, Abia State*. Oct. 16-20th. 109-111.

Food and Agricultural Organisation-FAO 2003, '*FAOSTAT, FAO Statistical Database Agriculture',* Food and Agricultural Organization Available. Http:// Faostat.

Howeler, RH 1991, 'Long-term effect of cassava cultivation on soil productivity', *Field Crops Resources*, vol. 26, no. 1, pp. 1-18.

Ivan, BC 2014, Investigating the effect(s) of contrasting nitrogen (N), phosphorus (P), and potassium (K) fertilizer rates on cassava tuber yield and quality and maize grain yield in Southern Africa. *A thesis presented for the Master of Science degree*. University of Tennessee, Knoxville.

Jongruaysup, S, Trelo-ges, V & Chuenrung, C 2003, 'Minimum tillage for cassava production in Khon Kaen Province, Thailand', *Songklanakarin Journal of Science and Technology*, vol. 25, no. 2, pp. 191-196.

Kang, BT & Okeke, JE 1984, Nitrogen and potassium responses of two cassava varieties grown on an Alfisol in Southern Nigeria. In: *Proceeding, 6th Symposium of the Internationa Society of Tropical Root Crops, 1984, Lima, Peru*, pp. 231-234.

Lahai, MT & Ekanayake, IJ 2009, 'Accumulation and distribution of dry matter in relation to root yield of cassava under a fluctuating water table in Inland valley ecology', *African Journal of Biotech*, vol. 8, pp. 4895-4905.

Olaniran, OJ 1988, 'Climate and the planning of agriculture land use in Nigeria: The NRBDA area as a 'case study', *Journal of Agric. Meteorology*, vol., *43*, no.4, pp. 285-294.

Olanrewaju, RM 2009, 'Climate and the growth cycle of yam plant in the guinea savannah ecological zone of Kwara State, Nigeria', *Journal of Meteorological and Climate Science*, vol. 7, pp. 43-48.

Olowolafe, EA & Olushola, B 2013, 'Effects of corralling on the properties of an inceptisol in Vom Area, Jos Plateau, Nigeria', *Nigeria Journal of Soil and Environmental Research*, vol. 2, no. 11, pp. 4-40.

Oriola, EO, Babatunde, OR & Salami, AA 2019, 'Soil characteristics of cassava growing ferralsols and ferruginous Soils in Kwara State, Nigeria', *Sri Lankan Journal of Agriculture and Ecosystems*, vol. 1, no. 1, pp. 87-101.

Oriola, EO & Hammed, AT 2012, 'The influence of cattle wastes on degraded savanna soils of Kwara State, Nigeria', *Ethiopian Journal of Environmental Studies and Management*, vol. 5, pp. 3-9.

Ogbe, FO, Emehute, JK & Legg, J 2007, 'Screening of cassava varieties for whitefly populations', In: *NRCRI Annual Report 2007*, pp. 30-33.

Salami, AA, & Tilakasiri, SL 2020, 'Impact of climate change on refugees and food shortage crises in Africa', *International Journal of Multidisciplinary Studies (IJMS)*, vol. 6, no. 2, pp. 58 – 78.

Salami, BT, & Sangoyomi, TE 2013, 'Soil fertility status of cassava field in south western Nigeria', *American Journal of Experimental Agriculture*, vol. 3, no.1, pp. 152-164.

Tilakasiri, SL, Olanrewaju, RM & Salami, AA 2017, Climate change induced migration and conflict in African States. In Saliya De Silva (Ed.), *Development dynamics: Transforming societies for sustainable futures* (pp. 337-335). Japan: Saga University.

Tshiunza, M, Nweke, FI & Tollens, EF 1999, 'Performance of high-yielding cassava varieties in terms of quality of garri per unit of labor in Nigeria', *Tropicutura,* vol. 4, pp. 193-19