# Soil fertility evaluation of some Kola plantations in Kwara and KogiStates, Nigeria for enhanced productivity


## Abstract

This study was carried out to assess the soil fertility condition of some selected kola plantations in Kwara and KogiStates.Ten core soil samples at 0-20cm and 20-40cm depth were randomly collected in each plantation using soil auger and bulked into composite samples to obtain representative soil samples. The soil samples were air dried, sieved through 2mm sieve and some physical and chemical properties were determined following standard laboratory procedures.Thesoil texture of the plantations studied inKwara and Kogi States were either loamy sand or sandy soils. Soil organic carbon contents of both states were lower than the critical value of 30.00g/kg soil considered to be optimum and ideal for tree crop plantation. This indicates that there has been a great loss of organic matter from the soil reflecting the sandy texture of the plantations. The low organic matter content and slightly acidic soil could affect major nutrients availability and may result in nutrient imbalance. Nitrogen content of some of the location studied were low, this could be because sandy soil under high rainfall are prone to N deficiency which may have affected N leafcontent as well, this makes N fertilizer application necessary because N is needed for vegetative growth and profitable yields. Available P and exchangeable cation (Mg and Ca) were found adequate for most of the plantations. The kola leaf N contents were below critical levels of 1.09% recommended for kola.Variation in soil nutrient content of top soil and sub soil of some of the plantation shows that an adequate fertilizer management system specifically directed to address the need of the soil is required.



**Keywords**: Soil fertility, Kola Plantation, Kwara and KogiState


## Introduction

Kola nut is a traditional important economic cash crop with about forty species out of which *C. nitida* and *C. acuminate* are the most cultivated species in Nigeria(Ndagi*et al*., 2012). Apart from their industrial uses in wine, liquor, drug production, the nut is used in the production of alkaloids and other phytocompounds.It is alsousedin the textile industry because of its tannin contents(Azeez, 2015; Ndagi*et al*.,2012, Odeyemi*et al*., 2022). Thenut when chewed serves as an energizer and stimulant (Adejoke*et al*., 2020). Kola production level over the years has been reported to decline due to numerous factors which include self-and-cross incompatibility among trees, old age, diseases, fieldand storage pests,(Ndagi*et al*., 2012; Mokwunye*et al*., 2017)and decline in soil fertility(Ipinmoroti*et al* 2013). Soil nutrient of most kola plantations gradually decline below required levels with continuouspod harvesting without fertilizer application (Asogwa et al., 2012). Nigerian farmers rarely apply fertilizers on their farms hence; crops depend on natural supply of nutrients and more importantly, micronutrients, which are supplied from the soil with no effort through fertilizer application (Iremiren and Ekhomun 2005). Soil nutrient maintenance of most kola farm is constrained by the limited use of inorganic fertilizer due to high cost (Ndagi*et al*., 2012) and limited understanding of benefit of organic amendments to soil. To ensure proper growth and profitable yield, nutrient management is an important part that must be focused on by farmer. Many experiments have been conducted which show effects of soil and leaf nutrient level decline on kola growth and yield after many years of pods removal(Asogwa*et al*., 2012). There is need for further information on soil type and fertility status of various kola plantations across Nigeria. This research on soil nutrient levelofsome kola plantationsin the North central region of Nigeria wasexecutedto recommend appropriate soil fertility management that will enhance yield and ensure sustainable production.Kwara and Kogi states are located in North Central part of Nigeria. Kwara and KogiStatesare both kola nutproducing Statesin Nigeria(Ndagi*et al*., 2012).Hence,theaim of this study was to evaluate the physico- chemical properties of the soil and determine leaf nutrient status of the kola plantations so as to make adequate fertilizer recommendation.

**Materials and Methods**

The study was carried out in two Local Government Areas ofKwara State (Oyun and Irepodun) and Kogi State (Ijumu and Yagba East). Soil and leaf samples were collected from two selected farms for study per local government area. A distance of 25 m by 25 m quadrat was given between point of sampling and leaves were collected from closer kola trees to the point of sampling. Soil samples were randomly taken with soil auger at soil depths of 0-20cm and 20-40cm,which were considered as topsoil and subsoil respectively. A total of 25 random sampling points were made per plantation and thoroughly mixed to form composite sample for each depth. The soil samples were air dried and sieved using 2mm sieve, while the leaf samples were oven dried at 70 $^{O}$C to constant weight and milled.Soil samples collected were analyzed for the physical and chemical properties. Particle size analysis was determined using hydrometer method (Bouyoucos, 1951). Total nitrogen was determined by Kjeldahl method (Bremner, 1996). The pH was determined in distilled water using pH meter. Organic matter was determined using Walkley – Black wet oxidation method (Nelson and Sommers, 1982). The soil available phosphorus was by Bray 1 method (Olsen and Summers, 1982), while the soil cation contents- Ca, Mg, K and Na were extracted with 1.0 M ammonium acetate ($NH_4OAc$) solution at pH 7.0. Exchangeable Ca and Mg in the leachate were determined by atomic absorption spectrophotometer (AAS) while exchangeable $K^+$ and $Na^+$ were determined by flame photometer. The soil exchangeable acidity ($Al^{+3}$ and $H^+$) was by leaching the soils with 1.0NKCl and titrated with 0.05N NaOH and HCl solutions (Mclean, 1982).The soil micronutients – Zn was determined after extracting the soils with 0.1NHCl and the filtrate was read using AAS (AOAC 1990). The Leaf samples were ashed with Murphy furnace at 500 $^{O}$C for 5 hours, cooled, dissolved with 5-mL of 0.4 NHCl and leached to 100-mL with distilled water. The filtrates were used to determine Na+ and K+ by flame photometry, Ca2+ and Mg2+ contents by AAS, P by colorimetry and N by the Kjeldahl distillation method and Zn content (AOAC 1990).

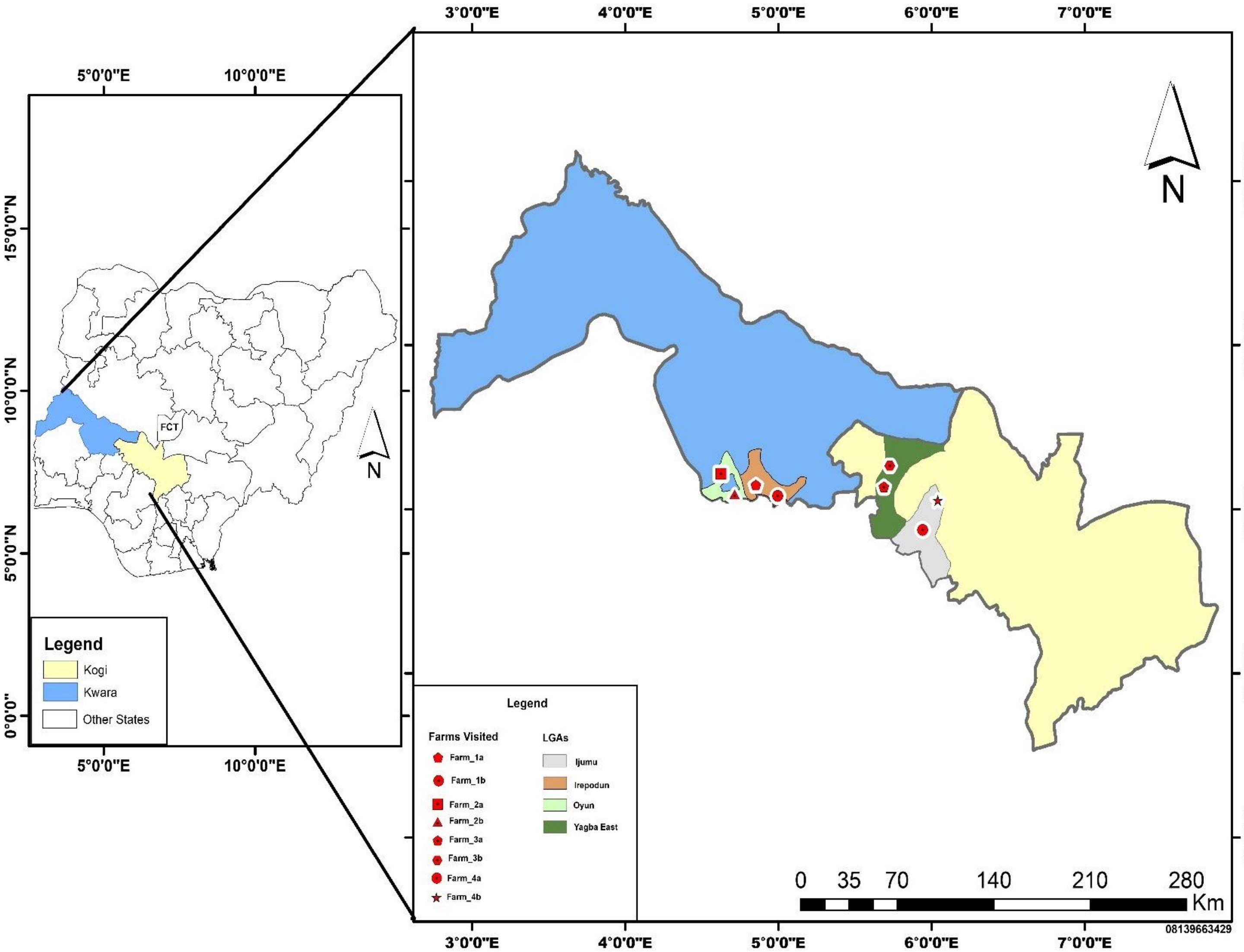


**Figure 1: Map of Nigeria showing Kola plantations where soil and leaf samples were taken in Kwara and Kogi States**

**Results and Discussions**

The pH of the soils in Irepodun and Oyunlocal government areas(Kwara state) ranged between 5.55 to 6.30 (Table 1), hence, the soil is moderately to slightly acidic. In Kogi state the pHis also slightly acidic with ranges of 5.25 to 6.50 andIjumu LGA (Table 2) particularly wasstrongly acidic withpH values as low as 5.25, this isbelow values reported to be suitable for kola (Opeke, 1987, Wood and Lass 1985). Therefore, any activity that will further acidify the soil should be avoided in both states. These plantations will require a soil fertility improvement programme that includes application of lime to raise pH to value (6.0 –6.5) required for adequate nutrient uptake and improved microbial activities. The results also showed that soil texture of Kwaraand Kogi States were either loamy sand or sandy soils.

**Table 1: Selected soil Physical and Chemical Properties of Kola Plantations in Kwara State**

| Soil Sample | pH Water (1:1) | Particle size (g/kg) | | | Textural Class | Organic C (g/kg) |
|---|---|---|---|---|---|---|
| | | Sand | Clay | Silt | | |
| **Irepodun I** | | | | | | |
| **0-20** | 6.05 | 838.00 | 48.00 | 114.00 | Loamy sandy | 17.00 |
| **20-40** | 5.95 | 818.00 | 48.00 | 134.00 | Loamy sandy | 14.40 |
| **Irepodun II** | | | | | | |
| **0-20** | 5.75 | 878.00 | 48.00 | 74.00 | Sandy soil | 9.00 |
| **20-40** | 5.75 | 918.00 | 48.00 | 34.00 | Sandy soil | 7.30 |
| **Oyun I** | | | | | | |
| **0-20** | 5.80 | 868.00 | 60.00 | 74.00 | Sandy soil | 13.20 |
| **20-40** | 5.55 | 826.00 | 140.00 | 34.00 | Loamy sandy | 6.10 |
| **Oyun II** | | | | | | |
| **0-20** | 6.30 | 886.00 | 60.00 | 54.00 | Sandy soil | 20.20 |
| **20-40** | 6.00 | 806.00 | 120.00 | 74.00 | Loamy sandy | 9.70 |

**Table 2: Selected soil Physical and Chemical Propertiesof Kola Plantations in Kogi State**

| Soil Sample | pH(Water) 1:1 | Particle (g/kg) | | | Textural Class | Organic C (g/kg) |
|---|---|---|---|---|---|---|
| | | Sand | Clay | Silt | | |
| **Ijumu I** | | | | | | |
| **0-20** | 5.90 | 878.00 | 48.00 | 7.40 | Sandy soil | 28.40 |
| **20-40** | 5.85 | 858.00 | 4.80 | 9.40 | Loamy sandy | 23.00 |
| **Ijumu II** | | | | | | |
| **0-20** | 5.90 | 918.00 | 4.80 | 3.40 | Sandy soil | 24.60 |
| **20-40** | 5.25 | 75.80 | 4.80 | 19.40 | Loamy sand | 12.20 |
| **Yagba East I** | | | | | | |
| **0-20** | 6.45 | 83.80 | 4.80 | 11.40 | Loamy sandy | 24.10 |
| **20-40** | 6.50 | 77.80 | 8.80 | 13.40 | Sandy loam | 8.30 |
| **Yagba East II** | | | | | | |
| **0-20** | 6.50 | 81.80 | 6.80 | 11.40 | Loamy sandy | 19.70 |
| **20-40** | 6.20 | 83.80 | 6.80 | 9.40 | Loamy sandy | 8.20 |

Nitrogen (N) contents (Table 3) were adequate except for Irepodun II and Oyun I which were below the critical level of 1.0 g/kg recommended for kola cultivation. Therefore, application of N on these plantations is needed for sustainable and profitable yield. Available Phosphorus for the plots in Kogi state were above the critical value of 3.7mg/kg required except at the sub soil in Ijumu II and Yagba East II. Exchangeable Potassium (Table 1 & 2)for Kwara and Kogi States wereabove the critical value of 0.12cmol/kg needed for kola cultivation (Egbe *et al*., 1989). The Magnesium, Mg contents of the soils in Kwara state were found to be adequate for kola cultivation except for Irepodun II which was totally deficient while soil of Irepodun II and sub soil of Oyun II were below the critical level of 0.8cmol/kg recommended for kola cultivation (Egbe *et al*., 1989). Also, Ca content of the soil was generally higher than the critical levels of 0.8cmol/kg established for kola (Egbe *et al*., 1989) in both states. The soil Zn content ranged from 6.02 to 31.39mg/kg as shown in Table 2. These values were higher than the soil critical value of >1.0 mg kg-1 (McKenzie 2001).This indicates that the soil Zn content was adequate and would not be a source of nutritional problem in the plantations. This is similar to the observation made by Ipinmoroti and Ogeh(2013).

**Table3: Selected nutrient content of soils in Kwara State**

| Soil Samples | Total N (g/kg) | Avail P (mg/k) | Exchangeable Cations (cmol/kg) | | | | Zn (mg/kg) |
|---|---|---|---|---|---|---|---|
| | | | Ca | Mg | K | Na | |
| **Ijumu I** | | | | | | | |
| **0-20cm** | 1.7 | 11.86 | 6.82 | 1.410 | 0.57 | 0.39 | 29.18 |
| **20-40cm** | 1.9 | 11.50 | 5.78 | 1.090 | 0.48 | 0.36 | 27.27 |
| **Ijumu II** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **0-20cm** | 1.5 | 11.70 | 6.54 | 1.160 | 0.51 | 0.34 | 30.00 |
| **20-40cm** | 1.6 | 3.63 | 2.12 | 0.810 | 0.35 | 0.28 | 16.64 |
| **Yagba East I** | | | | | | | |
| **0-20cm** | 2.1 | 8.64 | 6.12 | 1.920 | 0.70 | 0.46 | 31.39 |
| **20-40cm** | 1.1 | 5.01 | 5.17 | 1.510 | 0.38 | 0.26 | 19.70 |
| **Yagba East II** | | | | | | | |
| **0-20cm** | 1.3 | 5.11 | 5.91 | 1.590 | 0.43 | 0.27 | 22.92 |
| **20-40cm** | 1.2 | 2.20 | 3.71 | 1.220 | 0.45 | 0.25 | 16.44 |

**Table 4: Selected nutrient content of soils inKogi State**

| **Soil Samples** | **Total N (g/kg)** | **Avail P (mg/kg)** | **Exchangeable Cations (cmol/kg)** | | | | **Zn (mg/kg)** |
|---|---|---|---|---|---|---|---|
| | | | Ca | Mg | K | Na | |
| **Irepodun I** | | | | | | | |
| **0-20cm** | 1.0 | 2.35 | 4.58 | 0.839 | 0.40 | 0.16 | 16.72 |
| **20-40cm** | 1.1 | 4.85 | 3.90 | 1.110 | 0.34 | 0.21 | 15.50 |
| **Irepodun II** | | | | | | | |
| **0-20cm** | 0.7 | 2.25 | 3.23 | 0.780 | 0.18 | 0.20 | 8.92 |
| **20-40cm** | 0.9 | 1.23 | 2.60 | 0.512 | 0.09 | 0.12 | 9.11 |
| **Oyun I** | | | | | | | |
| **0-20cm** | 0.8 | 9.51 | 6.38 | 1.517 | 0.16 | 0.18 | 16.15 |
| **20-40cm** | 0.7 | 13.49 | 4.21 | 1.050 | 0.18 | 0.18 | 6.02 |
| **Oyun II** | | | | | | | |
| **0-20cm** | 1.3 | 8.94 | 6.66 | 1.330 | 0.70 | 0.28 | 20.72 |
| **20-40cm** | 1.1 | 1.23 | 2.60 | 0.512 | 0.09 | 0.12 | 9.11 |

Soil organic carbon contents of both states(Table 1) were lower in the range of 6.10 to 28.40g/kg which is lower than the critical value of 30.00g/kg considered to be optimum and ideal for tree crop plantation (Egbe *et al.*, 1989). This result indicates that there has been a great loss of organic content from the soil reflecting the sandy texture of the plantations. The higher organic carbon content of the topsoil (0-20cm depth) at both Kwara and Kogi States may be attributed to the accumulation and decomposition of large amounts of leaf litter falls over the years. This result is in agreement with the findings of Iloyanomon and Ogunlade (2011).

The kola leaf N contents (Table 5) were below critical levels of 1.09% recommended for kola (Egbe *et al*., 1989). The low N in Kola leaf might be as a result of the low soil pH whhich makes soil N unavailable to the plant. Phosphorus content of IrepodunI,OyunII and Ijumu II were 0.85%, 0.86% and 0.86% respectively in Kwara state were higher than the critical value of 0.08%(Egbe *et al*., 1989) while Irepodun II Oyun I, Ijumu I and Iyagba east I and IIwith value of 0.78%, 0.70%, 0.63, 0.77% and 0.59% respectively were below this value.Leaf K contents of kola plant were below 1.2% recommended for kola (Egbe *et al.*, 1989) in all locations except for Irepodun I which was 1.284% and adequate compared to the critical value. The plant Mg contents were lower than the critical value of 0.34% in all the locations. The Ca contents were higher than the critical value of 0.47% recommended for kola in all locations. Organic carbon contents of the leaves ranged from 12.14 to 15.31%. Zinc leaves (Table 5) contents were above 2.5% recommended for tree crop cultivation (McKenzie, 2001).

**Table 5: Leaf nutrient content of kola plantations in Kwara and Kogi States**

| Leaf Sample | Total N % | Avail. P % | Ca % | K % | Mg % | Organic C % | Zn mg/kg |
|---|---|---|---|---|---|---|---|
| **Irepodun I** | 1.06 | 0.85 | 1.20 | 1.28 | 0.14 | 14.07 | 72.13 |
| **Irepodun II** | 0.56 | 0.78 | 0.94 | 1.09 | 0.11 | 15.31 | 57.74 |
| **Mean** | **0.81** | **0.82** | **1.07** | **1.19** | **0.13** | **14.69** | **64.94** |
| **Oyun I** | 0.83 | 0.70 | 0.60 | 0.87 | 0.13 | 13.59 | 67.33 |
| **Oyun II** | 0.15 | 0.86 | 0.89 | 1.13 | 0.13 | 12.14 | 59.35 |
| **Mean** | **0.49** | **0.78** | **0.75** | **1.00** | **0.13** | **12.87** | **63.34** |
| **Ijumu I** | 1.09 | 0.63 | 1.03 | 1.07 | 0.11 | 14.48 | 68.76 |
| **Ijumu II** | 0.79 | 0.86 | 0.62 | 1.15 | 0.12 | 12.41 | 65.41 |
| **Mean** | **0.94** | **0.75** | **0.83** | **1.11** | **0.12** | **13.45** | **67.09** |
| **Yagba East I** | 1.01 | 0.77 | 0.60 | 1.34 | 0.12 | 12.55 | 74.75 |
| **Yagba East II** | 0.59 | 0.59 | 0.72 | 0.93 | 0.12 | 14.76 | 59.21 |
| **Mean** | **0.80** | **0.68** | **0.66** | **1.14** | **0.12** | **13.66** | **66.98** |



## Conclusion

The low organic matter content and slightly acidic nature of the soil could affect major nutrients availability and may result in nutrient imbalance. The low N content of some of the plantation soil is not surprising as sandy soil especially under high rainfall are prone to N deficiency which must have affected N leaves content, this makes N fertilizer application necessary because N is needed for vegetative growth and profitable yields (Snoeck*et al*., 2016). Available P and exchangeable cation (Mg and Ca) were found adequate for most of the plantations. Variation in soil nutrient content of top soil and sub soil of some of the plantation shows that fertilizer management system that is specifically directed to address the need of the soil is required. Despite the low level of leaf nutrient (such as N, P, K and Mg) none of these plantations shows deficiency symptoms.

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