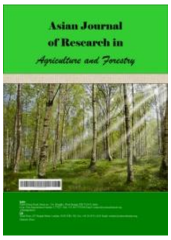


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# Suitability of Idi-Apa Oke-Oyi Soil for Groundnut Cultivation

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Soil supplies most of the mineral nutrients for plant growth through the plant's root system. The need to determine the soil nutrient supplying capacity of the soil at Idi-Apa, Oke-Oyi area of Kwara State, Nigeria for groundnut cultivation is of major concern before embarking on large-scale cultivation of groundnut to avoid great loss. The project was therefore conducted to analyse the soil at Idi-Apa, Oke-Oyi area based on the fertility for the cultivation of groundnut.

Soil samples were taken at depths 0–30 cm and 30–60 cm (which is the maximum rooting depth for groundnut) from the land. The samples which were collected through the random method were sent to the laboratory and analysed for chemical parameters: pH; organic carbon (OC); organic matter (OM); calcium (Ca); magnesium (Mg); sodium (Na); potassium (K); and nitrogen (N). Physical properties (textural class) and other properties such as sodium adsorption ratio (SAR); exchangeable sodium percentage (ESP); base saturation (BS) and cation exchange capacity (CEC) were determined.

The result of the analysis showed that the pH (7.1-7.8), OM (2.36-6.93%), OC (1.37-4.98%), Na (0.04-0.15%), ESP (1.04 – 1.28%) and BS (95.37-95.85%) were found to be in the range of the requirements for groundnut production, while the other analyses parameters were outside the required range.

Generally, some of the major nutrients like and potassium needed by the crop have deteriorated while some others like calcium are available in sufficient quantities. This calls for the application of

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fertilizer to the soil to provide the lost nutrients and proper monitoring of the soil before the cultivation of groundnut. An integrated approach that involves the cultivation of nutrient-efficient varieties of groundnut on nutrient-deficient soils is suggested. In the absence of magnesium-efficient varieties, the application of magnesium as fertilizer is recommended.
There were no significant differences (p >.05) in the results between the two soil layers for all chemical properties considered except for organic where OM was significantly higher in the subsoil than in the topsoil.

*Keywords: Groundnut; suitability; soil; physical properties; chemical properties.*

## 1. INTRODUCTION

Soils are natural media or materials for the growth of plants. In other words, it is any earth material that contains all the necessary nutrients required for plants to grow well. A fertile soil contains two solid components namely mineral and organic matter (which is the remains of decayed cells of plants and animals). Plant roots depend on the process of respiration to obtain energy. Respiration is an important function of soil which allows carbon dioxide to escape and fresh oxygen to enter the root zone [1]. The chemical properties of soil indicate the status of the soil in terms of acidity or alkalinity, its soluble salt content, cation holding capacity, cations and anions content, important plant nutrients such as nitrogen, phosphorus, and potassium, organic matter and carbonate. These properties will give a strong indication as to the fertility status of the soil in terms of its ability to provide essential nutrients to plants/crops and the favourability of the soil's chemical environment for plant growth i.e., whether it is too acidic, too alkaline or too saline, all of which would adversely affect plant growth [2].

Groundnut (*Arachis hypogaea* L.), also known as peanut, earthnut and goobers is an annual legume of the *Fabaceae* family [3]. It is one of the world's principal oil seed crops widely grown. On an average, it has been reported that groundnut is grown on 26.4 million hectares worldwide with a total production of 36.1 million metric tonnes, and an average yield of 1.4 metric tons/ha [4]. Groundnut is grown in nearly 100 countries with China, India, Nigeria, U.S.A, Sudan, Senegal, Myanmar, Argentina, Guinea, and Indonesia as major producers [5]. Nigeria is one of the world's largest groundnut producers, accounting for 10%, 39% and 51% of the total world's, Africa's and West Africa's groundnut production, respectively. Total production accounted for 70% of Nigeria's total export prior to petroleum oil boom [6].

Several agricultural soils which could have been used for the cultivation of crops have been abandoned due to the probability of the soil not being fertile enough for good productivity leading to a decrease in food available for the increasing population and thereby encouraging the importation of agricultural produce. Therefore, this study was set out to evaluate the soil status of Idi-Apa in Oke Oyi soil and to ascertain its fertility as well its suitability for groundnut cultivation.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out at the Idi-Apa, Oke-Oyi area of Kwara State, Nigeria (Fig. 1). It is located in Asa Local Government Area (LGA) and it is one of the sixteen LGAs of Kwara State. It is located at latitude 8° 16' N and longitude 4° 23' E. It shares boundaries with Ilorin South LGA to the south, Ilorin West LGA to the west, Moro LGA to the north and Ifelodun LGA to the east. Oke-Oyi is the local government headquarters.

Presently, the land area (about 250 ha) falls in the western upland physiographic region of the state. Idi-Apa, Oke-Oyi land has an average height of about 360 m above sea level and a slope of <10°. The highest air temperature of 35°C is often recorded in March/April and the lowest (25°C) is recorded between July and August. The area belongs to dry sub-humid climatic regions [7]. This climatic condition no doubt dictates the human activities in the study area with various agricultural practices including traditional, irrigation agricultural systems dominating the rural landscape. The climate of the area is characterized by wet and dry seasons each lasting six months. The average rainfall is about 50.8 mm during the driest month (November to April). The people of the area are predominantly farmers cultivating crops such as yam, maize, cassava, guinea corn, and vegetables among others.

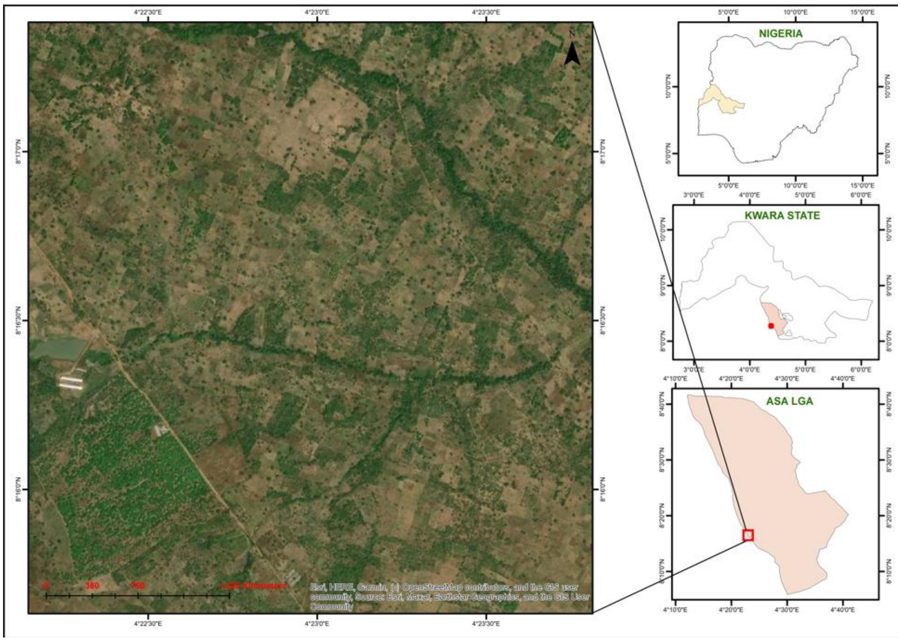


**Fig. 1. Location of the study area in Idi Apa, Oke Oyi**

## 2.2 Sample Collection

Disturbed soil samples were collected at four locations within the irrigation scheme. Soil samples were collected from the 0–30 and 30–60 cm soil layers at each sampling point with the aid of a soil auger. Soil samples were collected in three replicates. Random sampling approach was employed for the collection of the soil samples on the field [8]. This method entails taking samples in a random pattern across the field, generally avoiding unusual or problem soil areas within the field. The collected soil samples were packed in different polythene bags to prevent atmospheric influences. The samples were sent to the laboratory of the Lower Niger River Basin for physical and chemical analysis.

## 2.3 Soil Sample Analysis

Soil samples were analysed according to the USDA textural classes [9]. Physical properties of interest in the soil analyses include texture, while chemical properties of concern include pH, organic carbon (OC) and organic matter (OM), exchangeable cations–calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) and total nitrogen (TN) and were determined using [9] laboratory soil standards. Cation exchange capacity (CEC) was obtained by summation of the exchangeable bases. Exchangeable sodium percentage (ESP) was determined using ammonium acetate ($NH_4OAC$) method. Mechanical analysis of soil was done by the Bouyoucos or hydrometer method [10] by sieve and sedimentation analysis; and corresponding textural classes were determined.

SAR was determined by the following formula:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

where:

Na is Concentration of sodium (meq/l); Ca is Concentration of calcium (meq/l); and Mg is Concentration of magnesium (meq/l).

Base Saturation BS (%) was determined by

$$BS\ (\%) = \frac{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+} + \mathrm{K}^{+} + \mathrm{Na}^{+}}{CEC} \times 100$$

## 2.4 Statistical Analysis

Data were statistically analyzed for variance (ANOVA) using the SPSS (v. 20) statistical package. A threshold of P =.05 was used to define statistical significance.

# 3. RESULTS AND DISCUSSION

## 3.1 Soil Textural Classification

The soil textural class at the topsoil for all sampling points was loamy-sand while the subsoil samples were sandy-loam (Table 1). According to [11], the ideal field for groundnut production should have soil that is well-drained and light-coloured with either sandy, loamy sand, or sandy loam texture. Thus, the soil texture in this location is considered suitable for groundnut production [11].

### 3.2 Soil Chemical Properties

The results of mean values of soil chemical properties were presented in Table 2 and Fig. 2.

**Soil pH**: Soil pH at both soil layers ranged between 7.1–7.8, which indicates that the soil was slightly alkaline [12]. The desirable pH range for optimum plant growth varies among crops. Crops like groundnut grow best in the 5.3–8.0 pH range [13]. Others may grow well under slightly acidic conditions. If the pH is higher than 8.0, certain elements such as iron and zinc become unavailable. Since soil at both layers falls within this range, therefore the soil is good for groundnut cultivation.

**Organic matter and Organic carbon**: Using the Walkley–Black scale, the ideal soil organic matter level from the nutrient cycling and fertility standpoint is generally considered as 5–8%. Thus, considering the state of the soil from both depths, the subsoil organic matter was adequate since it ranges between 4.46 and 6.93%, which falls within the recommended range of the Walkley – Black scale. Hence the values of organic matter in the soil especially the subsoil layers were generally moderate and suitable for groundnut cultivation. Organic carbon also follows the same trend as OM.

**Calcium:** Ca is required by groundnut plants from the time when pegs begin to appear, and fruit formation, until the pods are mature. The level of calcium in the sampled area ranges from 5.7–9.5 cmol/kg and is considered adequate for the production of good-quality groundnut kernels stated by [14].

**Magnesium**: The level of Mg in both soil layers of the sample area is significantly lower than the standard soil magnesium requirements for groundnut cultivation of 1.82 cmol/kg. The level of Mg in the top soil ranged between 0.3 and 0.9 cmol/kg, and between 0.2 and 0.7 cmol/kg in the subsoil. Magnesium of both the top and subsoil is below the limit of standard requirement for groundnut cultivation. This might limit groundnut yield as it reduces the availability of potassium in the soil [15]. More importantly, low soil Mg will limit the synthesis of oil which is important in groundnut oil production for commercial purpose.

**Sodium:** Sodium is found in all plant materials. Although it does not seem to be necessary for the growth and development of plants, it is used advantageously, particularly when potassium is low, sodium seems to be able to partly substitute for potassium. Excess sodium is a problem in many dry areas particularly if the irrigation water system is alkaline. The excess sodium suppresses soil biology, root development and nutrient availability [16]. From the result the topsoil (0.04-0.08 cmol/kg) and subsoil (0.09-0.15 cmol/kg) values respectively are within (0.007-0.3 cmol/kg) as recommended by [17].

**Potassium:** Potassium is important for increasing crop resistance to disease, and for stimulating rooting activity, photosynthesis, starch formation, translocation of sugar, chlorophyll production and more. Potassium is a regulator of metabolic activities. Result indicates that both the top-soil and sub-soil values range between 0.10 and 0.24 cmol/kg, which are far below the recommended value of 0.5 cmol/kg for groundnut cultivation [4].

**Table 1. Soil textural classification**

| Sampling Point | Depth (cm) | Sand (%) | Silt (%) | Clay (%) | Textural Class |
|---|---|---|---|---|---|
| A | 0-30 | 80.80 | 11.0 | 8.20 | Loamy Sand |
| | 30-60 | 68.80 | 21.00 | 10.20 | Sandy Loamy |
| B | 0-30 | 82.50 | 8.00 | 9.50 | Loamy Sand |
| | 30-60 | 63.50 | 23.00 | 13.50 | Sandy Loamy |
| C | 0-30 | 85.50 | 6.10 | 8.40 | Loamy Sand |
| | 30-60 | 60.00 | 25.00 | 15.00 | Sandy Loamy |
| D | 0-30 | 78.80 | 13.00 | 8.20 | Loamy Sand |
| | 30-60 | 67.00 | 23.00 | 10.00 | Sandy Loamy |

**Nitrogen:** The results show that the nitrogen present in the soil is ranged between 0.17 and 0.45% which is below (1–6%) for soils [18]. Nitrogen exists in the air spaces in the soil, but most plants and microbes cannot make use of this gaseous form until it is "fixed" into a more available, soluble form (either ammonium ($NH_4$) or nitrate ($NO_3$)). This process of converting gaseous nitrogen to a mineralized available form is called nitrogen fixation. Being a leguminous crop, groundnuts can fix atmospheric nitrogen (N) with the aid of root bacteria [19]. For this reason, groundnut is not dependent on nitrogen fertilisation.

## 3.3 Other Properties

**Sodium Absorption Ratio:** The result for SAR value for topsoil and subsoil are 0.44 and 0.06%, respectively. The result shows that both of the depths have a very low SAR, although ideally, soil SAR should be < 13% adapted from [4].

**Exchangeable Sodium Percentage:** This gives a measure of the percentage of sodium ions in the total base cations. It is recognized in the literature as one of the indices of soil salinity with a reported threshold of 15 %. [20] also opined that the critical values of ESP above which most crops are affected negatively was established as 15 %. Excess ESP has an adverse effect on the physical and nutritional properties of the soil, with consequent reduction in crop growth, significantly or entirely. The exchangeable sodium percentage (ESP) of the soil ranged from 1.04 to 1.28%. Soils with ESP of less than 15% are said to be non-sodic according to [21], thus making the soil suitable for the cultivation of groundnut.

**Base Saturation:** BS is the fraction of exchangeable cations that are base cations (Ca, Mg, K and Na). It is always expressed as a percentage and called *percent base saturation*. The higher the BS, the more acidity can be neutralized in the short time perspective according to [22]. From Table 3 above, the topsoil has (95.37%) and subsoil (95.85%). Base saturation values greater than 50% indicate fertile soils while values less than 50% indicate low fertility [23]. This implies that the soil is fertile and good for the cultivation of groundnut.

**Cation Exchange Capacity**: Cations are positively-charged elements in the soil, such as potassium, calcium, magnesium and sodium. These cation minerals are held in the soil by interaction with negatively-charged particles of clay and humus. The cations can be mobilized and made available to a plant when one cation is exchanged for another on the exchange site. This process is called Cation Exchange, and the soil's ability to provide "exchange sites" for cation minerals is called Cation Exchange Capacity (CEC). CEC in the topsoil and subsoil are 8.99 and 9.80%, respectively. These values are high and out of the limit range (3.09 - 8.50%) of the standard requirement of agricultural soil for groundnut cultivation.

**Table 2. Mean value of the soil chemical properties**

| Sampling Point | Depth (cm) | pH | OC (%) | OM (%) | N (%) | Ca cmol/kg | Mg cmol/kg | Na cmol/kg | K cmol/kg |
|---|---|---|---|---|---|---|---|---|---|
| A | 0-30 | 7.5 | 2.55 | 4.39 | 0.4 | 7.25 | 0.45 | 0.04 | 0.12 |
| | 30-60 | 7.4 | 4.98 | 5.72 | 0.27 | 7.2 | 0.50 | 0.12 | 0.24 |
| B | 0-30 | 7.8 | 1.53 | 2.63 | 0.28 | 6.6 | 0.50 | 0.05 | 0.13 |
| | 30-60 | 7.2 | 4.02 | 6.93 | 0.44 | 9.5 | 0.30 | 0.13 | 0.20 |
| C | 0-30 | 7.7 | 1.40 | 2.41 | 0.35 | 8.4 | 0.30 | 0.06 | 0.10 |
| | 30-60 | 7.1 | 2.43 | 4.46 | 0.32 | 8.2 | 0.20 | 0.15 | 0.15 |
| D | 0-30 | 7.6 | 1.37 | 2.36 | 0.45 | 5.7 | 0.90 | 0.08 | 0.20 |
| | 30-60 | 7.5 | 3.79 | 5.49 | 0.17 | 7.0 | 0.70 | 0.09 | 0.13 |

**Table 3. Other properties of the soil**

| Parameters (%) | Depth (cm) | |
|---|---|---|
| | **0 – 30** | **30 – 60** |
| SAR | 0.44 | 0.06 |
| ESP | 1.04 | 1.28 |
| BS | 95.37 | 95.85 |
| CEC | 8.99 | 9.8 |

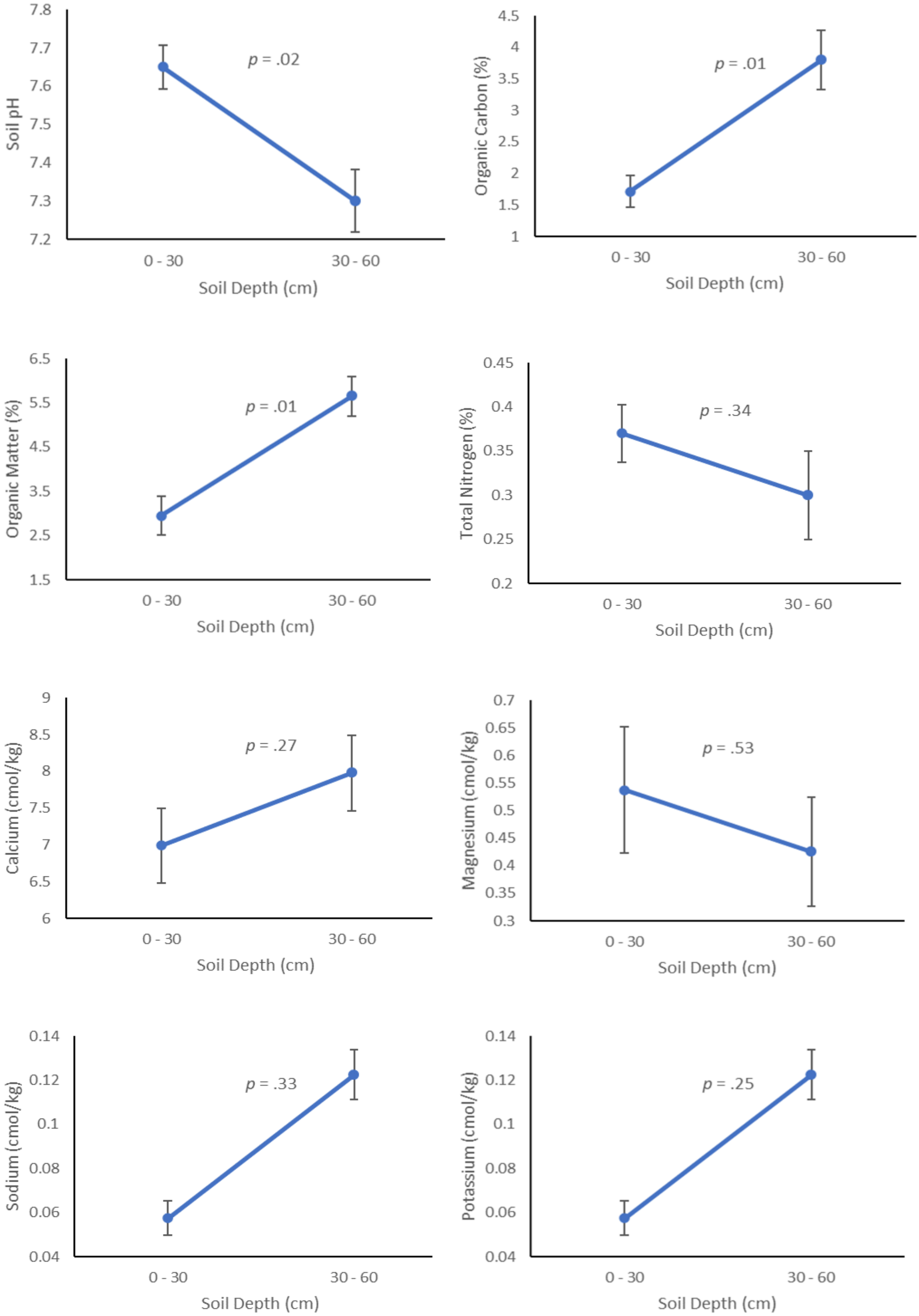


**Fig. 2. Soil chemical analysis of Idi-Apa Oke-Oyi soil**

**Table 4. Analysis of variance of selected chemical properties**

| Chemical Properties | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| pH | Between Groups | .245 | 1 | .245 | 9.800 | .020 |
| | Within Groups | .150 | 6 | .025 | | |
| Organic Carbon | Between Groups | 8.757 | 1 | 8.757 | 12.313 | .013 |
| | Within Groups | 4.267 | 6 | .711 | | |
| Organic Matter | Between Groups | 14.607 | 1 | 14.607 | 14.853 | .008 |
| | Within Groups | 5.901 | 6 | .983 | | |
| Total Nitrogen | Between Groups | .010 | 1 | .010 | 1.097 | .335 |
| | Within Groups | .054 | 6 | .009 | | |
| Ca | Between Groups | 1.950 | 1 | 1.950 | 1.500 | .267 |
| | Within Groups | 7.799 | 6 | 1.300 | | |
| Mg | Between Groups | .025 | 1 | .025 | .441 | .531 |
| | Within Groups | .344 | 6 | .057 | | |
| Sodium | Between Groups | 3.458 | 1 | 3.458 | 1.102 | .334 |
| | Within Groups | 18.828 | 6 | 3.138 | | |
| Potassium | Between Groups | .004 | 1 | .004 | 1.658 | .245 |
| | Within Groups | .013 | 6 | .002 | | |

### 3.4 ANOVA of the Chemical Properties

ANOVA for statistical variance is presented in Table 4. There were no significant differences (p >.05) in the results between the two soil layers for all chemical properties considered except for pH, OC and OM. Soil pH was significantly higher in the topsoil than in the subsoil; whereas OC and OM were significantly higher in the subsoil than in the top soil. Usually, it is expected that the surface layer or topsoil is more enriched with organic matter than subsoil. The disparity, in this case, could be due to erosion of nutrients in the topsoil as a result of rainfall or anthropogenic activities. Also, this could be because the soil is under cultivation.

## 4. CONCLUSION

Analysis was carried out on the soil physical and chemical properties to determine its suitability for groundnut production as compared with the standard values provided by some researchers. The results show that some soil properties such pH, organic carbon, organic matter, and sodium values were within the standard requirements while other properties such as potassium and magnesium, had values outside the standard threshold. On the textural class, results were found to be within the range required for the cultivation of groundnut. An integrated approach that involves the cultivation of nutrient-efficient varieties of groundnut on nutrient-deficient soils is suggested. In the absence of magnesium-efficient varieties, the application of magnesium as fertilizer is recommended. There may be a need to explore groundnut varietal response to low K and Mg in soil.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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