

Original Research Article

Analysis of Physio-Chemical Properties Of Idi-Apa Oke-Oyi Soil for Groundnut Cultivation

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 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 magnesium needed by the crop have deteriorated while some others like calcium are available in high quantities. This calls for the application of fertilizer to the soil to provide the lost nutrients and proper monitoring of the soil before the cultivation of groundnut.

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; Soil Properties; Soil Samples, Soil

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

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Comment [up1]: Should be Physico-chemical and not Physio-chemical.

Comment [up2]: Modify Title to read 'Suitability of Idi Apa Oke-Oyi Soil for Groundnut Cultivation.'

Comment [up3]: Replace with g /k g

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Comment [up5]: replace with C mol / Kg

Comment [up6]: What about Potassium?

Comment [up7]: Is the Calcium in high quantity or adequate quantity? High is above adequate. Sufficient is same as adequate. Be sure and consistent please.

Comment [up8]: what if the farmer cannot afford the fertilizer? An integrated approach that involves the cultivation of nutrient - efficient varieties of groundnut on nutrient-deficient soils. Climate change is de-emphasizing the abuse of inorganic fertilizer. In the absence of Magnesium-efficient varieties, you can then recommend the application of Magnesium as fertilizer.

Comment [up9]: Keywords should be : Groundnut, Suitability, Soil, Physical, Chemical, Properties.

24 capacity, cations and anions content, important plant nutrients such as nitrogen, phosphorus
25 and potassium, organic matter and carbonate. These properties will give a strong indication
26 as to the fertility status of the soil in terms of its ability to provide essential nutrients to
27 plants/crops and the favourability of the soil's chemical environment for plant growth i.e
28 whether it is too acidic, too alkaline or too saline, all of which would adversely affect plant
29 growth [2].

30 Groundnut (*Arachis hypogaea* L.), also known as peanut, earthnut and goobers is an annual
31 legume of the *Fabaceae* family [3]. It is one of the world's principal oil seed crops widely
32 grown in areas ranging from latitude 40° North and South. It is a major crop rotation
33 component in many sub-Saharan countries in the world [4]. Nigeria is one of the major
34 groundnut producers in Africa. With 11% area, the country produces 7% of the world's
35 groundnut production [3]. Kwara state accounts for ----% of Nigeria's groundnut production
36 [Ref.]

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

44 2. MATERIAL AND METHODS

46 2.1 Study Area

49 The study was carried out at, Idi-Apa, Oke-Oyi area of Kwara State, Nigeria. It is located in
50 Ilorin East Local Government Area (LGA) and it is one of the sixteen LGAs of Kwara State. It
51 is located on latitude 8°30 and 9°00 and longitude 4°30 and 5°00 East. It shares boundaries
52 with Ilorin South LGA to the south, Ilorin West LGA to the west, Moro LGA to the north and
53 Ifelodun LGA to the east. Oke-Oyi is the local government headquarters.

54 Presently, the land area (about 250 ha) falls in the western upland physiographic
55 region of the state. Idi-Apa, Oke-Oyi land has an average height of about 360 m above sea
56 level and a slope of less than 10 degrees. The highest air temperature of 35°C is often
57 recorded in March/April and the lowest (25°C) is recorded between July and August. The
58 area belongs to dry sub-humid climatic regions [5]. This climatic condition no doubt dictates
59 the human activities in the study area with various agricultural practices including traditional,
60 irrigation agricultural systems dominating the rural landscape. The climate of the area is
61 characterized by wet and dry seasons each lasting six months. The average rainfall is about
62 50.8 mm during the driest month (November to April). The people of the area are
63 predominantly farmers cultivating crops such as yam, maize, cassava, guinea corn and
64 vegetables among others.

66 2.2 Sample Collection

68 Disturbed soil samples were collected at four locations within the irrigation scheme.
69 Soil samples were collected from the 0–30 and 30–60 cm soil layers at each
70 sampling point with the aid of a soil auger. Random sampling approach was
71 employed for the collection of the soil samples on the field [6] at 4 locations with
72 GPS coordinates as follows:. This method entails taking samples in a random
73 pattern across the field, generally avoiding unusual or problem soil areas within the
74 field. The collected soil samples were packed in different polythene bags to prevent

Comment [up10]: This should be the beginning of another paragraph.

Comment [up11]: How much of Nigeria's groundnut production does Kwara state account for?

Comment [up12]: Can you provide a map showing the 4 soil sampling locations on Idi-Apa, Oke Oyi area ?

Comment [up13]: Do you mean 250°C or 25°C?

Comment [up14]: Supply the GPS coordinates of the locations.

75 atmospheric influences. The samples were sent to the laboratory of the Lower Niger
76 River Basin for physical and chemical analysis.

77 **2.3 Soil Sample Analysis**

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79 Soil samples were analysed according to the USDA textural classes [7]. Physical properties
80 of interest in the soil analyses include texture, while chemical properties of concern include
81 pH, organic carbon (OC) and organic matter (OM), exchangeable cations–calcium (Ca),
82 magnesium (Mg), sodium (Na) and potassium (K) and total nitrogen (TN). Other properties
83 such as sodium adsorption ratio, SAR; exchangeable sodium percentage, ESP; base
84 saturation, BS and cation-exchange capacity, CEC were determined. Mechanical analysis of
85 soil was done by the Bouyoucos or hydrometer method [8] by sieve and sedimentation
86 analysis; and corresponding textural classes were determined.

87 **2.4. Treatments and Experimental Design**

88 **2.4 Statistical Analysis**

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

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93 **3. RESULTS AND DISCUSSION**

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95 **3.1 Soil Textural Classification**

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97 The soil textural class at the topsoil for all sampling points were loamy-sand while the subsoil
98 samples were sandy-loam (Table 1). According to [9], the ideal field for groundnut production
99 should have soil that is well-drained and light-coloured with either sandy, loamy sand, or
100 sandy loam texture. Thus, the soil texture in this location is considered suitable for groundnut
101 production [9]

102
103 **Table 1. Soil Textural Classification**

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Sampling Point	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
A	0-30cm	8.08	1.1	0.82	Loamy Sand
	30-60cm	6.88	2.1	1.02	Sandy Loamy
B	0-30cm	8.25	0.8	0.95	Loamy Sand
	30-60cm	6.35	2.3	1.35	Sandy Loamy
C	0-30cm	8.55	0.61	0.84	Loamy Sand
	30-60cm	6	2.5	1.5	Sandy Loamy
D	0-30cm	7.88	1.31	0.82	Loamy Sand
	30-60cm	2.03	2.3	1	Sandy Loamy

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107 **3.2 Soil Chemical Properties**

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

110

111 **Soil pH:** Soil pH at both soil layers ranged between 7.1–7.8, which indicates that the soil
112 was slightly alkaline [10]. The desirable pH range for optimum plant growth varies among
113 crops. Crops like groundnut grow best in the 5.3–8.0 pH range [11]. Others may grow well
114 under slightly acidic conditions. If the pH is higher than 8.0, certain elements such as iron

Comment [up15]: Bouyoucos and not Bouyoucous

Comment [up16]: 2.4 should be Treatments and Experimental Design. Treatments are soils sampled at 2 depths from 4 locations cultivating Groundnut.

Comment [up17]: Was there any replication of Treatments?

Comment [up18]: Change (%) to (g/Kg)

Comment [up19]: multiply values by 100

Comment [up20]: multiply values by 100

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Comment [up26]: multiply values by 100. Also crosscheck the values. Two or more of the values are not correct.

115 and zinc become unavailable. Since soil at both layers falls within this range, therefore the
116 soil is good for groundnut cultivation.

117
118 **Organic matter (OM) and Organic carbon (OC):** Using the Walkley–Black scale, the ideal
119 soil organic matter level from the nutrient cycling and fertility standpoint is generally
120 considered as 5–8% [Ref]. Thus, considering the state of the soil from both depths, the
121 subsoil organic matter was adequate since it ranges between 4.46 – 6.93% which falls
122 within the recommended range of Walkley – Black scale. Hence the values of organic matter
123 in the soil especially the subsoil layers were generally moderate and suitable for groundnut
124 cultivation [Ref]. Organic carbon also follows the same trend as OM.

Comment [up27]: Provide reference

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126 **Calcium (Ca²⁺):** Calcium (Ca) is required by groundnut plants from the time when pegs
127 begin to appear, and fruit formation, until the pods are mature. The level of calcium in the
128 sampled area ranges from 5.7–9.5 cmol/kg and is considered adequate for the production of
129 good-quality groundnut kernels as stated by [12].

130
131 **Magnesium (Mg²⁺):** The level of Magnesium in both soil layers of the sample area is
132 significantly lower than the standard soil magnesium requirements for groundnut cultivation
133 of 1.82 cmol/kg. The level of magnesium in the top soil ranged between 0.3 and 0.9 cmol/kg,
134 and between 0.3 and 0.7 cmol/kg in the subsoil. Magnesium of both the top and subsoil is
135 below the limit of standard requirement for groundnut cultivation. [This might limit groundnut
136 yield as it reduces the availability of potassium in the soil [13].

Comment [up29]: More importantly, low soil magnesium will limit the synthesis of oil which is important in groundnut oil production for commercial purpose. Apart from that, Mg is the only metallic constituent of the chlorophyll molecule.

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138 **Sodium (Na⁺):** Sodium is found in all plant material. Although it does not seem to be
139 necessary to the growth and development of plants, it is used advantageously, particularly
140 when potassium is low, sodium seems to be able to partly substitute for potassium. Excess
141 sodium is a problem in many dry areas particularly if the irrigation water system is alkaline.
142 The excess sodium suppresses soil biology, root development and nutrient availability [14].
143 From the result the topsoil (0.04 -0.08 c-mol/kg) and subsoil (0.12- 0.15 c-mol/kg) values
144 respectively are within (0.007 - 0.3 c-mol/kg) as recommended by [15]

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146 **Potassium (K⁺):** Potassium is important for increasing crop resistance to disease, and for
147 stimulating rooting activity, photosynthesis, starch formation, translocation of sugar,
148 chlorophyll production and more. Potassium is a regulator of metabolic activities. Result
149 indicates that both the top-soil and sub-soil values ranges between 0.1- 0.24 cmol/kg, which
150 are far below the recommended value of .0.5 cmol/kg for groundnut cultivation [16].

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152 **Nitrogen:** The results show that the nitrogen present in the soil is ranged between 0.17 and
153 0.45% which is below (1–6%) for soils [17]. Nitrogen exists in the air spaces in the soil, but
154 most plants and microbes cannot make use of this gaseous form until it is "fixed" into a more
155 available, soluble form (either ammonium, NH₄ or nitrate, NO₃). This process of converting
156 gaseous nitrogen to a mineralized available form is called nitrogen fixation. Being a
157 leguminous crop, groundnuts can fix atmospheric nitrogen (N) with the aid of root bacteria
158 [Ref]. For this reason, groundnut is not dependent on nitrogen fertilisation in the presence of
159 effective root bacteria. Groundnuts with effective root bacteria do not need additional
160 nitrogen.

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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	0-30cm	7.5	2.5	4.3					
	30-60cm	7.4	4.9	5.7	0.4	7.25	0.45	0.04	0.12
	60cm	7.8	1.5	2.6	0.27	7.2	0.5	0.12	0.24
B	0-30cm	7.8	3	3	0.28	6.6	0.5	0.05	0.13
	30-60cm	7.2	4.0	6.9					
	60cm	7.2	2	3	0.44	9.5	0.3	0.13	0.2
C	0-30cm	7.7	1.4	1	0.35	8.4	0.3	0.06	0.1
	30-60cm	7.7	2.4	4.4					
	60cm	7.1	3	6	0.32	8.2	0.2	0.15	0.15
D	0-30cm	7.7	1.3	2.3					
	30-60cm	7.6	7	6	0.45	5.7	0.9	0.08	0.2
	60cm	7.5	3.7	5.4					
			9	9	0.17	7	0.7	0.09	0.13

Comment [up33]: Change (%) to (g/Kg). This time, do not multiply values by 100

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3.3 Other Properties

Sodium Absorption Ratio (SAR): The result for SAR value for topsoil (0.44) and subsoil (0.06) respectively. The result shows that both of the depths have a very low SAR, although ideally, soil SAR should be < 13% as adapted from [16].

Comment [up34]: should read 'for top soil and subsoil are 0.44 and 0.06% respectively'.

Exchangeable Sodium Percentage (ESP): 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 %. [18] 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 [19], thus making the soil suitable for the cultivation of groundnut

Base Saturation (BS): 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 [20]. 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 [21]. This implies that the soil is fertile and good for the cultivation of groundnut.

Cation Exchange Capacity (CEC): 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

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197 exchange site. This process is called Cation Exchange, and the soil's ability to provide
198 "exchange sites" for cation minerals is called Cation Exchange Capacity (CEC).

199 Cation Exchange Capacity (CEC) is the number of exchangeable cations per dry weight that
200 a soil is capable of holding, at a given pH value, and available for exchange with the soil
201 water solution [22]. The topsoil (0 – 30cm: 8.99%) and the subsoil (30 – 60cm: 9.80%). But
202 the two depths (0 – 30cm and 30 – 60cm respectively) are high in CEC and out of the limit
203 range (3.09 - 8.50) of the standard requirement of agricultural soil for groundnut cultivation
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Comment [up35]: This sentence is standing alone.. Let it be in bracket and let it come after the inserted ' in CEC '

Comment [up36]: What is/are the implication(s) of out of the limit range? Are we expecting too much cations to be at the exchange site at the detriment of groundnut growth and yield? What other soil property could be contributing to this out of the limit range? Is it possible that too much cations at the exchange site could lead to their accumulation at toxic levels? Please improve discussion here.

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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

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209 3.4 ANOVA of the Chemical Properties

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

Comment [up37]: Reason is weak. Note that for fallow soils, OC and OM are higher at Top soil than Subsoil. for cultivated soil, the reverse is the case. Therefore the major reason why the subsoil was higher in OC and OM is because the soil is under cultivation

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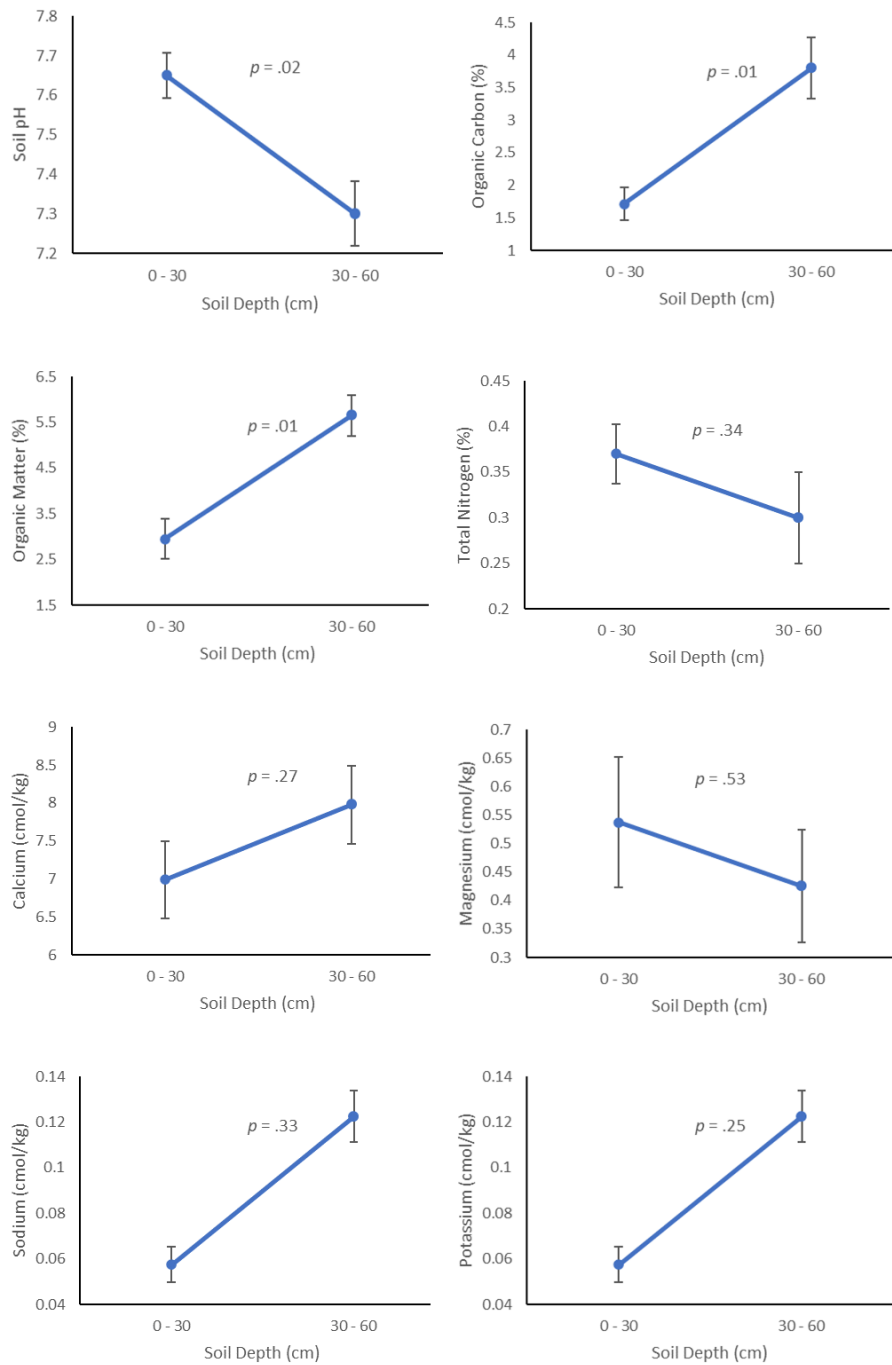


Fig. 1. Soil Chemical Analysis of Idi-Apa Oke-Oyi Soil

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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		

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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 required while other properties such as potassium and calcium had values outside the standard threshold. On the textural class, results were found to be within the range required for the cultivation of groundnut. Both fertilization and soil amendments would be required to bring the soil to the required level for the profitable cultivation of groundnut.

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255 Varieties of Groundnut (*Arachis Hypogaea*, L.) on the Jos, Plateau," *Int. J. Innov. Sci.*

Comment [up38]: what about magnesium? Did you not report that Calcium was adequate in line 128 ? Be consistent please.

Comment [up39]: Be specific about the soil amendments that would be required to make the soil profitable for groundnut cultivation. There may be the need to explore varietal response to low K and Ca in soil.

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Comment [up40]: With the exception of References [3], [12] and [14], all References are not within the last 5 years. Therefore update references especially those before year 2000.

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