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In-Depth Analysis on the Germinability, Soil Mineral Composition and Seed Oil Content of Barbados Nut (*Jatropha Curcas* L.)

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Abstract: ***A study was carried out to determine the seed viability and influence of growth in Barbados nut, (Jatropha curcas) on soil nutrient. In the germinability, quality seeds were obtained considering the vigor of seeds as analyzed under different textural classes of soil samples. The highest sample found within 0-2, 15 and 30cm was sandy with a Mean percentage (%) 50.67 (SE ±0.30), organic matter, moisture content; pH, density and cat ion exchange capacity (CEC) were all analyzed. The mean composition of mineral nutrients in a triplicate soil samples collected was recorded highest in Mg (0.076%), N (0.050%) and Ca (0.034%) respectively. Each fruit pod contains 2-4 seeds black spindle shaped and measured about 1-2cm. 1000 seeds yielded 577.4g and a total of 300 seeds (85.7%) sank when immersed in water and were considered viable, while 50 seeds (14.3%) were considered non viable. each with a mean weight of 0.5774g. The investigations on the volume of oil extracted revealed that 2.50kg liters of oil could be generated from 2.31kg of seeds and lipid has the highest (41.6 to 46.3%) mean percentage in the proximate analysis of the seed cake extracted. Meanwhile, seeds were highly viable with 98.33% mean germination with fertilizing effect when grown on soil. It is recommended that a means of enlightening the local farmers and plant scientists should be identified and effectively used to encourage for commercial production of seed oils and planting the tree as life fence around farms in order to reduce the effect of grazing animals and land dispute with cattle rearers.***

Keywords: Barbados nut, germinability, seed pod, mineral nutrient, proximate, oil content

1. Introduction

Barbados nut (*Jatropha curcas* L.) commonly known as physic or purging nut, is a species of flowering plant in the spurge family, Euphorbiaceae, that is native to the American tropics, most likely Mexico and Central America It is a poisonous, semi-evergreen shrub or small tree, with a smooth grey bark, reaching a height of 6 meters. It exudes whitish colored watery latex when cut and is resistant to a high degree of aridity, allowing it to be grown in deserts [1].

The plant has yellow-green flowers and large heart-shaped (pale) green leaves, arranged alternately [2]. The leaves of this plant are used against stomachache; when diagnosed in children: boiled leaves for conditions of the gums and throat; tea of the leaves for stoppage of urine, constipation, backache and inflammation of ovaries [3].The seeds of Barbados nut contain 27- 40% oil (average: 34.4%) that can be processed to produce a high-quality biodiesel fuel, usable in a standard diesel engine.

The proportion of agro-forestry faces a very low state of adoption in Nigeria. One way of increasing the adoption rate is to promote utilization of other products from the tree such as roots, stems, leaves, fruits, seeds and flowers. Alternative way of utilizing seed is to extract oil from from it. The oil content and proportion of various fatty acids in oil seeds vary with growing conditions. High temperature in seed development reduced oil content and proportion of linolic acid [4].

The oil plant, Barbados nut (*J. curcas*) however, is a hardy species reaching maturity after two years and yield small, black pods. Each pod contains two, three or four seeds respectively [5]. The seeds are small and black spindle in shape covered with light white husks. The seed pod (a three, bi-valved cocci) contains 2 or 3 large black, oily seeds. These seeds, about 2½ cm long, become mature when the fruit changes from green to yellow. The black, thin shelled seeds are considered toxic; they contain the toxalbumin curcin [6]; and this makes them fatally toxic; there are however non toxic varieties. Barbados or physic nut has insecticidal and fungicidal properties; it has latex that contains an alkaloid (jatrophine) which shows anti-cancerous properties. The constituents are: alkaloids, tannins, sapogenins, ethereal oils, toxalbumins and cyanogenic compounds [7].

Seed extraction is made simple with the use of the Universal Nut Sheller, an appropriate technology designed by the Full Belly Project. Oil content varies from 28% to 30% and 80% extraction, one hectare of plantation will give 400 to 600 liters of oil if the soil is average [8].

The oily seeds are processed into oil which may be used directly ("Straight Vegetable Oil") to fuel combustion

engines or may be subjected to trans-esterification to produce biodiesel [2]. *Jatropha* oil is not suitable for human consumption, as it induces strong vomiting and diarrhea.

The current distribution shows that introduction has been successful in the drier regions of the tropics with annual rainfall of 300 to1000mm, occurring mainly at lower altitudes 90 to 500m in areas with average annuals temperatures well above 20^{o}C but can grow at higher altitude on well drained soils with good aeration, adapted to marginal soils with low nutrient content [9].

Being drought tolerant, *Jatropha* can be used to reclaim eroded areas, be grown as a boundary fence or hedge in the semi arid and arid areas. The wood and fruits of *J. curcas* are of great importance. The seeds contain 50% by weight of viscous oil, used in cosmetic industry for manufacture of candles, cooking and lightening or as a diesel/paraffin substitute or extender. Besides the industrial uses such as fine lubricant and perfumery, the fatty acids profiles of the oil with its very high content of oleic acid may make it oil with potential for further industrial use [10]. One of the effective ways to reduce poverty in rural areas and local inhabitants is to promote utilization of other products from trees, through extracting oil from their seeds. This necessitates the choice of plant species that can survive long period of drought and not grazed upon by animals and disease resistant. The trees must be adapted to marginal, gravelly, sandy, saline and stony soils with low nutrients content. A closed observation and study of the tree species growing in the study area revealed Jatropha curcas as the species with the potentials.
The purpose of this study was to evaluate the germinability and to analyze on the mineral composition and volume of extractable oil from the seeds of *Jatropha curcas*.

2. Materials and Methods

2.1 Study Area

Gusau lies on latitude 12˚.17`N, longitude 6$^{o}$.7`E and altitude 463m above sea level in Zamfara State, Nigeria. The climate is characterized by two dominant seasons, rainy (April-October) and dry season (November-March). The principal soil types in the area includes the brown calcimorphic soils frequently developed under 300mm to 500mm rainfall or more where site drainage is imperfect [11]. The monthly precipitation over the past 50 years in Gusau shows that about 95% was concentrated in five months from May to September. The annual precipitation in the study area is about 1000mm.The annual average number of rainy days is about 50 in a year. The average daily temperature in the area increase during the first part of the year, reaching a peak in April and May when the maximum is about 40˚C and mean minimum is about 26˚C.

2.2 Collection and Analysis of Seeds Sample

Seeds of *Jatropha curcas* (in pods) were collected from thirty (30) trees of the species by hand seeds plucking. The pods were sun dried and separated from the husks with the help of wooden mortar and pestle.

2.2.1 Seed Weight

The seeds collected were weighed in the Chemistry Laboratory of the Federal College of Education (Technical) Gusau using Mettle Balance Model P163. One thousand (1, 000) healthy seeds were weighed in accordance with Kozlowski (1972) method, and the means weight per seed was determined thus;

$$\text{Weight/seed} = \frac{\text{Weight of 1 000 seeds}}{1000}$$

2.2.2 Simple Viability Test

Simple viability test was carried out by immersing 350 seeds in a beaker containing water and allowed to stand for about 30 minutes, in order to find out whether the seed is viable or not.

2.2.3 Seed Germination

Three hundred viable seeds of *Jatropha curcas* were planted early August, 2007 in the Biology Garden of Federal College of Education (Technical) Gusau. The seeds were planted in sandy loam at about 35˚C. This process of seed germination was followed in line with the [12] method.

2.3 Collection and Analysis of Soil

Three soil samples from different depths (0.2cm, 15cm and 30cm) were collected in the study area using hand trowel and analyzed in the laboratory to determine the following parameters:

2.3.1 Soil Particles Size Analysis

Soils collected were analyzed to determine texture and particle size composition as adopted by [13]. The samples were put together as samples A, B and C. The well dried soil sample was passed through a sieve mesh number 10 to remove stones and inorganic debris. Thirty grams (30g) of the sieved soil samples above was passed through a sieve mesh number 60 to sieve out particles sizes of 2.00mm and below, which is referred to as the fine earth consisting a coarse sand, fine sand, silt and clay. The fine earth was passed through sieve mesh number 80 to separate particle sizes above and below 0.2mm, the former is the coarse sand the latter was passed through a, sieved mesh number 100 to separate particle size above and below 0.02mm, the former here is the fine sand the latter consist of silt and clay particles.

To separate silt from clay, distilled water was added to the sieved soil in a porcelain crucible and stirred at intervals for one hour using a stirring glass rod. This procedure was repeated seven times until the supernatant liquid was clear for the sample. The remaining moist soil was allowed to evaporate. The dry condensed material representing silt was weighed weight of clay content was obtained by subtracting wt 5 from wt 4.

Thus, Wt_1 = Weight of soil particle 2.0mm and below (Fine Earth).
Wt_2 Weight of soil particle 2mm to 0.02mm (Coarse Sand).
Wt_3 = Weight of soil particle 0.2mm to 0.02mm (Fine Earth).
Wt_4 = Weight of soil particle 0.02mm and below (combination of silt and clay)
Wt_5 = Weight of soil particle 0.002mm to 0.02mm (silt).

Wt_4 = Wt.5 = Weight of soil particle less than 0002mm (Clay)

Percentage sand, silt and clay proportions determined the general texture class for the soil samples in accordance with international scale, using the formula as follows:

$$\%Sand = \frac{\text{Fine Earth Proportion (g)} - \text{Silt and Clay Proportion (g)}}{\text{Sample weight (g)}} \times 100$$

$$\%\ Silt = \frac{\text{Silt Proportion (g)}}{\text{Sample weight (g)}} \times 100$$

$$\%Clay = \frac{\text{Clay Proportion (g)}}{\text{Sample weight (g)}} \times 100$$

2.3.2 Soil Organic Content

Weight in gram of a porcelain crucible was determined and recorded as wt 1

70g of the dry soil sample was placed in the crucible, weighed together and recorded as wt 2. The sample was allowed to cool to room temperature and then reweighed and recorded as wt 3. After determining wt 1 to wt 3 for each soil sample, the percentage organic matter content was calculated using a formula as described by [13], as follows:

$$\text{Percentage Organic Matter} = \frac{\text{wt 2 - wt 3}}{\text{wt 2 – wt 1}} \times 100$$

2.3.3 Soil Moisture

Oven drying method [14] was used to determine simultaneously the moisture content of the three soil samples collected from the experimental farm and immediately put to test as follows: A porcelain crucible was weighed and recorded as Wc. 50g of soil sample was placed in the pre weighed crucible and reweighed together and recorded as Ww.

The crucible and sample were placed in hot air oven and dried at 105^{o}C for 24 hours. The crucible with the content was allowed to cool in a desicator containing silica gel for another 24 hours.

After cooling the crucible with the content was weight to obtain Wd. The percentage moisture content (M) was then calculated for all the samples by the formula:

$$\%M = \frac{\text{Ww - Wd}}{\text{Wd-Wc}} \times 100$$

2.3.4 Soil pH Determination

The pH value of the soil samples determined in 0.01m $CaCl_2$ is independent of the initial salt concentration and the soil to water ratio [14]. The pH meter was standardized with buffer solutions of pH 10 and pH 4 and was adjusted to room temperature. Three readings were taken and the mean pH value determined accordingly for the sample by the following formula:-

$$\text{Mean pH value} = \frac{\text{Sum of readings for the sample}}{\text{Number of reading taken}}$$

2.3.5 Determination of Soil Density

The soil samples were weighed in a core sampler and then dried at 105^{o}C to a constant weight. The said soil was then weighed again. The percentage density was calculated using the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

2.3.6 Determination of Cation Exchange Capacity (CEC)

The percentage CEO of the soil sample was obtained by NH_4OAC saturation method. 25g of air-dried soil were weighed in a 500ml Erlenmeyer flask. 200ml of IN NH_4OAC solution were added and shaken well for 30 minutes or more. The saturated soil was filtered in a Buchner funnel. It was then washed with another 200ml volume of NH_4OAC using 50ml for each washing. The soil residue was washed in Buchner funnel with two 50ml portion of methyl alcohol. The washed soil plus filter paper were transferred in to another Erlenmeyer flask. 200m1 4% Kel were added and shaken for 30 minutes. It was filtered in Buchner funnel, and washed two times with 50ml portions of the Kel solution.

The filtrate was then transferred into 800ml Kjedahl flask and set on the distillation rack. Fifty milliliter (50ml) of NaOH was added from the side arm and the distillate was received in 50ml boric acid solution plus a few drops of the mixed indicator in a 250ml Erlenmeyer flask kept under the delivery tube. The distillation was continued until 2/3rd of the content was distilled.

The distillate was titrated with standard H_2SO_4 solution. A blank was run containing 400ml Hel solution. The CEO is calculated as follows:

$$CEC = \frac{\text{ml of } H_2SO_4 \text{ x normality of } H_2SO_4}{\text{Oven - dry weight of soil}} \times 100 \text{ me/100g of soil}$$

Or

$$\frac{\text{TVX NX 100}}{\text{Volume of soil}}$$

2.3.7 Determination of Nitrogen in Soil Sample

Nitrogen in the soil sample was determined using macro Kjeldahl digestion apparatus and macro-Kjeldahl flask 500mm and 750ml.

Two grams of soil samples containing about 10mg of N (air-dried, ground to pass 0.5mm sieve) were weighed in a dry 25ml macro Kjeldahl flask. 20ml of distilled water was added. The flask was swirled for a few minutes then allowed to stand for 30 minutes.

One tablet of mercury catalyst and 10g of K_2SO_4 was added. 20ml of conc H_2S0_4 was added through an automatic pipette. The flask was heated cautiously at low heat on the digestion stand. When the water has been removed and frothing has ceased; the heat was increased until the digest was cleared. The mixture was boiled for 5 hours. The heating was regulated during the boiling so that the $H2SO_4$ condenses about half way up the neck of the flask. The flask was allowed to cool and slowly about 100mI of water was added to the flask. The digest was carefully transferred into another clean Macro Kjeldahl flask (750ml). All the sand particles were retained in the original digestion flask because sand can cause severe bumping during Kjeldahl distillation. The sand residue was washed with 50m1 of distilled water four times and the aliquot was transferred in to the same flask. 50m1 H_3BO_3 indicator solution was added into a 50ml Erlenmeyer flask which was then placed under the,

condenser of the distillation apparatus. The end of the condenser was about 4cm above the surface of the H_3BO_3 solution

The 750ml Kjeldahl flask were attached to the distillation apparatus. About 150ml of 10N NaOH was poured through the distillation flask with funnel stop cock opened and distillation was commenced. The condenser was kept cool (below 30°C) allowing sufficient cold water to flow through and heat was regulated to minimize frothing and prevent suck- back.

The 150ml distillate was collected and the distillation was stopped. The NH_4-N in the distillate was determined by titrating with 0.01N standard HCl using a 25ml burette graduated at 0.1ml intervals. The color changed at the end point i.e. from green to pink. The percentage Nitrogen content in the soil sample was calculated thus:

$$\% \text{ Nitrogen} = \frac{TV \times N \times 0.014 \times Vol.}{\text{Weight of sample} \times \text{aliquot of digest}} \times 100$$

2.3.8 Determination of Potassium (K) and Sodium in Soil Sample

Potassium and Sodium were determined by Flame photometer. The flame photometer was set for K by inserting appropriate filter (usually of 768m = wavelength). The instrument was set to 100% transmittance by feeding 25ppm K solution, AU the standard solutions were ran and standard curves prepared by plotting transmittance reading against concentration of standard potassium (K) solution. The soil extract was run and the amount of potassium present in the soil per 100g oven-dry weight of the soil was calculated by getting potassium concentration in the extract from standard curve.

The flame photometer for sodium (Na) was set by inserting appropriate filter (usually of 589 me wavelength). The instrument was set to 100% transmittance by feeding 25pprn sodium (Na) solution. The said steps were repeated 3-5 times as for potassium (K) determination

2.3.9 Determination of Calcium and Magnesium

Calcium and Magnesium were obtained by ethylene diaminetetraacetic acid (EDTA) titration method. The Ca and Mg were determined in the filtrate from the C.E.O experiment after making up to a definite volume. Aliquots of this extract were used to determine Ca + Mg, and Ca alone, the value for Mg being obtained as the difference (A Calibration of the EDTA solution)

In calcium- Two 5ml of aliquots of Ca standard solution were pipetted into two titration flasks and the volume brought to approximately 150ml with distilled water. 10 drop each of KCN, NH_4ON, HCl and triethanolamine were added. Then 1ml of 10% NaOH was added to an amount sufficient to raise the pH to 12 or slightly higher. The pH was checked with a pH meter. 0.3g of murexide was added and titrated with EDTA solution until when the pink changed to purple and reached the point at which there is no further color change, A blank titration was ran for all except Ca standard. The corresponding amount of Calcium per mililiter of EDTA was calculated as:

$$\text{Mg/Ca/m/EDTA} = \frac{0.2 \times 5\text{ml Ca Standard Solution}}{\text{Net ml EDTA ml for standard - ml for blank}}$$

Net ml EDTA = ml for stand - ml for blank

In magnesium- Two 5ml aliquots of Mg Standard solution was pipetted into two titration flasks, and the total volume was made to about 100mI by adding distilled water. 20ml of buffer solution was added to get a pH of 10 and the solution was checked with a pH meter to prevent doubt, 10 drops each of KCN, NH_2OH, HCl, $K_4Fe(CN)_6$ and triethanolamine were added. 10 drops of eriochrome black T (EBT) indicator were added and the solution was titrated with EDTA from a red to permanent blue color and Mg end point was slow.

The corresponding amount of magnesium was calculated per milliliter of EDTA as follows:

$$\text{Mg mg/ml EDT} = \frac{0.1216 \text{ ml mg standard solution}}{\text{Net ml EDTA to the end point}}$$

Net ml EDTA = ml standard - ml blank

2.3.10 Determination of Calcium plus Magnesium

Two milliliter aliquot of the extract was pipeted in to 2 titration flasks and diluted to 150ml with distilled water. 15m1 of buffer solution and 10 drops each of KCN, NH_2OH, HCl, $K_4Fe(ON)_6$ and triethanolamine were added. A few minute was allowed for reaction to take place. 10 drops of EBT indicator were added and the solution was titrated with EDTA to the permanent blue color, A blank titration was ran with 5ml of the 1 N NH_4OAC solution and the net ml EDTA was calculated for the soil sample extract by subtracting this titre from that of the extract. Net EDTA was titrated for both Ca plus mg in the extract.

$$\text{Thus, \% Ca} = \frac{TV \times NA}{\text{Vol. of Sample}} \times 100$$

$$\text{Ca + Mg} = \frac{TV \times NA}{\text{Vol. of Sample}} \times 100$$

Therefore, Ca + Mg - % Ca = % Mg

2.3.11 Determination of Calcium alone

2ml aliquot of the extract was pipetted in to two titration flasks and distilled water was added to get a volume of about 150ml. 10 drops each of KCH, NH_2OH, HCl and triethanolamine were added and enough 10% NaOH (usually about 4ml) was added to raise the pH to 12 or slightly higher. The pH was checked with a pH meter. 0.3g of murexide was added and titrated with EDTA to purple end point. The pH was raised to 12 to precipitate magnesium as $Mg(OH)_2$. A blank was ran with 5m1 of NH_4OAC solution the net ml of EDTA was calculated by subtracting the liter from that needed for the extract.

2.4 Oil Extraction and Filtration

The oil was extracted from the seeds using local method. About 2, 309g weighed of *J. curcas* seeds were used in the processes (2 local measures). The seeds were fried locally using metal frying pan on fire fueled by wood. While still on fire the content was constantly stirred to ensure uniform heating. After heating the seeds were milled using grinding machine. The milled turned to thick dough in about 45 minutes. The dough was then put in to a mortar and compressed gradually with a help of a wooden stick adding

little quantity of hot water at intervals to help separate the oil from the dough. After about 25 minutes, the oil together with the cakes was then poured into big bowl and hand-pressed to separate oil from the cake. The crude oil obtained after pressing was sieved using kitchen sieve. After extraction, the oil then collected in a glass bottle and the cake was sun-dried. A closed system neutralizes the acid and releases ammonia which is distilled into boric acid solution and titrated against 0.01N hel end point.

Three steps were involved in this analysis which encompasses digestion, distillation and titration.

2.4.1 Digestion

Two grams of the sample were collected and placed on a filter paper placed at the bottom of a Kjeldahl flask. 200ml of conc. H_2SO_4 was added to the flask, which was then swirled to soak the sample.

One table of Kjeldahl catalyst was added to it. The flask was heated gently on an electric heater in a fumes chamber until the solution became blackened and then clear so as to convert any nitrogen present to ammonium sulphate and organic matter to carbon (iv) oxide.

2.4.2 Distillation

A round bottom flask was heated in the micro Kjeldahl apparatus for 10 minutes. Five milliliter of boric acid containing indicator was placed in a 100ml conical flask and placed under a the condenser such that the condenser tip was just under the liquid. Five of diluted digest was poured into the distillation apparatus and rinsed down with distilled water followed by 5ml of 60% NaOH solution. The NaOH solution was let in carefully through the funnel and little was left behind to prevent the escape of ammonia. Steam was then let through for about 3 minutes, (until the amount of liquid in the receiving conical flask was twice what it was at the beginning of the distillation). This was then titrated with 0.O1N HCI to endpoint and the titre value was recorded. The crude protein content was calculated from the titre value using the following relation:

$$\% \text{ Nitrogen} = \frac{TV \times NA \times 0.014 \times VOL}{\text{Weight of sample} \times M/S \text{ of Aliquot}} \times 100$$

% Nitrogen x CF = % crude protein

2.4.3 Crude Lipid Determination

The analysis was done using [15] method. After sample of the cake (in the filter paper) was placed into the barrel of the extractor, the heated solvent, petroleum ether dissolves the fats in the sample and later collected in a round bottom flask of the extractor.

Fifty grams (50g) of the dried sample was placed into a thimble with the opening plugged with cotton wool. As an alternative, the sample was wrapped in a filter paper. The thimble was then introduced into a barrel of the extractor. A known weight of quick fit round the bottom flask was filled with petroleum ether up to ¾ of its volume. The flask was then heated at 50°C for 6 hours of the total extraction, after which the petroleum ether containing the extracted fat was evaporated. The residue (Crude lipid) left in the flask was then weighed to know the content of the crude lipid.

$$\% \text{ lipid} = \frac{\text{Weight gain by the flask}}{\text{Weight of sample}} \times 100$$

$$\% \text{ lipid} = \frac{W1-W2}{W3} \times 100$$

Where W1 = weight of flask + oil
W2 = weight of flask only
W3 = weight of sample

2.4.4 Ash Content Determination

The ash content was determined using [15] method. The crucible was first washed, dried in an oven at about 180°C for 30 minutes and cooled and then weighed (W_{0g}). Two grams of sample was placed in the crucible and weighed (W_{1g}). The crucible was transferred into the muffle furnace, whose temperature was set at 600°C and allowed to stay for 5 hours, until the content became white. After which the crucible was cooled in a dessicator, and weighed (W_{2g}). The percentage ash content was then calculated using the relation below

$$\% \text{ Ash content} = \frac{\text{weight of ash (g)}}{\text{weight of sample (g)}} \times 100$$

$$\frac{W_2 - W_2}{W_1 - W_0} \times 100$$

2.4.5 Moisture Content Determination

This is achieved by placing the sample in an oven at about 105°C for 24 hrs. It was cooled in a dessicator for 15 minutes and weighted (W2g). The crucible was then returned into the oven and weighed after 3hrs for as many times as possible until a constant value was obtained, out of which, the percentage moisture was calculated, thus:

$$\% \text{ Moisture content} = \frac{\text{Loss in weight by drying (g)}}{\text{Sample weight (g)}} \times 100$$

$$= \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

2.5.6 Crude Fiber Determination

100mI digestion mixture was added to 2g of sample in 250ml conical flask, followed by occasional shaking for 45mins. The mixture was filtered through a filter paper of known weight. 100mI of boiling water, 50ml of ethanol and 50ml of petroleum ether were used to wash it down.

The residue was dried at 100°C to constant weight in the oven followed by aching at 600°C so as to burn of the crude fiber content. The ash obtained was weighed and the crude fiber content was determined from the decrease in weight. Therefore, Weight of dried residue - Weight of ash will be

$$\% \text{ Crude fiber} = \frac{\text{Weight of crude fiber in digested cake}}{\text{weight of sample used}} \times 100$$

or

$$\frac{X-X}{\text{Weight of sample}} \times 100$$

2.5.7 Carbohydrate Determination

When all other analysis has been carried out, percentage (%) carbohydrate is then calculated by subtracting the sum of lipid, crude protein, fiber and ash from 100. whatever remains is the percentage carbohydrate.

Thus: % lipid + % crude protein + % fiber+ ash - 100 % carbohydrate

3. Results

3.1 Seed Collection

The results from seed collection indicated that each fruit pod of Barbados nut, (*Jatropha curcas*) contains 2-4 seeds. The seeds were black, spindle shaped and measured about 1-2cm in length.

3.1.2 Seed Weight

One Thousand seeds from the samples collected were weighed and yielded a total weight of 577.4g which is equivalent to two mudu (Local measure). The mean weight per seed was calculated to be 0.5774g.

3.1.3 Seed Viability

The results obtained from seed viability test shows that out of 350 seeds immersed in water for 30mins, 300 (85.7%) sank in the bottom which were considered viable, while 50 seeds floated on the surface of the water and were considered to be nonviable and discarded.

3.1.3 Seed Germination

The germination results showed that 295 (98.33%) out of the 300 seeds sown germinated within 5 days but, 5 seeds failed to germinate completely even after leaving them for up to about 2 weeks.

3.1.4 Soil Analysis

The analysis of the soil showed that the mean percentage of sand ranged from 4791 50 67%. The highest percentage was seen in soil sample 0 to 2cm depth (50.67%), followed by the soil of 15cm depth (49.06%) and lowest in the soil of 30cm depth (47.91%) as shown in Table 1.

However, the mean percentage of silt in the three soil samples were highest in soil of 30cm depth (42.35), followed by the soil of 0-2cm depth (41 .50) as seen in Table 1.

The mean percentage of clay content ranged from 1.23 to 2.17%. The highest mean was seen in soil of 30cm depth (2.17%) followed by the soil of 0-2cm depth (1.44%) and lowest in soil of 15cm depth (1.23%) as indicated in Table 1.

However, the results from soil analysis revealed that all the three soil samples were sandy loam (Table 1)

It could be seen in Table 1 that, the mean percentage of organic matter content in the said soils ranged from 0.70 to 0.88%. Soil sample of 0 to 2cm depth has the highest percentage (0.88%), followed by soil of 15cm depth (0.71%) and the lowest is the soil of 30cm depth (0.70%).

However, the result also shows that the mean percentage of moisture content ranged from 10.65 to 16.78% (Table 1). The highest was soil of 0 to 2cm depth (16.78%), followed by soil of 15cm depth (12.48%) and lowest in soil of 30cm depth (10.65%) as seen in Table 1.

The pH analysis revealed that the mean pH value determined for the three soil samples ranged from 5.65-6.70. Soil samples 0 to 2cm depth (pH 6.70) were slightly acidic, while soils of 15cm depth (pH 5.65) and 30cm depth (pH 5.67) were also acidic in nature.

The result also showed that the mean percentage of density ranged from 0.82 to 0.89%. The highest percentages were the soil of 0 to 2cm depth (0.89%), followed by 15cm depth (0.85%) and lastly soil of 30cm depth (0.82%).

However, the results in Table 1 also, showed that the mean percentage of CEC in the soil samples ranged from 1.03% to 8.91%. The highest mean was in the soil of 30cm depth (8.91%), followed by soil of 15cm depth (7.83%) and the lowest in soil of 0 to 2cm depth (1.03%).

Table 1: Mineral Composition, Textural class, Density and related chemical properties of Soil sample collected at different depth under *Jatropha curcas* in Gusau, Zamfara State Nigeria, 2007

Depth	Replicates	Sand %	Silt %	Clay %	Textural Class	Organic Matter	Moisture Content	pH	Density	CEC
0 to 2cm	1	48.33	41.60	1.66		0.83	14.17	6.70	0.91	1.02
	2	52.00	40.70	1.00	Sandy	0.88	20.17	6.80	0.89	1.06
	3	51.67	43.30	1.67	Loam	0.93	16.00	6.60	0.89	1.02
Mean		50.67	41.87	1.44		0.88	16.78	6.70	0.89	1.03
SE		±0.030	±0.22	±0.20		±0.038	±0.104	±0.0099	±0.07	±0.009
15cm	1	52.60	40.00	1.00		0.75	12.98	5.82	0.89	7.9
	2	43.30	41.30	1.20	Sandy	0.68	12.50	5.00	0.82	8.1
	3	51.30	42.30	1.50	Loam	0.70	11.95	6.13	0.85	8.1
Mean		49.06	41.50	1.23		0.71	12.48	5.65	0.85	7.83
SE		±0.08	±0.13	±0.14		±0.03	±0.11	±0.076	±0.03	±0.029
30cm	1	51.25	40.50	1.50		0.70	10.58	6.25	0.90	9.50
	2	50.00	45.25	2.00	Sandy	0.69	11.12	4.90	0.75	8.25
	3	42.50	41.30	3.00	Loam	0.72	10.25	5.85	0.82	9.00
Mean		47.91	42.35	2.17		0.70	10.65	5.67	0.82	8.91
SE		±0.0001	±0.0291	±0.92		±0.01	±0.004	±0.089	±0.60	±0.50

3.2 Percentage Composition of Mineral Nutrients

Table 2 illustrates the percentage composition of mineral nutrient in the three soil samples. The mean percentage of sodium (Na) ranged from 0.00013 to 0.00020%. The highest percentage was found in soil of 0 to 2cm (0.00020%), followed by soil of 15cm depth, (0.0014%), and lowest in the soil of 30cm depth (0.0013%).

However, the results also indicated that the mean percentage of nitrogen in the soil samples ranged from 0.032 to 0.050% soil of 15cm depth has the highest percentage of nitrogen (0.050%), followed by the soil of 0 to 2cm depth (0.037%), and lastly the soil with 3cm depth (0.032%).

The mean percentage of potassium ranged from 0.00023to 0.00029%. The highest percentage was in soil of 0 to 2cm depth (0.00029%), followed by the soil of 30cm depth (0.00028%), and the lowest appeared in soil of 15cm depth (0.00023%) as seen in Table 2. However, mean percentage of magnesium ranged from 0.031 to 0.076%, with the highest means in the soil of 0 to 2cm depth (0.076%), followed by soil of 30cm depth (0.035%) and lowest in the soil of 15cm depth (0.031%).

Table 2: Percentage Composition of Sodium, Nitrogen, Potassium, Calcium and Magnesium in Soil Samples Collected at Different depth under *Jatropha curcas* in Gusau, Zamfara State Nigeria, 2007

Depth	Parameter	1	2	3	Mean	SE
0 to 2cm	Na	0.00021	0.00020	0.00020	0.00020	±0.500
	N	0.039	0.039	0.035	0.037	±0.500
	K	0.00030	0.00029	0.00029	0.00029	±0.0103
	Ca	0.018	0.015	0.020	0.017	±0.117
	Mg	0.0102	0.107	0.110	0.076	±0.724
15cm	Na	0.00014	0.00016	0.00011	0.00014	±0.021
	N	0.049	0.050	0.051	0.050	±0.013
	K	0.00023	0.00025	0.00021	0.00023	±0.056
	Ca	0.036	0.031	0.035	0.034	±0.059
	Mg	0.037	0.028	0.030	0.031	±0.086
30cm	Na	0.00012	0.00015	0.00012	0.00013	±0.076
	N	0.037	0.027	0.032	0.032	±0.281
	K	0.00027	0.00028	0.00029	0.00028	±0.025
	Ca	0.027	0.025	0.021	0.024	±0.0139
	Mg	0.037	0.035	0.032	0.035	±0.00095

The highest amount of oil was obtained in the first trial (2.50L) followed by the third trial (2.25L) while the second trial yielded the least amount (2.00). The mean percentage of the oil extracted was 2.251 + 0.074 Table 3.

Table 3: Volume of Oil Extracted from the Seeds of *Jatropha curcas* in Gusau, Zamfara State Nigeria, 2007

Replicates	Seeds Weight (kg)	Volume of oil in liters
1	2.31	2.50
2	2.31	2.00
3	2.31	2.25
	Mean	2.25
	SE	±0.0974

3.3 Proximate Composition of Seed Cake

Table 4 illustrates the proximate composition of the seed cake. The lipid percentage ranged from 41 .6% to 46.3% with a mean percentage of 44.2%; while the percentage of crude protein ranged from 11.81 to 12.43% with a mean percentage of 12.11%. However, the ash content of the seed cake ranged from 5.9 to 6.5% with a mean percentage of 6.5%. The results also revealed that the percentage of moisture content ranged from 2.94 to 3.03% a mean percentage of 2.99% and fiber content ranged from 9.50 to 10.50% with a mean value of 10.16%. The percentage of carbohydrate ranged from 24.29-30.57%, with a mean percentage of 27.15%

Table 4: Proximate Composition of the Seed Cake of Jatropha curcas in Gusau, Zamfara State Nigeria, 2007

S/No.	Parameters	Replicates			Mean	SE
		1	2	3		
1.	Lipid	44.8	46.3	41.6	44.2	±0.322
2.	Crude protein	12.10	11.81	12.43	12.11	±0.0173
3.	Ash content	6.50	7.10	5.90	6.50	±0.062
4.	Moisture	3.00	2.94	3.03	2.99	±0.0111
5.	Fiber	10.00	10.50	9.50	10.16	±0.005
6.	Carbohydrate	26.60	24.29	30.57	27.15	±0.084

3.4 Proximate Analysis of Mineral Content

The outcome from analysis of the mineral content is presented in Table 5. The percentage of magnesium ranged from 0.22 to 0.23%. The highest percentage was in the third trial (90.23%), followed by the first and second trial (0.22%) each. It could be deduced from the analysis that the mean percentage is 0.22 ± 0.02 percentage of sodium ranged from 0.000645 to 0.00060. Third trial had the highest percentage (0.00666%), followed by the first trial (0.006650%), and the least in the second trial (0.000645). The percentage mean value is 0.060652 ± 0.012.

However, the highest percentage of potassium was in the first trial 0.03075%), followed by second trial (0.03063%) The mean percentage value was 0.0308 + 0.005%

Calcium ranged from 0.043 to 0.045%; the highest was in the second trial (0.048%) followed by the first trial (0.045%) and the least percentage in the third trial (0.043%). The mean percentage value was 0 0450 ÷ 0.007%.

Table 5: Proximate Analysis of the Mineral Content of Seed Cake of *Jatropha curcas* in Gusau, Zamfara State Nigeria, 2007

S/No.	Parameters (%)	Replicates			Mean	SE
		1	2	3		
1.	Mg	0.22	0.22	0.23	0.22	±0.02
2.	Na	0.000560	0.000645	0.000660	0.000652	±0.0012
3.	K	0.000560	0.3062	0.0310	0.0308	±0.005
4.	Ca	0.045	0.043	0.043	0.045	±0.007

4. Discussion

The results obtained from various aspects of this study indicated that Barbados nut, *Jatropha curcas* is an oil yielding plant. Seed collection and weighing carried out have shown that much number of seeds per fruit pod and weight of the plant have a great potential to produce vigorously within the shortest possible time. This might be due to the fact that, the weight of the seed is an indication that it contains adequate amount of food reserve (endosperm) to enable it sustained the embryo during germination process, and this may in turn influence the amount of oil extraction from the plant. The report however, indicated that *J. curcas* plants can establish easily irrespective of the seed source. According to [16], the use of physic nut seeds for seedlings should be derived from the fruits, which skin is yellow up to blackish yellow in color, because they have high percentages of viability and vigority, i.e. 89 and 81%, respectively.

The high percentage of seed viability and germinability (65.7 and 98.33%) was reported in this research as coupled with the species ability to regenerate through stem cuttings have probably helped to ensure its abundance in the study area. This might be due to favorable temperature, humidity, seed drying or storage conditions and seed oil content among others. Between 40% - 60% moisture content, metabolic activities increase and seed germination is triggered off [17]. [18] documented that temperature, water, oxygen and light are important external conditions necessary for seed germination. [19] also viewed seed quality as a multiple criterion that encompasses several important seed attributes: genetic and chemical composition, physical condition, germination and vigor, seed size, seed moisture content, drying and seed physical appearance.

It was reported from this research that the soil sampled out, including the sandy fraction tends to decreases with depth, while silt and clay in the soil samples determine its textural class as sandy loam. The presence of sandy loam in the study area may be the reason why *Jatropha curcas* thrived well. However, high percentage (0.88%) of organic matter content in the surface soil may be attributed to the decomposed leaves of the plant which tails on the soil surface. These contributed a lot in the fertility of the soil and stimulate growth of microbes which in turn improve the soil structure. The moisture content of the soil sample was higher in the samples from the surface (16.78%), followed by soils from 15cm and 30cm depths (12.48 and 10.65%) respectively. This variation in moisture content may be attributed to the presence of organic matter and fibers in the soil surface which helped in retaining the moisture. This may eventually be utilized by the plant for growth and growth and development. The most frequently tested seed quality parameters according to [20] rules and standards are: physical purity, germination percentage, analytical purity, vigor, and seed health. Among these parameters, seed health testing currently suffers limited application, but germination potential is perhaps the most important quality parameter which is often used to determine sowing rates, time of sowing or whether the seed can be stored [21]; [22]. [23] contended that sowing of high quality seed in fermented loam and sandy-loam soils is essential for improving crop yields and increasing food production. Thus, assessing seed quality before planting is most important for famers and plant geneticists These reports are in line with the work of [24] who noticed that seed germination in *Jatropha curcas* was found to be high ranging between 68% and 90% but

these values were lower than those obtained before the seeds were dried (90% and 97%).

The variation in the mean pH value i.e. 6.70 and 5.56 to 5.67 for the three soil samples at different depths respectively showed that *Jatropha curcas* decreases the soil pH from slightly acidic 6.70 (surface soil) to moderately acidic 5.65 and 5.67 respectively (down soil). [25] reported that elements such as nitrogen, phosphorus, potassium calcium and magnesium are generally more available in pH range of 6.5 - 7.5. The acidity of the soil in the study area may be attributed to the presence of *Jatropha curcas*. But, [26] reported that *Jatropha curcas* grows best on well drained soils (pref pH 6-9) with good aeration and well adapted to marginal soils with low nutrient content.

However, it has been established in this study that the density of the soil samples appeared to be higher on the surface (0.89%) and moisture decreases down ward 0.85 and 0.82% respectively. The higher density on the surface may be due to the presence of *Jatropha curcas* plant.

The mean percentage of exchangeable cat ion ranged from 1.03 to 8.91; this greater variation may be due to influence of *Jatropha curcas* plant. The results presented in this regard illustrated the percentage content of magnesium, nitrogen and calcium which is generally greater than sodium and potassium. This showed that the mentioned nutrients contributed a lot in the growth and development of the plant. From the results obtained in oil extraction process, the first (1^{st}) trial yielded 2.5L, followed by the 2^{nd} and 3^{rd} trials. The variation in the amount of oil extracted in the three trials may be attributed to the size of the seeds used. If planted in hedges, the reported productivity of *Jatropha* is from 0.8 kg to 1.0 kg of seed per meter of live fence. The seed production is around 3.5 tons / hectare but, seed yields under cultivation can range from 1,500 to 2,000 kilograms per hectare, corresponding to extractable oil yields of 540 to 680 liters per hectare [27].

Jatropha curcas is a drought resistant tropical tree and the oil from its seeds has been found useful for medicinal and veterinary purposes, as insecticide, for soap production and as a fuel substitute [28].

However, the results obtained from proximate analysis of the seedcake of *Jatropha curcas* indicated that the percentage of lipid ranged from 41.6 to 46.3% with the mean percentage of 44.2%. The high percentage of lipids showed that the plant *Jatropha curcas* have the potential of yielding a consideration amount of oil. [29] reported the composition of *Jatropha curcas* where seeds contained 5.12% moisture, 48.5% crude oil, 25% crude proteins, 7.78% carbohydrate by difference, 9.4% crude fiber and 4.2% ash. According to [30], the mature seed yields 36–64% oil.

The value of crude protein obtained (12.11%) showed that the cake may be a very good source of protein for animals. This is true in the sense that literature cited revealed that the seed cake is poisonous but it is treated, it can be consumed by animals, In terms of ash content, the results of 6.5 ± 0.062 gives us a highlight as to the amount of inorganic materials present in the soil samples analyzed. It should be noted that high percentage of ash content means high content of minerals, while low content of minerals is indicated by the low percentage of ash content [31]. Most importantly, ash contains the minerals calcium magnesium, phosphorus and potassium. This may be the reason why the seedcakes are very important sources of fertilizer because the minerals discovered in this study are very important for the growth and development of the plants. [32] reported a 47.25% yield by weight of the seed. Variation in oil yield may be due to the differences in variety of plant, cultivation climate, ripening stage, the harvesting time of the seeds and the extraction method used. Among the minerals reported in this aspect of research, it is of interest to note that the most prevalent mineral element in *Jatropha curcas* seeds is Potassium which is high as 518.35 ± 0.44 mg/100g dry matter. Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins [33]. But, [34] reported that Magnesium (483.30 ± 0.02mg/100 g dry matter) plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls in *Jatropha curcas*.
The third trial yielded the highest moisture content, followed by the first and the second trials (3.00 and 2.94%) respectively. The amount of moisture obtained from the seed cake may be attributed to the oil extracted leaving a minute amount of moisture. [23] reported that seed oil content of *Jatropha curcas* seed was significantly affected ($p > 0.05$) when dried to 10% and 8% moisture levels, and the seed oil content remained high (42% and 55%) and higher than those observed by [35] who reported a range 73 between 36-40%.

The large amount of carbohydrates (27.15 ± 0.084) reported in this research showed that, if the cakes will be treated, it might be a very good source of energy for animals and man. The mineral contents of the seed cake revealed that magnesium has the highest mean percentage value 0.22 ± 0.02, followed by calcium and potassium 0.0450 ± 0.007 and 0.0308 ± 0.005 and the least percent in sodium 0.000652 ± 0.012. These minerals may potentially be a very good source of oil and calorific value if supplied in an appreciable amount; and may also contribute immensely to the growth of some oily-seeded plants in some Arid and Semi-Arid zones. [36] reported the moisture content of wild melon (*Citrillus ecirrhosis*) seeds to be 3.73 ± 0.25% in dry weight (DW) composition and added that, oil yield for the decorticated seeds as 50.67 ± 0.76%, as compared to Physic nut (62%) and sesame (54.0%) seeds.

5. Conclusion

From the research and analysis carried out, there is evidence that Barbados nut, *Jatropha curcas* is economically important because, it can yield a considerable amount of oil which may be used as a substitute for fuel and other valuable uses, such as soap making, source of nutrients, source of medicine, and live fence. The plant also produced seeds incorporated with nutrients along with biochemical composition that in turn yielded reasonable amount of oil for commercial purposes.

During the collection of seeds in this research, some seeds were found to be infested with golden flea (*Podagrica* Spp.,) in this cause the seeds lack endosperm which assist embryo

for germination, weightless when measured. They also tend to float on the surface of water when immersed and as such germinability test could not be carried out on them. It is recommended that survey and analysis be carried out by subsequent researchers to investigate the pest and diseases attacking the yield of J. *curcas* plants in the study areas.

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