



# **Bio-fuel Production Potentials of Jatropha, Produced by Combined Application of Rice Husk Dust and NPK in Southeastern Nigeria**

**E. O. Azu Donatus<sup>1\*</sup>, B. A. Essien<sup>1</sup>, S. I. Ijearu<sup>2</sup> and P. E. Nweke<sup>2</sup>**

<sup>1</sup>*Department of Horticulture and Landscape Technology Akanu Ibiam Federal Polytechnic, Unwana, Afikpo Ebonyi, Nigeria.*

<sup>2</sup>*Department of Agricultural Technology Akanu Ibiam Federal Polytechnic, Unwana, Ebonyi, Nigeria.*

## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author EOAD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BAE and SII managed the analyses of the study. Author PEN managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

In this study, we investigated the fruit, seed yield and biofuel production potentials of *Jatropha curcas* in soils fertilized with different rates of rice husk dust (RHD) and NPK 10:10:10. This study took place at the Teaching and Research Farm of the Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic, Unwana from April 2020 to March 2021. Treatments comprised of six rates (0, 1, 2, 3, 4 and 5 ton ha<sup>-1</sup>) each of RHD and NPK, arranged in Randomized Complete Block Design (RCBD) in Randomized Complete Block Design (RCBD) in a factorial pattern. Nursery *Jatropha* seedling of average heights of about 30 cm and 5-6 true leaves were transplanted to the field a month after treatment application. Our measurement between 10 to 12 months of *Jatropha* growth focused on the number of fruits, weight of fruits, number of seeds, weight of seeds and quantity of oil per plant. Analysis of variance (ANOVA) and Least Significant Difference (LSD) tools were used to analyze the obtained data and separated the significant means respectively. The relationship between yield parameters and selected soil chemical properties was determined using correlation analysis. Results indicated that relative to control, addition of RHD

\*Corresponding author: E-mail: donblessed01@gmail.com;

and NPK as lone and combined treatments increased the fruit, seed yield and oil quantity of *Jatropha*. Relative to control, fruit number increased by 72.80%, fruit weight by 79.81% and number of seeds by 80.73%. Similarly, the seed weight and oil content increased by 28.11% and 21.485 respectively. Organic matter, available phosphorus and total nitrogen had highly significant correlation with fruit, seed yield and oil quantity. Treatments combination of 5tonha<sup>-1</sup> RHD and 5tonha<sup>-1</sup> relatively gave the most appreciable result in fruit, seed yield and oil quantity and therefore recommended.

**Keywords:** *Jatropha*; rice husk dust; NPK bio-fuel and yield.

## 1. INTRODUCTION

Energy is fundamental to all human activities, impacting on every aspect of our socio-economic life [1]. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible sustainable and environmentally friendly [2]. The increased dependence on petroleum products in Nigeria has no doubt created an unfortunate scenario of lapses and setback to national development [3]. Furthermore, Pipeline vandalism, kidnappings, and militant activities around oil facilities, depletion of crude oil reserves, unstable and rising cost, and environmental problems have created serious national energy crisis Fatai [4]. These realities have prompted a boost to the search for renewable a sustainable, technically feasible, economically competitive, environmentally acceptable and easily available alternative to fossil fuels [5,6]. Research showed that a very common plant in the tropics and especially Nigeria, *Jatropha* can provide bio-diesel from its seed [6].

*Jatropha curcas* plants are usually found economically un-useful and invaluable, except when they are used as fences for house, a factor that has limited its propagation in Nigeria. *Jatropha* had often been classified as an ideal “pro-poor” crop due to its potential for biofuel production in marginal and degraded lands [7]. *Jatropha* plants which are abundantly found in abandoned lands can be easily propagated by cuttings in arid and semi-arid conditions and is well effective in erosion control. Despite the energy supply potentials and the economic relevance of *Jatropha*, the plant is yet to receive considerable research, political and commercial interest, thus limiting the commercial production of the plant using conventional nutrient input protocols.

Agronomists have long recognized the benefit of maintaining and increasing soil organic

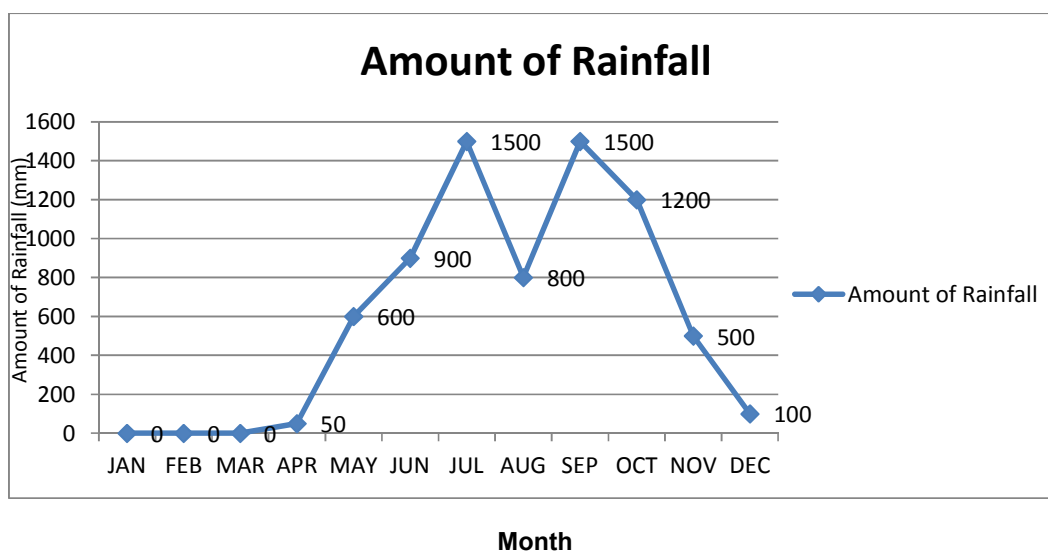
matter and one of the organic fertilizer sources is rice husk dust [8]. During rice refining processes, the husks are removed from grains. It is of little commercial value and because of its high silicon dioxide content; it is not useful to feed either human or cattle, but can be incorporated into the soil to enhance soil and crop productivity. For example, organic modification of soil with rice husk was found effective in the yield of many crops like cowpea and rice [8]. The increasing heaps of rice husk around rice mills in Ebonyi State and the evident that there will be continuous growth of this heaps due to the present federal government policies on ban on rice importation may in long-run become a threat to our environment if nothing is done to remove these wastes. Considering the present and future scenarios of energy crisis occasioned by poor electricity supply and the dwindling and high cost of petroleum products in Nigeria, there is urgent need to explore the potentials of rice husk dust and NPK fertilizers on commercial *Jatropha* production for sustainable energy supply in Ebonyi State. This study was therefore designed to investigate the combined effect of decomposed rice husk and NPK fertilizers on the yield and biofuel production of *Jatropha* in an ultisols of southeastern Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The research was conducted at the Teaching and Research Farm, Department of Horticulture and Landscape Technology, Akanu Ibiam federal polytechnic Unwana from April 2020 to March 2021 under rainfed conditions. The geographical co-ordinates of Unwana are latitude 5°48'N and longitude 7°55'E [9]. Fig. 1 shows the monthly rainfall of the study area for the period of the study.

The climate and vegetation type are generally humid tropical rainforest with annual rainfall of about 3500 mm relative humidity of between 60-



**Fig.1. Rainfall distribution pattern in the study Area**

Source: Ogah [10]

80% and daily temperature range of 32°C- 21°C [11].

## 2.2 Soil Condition

The soils which are derived from shale and sand stone belong to the order ‘Ultisol’ and have been classified as typic hapludult [12,13]. Pre-treatment soil sample was collected and the following soil fertility parameters were analyzed according to standard methods: Particles size distribution: This was determined using the Bouyocous hydrometer method as described by [14]. Soil pH was determined in soil to water and soil to CaCl<sub>2</sub> at the ratio of 1:2.5, using glass electrode pH meter [15]. Organic carbon was determined by the wet oxidation method of Walkey and Black as described by [16] Total nitrogen determination was done by the macro Kjeidahl digestion method [17]. Exchangeable acidity was determined by the 1M KCl extraction procedure as described by [15] Exchangeable basic cations (K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>) were determined by the ammonium acetate method [18]. Effective Cation Exchange Capacity (ECEC) was obtained by summation of all the exchangeable cations and exchangeable acidity as described by [15] base Saturation was obtained mathematically with:

$$BS (\%) = \frac{TEB}{ECEC} \times \frac{100}{1}$$

BS = Base saturation, TEB = Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity

## 2.3 Experimental Materials

Rice husk was obtained from a local rice mills in Afikpo, Ebonyi State, Nigeria, while the Jatropha seeds used for this experiment were obtained from the National Institute of Horticulture sub-station, Umulolo, Okigwe, Imo State

## 2.4 Nursery Establishment and Management

The Jatropha seeds were sown in polythene bags filled with free-draining growth media containing adequate organic matter. Growth media containing a mixture of sand, topsoil and poultry manure at the ratio of 1:1:1 was used for raising the seeds. All nursery management practices such as watering, weeding, pest control were observed throughout the three months nursery period.

## 2.5 Field Experiment

A Randomized Complete Block Design (RCBD) in factorial with three blocks (replications) was used for the study. The experiment covered a total land area of 52, 000m<sup>2</sup> (400m x 130m). Each blocks consisted of 36 sub- plots measured 1.8m x 1.8m in area with spacing of 1.0m between sub- plots and 2.0m between blocks. Thirty six (36) treatments in total comprising of six rates (0, 1, 2, 3, 4, and 5tonha<sup>-1</sup>) Rice Husk Dust and six rates ( 0, 1, 2, 3, 4, and 5tonha<sup>-1</sup>) NPK, replicated three times were randomly assigned to each each treatment unit.

Seedlings were transplanted one month after treatment applications with one seedling per plot, and these gave a total of one hundred and eight (108) observational units. The transplanting to soil in the field was done when the plants reached an average height of 30 cm and developed 5-6 true leaves.

### 2.6 Data Collection

At 10 to 12 months after planting the following yield parameter were collected.

**Number of fruits per plant:** Matured Jatropha fruits were harvested manually weekly from each tree for a period of 2 months.

**Weight of fruits per plant:** This was measured with precision balance.

**Number of seeds:** This was done by removing the fruit shell and the number of seeds counted.

**Weight of seeds:** The precision balance was also used to determine the weight of seeds from each tree.

**Quantity of oil in litre extracted from each plant:** Processing of the fruits for oil extraction involved drying the fruits, removing the shells and the seeds further sun dried to reduce the moisture content for efficient oil extraction. Extraction of oil was done mechanically using the Bielenberg ram press and the quantity of the oil per tress in volume was determined using a measuring cylinder.

### 2.7 Statistical Analysis

Analysis of variance (ANOVA) for number of fruits, weight of fruits, number of seeds, weight of seeds and oil content was performed using GENSTAT 2009 version and means that

showed significant difference were separated using Least Significant Difference (LSD) test at 5% level of significance. Correlation analysis between selected soil properties and the yield parameters was performed using SPSS software (Version 22).

## 3. RESULTS AND DISCUSSION

The pre-amendment and pre-planting soil analysis showed that the textural class of the soil was clay loam with clay occurring at 35.29% Table 1. It was acidic with low organic carbon and nitrogen and phosphorus. However, the basic cations especially calcium was relatively high. High value of exchangeable acidity was also observed Table 1.

The implication of the result of the soil nutrient condition is that it may not able support good crop production without external manure input and liming to reduce the observed acidity. The result and the recommendations are in line with other studies in the soils of this region [9,19,20].

Similarly, results of the chemical and elemental analysis showed that rice husk dust was rich in nutrients including organic carbon, available phosphorus and basic cations Table 2. Worthy of note are the high content of calcium and nitrogen. Other Researchers have also reported high nutrient content in rice husk [21-23]. According to Gailhre et al. [24] rice hull contains numerous elements essential for plant growth, including nitrogen, phosphorus and potassium. Similarly, Zeynep and Gulser [25] reported high nutrient content especially, carbon, phosphorus, nitrogen and exchangeable cations

**Table 1. Some physical and chemical properties of the soil of the study area**

Sand	Silt	Clay	pH	Org.C	TN	AV. P	Ca	Mg	K	Na	TEA	ECEC
→ %	← %		H <sub>2</sub> O	%	%	mg/kg	→	→	Cmol/kg	←		
53.13	11.58	35.29	4.00	1.58	0.13	9.21	3.03	1.21	0.30	0.01	2.44	6.990

**Table 2. Nutrient compositions of the Rice Husk Dust (RHD) used for the study**

pH(H <sub>2</sub> O)	pH (CaCl <sub>2</sub> )	Carbon	Nitrogen	Phosphorus	Ca	Mg	Na
		%	%	mg/kg	Cmol/kg		
8.00	7.13	3.10	2.82	21.23	5.59	2.22	1.87
							0.14

The high basic cation especially calcium content may have played crucial role in ensuring the neutral and slightly alkaline property of the rice husk dust. Thus, it is expected that the rice husk dust will not only play a role in nutrient supply, but will also serve as a potential lime material for neutralizing the high acidity in the soil of the study area.

### **3.1 Effect of Rice Husk Dust and NPK fertilizer on the number of fruits, weight of fruits and number of seeds**

The number of fruits, weight of fruits and the number of seeds per plant from 10 to 12 months of planting is shown in Fig. 2. Fruit production began three months of planting and the maximum yield within the period under study occurred at 13 months.

Relative to the control experiment, addition of RHD and NPK improved the number of fruits, weight of fruits and the number of seeds. These parameters increased with increased rate of amending materials. Generally, there were significant differences ( $P < 0.05$ ) in the number of fruits, weight of fruits and the number of seeds for the main effect of RHD and NPK and their interactions Table 3.

The mean of the number of fruits, weight of fruits and number of seeds ranged from 56.67 – 151.67, 97.73 – 386.3g and 276.70 – 1158.9 respectively and the highest values for these yield parameters were obtained in the experimental plot that had 5tonha<sup>-1</sup> RHD and 5 tona<sup>-1</sup> NPK as treatments.

The early study undertaken by Lal et al. [26] established that the maturity and maximum yield of *Jatropha* in rain fed marginal lands was observed in the first year with a yield of between 3.2 to 4.1 ton seeds ha<sup>-1</sup>. This information on *Jatropha* maturity and yield in terms of fruits number, weight of fruits and number of seeds within a year is comparable to the results of this study. However, these results do not agree with the data provided by Euler and Gorriz [27] and Achten et al. [28] who observed that *Jatropha* shows considerable fruit and seed production at younger ages due to the inefficient interception of solar radiation, therefore the distribution of dry matter to permanent biomass instead of the harvestable parts such as fruits and seeds. The results this findings also differ from the eight years required by *Jatropha* to reach maturity and meaningful yield as observed by GTZ [29]. What

was still unclear on the general phenomenon of low *Jatropha* yield at younger ages has been made clearer through the improvement on soil fertility properties by the addition of RHD and NPK. The soil fertility enhancement potentials of rice husk dust in highly weathered acidity tropical soils have been reported by several authors [30] Azu et al. [9] Nwaite, et al. [31]. *Jatropha* cultivation traditionally receives minimal care in terms of soil fertility maintenance. This could significantly affect productivity potentials and sustainability of *Jatropha* plantations [7]. Therefore, the productivity of *Jatropha* in terms of fruit and seed quantity and quality observed in this study is a real scenario for *Jatropha* when produced in soils where adequate nutrients are provided through external manure input. In this case, combined application of RHD and NPK fertilizer has proved to be efficient in promoting the productivity of *Jatropha* in marginal and poor inherent nutrient soils.

### **3.2 Effect of Rice Husk Dust and Npk on the Weight of Seeds Per Plant and Quantity of Oil Produced**

Significant difference in seed weight and oil content were found among treatments and their interactions. Mean seed weight and oil quantity varied from 150.2g to 865.4g and 0.031 to 0.165 litres (Table 4 and 5). This represents about 28.11% and 21.48% increase in seed weight and oil quantity respectively. The seed weight and oil quantity increased with increased application of RHD and NPK, thus, the plot treated with 5 ton ha<sup>-1</sup> RHD and 5 ton ha<sup>-1</sup> NPK had the most appreciable increase in the seed weight and quantity of oil. The variation in seed weight and oil content found in the present investigation is a sufficient viable evidence of the impact of different rates of RHD and NPK on the productivity of *Jatropha*. It is noteworthy to mention that these results compared favourably with the reports of several literatures putting into consideration the variation in the seed yield and oil content among the various treatment groups. Furthermore, the results of this study has shown improvement in seed yield and oil quantity of 56.7% and 63.2% increase compared to the finding of Kabir et al. [32]. The most appropriate explanation for this observation is the addition of rice husk dust and NPK and their subsequent release of essential nutrient for the growth and productivity of the *Jatropha*. Singer et al. [33], mentioned that seed oil concentration does not only depend on the genotype, but is also affected by environment such as manure input to the soil.

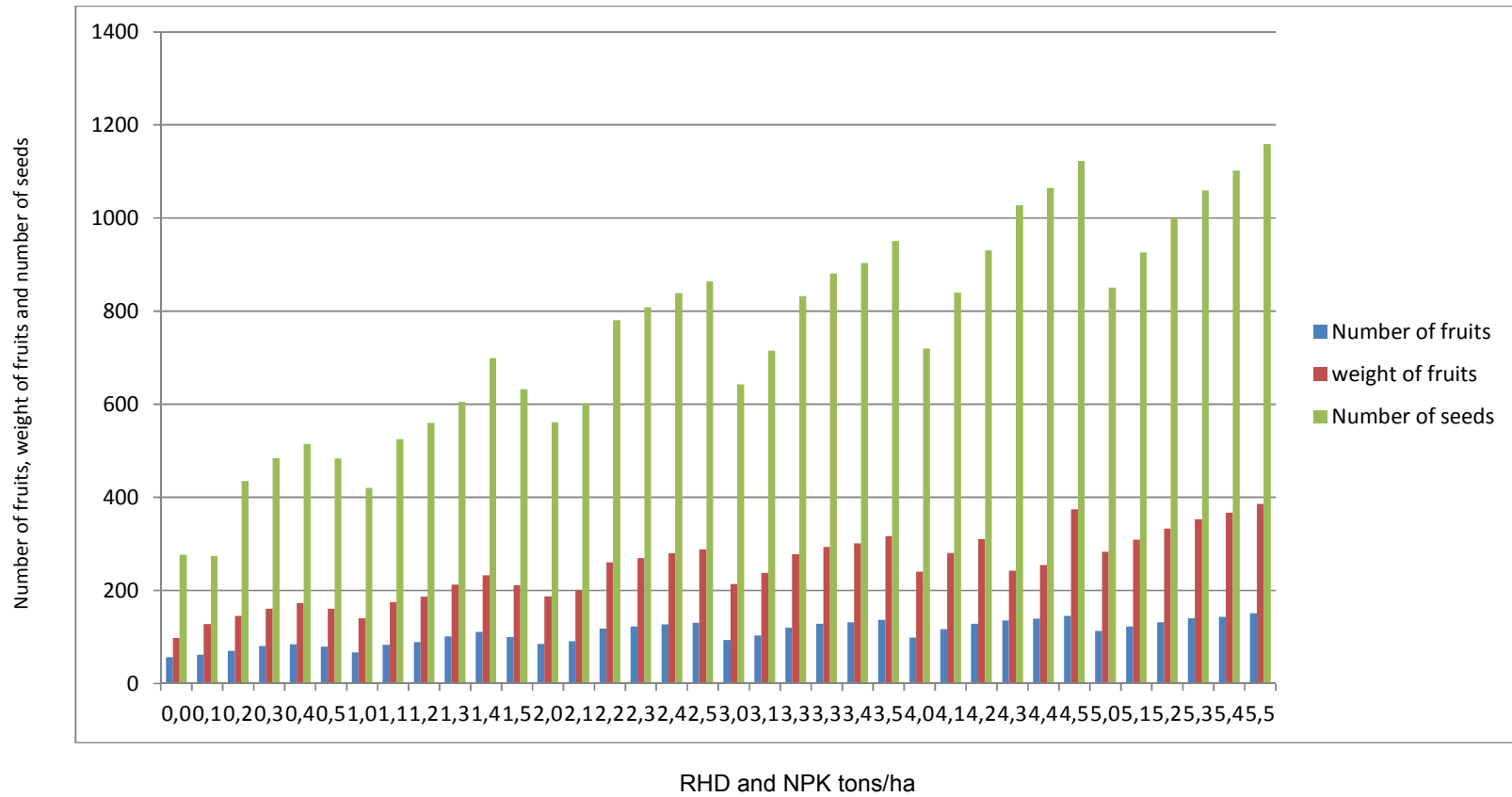


Fig. 2. Mean effect of rice husk dust and NPK fertilizer on number of fruits, weight of fruits and number of seeds

**Table 3. Significance (p-value) of effect of Rice Husk Dust and NPK on number of fruits, weight of fruits and number of seeds**

Effects	Sources of variation (p-value)		
	Number of fruits	Weight of fruits	Number of seeds
RHD	2.167	6.552	21.14
NPK	2.167	6.552	21.14
RHD X NPK	5.317	16.048	51.78

**Table 4. Effect of rice husk dust and NPK on the weight of seeds per plant**

RHD	Rice Husk Dust (Tonha <sup>-1</sup> )							MEAN
	0	1	2	3	4	5		
0	150.2	214.7	265.6	298.9	319.5	294.8	257.3	
1	277.2	351.6	375.2	427.7	466.2	425.7	387.3	
2	368.4	405.4	533.5	549.5	567.3	567.5	498.6	
3	469.1	535.0	630.1	654.8	659.8	681.7	605.1	
4	590.4	669.5	732.2	773.3	780.6	804.6	797.1	
5	728.6	749.8	800.2	822.9	815.7	865.4		
MEAN	430.7	487.7	556.1	587.8	601.5	606.6		

Lsd 0.05 RHD = 14.40  
 Lsd 0.05 NPK = 14.40  
 Lsd 0.05 RHD X NPK = 35.27

Kabir et al. [32], in their submission noted that, although *Jatropha* grows in soil with low fertility and alkalinity, the yield in poor-quality soils can be improved greatly with addition of fertilizers. Thus, Omar et al. [34] discovered significant increase in seed and oil quantity of *Jatropha* produced in soils treated with different rates of nitrogen and potassium fertilizers. Njoku et al. [8] and Nwaite et al. [31], in their separate studies observed improved soil fertility and corresponding plant response when rice husk dust was used as manure in ultisols of southeastern Nigeria.

### 3.3 Correlation between some Soil Chemical Properties and Yield Parameters of *Jatropha*

The yield parameters of *Jatropha* were correlated with some soil properties and the results showed that available P, organic matter and total nitrogen correlated significantly and positively with weight of fruits, number of seeds and quantity of oil Table 6. This shows that the higher the concentration of these nutrient indices in the soil, the more the yield of *Jatropha*. This soil chemical condition was accomplished with the addition of RHD and NPK fertilizer in the present study. Singh et al. [35] observed that seed and oil yield in oil seeds increased with sulphur, nitrogen and phosphorus, while Bouchet et al. [36] reported

significant increase in oil content of oil seed with increased addition of organic matter and nitrogen. The findings of this study corroborates with these earlier findings. Thus the organic matter, sulphur, phosphorus, nitrogen contribute more to oil production in oil seeds such as *Jatropha*.

Significant positive correlation between seed weight and oil quantity was observed Table 6. This indicates the seed weight in the primary plant factor that determines the quantity of oil content in *Jatropha*. Alvaro et al. [7] in their study reported linear relationship between seed weight and oil content. Also, studies conducted by Rao et al. [37] and Karaj and Muller [38] pointed out the significant statistical correlation between seed weight and oil content can be considered an important trait for early selection of seed sources. The present study which observed significant positive relationship between seed weight and soil organic carbon, available phosphorus and nitrogen infers that addition of RHD and NPK to the soil promotes the availability of these nutrient elements and thus improves seed weight for more oil production in *Jatropha*. Thus, the availability of these elements in soil through RHD and NPK addition may reflect the seed weight and therefore can be used as precursors for oil quantity and quality in *Jatropha*.

**Table 5. Effect of Rice Husk Dust and NPK on Quantity of Oil (Litres)**

Rice Husk Dust (tonha <sup>-1</sup> )							
NPK	0	1	2	3	4	5	MEAN
0	0.03100	0.04100	0.05067	0.05667	0.06067	0.05633	0.0494
1	0.05267	0.06733	0.07133	0.08133	0.08800	0.08067	0.0736
2	0.07000	0.07767	0.10233	0.10467	0.10800	0.10833	0.0952
3	0.08933	0.10167	0.11967	0.12467	0.12567	0.13000	0.1152
4	0.11267	0.12767	0.13967	0.14767	0.14900	0.15567	0.1387
5	0.13867	0.14267	0.15233	0.15667	0.15567	0.16500	0.1518
Mean	0.08239	0.09300	0.10600	0.11194	0.11450	0.11600	

*Lsd 0.05 RHD* = 0.00296  
*Lsd 0.05 NPK* = 0.00296  
*Lsd 0.05 RHD X NPK* = 0.00296

**Table 6. Coefficients of simple Linear Correlation between some soil chemical properties and yield parameters of Jatropha**

	Weight of fruits	NO of seeds	weight of seeds	Quantity of oil
Av. P	0.868*	0.912**	0.878*	0.877**
Org. matter	0.847*	0.852**	0.909**	0.909**
Total N	0.813*	0.850**	0.791*	0.790*
Weight of seeds	0.961**	0.984**	0.999**	1.000**

\*\*Correlation is significant at 0.01 level, \*Correlation is significant at 0.05 level

#### 4. CONCLUSION

From the energy outlook of Nigeria, it is very clear that the energy demand is very high and is increasing geometrically while the supply remains inadequate, insecure, and irregular and is decreasing with time. Production of biofuel from plant materials is a major step toward harnessing one of the world's most prevalent, yet least utilized renewable energy resource. *Jatropha curcas* has a great deal of potentials. Although, *jatropha* is often grown in marginal and poor nutrient soils, the yield in terms of oil production can be enhanced through soil fertility maintenance. Here, the effect of rice husk dust and NPK fertilizer was studied. This study revealed that the fertilization of *J. curcas* plants with rice husk dust and NPK fertilizer at 1,2,3,4 and 5 tonsha-1 each increased fruit and seed production by more than 90%, as compared with the unfertilized control, and represents an almost two-fold increase in oil production that rose from 0.031 to 0.165 litres. Significant differences among the yield variables due RHD and NPK addition were observed. The plot treated with 5 ton ha<sup>-1</sup> RHD and 5 ton ha<sup>-1</sup> NPK consistently gave the most appreciable increase of these parameters. The organic matter, available phosphorus and nitrogen were found to relate positively with the yield parameters of *Jatropha*.

Thus, increasing the concentrations of these nutrient elements will have corresponding increase in the quantity of fruits, seeds and oil produced. Therefore to ensure high yield of *Jatropha* in terms of biofuel production, the cultivating soil should be enriched with the necessary nutrients through the application of 5tonsha<sup>-1</sup> RHD and 5ton ha<sup>-1</sup>NPK in order to produce large quantities of oils that will help to overcome the oil-shortage crisis in Nigeria.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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