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Germination and early growth of *Jatropha curcas* L from different seed sources

Abstract

Germination and early growth of *Jatropha curcas* from different seed sources in Benue State were assessed over a period of ten weeks. *Jatropha curcas* L. is a tropical species from the family *Euphobiaceae.* Special interest has been shown in the cultivation of the species for oil extraction, especially since it is drought resistant and can be cultivated on marginal land, without competing with food crops. The ripe fruits of *Jatropha curcas* were collected from the ground; and directly on mother trees from distinct sources (provenance) (Ukum, Makurdi and Otukpo) areas in Benue, Nigeria. Benue state was stratified into three ecological zones; and each source (provenance) was purposively selected from each zone as a result of seeds availability. Fifty seeds where collected from each of the three sources; making a total of 150 seeds planted for this study. The data collected were based on germination rate, seedlings girth, number of leaves, height, and leaf area. The data collected were analysed using descriptive statistic. The results of the germination indicated that for the first 5 days there was no germination. The seeds sourced from Otukpo had the best growth performance in terms of seedling height (15.25cm), leaf number (4.39), girth (0.8cm), leaf area (62.63cm^2). While seeds sourced from Makurdi had the least growth performance. Thus, it is recommended that *J. curcas* plantation can be established in the study area, using seeds sourced from Otukpo.

Keywords: germination, growth rate, provenance, plantation, species

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Introduction

In consideration of invaluable importance of *Jatropha curcas* to the people, a reliable source for its seeds collection is necessary for any successful plantation establishment; so as to make it more available to the local populace and species sustainability. Seed sources aid in bringing out a more reliable source for seed collection for plantation establishment. Economic tree species such as *J. curcas* is fast depleting due to high rate of deforestation and low planting rate of the species in most areas in Nigeria. This challenge can be resolved by establishing plantation of this species through artificial regeneration. Successful production of healthy seedlings in the nursery can be ensured through seeds sources using viable seeds.

J. curcas is a species of flowering plant in the spurge family *Euphorbiaceae*. It is a native to the American tropics most likely Mexico and Central America. It is now widely cultivated in both tropical and sub-tropical regions around the world.[1] Today *Jatropha curcas* has gained much attention for both oil and non-oil producing countries around the world.[2–5] African countries are no exception and countries such as Mali and Tanzania have been extracting *Jatropha curcas* oil for years. The species has a high yield for diesel engines as well as for medicinal and insecticidal purpose.[6] Since the surge of interest in renewable-energy alternatives to liquid fossil fuels began in 2004/5, the possibility of growing *Jatropha curcas* for the purpose of producing biofuel has attracted the attention of investors and policy-makers worldwide. The seeds of *J. curcas* contain non-edible oil with properties that are well suited for the production of biodiesel. Despite the invaluable importance of this species, no plantation of its kind is established in the study area. This study seeks to determine the most vigorous and quality seed source within Benue state, so as to advocate for its plantation establishment.

Materials and method

Study area

This study was conducted at the Forestry Nursery of the Department of Forestry, Wildlife and Range Management, University of Agriculture Makurdi, Nigeria. The study area lies between Longitude 8°21' and 9°E and Latitude 7°21' and 8°N within the southern guinea savanna ecological zone. The climate of the area is tropical sub-humid with high temperatures and high humidity. The maximum temperature is 35°C while the minimum temperature is 23°C.The climate is characterized by two distinct seasons namely; rainy and dry seasons with an annual rainfall of 1200mm–1500mm.

Seed collection and experimental design

Benue state was stratified into three zones based on observed variation of the forest cover. From each of the ecological zone, a Local Government Area (L.G.A) was purposively selected as a result of species availability; one provenance was selected as seed source from the three L.G.A. The seeds provenances (sources) were Ukum, Makurdi and Otukpo. In all the three provenances, *Jatropha curcas* was readily available. The seeds of *J. curcas* were collected directly from the mother trees. The Experimental Design was laid out in Completely Randomized Block Design (CRBD) with three (3) replicates. The treatments include: Ukum (T_1), Makurdi (T_2) and Otukpo (T_3).

Field/nursery materials

The top soil used was collected beside the nursery of Forestry Department Federal University of Agriculture Makurdi. The seeds of *Jatropha curcas* were first tested for viability through floatation method; this was to ensure viable seeds were used for this study. The

materials used were Hoe, Shovel, Watering can, veneer Caliper, Graph sheet, Wheelbarrow, Hand trowel, Ruler, pencil, cutlass.

Data collection

Germination commenced on the 6th day after sowing. The stem height was measured in centimeter (cm) using meter rule, leaf area was measured in centimeter square using graph sheet, girth was measured using diameter tape, and number of leaves was determined by manual counting. After germination was first observed, readings were taken after 14 days for interval of 2 months.

Measurement of variables

a. The germination rate was calculated using the following formula;

$$Rate\ of\ Germination = \frac{No\ of\ seeds\ germinated}{No\ of\ days\ taken}$$

b. The percentage germination was calculated using the following formula;

$$Germination\% = \frac{No\ of\ seeds\ germinated}{Total\ No\ of\ seeds\ sown} \times 100$$

Data analysis

Data collected on seed germination and growth rate (seedling heights, number of leaves, collar diameter, leaf area, fresh and dry weights) were subjected to descriptive statistics (percentages, mean and standard deviation) and inferential statistics (one-way analysis of variance (ANOVA)) were adopted using the statistical package (SPSS version 21.0); where significant differences occurred between the treatments means, L.S.D method was used to separate the means.

Results

Figure 1 shows germination percentage of *J. curcas* seeds sourced from different provenances. Based on the result of this finding, there was no germination observed on the first five days. On the 6th day germination commenced with Otukpo provenance recorded the highest germination percentage of 35.6%, followed by Ukum which had 20% while Makurdi had 8.9%. It was also observed that on the 9th day germination percentage of Otukpo provenance was the highest (82.2%) while Ukum and Makurdi recorded 57.8%, each. It was also observed that on the 14th day, Otukpo recorded the highest germination percentage of (84.4%) while Makurdi recorded the lowest germination of 57.8%.

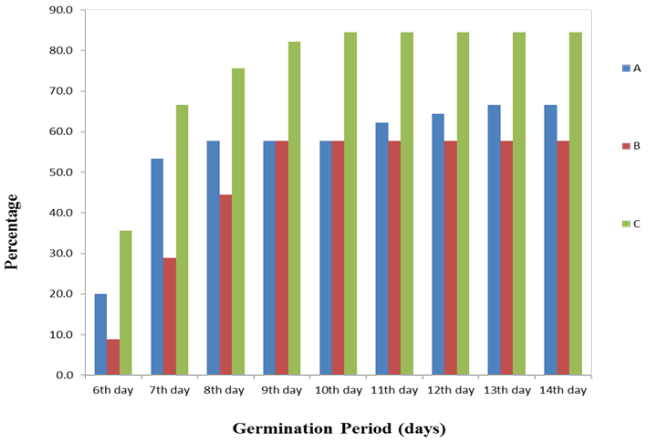

Figure 1 Germination Percentage in *Jatropha curcas* Seeds from different Sources in the Study Area.

A, Otukpo; B, Ukum; C, Makurdi.

The result on Table 1 shows the number of leaves from *Jatropha curcas*, the seeds collected from Otukpo source had the highest leaf number of 4.39 while Makurdi recorded the least with mean value of 3.81. Also, in terms of height, Otukpo recorded the highest mean height of 15.25cm while Makurdi recorded the least with a mean value of 13.13cm. *Jatropha curcas* seedlings sourced from Otukpo had the highest mean girth of 0.86cm while Makurdi recorded the least with the mean value of 0.73cm. Based on the result (Table 1), the highest mean leaf area was recorded in Ukum with mean value of 62.63cm^2 while Makurdi recorded the lowest with mean value of 59.71cm^2.

Table 1 Effects of Seed sources on the Mean number of leaves, Height, leaf area and Girth of *Jatropha curcas* Seedlings

Variables	Source	Mean	Std. deviation	Std. Error	95% Confidence interval for mean	
					Lower bound	Upper bound
No of Leaves	Ukum	3.88	1.65	0.10	3.59	4.18
	Makurdi	3.81	1.77	0.16	3.49	4.13
	Otukpo	4.39	1.06	0.10	4.20	4.58
Height(cm)	Ukum	14.13	5.05	0.46	13.21	15.04
	Makurdi	13.13	5.89	0.54	12.06	14.19
	Otukpo	15.25	3.02	0.28	14.71	15.80
Girth(cm)	Ukum	0.76	0.30	0.03	0	0.81
	Makurdi	0.73	0.33	0.04	0.67	0.79
	Otukpo	0.86	0.19	0.02	0.82	0.89
Leaf Area(cm^2)	Ukum	62.63	9.93	2.03	58.43	66.82
	Makurdi	59.71	9.89	2.02	55.53	63.88
	Otukpo	62.02	13.39	2.73	56.37	67.68

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As shows on Table 2, there was no significant difference (p=0.006) on the number of leaves sourced from Ukum (3.88), and Makurdi (3.81) whereas there was significant difference between Otukpo (4.39) and Ukum (3.88) provenances and between Otukpo (4.39) and Makurdi provenance (3.81). Seedlings from Otukpo provenance had 4.39 which was observed as the highest mean number of leaves, while seed from Makurdi provenance recorded the least mean value of 3.81. In terms of plant height, Ukum provenance had 14.13cm, Makurdi (13.12±5.89cm) while Otukpo (15.25cm); the provenances were significantly different (p=0.003); whereas Otukpo recorded the highest growth on stem height, but lowest at Makurdi.

Table 2 Comparative Effects of Seed sources on the Mean number of leaves, Height and Girth of *Jatropha curcas* Seedlings

Seed source	Variables			
	No. of Leaf.	Height(cm)	Girth(cm)	Leaf area(cm²)
Ukum	3.88±1.64^{b}	14.13±5.05^{ab}	0.76±0.30^{b}	62.63±9.89^{a}
Makurdi	3.81±1.77^{b}	13.12±5.89^{b}	0.73±0.33^{b}	59.71±13.39^{a}
Otukpo	4.39±1.06^{a}	15.25±3.02^{a}	0.86±0.19^{a}	62.02±11.11^{a}
P-value	0.006	0.003	0.001	0.637

Means on the same column with different superscript are statistically significant (p<0.05)

In terms of girth, there was no significant difference between Ukum (0.76 cm) and Makurdi (0.73cm) but there was significant difference between the other seed source (0.86±0.19cm).Where Otukpo (0.86±0.19cm) had recorded highest growth in stem girth, but lowest at Makurdi (0.73±0.33cm). In relation to leaf area, there was no significant difference across the seed sourced from Ukum, Makurdi and Otukpo (p=0.637, while Ukum (62.63cm²) recorded the highest growth in leaf area, but low at Makurdi (59.71cm²).

Figure 2 shows effects of seed source on the mean height (cm), number of leaves, girth (cm) of *J. curcas* seedlings in Benue state, Nigeria. The result showed that *J. curcas* seedlings sourced from Otukpo provenance had the highest mean height of 15.25cm while Makurdi provenance had the lowest mean height of 13.13cm. The number of leaves from seedlings under Otukpo provenance had the highest mean of 4.39 cm while Makurdi had lowest mean value of 3.81 cm. In terms of girth, Makurdi provenance had a mean value of 4.3cm while Ukum provenance had a mean value of 3.65cm which was the highest mean girth.

Figure 3 shows the effects of seeds source on the mean leaf area (cm²) of *Jatropha curcas* seedlings from the study area. The results showed that the highest mean of *J. curcas* seedlings was recorded in Ukum provenance, which had a mean value of 62.63cm² while the lowest was recorded under Makurdi provenance 59.71cm². Table 3 shows the growth rate of *J. curcas* seedlings in the study area over a period of eight weeks. There was significant different (p=0.001) in the number of leaves from 2nd to 8th week between the seeds sourced from different sources. The seedlings height from 2nd to 8th week showed a significant difference (p=0.002) between seeds provenances. In terms of girth, from 2nd to 8th week, there was significant difference (p=0.001) across the different seeds sources (p=0.001). The result on leaf area showed that from 2nd to 8th week there was significant difference (p=0.001) between the provenances.

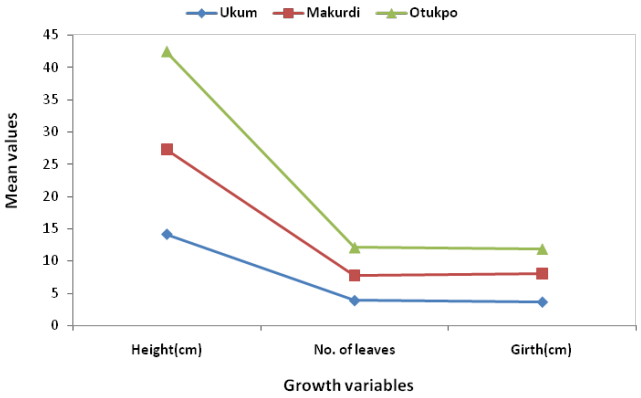

Figure 2 Effects of Seed source on the Mean Height (cm), Number of Leaves and Girth (cm) of *Jatropha curcas* Seedlings in the study Area.

Table 3 Effect of Seed sources on mean number of leaf, Height, Girth, and Leaf area of *Jatropha curcas* Seedlings over a period of Eight Weeks

Variable	Time	Seed sources			*p*-value	Remark
		Ukum	Makurdi	Otukpo		
No. of leaf	Week 2	2.67±0.80^{b}	2.57±1.04^{b}	3.00±0.26^{a}	0.001	Sig.
	Week 4	3.67±1.30^{b}	3.63±1.50^{b}	4.10±0.31^{a}	0.001	Sig.
	Week 6	4.23±1.63^{b}	4.30±1.75^{b}	4.90±0.61^{a}	0.001	Sig.
	Week 8	4.97±1.75^{b}	4.73±1.95^{b}	5.57±0.57^{a}	0.001	Sig.
Height(cm)	Week 2	12.93±3.89^{a}	11.23±5.00^{b}	12.97±2.23^{a}	0.002	Sig.
	Week 4	14.33±5.27^{b}	13.58±6.47^{c}	16.25±2.73^{a}	0.002	Sig.
	Week 6	14.05±5.24^{b}	13.38±5.69^{c}	15.57±2.96	0.002	Sig.
	Week 8	15.20±5.60^{b}	14.30±6.14^{c}	16.23±2.93^{a}	0.002	Sig.

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Table continued....

Variable	Time	Seed sources			*p*-value	Remark
		Ukum	Makurdi	Otukpo		
No. of leaf	Week 2	2.67±0.80[b]	2.57±1.04[b]	3.00±0.26[a]	0.001	Sig.
	Week 4	0.73±0.27[b]	0.70±0.29[b]	0.82±0.06[a]	<0.001	Sig.
	Week 6	0.80±0.33[b]	0.83±0.34[b]	0.97±0.09[a]	<0.001	Sig.
	Week 8	0.90±0.33[a]	0.87±0.37[b]	0.91±0.10[a]	<0.001	Sig.
Leaf area($cm^{2)}$	Week 2	57.08±11.42[a]	60.33±10.7[a]	52.33±12.40[a]	0.632	Not sig.
	Week 4	66.42±6.12[a]	56.58±8.52[a]	66.00±18.73[a]	0.632	Not sig.
	Week 6	65.83±13.57[a]	60.83±13.47[a]	61.00±8.41[a]	0.632	Not sig.
	Week 8	61.17±5.69[a]	61.08±8.03[a]	68.75±7.92[a]	0.632	Not sig.

Means on same rows with different superscript are statistically significant (P<0.05).

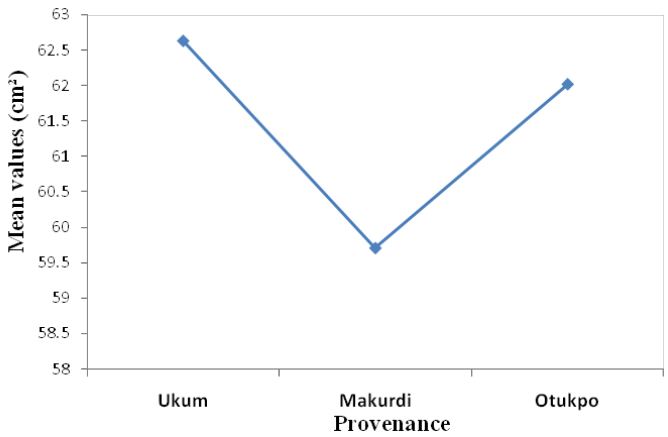

Figure 3 Effects of Seed sources on the Mean Leaf Area (cm^2) of *Jatropha curcas* Seedlings.

Discussion

Germination rate

The results on germination rate showed that germination of seeds sourced from different sources varies significantly from each other (P<0.05). Seeds that were collected from Otukpo had the best germination percentage of 84.4% on 14th day. This study is in agreement with Samba et al.,[7] who worked on germination and propagation methods of *Jatropha curcas* L. and recorded maximum germination percentage of 86% within 15 days after sowing. This research work is also not at variance with the results of Charlic[8] who investigated the seed germination and seedlings performance of *Jatropha curcas* L. fruit base on the colour at two different seasons in Northern Philippines and attained a maximum germination of 93.3% from dark yellow fruit. High germination percentage is one of the early growth indicators for a successful plantation programme especially in large scale plantings which involve huge capital. Poor germination could lead to failure in meeting seedlings demand either in private or commercial nurseries. Record and history of germination performance of a desired species would be a useful tool for plantation farmers and managers.

Seedlings height

Seedlings height from seeds sourced from Ukum, Makurdi and Otukpo provenances were significantly different (p<0.05). Thus, the mean value from Otukpo provenance was higher while the lowest was recorded in Makurdi. Growth in height generally was highest for the 8th weeks in all the seed sources (Table 3). The lowest percentage growth rate was recorded on the 2nd week (Table 3). Seedlings height at the early stage is a vital indicator of plant success in the field because all other observable morphological characteristics of plant especially the ones involved in this study are controlled by seedling height. The number of leaves a plant produces depends on the plant height and the branching pattern. The taller the plant especially at the early growth stage, the more number of leaves produced along the whole length.

Plant height is the first observable morphological characteristics when assessing growth. Height growth in plants is as a result of apical bud. Highly significant variation in height was observed between the seed sources. This variability may have to do with genetic characteristic of the seed and environmental factors. This is in agreement with Kramer & Kozloweski[9] who stated that interval between growth flushes among the tree populations and climatic regimes. Wolde Meskel & Sindair[10] reported that *Acacia nilotica* from different Seed sources were significant in variability of shoot length.

Girth

Results on seedlings girth Table 2 indicated that seedlings collar diameter from seeds sourced from Ukum and Makurdi provenances was not significantly different from each other (p>0.05). However, there was significant difference between Otukpo and Makurdi and between Otukpo and Ukum (p<0.05) although that of Otukpo had a higher mean value. The lowest mean collar diameter was recorded from plant which seed collected were from Makurdi. Collar diameter is one of the useful morphological measures of seedlings quality.[11] It indicates the durability of seedlings and those with larger diameter are better supported and could withstand bending better than those with smaller diameter. Yakubu et al.[12] & Ige et al.,[11] had stated that seedling with larger diameter performed better on the field when transplanted.

Number of leaves

Table 2 showed that leaf seedlings whose seeds were collected from Ukum and Makurdi were not significantly different from each other ($p>0.05$). Whereas there was significant difference between Otukpo and Ukum, and between Otukpo and Makurdi ($p<0.05$).This is in agreement with the results of Jimoh who reported that, there were significant differences among the stem cuttings of *Tetrapleura tetraptera* from different seed sources. However, in Figure 3 Otukpo had higher mean number of leaves while Makurdi recorded the least

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mean value. Number of leaves and specific leaf area are very important in the sequestration of carbon II oxide. It is useful in amelioration of climate change.

Leaf area

Plant leaf area from seeds that were collected from Ukum, Makurdi and Otukpo were not significantly different ($p>0.05$) with one another (Table 2). Ukum seed source recorded the highest performance in leaf area while the least performance was recorded in Makurdi seed source. This disagrees with the results of Chijioke[13] that *Tithonia diversiflora* from different seed sources were significant in variability of leaf area.

Conclusion

J. curcas seeds sourced from different provenances was significantly different in the study area. This implied that seed sources (provenances) had significant effect on the germination rate and seedlings growth of *J. curcas* seeds in the study area. Seeds from different provenances had varying viability as it was observed that seeds sourced from Otukpo provenance had the highest germination rate and growth variables. Germination rates were highly significant among the three provenances. Thus, this finding attested that *J. curcas* can be best grown for successful plantation establishment in the study area with seeds sourced from Otukpo provenance. Therefore, it is recommended that when raising *J. curcas* seedlings for plantation establishment in the study area, seed source should be considered as a factor; because it aids in bringing out a vigorous and quality source for seeds collection during plantation establishment for sustainable forest management.

Acknowledgments

None

Conflicts of interest

The author declares there are no conflicts of interest.

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