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Research Article

Eco-zone Variation in Early Growth and Seedling Morphology of *Jatropha curcas* in Nursery Environment in Southern Guinea Savanna, Nigeria

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ABSTRACT

Scientists reported that *J. curcas* thrive on all environments without stating its responses in growth characteristics across geographic regions. We carried out this study to investigate differences in early growth morphology of *J. carcus* across four ecological zones in Nigeria to determine best provenance for plantation establishment. Seeds were collected from four zones and raised in nursery in complete randomized design (CRD) with four replications per zone for 18 weeks. Growth parameters were assessed. Collected data were analyzed. (ANOVA) revealed that growth parameters were highly significantly different ($p \leq 0.1$) from each other. Mean LSD shows that Gusau provenance gave the best values 16.010 cm for height, 5.720 cm for collar diameter, 9.685 cm for number of leaves, and 8.827 cm for stalk length. Measured parameters of plant from Lafia provenance were the least. *J. curcas* varies in growth characteristics across ecological zones. Best provenance for Southern Guinea is Gusau, in Northern Guinea savanna.

Key words: Eco-variation, provenance, seedling morphology, *Jatropha carcus*, carbon sequestration

INTRODUCTION

Jatropha curcas is believed to be a wild plant and is reported (Jongschaap *et al*., 2004; Tiwari *et al*. 2007; Good, 1974) to be able to withstand drought and harsh soil conditions. It has also been reported (Behera *et al*. 2010; Jongschaap *et al*., 2007) that the plant could grow on diverse habitat and eco-physiological regions with minimum cultural practices. Its natural habitat cuts across continents and wide range of ecological zones (Reidacker and Roy, 1998) yet there is no research information on its early growth characteristics. *Jathropha curcas* had been introduced into Africa particularly Zimbabwe, in the 1940's and had since then spread to many parts of that country with concentration in the north eastern districts among rural farmers. It has been widely distributed in Ghana and in Nigeria, it has been found to sequester a high percentage of atmospheric carbon dioxide with specific leaf area of 393.773cm^2 gm^{-1} apart from biofuel production (Muys *et al*., 2007; Agaceta *et al*. 2006; Igboanugo *et al*., 2010).

There has been global awakening in efforts towards harnessing the potentials of *Jatropha curcas* in carbon sequestration, land reclamation (Jones and Miller, 1991), erosion control (Raidacker *et al*., 1998), and bio-fuel production (Kumar, 1998; Raina, 1985; FAO, 2000). Despite these potentials the species is still regarded as a wild plant which tends to hinder plantation establishment in Nigeria. Traditionally, *J. curcas* is propagated through cuttings and planted as live fences around homestead, in field boundaries, garden and along roads either to keep out livestock, or as boundary line. Plants generally respond differently to different environmental conditions depending on the climatic factors prevailing in that ecological zone. If the plant must remain a resource base for carbon sequestration in the midst of global warming impacts, there is need for domestication through plantation establishment. This study was undertaken to ascertain the best provenance in Nigeria based on early growth and seedling morphological characters, for a successful large scale establishment programme.

MATERIALS AND METHODS

The study was carried out at the Forest nursery Department of Forestry, Wildlife and Fisheries, Nasarawa State University, Lafia Campus, Nasarawa State, Nigeria. It falls within the southern guinea savanna zone of Nigeria

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and lies between latitude 08.33' N, and longitude 08. 32'E. It has an elevation of 175m above sea level, with sandy loam soil.

Mean rainfall per annum is 1132mm while the minimum and maximum temperature per annum is 24°C and 33°C. Mature and healthy seeds of *Jartropa curcas* were collected from trees from four locations which fall into four ecological zones in Nigeria namely Ibadan (Rain forest zone), Sokoto (Sudan savanna zone), Gusau (Northern Guinea savanna zone), and Lafia (Southern guinea savanna zone). Seeds were sun-dried for one week and sown on a prepared germination beds. The sowing was arranged in a Completely Randomized Design (CRD) with four treatments which were the provenances. Each treatment (provenance) had five beds of dimension 60 x 60cm with one seed of the plant sown on them and replicated four times. There were a total of 20 seeds under each treatment making a sum of 80 seeds for the experiment.

Germination counts were recorded on daily basis from the first day of germination through for 30 days. Measurement for early growth characteristics such as survival percentage (%), collar diameter (cm), total height (cm), number of leaves and stalk length (cm) were recorded weekly from the 30th day after sowing, for twelve weeks. The data from germination and early growth characteristics were subjected to two-way analysis of variance (ANOVA) to determine the degree of variation between the provenances. Germination data were transformed using Arcsine percentage transformation to conform to the general assumptions of ANOVA. Treatments found to be significantly different were separated using Fisher's Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Variation in germination count

The result of this study (Table 3) showed that germination count of seeds that were collected from the four ecological zones varies significantly from each other (P> 0.5) Seeds that were collected from Gusau (Northern Guinea Savanna) had the best germination percentage. The next better germination count was recorded from seeds collected from Sokoto (Sudan Savanna) while the least was from those collected from lafia (Southern Guinea Savanna). 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 desire species would be a useful tool for plantation farmers and managers.

Analysis of variance result (Table 2) showed that plant height, collar diameter, number of leaves and stalk length were highly significantly (P>0.5) different from one another across the ecological zones.

Plant height

Plant height from seeds that were collected from Gusau and Sokoto were not significant in their differences (P>0.5) with one another (Table 3). However, the mean height for Gusau was higher. Plant height of seeds collected from Ibadan was significantly different from the one obtained from Lafia which had a better mean height. Growth in height generally was highest for the first 6 weeks amounting to 36.5% (Table 1) while it was 4.82% for the last 6 weeks of observation. There was a rapid rate of growth in height during the first 2 weeks after germination (73%) but as it approached the 4th week, the rate fell from 54% in the 3rd week to 29.43% thereon to the 12th week. The least percentage growth rate was recorded in the 5th week (2.35%). Within the first 2 weeks of growth and thereon, the plant draws from the carbohydrate stored in the seed and thus showed growth response rapidly. As the period of observation increases the seedlings began to exhaust the carbohydrate stored in the seed by reason of on-going growth, thereby began to show reduction in growth characters while the root began to form in preparation to absorb nutrients from the soil. When that process is completed, growth parameters would become increasing again. These could bring about fluctuation in growth rate of seedling height and indeed other morphological characters.

Plant 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 control 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.

Collar diameter

The percentage growth for collar diameter (Table 1) was 75.42% for the first 6 weeks, with profuse rate of 368.97% within the 1st 2 weeks, thereby fluctuating decreasingly to the end of the experiment. The maximum weekly rate was recorded in the first 2 weeks 668.97% while the minimum was recorded in 7th week of observation (0.01%). Result of least significant test (Table 3) indicated that plant collar diameter from seeds collected from Gusau and Ibadan were not significantly different from each other (P>0.5) although that of Ibadan had a higher mean value. Also, collar diameter of plants which seeds came from Sokoto and Lafia were not significantly different from each other (P<0.5). The least mean collar diameter was recorded from plant which provenance was Sokoto.

Collar diameter is one of the useful morphological measures of seedlings quality (Ige *et al*., 2010).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.*, 2010) and Ige *et al*., (2010) had stated that seedling with larger diameter performed better on the field when transplanted.

Number of leaves

The mean percentage number of leaves produced within the first 6 weeks was 143.07% with the highest percentage recorded in within the first 2 weeks (368.97%) (Table1). Mean percentage leave production in the last 6 weeks of observation was 6.57%. That has shown that leaf

Table 1: Means and percentage growth in seedling morphology of *J curcas* from 1-12 weeks

Wk	Ht(cm)	CD(cm)	NL	SL(cm)
1	3.422	0.564	0.562	0.578
	73.14%	368.97%	788.07%	392.04%
2	5.925	2.645	4.991	2.844
	54.00%	43.97%	32.91%	67.36%
3	9.125	3.812	6.634	4.800
	36.98%	13.11%	11.16%	36.18%
4	11.500	4.312	7.375	6.537
	29.34%	21.75%	22.71%	33.62%
5	14.875	5.250	9.050	8.735
	2.35%	4.76%	3.59%	10.89%
6	15.225	5.500	9.375	9.687
	21.10%	20.80%	12.73%	12.26%
7	18.438	6.644	10.569	10.875
	3.45%	0.01%	6.44%	0.61%
8	19.075	6.645	11.250	10.942
	3.01%	9.85%	6.16%	3.36%
9	19.650	7.300	11.944	11.310
	8.72%	8.13%	7.51%	2.95%
10	21.364	7.894	12.841	11.644
	3.88%	3.87%	6.43%	4.66%
11	22.193	8.200	13.667	12.187
	5.15%	6.12%	1.33%	6.26%
12	23.338	8.702	13.850	12.950

Ht=Height, CD=Collar diameter, NL= Number of Leaves, SL=Stalk length

Table 2: Analysis of variance for Height, Collar diameter, Number of leaf and Stalk length versus location and duration

SV	df	SS	MS	F-cal	
Ht (cm)	Lc	3	101.2536	33.7512	0.001**
	Wk	11	7577.7307	688.8846	0.001**
	Lc+Wk	33	105.4642	3.1959	0.001**
	Error	141	38.7457	0.2748	
	Total	191	7827.4470		
Cd (cm)	Lc	3	5.6252	1.8751	0.001**
	Wk	11	1052.5949	95.6904	0.001**
	Lc+Wk	33	39.8084	1.2063	0.001**
	Error	141	41.5681	0.2969	
	Total	191	1110.3101		
NL	Lc	3	22.2395	7.4132	0.001**
	Wk	11	2727.7151	247.9741	0.001**
	Lc+Wk	33	47.9382	1.4527	0.001**
	Error	141	71.5844	0.5077	
	Total	191	2871.0691		
SL (cm)	Lc	3	25.8533	8.6178	0.001**
	Wk	11	2823.3252	256.6659	0.001**
	Lc+Wk	33	51.8528	1.5713	0.001**
	Error	141	41.3283	0.2931	
	Total	191	2943.7515		

** Highly significant at 1% level of probability.

Table 3: LSD in means across ecological zones

Source	Germination %	Ht (cm)	CD(cm)	LN	SL
Gusau	100^{a}	16.010^{a}	5.720^{a}	9.685^{a}	8.827^{a}
Sokoto	71^{b}	15.673^{a}	5.408^{b}	9.177^{c}	8.362^{b}
Ibadan	62^{c}	15.575^{b}	5.847^{a}	9.643^{b}	8.989^{a}
Lafia	54^{d}	14.118^{c}	5.515^{b}	8.865	8.068^{C}

Mean with the same superscript alphabet are not significant different at 5% level of probability.

production decreases as the period of observation increases. However, with onset of branches in a plant, the number of leaves produced is bound to increase. The minimum mean percentage leaves production occurred at the last two weeks of observation (1.33%). Means separation (Table 3) showed that leaves number from seedlings whose seeds were collected from Gusau and Lafia were not significantly different from each other (P>0.5) but those from Lafia had higher mean number of leaves. There were significant differences in number of leaves (P>0.5) between seedlings of Ibadan and Sokoto provenances; however, Sokoto provenance had the least mean number of leaves.

Number of leaves and specific leave area is very important in the sequestration of carbon II oxide (Co_2). It is useful in amelioration of climate change. However, leave size earlier investigated by Igboanugo *et al*. (2010) was not repeated in this study.

Stalk length

In the first 6 weeks of observation (Table 1), the first 2 weeks recorded the highest mean percentage growth in the stalk length of the plant (392.04%). Mean percentage increase for the last 6 weeks was 5.01% with the minimum recorded at week 7 (0.061%). The general observation on table 1 is that all the measured early growth characteristics were highest in performance within the first 2 weeks of experiment. That is because there had been an earlier record of plant height of 73% within that period which directly positively affected the collar diameter, the number of leaves and the stalk length.

The result (Table 3) showed that stalk length from seeds which seeds were collected from Gusau and Ibadan were not significantly different (P<0.5). Those from Sokoto and Lafia provenances were different significantly (P>0.5) from each other. Ibadan provenance had better mean stalk length than Gusau provenance. Sokoto provenance had the least mean stalk length. Stalk length of plant is an important factor when making choice of species with the intention of erosion control and soil stabilization. The shorter the leaf stalks, the closer the leaves to the main plant, and the less the open space for direct force of rain drops on soil. The closer leaves by virtue of short leaf stalk are able to shade rain drops leading to soil stabilization and reduction in water-soil erosion.

Eco-zone variation in morphological characteristics

Result (Table 3) showed that all four early growth morphological characteristics including germination count investigated in this study namely plant height, collar diameter, number of leaves and leaf stalk length of seeds collected from the northern guinea savanna was the most significant (P<0.5) among the four ecological zones.

The northern guinea savanna is characterized with long dry season from September (Unanaonwi, 2008). Rainfall in the zone is erratic in nature and small in quantity with annual mean of 724mm and of uneven distribution with peak in August. Mean annual temperature fluctuates between 15^{o} C and 41^{o} C, January and April respectively (ZADP, 1996). Climatic and edaphic conditions in the southern guinea savanna is relatively better than that of the northern guinea savanna but surprisingly the Lafia provenance did not give the highest level of significance in the growth characters investigated. The reason could be that of adaptability. The Lafia provenance were already adapted to its natural ecology and therefore showed no significant differences in growth characters from other provenances because the plants were raised in its natural geographic environment.

The Gusau provenance being raised in the nursery environment in the southern guinea savanna could have taken advantage of the improved climatic and soil conditions there and thereby performed better. Seeds of Ibadan provenance in the rain forest zone could perform low in growth assessment on crossing to the southern guinea savanna zone due to sharp climatic differences. The Sudan savanna provenance was the second best of the four provenances. It as well indicated that there is relationship between performance in growth characteristics from one ecological zone to another The Sudan savanna is drier than the northern guinea and seeds from Sokoto could probably not have responded so sharply on being planted in the southern guinea even though the conditions were better. Seedlings would need to adjust away from its known harsh conditions of growth when raised in a better environment, thereafter, it could pick up in the second generation. Sokoto provenance could not surpass Gusau provenance though in the same axis, because the northern guinea savanna is still nearer to the southern guinea savanna than the Sudan savanna. Since Lafia provenance did not give the best results in the growth characters assessed despite climatic and edaphic adaptability, it therefore means that if the provenances are held constant while the nursery environment is varied across the four ecological zones, there would be significant differences recorded in these parameters as well. This study has however, showed that the best provenance for planting within the southern guinea savanna should come from the northern guinea savanna.

Conclusion

The study has indicated that *J. curcas* will respond differently in growth characteristics when raised in different ecological zones. Measurements taken from seeds of Gusau provenance in the northern guinea savanna gave the best early growth performance results. Seeds for planting in the southern guinea savanna zone should be collected from the northern guinea savanna zone.

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