

Nig. J. Biotech. Vol. 38 (1) : 109-119 (June 2021)
 ISSN: 0189 1731
 Available online at
<http://www.ajol.info/index.php/njb/index>
 and www.biotechstocietynigeria.org
 DOI: <https://dx.doi.org/10.4314/njb.v38i1.13>



Morphological diversity in growth characteristics of *Jatropha curcas* I. accessions from South- West Nigeria

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Abstract

Jatropha curcas is a multi-purpose tree with significant economic importance that has not been fully exploited due to lack of adequate breeding programme in Nigeria. Consequently upon this, 31 accessions collected from 4 states in Southwestern Nigeria were assessed for their morphological diversity in order to establish this as a bed rock for further breeding programmes. Data were collected on plant height, numbers of leaves and collar diameter; these were subjected to analysis of variance, principal component analysis and cluster analysis using Minitab version 17. The results showed significant differences ($p \leq 0.05$) among the 31 accessions assessed. Principal component analysis indicated that the first three axes contributed 97.8% of the total variation observed. The first axis accounted for 68% of the total variation while the second and third axes accounted for 24.7% and 5.1%, respectively, of the total variation recorded. Cluster analysis as well as the dendrogram revealed three distinct clusters of genetic similarities and differences. High genetic similarities were observed among accessions collected from the different states whereas some accessions collected from similar regions had low genetic similarities. Cluster 1 consisted of 21 genotypes with their characters falling below the grand mean. Cluster 2 had nine genotypes, they produced the highest values for all the characters assessed. Cluster 3 with only one genotype has its values below the ground mean. Members of cluster 2 have proven to be superior. The existence of morphological diversity offers potential for selection among the accessions in the breeding of *J. curcas* from southwestern Nigeria.

Keywords: diversity, clustering, accessions, *Jatropha curcas*, characters

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Introduction

Jatropha curcas belongs to the family of *Euphorbiaceae*. It is also known as a physic nut. It is a tree with economic importance and many uses. It grows well in arid and semi-arid regions and can be used to prevent soil erosion (Nahar and Ozores-Hampton, 2011). *J. curcas* grows well in areas with varying rainfall distribution and so it can withstand drought. It is easy to propagate through seeds, requires minimum silvicultural practices and can produce seeds for about 50 years. Biodiesel, which is an

alternative diesel fuel, can be produced from natural renewable sources such as vegetable oils and fats from animals (Sukarin *et al.*, 1987; Kumar and Sharma 2008; Sujatha *et al.*, 2008; Sharama *et al.*, 2011). Due to the 30% oil composition of its nut and with the increasing interest in the production of biodiesel, *J. curcas* is now considered as one of the promising sources of biodiesel (Shabanimofrad *et al.*, 2011; Cai *et al.*, 2010; Divakara *et al.*, 2010; Gohil and Pandya 2009; Achten *et al.*, 2008; Ganesh Ram *et al.*, 2008). Reports have shown that the maximum oil content for *J. curcas* seeds has been close to 47%

whereas the accepted oil content average is 37 - 40%. Thus, *J. curcas* is seen as a potential plant for future production of biodiesel (Jongschaap, *et al.*, 2007). Apart from its potentials for biodiesel production, *J. curcas* can also be used for several purposes which include but not limited to saponification of oil in the process of making soap, cleaning, dye for clothes, and organic fertilizer. It is used also in cosmetic manufacturing in many tropical countries (Martinez-Herrera, *et al.*, 2006). *J. curcas* oil is also used to soften leather and can serve as a lubricant for machines and its parts. Virtually every part of the plant has its own uses which makes it an economically important species (Gubitz, *et al.*, 1999).

Of the many species existing in different parts of the world, *J. curcas* is the commonest species found in Nigeria. In fact, Heller, in 1996 reported that there are about 165-175 known species from the genus *Jatropha*. There are several names used to describe the plant in different parts of Nigeria. It is known as Binidazugu in Hausa language and Lapalapa in Yoruba language. (Blench, 2007 and Blench, 2003)

The change in color of the capsule from green to yellow is an indication that the seeds are mature. A mature seed generally contains around 20% saturated fatty acids with 80% unsaturated fatty acids. It can yield up to 25%–40% oil by weight. The oil basically consists of Linoleic and Oleic acids (Nahar, and Ozores-Hampton, 2011).

Due to the enormous potentials of this species for biodiesel production, several people have started to embark on its plantation (King *et al.*, 2009), but despite this effort, quality planting material is still not available (Ghosh and Singh 2011; Shuit *et al.*, 2010).

Knowledge about the degree of genetic diversity between inter and intra populations are needed to gain the first ideas about where to find potentially important genetic material. *J. curcas* genetic resources have been reported but only limited and scattered knowledge is available on the basic reproductive biology of the species. In addition, little information has been reported on its quantitative genetic variations, such as genetic variance components, heritability, heterosis and effects of interaction between genotypes and environment. Also, one factor of key importance for conducting breeding programs is genetic variability but there is dearth of information available for *J. curcas* (Franco *et al.*, 2001; Achten *et al.*, 2010; Sun *et al.*, 2008).

In recent years, some researchers have reported genetic variation in the *Jatropha* populations from India, China, Latin America and Malaysia based on morphological and agronomical characters by using morphological and molecular techniques (Shabanimofrad *et al.*, 2013; Rafii *et al.*, 2012a; Rao *et al.*, 2008; Kaushik *et al.*, 2007; Ginwal *et al.*, 2005). But such information has not been documented for the *J. curcas* population in Southwestern Nigeria; hence, this study is aimed at investigating the morphological diversity of *J. curcas* accessions and to determine the genetic components of the important characters in the *J. curcas* accessions.

Materials and Methods

Sources of Planting Materials

Thirty one (31) accessions of *J. curcas* seeds were collected from various communities across several states in South-Western Nigeria. In each of the states, plant samples were collected over a distance not less than 20m apart in order to avoid collecting multiple seeds from the same parents. From each individual plant, seeds were collected, labelled and placed in plastic bags.

Table 1: List of accessions and their source

Genotypes	Accession Code	Source
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G1	JAT01	Ibadan, Oyo State
G2	JAT02	Shaki, Oyo State
G3	JAT03	Iseyin, Oyo State
G4	JAT04	Igbo-Ora, Oyo State
G5	JAT05	Igbeti, Oyo State
G6	JAT06	Igboho, Oyo state
G7	JAT07	Sepeteri, Oyo State
G8	JAT08	Kisi, Oyo State
G9	JAT09	Eruwa, Oyo state
G10	JAT10	Ife, Osun State
G11	JAT11	Osogbo, Osun State.
G12	JAT12	Ilesha, Osun State.
G13	JAT13	Ikirun, Osun State.
G14	JAT14	Ede, Osun State.
G15	JAT15	Ila, Osun State.
G16	JAT16	Iwo, Osun State.
G17	JAT17	Gbongan, Osun State.
G18	JAT18	Ado-Ekiti, Ekiti State.
G19	JAT19	Ijero, Ekiti State.
G20	JAT20	Ikole, Ekiti State.
G21	JAT21	Oye, Ekiti State.
G22	JAT22	Emure, Ekiti State.
G23	JAT23	Ikere-Ekiti, Ekiti State.
G24	JAT24	Akure, Ondo State.
G25	JAT25	Okitipupa, Ondo State.
G26	JAT26	Ikare, Ondo State.
G27	JAT27	Owo, Ondo State.
G28	JAT28	Akungba, Ondo State.
G29	JAT29	Idanre, Ondo State.
G30	JAT30	Ilara-Mokin, Ondo State.
G31	JAT31	Oka-Akoko, Ondo State

Experimental site

The experiment was carried out at the arboretum of the Forestry Research Institute of Nigeria (FRIN). Headquarters, Jericho, Ibadan. Nigeria is located between 07023'18"N to 07023'43"N longitude and 03051'20"E to 03051'43"E latitude. The climate of the area is the West African monsoon with distinct dry and wet seasons. The dry season usually starts from November and runs through March. The wet season on the other hand, generally runs through April to October with strong winds and thunderstorms occasionally. Mean annual rainfall falls around 1548.9 mm approximately, within 90 days. The temperature ranges from 31.9°C maximum to 24.2°C minimum, while the relative humidity is about 71.9% daily (FRIN 2015).

Description of the plant material

Twenty seeds from each of the accessions were sown in germination trays. After which fifteen seedlings from each of the accessions were transplanted into polythene pots, from these ten seedlings were selected in each of the accessions for data collection. The experiment was laid out in a Completely Randomized Design (CRD) with ten replications.

Data for each character were recorded on 310 individual seedlings.

Data collection and analysis

Data was collected on

- Number of leaves by counting the leaves
- Collar diameter by the use of digital vernier caliper
- Plant height by the use of meter rule

Data collected were subjected to analysis of variance, principal component analysis as well as cluster analysis using Minitab version 17. Means were separated using fisherman's significant difference ($p \leq 0.05$).

Results

The mean square analysis for the thirty one accessions of *J. curcas* revealed significant differences for all the characters, which validated further statistical analysis (Table 2). These results indicate the presence of morphological variation among the accessions studied. The accessions differ significantly at $p \leq 0.05$.

Table 2: Mean square analysis for variation in morphological characters in 31 accessions of *J. curcas*

Source of variation	Sum of Squares	Df	CD	NL	PH.
Accession	173.254	30	5.775*	3.241*	37.368*
Error	1694.511	279	6.074	1.937	30.965
Total	1867.765	309			

* $p \leq 0.05$, CD= collar diameter, NL= number of leaves, Ph=Plant height

The mean values for different three morphological traits are presented in Table 3. Out of 31 accessions, only 16 accessions (51.61%) have means above the average collar diameter. Collar diameter ranged from 6.183mm to 9.078mm with accession JAT23 showing the least collar diameter. Highest collar diameter was accessioned JAT03 (9.078mm), followed by JAT26 (8.599mm) and JAT12 (8.596mm).

Highest number of leaves was found in accession 19 (**6.135**), followed by accession 31 (6.02) and accession 25 (6.01), two of which are from Ondo state (JAT 25 and JAT 31) while JAT 19 was from Ekiti state. The number of leaves ranged from

3.665 (JAT1) to 6.135 (JAT19). Less than 50% of the accessions (15 accessions) have a high number of leaves. Out of this, 12 accessions had both high collar diameter as well as high number of leaves.

The mean values for plant height ranged from 12.166cm (JAT 23) to 20.387cm (JAT4). Seventeen accessions (54.839%) had their means greater than the grand mean. Out of these, 7 accessions (22.58%) have high collar diameter, number of leaves and plant height.

Table 3: Mean performance of 31 accessions for morphological traits in *J. curcas*

Accessions code	Collar diameter	Number of leaves	Plant height
JAT01	6.241737	3.665	14.70158
JAT02	7.806684	4.855	19.45895
JAT03	9.077737	5.125	17.48526
JAT04	8.187105	4.845	20.38789
JAT05	8.212053	5.155	17.98421
JAT06	7.005789	4.255	14.91053

JAT07	7.228947	4.390	16.22211
JAT08	6.516368	4.570	14.68421
JAT09	8.231474	5.495	19.97421
JAT10	8.136947	5.015	19.21053
JAT11	8.298895	4.945	19.08
JAT12	8.596211	5.265	18.99632
JAT13	7.648895	5.085	17.10579
JAT14	7.401632	5.185	17.27684
JAT15	6.572421	4.870	16.52053
JAT16	7.775842	5.470	17.48737
JAT17	8.305105	5.810	19.35316
JAT18	7.706421	5.400	15.66842
JAT19	8.584211	6.135	15.16632
JAT20	7.450474	5.230	16.17158
JAT21	8.173947	5.664	17.27737
JAT22	6.396368	4.905	15.46
JAT23	6.183737	4.735	12.16632
JAT24	8.147895	5.590	19.59895
JAT25	7.782474	6.010	17.17474
JAT26	8.599316	5.970	19.54947
JAT27	7.373684	5.430	16.08368
JAT28	7.756105	5.800	15.77632
JAT29	7.606368	5.915	16.52158
JAT30	6.897	5.190	17.21558
JAT31	8.388158	6.020	15.44947
Mean \pm SE	7.687 \pm 0.136	5.226 \pm 0.102	17.101 \pm 0.347

Fisherman (5%)	0.544	0.018	0.218
CV	9.89	10.89	11.3

Table 4 shows the Eigen values, percentage of total variation accounted for and the cumulative percentage of the first three component axes of *J. curcas*. The first three axes contributed 97.8% of the total variation observed. The first axis accounted for 68% of the total variation while the second and third axes accounted for 24.7% and 5.1% respectively of the total variation seen.

Table 4: Eigen values, percentage of total variation accounted for and cumulative percentage by the first three component axes of *J. curcas*

Principal component	Eigen value	Percentage variation accounted for	Cumulative percentage
1	2.04	68.00	68.00
2	1.74	24.70	92.70
3	1.20	05.10	97.80

Table 5 shows the three axes and their character loading. According to Hair *et al.*, (1995) usually, Eigen values greater than one are considered significant and component loading greater than 0.30 are also considered to be meaningful. All the

characters contributed to the variation in the first principal component axis. The second axis was loaded by plant height and number of leaves while the all three characters made entries and loaded the third axis.

Table 5: The three axes and their character loading

Variable	PC1	PC2	PC3
Plant height	0.546	-0.676	-0.495
Number of leaves	0.523	0.736	-0.430
Collar diameter	0.655	-0.024	0.755

Means characters of three *J. curcas* groups is as presented in Table 6. Cluster 1 comprises 21 genotypes. All their characters are below the grand mean. Cluster 2 had nine genotypes, they produced the highest values for all the characters assessed. Cluster 3 with only one genotype with its values fallen below the ground mean.

Table 6: Mean of Morphological characters evaluated in three *J. curcas* clusters

Variables	Cluster1 1,6,8,7,15,22,3,5,13,14,30,16,21	Cluster2 2,9,10,11,12, ,17 24,26,4	Cluster3 23	Mean and standard deviation
Plant height	16.302	19.512	17.100	17.638(1.671)

Number of leaves	5.213	5.310	5.223	5.249(0.053)
Collar diameter	7.514	8.257	7.687	7.819(0.389)
Cluster sum of square	39.483	3.476	0	
Average distance	1.242	0.594	0	

The dendrogram from the Complete Linkage Cluster Analysis is as presented in Figure 1. This illustrated the relationship in terms of similarities and differences among the 31 accessions. At 100% level of similarity, all the genotypes had

formed a single cluster, meaning that all the accessions were distinct at 100% level of similarity. The dendrogram revealed three distinct clusters of the genotype at 33.33% similarity level.

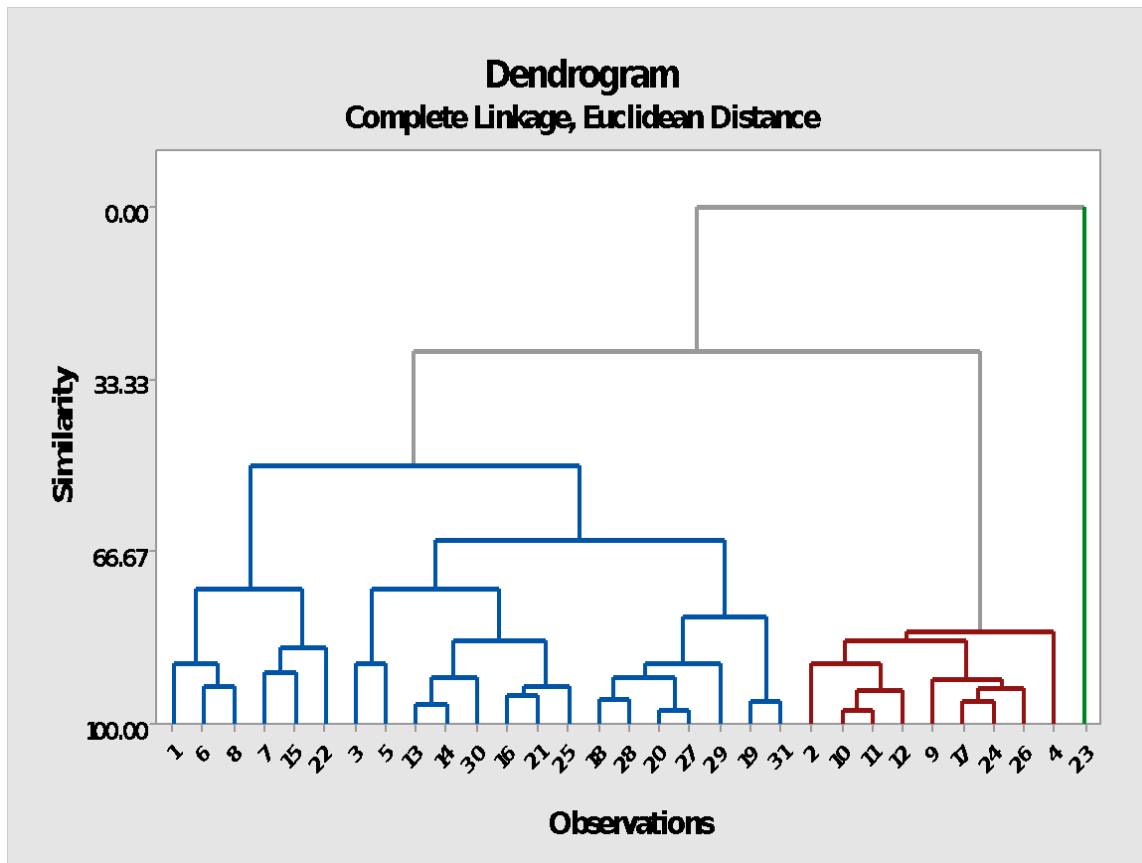


Figure 1: Dendrogram of 31 accessions of *Jatropha curcas*

The biplot of Principal axes 1 and 2 is presented in Figure 2. It showed that genotypes 30, 28, 27, 8 and 23 were the most distinct genotypes as well

as genotype 1 and 13. Genotypes 2, 4, 7, 9, 16, 18, 21, and 31 are the least variable.

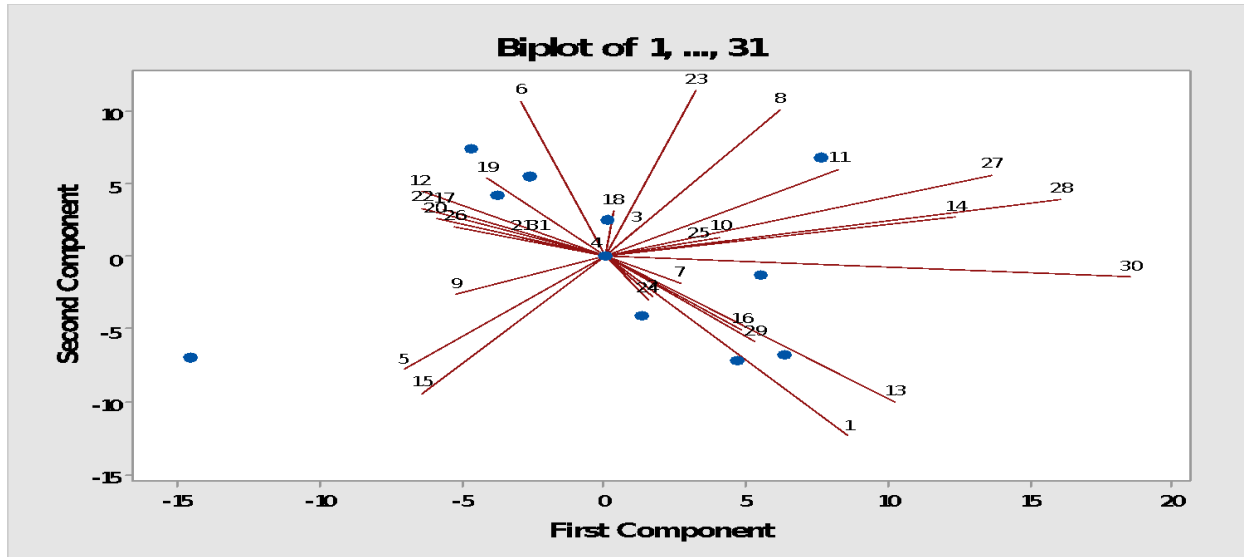


Figure2: Biplot of Principal Component Axes 1 and 2 of 31 Accessions of *J. curcas*

Discussion

Genetic diversity is an important factor in plant breeding because it informs the choice of genotypes for selection and providing this in *Jatropha* breeding for traits improvement is very crucial. There were significant differences observed among the accessions used in this study for all the morphological characters (number of leaves, collar diameter and plant height) examined as this is an indication of broad genetic base in the accessions used. The result from the assessment of these traits from all the accessions under study clearly showed that 7 (22.58%) out of the 31 accessions have their mean greater than the grand mean. 1 from Oyo state, 3 from Osun state, 1 from Ekiti and 2 from Ondo state. This reflects greater adaptability of some *J. curcas* to agro climatic conditions and further suggests that variability is not related to geographical origin. This shows similarity with the work of Melo *et. al.*, (2007) who reported intraspecific variability in leaves of *J. curcas*

The differences observed were attributed to the differences in the genetic makeup of the 31 accessions used. This diversity observed therefore offers potential for selection among the accessions.

Morphological variations among the genotypes were further evaluated by Principal Component Analysis, the analysis indicated that the overall diversity observed in *J. curcas* could be explained

by the first significant three Eigen vectors. Characters like number of leaves as well as plant height were fairly distributed among three axes. Collar diameter was also important to the variations in two out of the three principal components. The differences in the contributions of the characters to the total variation is as a result of genetic differences. According to Cruz *et. al.*, (2012), knowledge on the contribution of characters to the variation observed are important in order to select those characters which best differentiate the accessions and exclude those that do not effectively contribute to genotype discrimination. Many authors have worked on the major role of morphological traits in genetic variation in plant species, such as *Irvingia gabonensis* (Atangana *et al.*, 2002) and *Dacryodes edulis* (Alaje *et. al.*, 2018; Waruhiu *et al.*, 2004)

The Dendrogram constructed revealed three distinct clusters of genetic similarities and differences. High genetic similarities were observed among genotypes collected from different States whereas some genotypes collected from similar regions had low genetic similarities. For example , genotypes JAT01 and JAT02 were collected from Oyo state but were genetically dissimilar while genotypes JAT01 and JAT30 that were collected from Oyo state and Ondo state respectively were genetically similar. This pattern of clustering indicated that there was

no association between eco-geographical distribution of genotypes and genetic diversity as genotypes selected under diverse locations, got clustered together. This indicates that genetic drift produce greater diversity than the geographic diversity (Singh *et al.*, 1996; Selvakumar *et al.*, 1989). This also is in agreement with the study of Josephine *et al.*, 2015, who reports that the genetic diversity detected in *Dacryodes edulis* was intra-population.

The cluster analysis of the 31 genotypes of *J. curcas* that exhibited three different clusters further confirmed the relationship that existed between characters. The characters contributing to the differences are usually given greater emphasis for deciding the type of clusters. This is mainly for the purpose of further selection and the choice of parent for hybridization (Jagadeb and Semal, 1991).

The significant differences observed within the *J. curcas* accessions used in this study indicated genetic divergence which is useful in breeding superior lines. Cluster analysis of the cluster mean revealed three distinct clusters of *J. curcas*. Members of cluster 2 have proven to be the superior genotypes in terms of plant height, collar diameter and number of leaves. Seven out of the 31 accessions used have high values for collar diameter, number of leaves and plant height and this offer great potential for selection. There is therefore enormous potential for selection among the genotypes due to their genetic differences.

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