Provenance Variation and Morpho-Genetic Diversity Associated with the Ecology of *Jatrophacurcas*(L) in some Selected North-Central States of Nigeria

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Abstract: A study was carried out on the provenance variation and morpho-genetic diversity associated with the ecology of *Jatrophacurcas* (L). Fifty seven provenances of *Jatrophacurcas*were collected in some locations in north-central Nigeria using structured and constructive questionnaires to obtain information on farmers' cultural and management practices. The fifty seven collections were laid out in Radom Complete Block Design (RCBD), with three replications, at the experimental and Research Garden of Plant Science and Biotechnology, Department of Biological Sciences, Nasarawa State University Keffi from 2011 to 2012 cropping seasons. Data collected were subjected to statistical analysis using descriptive statistic (ANOVA) and Principal Component Analysis to determine the pattern of variations. Cluster analysis was also carried out to determine the relationships among ecological collections. The paper discusses the results of farmer's management practices in relation to the morphogenetic diversity observed among the accessions across locations and how this can be positively engaged in the breeding and selection of this energy crop.

Key notes: *Jatrophacurcas,* Morpho-genetics, Ecology and North Central States Nigeria

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INTRODUCTION

*Jatrophacurcas*L. *(*Euphorbiaceae*)* is a small deciduous tree which can grow up to 5metres and it originated from Mexico and Central America, although nowadays it is growing pan tropic (Heller, 1996). The multipurpose crop is traditionally used for medicinal purposes, but it is also useful as living fence and for the prevention and control of soil erosion (Gitbtz*et al.*, 1999; Henning, 2006). As a pioneer species, adopted to semi-arid climates, *Jatrophacurcas* is promising to simultaneously combat desertification, produce bio-diesel and enhance socio-economic development in degraded rural areas (Francis *et al.*, 2005). In an ideal condition, the plant will fruit once in a year, yielding 2-5 tons of dry seed/ha/year, after 5 years, depending on the genetic variety, agro-climatical conditions and the management input (Heller, 1996; Francis *et al.*, 2005; Tewari, 2007). *Jatrophacurcas*withhigh adaptability (Heller, 1996) grows in a wide range of conditions. As a succulent that sheds its leaves during the dry season, the tree is well adapted to arid and semi-arid conditions (Foidi*et al.*, 1996).

The Genus *Jatropha* of Euphorbiaceae family is one of the respective biodiesel yielding tree crops. It is morphologically a diverse genus comprising 160-175 species of shrubs, herbs and small trees. About nine species of *Jatropha* have been recorded in India. Out of these important ones are *Jatrophacurcas, Jatrophagossypifolia, Jatrophaglandulifera, Jatrophamultifida*, and *Jatrophapodagrica.* Out of these nine species, *Jatrophacurcas*is one of the most important biodiesel-yielding crop. *Jatrophacurcas,*sometimes called physic nut, is a multipurpose tree of significant economic importance. It is a native of Mexico and tropical South America. The plant is reported to have been introduced to Asia and Africa by Portuguese as an oil-yielding plant. It is occurring almost throughout India and Andaman Island in semi wild condition. It is found throughout most of the tropics and is known nearly by 200 different names indicating its significance and various possible uses. It adapts well to semi-arid marginal site, waste land and dry environment (Keith, 2000).

Usman *et al.* (2013) have observed highly significant variation among 21 provenances of *Jatrophacurcas* studied for all the morphological traits studied except main stem height which showed significant differences at 0.05 level of significance only. The existence of these differences suggests the presence of considerable genetic variability among the provenances for these traits, this is most likely because these provenances were sourced from different natural environments which might have been affected by natural selection. These variations found in the morphological traits present us with a viable selection alternative at a very early stage (germplasm collection) from base seed material. This could be of use in improvement programmes especially considering the fact that *Jatrophacurcas*is a new crop in which crop breeding is still in its infancy. Provenances could be selected on the basis of distinguishable desirable traits and hybridized to obtain superior genotypes.

The genetic diversity in the natural population appears narrow since no remarkable morphological differences have been observed. Studies with mutation breeding and interspecific crossing have made little headway in increasing variability in this species. A great number of the new approaches to genetic manipulation relied on the use of cell or tissue culture and this technique can be applied to crops like *Jatrophacurcas*where the genetic variability is limited (Sujatha and Mukta, 1996). This research is aimed atevaluating the provenance variations associated with the ecology of *Jatrophacurcas*collected from some locations in North central Nigeria.

MATERIALS AND METHODS

A Randomised Complete Block Design (RCBD) with three replications was used for this research. The accessions collected from each provenance was randomly selected for the germination test in the nursery. In each plot, fifty (50) seeds of each accession collected were randomly planted. Plot sizes of 2m × 3m ($6m^2$) were used and $1m^2$ row spacing was used to separate each plot. Plots were labelled accordingly and Data was collected for the following parameters. The following morphological characteristics were observed and recorded: Plant height, leaf length, leaf diameter, seed weight, seed length, stem girth, number of branches and percentage oil content out of the 50 seeds planted only about 25 were monitored for morphological data.

The results of the data obtained were subjected to statistical analysis, such as analysis of variance to separate the means between the variables among the provenances covered. The principal component analysis was employed in order to identify the correlation and similarities among the provenances. The cluster analysis was used to determine the genetic variations among the provenances. SAS Statistical Package (SAS institute Inc. 2004) was used for all analysis, with $P \leq 0.05$ considered statistically significant for all tests. Analysis of variance were carried out using the mean separation done by Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The response of farmers (Table 1) with respect to production practices showed that many farmers propagate the crop by stem planted at some regular intervals compared to the use of seeds as a means of propagation. This is in line with the finding of Chikera*et al.* (2007) who reported on the effects of plantation spacing on yield and showed that seed yield per plant was increased significantly by increasing the spacing between plants which will reduce the seed yield per hectare. The optimum spacing could vary in different climatic and soil types. The result is also in agreement with that of Feike*et al.* (2007) who observed from his studies on the *Jatropha*plants, the propagation by cutting is more reliable than the seeds because it showed the highest biomass production.

Most farmers grow *Jatrophacurcas*crops for many uses ranging from medicinal, fencing of the house and oil production as an alternative to energy biofuel. This is in line with the findings of Abubakar (2012), who reported that the crop *Jatrophacurcas*has several industrial, pharmaceutical, environmental and other uses rather than the commercial purposes.

Farmers in all locations weeded four times and crops were reported to have matured between 1 and 2 years across location. This is because *Jatrophacurcas* is a small crop that can either be annual or biennial this is in agreement with the work of Garg*et al*. (2011) who reported that *Jatropha* crop is a small tree or large shrubs that is annual or biennial.

The analysis of variance for the different traits showed that generally, there were highly significant variation among the 57 of *Jatrophacurcas* for all the morphological traits studied except main stem height which showed no significant difference at 0.05 level of significance only. The existence of these differences suggests the presence of considerable genetic variability among the provenances for these traits. This is most likely because these provenances were sourced from different natural environments which might have been affected by natural selection. These variations found in the morphological traits present us with a viable selection alternative at a very early stage (germplasm collection) from base seed material. This could be useful in improvement programmes especially considering the fact that the *Jatrophacurcas* crop breeding is still underexploited. Provenances could be selected on the basis of distinguishable desirable traits and hybridized to obtain superior genotypes. This is in agreement with Chauhan *et al*., (2002) and Henning (2006), who were of the view that hybrids from combining different provenances may result in hybrid vigor for many characters. This also agrees with the report of Westoby (1993) that provenance selection is the simplest and quickest means of improving trees. Traits such as high number of lateral branches and high number of fruit bunch per lateral branch indicate high quality of fruits and ultimately high quantity of seeds per plant. This suggests that provenance with traits can be selected for high seed yield per plant.

The results from this study can be compared to a similar work conducted by Usman *et al*. (2013). It was observed that number of lateral branches and number of capsules per lateral branch have higher genotypic variance than other variances indicating little environment influence on these traits. Result from principal component analysis shows that three out of the ten principal components extracted had Eigen value greater than one and altogether explained 52.6 % of the total variability. Principal components 1, 2, 3, 4, and 5 contributed an additional 35.5%, 8.5%, 1.6% and 1.4%, respectively. All five principal components Table 9 together in this case explained 100% of the overall variance and the first two already explained 88.5% as was observed similary by Usman *et al.,* (2013). Seed size and seed weight are two important characters for improving seedling productivity and reducing nursery cost through the selection of quality seeds, apart from selecting and delineating provenances (Arm Strong &Westoby 1993; Isik 1986; Uniyal*et al.*, 2002). The purpose for the provenance testing is to measure the pattern of the genetic variation and to aid in selection of well adopted and highly productive seed source for agricultural practice. Within the zones which covered 57 locations of provenances studied, produced highest seedling length in their respective zones. Hence, it is clear that seeds with greater seed weight produced seedlings with higher short length. This may be due to greater nutrient reserves in larger seeds (Kathyn*et al.*, 1978). Similar trend was also reported for VirolaKoschyni (Gonzoles 1993), HardwickiaBinata (Roy 1985). Thus it could be concluded that seed size has operational importance.

Significant zonal impact revealed that environmental factors contribute in changing external appearance as the species grow in a wide range of ecological conditions and hence, population can be expected to experience markedly selective pressure on seed characters. This could arise from genetic diversity which needs to be studied in detail. Therefore, contradictory evolutionary actions mediated by biotic and abiotic agents potentially act upon plants to produce seed size distribution observed in natural plant populations (Erikson, 1999). This could be of use in improvement programme especially considering the fact that breeding is still in its infancy.

The seed observed in this study ranged between mean value of 57.61g and 67.01g (Table 3). However, seeds from Nasarawa State weighed heavier (69.01g) than Niger State and FCT (Table 6). The observed differences in seed weight might not be farfetched from the different variation for climate in seed collection centres. The average weight observed in this study is not in line with the observation of Henning (2004) and Benge (2006) who reported higher see weight of 727g from plant growing from other part of the world were generally higher in weight.

Seeds collected from all the provenances showed that Niger State and Benue State produced taller plants. Plants from Nasarawa State and Benue State produced more leaves but not statistically different from other parameters at week two. This could be attributed to high germination observed (Table 6). This finding is line with the report of Cantliffe (1998) that vigorous seeds germinated rapidly and produce normal seedling with a wide range of environmental conditions.

Plants from Niger and Benue States showed superior performance in plant height, number of branches, Girth size and leaf diameter than plants seeds from Nasarawa State, Kogi State and the FCT. This showed that plants of seeds from Benue State and Niger State channeled thephotosynthates towards height and petiole development. Whereas those from Kogi, FCT and Nasarawa States utilized the photosynthates for other parameters. The utilization of photosynthates for structural development and influence from the environment was reported by Gardner *et al*., (1985).

Selection of one trait leads to the improvement of other traits in the same direction. Plant height and number of lateral branches are important characters that can be considered as major selection indices when the objective is to incorporate Jatrophacurcas in an agro forestry system.

From the cluster analysis, it is clear that there was similarity between the leaf length and leaf diameter plants height and number of branches while girth size and the number of seed germination have no direct similarity with the remaining variables.
This showed that plants with good branching habit tend to develop more number of capsules. This is in agreement with the work of Rao *et al*,. (2008). The number of branches, leaf length and leaf diameter indicate strong correction of variables; This results indicated that selection for any of these traits will indirectly results in high seed yield obtainable from a tree. Plant height and main stem height have significant correlation with each other showing that the number of fruit bunch per branch was in agreement of Rao *et al*,. (2008).

The existence of correlation of all the morphological traits is in agreement with the findings of Alireza *et al*,. (2012) and Rao *et al*,. (2011), However, this result is not in line with the results of Rafii*et al*,. (2012) and Rao (2008)

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who reported that morphological traits may not be noticed at early stage of development. This could not be far fetch from the fact that, at one year the yield of *Jatropha* plant has not yet reached its full potentials.

CONCLUSSION

Highly significant correlation was found between the leaf height and leaf diameter, plant height and girth size and number of branches.

Principal component analysis identified number of branches, girth size, plant height and the main stems as the major traits responsible for the variation in Jatropha*curcas* L. provenance Kogi, Nasarawa State, Niger Benue and the FCT were identified as potential materials that could be used in improvement of *Jatrophacurcas*L in Nigeria. This significant difference in various morphological traits of *Jatrophacurcas* L is indicative of the possibility of selecting large and heavier seeds for further improvement work. The significant variation also revealed that environmental factors contribute in changing external appearance as the species grows in wide range ecological conditions and hence population can be expected to experience markedly selective characters of *Jatrophacurcas.* L. This could also arise from genetic diversity which needs to be studied in detail.

Table 1: Responses of farmers to Production Practices of *Jatrophacurcas*

State	Frequency	Planting method			Weeding (number of times)	Maturity (years)
		Seed	Stem	Not stated		
Benue	10	2	8	0	4	1 to 2
FCT	6	1	5	0	4	
Nasarawa	11	2	9	0	4	
Niger	8	1	6	1	4	
Total	**35**	**6**	**28**	**1**		
Standard Error	**1.11**	**0.29**	**0.91**	**0.25**		

Table 2: Frequency of collections of *Jatrophacurcas* in some North Central States of Nigeria

State	Frequency	Percent	Valid Percent	Cumulative Percent
Benue	10	28.6	28.6	28.6
FCT	6	17.1	17.1	45.7
Nasarawa	11	31.4	31.4	77.1
Niger	8	22.9	22.9	100.0
Total	**35**	**100.0**	**100.0**	

Table 3: Collection points of *Jatrophacurcas* across North Central States of Nigeria

Locations	State	Frequency	Percent

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JuniorQuarters	FCT	2.86	2.86
AbajiSeniorQuarters	FCT	2.86	2.86
Abinsi	FCT	2.86	2.86
AbiwaMbagen	BN	2.86	2.86
Aboshon	NS	2.86	2.86
Agwan-Gimba	NS	2.86	2.86
Agwan-Wuta	NS	2.86	2.86
Akwanga town	NS	2.86	2.86
Angwan-Lambu	NS	2.86	2.86
Angwan-NEPA	NS	2.86	2.86
Atako	NIG	2.86	2.86
Baida	NIG	2.86	2.86
Buga	NIG	2.86	2.86
Gada-Biu	FCT	2.86	2.86
Gade town	NIG	2.86	2.86
GangareYashi	NIG	2.86	2.86
Gudi	NIG	2.86	2.86
	NS	2.86	2.86
Gussase	NIG	2.86	2.86
Kaliko	NIG	2.86	2.86
Kampani	BN	2.86	2.86
Kashion	BN	2.86	2.86
Low Cost	NIG	2.86	2.86
Maikunkele		2.86	2.86
North Bank	NIG	2.86	2.86
Paggo	NIG	2.86	2.86
Raffin-Yashi	NIG	2.86	2.86
Sabon-Gida	BN	2.86	2.86
Tse-Alashi	BN	2.86	2.86
Tseku-cha	BN	2.86	2.86
Tyowaye		2.86	2.86
Uchi-mbako	BN	2.86	2.86
Utenge-mbakor	BN	2.86	2.86
Wowyen	BN	2.86	2.86
Zungeru	NS	2.86	2.86
Total	NS	**100.1**	**100.1**
	NG		
	35		

Table 4: Number of years of growing *Jatrophacurcas* in North-central Nigeria

Number of years	Frequency	Percent	Valid Percent	Cumulative Percent
2	9	25.7	25.7	25.7
3	5	14.3	14.3	40.0
4	7	20.0	20.0	60.0
5	8	22.9	22.9	82.9
6	5	14.3	14.3	97.2
Not stated	1	2.9	2.9	100.0
Total	**35**	**100.0**	**100.0**	

Table 5: Farmers response on planting time of *Jatrophacurcas*in North Central Nigeria

Months	Frequency	Percent	Valid Percent	Cumulative Percent
March	7	20.0		57.1
April	13	37.1	20.0	37.1
May	6	17.1	37.1	74.2
Not	9	25.7	17.1	100.0
stated	**35**	**100.0**	25.7	
Total			**100.0**	

Table 6: Combined analysis (Fct, Nasarawa, Niger, Kogi& Benue)

Principle Component Analysis
Correlation Half-Matrix

	Plant Height	*Leaf Length*	*Leaf Diameter*	*No of Branches*	*Girth Size*
Plant Height	1				
Leaf Length	0.005981485	1			
Leaf Diameter	0.607182907	0.314575487	1		
No of Branches	0.029684203	0.920501659	0.238577	1	
Girth Size	0.909459075	0.134307411	0.651597	0.160413	1

Table 8: constitution of the first 5 PC for the combined states analysis.

Latent Vectors	**PCA 1**	**PCA 2**	**PCA 3**	**PCA 4**	**PCA 5**
Plant Height	0.496	-0.382	0.351	0.690	0.094
Leaf Length	0.324	0.619	0.001	0.203	-0.686
Leaf Diameter	0.508	-0.101	-0.843	-0.012	0.145
No of Branches	0.319	0.614	0.237	-0.102	0.674
Girth Size	0.537	-0.291	0.332	-0.687	-0.211

Latent Vectors (Eigenvector)

Table 9: Eigenvalues for the Principal Component Analysis

PCA #	**(**Eigenvalue) Latent Roots	(Proportion**)** **Percentage Variance**	**Cumulative Variance**
PCA 1	2.631	52.630	52.630
PCA 2	1.795	35.898	88.528
PCA 3	0.423	8.458	96.986
PCA 4	0.082	1.635	98.621
PCA 5	0.069	1.380	100.001

Fig. 4: Cluster analysis for morphological characteristics of Nasarawa State Samples of *Jatrophacurcus*

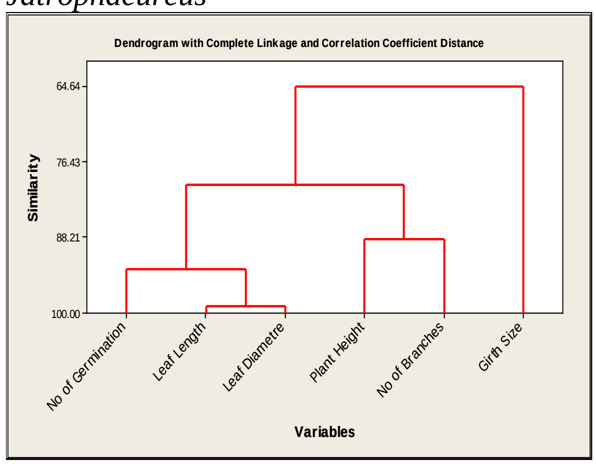

Figure 1: Cluster analysis for morphological characteristics of Niger State Samples of *Jatrophacurcus*

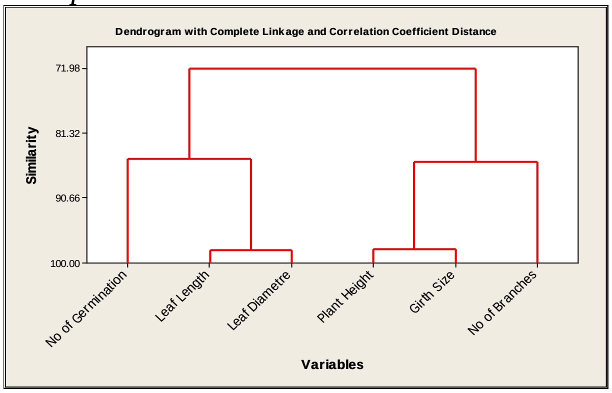

Fig. 2: Cluster analysis for morphological characteristics of Benue State Samples of *Jatrophacurcus*

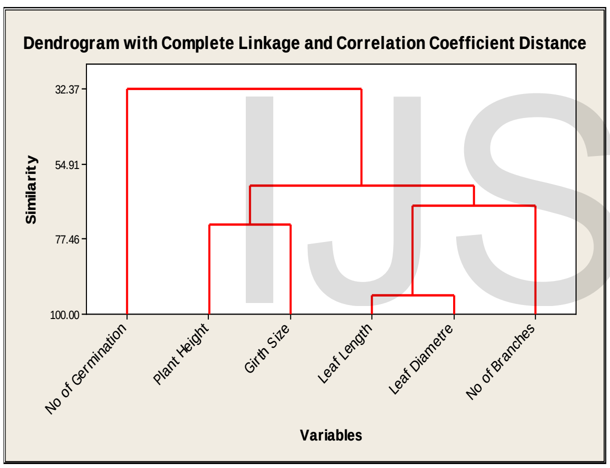

Fig. 3: Cluster Analysis for morphological characteristics of Kogi State. Samples of *Jatrophacurcus*

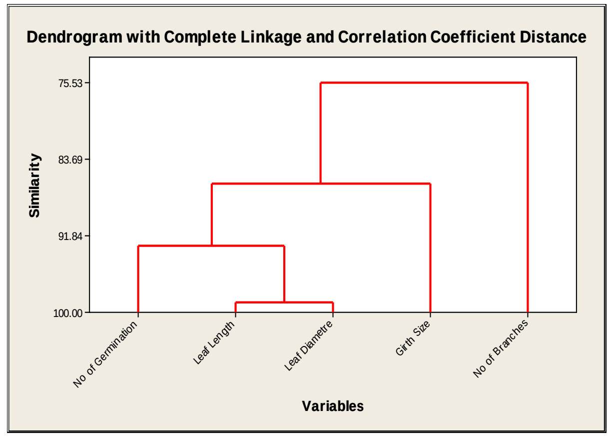

Fig. 5: Cluster analysis for morphological characteristics of FCT Samples of *Jatrophacurcus*

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