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Original Research Article

Title: Variability of fruit and seed characters and oil content of 35 accessions of *Jatropha curcas* L. grown in a semi-aride site in Senegal

Abstract

Aim: This studyhas evaluated variations in seed and fruits traits as well as the oil content of 35 accessions of *Jatropha curcas* grown in the same soil, and agroclimatic conditions in Senegal.

Methodology: The study was conducted on 35 accessions of *J. curcas* planted at the research station of Ecole Nationale Supérieure d'Agriculture located in Thies, Senegal. Fruits were collected from 1-4 years old plantations. Then, for each accession, 30 dry fruits were randomly selected and were subjected to measurements of the size parameters (length, diameter) and weight using respectively an electronic caliper and an electronic balance. Fruits were peeled and shells weighed. A sample of 20 seeds per accession was selected with 3 replications for seed traits measurements (length, width and thickness) and seed oil content by Soxhlet method.

Results:The results showed significant differences ($p < .001$) in seed and fruit traits as well as the oil content between accessions. Oil content, weight of kernel / weight of seed coat ratio and 100-seed weight are highly correlated quantitative characters which have also, high heritability broad sense (92.51%, 100% and 87.14% respectively) and genetic advance values (39.32%, 36.44% and 28.77% respectively). Also, this study has highlighted four local accessions (Keur Samba Gueye, Notto 3, Ndary and Soutra) with high oil content (> 55%).

Conclusion:

There is high genetic variability of *Jatropha curcas* in Senegal in terms of seed, fruit and oil traits. The quantitative characters such as oil content and 100-seed weightmight be used for early selection of promising accessions. The local *J. curcas* plant materiel is interesting enough to perform breeding programs and support nationalsustainableproduction of biofuel.

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25 **Key words**: *Jatropha curcas*, seeds, variability, oil content, Senegal, West Africa

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1. Introduction

The energy issue is widely discussed in the world, because of the widening gap between decreasing supply and an increasing demand. This imbalance leads to a global crisis that affects the countries' economy. None African oil producers countries like Senegal are more affected by this crisis. For example in 2006, almost 140 billion CFA francs were spent to subsidize the energy sector. Also, Senegal'soil bill rose from 185 billion FCFA in 2000 to 384,000,000,000 FCFA in 2006 and to 623 billion FCFA in 2008, an increase of over 40% in two years. Also, over 46% of export revenue are mobilized to meet this invoice [1]. This energy shortage has created a renewed interest in renewable energy. Senegal, like some African countries embarked on biofuel production by opting for the promotion of Jatropha (*Jatropha curcas* L.).

The choice of this plant is justified by the fact that its seeds contain oil of high energy value whose properties are comparable to those of diesel. In addition, this plant is little exigent. It provides various products and benefits that promote an integrated rural development [2].

However, there are many agronomic challenges to overcome for a sustainable development of Jatropha biofuel value chain. Among them, the increase in seed yield or in oil content is probably the most emergent for producers. This might involves identifying a more productive plant material and the development of suitable cropping systems.

Therefore, many studies have been conducted in Asia [3, 4, 5, 6] as well in West Africa [7, 8, 9] on agromorphological, biochemical and genetic characterization of Jatropha's germplasm. These studies have shown a high variability inseed traits and oil content between accessions. This suggests that the accessions analyzed are different ecotypes well adapted to different local conditions. However, this hypothesis cannot be validated if and only if, a genetic basis of

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variation is established and phenotypic plasticity responses due to environmental differences can be excluded.

Unfortunately, this is not the case for the studies carried out in West Africa [7, 8, 9]; theseworks havecompared different accessions using seeds harvested on their sites of origin.

In this context, the objective of this work is to analyze variability in seeds and fruits traits as well as oil content of 35 accessions of *J. curcas*collected from different agroclimatic zones of Senegal but which have been planted on the same site.

2. MATERIALANDMETHODS

2.1 Study area

The present study was conducted at the research station of "Ecole Nationale Supérieure d'Agriculture (ENSA)" located in Thies city, Senegal (latitude 14° 42'52" N; longitude 16° 28'64" O). The climate is tropical semi-arid with an annual average rainfall of about 450 mm [10]. However, the total rainfall of the study year recorded by a weather station is 500.02 mm. The minimum mean annual ambient temperature is 20° C and a maximum mean annual ambient temperature of 33° C. [11]. The soils are poorly developed with a sandy loam texture and a pH of 5.0. Their level of fertility is poor with organic carbon and nitrogen, respectively, less than 5% and 0.3% [12].

The mean annual minimum ambient temperature is 20° C and the mean annual maximum ambient temperature is 36° C, with a marked seasonal variation[13].

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2.2 Plant material

The plant material consists of 35accessions of *J. curcas* planted in the research station of "Ecole Nationale Supérieure d'Agriculture" (ENSA). Thirty three are from Senegal while 2 others were introduced from Mozambique (Southern Africa) and Tanzania (East Africa).

2.3 Methods of the survey

The fruits were collected between September 9th and December 12th, 2013 fromplantations of 1-4 years old. For each accession, harvesting was done on 4-6 trees among the most vigorous. Only ripen fruits of yellow or brown color were collected and then dried in the laboratory at ambient temperature (about 25 °C).

For each source, 30 fruits were randomly selected. They were pre-dried in an oven at a temperature of 65 °C for 72 hours to obtain a constant weight. Then, each fruit has its length and diameter measured using an electronic caliper, the weight was also determined with an electronic balance (1/1000 g). At the end of these measurements, 30 fruits were peeled and shells were weighed with the same balance as before. To determine seeds traits, a sample of 20 seeds per accession was selected with three (3) replications. These seeds were subjected to measurement of the length (longitudinal axis of the seed with electronic calipers), the width (lateral axis of the seed) and the thickness (radial axis).

The weight of each lot of 20 seeds was measured with an electronic balance (1/1000 g). From the weight of 20 seeds, 100-seed weight were calculated :

Weight of 100 seeds (g) = (Weight of 20 seeds / 20) x 100

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For each accession, the three lots of 20 seeds that were used to determine seed traits were used also, to measure the average seed oil content by Soxhlet method [3]. To do this, the kernel was separated from husks and placed in an incubator at 65 °C for 48 hours. Then, they were crushed using a mortar. Thereafter, it was taken 2 g of kernel (sample) for Soxhlet extraction with 3 replications peraccession. The oil content of the kernel was determined by the following formula:

% oil = (oil mass / mass of sample) * 100

2.4 Data analysis Method

Analysis of variance was performed using the software called Statistix to highlight the influence of the accession factor over the seed and fruit-shape variables as well as the oil content. Comparison of means was performed using Tukey's test at 5%.

Genetic parameters were estimated to identify the genetic variability between accessions and determine the effects of the genotype and environment on various studied traits. These genetic and phenotypic variance components, coefficients of variation, heritability in the broad sense and genetic gain were calculated by adjusting the formula suggested by [14] and [15]:

$\sigma^2 g$ = (genotypic variance) = (MSG - MSE) / r

MSG = inter accession variance;

$\sigma^2 E$ = MSE = environnemental variance;

r = number of replications;

$\sigma^2 p$ = (phenotypic variance) = (+ $\sigma^2 g$ $\sigma^2 E$)

PCV (phenotypic coefficient of variation) = ($\sqrt{\sigma^2 p}$) / X * 100

X = mean of traits;

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GCV (genotypic coefficient of variation) = $(\sqrt{\sigma^2 g}) / X * 100$

h^2B = (broad sense heritability) = σ^2E / σ^2p

= GA (genetic gain) = $K * (\sqrt{\sigma^2 p}) / X * 100 * H2B$

K = constant = 2.06

The XLSTAT 2010 software was used for testing significance of Pearson correlation coefficients and thus assesses the relationships between the different variables studied.

A hierarchical clustering based on the calculation of the Euclidean distance between the accessions has been performed using the software PAST. It generated a dendrogram that grouped the accessions according to the similarity of their behavior on the studied variables.

3.RESULTS

3.1 Variability in fruits,seeds and oil content traits

The results of the analysis of variance (Table 1) show that the accession-factor has a significant influence on all morphological parameters of fruits and seeds and the oil content ($p<.0001$).

The coefficients of variation are highest for fruits traits with values of 23.92% for weight, 8.98% for diameter and 7.69% for length. For seeds, the highest coefficients of variation were obtained with Kernel weight/Seed coat weight (K/SC) ratio (7.60%), 100-seed weight (5.78%) and oil content (5.65%).

The average values of seed traits are: 18.25 mm for length, 11.04 mm for width, 8.70 mm for thickness, 60.25 gf for 100-seed weight, 44.68% for oil content and 1.26 for K/SC ratio. For fruits,

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the average values of the measured parameters are 25.68 mm for length, 20.19 mm for diameter and 2.34 g forweight.

For the different studied parameters, the accessionsthat obtained the highest values are:

- 17 (19.16 mm), 19 (19.11 mm) and 7(19.03 mm) for seed length;
- 9 (11.41 mm), 20 (11.35 mm) and 30 (11.32 mm) for seed width;
- 7 (9.22 mm), 13 (9.09 mm) and 17 (9.06 mm) for seed thickness;
- 24 (72.65 g), 31 (72.65 g) and 13 (71.00 g) for 100-seed weight;
- 24 (57.16%), 31 (56.50%) and 13 (55.33%) for oil content;
- 24 (1.65), 31 (1.63) and 26 (1.58) for K/SC ratio;
- 19 (27.29 mm), 6 (27.16 mm) and 8 (26.99 mm) for fruit length;
- 27 (21, 64 mm), 6 (21.54 mm) and 17 (21.45 mm) for fruit diameter;
- 31 (2.91 g), 35 (2.82 g) and 27 (2.77 g) for fruit weight

Table 1. Seed, fruit and oil content traits variability in *Jatropha curcas*

Accession N°	Locality	Seed						Fruit		
		Length (mm)	Width (mm)	Thickness (mm)	100 seed weight (g)	Kernel/Seed coat ratio	Oil content (%)	Length (mm)	Diameter (mm)	Fruit weight (g)
1	Karang	18,37	11,02	8,78	64,65	1,40	47,00	25,38	20,36	2,45
2	Darou mousty	17,44	11,31	8,30	52,00	1,05	36,66	25,10	19,23	2,10
3	Dianamalary	18,74	11,04	8,86	62,30	1,19	46,33	26,55	21,10	2,48
4	Diassime Mandina	18,06	10,65	8,62	56,65	1,15	42,33	25,96	20,33	2,20
5	Diouroup	18,88	11,08	8,96	67,30	1,25	53,00	26,51	20,56	2,44
6	Fimela	18,65	11,09	8,74	65,65	1,32	52,66	27,16	21,54	2,67
7	Fois 1	19,03	11,24	9,22	67,00	1,23	51,83	25,35	20,18	2,16
8	Gandiaye	18,17	10,99	8,65	64,65	1,29	48,83	26,99	20,59	2,7

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9	Ngoule	17,25	11,41	8,23	43,75	0,77	30,16	24,41	18,61	1,89
10	Gourel Bowe	17,39	10,81	8,39	48,00	0,92	30,33	24,66	18,62	1,90
11	Kagnobon	16,93	10,32	7,84	31,30	0,74	23,00	21,48	17,14	1,30
12	Kamonghone	16,89	10,87	8,16	56,30	1,37	43,00	23,23	19,07	1,94
13	Keur Samba Gueye	18,93	11,21	9,09	71,00	1,46	55,33	26,96	21,22	2,49
14	Koumbal	18,31	10,75	8,11	48,65	1,06	32,16	25,63	20,43	2,19
15	Linguere	18,66	10,93	8,73	58,00	1,11	42,66	26,34	20,35	2,26
16	Lompoul	17,17	11,28	8,25	52,30	1,23	35,33	24,61	19,24	2,15
17	Madiop Boye	19,16	11,30	9,06	68,00	1,41	54,00	26,71	21,45	2,70
18	Maleme Hoddar	18,43	10,96	8,82	67,00	1,48	50,16	26,08	19,83	2,32
19	Maleme Niani	19,11	11,26	8,73	57,65	1,06	42,33	27,29	20,20	2,30
20	Medina Sabakh	17,76	11,35	8,88	63,30	1,32	46,33	25,23	19,07	2,23
21	Mozambique	18,13	10,84	8,75	61,65	1,36	44,00	25,64	20,56	2,28
22	Mpack	18,07	10,53	8,52	62,30	1,40	44,50	26,39	20,37	2,70
23	Ndande	18,09	11,00	8,47	56,00	1,11	40,83	25,96	20,41	2,35
24	Ndary	19,00	11,15	8,89	72,65	1,65	57,16	26,04	20,54	2,69
25	Nguekokh	17,88	10,67	8,64	56,00	1,23	39,83	25,13	20,08	2,16
26	Notto 3	18,78	11,04	8,71	70,65	1,58	55,16	25,44	20,69	2,70
27	Ouassadou	18,63	11,10	8,92	69,30	1,43	54,50	26,71	21,00	2,77
28	Porokhane	18,11	11,28	9,01	62,00	1,20	44,66	25,02	18,86	2,06
29	Sangalkham	18,32	11,09	8,53	54,65	1,13	36,33	25,60	20,13	2,24
30	Sare Diatta Folere	18,30	11,32	8,67	48,65	0,87	30,83	26,69	20,82	2,03
31	Soutra	18,89	11,22	8,85	72,65	1,63	56,50	26,48	21,27	2,91
32	Tanzanie	18,68	11,31	8,74	68,70	1,53	54,16	25,97	20,66	2,61
33	Tapha Kane	17,69	10,84	8,47	53,00	1,35	36,50	22,81	19,66	1,87
34	Touba Peykouk	18,57	11,03	8,96	68,65	1,47	54,00	26,62	20,69	2,65
35	Velingara	18,30	11,06	8,70	66,30	1,36	51,33	26,59	20,98	2,82
Mean		18,25	11,04	8,66	60,25	1,26	44,68	25,68	20,19	2,34
Minimum		16,89	10,32	8,30	31,30	1,23	23,00	21,48	17,14	1,30
Maximum		19,16	11,41	9,22	72,65	1,65	57,16	27,29	21,64	2,91
Coefficient of variation (%)		1,19	1,17	1,43	5,78	7,60	5,65	7,69	8,98	23,92
F		24,80	11,30	18,10	21,10	16,50	38,10	12,20	8,57	11,20

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P	< 0.0001

3.2Estimation of genetic variables for 9 morphological traits of *Jatrophacurcas*.

Table 2 shows the values of genetic parameters for different agro-morphological characteristics of the seeds and fruits of *J. curcas*. Its analysis reveals that the oil content has the highest phenotypic and genotypic variances with 84.89% and 78.63% respectively. This character is followed by the fruit length that has respective values of 8.34% and 9.46%. The third character that has the highest variance is the 100 seeds -weight with 3.73% of the phenotypic variance and 3.25% for the genotypic variance.

Regarding the coefficient of genotypic variation, it appears that the characters that have the highest values are in descending order fruit weight (24.40%), oil content (19.84%), K/SC ratio (17.74%) and 100-seed weight (14.96%). These characteristics also have higher coefficients of phenotypic variation and in the same order than previously.

The broad sense heritability is high for all of the studied characters except the fruit diameter for which the average value is (43.21%). However, the values are highest in K/SC ratio (100%), oil content (92.51%), seed-length (90.40%), seed-thickness (89.65%) and 100-seed weight (87.14%).

The oil content has the largest genetic advance (39.32%). It is followed by the K/SC ratio with 36.44%, fruit weight (35.85%) and 100-seedweight with 28.77%.

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157 Table 2. Estimation of genetic variables for seed, fruit and oil traits in *Jatropha curcas*

Traits	Variance		Coefficient of variation (%)		Heritability broad sense (%)	Genetic advance (%)
	Genotypic	Phenotypic	Genotypic	Phenotypic		
Length (mm)	0,37	0,41	3,36	3,53	90,40	6,58
Width (mm)	0,06	0,07	2,21	2,39	85,71	4,23
Thickness (mm)	0,08	0,09	3,39	3,59	89,65	6,62
100-seed weight (g)	3,25	3,73	14,96	16,03	87,14	28,77
Fruit weight (g)	0,32	0,63	24,40	34,08	51,25	35,87
Fruit diameter (mm)	2,48	5,75	7,80	11,87	43,21	4,50
Fruit length (mm)	4,46	8,34	8,22	11,24	53,52	12,39
Oil content (%)	78,63	84,99	19,84	20,63	92,51	39,32
K/SC*	0,05	0,05	17,74	17,74	100,00	36,44

158 *K/SC = kernel weight / seed coat weight

159 **3.3. Analysis of correlation coefficients among 9 morphological traits**

160 Table 3shows that oil content is significantly correlated to all the studied parameters. However,
161 the correlation is greater for 100-seed weight (r = 0.98) followed by K/SC ratio (r = 0.87), then
162 fruit weight (r = 0.85) and finally seed thickness (r = 0.80).
163 The 100-seed weight was also significantly correlated with all measured parameters. The highest
164 values are obtained with oil content, K/SC ratio (r = 0.89) and fruit weight (r = 0.87).
165 The K/SC ratio has a significant correlation with all other parameters except the width.

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All parameters are significantly correlated to the length of the seed; however, the correlation is stronger with the fruit diameter (r = 0.81) and seeds -thickness (r = 0.80).

The width is less correlated with other parameters with non-significant values for its relationship with K/SCratio, fruit diameter and fruit weight.

The thickness is significantly correlated with all other traits fruit and seed traits but with a highest correlation with oil content (r = 0.80).

As the thickness, fruit length is significantly related to any other parameter; however, this parameter is more correlated with fruit diameter (r = 0.83).

With the exception of the seed length, the fruit diameter is significantly correlated to all the studied parameters.

Finally, the fruit weight is significantly correlated to the set of measured parameters; However, there is a better link with the fruit diameter (r = 0.84).

Table 3. Correlation coefficients among 9 morphological traits of *Jatropha curcas*

Variables	Length (mm)	Width (mm)	Thickness (mm)	100-seed weight (g)	K/SC ratio	Oil content (%)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)
Length (mm)									
Width (mm)	0,338*								
Thickness (mm)	0,803*	0,462*							
100-seed weight (g)	0,748*	0,375*	0,834*						
K/SC**	0,508*	0,155	0,571*	0,886*					
Oil content (%)	0,739*	0,340*	0,800*	0,979*	0,869*				
Fruit length (mm)	0,777*	0,385*	0,656*	0,660*	0,360*	0,614*			
Fruit diameter (mm)	0,807*	0,250	0,630*	0,731*	0,578*	0,702*	0,834*		
Fruit weight (g)	0,712*	0,296	0,614*	0,867*	0,755*	0,846*	0,798*	0,844*	

**K/SC = kernel weight/seed coat weight; *Correlation is significant at the 0.05 level.

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3.4Regression equations for estimating oil content

Regression models for estimating oil content are presented in table 4. The statistical analysis of parameters such as the coefficient of determination (R^2) and the probability (p) reveals thatthree equations are significant and can be used to estimate oil content. However, equation 1 appears to be the best; it allows a very good estimate of the oil content.

Table4. Equations for oil content estimation in *Jatropha curcas*

N°	Equations	R^2	*P*
1	OC (%) = 0.95 x (P100) – 12.69	0.96	< 0.0001
2	OC (%) = 34.67 x (K/SC) + 0.97	0.75	< 0.0001
3	OC (%) = 19.94 x (FW) – 2.44	0.58	< 0.0001

OC: oil content (%), P100: 100-seed weight (g), FW: fruit weight (g), K/SC: kernel weight / seed coat weight ratio

3.5Cluster analysis

An hierarchical analysis was realized using data of the nine morphological studied traits of *Jatropha curcas*. The dendrogram obtained revealed five clusters (Figure 1). Cluster 1 (red) includes the maximum accession (12). Clusters 3 (purple) and 4 (green) each have 8 sources. Clusters 2 (blue) and 5 (yellow) respectively 6 and 1 accessions.

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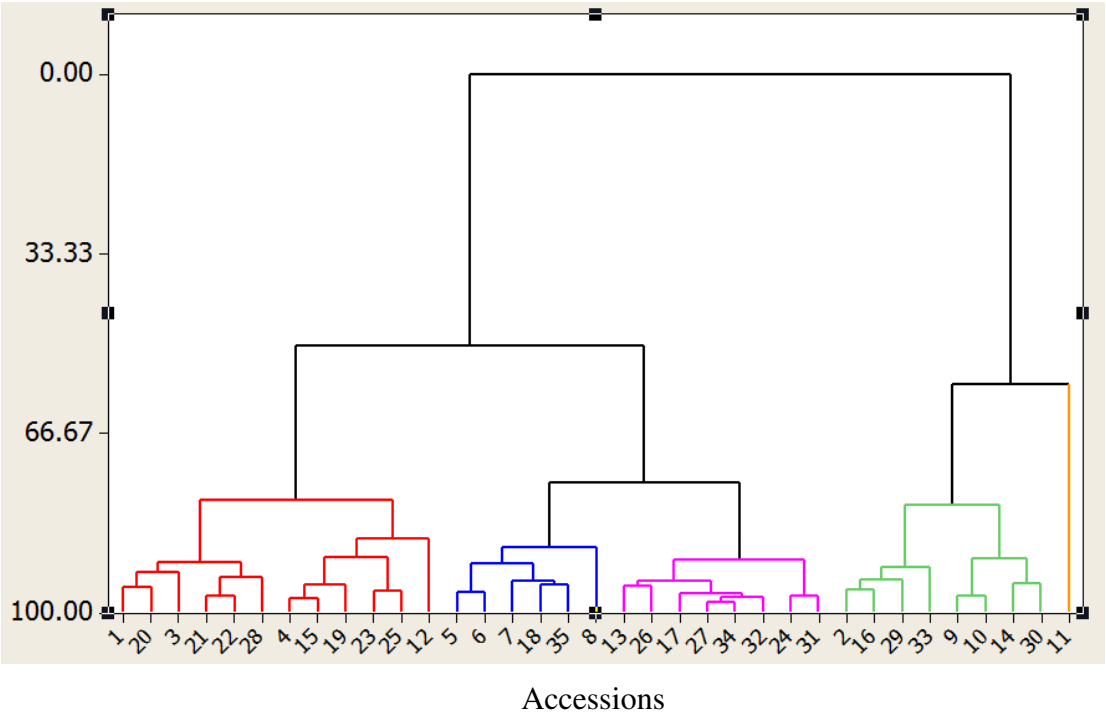

Fig. 1. The dendrogram of 9 morphological traits derived from 35 *Jatropha curcas* accessions constructed using hierarchical analysis method

The distribution of accessions according to the different groups is indicated in table 5:

- 1, 20, 3, 21, 22, 28, 4, 15, 19, 23, 25 and 12 are the cluster I;
- 5, 6, 7, 18, 35 and 8 are in the second cluster;
- 13, 26, 17, 27, 34, 32, 24 and 31 are the third cluster;
- 2, 16, 29, 33, 9, 10, 14 and 30 are the cluster IV:
- 11 is the only one of the cluster V.

Cluster 3 has the highest values for fruit and seed traits except for fruitlength (Table 5). For this group, the average values of seedlength, 100-seed weight, oil content and fruit diameter are respectively 18.83 mm, 70.20 g, 55.10% and 20.94 mm. The lowest values of theseparameters were observed in cluster 5.

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Considering only the oil content, it appears that the highest values are observed inclusters II and III.

Table5. Cluster mean value for fruit, seed and oil traits in *Jatropha curcas* accessions

Cluster	No of accessions	Accessions	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100 seed weight (g)	K/SC	Oil content (%)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)
I	12	1, 20, 3, 21, 22, 28, 4, 15, 19, 23, 25, 12	18,15	10,95	8,67	59,73	1,24	43,65	25,67	20,06	2,28
II	6	13, 26, 17, 27, 34, 32, 24, 31	18,57	11,07	8,84	66,31	1,32	51,3	26,44	20,61	2,51
III	8	31, 24, 26, 32, 34, 27, 17, 13	18,83	11,17	8,9	70,2	1,52	55,1	26,36	20,94	2,69
IV	8	2, 16, 29, 33, 9, 10, 14, 30	17,73	11,1	8,36	50,12	1,04	33,53	24,93	19,59	2,04
V	1	11	16,93	10,32	7,84	31,3	0,74	23	21,48	17,14	1,3

K/SC = kernel weight / seed coat weight

4. Discussion

This survey was conducted to quantify the variation in morphological characters of seeds and fruits but also the oil content of *J. curcas*, which can be attributed to genetic and environmental factors. For this, an experimental approach was adopted; it is based on the analysis of different characters on accessions from various geographical origins but which were transplanted in the same site where they were subject to the same technical itinerary from sowing to harvesting and

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seed storage. The establishment of the accessions in the common experimental field was made from cuttings therefore perfectly genetically identical material to mother-plant. This is considered by [16] as appropriate to reduce environmental impacts and estimate how much variability due to genotype in *J. curcas*.

The study of morphological characters of seeds from natural populations or low anthropic of a species, is an important step for the study of genetic variability [3]. This work has revealed that there are significant differences between the 35 studied accessions for the seed length, width and thickness, 100-seed weight, K/SC ratio, fruit length, diameter and weight and oil content. Previous studies have also reported a high variability of morphological traits [8, 9] and seed oil content [8] of *J. curcas* in Senegal. Similar results were obtained from other accessions collected in Africa including Nigeria [7] and Mozambique [16], but also in Asia [17, 3, 4, 6]. They can be attributed to the fact that *J. curcas* growths in a wide range of rainfall, temperatures, and soils [3].

The broad sense heritability is an important parameter in the selection of trees since it provides an indication of the relative importance of heredity and environment in the expression of many characters. High values of this parameter indicate that the environment has little influence on the studied traits. However, the use of broad sense heritability requires coupling it with other genetic parameters (variances and coefficients of genotypic and phenotypic variation); such an approach allows selecting characters that are strongly under genetic control and at the same time have a high genetic variability. Our results show that except for fruit diameter, all studied characters have high broad sense heritability values (> 45%); therefore we can consider that these characters are highly heritable. However, oil content, 100-seed weight, K/SC ratio and fruit weight appear to be the most interesting for breeding programs. These four characters have the

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highest values of heritability in broad sense (51.25 to 100%), genotypic variance (0.32 to 78.63) and coefficient of variation (14.96 to 24.4%). They also have the highest values of genetic advance (28.77 to 39.32%). Genetic advance is a parameter that provides information on the importance of genetic progress resulting from the selection of the best individuals.

Oil content, 100-seed weight, K/SC ratio and fruit weight are strongly correlated and this suggests that there are opportunities to select these characters together. The test of different linear regressions between these parameters allowed developing equations for a reliable estimate of the oil content by weight of 100 seeds ($R^2 = 0.96$). The estimation of oil content from the of 100-seed weight avoids money expenses and delays associated with oil analysis in laboratory when producers are interested in estimating the oil content of their plantations after harvesting.

The hierarchical analysis performed to classify accessions based on nine (09) studied traits revealed five (5) clusters, including cluster III which contains eight (08) accessions is the most interesting for breeding programs; it has the highest values for all characters. If one refers to [18], we can see that 50% of the accessions of this cluster have high oil content (> 55%); these accessions are 26 (55.16%), 13 (55.33%), 31 (56.15%) and 24 (57.16%). The hierarchical analysis also showed that the maximum distance between groups was observed between groups II and IV. According to [3], this shows a great diversity among the trees of these two groups whose crossing would provide new hybrids. Consequently, trees belonging to these groups should be chosen as parents in *J. curcas* breeding programs in Senegal.

Finally, this study showed that the geographic diversity of accessions does not necessarily reflect their genetic diversity. Indeed, the groups shown by the hierarchical classification are each of them made up with accessions from three main eco-geographical areas of the country. Our

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observations are consistent with the results of many studies conducted in Senegal [8, 9] and Asia [3, 6].

5. Conclusion

This study has shown that there is a high variability of seeds and fruits traits as well oil content in *J. curcas* in Senegal. Based on the calculated genetic parameters, all traits examined, with the exception of fruit diameter, can be considered as heritable charact. However, the oil content, K/SC ratio, the 100-seed weight and fruit weight are the most interesting characters for breeding programs. They have the highest values and genetic parameters are strongly correlated.

The hierarchical analysis revealed a cluster of eight (08) promising accessions for biofuel production among them, 7 are local while the eighth is from Tanzania. They have high levels of oil comparable (> 55%) to the best accessions found in Asia. These results show that the local *J. curcas*plant materiel is interesting enough to perform breeding programs and support domestic production of biofuel.

This study showed also, that the geographic diversity of accessions does not necessarily reflect their genetic diversity

Finally, this study has developed a simple linear regression for a reliable estimation of the oil content and 100-seedweight; this equation could reduce the money expenses of determining the oil content in the laboratory and easily estimate the oil production plantations of *J. curcas*.

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