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RESEARCH ARTICLE

Variation in seed traits and distribution of *Jatropha curcas* L. in Senegal

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ABSTRACT

A thorough and extensive germplasm exploration survey was undertaken during 2009 and 2010 to assess the distribution and variability in seed traits of *Jatropha curcas* L. in Senegal. Nineteen accessions from different agro ecological zones of the country were collected to evaluate variability in seed characters. Trees aged at least 5 years only were considered. Among the seed traits studied, 100 seed weight ranged from 63.68 to 77.83 g and seed length from 17.89 to 19.15 mm. The highest 100 seed weight (77.83 g) was recorded for the accession Jc-16 collected from Mampatim. Accessions from Soudanian zone showed high values of seed traits while low seed traits were recorded in Soudano-Sahelian zone. Variability in seed traits was not linked to geographic location. Old plantations of *Jatropha curcas* are spread in the central, south and coastal zones of Senegal where the species is well known by the populations. However, the species was least represented above 400 mm isohyet and unfamiliar. No old plantation was observed in extreme north of Senegal.

INTRODUCTION

During the last years, *Jatropha curcas* L. has gained interest in Sahelian zone as biofuel crop. *J. curcas* is an oil bearing species and its oil can be converted to biodiesel that meets the American and European biodiesel standards (Tiwari *et al*., 2007). The interest for *J. curcas* in Sahelian zone is probably due to its high adaptability to wasteland then can be cultivated on marginal soils without compromising the food, fodder security and improve livelihoods in arid regions (Reddy *et al*., 2008). It sheds its leaves during the dry season, therefore is well adapted to arid and semi arid conditions characteristic of Sahelian zone. *J. curcas* belongs to Euphorbiaceae family and native from tropical South America (Carels, 2010). It was introduced in Africa and India by Portuguese seafarers (Heller, 1996). Cultivation of *J. curcas* can be done on well drained soils and requires low nutrient content (Heller, 1996). However, great variability in *J. curcas* growth and productivity was reported (Achten, 2008). Annual seed production can range from about 0.2 kg to more than 2 kg per plant (Francis et *al*., 2005). The major concern is that *J. curcas* is a wild species that domestication is at embryonic stage. Many authors recommended selection of best genotypes with high yield and oil content and variability studies are carried out to identify genotypes that can be used for amelioration programs of the species. The systematic work on germplasm exploration, characterization, utilization and documentation is of great importance to identify genetic variability for desired traits. Wide variation in 100 seed weight and oil content in accessions collected from India was reported (Ginwal et *al*., 2005; Rao et *al*. 2008, Kaushik et *al*., 2007; Wani *et al*., 2006). In spite of wide spread of *J. curcas* in Senegal, little work has been done so far in this aspect and information on local *J. curcas* variability is at infancy stage. Though, tree species with a wide geographical distribution exhibits considerable variation in anatomy, physiology, morphology and genetics to survive and reproduce under varying environmental conditions over generations (Antonovics, 1971; Nienstaedt, 1975).Variation in germination behavior (Ouattara *et al*., 2011) and seedling growth inoculated with arbuscular mycorhizae (Leye *et al*., 2009) has been reported in *J. curcas* accessions from Senegal. Early, Heller (1996) has reported variability in plant growth and seed yield in trial experimentation in Senegal. The study of seed characters of tree born oilseed crops of natural population is often considered to be useful in evaluation of the genetic variability (Mohapatra *et al*., 2010). Genetic variation in seed traits of *J. curcas* can be of great potential in tree improvement programs, particularly selection of genotypes having more oil content and yield. The present study aims at identifying the regions of Senegal where old plantations are well represented and characterizing the variability in seed traits of 19 old accessions collected in three agro-ecological zones in the country.

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MATERIAL AND METHODS

Several explorations of germplasm of *J. curcas* across Senegal have been undertaken between 2009 and 2010. Mature yellow fruits of *J. curcas* were collected from 19 accessions in November 2010 in three agro-climatic zones of Senegal (Fig 1). Climatic conditions of *J. curcas* fruits origins were represented in Table 1. Fruits were collected from at least ten trees in the same population spaced at least 10 m and randomly selected to ensure inclusion of local genetic

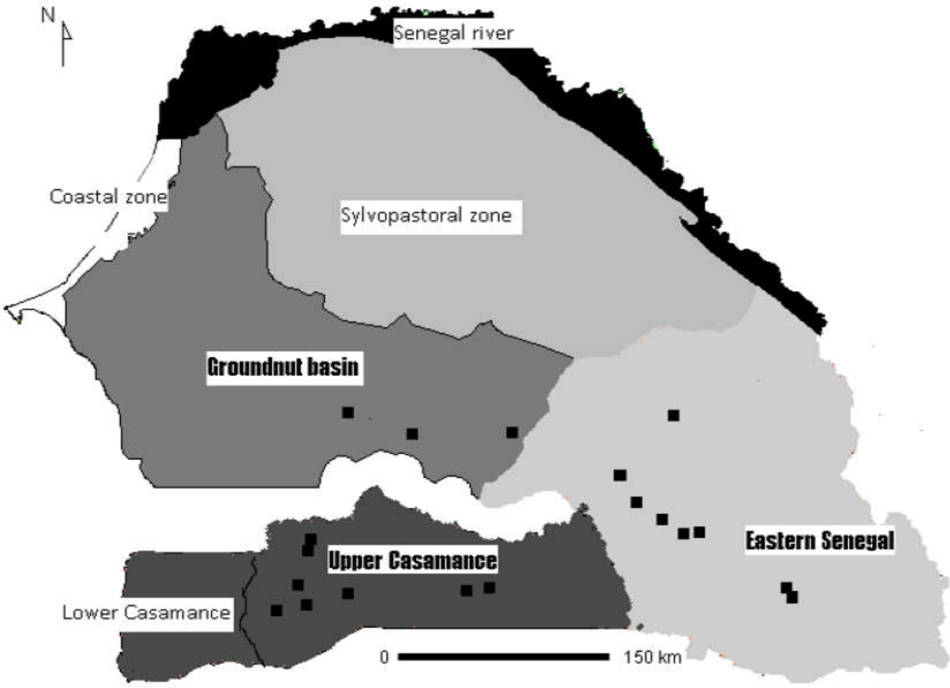

Figure 1. Mapping of the 19 accessions of *J. curcas* collected in Groundnut basin, Eastern Senegal and Upper Casamance of Senegal. Seed origins locations in black square; the different colors represent the different agro-ecological zones of Senegal (Map Adapted from Centre national de suivi écologique 1996).

Table 1. Geographical locations and agro-climatic characteristics of *J. curcas* seed origins

Locality	Seed source code	Latitude (°N)	Longitude (°W)	Altitude (m)	Rainfall (mm) Salack et *al*. 2011	Mean temp. °C (min-max)
Maleme thialene	Jc-01	14.04	15.14	31	600-800	35.51-21.73
Hamdalaye pont	Jc-02	13.37	13.35	30	600-800	35.51-21.75
Barkeyel	Jc-03	13.28	13.27	80	600-800	35.51-21.75
Dialacoto	Jc-04	13.18	13.17	61	800-1100	35.51-21.73
Medina Maka	Jc-05	13.13	13.08	62	800-1100	35.51-21.73
Bantancountou	Jc-06	13.15	13.04	52	800-1100	35.51-21.73
Niemenike	Jc-07	12.52	12.21	103	800-1100	34.73-22.2
Mako foukola	Jc-08	12.5	12.21	83	800-1100	34.73-22.2
Bala	Jc-09	14.01	13.09	81	600-800	35.51-21.73
Faskoto	Jc-10	13.54	14.12	58	600-800	35.51-21.73
Djeydina	Jc-11	13.12	15.31	112	800-1100	33.69-20.22
Sare alpha	Jc-12	13.06	15.35	50	800-1100	33.69-20.22
Sefa soukototo	Jc-13	12.49	15.34	52	800-1100	33.69-20.22
Yacine madina	Jc-14	12.46	15.44	30	800-1100	33.69-20.22
Dabo	Jc-15	12.52	14.28	40	800-1100	35.13-20.06
Mampatim	Jc-16	12.53	14.20	64	800-1100	35.13-20.06
Maka	Jc-17	12.50	15.17	21	800-1100	35.13-20.06
Diaroume	Jc-18	12.58	15.37	40	800-1100	35.13-20.06
Ndawene	Jc-19	13.56	14.49	29	600-800	35.51-21.73

variability. In this study, the accession represented fruits collected from trees in the same life fence or from isolated trees in the same farm or village. Trees were at least 5 years old to avoid *J. curcas* introduced in the country in 2007 from India in order to explore local variability. Accessions were distant each other at least 20 km. Fruits were labeled to keep identity of each accession. The collection sites coordinates were recorded using the Global Positioning System and Arcview 3.3 was used for point mapping. Fruits were air dried until constant weight under similar conditions of temperature and humidity. To determine Seed/fruit ratio, ten samples including 20 fruits each were weighted and seeds from capsule were extracted through manual threshing and weighted. Seed/fruit ratio was determined as the ratio of seeds Weight to the corresponding fruits weight. Three replicates of 100 undamaged seeds of each accession were chosen randomly and their sizes (Length, breadth and thickness) were measured using an electronic vernier calliper. Five random samples including 100 seeds each were taken from each accession to determine seed weight using an electronic scale.

Statistical analysis

Variation recorded for each seed trait was partitioned into components due to genetic and environmental factors using Johnson et *al.* (1955) formula. Phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) were computed as suggested by Burton, (1952). Heritability in Broad sense was calculated according to Allard (1999) as the ratio of the genotypic variance (Vg) to the phenotypic variance (Vp). Genetic advance (GA) as per cent of the mean assuming selection of the superior 5% of the genotypes was estimated in accordance with Johanson et *al*. (1955).

RESULTS

J. curcas mainly occurs in south, central and coastal zones of Senegal. Many old plantations have been observed in the regions of Zinguinchor and Fatick (Fig 2).The species is well known in these localities where it is used as land and farm fences or

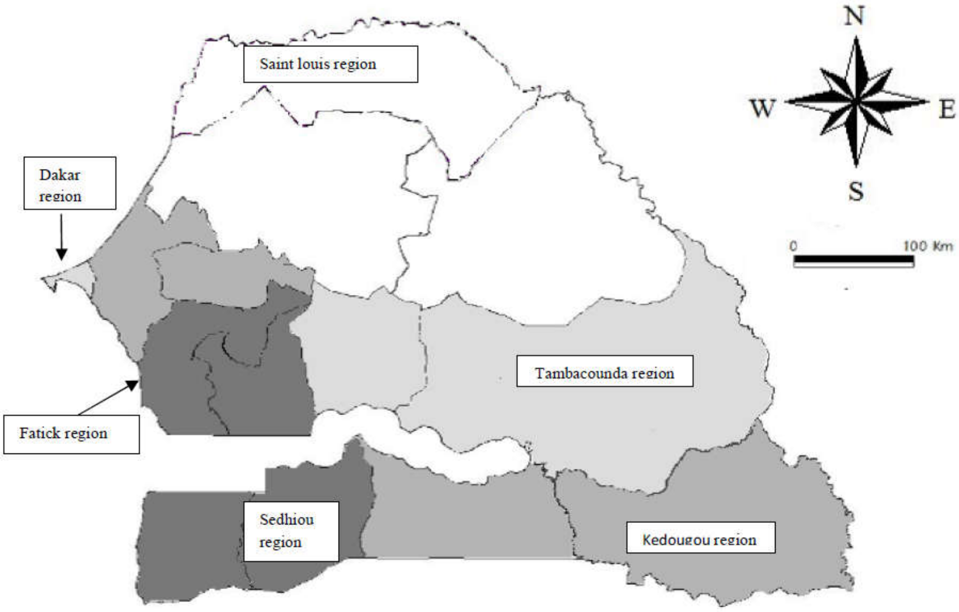

Figure 2. Importance of old plantations of *J. curcas* in the different regions of Senegal (the degree of darkness indicated the importance of old plantation of *J. curcas* encountered).

isolated trees in farm or courtyard in villages. *J. curcas* is well known under the name of *''Tabanani''*, but in certain villages the plant is called *''Kidi''* or *''Touba taba''*. No old plantation above 5 years was found in extreme north and north-east of the country. In certains villages, *J. curcas* oil is used by women in soap production. *J. curcas* was multiplied mainly by cutting to build fences. According to helder met in certain villages, *J. curcas* is a medicinal plant and treats various ills. They highlighted that *J. curcas* leaves are used to treat wounds and toothaches. The latex is used to treat gingivitis affections. Significative differences were recorded among accessions for seed traits ($p< 0.01$). One hundred Seed weight ranged from 63.68 to 77.83 g with a mean value of 71.42 g. The highest weight (77.83 g) were recorded in Jc-16 from Upper Casamance followed by Jc-10 (76.16 g) from South Groundnut basin (Table 2).

Table 2. Seed traits variability in *J. curcas*

Seed source	100 seeds weight (g)	Length (mm)	Breadth (mm)	Thickness (mm)	Seed/fruit ratio (w/w)
Jc-01	65.03	18.36	10.94	8.84	0.63
Jc-02	70.39	18.55	11.02	8.62	0.71
Jc-03	71.94	18.38	11.13	8.63	0.69
Jc-04	70.9	18.41	11.25	8.64	0.72
Jc-05	73.97	18.82	11.09	8.65	0.73
Jc-06	74.09	18.86	11.02	8.66	0.70
Jc-07	68.89	18.65	11.21	8.61	0.69
Jc-08	72.76	18.63	11.02	8.46	0.71
Jc-09	69.09	18.27	11.15	8.56	0.71
Jc-10	76.16	19.15	11.11	8.61	0.68
Jc-11	72.64	18.86	11.18	8.77	0.71
Jc-12	68.65	18.45	11.02	8.68	0.70
Jc-13	74.97	18.55	11.15	8.76	0.71
Jc-14	69.45	18.59	11.06	8.9	0.69
Jc-15	75.66	18.65	11.01	8.78	0.68
Jc-16	77.83	19.02	11.36	8.91	0.70
Jc-17	69.47	18.69	11.29	8.97	0.72
Jc-18	71.37	18.76	11.24	8.88	0.71
Jc-19	63.68	17.89	10.97	8.45	0.70
SE mean	0.51	0.04	0.02	0.02	0.00

The lowest 100 seed weight (63.68 g) was recorded in Jc-19 from South Groundnut basin. Mean seed length was 18.61 mm with a maximal of 19.15 mm measured in Jc-10 and minimal of 17.89 mm observed in Jc-19 from Groundnut Basin. Mean seed breadth was 11.12 mm while mean seed thickness was 8.7 mm. In general, high values of seed traits were recorded in Upper Casamance where rainfall closed to 1100 mm. Low seed traits were observed in South Groundnut basin accessions where rainfall was comprised between 600 to 800 mm. However, certain accessions like Jc-10 from South Groundnut basin showed high seed traits. We also noted low seed traits in accession Jc-12 from Upper Casamance. Mean Seed/fruit ratio was 70%. High seed/fruit ratio (0.73) was recorded in Jc-05 and the low value in Jc-01 (0.63). Variability in seed/fruit ratio was weak with approximately similar values in all the accessions. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated (Table 3). Highest PCV (5.12%) and highest GCV (4.59%) were recorded in seed weight. Low PCV (1.04%) and low GCV (0.96%) were noted in seed breadth. PCV and GCV for seed/fruit ratio were higher than PCV and GCV of all seed traits except in seed weight. The lower heritability in broad sense (76.87%) was recorded in seed/fruit ratio when it was higher than 89.59% for the others seed traits. Genetic advance was higher than 9.45% in seed weight with lowest value (1.97%) observed in seed breadth. Significative correlation has been recorded between seed traits (Table 4). All significative correlation coefficients were positive. Seed length was significatively correlated to all seed traits excepted Seed/fruit ratio. Seed breadth was correlated to all seed traits excepted to 100 Seed weight. Dendrogram with complete linkage based on square euclidean distance between the different traits showed five clusters (Fig 3). Cluster III (green color) and cluster IV (blue color) were morphological closed. Maximum accessions fallen into cluster IV that grouped 9 accessions. Cluster II (yellow color) included only one accession and was closed to cluster I (red color) that grouped 2 accessions.

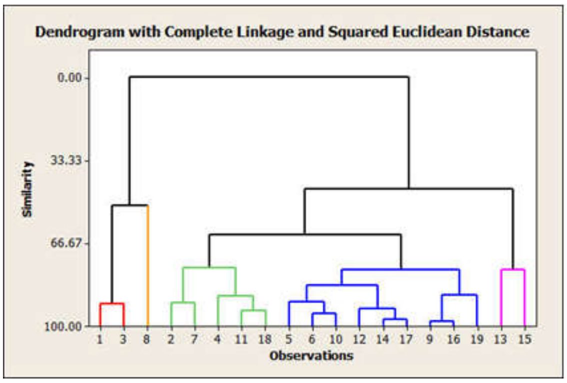

Figure 3. Dendrogram showing the different clusters based on seed traits of the 19 *J. curcas* accessions

Table 3. Estimation of genetic variables for seed traits in *J. curcas*

Seed source	Variance		Coefficient of variation (%)		Heritability (broad sense)	Genetic Advance as % mean
	Phenotypic	Genotypic	Phenotypic	Genotypic		
100 seed weight (g)	13.3300	10.7000	5.1254	4.5920	0.8027	9.4596
Length (mm)	0.0907	0.0830	1.6194	1.5491	0.9151	3.1912
Breadth (mm)	0.0135	0.0114	1.0470	0.9604	0.8414	1.9784
Thickness (mm)	0.0218	0.0198	1.6943	1.6162	0.9098	3.3293
Seed/fruit ratio (w/w)	0.0004	0.0002	2.7979	2.1507	0.5909	4.4305

Table 4. Correlation coefficient among seed traits in *J. curcas*

Seed trait	Length	Breadth	Thickness	100 Seed weight
Breadth	0.3654**			
Thickness	0.4214**	0.3961**		
100 Seed weight	0.5930**	0.1917	0.1947	
Seed/fruit ratio	-0.0269	0.2509*	-0.1411	0.1083

** Significant at the 0.01 level
* Significant at the 0.05 level

DISCUSSION

J. curcas is well known by the populations of south, central and coastal zones of Senegal. Particularly the species is well known in the south Senegal (Casamance) where it seems to be introduced from Bissau Guinea. *J. curcas* was distributed by Portuguese seafarers from the Caribbean via the Cape Verde Islands and Bissau Guinea to other countries in Africa and Asia (Heller, 1996). According to Berhaut (1967) *J. curcas* is known under various names as *''Tabanani'', ''Kidi''* in Senegal. However, the author didn't mentioned the name *''Touba taba''*. Based on old plantations distribution in Senegal, Casamance, Eastern Senegal and South Groundnut basin zones are the favorable areas where *J. curcas* establishment would be easy. Since *J. curcas* is well known and occurring in these zones as live fences in land or farm, it is adapted to their environmental conditions and populations will adopt easily the species. High variability was observed in *J. curcas* seed traits among the accessions. 100 seed weight ranged from 63.68 to 77.83 g that is in line with Halilu *et al.* (2011) who reported that 100 seed weight in their samples ranged from 28.558 to 80.046 g. Variability in environmental conditions of mother trees may explain the variation observed in seed traits. Indeed, *J. curcas* accessions were collected in different agro ecological zones that present different climatic conditions and soil characteristics. Soil and climate of the place of seed origin are considered as important factors affecting the seed traits (Salazar and Quesada, 1987). Such variations in habitat have been reported in *J. curcas* (Kaushik *et al.*, 2007, Ginwal *et al.*, 2005) and others tree species (Jindal *et al.*, 1999; Gera *et al.* 1976, Kumar *et al.*, 2004).

According to Mathur *et al*. (1984), variability occurring in seed traits might be attributed to genetic in nature as a result of adaptation to various environmental conditions prevailing throughout their distributional range. However, environmental conditions cannot explain alone all the variability observed in seed traits. Accessions from the same agro ecological zone often presented various seed traits. It is clear that one part of the variability is under genetic control. Some genotypes of *J. curcas* seem to produce large seed traits than others. This is confirmed by the few difference between phenotypic variance and genotypic variance. High values of heritability also indicated that variability in seed traits had genetic base. All the seed traits except seed/fruit ratio showed heritability superior to 80%. The important place of heritability in plant improvement program as it provides an index of the relative role of heredity and environment in the expression of various traits has been reported (Kaushik *et al.*, 2007). Comparing seed traits variability it has been noted that 100 seed weight recorded the highest variability. Genetic advance as percent of mean was high for 100 seed weight (9.45%) further suggested the potentiality of the test material for future improvement through selection. High heritability and high genetic advance for 100 seed weight have been reported by Kaushik *et al.* (2007) in *J. curcas*. Hence these characters can be considered as best gain characteristics for *J. curcas* improvement program because of its strong genetic control and the wide variability. In addition, in early reports (Ponnammal *et al.*, 1993, Kaushik *et al.*, 2001; Kaushik *et al.*, 2003), high seed traits recorded better germination and seedling growing. Halilu *et al.* (2011) highlighted that 100 seed weight is positively correlated to oil content. So, attention can be done to accessions with high seed traits that could be useful for breeding programs. Positive correlation coefficients were recorded between seed traits. Seed weight was correlated to seed length. Similar results were found by Mohapatra and Panda (2010) who reported positive correlation between seed length and 100 seed weight. Contrary to Kaushik *et al*. (2007), no significance correlation has been found between 100 seed weight and seed breadth neither between 100 seed weight and seed thickness.

Seed length was found positively correlated to seed breadth and seed thickness. Similar results have been reported in *Acacia catechu* (Ramchandra *et al*., 1996; Kumar *et al*., 2004). Strong positive correlation among seed traits indicated that genes involved in these traits might be closely linked or might have pleitropic effects (Das *et al*., 2010). The dendrogram based on seed traits fallen to group accessions from the same agro ecological zone together. Indeed, accessions from Upper Casamance and South of Eastern Senegal are grouped together. So geographical diversity did not necessarily represent genetic diversity. Similar results have been reported in *J. curcas* (Kaushik *et al*., 2007) and *C. tetragonaloba* (Saini *et al*., 2004). However, at the level of 45 of similarity, two majors cluster were formed. The first cluster grouped accessions from Soudano-sahelian zone, were rainfall varies between 500 to 900 mm, and the second cluster grouped accessions from Soudanian zone, where rainfall varies from 900 to 1100 mm (FAO, 2007). Cluster from Soudanian zone showed large seed traits. Wet zones are most favorable to *J. curcas* and the species is not common in regions with arid and semi-arid climate (Maes *et al*., 2009). As described by several authors (Kaushik *et al*., 2007; Ginwal *et al*., 2005), variation in *J. curcas* seed sources with respect to their morphological characters could be due to fact that the species grows over a wide range of rainfall, temperature and soil type.

Conclusion

The present study revealed that considerable genetic variability exists in *J. curcas* in Senegal with respect to seed morphology. On the basis of our results, wet zones are favorable to *J. curcas* where it produces high values of seed traits. *J. curcas* is widely distributed in south and central of Senegal where the species is well known. Accessions with high 100 seed traits identify hereby might be used in further breeding programs. This study is merely an indication that variability in seed traits is present in senegal and researches are need to identify consistently high yielding and high oil content in local ecotypes that are best adapted to Senegal climatic conditions.

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