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Improvement of physic nut (*Jatropha curcas* L.) by intraspecific hybridization between ecotypes of Africa and Americana

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***Jatropha curcas* is a plant with several attributes, multiples uses and considerable potentials. To mitigate the effects of climatic change, it is necessary to alleviate fossil power energy and increase biofuel energy. Plant-based fuels are among the best renewable sources, and their use can lead to a better balance of CO_2 and other greenhouse gases responsible for global warming. The aim of this work was to study the progeny of intraspecific cross of *J. curcas* (Equator × Senegal (Dialocoto)) in order to improve the productivity of the cultivated species through intra specific hybridization. The results showed that hybrids obtained from the cross between Equator ecotypes and Senegal ecotype (Dialocoto) showed the best production traits. For the width and length of the leaves, Equator ecotypes and hybrids had almost the same size (19.79 and 17.73 cm for Equator ecotypes and 19.0 and 17.23 cm for hybrids). The physical fruit properties of the hybrid showed dominance in comparison with the best parent due to heterosis effect. The hybrids showed a positive heterosis in fruit length, with significant H (30.17%) and Hb (3.47%) values. For the qualitative data, hybrids had the same leaf and petiole color as the Senegal ecotype, but the same leaf size with the Equator ecotype. The introduction of genetic variability can be performed by intraspecific cross.**

Key words: Benin, ecotype, *Jatropha curcas*, heterosis, hybrids.

INTRODUCTION

Jatropha curcas L. is an oleaginous plant which is not very exacting and can be adapted comfortably to the most climates conditions of tropical and subtropical regions. The better propitious zones to the culture of the plant are those where the annual mean of temperature varies from 18 to 29°C, with optimum values between 26 and 27°C (Trabucco et al., 2010). It has low requirements to soil fertility and can grow under low rainfall conditions (Sarin et al., 2007). It is a plant with several attributes, multiples uses and considerable potentials (Heller, 1996; Opensahw, 2000). *J. curcas* is a plant belongs to the family Euphorbiaceae, native to South America having a great economic, environmental and medical value. In the recent years, it has drawn attention as a source of seed oil that can provide an economically viable substitute for motor fuel (Opensahw, 2000; Adebowale and Adedire,

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2006; Chen et al., 2006). Banerji et al. (1985), Kaushik et al. (2007) and Sunil et al. (2008) mentioned that the seed contains 23 to 42% of oil which can be converted in a biodiesel, renewable energy source alternative to conventional petrodiesel (Mandpe et al., 2005; Ghosh et al., 2007). Biodiesel derived from *J. curcas* seed oil has the desirable physiochemical characteristics; performance was demonstrated to be superior to conventional petro-diesel (Heller, 1996; Opensahw, 2000; Sudheer et al., 2010). It is also a biofuel which allows reduction of the environment pollution by the greenhouse gas emissions. *Jatropha* is highly cross-pollinated and variations among the same species are limited. The majority of the vegetal material used to date comes from a simple selection within the semi-natural populating or local varieties. The inter-plants variations concerning the vigor and yield in seeds are enormous and we can expect that a good systematic selection with hybridization give great genetics improvements for yield in seeds and others significant characteristics. However, it is now well documented that some selections are rare and possess beneficial characteristics such as high yield, high oil content, drought resistance, photoperiod insensitivity, resistance/tolerance to major insect pests and diseases (Mohan et al., 2011). There were also significant differences ($P < 0.05$) in seed size, 100 seeds weight, oil content between accessions and low phorbol ester (PE) content (Ginwal et al., 2004; Ovendo-Medina et al., 2011). An approach to increase the productivity of physic nut (*J. curcas*) is to exploit hybrid vigor of the F1 progeny for possible production of hybrid varieties. Genetic improvement of physic can be done through many options like classical breeding, combining ability, heterosis breeding, mutation breeding, interspecific hybridization and genetic transformation (Divakara et al., 2010). Before using all potentialities of *J. curcas*, genetic improvement is necessary. Selection work and particularly genetic improvement is important to day so as to guarantee a high and stable yield for this culture. Physic nut has been recently domesticated and because of its high oil content, breeders want to select superior genotype for this character and others. The exploitation of heterosis is a common objective in plant breeding (Mayo, 1987). Application of heterosis breeding can boost physic nut oil content, yield, phorbol ester content, number of branches, seed size, size leaves, earlier maturity, reduced plant height, resistance to pests and diseases, drought tolerance, higher ratio of female to male flowers and improved fuel properties (Sujatha, 2006). Literature on *Jatropha curcas* improvement through heterosis are scarce (Divakara et al., 2010). A global effort to evaluate the genetic variability in *J. curcas* was initiated by Montes et al. (2008) using 225 and accessions collected from 30 countries in Asia, Africa and Latin America. Intraspecific diversity analysis by RAPD and AFLP of *J. curcas* collected from different geographical regions of India indicated the existence of low genetic diversity (Sudheer et al., 2009). The same work was done by Ouattara (2013) using 103 accessions. They found low genetic variation in African and Indian accessions and high genetic variation in Guatemalan and other Latin American accessions. That is the reason why Equator Hyderabad ecotype was chosen in the cross. Thus, the aim of this work was to improve the productivity of the cultivated species through intra specific hybridization involving two ecotypes of *J. curcas* from Senegal and Equator, respectively.

METHODOLOGY

Study area

The study was conducted at Ouedo-Adjagbo (06°29 N and 02°16 E), an administrative district of Abomey-Calavi Township, located in the south of Benin, around 22 km of Cotonou (Figure 1). The soil is clayey with sand. The climate is the sub equatorial with two rainy seasons and two dry seasons. The annual average temperature is 27.5°C, mean altitude is 41.25 m, average annual of rain is 1200 mm and mean humidity 84.47% (ASECNA, 2015).

Materials

The plant material used in this study consisted of two *J. curcas* ecotypes from Equator and Senegal (Dialacoto) and hybrids obtained from the crossing between *J. curcas* Equateur (♀) × *J. curcas* (♂) (Senegal). The crosses were performed in Senegal and the seeds of hybrids and ecotypes (Senegal and Equator) were sent to Benin by Pr. Guy Mergeai of Belgium. After harvesting, seeds were put into envelopes and kept to room temperature until sowing.

Approach

The seeds of the two ecotypes and 18 seeds of F1 hybrids were sown in 22.5 × 12.5 cm plastic bags filled with 2.5 kg of soil at Ouedo-Adjagbo district and were watered daily. It should be noted that one seed was sown per bag. Three months old, healthy seedlings (about 30 cm height and 8 to 10 true leaves) were randomly transplanted together in the experimental field in an interval of 2 × 2 m with their parents. A total of 15 plants for Senegal ecotype, 15 for Equator and 7 for hybrids were grown in the field and water was applied as needed to supplement natural rainfall.

Agronomic evaluation

Seven plants were chosen per ecotype and hybrids for measurement. The following parameters were measured: canopy height (cm) from the ground at the stem base to the top apex, number of branches, stem base diameter (cm), color of the stem, color of the leaf, color of the petiole, leaf length (cm) and leaf width (cm) of the 6eme leaf completely opened from apex, fruit length (cm), fruit width, fruit weight, number of fruits per plant, number of kernel, average weight (g) of seed per fruit, proportion of kernel per seed (kernel ratio) kernel length, kernel width, and kernel weight (Table 1). A total of 16 quantitative and 3 qualitative traits were evaluated.

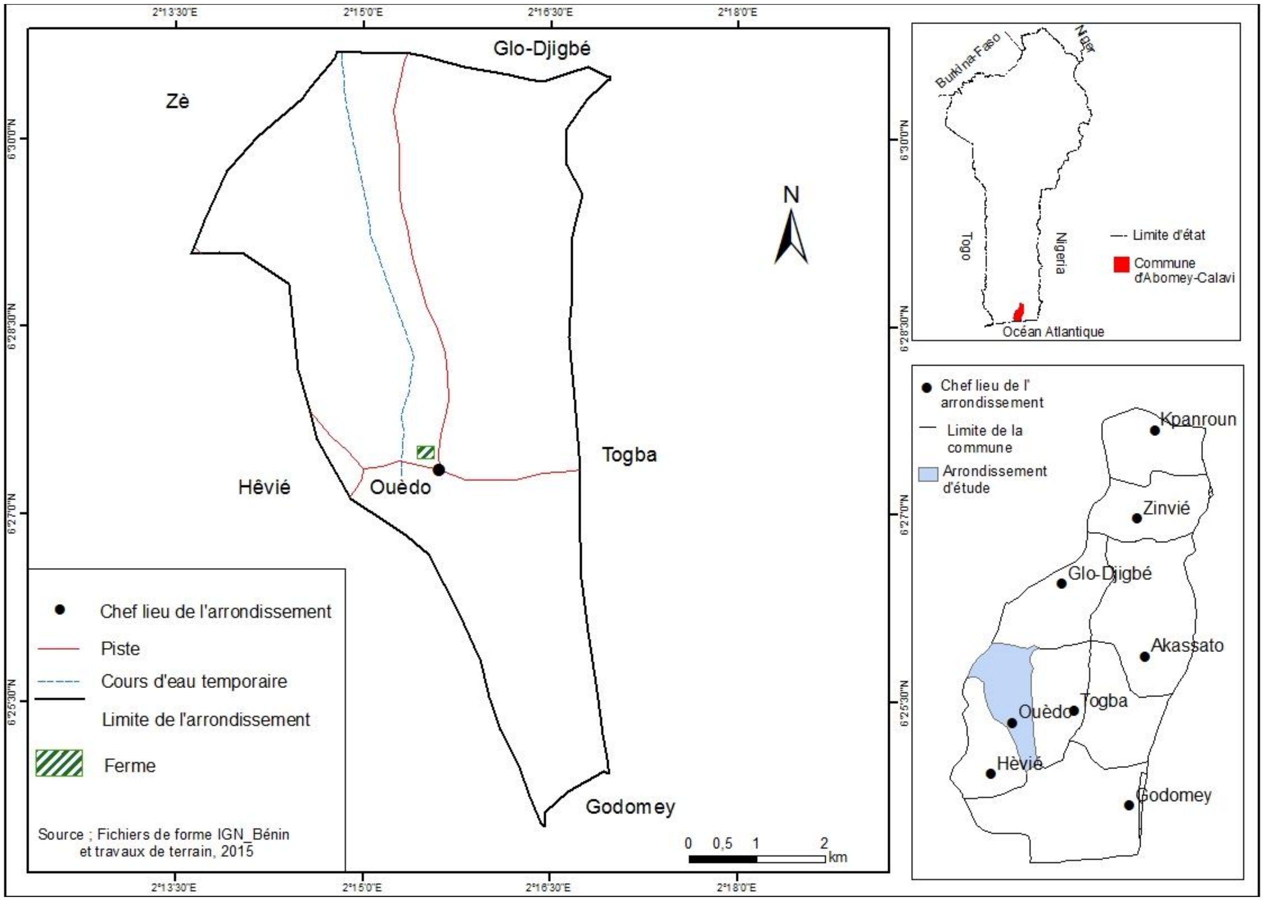

Figure 1. Map of Benin showing Abomey-Calavi Township and the study area at Ouedo.

Table 1. List of quantitative variables.

Designation	Abbreviations	Unity
Production	Prod	Number of fruits
height	Heig	cm
Number of branches	Npbr	-
Collar Circumference	Ccir	cm
Leaf width	Lwid	cm
Leaf length	Llen	cm
Fruit width	Fwid	mm
Fruit length	Flen	mm
Fruit weigth	Fwei	g
Seed width	Swid	mm
Seed length	Slen	mm
Number of kernel	Nker	-
Kernel weigth	Kwei	g
Kernel ratio	Krat	%
Kernel width	Kwid	mm
Kernel length	Klen	mm
Leaf color	Lcol	-
Petiole color	Pcol	-
Stem color	Scol	-

Table 2. Germination percentage of *J. curcas* from Senegal, Equator and hybrids.

Parameter	Number of seeds sowed	Harvesting year	Date of sowin	Date of counting	Number of seeds germinated	% of germination
Equator	40	2013	25/05/14	10/06/14	33	82.5
Senegal (Dialacoto)	40	2013	25/05/14	10/06/14	15	37.5
Hybrids (Equator (♀) × Senegal (♂)	18	2013	25/05/14	10/06/14	9	50

Statistical analysis

The collected data were encoded and entered into Excel 2007 software. Genstat 9 was used to compute the classical parameters such as mean, standard deviation, coefficient of variation, minimum and maximum. It was also used for the analysis of variance (ANOVA). For fruit weight, kernel weight, kernel length which conditions of normality and equality of variances were not satisfied, those variables are transformed. For other variables (kernel ratio, kernel width, kernel number, fruit length and fruit width), the test of Kruskal-wallis (a non-parametric alternative test analysis of variance) was used to separate means at P = 0.05. A simple description for frequency or proportion of different categories of each categorical variable was performed for qualitative data.

The values of mid-parent heterosis (H) and better-parent heterosis (heterobeltiosis, Hb) were calculated according to Equations 2 and 3, respectively (Tar et al., 2011).

$$\%H = (F1 – MP) \times 100/MP \quad (1)$$

$$\%Hb = (F1 – BP) \times 100/BP \quad (2)$$

where MP (mid-parent value) = (P1 + P2) /2; P1and P2 are the mean values of parents 1 and 2, respectively; F1 is the mean value of hybrid progeny; BP is the mean value of the better parent (showing the more desirable value of that trait) in the cross. The data from different characters were analyzed and statistically tested according to Soehendi and Srinives (2005), in this study, the significance of H and Hb in each character was determined by t-tests using Equations 3 and 4, respectively:

$$t\text{-test for } H = (F1 – MP)/ SH \quad (3)$$

$$t\text{-test for } Hb = (F1 – BP)/ SHb \quad (4)$$

where SH and SHb are the standard error of estimates of H and Hb, respectively.

RESULTS

Germination rate

Table 2 shows that the lowest germination % was recorded with Senegal ecotype while the highest germination rate was obtained with Equator ecotypes. Before transplanting the plants, two seedlings of hybrids were died.

Results of quantitative data

Table 3 shows the mean, standard deviation, coefficient of variation, minimum and maximum values of phenotypic characteristics for hybrids and ecotypes. The fruit production varies from 0 to 33 for ecotypes and hybrids. Senegal ecotype had the highest production and the lowest production was recorded in Equator ecotype (Table 3). For plant height, Equator ecotype had the best height and the Senegal ecotype had the lowest height. Hybrids' height was between the two parents and had the low coefficient of variation (CV= 6.30). Equator ecotypes and hybrids had almost the same leaf width and length (19.79 and 17.73 cm for Equator ecotypes and 19.0 and 17.23 cm for hybrids). There was no significant difference between hybrids and Equator parent for the leaf size (Table 4). Hybrids had the best fruit weight and the average weight of hybrids was better than the Senegal ecotype which was the best parent.

Correlation between variables

Significant correlation was observed between some variables (Table 5). The production (number of fruits per plant) was positively correlated with fruit width, fruit length, fruit weight, number of kernels, kernel weight, kernel ratio, width and length of kernel. On the other hand, the width and length of the leaves were negatively correlated with the number of fruits. Plant height had a positive correlation with the collar circumference, leaf dimensions and negatively with the number of branches. The collar circumference had a positive correlation with some variables: fruit length, fruit width, fruit weight, number of kernel weight, kernel ratio, kernel length and width. An increase in the collar circumference affects positively the fruit physical proprieties. It has been noticed that the fruit width correlated with the fruit length, fruit weight, kernel weight, the kernel ration kernel width and length. These different positive correlations can improve crossing results.

Heterosis of agronomic characters

The two ecotypes used in this study, demonstrated a wide diversity with interesting characters which can be transferred into hybrids plants. These interesting characters which were transferred into hybrids were

Table 3. Quantitative parameters' values of ecotypes and hybrids.

Ecotypes and hybrids	Variables	Total plant	Mean	Standard deviation	CV (%)	Minimum	Maximum
Equator (E)	Prod	7	7.29	8.48	116.39	0.00	19.00
	Tall	7	142.64	19.27	13.51	120.00	171.00
	Nbra	7	2.43	1.81	74.64	1.00	6.00
	Ccir	7	15.26	1.05	6.90	14.10	17.00
	Lwid	7	19.79	3.92	19.83	11.30	23.40
	Llen	7	17.73	1.03	5.83	15,80	18.60
	Fwid	7	11.67	10.98	94.09	0.00	21.87
	Flen	7	15.70	14.69	93.58	0.00	28.35
	Fwei	7	1.74	1.65	94.98	0.00	3.38
	Swid	7	11.66	10.97	94.09	0.00	21.87
	Slen	7	15.70	14.70	93.58	0.00	28.35
	Nker	7	1.50	1.44	95.65	0.00	2.90
	Kwei	7	1.23	1.21	98.48	0.00	2.54
	Krat	7	39.88	37.91	95.06	0.00	76.09
	Kwid	7	6.60	6.18	93.61	0.00	11.84
	Klen	7	11.04	10.33	93.56	0.00	19.61
Senegal Dialacoto (DS)	Prod	7	17.14	8.93	52.11	4.00	33.00
	Tall	7	119.64	15.80	13.21	88.00	138.50
	Nbra	7	5.43	2.51	46.18	3.00	10.00
	Ccir	7	15.51	1.44	9.25	13.40	17.40
	Lwid	7	11.61	2.36	20.35	8.60	14.80
	Llen	7	11.53	1.60	13.89	8.70	13.20
	Fwid	7	20.72	0.62	3.00	20.06	21.90
	Flen	7	26.63	1.26	4.73	24.51	27.97
	Fwei	7	2.87	0.29	10.07	2.54	3.40
	Swid	7	20.87	0.56	2.70	20.07	21.90
	Slen	7	27.03	0.79	2.93	25.78	27.97
	Nker	7	2.61	0.33	12.61	1.93	3.00
	Kwei	7	1.98	0.31	15.76	1.53	2.58
	Krat	7	69.10	8.87	12.84	80.87	77.19
	Kwid	7	11.01	1.28	11.60	8.15	11.76
	Klen	7	18.62	0.20	1.06	18.34	18.84
Equator × Senegal (ES)	Prod	7	13.00	10.49	80.68	1.00	32.00
	Tall	7	135.16	8.52	6.30	126.10	149.00
	Nbra	7	3.29	2.21	67.40	0.00	5.00
	Ccir	7	15.20	0.70	4.59	14.30	16.50
	Lwid	7	19.00	4.33	22.81	11.70	23.70
	Llen	7	17.23	2.34	13.55	14.10	20.90
	Fwid	7	21.05	1.09	5.20	19.25	22.09
	Flen	7	27.55	0.94	3.41	25.98	28.69
	Fwei	7	3.11	0.36	11.68	2.51	3.44
	Swid	7	20.95	1.11	5.27	19.26	22.09
	Slen	7	27.55	0,94	3.41	25.98	28.69
	Nker	7	2.81	0.19	6.68	2.54	3.00
	Kwei	7	2.27	0.32	14.27	1.72	2.58
	Krat	7	72.70	2.89	3.98	68.53	76.58
	Kwid	7	11.52	0.23	1.97	11.29	11.95
	Klen	7	19.10	0.36	1.91	18.64	19.61

Table 4. Segregating mean of agronomic characters of hybrids and their parents.

Parameter	Equator	Senegal (Dialacoto)	Hybrids	CV (%)	Probability
Prod	7.29 ± 8.48^{a}	17.14±8.93^{a}	13.00±10.49^{a}	74.86	0.169^{ns}
Tall	142.64 ± 19.27^{a}	119.64±15.8^{b}	135.16±8.52^{ab}	11.48	0.0326*
Nbra	2.43 ± 1.81^{b}	5.43±2.51^{a}	3.29±2.21^{ab}	59.14	0.0534^{ns}
Ccir	15.26 ± 1.05^{a}	15.51±1.44^{a}	15.20±0.70^{a}	7.21	0.853^{ns}
Lwid	19.79 ± 3.92^{a}	11.61±2.36^{b}	19.00±4.33^{a}	21.67	0.000854***
Llen	17.73 ± 1.03^{a}	11.53±1.60^{b}	17.23±2.34^{a}	11.23	0.00003***
Fwid	11.67 ±10.98^{b}	20.72±0.62^{a}	21.05±1.09^{a}	35.81	0.0202*
Flen	15.70 ± 14.69^{b}	26.63±1.26^{a}	27.55±0.94^{a}	36.63	0.0324*
Fwei	1.74 ± 1.65^{b}	2.87±0.29^{a}	3.11±0.36^{a}	38.50	0.0413*
Swid	11.66 ±10.97^{b}	20.87±0.56^{a}	20.95±1.11^{a}	35.76	0.0198*
Slen	15.70 ±14.70^{b}	27.03±0.79^{a}	27.55±0.94^{a}	36.34	0.0292*
Nker	1.50 ± 1.44^{b}	2.61±0.33^{a}	2.81±0.19^{a}	37.19	0.0226*
Kwei	1.23 ± 1.21^{b}	1.98±0.31^{ab}	2.27±0.32^{a}	40.89	0.0484*
Krat	39.88 ±37.91^{b}	69.10±8.87^{a}	72.70±2.89^{a}	37.22	0.0266*
Kwid	6.60 ± 6.18^{ab}	11.01±1.28^{a}	11.52±0.23^{a}	37.54	0.0404*
Klen	11.04 ± 10.33^{ab}	18.62±0.20^{a}	19.10±0.36^{a}	36.73	0.0362*

*Significant at P < 0.05; **Significant at P < 0.01; ***Significant at P < 0.001; ns: no significant. On the same row, means with the same letters are not significantly different.

Table 5. Correlation between quantitative variables.

Prod	1.00															
Tall	0.19	1.00														
Nbra	0.34	-0.29	1.00													
Ccir	0.46	0.48	0.47	1.00												
Lwid	-0.15	0.46	-0.46	-0.15	1.00											
Llen	-0.28	0.40	-0.52	-0.13	0.84	1.00										
Fwid	0.53	0.03	0.37	0.36	-0.36	-0.26	1.00									
Flen	0.53	0.08	0.30	0.36	-0.35	-0.23	0.99	1.00								
Fwei	0.52	0.07	0.36	0.39	-0.29	-0.17	0.98	0.96	1.00							
Swid	0.54	0.02	0.37	0.36	-0.36	-0.26	1.00	0.99	0.98	1.00						
Slen	0.53	0.06	0.32	0.36	-0.36	-0.24	0.99	1.00	0.96	0.99	1.00					
Nker	0.51	0.06	0.35	0.32	-0.28	-0.19	0.98	0.97	0.97	0.98	0.96	1.00				
Kwei	0.49	0.10	0.35	0.33	-0.19	-0.11	0.95	0.92	0.97	0.95	0.92	0.98	1.00			
Krat	0.53	0.06	0.35	0.30	-0.28	-0.21	0.98	0.97	0.95	0.98	0.97	0.99	0.96	1.00		
Kwid	0.51	0.06	0.32	0.33	-0.33	-0.20	0.98	0.99	0.95	0.98	0.98	0.98	0.94	0.99	1.00	
Klen	0.52	0.05	0.33	0.35	-0.35	-0.22	0.99	0.99	0.97	0.99	0.99	0.97	0.92	0.97	0.98	1.00

revealed through the highest values of phenotypic traits recorded in the hybrids. These gains can be observed through heterosis. Significant values of H and Hb were detected in the cross (Table 6). The F1 hybrids had more length and width in fruit than their two parents. Hybrids had the highest kernel (length, width, weight) (19.10 mm, 11.52 mm and 2.27 g, respectively) than the two parents (18.62 mm, 11.01 mm and 1.98 g for Senegal parent and 11.04 mm, 6.60 m and 1.23 g for Equator) and significant heterosis values were observed (Table 6). The crosses between Equator and Senegal showed a positive heterosis in fruit length, with significant H (30.17%) and Hb (3.47%) values. Overall, it has been observed that most of the H (mid-parent) values were significant except for production, height, collar circumference and leaf width. On the other hand, Hb (heterobeltiosis) values were significant for kernel, fruit length and height.

Results of qualitative characters

From qualitative point of view, leaves were palmatilobed

Table 6. Heterosis of quantitatives agronomic characters.

Variable	%H	%Hb
Prod	6.43ns	-24.17ns
Tall	3.06ns	12.97**
Nbra	-16.36*	-39.47*
Ccir	-1.21ns	-2.03ns
Lwid	21.02ns	-3.97ns
Llen	17.77*	-2.82ns
Fwid	30.00***	1.59ns
Flen	30.17***	3.47*
Fwei	34.94***	8.35ns
Swid	28.80***	0.38ns
Slen	28.93***	1.91ns
Nker	36.76***	7.78*
Kwei	41.50**	14.81ns
Krat	33.43***	5.22*
Kwid	30.89***	4.70***
Klen	28.75***	2.55*

*Significant at P < 0.05; **Significant at P < 0.01; * **Significant at P < 0.001; ns: non-significant.

regardless of the ecotype considered with a green-pale color for Senegal but dark for Equator. The petiole color of Equator ecotype was brown, while it was green-pale with a tiny brown line for Senegal. Hybrids had the same type of petiole like Senegal petiole. The stem of all hybrids were green-pale like Senegal parent. Taking into account the leaf size, we observed that these characters of Equator were dominant. Hybrid plants had the same color of leaf and petiole like Senegal ecotype (Figure 2).

DISCUSSION

The used ecotypes in this work were obtained from two different regions of the world. The germination of the two ecotype seeds showed great variation probably due to their origin. According to Sharma (2007), ecotype had great effect on the germination power of the seed and the germination time. Kobilke (1989), when compared the germination power of the seeds aged from 1 to 24 months, Kobilke observed a germination power inferior to 50% for the seeds of which the time of storage exceeded 15 months. For Moncaleano-Escandon et al. (2013), storage duration, combined with temperature, had strong effects on the germination of *Jatropha* seeds and the germinability decreased as age increased. These two factors certainly affected our seeds and this is why the germination % was low. According to Hartmann et al. (1990), genetic and environmental factors determine germination rate, speed of germination, and vigor of seed and seedling. In this work, the coefficients of variation differed for quantitative data. Similar results were found by Sunil et al. (2008) and Mishra (2009), who selected better plants and accessions of *J. curcas* from India. Correlation coefficients revealed interesting relationship with the seed characters as well as the growth studied parameters. The correlation matrix showed a good correlation between seed weight, seed width; therefore, seed weight can be considered as important trait for early selection from seed sources. Similar results had been reported by Kaura et al. (1998). The number of branches contributed to higher number of flowers which in turn contributed to higher number of female flowers which finally culminated in higher yield. In this study, at the younger stage, the number of branches of hybrids was higher than that of Equator parent. This is vital in the genetic improvement. Morphological characteristics (plant height, collar height and thickness, number of primary branches, petiole length, number of fruits per cluster, pedicel length and seed yield) were also correlated with the oil content of the seed. The two ecotypes plants exhibited some characteristics due to their provenance. The assessment of parameter variability in the study is in close approximation with the findings of genetic parameters in *J. curcas* (Das et al., 2010; Singh et al., 2013; Nath et al., 2014). This variability relative to the ecotype origin was also expressed through the studied qualitative and quantitative variables. For Heller (1996), the key for success of any genetic improvement program lies in the availability of genetic variability for desired traits. The gains from tree breeding programs depend on the type and extent of genetic variability.

Some provenances may differ relatively from others if cultivated at different sites, which is due to genotype ×

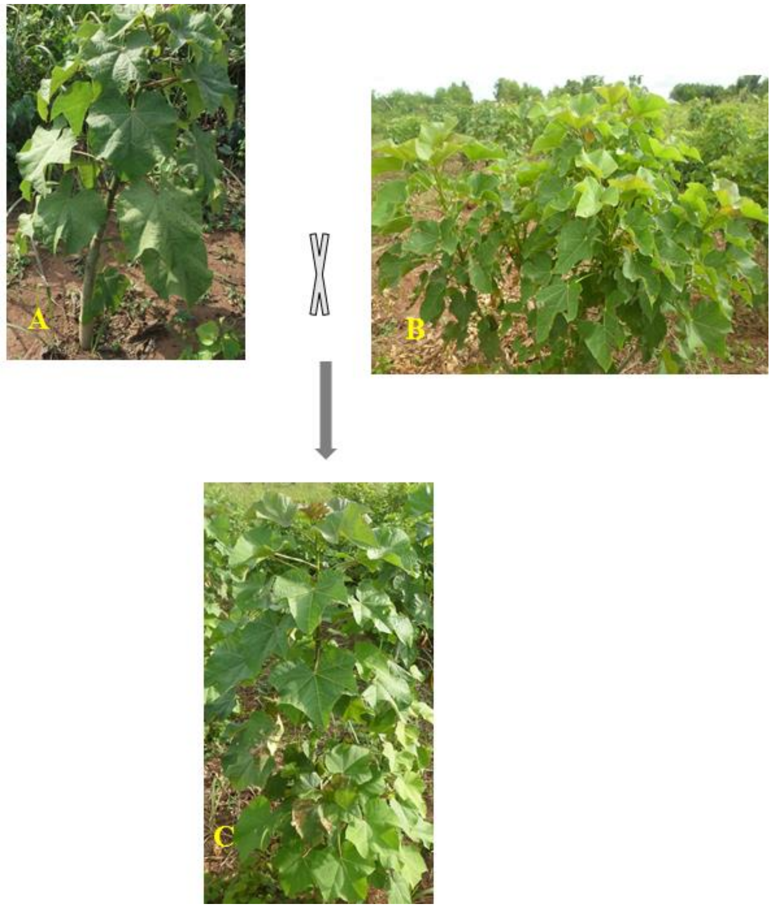

Figure 2. Plants of *J. curcas* studied: A: Equator, B: Dialakoto, Senegal C: Hybrid.

environment interaction. The two ecotypes from Equator and Senegal demonstrated different traits which were advantageous for this cross. The evaluation of hybrids' performance can be done through the analysis of the heterosis values determined by the value of mid-parent and the value of the better parent. It is demonstrated by some authors (Koutroubas et al., 1999; Sunil et al., 2008; Tar et al., 2011) that when physic nut was younger than one year, canopy height, canopy diameter, stem base diameter and number of primary branches were considered important agronomic characters affecting yield per plant. The obtained hybrids from ecotype of Senegal and Equator and used in this work showed similar characters at their younger stage. Thus, the obtained hybrids demonstrated better improvement than their mid-parent for the measured quantitative characters (%H > 0) except the number of branches. Our results are consistent with those obtained by Tar et al. (2011) who worked on the hybrids obtained from the crosses between six toxic parental accessions with a non-toxic accession. It was observed that the physical fruit proprieties showed an improvement of 28% when compared with the mid-parent and 2% more than the best parent. In the present study, moderate genetic gain values obtained for seed characters indicate that improvement could be done with these characters. These hybrids constitute a superior germplasms which stem cutting and their utilization as cultivars can increase the yield in seeds and oil of *Jatropha*.

Conlusion

Conclusively, the present study provided some information about the hybrids from the cross between Senegal and Equator. Thus, the obtained F1 individuals have a great genetic value in comparison with the mid-parent for all quantitative variables studied except the number of branches and the stem collar. These plants possessed also significant great genetic values compared to the best parent for the quantitative variables measured except the production, the number of branches, the stem collar and leaves dimensions. The performances of hybrids were the fruit quality inherited from their parent. The character like leaf size of Equator ecotype is dominant and was transferred to the hybrid, while the petiole and leaf color of Senegal ecotype were dominant and transferred also to the hybrids. The Equator ecotype expressed a great variability with all quantitative variables. The coefficient of variation was higher for phenotype (quantitative data), indicating a predominant role of the environment. In general, it appears that the environment has a preponderant role in the morphological variation of the two used ecotypes. It was noticed that the introduction of genetic variability can be performed by intraspecific crossing. Classical breeding is suitable for selecting traits, such as seed yield, seed size, number of branches and oil yield, but also for developing planting material adapted to local environmental conditions.

CONFLICT OF INTERESTS

The authors have not declared ant conflict of interests.

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