INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 16, No. 4, p. 36-42, 2020

RESEARCH PAPER

OPEN ACCESS

Effets of two plants propagation methods on *Jatropha curcas* (L.) growth and seeds yield in Tandjilé region (Chad)

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Article published on April 30, 2020

Key words: *Jatropha curcas*, Plants propagation methods, Seeds yield, Tandjilé (Chad)

Abstract

Field trial was carried out in Chad to investigate the effects of two plants propagation methods on productivity of *Jatropha curcas* L. cultivated in four localities (Djoun, Insatal, Laï-Djoum and Tchoua) at Tandjilé region in Chad. Planting was done following a randomized block design with four replications and two treatments (plants propagation methods: cuttings of stem and seedling). Physico-chemical properties of growing soils were assessed. The growing parameters and seeds yield were evaluated. Results shown that growing parameters and seeds yield were significantly different ($p<0.05$) between both plants propagation methods and four study localities. *J. curcas* adapted better in Tchoua locality than other three experimental sites. Cuttings of stem exhibited the highest (104±1.9 Kg/ha) seeds yield while the lowest (88±3.7 Kg/ha) is observed under seedling plants propagation method in each of four study sites. It comes out from this study that plants propagation method using cuttings of stem can be recommended to farmers of Tandjilé region (Chad) to be integrated into their agricultural systems for *J. curcas* growth.

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Introduction

National communities, non-governmental organizations, national and international institutions have in recent years become aware the danger posed by the emission of greenhouse gases, particularly carbon dioxide whose fossil fuel constitutes the main emission source (Minengu *et al.*, 2014). Faced with the industries development and exponential growth of world's population, it is urgent to find a source of alternative energy to avoid energy crisis (Fall, 2007; Sall, 2007). Research focuses on bioenergy, particularly on non-edible plants that can produce oils with biofuel potentiality (Dieye, 2007; Bellefontaine, 2001; Nwaga, 2009). *Jatropha curcas* L., a shrub belonging to the Euphorbiaceae family, is one of the vegetable species that can solve energy problems because the oil extracted from its seeds can be used as biofuels without competing with food crops. *J. Curcas* growth well in intercropping with food crop (Dauriat *et al.*, 2001, FAO, 2010). This plant is not edible for humans or livestock. It is widely used in traditional medicine. Seeds oil from *J. curcas* is used in the manufacture of biofuel, handmade soap, ointment and then used as insecticides and nematocides for crops protection (Hammaoui, 2006).

The cake obtained after seeds oil extraction is an excellent organic fertilizer for crops (Penjit, 2012). This cake can be used as fodder for livestock after detoxification (Kasuya *et al.*, 2013). The stem of *J. curcas* is used for hedgerows construction. *J. curcas* adapts to various soils, withstands long periods of drought and requires very little maintenance. But its optimal production requires a well-drained and fertile soil (Bellefontaine, 2001; Olivier, 2007). Many countries in the world, including America, Asia and recently some West African countries have embarked on its culture for biofuels production. The Sudanian zone of Chad offers a favorable climate for planting this shrub in order to solve the socio-economic needs of population stricken by poverty. The purpose of this work was to evaluate (1) the physico-chemical characteristics of soils from Sudanian savannah of Tandjilé (Chad), (2) plants propagation methods (seedling and cuttings of stem) as well as localities of Sudanian savannah of Tandjilé (Chad) on *J. curcas* growth and development. The importance and usefulness of this work follows from the fact that the plants propagation method and the Chad study area which will provide the highest seeds yield of *J. curcas* will be popularized.

Materials and methods

Description of experimental sites

The field study took place from May to December 2016 in Tandjilé region, located in southern Chad. Study took place in four localities of this region: Djoun: 09°46’ 03, 4” North latitude, 017°10’ 57,8” East longitude and 382,2m altitude ; Insatal: 09°17’ 16,7” North latitude, 016°55’ 47,6”East longitude and 334,9m altitude ; Laï-Djom: 09°45’15’6’ ’North latitude, 018°25’25,7” East longitude and 375,4m altitude and Tchoua : 09°18’ 16,7” North latitude, 016°55’ 47,6” East longitude and 354,9m altitude. The climate belongs to Sudanian type, characterized by two seasons: a rainy season (May to October) and a dry season (November to April). Rainfall varies between 800 to 1200mm. The temperatures present absolute minimums in December-January (15°C) and averages of the relatively high maxima in March-April (35°C). Annual average temperatures range between 28°C and 32°C and the relative humidity of the air is maximum (80%) in July-August-September. The soils are variable depending places (vertisols, tropical ferruginous soils and hydromorphic) and favorable to agriculture and livestock (Anonymous, 2017). The Tandjilé region is located in the Logone basin area. Soil was covered by graminaceous and is rich in legumes during the rainy season. The dominant tree and shrub species were Combretaceae (*Combretum colinum*, *Combretum aculeatum*), Moraceae (*Ficus* spp), Cesalpinaceae (*Piliostigma thonningii*), Annonaceae (*Annona senegalensis*). Also, Sapotaceae (*Vitellaria paradoxa*) and Mimosaceae (*Parkia biglobosa*) were observed in our experimental sites.

Materials

Seeds and cuttings of stem of *Jatropha curcas* are used. They were collected locally. Fruits and cuttings were picked in November 2015 on *J. curcas* planted in hedge. These plants are 5 years old. Subsequently, the seeds are extracted from the fruits and they were stored in a dry place (room temperature) until the sowing day. These seeds were black in color and presented 1.86cm length, 1.10cm maximal diameter and 0.72g weight at planting. Cuttings presented 2.5cm diameter and 60cm long and they were made at sowing day.

Fig. 1. Seeds of *Jatropha curcas*

Fig. 2. Cutting of *Jatropha curcas*

Methods

Assesment of plants propagation methods on Jatropha curcas growth and yield

Land preparation and experimental design

All wild plants were cut off from the experimental sites. Thereafter each site was plowed to 50 cm depth and ridges of 10 m × 6 m (60 m²) were formed. Space between two consecutive ridges was 3 m. The experimental design consisted of two treatments (plants propagation methods) lay out randomly and repeated in four blocks. The same experimental design was adopted in the four study localities (Djoun, Tchoua, Laï-Djom and Insatal).

Studied parameters and statistical analyzes

Growth parameters (plants height, number of leaves per plant, number of ramification per plant and dry biomass of plants) and production parameters (number of fruits per plant and seeds yield) were assessed on 30 targeted plants. Carbon stock was assessment according to GIEC (2006) and Mugnier *et al.* (2009), using this formula : CS=BS×0,475 where CS=carbon stock and BS=total biomass of *J. curcas* plants. All data were statistically analyzed using the Stagraphic plus Program version 5.0. The significance of differences was determined using Duncan test.

Results and discussion

Chemical properties of growing soils

Growing soil presents a sand-clay texture with silt levels ranging from 1.68% to 5.05%. All soil samples have a neutral pH (6.59-7.38) (table 1), thus suggesting the optimal availability of mineral elements at different experimental sites (Kanabo and Gilkes, 1987). Organic matter and soil carbon content are relatively low (less than 1%) (Table 1). Crops have difficulty in extracting nutrients from soil and microfauna activity is reduced when soil organic matter is less than 1% (Martin *et al.*. 1990).

In this respect, fertilization using compost would increase the agricultural values of our growing soil, but this needs to be investigated. Phosphorus and potassium contents of growing soil range from 250 to 480 ppm and from 100 ppm to 180ppm respectively. Concerning chemical properties of growing soil. soil from four study sites presented globally a good agricultural values; they are all likely to guarantee a good productivity of plants like *Jatropha curcas* L. However it would be appropriate to improve the low organic matter content of these soils by adding organic manure.

Effect of plants propagation methods on Jatropha curcas growth and development

Plants height, number of leaves per plant and number of bunches per plant

The analysis of variance (ANOVA) shows that there is no significant difference on plant height between both plants propagation methods (seedling and cuttings of stem). However the four experimental sites influence significantly ($p<0,05$) the height of *Jatropha curcas* plants (Table 2).

Plants from Tchoua locality exhibited the highest (62.89 ± 1.30 cm) plant height. Furthermore, both plants propagation methods and the four experimental sites influence significantly (p<0,05) foliar production and number of bunches per plant. The greatest (70.60 ± 2.56) number of leaves per plant is observed on *J. curcas* plants growth in Tchoua locality while Djoum experimental site exhibited the lowest (49.93 ± 1.19) value of this growth parameter.

Table 1. Physico-chemical properties of growing soils

Study Sites	Texture			pH	Conductivity (µs/cm)	Organic matter (%)	Carbon (%)	N (ppm)	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	Fe (mg/g)
	Sand (%)	Silt (%)	Clay (%)										
Djoun	86.68	3.14	10.18	6.97	22.19	0.03	0.01	10.18	250	145.0	20.00	245.0	8.00
Insatal	88.19	2.02	9.79	6.64	20.46	0.05	0.03	35.75	255	157.5	47.00	260.0	6.05
Laï-Djom	89.19	1.68	9.13	6.70	18.9	0.04	0.03	5.50	260	140.0	37.50	250.0	11.00
Tchoua	87.17	2.37	10.46	6.59	53.7	0.06	0.04	66.00	265	175.0	55.00	250.0	1.10
Mean	87.80	2.30	9.89	6.72	24.08	0.05	0.03	29.35	257	154.4	39.87	251.2	6.53

Table 2. Plants height, number of leaves per plant and number of bunches per plant depending experimental site

Experimental sites	Plants propagation methods					
	Seedling			Cuttings of stem		
	pH	NLP	NBP	PH	NLP	NBP
Djoun	44.23±0.47^{a}	50.06±0.94^{a}	4.46±1.08^{a}	40.63±0.47^{a}	49.80±1.43^{a}	9.96±0.72^{a}
Insatal	56.56±0.97^{c}	63.8±1.07^{b}	4.51±1.17^{a}	47.5±1.06^{b}	73.53±3.23^{b}	9.96±0.12^{a}
Laï-Djoum	50.46±1.33^{b}	54.66±0.70^{a}	8.06±1.94^{b}	47.70±0.8^{b}	87.00±2.53^{c}	11.00±0.24^{a}
Tchoua	61.73±1.24^{c}	70±2.9^{b}	12.00±0.46^{c}	64.06±1.37^{c}	87.20±2.26^{c}	15.40±0.59^{b}

P^{H}: Plants height; NLP : Number of leaves per plant ; NBP : Number of bunches per plant. Values in the same column for each plants propagation method followed by the same letter are not significantly different.

Plant leaves absorb co_2 through photosynthesis, thus contributing to fight against climate change. It can also limit sunstroke, increase soil moisture content and reduce erosion (Ouédraogo, 2000; Singh and Rathod, 2002; Tchuenteu *et al.*, 2013). Plants leaves represent a biomass that can be degraded and released nutrient necessary for improving soil fertility and plants nutrition (Bunch, 2004; Sall, 2007).

In the present study, Tchoua locality exhibited the greatest foliar production, suggesting that *J. curcas'* cultivation in Tchoua locality would contribute effectively to fight against climate change as well as improving soil fertility compared to other three experimental sites, but this remains to be studied.

In this study, plants height, foliar production and number of bunches per plant vary according to experimental area, this result does not surprise us: indeed, several authors (Reinhard and Tianasoa, 2005; Fresco, 2003 and Megueni *et al.*, 2011) reported that plants growth parameters vary depending on cultural practice and experimental area.

Dry biomass and carbon stock

The dry biomass, carbon stock and equivalent CO_2 sequestred depending experimental site and plants propagation method are presented in Table 3. The analysis of variance (ANOVA) showed that both plants propagation methods and the four study localities influenced significantly (P <0.001) the dry biomass of plants of *J. curcas*, consequently carbon stock and equivalent CO_2 sequestered. Plants with a high biomass correspond to those with high carbon values sequestered by photosynthesis mechanism (Tchobsala, 2016). Plants from Tchoua locality exhibited the highest (0.26±0.03Kg) dry biomass, consequently the highest (0.13± 0.05Kg) carbon stock compared to those from other localities.

In this respect, the culture of *J. curcas* in Tchoua locality would contribute effectively to fight against climate change compared to Djoun, Insatal and Laï-Djoum areas.

Number of fruits per plant and seeds yield of Jatropha curcas plants

Both plants propagation methods as well as different study areas significantly (P< 0.001) influence the number of fruits per plant and seeds yield of *J. curcas*. Seeds yield vary from 55±4.92Kg/ha in Djoum locality to 104±1.90Kg/ha to Tchoua locality. Globally Tchoua locality exhibited the highest (96±2.82 Kg/ha) seeds yield while the lowest (57.5±3.22Kg/ha) is observed in Djoun locality.

Table 3. Dry biomass and carbon stock depending plants propagation method and experimental area.

Experimental sites	Plants propagation methods			
	Seedling		Cuttings of stem	
	DB (Kg)	CS (Kg)	DB (Kg)	CS (Kg)
Djoun	0.05±0.01[a]	0.02±0.00[a]	0.15±0.09[a]	0.07±0.02[a]
Insatal	0.15±0.08[c]	0.07±0.01[b]	0.20±0.01[b]	0.10±0.02[b]
Laï-Djoum	0.08±0.01[b]	0.04±0.01[a]	0.18±0.37[b]	0.09±0.02[b]
Tchoua	0.20±0.03[d]	0.10±0.07[b]	0.31±0.03[c]	0.15±0.04[c]

DB: dry biomass; CS: Carbon stock, ECS; Values in the same column for each seedling mode followed by the same letter are not significantly different.

The seeds yield from cuttings plants propagation methods is higher (72±3.15Kg/ha) than that from seedling plants propagation method (66±3.9Kg/ha). In this study growing and production parameters of *J. curcas* vary according to study area. This result corroborates data found in literature. Indeed, several authors (Koutroubass *et al.* 1999; Tchuenteu *et al.*, 2013 and Derogoh *et al.*, 2018) reported that plant productivity vary depending to experimental area. In this study, seeds yield ranged from 55±4.92Kg/ha to 104±1.90Kg/ha. These values are lower than data found in littérature. The low seed yield obtained in this study is due to the fact that no fertilizer was applied in this work. Seeds yield can be improved if soil amendment, cultural and growing conditions are improved. Indeed, Bambang *et al.* (2016) study the yield performance of *J. curcas* after pruning during five years production cycles in North Lombok dry land, Indonesia and reported that The total yield was higher (16,314.6 kg Ha-1), compared to un-pruned tree (14,800.1 kg Ha-1). In addition, Chengxin *et al.* (2014) study on a new *J. curcas* variety (JO S2) with improved seed productivity and found that this *J. curcas* variety produced up to 2.95 t/ha of dry seeds in the first year and up to 4.25 t/ha of dry seeds in the second year, much better than the local variety control.

The small seed yield obtained in this study can be explained by the fact that this work was not carried out under the same experimental conditions as those of our predecessors. In addition, it was been reported that plant productivity vary according to genotype, experimental area, and year of experimentation (Koutroubass *et al.*, 1999, Tchuenteu *et al.*, 2013). In this study, Tchoua locality is more favorable for J. curcas growth compared to Djoun, Insaltal and Lai-Djoum. Moreover, *J. curcas* growth and seeds yield is higher under cuttings of stem plants propagation method than under seeds propagation.

Table 4. Number of fruits per plant and seeds yield of *Jatropha curcas*.

Localities	Plants propagation methods			
	Seedling		Cuttings of stem	
	NFP	SY (kg/ha)	NFP	SY (kg/ha)
Djoun	31 ± 1.63[a]	60 ± 1.52[a]	29 ± 1.52[a]	55 ± 4.92[a]
Insatal	30 ± 2.70[a]	57 ± 6.53[a]	39 ± 2.52[a]	74 ± 3.51[b]
Laï-Djoum	31 ± 1.77[a]	59 ± 3.81[a]	30 ± 3.57[a]	56 ± 2.3[a]
Tchoua	46 ± 3.30[b]	88 ± 3.74[b]	55 ± 3.57[b]	104 ± 1.90[c]

NFP : Number of fruits per plant ; SY : Seeds yield Values in the same column for each seedling mode followed by the same letter are not significantly different.

Conclusion

Soils from Sudanian savannah zone of Chad are favorable for well *Jatropha curcas* growing. The growing parameters of *J. curcas* as well as seeds yield vary depending study area and plants propagation method. J. curcas plants from Tchoua locality exhibited the highest growing parameters and seeds yield (96±2.82Kg/ha). Cuttings of stem exhibited the highest (104±1.9 Kg/ha) seeds yield while the lowest (88±3.7) is observed under seedling plants propagation method in each of four experimental areas. Cuttings of stem propagation method is recommended for *J. curcas* growing in Chad. Further research will then investigated the effect of organic manure on *J. curcas* growing in Tchad.

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