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EFFECTS OF PLANTATION DENSITY ON *JATROPHA CURCAS* L. GROWTH AND PRODUCTION, ON TROPICAL FERRUGINOUS SOIL IN BURKINA FASO

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ABSTRACT

Management methods in farm are an essential factor in improving *Jatropha curcas* development and fruit production. Reduction of cultivable land under demographic pressure, requires researching densities that allow a better expression of *Jatropha curcas*. It is in this context that this study was initiated. The design is a complete randomized block with 3 repetitions and 4 treatments which are following planting densities: T1 = 1 m x 1 m, T2 = 2 m x 2 m; T3 = 3m x 3m; T4 = 4 m x 4 m. The elementary plot, extends over 12m x 12m.Growth and production parameters were monitored for 52 months. From 20 to 31 months, *Jatropha curcas* shows strongest growth in total height and it is T2, T3 and T4 treatments which show the strongest growths. In addition, from 20 months, T2, T3 and T4 treatments show the greatest changes in diameter at base and crown surface.Treatments T2, T3 and T4 have the best yields, however, great variability between individuals and better trend for T4 (739.3 ± 465.1 kg / ha). T4 treatment could be a better option if we choose sustainability of combination system Jatropha-culture.

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INTRODUCTION

Introduced since colonial times in Burkina Faso (Bazongo *et al*., 2015), *Jatropha curcas* has mainly been used as an ornamental plant or as an alignment plant. However, we have to wait for the last ten years (Bazongo *et al*., 2015) to see its culture take on great importance. Indeed, faced with the country's increasingly high dependence on fossil energy and especially with regard to the soaring cost of oil, contributing to unbalance the country's economy, reinforcing its dependence from outside, the political authorities have to promote culture of *Jatropha curcas*. Species is known to have a high potential for producing energy oil (Heller, 1996; Kaushik *et al*., 2007; Openshaw, 2000; Shanker and Dhyani, 2006; Ullenberg, 2007; Terren *et al*., 2013). That is why several development projects will promote production and marketing of *Jatropha curcas* seeds.

The areas of this crop are evaluated between 70,000 and 150,000 ha (CIRAD-2ie, 2009). Penetration of *Jatropha curcas* is facilitated by the fact that it is reported that it is a hardy plant which produces well on degraded land which it helps to recover (Achten *et al*., 2008; Brittaine *et al*., 2010). Promoters of *Jatropha curcas* recommend its cultivation in degraded areas in order to avoid any competition with the cultures (Bazongo *et al*., 2015). However, producers in practice find this species to be more productive on fertile land. In addition, studies have shown that the productivity of *Jatropha curcas* is low on poor and marginal lands. Consequently a problem of management of the species compared to the other cultures or a better arrangement of the individuals of the species in the agricultural space, for a better yield is to be taken into account. In addition, for Diédhiou *et al*., (2012), the most urgent is the improvement of the low

yield of the plant to guarantee the profitability of the plantations. Management methods for the species in fields is an essential factor in improving productivity. Reduction of cultivable land under demographic pressure, requires researching densities that allow a better expression of *Jatropha curcas*. It is in this context that this study was initiated to determine the influence of the densities usually encountered in rural areas on the growth and productivity of *Jatropha curcas*..

MATERIAL AND METHODS

Study site: The study was conducted at the station of the Institute for the Environment and Agricultural Research (INERA), in Saria. The village of Saria is located 80 km southwest of Ouagadougou and at an altitude of 300 m. Its geographic coordinates are 12 ° 16'N latitude and 2 ° 09'W longitude (Figure 1).

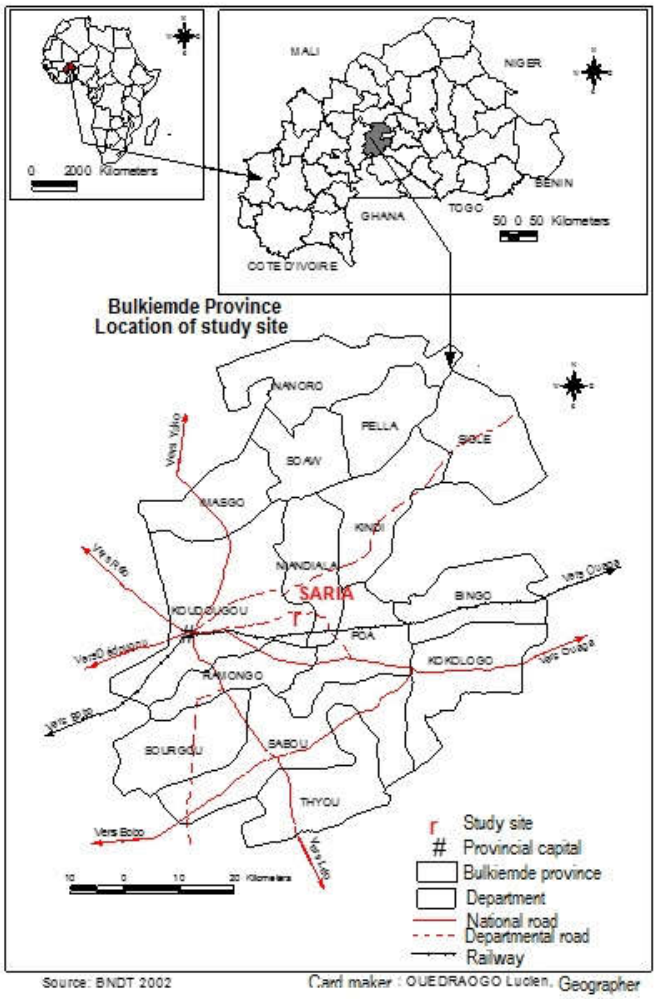

Figure 1. Study site location

Climate is of the North Sudan type, characterized by two contrasting seasons. The average annual rainfall is 800 mm, with strong spatio-temporal variations. The annual average temperature is 28 ° C with monthly maximums of 40 ° C (March April). The terroir of Saria is a very populated area, 102 inhabitants. / km2 (4), whose main activity is agriculture. The main crops are sorghum and millet. Soils are tropical ferruginous, leached or not, from a granitic source rock. They are poor in phosphorus, exchangeable bases and organic matter (Hien, 2004). Regarding vegetation, Saria belongs to the northern Sudanian sector, characterized by savannas with annual grasses, trees and shrubs. Woody vegetation is mainly composed of *Vitellaria paradoxa* Gaertn.f., *Lannea microcarpa* Engl. And Krause, *Tamarindus indica*, *Azadirachta indica* A.Juss. The shrub layer is dominated by sparse thickets of Combretaceae including *Guiera senegalensis* J.F.Gamel., *Combretum nigricans* Lepr. Ex Guill. and Perr. and *P.reticulatum*. The herbaceous layer consists mainly of *Loudetia togoensis* Hubb., *Dactyloctenium aegyptium* Beauv., *Cymbopogon giganteus* Chiev. and *Andropogon gayanus* Kunth..

METHODOLOGY

The test design is a complete randomized block with 3 repetitions and 4 treatments:

T1 = planting density of 1 m x 1 m
T2 = planting density of 2 m x 2 m
T3 = planting density of 3m x 3m
T4 = planting density of 4 m x 4 m

The elementary plot, square in shape, extends over 12m x 12m or 144 m2.
The installation of this test took place in late July 2012.
Growth and production parameters were monitored

The growth of *Jatropha curcas* was monitored through measures of:

- Total height or great height estimated by a graduated pole
- Average crown which is the average of the large crown and the small crown evaluated by the graduated pole;
- Circumference at the base of the trunk raised with a soft ribbon.

Measurements have been taken every two weeks since installation in July 2012 for 50 months.

Production of *Jatropha curcas* was assessed at the end of each production period in 2014, 2015 and 2016 through:

- Number of ripe fruits collected and counted
- Weight of the seeds obtained
- Weight of 100 seeds

The Mettler brand balance of sensitivity 0.01 g, capacity 4 kg was used.

Data analysis: Data were subjected to a factor analysis of variance (ANOVA) using Fisher's least squares test (LSD), in order to compare means of different growth and production parameters of *Jatropha curcas* at the threshold of 5%. . Statistical analyzes were performed using SPSS 2007 software.

RESULTS

Growth of *Jatropha curcas*

High Height: Evolution of great height whatever treatment shows four distinct stages in *Jatropha curcas* (Figure 2). From planting up to three months of age, regardless of planting density, feet are indistinguishable.From 3 months to 15

months, plants of high density (1m x 1m) show a higher height evolution and statistically different from densities 2 m x 2m, 3mx3m and 4mx4m which do not differ statistically between them (Table 1).From 15 to 20 months the growth in height of *Jatropha curcas* does not show any difference whatever treatment. Their evolution marks stagnation. However, from 20 to 31 months, *Jatropha curcas* shows the highest growth in total height. During this period, T2, T3 and T4 treatments show statistically identical growth and greater than density 1m x 1m. Inflection in evolution of total height towards a plateau shape is observed from 31 months regardless of treatment.

significant in 2016 where it went from 145.4 ± 135.6 kg for T0 to 739.3 ± 465.1 kg for T4. In addition, this production is characterized by great variability from one individual to another whatever the treatment as evidenced by the deviations.

DISCUSSION

Height growth: Height growth of *Jatropha curcas* is not straight regardless of the planting density. It is done in stages. The first three months after planting *Jatropha curcas*, are marked by a stagnation in height evolution.

Table 1. Statistical analyzes of studied parameters as a function of time

Month	HIGH Height			DIAMETER at base			crown diameter		
	ddl	F	Sig.	ddl	F	Sig.	ddl	F	Sig.
1	3	1,67	0,18	3	0,80	0,50	3	1,00	0,40
3	3	2,47	0,06	3	2,25	0,08	3	2,06	0,11
6	3	6,12	0,00	3	4,87	0,00	3	6,19	0,00
9	3	4,77	0,00	3	2,99	0,03	3	7,70	0,00
12	3	5,60	0,00	3	3,23	0,02	3	6,00	0,00
15	3	0,28	0,84	3	1,83	0,14	3	0,10	0,96
18	3	0,21	0,89	3	0,19	0,90	3	1,75	0,16
20	3	0,62	0,60	3	0,89	0,45	3	0,30	0,82
31	3	6,29	0,00	3	6,90	0,00	3	9,78	0,00
39	3	7,38	0,00	3	6,16	0,00	3	7,38	0,00
42	3	4,50	0,00	3	2,28	0,08	3	8,79	0,00
51	3	3,51	0,02	3	7,68	0,00	3	20,38	0,00

Table 2. Evolution of production (kg / ha) of Jatropha curcas according to treatments from 2014 to 2016

	2014		2015		2016	
	Mean	Standart Deviation	Mean	Standart Deviation	Mean	Standart Deviation
T1	0a	0	10,8 a	11,4	145,4 a	135,6
T2	45,8 b	48,8	37,2 ab	36,4	315,6 ab	224,6
T3	87,8 c	70,1	63,5 b	56,8	552,0 bc	876,7
T4	52,0 b	66,8	101,7 c	85,4	739,3 c	465,1
F	*19,89*		*22,62*		*11,64*	
P	*<0,0001*		*<0,0001*		*<0,0001*	
Eta carré(%)	*30*		*28*		*17*	

Diameter at the base: From 1 to 3 months, different treatments do not show any statistical difference (Figure 3). However from 3 to 6 months, diameter at the base undergoes a strong evolution passing from approximately 2 to 3 mm to 20 to 25 mm for all the treatments. During this evolution, T1 treatment is distinguished from T2, T3, and T4 treatments which are statistically equal. This same trend of evolution with a relatively slower speed is observed until age of 15 months. From 15 to 20 months, diameter at the base of *Jatropha curcas*, remains identical for various treatments. From 20 months, treatments T2, T3 and T4 have a diameter at the base statistically identical but greater than that of the lowest planting density (T1).

Crown area: With *Jatropha curcas*, whatever density of planting, crown area changes slightly until the age of 20 months. Treatments are not statistically different. However from 20 months, high density (1m X 1m), has the smallest crown area whatever the age it remains less than 1 m^2. From age of 20 months, T4 treatment (4m x 4m) shows the greatest change in crown area ranging from 0.3 m^2 to approximately 2.8 m^2 at 51 months.

Fruit production of *Jatropha curcas:* Fruit production of *Jatropha curcas* increases with age from 2014 to 2016. In the first year of production, individuals in T1 treatment bear no fruit (Table 1). This increase in fruit production is especially

This period could correspond to adaptation of plant to its new environment and which is marked by the installation of root system. After three months, we observed a slow evolution of growth in height which could be explained by photosynthetic activity as well as root, medium. Planting densities 2m x 2m, 3m x 3m and 4m x 4m show a greater evolution than density of 1m x 1m plants. Density of 1m x 1m presents lowest change in height. Close proximity of seedlings in density 1m x 1m, from 3 months, would induce competition for light and root unfavorable to growth which explains this evolution (Lekadou *et al*., 2009). From 15 to 20 months,*Jatropha curcas* do not change in height and are statistically confused. For Diédhiou *et al*., (2012), during the dry season, *Jatropha curcas* plants stop growth and even decrease due to fall of leaves and buds. 2 to 3 years is period when species shows a stronger growth in height. From 31 months, growth of *Jatropha curcas* is relatively weak. For Diédhiou *et al*., (2012), it reaches maturity age from 3 to 4 years.

Diameter at base: During period which corresponds to adaptation of plant in its environment (1 to 3 months), diameter at base does not vary regardless of density, which could be explained by low synthetic activity at this age. Beyond 3 months, plants develop an important activity of synthesis (photosynthesis) which explains strong evolution of diameter at base. At 3 to 6 months, density of 1m x 1m was more favors to diameter at base evolution and this, until 15 months.

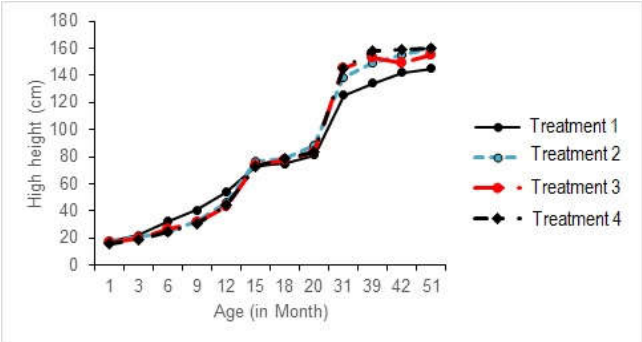

Figure 1. Evolution of *Jatropha curcas* high height

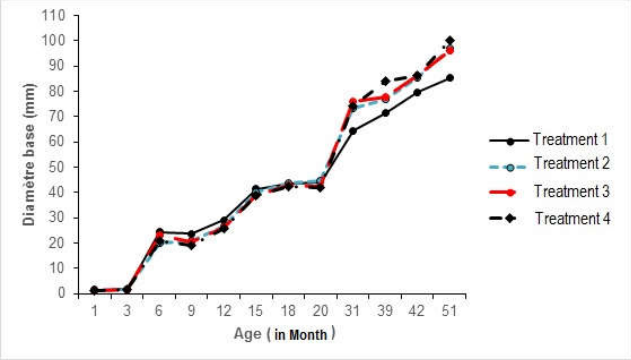

Figure 2. Evolution of Jatropha curcas diameter at base

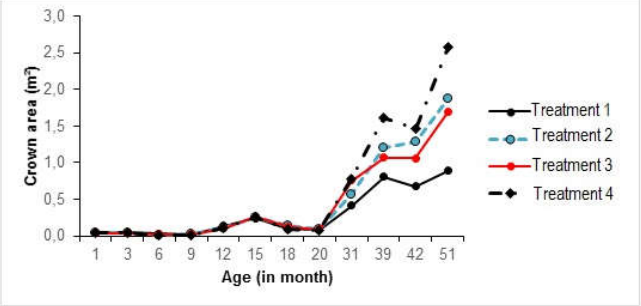

Figure 3. Evolution of *Jatropha curcas* crown area

During this same period, it appears that a larger spacing does not significantly increase development of diameter at base. Up to 15 months, *Jatropha curcas*diameter growth is strongest statistically in densities of 1m x 1m, this is explained by a greater importance of photosynthetic activity due to better development of above ground biomass. However from 20 months there is a decrease in the diameter at base in density of 1m x1m, this could be explained by the size of the aerial biomass which then induces competition between individuals due to their close proximity. The diameter at base of species is on the other hand better in plants of 2m x 2m, 3m x 3m and 4m x4m statistically identical because the size of the crown differs little at this age. Our results corroborate those of N'guessan, (2006) and Lekadou *et al*., (2009) who showed that diameter changes with spacing of plantation. Whatever treatment, there is great variability over time in crown diameter. For Kaushik *et al*., (2007) and Diédhiou *et al*., (2012), species shows great variability in growth.

Crown size: In Saria site, crown area varied lighly until 20 monthes for all treatments (tree density). Crown area was strongly correlated with number of ramification and leaf biomass. Crown area was strongly correlated with number of ramification and leaf biomass. Many authors (Ahoton *et al*., 2011; Gandonou *et al*., 2012; Ouattara *et al*., 2013) Sama *et al*., 2013 have shown that agro-morphology characteristics variabilitydepend on species attainments. Ecotype in this study being of sub-Sahelian origin, branching is slow and weak, hence small crown area obtained until 20 months, whatever density of plantation. Density of 2m x 2m, 3m x 3m and 4m x 4m due to the relatively large spacing, allowing better growth of crownwidth, have a larger crown area. For Lekadou *et al*., (2009), "in low density association, trees are less subject to competition for light, water and mineral elements, which explains their highest number of multiple stems "And therefore of the crown area. On other hand, density of 1m x 1m marked by a strong proximity of individuals, spatial congestion, lead crowns to develop more upwards to capture more solar radiation (Bazongo *et al*., 2018). From 20 to 51 months we observe a strong evolution of crown area in species which could be explained by age of maturity. Density of 4m x 4m, although statistically identical to densities 2m x 2m and 3m x 3m, resolutely stands out from 4 years.

Yield of *Jatropha curcas:* In the same year, disparity in yield is highly dependent on planting densities. During the first year, high density of planting (1m x 1m) is characterized by an absence of production. Indeed it has been given to us to note that on density of 1m x 1m reproductive organs grow quite late. In addition, low yield observed, all treatments combined, first year and second year of production should be compared with poor development of crown area. For Yélémou *et al*., (2009), the yield is strongly linked to the crown area. Yields obtained during the 3rd year for T4 treatment (739.3 kg / ha) are similar to those obtained by Bazongo *et al*., (2018) in the southern Sudanian zone of Burkina Faso, for 6-year-old plants in hedges (727, 47 to 796.26 kg / ha). While admitting that water factor is important for fruit production of *Jatropha curcas* (Dommergue and Pirot, 2008) as well as quality of soils (Derra, 2014; Rajaona *et al*., 2011;Trabucco *et al*., 2010) of the species also seem to be linked to cultivation methods (Bazongo *et al*., 2018). Also Assogbadjo *et al*, (2009) and Ahoton *et al*., (2011), showed existence in *Jatropha curcas*, of significant variability between individuals for height, diameter and yield parameters. Our results confirm these trends.

Conclusion

Planting densities of *Jatropha curcas* influence growth and its yield over time. Planting density effect on dendrometric parameters is expressed three months after planting. Evolution of dendrometric parameters is done in stages. At a density of 1 m x 1 m, *Jatropha curcas*have greatest height growth up to 15 months, as does crown diameter. Whatever dendrometric parameter, densities of 2m x 2m, 3m x 3m and 4m x 4m show higher values from the 20th month. In addition, density of 1m x 1m (T1) gives lowest yield compared to T2, T3 and T4. Density of 4m x 4m yield shows better trend. Our results also show a high variability in yield between individuals regardless of treatment. In view of these results, in case of cultivation in association with *Jatropha curcas*, it seems important to adopt the density of 4m x 4m in order to minimize interactions and promote better yield.

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