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Reponses of *Jatropha curcas* (L.) to various types of fertilizations grown on-farm in the locality of Tandjilé in the South of Chad

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Abstract
The promotion of bio carburant causes a renewed interest for the plantation of *Jatropha curcas* (L.) The culture of this nonfood plant has socio-economic and environmental advantages in the experimental zone. However it causes questions in connection with its consequences about the properties of the soils and possible competition with the food crop. The study was carried out in field during three years in soudanian savannah of Chad. The principal objective was to study the possibility of establishing and of diversifying the culture of *Jatropha curcas.* It is specifically a question of optimizing the development and the production of this plant under the effect of agricultural fertilizers (Organic, mycorhizien and chemical). The device is in completely randomized blocks with five treatments (Compost, mycorhizes, mycorhize-compost mixture, chemical fertilizer and control) and repeated four times. The effect of fertilizers brought was evaluated on the parameters of development and production of *J curcas* during the three years of culture. The fertilizers had a highly significant impact ($p<0,001$) on the parameters of growth and development (Size, number and area of leaves, number of branches, diameter of basal rod) and of production (A number of fruits and seed yield, total biomass, rate of carbon sequestration) of *J curcas* with an increase of 20 to 40% compared to the control. More particularly, the organic fertilization and mycorhizes prove to be beneficial substantially to increase the development and the production of *J. curcas* in optics to popularize its culture in the area of Tandjilé in Chad.

Keywords: *Jatropha curcas*, fertilization, production, Soudanian savannah, Tandjilé region (Tchad)

Introduction

Humanity had known for a few decades a serious problem of climatic change and a fluctuation in price of oil barrel. Industries became completely dependent on the fossil resources for energy needs. The world oil reserves which constitute the essence of the raw material chemical industries will be exhausted by 2050 (Chisti, 2007, FAO/FIDA. 2010) [6, 12]. Being conscious of pollution air caused by the gas emission for purpose of greenhouse, which carbon dioxide, coming mainly from the fossil oil combustion, has led the world powers to seek the substitute products to fossil fuels in the whole world, for a few years (Péan *et al.,* 2005) [28]. The biocarburants constitute one of the effective solutions judged to fight against the gas emission for purpose of greenhouse which degrades our environment. Several research converges towards the plants able to produce renewable energy (Diop, 2009; Tiwari *et al.,* 2007) [9, 38]. The oleaginous plants nonedible must be aimed not to worsen the food insecurity; more especially as the world population does not cease increasing. Thus the quantity of food available to nourish this population must be increased. Unfortunately several food plants use already the production of the biocarburants, the such as sugar cane, the beet, colza, the sunflower, the corn, the roots and the tubers, the palm tree with oil and the groundnut in Brazil, in the United States, to Europe and India for the production of bioethanol, substitute of the gas oil (Dieye, 2007; Kabutey *and et al*, 2010) [8, 20].

Among the many plants which produce seeds which one can extract from nonedible oils and with potentiality biocarburant, are the Ricinus and Jatropha. Oil of *Jatropha curcas* is proven to be the source of alternate fuel of the oil gasoil (Fall, 2007) [11] and of the experimental tests of use of this crude oil or after esterification in the ground engines and flying machines (planes) by several companies in the world were a success.

This potentiality bio carburant that the oil of *J. curcas* offers justifies the world interest related to this new and renewable energy, although its industrial exploitation reveals some problems of incomplete combustion at a certain temperature (Akowuah and *et al*, 2012; Gbetoho, 2016) [3, 15].

The research and the development of the Jatropha branch appear among the objectives of development of many countries. In addition to its capacity to produce biocarburant, the plant vegetates and adapts easily to various ground. It thus has potentials of carbon sequestration, reducing the carbon dioxide of the air, principal gas for purpose of greenhouse in the atmosphere. The plantation of *J. curcas* on a large area can be eligible at the markets carbons in the world, provided that it does not enter in competition with the plants intended for the human foods (Fresco O, 2003; Hammaoui, 2006; Nwaga D., 2009) [13, 17, 27].

It is necessary and urgent to direct itself towards the sources of new and renewable energies, more concerned of the environment for a durable management of the natural resources (Ahoton, 2011) [2]. In Africa, for ecological and agro-economic reasons, the use of the biocarburants makes it possible to reduce the invoices of electric consumption and to produce energy with a weak environmental impact. The valorization of pure vegetable oils in the farm motorization constitute a possible solution with the problems of the countries in the process of development (Dieye, 2007; Fresco, 2003) [8, 13].

The production of the oil of *J curcas* on a large scale requires an adapted farming technique and the consequent contribution of agricultural fertilizers. The massive use and not controlled chemical fertilizers pollutes the environment. To avoid disturbing the natural ecosystem, the use of biological manures is indicated. They are the practices of biological agriculture without environmental impact (Nwaga, 2000; Jamaludin and Singh, 2006; Jacquet, 2009) [27, 19, 18].

The objective of this work was to evaluate the effect of agricultural fertilizers on the development and the production of *J curcas*.

Materials and Methods

Description of experimental sites

The tests were carried out in field during three years and in two different sites: Tchoua, in the Tandjile-center and Laï-Djom, in Tandjilé-east; two localities of Tandjile region, in the south of Chad, approximately 500 km away from N'Djamena. The geographical position are respectively the following ones: Laï-Djom: 09°45'15'6''North latitude, 018°25'25,7''East longitude and 375,4 m altitude and Tchoua : 09° 18' 16,7'' North latitude, 016° 55' 47,6''East longitude and 354,9 m 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 1200 mm. 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 grounds are sablo-argillaceous.

Vegetable material

The biological material is consisted of the young seedlings of *Jatropha curcas* having spent three months in seedbeds.

The experimental device

The experimental device is in completely randomized blocks with five treatments (compost, mycorhizes, mycorhizes-compost mixture, chemical fertilizer and control) and the tests were repeated four times. It consists of four blocks having each one five (05) elementary pieces or experimental units of 10 X 6 meters. Three lines of five seed holes separated by 2 meters are are put in field, that is to say 15 feet per piece.

Treatments

Three types of fertilizers were used for the experimentation: chemical fertilizer NPK (20 10 10); the compost and mycorhizes. The control is represented by seedlings not having received any fertilizer all the period of the study.

Fig 1: Fertilizers used during the experimentation.(A) mycorhize inoculum, (B) Compost of cattle dung filtered (C), Chemical fertilizer NPK (20 10 10).

The mycorhizes inoculum applied came from the Center of Biotechnology of Yaounde I. It is a mixture of sand, fragments of roots and of three selected stocks of mycorhizes (*Glomus clarum; Gigaspora magarita* and *Scutellopora sp*). A mass of 30 g of mycorhizes is put by seed hole followed immediately of plantation. For the compost of cattle dung obtained after 5 months of composting, a mass of 3 kg is applied by seed hole in crown, without direct contact with the seedlings. The chemical fertilizer used consisted of 300g of NPK (20 10 10). The treatment combined Mycorhizes-Compost consists of 30 g of mycorhizes put in the seed hole at sowing and of 3 kg compost applied in crown to the turn of the vegetable material.

Studied parameters

Sampling is related to 30 seedlings by treatment. The impact of fertilizers is studied on the characteristics of growth and development (survival of the seedlings, seize, a number of formed leaves, a number of ramifications, diameter of the stem basal) and those of production (biomass, stock of carbon, number bunches, fruits, seeds yield).

Evaluation of the studied parameters

The evaluation of the rate of survival of the seedlings, of the number of leaves and bunches is obtained by simple counting. The size of the seedlings was measured with a decameter and the basal diameter of the stem, was measured using a slide caliper of precision 0, 1. The seed mass was given using an electronic balance of Diamond mark.

The biovolume, the biomass and the stock of carbon were estimated according to the methods of GIEC (2006) [16] and Mugnier *et al.* (2009) [24] using the following formulas:

$$\text{Biovolume (Cm}^3\text{)} = [(d2 \times \pi \times h)/4\ ] \times 0,546 \times 1,28$$

(π = 22/7;1,28 = "factor of roots expansion ";0,546 = factor forms tree;
D = diameter of the tree in cm; H = height of the tree in cm)

Biomass (kg) = (Biovolume X 0,58).10 $^{-3}$
(0,58 g/cm3 = density of wood by defect for the tropical forests of Africa
Stocks C = Biomass X 47,5/100 (47,5 % = carbon concentration of wood, selected constant

Statistical analysis

The statistical analysis of the results was carried out using the Statgraphic software plus 5.0.The data of the characteristics of growth, development and production were subjected to an analysis of variance (ANOVA) and their averages were compared using the test of Duncan to the threshold of probability of 5%.The tests of correlations (r) made it possible to show the existence of the relations between various variables. Other data were obtained according to calculation of percentage.

Results and Discussion

Rate of survival of the seedlings

The various fertilizers applied have a highly significant effect (*P*< 0,001) on the rate of survival of the seedlings at 360 days after the setting in field compared to the control all along the tests. The rate of survival of the seedlings after transplantation on average lay between 98 and 100% to three weeks after the setting in field (Figure 2). The rate of survival raised on the pieces treated with the compost and the mycorhizes would be due to the mineral contribution, with the retention of water under the plants. Ademe (2012) [1] affirmed that the granulous aspect of the compost confers to it a role similar to an absorbing water sponge and gradually releases it with the profit of the plant. The results of work obtained by Perrin (1991) [30] and Perret *et al.*, (2000) [29] proved that the mycorhizes give a beneficial role in the hydrous food of the plant. The compost and the mycorhizes ensure the protection of the plants (Yolande Daphé, 2005; Ngakou *et al.*, 2008; Leye *et al.*, 2009; Megueni *et al.*, 2011) [25, 21, 22]. The rate of survival is weak on all the pieces treated with the chemical fertilizer. Under this treatment, the seedlings were to abundantly have water for the dilution of mineral salt.

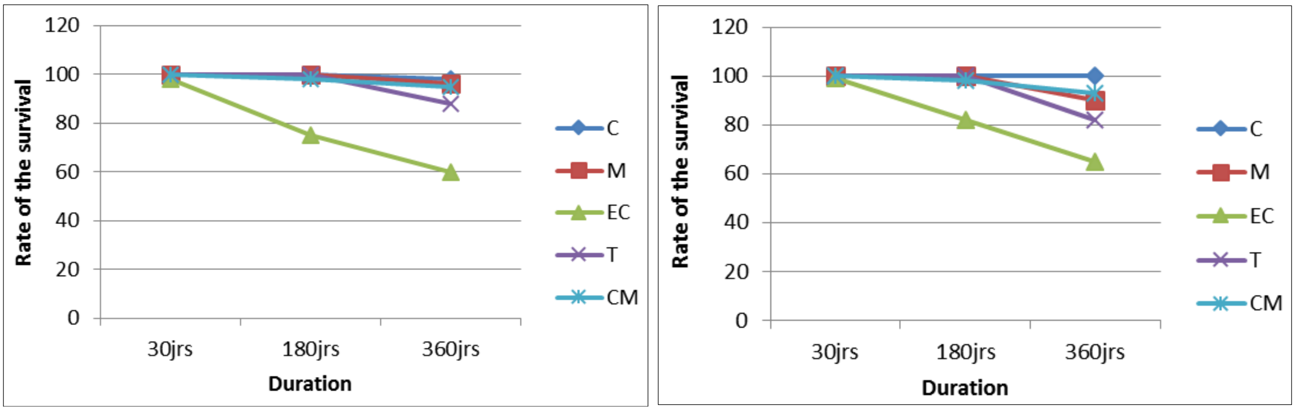

Fig 2: Rate of survival of the plants of *Jatropha curcas* resulting from the seedbeds, 360 after transplantation in field in Laï-Djom (A) and Tchoua (B). C:Compost; M:Mycorhizes; EC.: Chemical fertilizer; T: Control; CM: Compost-Mycorhizes; jrs stands for days.

Effects of fertilizers on the characteristics of growth and development of the seedlings of *Jatropha curcas*

The results of table 1 showed that there is a highly significant difference (*P*<0,001) between the various treatments. The seedlings treated with the compost (C) and the compost associated with the mycorhizes (CM) are of big size and have a significant number bunches and the solid base of the stems. All the plants having a big size and having many ramifications carried enough leaves. The plants treated with the compost, compost-mycorhizes and on the chemical fertilizer have very large and greener leaves; what indicates the level of mechanism of a strong photosynthesis at these plants compared to the seedlings inoculated to the mycorhizes and with the control (Table 1).

Table 1: Effects of fertilizers on the vegetative developement of *J. curcas*

Sites	Treatments	Plants height (cm)			Number of bunches			Basal diameter of stem (cm)		
		2016	2017	2018	2016	2017	2018	2016	2017	2018
Laï-Djom	C	81,73±1,2^{d}	124±0,15^{c}	174,67±5,03^{b}	7,63±0,9^{d}	63,22±3,70^{c}	146±7,57^{b}	3,36±0,5^{b}	7,92±1,60^{c}	14,00±1,73^{bc}
	M	50,63±1,5^{b}	96±0,22^{b}	152,10±1,06^{a}	2,35±1,4^{b}	12,66±1,22^{ab}	80±1,15^{a}	2,50±0,8^{a}	6,05±1,84^{ab}	12,33±0,58^{ab}
	EC	80,47±2,7^{d}	127±0,32^{c}	158,20±3,46^{a}	5,57±0,7^{c}	46,44±1,51^{c}	88±4,16^{a}	3,03±1,4^{b}	5,94±2,74^{ab}	12,41±2,08^{ab}
	T	44,00±2,3^{a}	68±0,14^{a}	144,05±5,29^{a}	1,03±0,6^{a}	7,55±3,57^{a}	82±1,53^{a}	2,20±0,7^{a}	4,66±0,70^{a}	11,33±1,15^{a}
	CM	77,50±3,3^{c}	123±0,20^{c}	186,12±1,21^{d}	6,92±0,5^{d}	53,77±3,02^{c}	172±3,46^{c}	3,87±1,6^{c}	7,92±1,56^{c}	15,00±1,01^{c}
	P	0,001	0,001	0,0005	0,001	0,0033	0,0001	0,001	0,0052	0,0021
Tchoua	C	85,63±0,9^{c}	134±0,11^{c}	166,67±1,15^{b}	12,62±3,7^{d}	68,00±2,79^{c}	145±2,51^{b}	3,61±0,4^{c}	7,22±0,79^{d}	13,67±6,51^{b}
	M	52,20±1,8^{a}	83±0,27^{b}	124,00±1,12^{a}	3,51±2,1^{b}	37,55±3,89^{b}	75±2,25^{a}	2,7±0,3^{a}	5,55±0,84^{b}	10,05±1,01^{a}
	EC	86,46±1,5^{c}	123±0,20^{c}	156,67±2,08^{b}	9,85±1,2^{c}	63,33±2,88^{c}	140±4,22^{b}	3,11±0,4^{b}	6,11±0,75b^{c}	13,33±1,52^{b}
	T	50,10±1,7^{a}	67±0,07^{a}	129,00±1,82^{a}	1,65±0,5^{a}	6,66±3,87^{a}	76±2,08^{a}	2,3±0,3^{a}	3,88±0,41^{a}	10,33±0,58^{a}
	CM	78,77±2,5^{b}	140±0,09^{c}	161,67±0,76^{b}	10,55±2,5^{c}	72,88±5,75^{c}	155±4,16^{b}	4,21±0,5^{d}	7,31±0,33^{d}	14,00±2,64^{b}
	P	0,001	0,001	0,0147	0,001	0,001	0,0001	0,001	0,001	0,0001

C:Compost; M:Mycorhizes;EC.: chemical fertilizer; CM: Combination compost-mycorhizes; T: control
The values of the same column followed by the same letter are not significantly different (*P*< 0,001).

a. Plans on seed hole fertilized with Compost-Mycorhizes mixture; b. Plans on seed hole fertilized with Compost; c. Plans on seed hole fertilized with Mycorhizes; d. Plants on seed hole fertilized with the chemical fertilizer; e. Plants on seed hole not fertilized or control

Fig 3: Plants of *Jatropha curcas* fertilized with the mixture of Compost-Mycorhizes(A), Compost (B), Mycorhizes (C), chemical fertilizer (D) and not fertilized or control (E) under an average daily temperature, 38°C (March).

Alexander *et al.* (1983) [4], Singh and Rathod (2002) [33] obtained similar results on the growth and the development of *J curcas*. These results corroborate those of Gandonou *et al.,* 2012 [14], Minengu *et al.* (2014) [23], and Tchobsala *et al.*, 2013 [36] who observed, respectively, the positive influence of the fertilizations and the farming technique on the vertical growth of *J curcas* in Benin, in Democratic Republic of Congo (DRC) and in the northern region of Cameroun. The significantive number of leaves is useful in the fight against the climatic change by the mechanism of carbon sequestration which can be operated by photosynthesis. It can also limit the insolation, increase the relative humidity of the ground and reduce erosion (Wiesenhiitter, 2003) [39]. The leaves represent organic biomass which can be recycled suitable for fertilize the ground while releasing from the biogenic salts necessary to the nutrition of the plants (Estève *et al.,* 1996; Bunch, 2004) [10, 5].

At the time of hydrous stress corresponding at the end of rain season and during the dry season (November to April), the seedlings reduce their leaves area gradually and then lose their leaves to support the period of secheress (Minengu *et al.,* 2014) [23]. On some seedlings treated with the mycorhizes (M), with the compost (C) and compost mixed with the mycorhizes (CM), the leaves of apical parts persisted all the period of strong hydrous stress (figure 3). These results show that the mycorhizes and the compost ensure a significant role in the maintenance of leaves on the tree for the periods of secheress (Strullu, 2000) [34]. The compost and the mycorhizes get an essential role in the retention of water under the root system for the food of the plants. What would have made it possible the seedlings resulting from these treatment to keep a significant number of their leaves (Yolande Daphé, 2005; Adme, 2012).

According to Reinhard and Tianasoa (2005) [37] the importance of the number of bunches of *J curcas* in field depends on the farming technique. The possibility for improvement of the growth and the development of *J curcas* by fertilizers starts since the first years of plantation.

The fertilizers brought have a highly significant effect on improvement of the radial growth of the seedlings. The beneficial effect of the organic manure on the radial growth would be with the significant contribution of nutritive elements provided by fertilizers for the development of the plant (Ngakou *et al.*, 2008; Megueni, 2011; Adme, 2012) [25, 22]. The effects of fertilizers are more perceptible, especially during the hydrous moment of stress (November to April of the first year).

Effect of various treatments on the biomass and carbon stock of *J curcas*

The results of table 2 show that there are very significant differences (P < 0,001) between the treatments. The treated plants have their biomass and stock of significant carbon compared to the plants control during the three years of culture. These results show that the compost and the mycorhizes bring sufficiently the nutritive elements to the plants to allow him its development and blooming in order to allow a good production of the plants (Tianasoa R., 2005; Ngakou *et al.*, 2008) [37, 25].

Table 2: Impact of the treatments on the biomass and carbon stock of *J. curcas* at 3 years in field.

Sites	Treatments	Biomass (kg/plantes)			carbon stock (kg/plantes)		
		2016	2017	2018	2016	2017	2018
Laï-Djom	C	0,293±0,33^b	2,474±0,17^b	10,893±0,17^c	0,139±0,33 ^{b}	1,175±0,33^b	5,174±0,17^c
	M	0,106±0,17^a	1,118±0,33^a	7,357±0,29^b	0,478±0,19 ^{a}	0,531±0,19^a	3,495±0,29^b
	EC	0,235±0,27^b	2,425±0,11^b	7,752±0,19^b	0,116±0,33 ^{b}	1,152±0,13^b	3,685±1,33^b
	T	0,067±0,27^a	0,469±1,11^a	5,884±0,33^a	0,032±0,17^a	0,223±0,27^a	2,794±0,23^a
	CM	0,369±0,17^c	2,455±0,33^b	13,325±0,33^d	0,175±0,12^c	1,166±0,21^b	6,329±0,31^d
	P	0,001	0,001	0,001	0,001	0,001	0,001
Tchoua	C	0,355±0,23^b	2,222±0,22^c	9,910±0,12^c	0,168±0,23^b	1,055±0,31^c	4,707±0,21^c
	M	0,121±0,19^a	0,813±0,12^b	3,985±0,13^a	0,057±0,21^a	0,386±0,31^b	1,892±0,31^a
	EC	0,266±0,22^b	2,461±0,22^c	8,858±0,32^b	0,126±0,23^b	1,194±0,22^c	4,207±0,24^b
	T	0,084±0,12^a	0,321±0,27^a	4,381±0,19^a	0,041±0,17^a	0,152±0,13^a	2,085±0,23^a
	CM	0,444±0,33^c	2,384±0,22^c	10,089±0,24^c	0,211±0,23^c	1,137±0,31^c	4,793±0,12^c
	P	0,001	0,001	0,001	0,001	0,001	0,001

C:Compost; M: Mycorhizes; EC.: chimical fertiliser; CM: compost-mycorhizes mixture; T: plants control

The values of the same column followed by the same letter are not significantly different (P<0,001).

These results corroborate those several work which indicates that the fertilization has a beneficial effect on the production of the dry biomass of the plants of *J curcas* (Janaludin *et al.*, 2006; Megueni *et al.*, 2011) [19, 22]. The seedlings which have a significant biomass correspond to those having had a great quantity of equivalents of carbon sequestered by the mechanism of photosynthesis.

Effect of various treatments on *J. curcas* production of fruits and seed yield
The fertilizers brought have a highly significant effect ($P<$ 0,001) on the production of *J curcas* during the three years of their setting in field (Table 3).

Table 3: Impact of the treatments on the number of fruits and seeds yield of *J. curcas* at 3 years in field.

sites	Treatments	Number of fruits per plants			Seeds yield (kg/ha)		
		2016	2017	2018	2016	2017	2018
Laï-Djom	C	35,81±4,22^{c}	440,66±2,53^{c}	802±1,52^{b}	16,30±4,21^{b}	369,63±2,51^{c}	3342,5±1,52^{b}
	M	4,47±3,31^{a}	120,22±1,25^{a}	720±1,01^{a}	8,50±5,51^{a}	188,50±5,1^{a}	3000±1,01^{a}
	EC	11,18±2,10^{b}	240,00±1,45^{ab}	822±5,04^{b}	15,38 ±2,78^{b}	352,38±1,01^{c}	3425±5,04^{b}
	T	3,05±3,24^{a}	80,88±1,86^{a}	699,07±1,52^{a}	7,38±3,50^{a}	153,38 ±5,51^{a}	2912,5±1,52^{a}
	CM	33,41±2,16^{c}	320,88±3,101^{bc}	1020±1,01^{c}	15,76 ±3,15 ^{b}	345,76±3,51^{c}	4250±2,02^{c}
	P	0,001	0,0033	0,0043	0,001	0,003	0,001
Tchoua	C	43,68±4,26^{b}	453,1±2,22^{c}	737±1,85^{ab}	29,02±2.21^{c}	377,20 ±1,2^{b}	3485±1,85^{b}
	M	12,81±5,21^{a}	221,1±1,32^{b}	703±3,51^{a}	13,83±3,21^{a}	220,83±3,2^{a}	2815±3,51^{a}
	EC	40,8±3,27^{b}	435,33±0,50^{c}	820±2.23^{ab}	21,52±2,89^{ab}	371,52±2,2^{b}	3400±1,91^{b}
	T	10,03±4,81^{a}	180,55±1,66^{a}	698±1,91^{a}	11,25±2,41^{a}	211,25±3,1^{a}	2790±4,28^{a}
	CM	59,33±3,26^{c}	463,33±1,04^{c}	886±4,36^{c}	35,97±2,22 ^{c}	465,97±2,6^{c}	3730±4,26^{b}
	P	0.001	0,018	0,05	0,001	0,018	0,002

C:Compost; M:Mycorhizes; EC.:chimicalfertiliser; CM:compost-mycorhizes mixture; T: plants control
The values of the same column followed by the same letter are not significantly different ($P<0{,}001$).

The weak pluviometry of the crop year 2016 made that certain seedlings treated with the mycorhizes and the plants control flowered very tardily. Many authors indicated that *J. curcas* needs 8 to 12 months favorable periods to arrive at flowering and fructification. (Minengu *et al.*, 2014) [23]. The formed seeds were badly filled and light. The optimal production of *J. curcas* would require a consequent pluviometry and an adequate technical agricultural.
Several authors affirmed that *J. curcas* seeds yield is weak the first and the second year of culture (Singh and Rathod, 2002; Reinhard and Tianasoa, 2005) [33, 32, 37]. These results are different of ours which indicate quite significant values to the hectare (377,2±1,2 kg/ha and 465,97±2,6 kg/ha in Tchoua) at the second year, respectively on pieces treated with the compost and the compost combined with the mycorhizes, compared to the first year when the seed yield with the hectare is unimportant for all the treatments. These results are due certainly to the importance of the fertilization which caused the precocity of flowering, of fructification and increase *J. curcas* seed yield
The studies undertaken on the fertilization showed that it contributes effectively to the increase on *Jatropha curcas* growth and seeds yield. Because of the high percentage of nitrogen, the cake of *Jatropha curcas* can be used as manure organic but exceeded 5 t/ha, it give the risk of phytotoxicity. It is marketed in Zimbabwe like fertilizer for its high content of NPK (Potolia *et al.*, 2007; Domergue and Pirot, 2008).

Impact of fertilizers on the physical characteristics of the fruits and seeds
It arises from tables 4 and 5, which there is a highly significant difference ($P<0{,}001$) of the effect of the various treatments applied to the physical characteristics of seeds and fruits. The seedlings treated with the compost (C), with the compost associated with the mycorhizes (CM), the mycorhizes (M) and the chemical fertilizer (E) had fruits having of size and high weight. The fruits collected on the plants having received fertilization contained three seeds at a rate (%) raised, 97,33 ± 0,01; 90 ± 0,4; 80 ± 0,7;73,33 ± 0,08 respectively for the plants on the seed holes treated with the compost-mycorhizes, with the mycorhizes, compost and artificial fertilizer compared to the plants controls (63,33 ± 0,12) on the site of Laï-Djom. These observations are made on the site of Tchoua compared to the impact of fertilizers on the fruit formation and of seeds. These results prove that the treatments contribute to the good mechanism of the fruit formation with seeds filled.
These results are in agreement with those of Tchobsala, 2009 [35]. Pirot Roland and Hamel Olivier, 2012 and Tchobsala, 2012, indicated the beneficial effect of the fertilizations on the development of *J. curcas.* According to Pirot (2012) [31], the yellow fruit is an almost spherical capsule, of 3-4 cm length and 2,5-3 cm thickness, with three separate cabins, containing each one a seed. The 4 cm length value of fruits is reached on the site of Tchoua (Table 4). The low values obtained here would be due to the climatic and edaphic factors of the zone of study.

Table 4: Fertilizers impact on the physical characteristics of the fruits.

Sites	Treatments.	Length of the fruits(cm)	Diameter of the fruits(cm)	dry weight of the fruits(g)	dry weight of pulps (g)	fruits having 3 seeds (%)
Laï-Djom	C	3,3 ± 0,13^{c}	2,44± 0,06^{b}	3,16 ± 0,33^{c}	1,66 ± 0,06^{c}	80 ± 0,7^{c}
	M	3,2 ± 0,16^{b}	2,42 ± 0,11^{b}	3,16 ± 0,18^{c}	1,33 ± 0,13^{b}	90 ± 0,4^{d}
	E	3,2 ± 0,16^{b}	2,40 ± 0,07^{b}	3,00 ± 0,31^{b}	1,66 ± 0,12^{c}	73,33 ± 0,08^{b}
	T	2,95 ± 0,19^{a}	2,26 ± 0,13^{a}	2,83 ± 0,11^{a}	1,16 ± 0,02^{a}	63,33 ± 0,12^{a}
	CM	3,16 ± 0,15^{b}	2,4 ± 0,12^{b}	3,33 ± 0,16^{d}	1,66 ± 0,08^{c}	97,33 ± 0,01^{e}
	P	0,001	0,001	0,001	0,001	0,001

Tchoua	C	4,06 ± 5,41[b]	2,38 ± 0,10[b]	3,00 ± 0,14[b]	1,58 ± 0,06[c]	86,66 ± 0,12[c]
	M	3,21 ± 0,19[ab]	2,41 ± 0,13[b]	3,16 ± 0,11[c]	1,36 ± 0,05[b]	83,33 ± 0,16[b]
	E	3,08 ± 0,16[ab]	2,38 ± 0,13[b]	3,00 ± 0,14[b]	1,36 ± 0,07[b]	83,33 ± 0,09[b]
	T	2,75 ± 0,17[a]	2,16 ± 0,01[a]	2,80 ± 0,08[a]	1,16 ± 0,14[a]	73,33 ± 0,14[a]
	CM	3,15 ± 0,18[ab]	2,4 ±0,12[b]	3,33 ± 0,14[d]	1,66 ± 0,07[c]	90 ± 0,07[d]
	P	0,001	0,001	0,001	0,001	0,001

Table 5: Impact of fertilizers on the physical characteristics of the seeds

Sites	Traitements	Length of the seeds (cm)	Thickness of seeds (cm)	dry weight of the seeds (g)	Weight of the shell(g)	Weight of the kernel (g)
Laï-Djom	C	1,86 ± 0,13[c]	1,1 ± 0,07[b]	0,71 ± 0,21[d]	0,3 ± 0,07[c]	0,41 ± 0,13[d]
	M	1,78 ± 0,09[bc]	1,08 ± 0,08[b]	0,69 ± 0,08[c]	0,29 ± 0,1[b]	0,40 ± 0,08[c]
	E	1,82 ± 0,06[bc]	1,06 ± 0,06[b]	0,68 ± 0,31[b]	0,3 ± 0,08[c]	0,38 ± 0,18[b]
	T	1,67 ± 0,14[a]	0,9 ± 0,15[a]	0,63 ± 0,23[a]	0,26 ±0,06[a]	0,36 ± 0,09[a]
	CM	1,74 ± 0,13[ab]	1,07 ± 0,11[b]	0,72 ± 0,11[e]	0,3 ± 0,11[c]	0,41 ± 0,16[d]
	P	0,001	0,001	0,001	0,001	0,001
Tchoua	C	1,78 ± 0,10[ab]	1,45 ± 0,06[c]	0,74 ± 0,08[c]	0,33 ± 0,08[b]	0,41 ± 0,14[b]
	M	1,82 ± 0,08[bc]	1,18 ± 0,07[b]	0,68 ± 0,17[b]	0,28 ± 0,16[a]	0,41 ± 0,13[b]
	E	1,76 ± 0,0[ab]	1,52 ± 1,8[d]	0,69 ± 0,07[b]	0,29 ± 0,09[a]	0,4 ± 0,07[a]
	T	1,74 ± 0,06[a]	1,03 ± 1,81[a]	0,65 ± 0,08[a]	0,29 ± 0,16[a]	0,36 ± 0,1[a]
	CM	1,85 ± 0,11[c]	1,53 ± 1,8[d]	0,75 ± 0,09[c]	0,34 ± 0,14[b]	0,41 ± 0,08[b]
	P	0,001	0,001	0,001	0,001	0,001

C:Compost; M:Mycorhizes; EC.: Chimical fertiliser; CM: compost-mycorhizesmixture; T: plants control
The values of the same column followed by the same letter are not significantly different ($P<0,001$).

Conclusion

The fertilizers used improved to a significant degree the parameters of growth (Size, a number of leaves, number of bunches, diameter of the stem), the parameters of production (Biomass, stock of carbon, production of fruits and seed yield) of the plants treated compared to the control. They also made it possible to increase the rate of survival and the resistance of *J curcas at* the hydrous stress moment in field during the dry season.

The plants treated with the compost, the compost-mycorhizes mixture and the chemical fertilizer are big size, a significant number of leaves and a good seed yield. Also, these fertilizers support the sequestration of CO2 and the precocity of flowering, production and maturity of the fruits.

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