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Behavior of Ricinus communis L. plants due to different volumes of containers and substrates

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Abstract: The objective of this study was to evaluate the production of castor BRS Gabriela seedlings (Ricinus communis L) as a function of different volumes of containers and substrates The work was conducted from May to June 2014, in the nursery of the State University of Paraíba, Campus IV, Catolé do Rocha, PB. The experimental design was a completely randomized design, adopting the 4 x 2 factorial scheme, with 6 replicates, with four container volumes: (polyethylene plastic bags with capacity 1000 cm^3; polyethylene plastic bags with a capacity of 500 cm^3; tubes with a capacity of 300 cm^3 and disposable cups with a capacity of 270 cm^3) and two types of substrates (S_1 = 50% soil + 50% earthworm humus and S_2 = 40% soil + 30% earthworm humus + 30% sand). The variables studied were: (LN) leaf number; (ULA) unitary leaf area; (RD) root diameter; (RL) root length; (SB) shoot biomass; (TPB) total plant biomass. All variables had a significant effect on cantainer volumes. Probably the largest container provided larger area of substrate to be explored. Castor bean seedlings of the BRS Gabriela variety respond well to larger container volumes. The substrate V_1 (50% soil and 50% humus) influenced the initial growth of BRS Gabriela seedlings. Treatment with 1000 cm^3 and substrate V_1 provides greater growth of castor seedlings.

Key words: BRS Gabriela variety, seedlings, protected environment, semi-arid.

Comportamento de plantas de *Ricinus communis* L. em função de diferentes volumes de recipientes e substratos

Resumo: Objetivou-se avaliar a produção de mudas de mamoneira BRS Gabriela (*Ricinus communis* L) em função de diferentes volumes de recipientes e substratos. O trabalho foi conduzido de maio a junho de 2014, no viveiro da Universidade do Estadual da Paraíba, Campus IV, Catolé do Rocha, PB. O delineamento experimental adotado foi o inteiramente casualizado, adotando o esquema fatorial 4 x 2, com 6 repetições, com quatro volumes de recipientes: (Sacos plásticos de polietileno com capacidade 1000 cm^3; sacos plásticos de polietileno com capacidade de 500 cm^3; tubetes de 300 cm^3 e copos descartáveis com capacidade de 270 cm^3) e dois tipos de substratos (S_1= 50% de solo + 50% húmus de minhoca e S_2= 40% de solo + 30% húmus de minhoca + 30% de areia). As variáveis estudadas foram: (NF) número de folha; (AFU) área foliar unitária; (DR) diâmetro da raiz; (CR) comprimento da raiz; (FPE) fitomassa da parte aérea; (FTP) fitomassa total da planta. Todas as variáveis sofreram efeito significativo em volumes de recipiente. Provavelmente o maior recipiente proporcionou maior área de substrato a ser explorada. Mudas de mamoneira BRS Gabriela respondem bem aos maiores volumes de recipiente. O substrato V_1 (50% de solo e 50% de húmus) influenciou no crescimento inicial de mudas de mamoneira BRS Gabriela. O tratamento com 1000 cm^3 e o substrato V_1 proporciona maior crescimento de mudas de mamoneira.

Palavras-chave: Mamona BRS Gabriela, Mudas, ambiente protegido, semiárido.

Introduction

The castor bean plant (*Ricinus communis* L.), belonging to the family Euphorbiaceae, is a rustic plant, heliophile, drought-tolerant and found in various regions of Brazil, with many subspecies, so that it is being commercially exploited as annual crop, aiming to provide raw material for biodiesel production (CAVALCANTI et al., 2005).

Frequently, the plating of the castor bean plant in these regions is carried out in a direct way, that is, the seeds are deposited directly to the soil where they will be cultivated, and this planting system can be considered risky, since the initial growth of the culture in the first month is slow (LIMA et al., 2006) affecting the development and final productivity, due to scarcity and irregular distribution of rainfall normally occurring in the semi-arid region. The production of castor bean seedlings is not a practice commonly adopted by producers, however, could become an alternative to planting in semi-arid region, as a strategy to improve the use of the short rainy season. (ANDRADE et al., 2012).

So, the production of the seedlings in nursery and posterior planting in models of arrangements of the most diverse that are designed according to the interest of the producer, being mostly with species that have commercial values, be it timber or non-timber, are being widely disseminated among family farmers, oriented by agricultural professionals from universities, institutes, technical assistance companies, farmer's associations and rural unions (ARAÚJO et al. 2013).

In the process of seedling production, the definition of the size of the container is an important factor to be considered, because it influences several morphophysiological characteristics of the seedlings, impacting on the percentage of survival in the field and, consequently, on crop productivity (SOUZA, 1995). The containers used in the production of seedlings should allow a good development of the root system during their stay in the nursery, considering their importance in the development of the future field plant (LESKOVAR and STOFFELA, 1995).

But, the substrate has a great influence on the production of seedlings, since the plant needs directly from the effects of it. Such as, porosity, adequate CTC and nutrient, in addition to enabling a good water dynamic. According to Silva et al. (2014), the use of alternative substrates in plant cultivation is becoming increasingly common in Brazil.

Since one of the barriers to castor bean production in the semiarid region would be the survival and emergence index of the plants in the field, as well as substrate sources, the objective this study was to produce seedlings of *Ricinus communis* L. in different volumes of containers and different substrates.

Materials and Methods

The study was conducted from May to June 2014 in the nursery of the State University of Paraíba (UEPB), Campus IV, Catolé do Rocha, PB (6°20’38” S; 37°44’48” W) and 275 meters of altitude.

The experimental design was a completely randomized design, in a 4 x 2 factorial scheme, with 6 replications, totaling 48 experimental plots, being container volumes: (polyethylene plastic bags with capacity 1000 cm^3; polyethylene plastic bags with a capacity of 500cm^3; tubes with a capacity of 300 cm^3 and disposable cups with a capacity of 270 cm^3) and two types of substrates (S_1 = 50% soil + 50% earthworm humus and S_2 = 40% soil + 30% earthworm humus + 30% sand). The irrigation was conducted with the help of a irrigator with a capacity of 6L during a single turn (morning).

The formulation of the substrates through mixtures of sand, soil and earthworm humus in different proportions where they were used to produce castor bean seedlings are presented in Table 1.

Table 1. Substrate formulation to produce castor bean seedlings in the semi-arid region of Paraíba.

Proportion (V: V) on each substrate		
Composition	Substrate 1	Substrate 2
Soil	50%	40%
Sand	-	30%
Earthworm humus	50%	30%

The soil samples were collected from 0-20 cm depth in an area located at UEPB, Campus IV, Catolé do Rocha. From the soil sample collected for use of filling the containers, sub-samples were taken for analysis. The chemical analyzes of the soil and earthworm compost (Table 2) were determined in Irrigation and Salinity Laboratory (LIS) from the Center of Technology and Natural Resources of the Federal University of Campina Grande (UFCG).

Table 2. Results of soil and earthworm humus chemical analysis used in the production of castor bean seedlings BRS Gabriela, submitted to different volumes of containers and substrates.

	pH H_2O	CE dS/m	P	K	Ca	Mg	Al	Na	T	V	M.O
				....		cmolc/dm3	....			.........%	....
Soil	8,20	1,53	3,27	0,26	5,09	1,66	0,00	0,26	7,71	100	1,19

	pH H_2O	CE dS/m	P	K	Ca	Mg	Al	Na	S	NaCl	SB
				....		cmolc/dm^3	....				
Humus	7,38	2,11	55,14	1,41	35,4	19,32	0,00	1,82	57,95	1,82	56,13

M.O = Organic matter; SB = Base sum

After 30 days were evaluated: LN – leaf number; ULA - unitary leaf area; RD - root diameter; RL - root length; SB - shoot biomass; TPB - total plant biomass.

The number of leaves was expressed by counting the leaves. The leaf area was calculated according to Silveira et al. (2004) S = 0.2439 x (P + T) 2.0898, where S = area, P = main rib length, T = average lateral rib length.

Root diameter was obtained through measurements of the lap of the plant with aid of a digital caliper. Root length was obtained through measurements of the lap up to the apical bud with the aid of a ruler graduated in millimeters.

Shoot biomass (SB) = SFM – SDM, where SFM = shoot fresh mass and SDM = shoot dry mass. Total plant biomass (TPB) = PFM - PDM, where PFM = plant fresh mass and PDM = plant dry mass.

The data were submitted to analysis of variance using the F test $P<0.05$, and subsequently linear and quadratic regressions using the statistical analysis software SISVAR® (FERREIRA, 2014).

Results and Discussion

The results of the statistical analyzes revealed that there was a significant effect for all the variables studied when submitted to the volumes of containers. However, root length did not suffer effect on substrate. It can be observed that unitary leaf area, shoot biomass and total plant biomass were interacted between the factors container and substrate volumes at 1% significance by the F test (Table 3).

Table 3. Summary of the analysis of variance of the morphological characteristics of castor bean seedlings BRS Gabriela.

Source	DF	Mean Square					
		LN	ULA	RD	RL	SB	TPB
Containers(C)	3	6.042**	458.752**	6.709**	82.177**	59.142**	82.641**
Substrate (S)	1	1.128**	511.364**	6.475**	7.848^{ns}	257.613**	56.593**
C x S	3	0.238^{ns}	60.136**	0.246^{ns}	5.677^{ns}	29.161**	144.152**
Error	40	0.184	0.826	0.437	10.829	2.180	4.463
CV		9.85	3.18	20.11	19.19	14.57	18.62
General averages		4.36	28.61	3.28	17.14	10.13	11.34

** 1%, * 5% and ^{ns} not significant by the F test respectively,DF – degree of freedom; LN – leaf number; ULA – unitary leaf area; RD – root diameter; RL – root length; SB – shoot biomass; TPB – total plant biomass.

The number of leaves was significantly affected by both factors. It can be verified that the lower the container volume, lower the number of leaves. Furthermore, the volumes of 1000 cm^3 capacity afforded a 31% increase in number of leaves (Figure 1A).

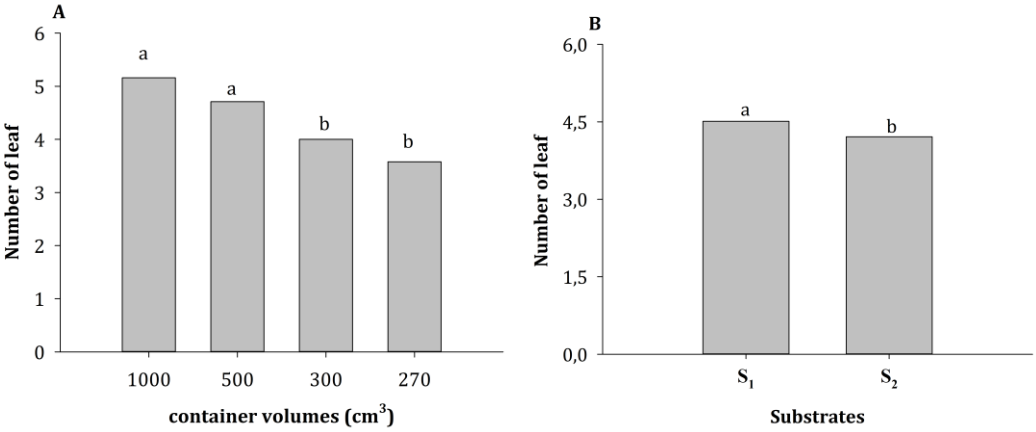

Figure 1. Leaf number as a function of different container volumes (A) and substrates (B) in BRS Gabriela castor bean plants (Ricinus communis L.).

Costa et al. (2010) corroborated the results, since the containers with higher substrate volumes in the development of papaya seedlings promoted higher plant heights and higher leaf numbers, also for Mesquita et al. (2012) that found larger stem diameter in the larger volumes in papaya plants.

However, the number of leaves submitted to the two types of substrates, it can be verified that the substrate S_1 favored the largest number of leaves (Figure 1B). Probably due to the absence of sand, which could facilitate the leaching of the nutrients. Andrade et al. (2014) certified similar responses in castor bean seedlings in substrate that there was no sand in their composition.

For the unfolding of the unitary leaf area, regardless of the substrate, there was a sudden drop when the container volume decreased. In which there was a decrease of 42.28% in S_1 and 34.52% in S_2. However, the substrate S_1 in unfolding in the volume of 1000 cm^3 instigated an increase of 23% in relation to the substrate S_2 (Figure 2).

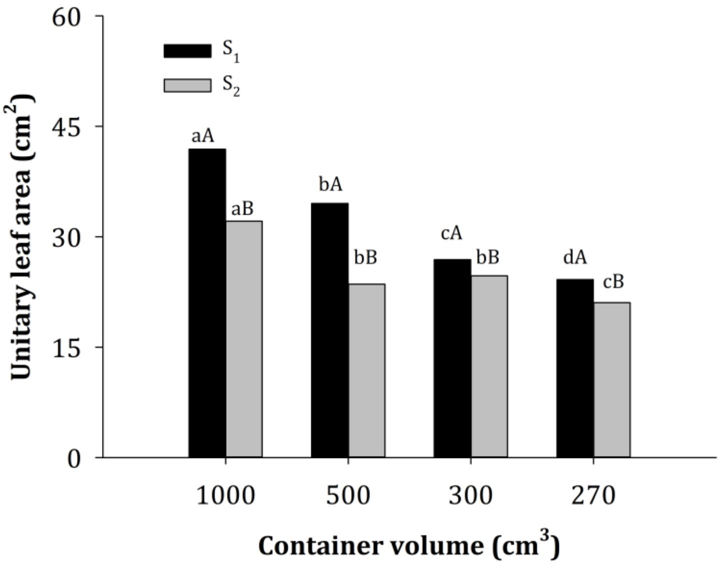

Figure 2. Unitary leaf area (ULA) under unfolding of container volume and substrate in castor bean seedlings BRS Gabriela (*Ricinus communis* L.). Lowercase letters do not differ between container volumes and uppercase letters do not differ between substrates. Lowercase letters do not differ statistically between volumes and capsules between substrates

The diameter of the root is influenced by the volume of the container and substrate (Figure 3A and B). It can be observed that the highest averages were found in the volume of 1000 cm^3. A similar result was verified by Abreu et al. (2015), found that the highest plant height results of *Enterolobium contortisiliquum* were found for the highest volume. Oliveira et al. (2013) found superior results in the largest container volume, R4 = 3300 mL by studying the shoot length.

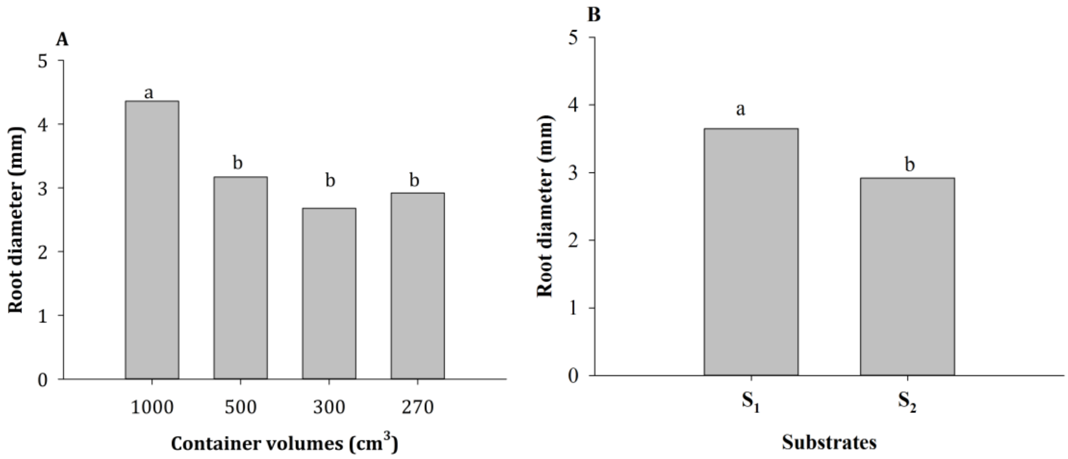

Figure 3. Root diameter as a function of different vessel volumes (A) and substrates (B) in BRS Gabriela castor bean plants (Ricinus communis L.)

The diameter of the root was observed higher mean diameter of 3.65 and 2.92 when submitted to S_1 and S_2, respectively, and providing a difference of 20%. Véras et al. (2014) found significant effects on plant height, number of leaves, on the effect of substrates and on Annonaceae seedlings. The container of higher substrate retention capacity provides a higher volume of soil to be harvested by the root system, increasing water and nutrient uptake, the rate of photosynthesis and consequently higher photoassimilates production, resulting in greater shoot development (ANDRADE et al., 2012).

The largest root length was found in the highest volume container. It is possible to observe a significant difference between the other volumes. It is still possible to verify the superiority of 6.33 cm related to the smaller volume, characterizing 46.4% (Figure 4A).

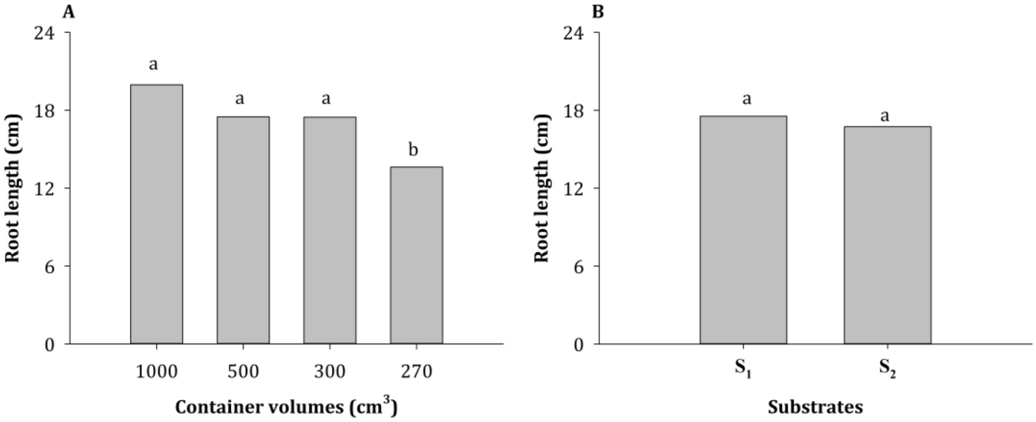

Figure 4. Root length submitted to container volume (A) and substrate (B) in castor bean seedlings BRS Gabriela (*Ricinus communis* L.).

The growth of the root system, besides being conditioned to the height of the containers, which in the case of plastic bags had higher height, is also related to the volume of each container, which involves the root system, making the supply production factors for seedling growth and development (MENEZES JÚNIOR et al., 2000). Santos et al. (2012) verified differences between the results of the present study, in which they found the largest root length in vessel volumes of 288 cm^3.

In relation to the substrate no significant difference was observed for the root length, but it can be noticed that S_1 promoted a higher result (Figure 4B). The root is one of the most important organs of the plant being efficient in the absorption of water and minerals providing the shoot growth. Menezes et al. (2013) found that the substrate based on earthworm humus was not efficient on root length in papaya seedlings. Vallone et al. (2010) verified that coffee seedlings grown in containers with higher volume and alternative substrates provided higher growth.

In the same way of the other variables, the shoot biomass also had its highest average in the container with the largest volume, regardless of the type of substrate. But the volume of 300 cm^3 did not differ statistically from the larger volume (Figure 5).

Probably, earthworm humus favored the increase of nutrients for the substrate and the greater volume of 1000 cm^3 provided a greater amount of substrate, since the duration of the seedlings in the container and a limiting factor in the production of the seedlings. Caixeta et al. (2013) verified greater weight of shoot biomass in the treatment composed by the largest container and substrate 50% of soil 50% of sand. Silva et al. (2013) found larger shoot biomass in the smaller volumes of containers in tamarind seedlings.

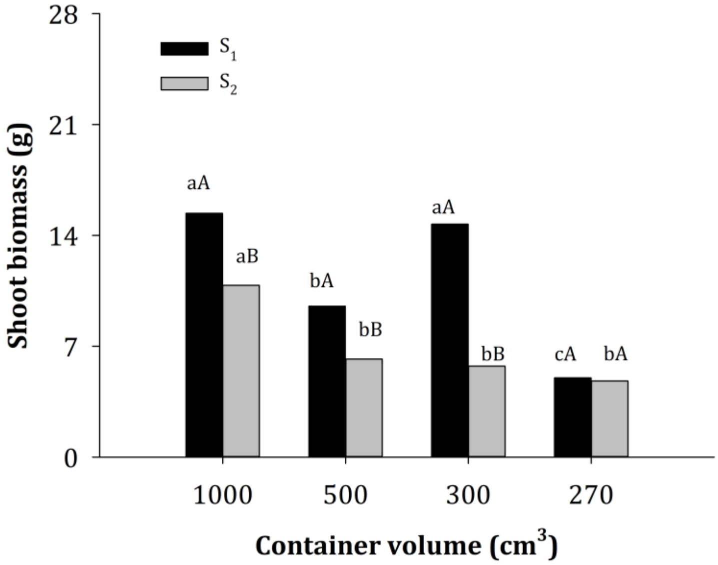

Figure 5. Shoot biomass (SB) under unfolding of container volume and substrate S1 (50% of soil + 50% of earthworm humus) and S2 (40% of soil + 30% of sand and 30% of earthworm humus), in BRS Gabriela castor bean seedlings (*Ricinus communis* L.). Lowercase letters do not differ statistically between volumes and capsules between substrates

It can be observed that the total plant biomass was influenced by the interaction of the factors studied. The volume 1000 and 300 cm^3 did not show a significant difference, differing from 500 and 270 cm^3 within the substrate S_1 (Figure 6). On the other hand, the volumes submitted to S_2 observed a larger total plant biomass in the volume of 1000 cm^3.

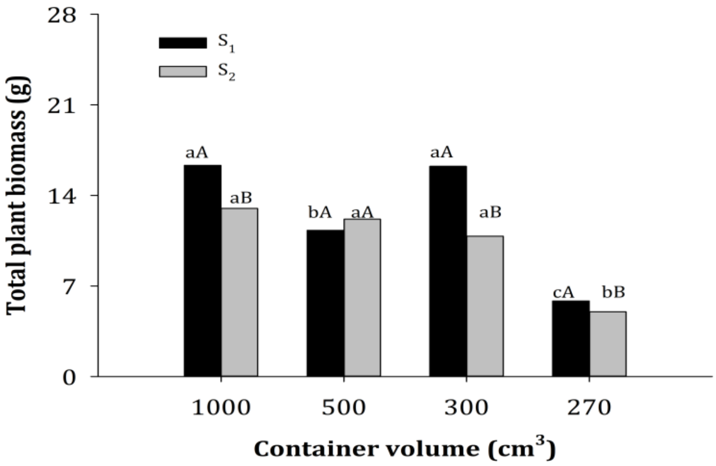

Figure 6. Total plant biomass (TPB) under unfolding of container volume and substrate S1 (50% soil + 50% earthworm humus) and S2 (40% soil + 30% sand and 30% earthworm humus), in BRS Gabriela castor bean seedlings (*Ricinus communis* L.). Lowercase letters do not differ statistically between volumes and capsules between substrates

The highest volume of the container allowed a higher growth of the root system due to the greater availability of nutrients (COSTA et al., 2009), and the authors verified that the highest values of shoot fresh and dry mass are in the container with greater volume. The higher volumes provide a better area to be explored by the root system, providing a better absorption of water and essential minerals (ANDRADE et al., 2015).

Similar results were observed by Ajala et al. (2012) the jatropha seedlings submitted to larger container volumes obtained the largest increments in height and stem diameter. Oliveira et al. (2011) did not find significance in the mass of total dry matter in *Copernicia hospital* seedlings as a function of container volume.

Conclusions

The BRS Gabriela castor bean seedlings (*Ricinus communis* L.) respond well to higher volumes of container;

The substrate S_1 (50% soil and 50% earthworm humus) influenced the initial growth of BRS Gabriela castor bean seedlings;

The volume of 1000 cm^3 and substrate S_1 promoted greater growth of castor seedlings.

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