DEVELOPMENT OF HYMENAEA COURBARIL SEEDLINGS IN FUNCTION OF CONTAINERS AND IRRIGATION BLADES[1]

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ABSTRACT – The objective of this work was to evaluate the effect of container sizes and irrigation levels on "jatoba" (*Hymenaea courbaril* L.) seedlings development. The experiment was conducted in a greenhouse from September 2010 to March 2011. The design was in randomized blocks, with three replications in split plots, in a 2 x 5 scheme. Two container sizes (rigid pots of 3.1 L and stiff plastic tubes of 4.0 L) were used in the plots, while five drip irrigation levels (20%, 40%, 60% 80% and 100% of potential evapotranspiration - ETp) were used in the subplots. The irrigations were accomplished daily. Each subplot was constituted by eight seedlings. In the period from 80 to 200 days after sowing (DAS), the seedling height (AM), stem diameter (DC), leaves number (NF), leaf area (AF), dry matter mass of roots (MSR) and seedling (MSM) and relation between root dry matter mass and aerial part (MSR/MSPA) were evaluated. The stiff plastic tube provided larger ETp, in comparison with the rigid pot and, consequently, more developed seedlings. Irrigation levels from 90% to 100% of ETp provided more vigorous seedlings. The increase of water deficit reduces all the parameters of jatoba seedlings, except the MSR/MSPA ratio.

Keywords: *Hymenaea courbaril* L.; Potential evapotranspiration; Water deficit.

DESENVOLVIMENTO DE MUDAS DE JATOBAZEIRO EM FUNÇÃO DE RECIPIENTES E LÂMINAS DE IRRIGAÇÃO

*RESUMO – O objetivo deste trabalho foi avaliar o efeito de lâminas de irrigação e tamanhos de recipiente no desenvolvimento de mudas de jatobazeiro (***Hymenaea courbaril** *L.). O experimento foi conduzido em casa de vegetação, no período de setembro de 2010 a março de 2011. O delineamento foi o de blocos ao acaso, com três repetições, em parcelas subdivididas, no esquema 2 x 5. Nas parcelas, utilizaram-se dois tamanhos de recipientes (vaso rígido de 3,1 L e citrovaso® reto de 4,0 L) e, nas subparcelas, cinco lâminas de irrigação (20%, 40%, 60%, 80% e 100% da evapotranspiração potencial - ETp) por gotejamento, aplicadas diariamente. Cada subparcela foi constituída por oito mudas. No período de 80 a 200 dias após a semeadura (DAS), foram avaliados a altura de muda (AM), diâmetro de caule (DC), número de folhas, área foliar (AF), massas de matéria seca de raízes (MSR) e de muda (MSM) e relação entre as massas de matéria seca de raízes e parte aérea (MSR/MSPA). O citrovaso proporcionou maior ETp, em relação ao vaso e, consequentemente, mudas mais desenvolvidas. Lâminas com 90% a 100% da ETp propiciaram mudas de jatobazeiro mais vigorosas. O aumento do deficit hídrico reduziu todos os parâmetros morfológicos avaliados das mudas de jatobazeiro, exceto a relação MSR/MSPA.*

Palavras-chave: **Hymenaea courbaril** *L.; Evapotranspiração potencial; Déficit hídrico.*

1. INTRODUCTION

The deforestation and the consequent need for recovery of degraded areas, have increased in Brazil the interest for the planting of native species, among them, the jatobazeiro (*Hymenaea courbaril* L.). The jatobazeiro is a semideciduous tree, from Fabaceae family, that naturally occurs in several Brazilian biomes, since the Piauí until the north of Paraná, may reach 10 to 15 m in height (CARVALHO FILHO et al., 2003), or up to 30 m, in the Amazon (NASCIMENTO, 2009).

Their wood is highly resistant, quite marketed and used in civil construction. The starch pulp of the fruits is rich in nutrients and used in human food, whether "in natura", or in the form of cakes, bread, jam, liquor and porridges and may the flour of the jatoba partially replace wheat flour (SILVA et al., 2001). Given its importance in the timber and food sectors, information is necessary on potential evapotranspiration of *H. courbaril* in containers of different sizes, for an appropriate management of irrigation in seedlings of this species.

With relation to the container, the higher the volume, the greater is the need for space in the nursery and the cost with the substrate, labor, benches, transport and distribution of the seedlings in the field. However, small containers can cause damage to the development of the seedlings, both in the nursery phase, and after transplanting. Neves et al. (2005) concluded that the volume of the container has influenced the quantity of roots and the architecture of the root system of acacia-black (*Acacia mearnsii*) in the field because some containers have induced the development of curved shapes roots. Samôr et al. (2002), to discuss the effect of receptacles in angico seedlings (*Anadenanthera macrocarpa*), affirm that, with the seedlings in stress conditions, it tends to occur allocation increase of photoassimilated to the roots, to the detriment of the aerial part.

Nurseymen generally use tubes for the production of seedlings of species of the genera *Pinus* e *Eucalyptus*. However, species as *H. courbaril* require larger containers, due to the size of its seeds, in addition to the longer time required for staying of the seedlings in the nursery. Carvalho Filho et al. (2003), experiencing two environments (A), four substrates (S) and two sizes of vases (R) on growth of seedlings of *H. courbaril*, verified significant interaction between A and R at the height of the seedlings (AM), between R and S in the diameter of the stem (DC) and mass of root dry matter (MSPA) and, between A, S and R in DC. At 180 days after sowing, the AM was greater in the container of greater volume (polyethylene bag (15 x 20 cm) under netted shade. The MSPA was also greater in this container filled with soil + sand 1:1 or soil + sand + cattle manure (1:2:1, as well as the DC, when you put it under netted shade, using soil + sand 1:1.

Ferraz and Engel (2011) verified that containers of less volume reduce quality of seedlings of H. *courbaril*. They concluded that vials of greater volume (300 cm^3) showed seedlings with height and diameter of the superior lap to those produced in tubes of 50 and 110 cm^3, enabling to reduce time to production of seedlings in up to 70 days.

With relation to irrigation, water is essential in the processes of absorption, sap flow, transpiration and turgidity (SANTOS; CARLESSO, 1998). The stomatic closing, the reduction of perspiration and leaf area are prominent responses of plants to water *deficit* (FIGUEIRÔA et al., 2004; PEREIRA et al., 2006). Both the deficit and the water excess are harmful to plants, depending on its intensity and duration. Leles et al. (1998) experienced three water regimes (daily irrigation, every seven days and every 15 days) in the production of seedlings of *H. courbaril*, elevating the moisture of the substrate to the "field capacity" after each scheme. They verified that, to the 110 days after seeding, the irrigation every seven days increased significantly the MSR, 1.13 to 1.80 g $seedling^{-1}$, in relation to daily irrigation. However, there was no significant difference on the height, stem diameter and dry matter of the aerial part of the seedlings in the two schemes.

The appropriate management of irrigation acquires a significant importance, because the *water deficit* can cause the decrease in the nutrients absorption, while the excess favors the leaching of nutrients and enhances favorable microclimate to the development of diseases, in addition to increasing the consumption of water, energy and fertilizers (Lopes et al., 2005).

Lee and Langenheim (1975) affirm that H. *courbaril* is undemanding in soil moisture, however, Nascimento et al. (2011) concluded that the production of dry matter of seedlings of this species is the most sensitive variable to water deficiency, being necessary other experimental research for better research of water needs of that species. The latter verified that humidity levels below 50% of the retention capacity of the soil, in the period of 50 to 155 days after germination, substantially restrict the height, number of leaves, diameter of the stem and leaf area of the seedlings. Containers of different sizes can present distinct evapotranspirometric demands and, consequently, greater or lesser need for irrigation, in reason of the height, volume of substrate and evaporative area being different.

Thus, the objective of this work was to evaluate the development of seedlings of H. *courbaril* L. in function of container sizes and blades of irrigation, in vegetation house.

2. MATERIALAND METHODS

The experiment was conducted in the period from September 2010 to March 2011, on benches, in vegetation house, under the conditions of temperature and relative humidity indicated in Figure 1 (22º42'41"S and 47º37'46"W, 561 m of altitude), installed in the east-west direction, in the Engineering Department of Biosystems College of Agriculture "Luiz de Queiroz", in Piracicaba, SP.

The substrate used was a mixture of 50% of commercial substrate and 50% of fine sand air dried, volume-based, whose physical and chemical analyzes are presented in Table 1. For every 100 L of the mixture 15 L of vermiculite and 200 g of fertilizer 20-11-15 (N-P_2O_5-K_2O) were added, also composed of micronutrients (0.2% Fe; 0.1% Zn; 0.05% of B, of Mn and Cu; 0.005% of Co and Mo).

Seeds of jatobazeiro were obtained from four parent trees in good phytosanitary conditions, in the municipality of Orizona (GO). Then, they were selected, eliminating those with flattened shape and with a mass less than 3.0 g, being obtained a batch of 400 seeds, with a mass equal to 2325 g. The same were mixed, scarified in metal sanding and soaked in water at room temperature for 24 hours, according to Azerêdo et al. (2003). Then, they were treated with the fungicide carbendazim (150 g L^{-1}) + Thiram® (350 g L^{-1}), at a dose of 6.0 mL of the commercial product per kg of seed. Sowing was performed in 300 mL plastic cups, perforated in the base and filled with the mixture.

At 30 days after sowing (DAS), seedlings of uniform development, with the first pair of leaves open, were transplanted to receptacles. The experimental design was randomized blocks, with three repetitions, the split plot scheme 2 x 5. In the plots, two sizes of vases were used (rigid bottle of 3.1 L and citrovase® rectus of 4.0 L, container aimed especially for the production of citrus seedlings) and at the plots, five irrigations slides (20%, 40%, 60%, 80% and 100% of the daily evapotranspiration potential - ETp). Each subplot consisted of eight seedlings, totaling 240. The vases

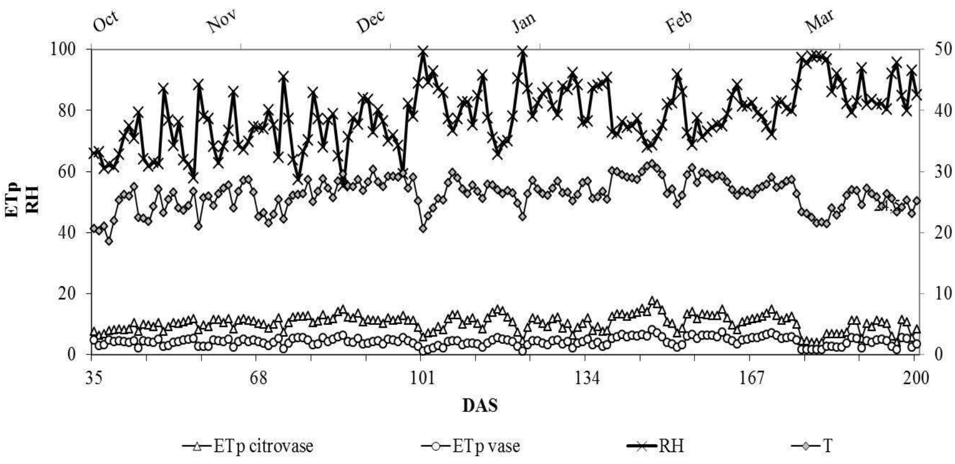

Figure 1 – Average daily of temperature (T, °C), relative humidity (RH, %) and potential evapotranspiration (ETp, mm dia^{-1}) of jatoba seedling, in function of containers, in the period from 35 to 200 days after sowing (DAS), in greenhouse, in Piracicaba, SP.

***Figura 1** – Valores médios diários de temperatura (T, ºC), umidade relativa do ar (UR, %) e evapotranspiração potencial (ETp, mm dia^{-1}) de mudas de jatobazeiro, em função dos recipientes, no período de 35 a 200 dias após a semeadura (DAS), em casa de vegetação, em Piracicaba, SP.*

Table 1 – Results of physical and chemical analysis of the commercial substrate and fine sand mixture.
***Tabela 1** – Resultados de análises físicas e químicas1 da mistura de substrato comercial e areia fina.*

Physical analysis									
Porosity		Water retention			Density		Granulometry		
Macro	Micro	PT	θ_{cc}	θ_{pmp}	Ds	Dp	Total sand	Silt	Clay
cm³ cm⁻³					g cm⁻³		%		
0.3597	0.1763	0.5360	0.2623	0.1544	1.02	2.44	85.9	2.8	11.3

Chemical analysis													
Analysis conditions		Macronutrients						Micronutrients					
		N	P_2O_5	K_2O	Ca	Mg	S	Cu	Mn	Zn	Fe	B	Na
		%						mg kg^{-1}					
Air-dry		0.29	0.19	0.07	0.92	0.11	0.03	7	81	19	6167	3	474
Dry basis	60-65ºC	0.31	0.20	0.07	0.97	0.12	0.03	7	85	20	6498	3	499
	110ºC	0.31	0.20	0.07	0.98	0.12	0.03	7	86	20	6536	3	502

[1] Analyzes performed in the Laboratory of the Department of Soil Science, ESALQ/USP. PT, total porosity; θ_{cc}, humidity in the "field capacity", volume-based; θ_{pmp}, humidity of permanent wilting point; DS, density of the substrate; Dp, particle density of the substrate.

exhibited 19.0 cm in diameter in the top edge, 15.0 cm of diameter at the base and 15.0 cm of height, while citrovases measured 14.0 cm of superior diameter, 10.2 cm of diameter at the base and 35.5 cm high. The containers were made of polypropylene, with eight holes in the base. The seedlings were distributed on the benches in four lines, each with 60 seedlings, according to the direction of the side lines of the irrigation system.

It was used the system by dropping, with self-compensating sprinklers, flow rate equal to 2.0 and 4.0 L h^{-1}, in different adapters combinations for 2 and 4 outputs, to obtain adequate flow (0.5; 1.0; 1.5; 2.0 and 2.5 L h^{-1}) equivalent to blades with the irrigation time equal in all the treatments of the same container. The blades were applied daily irrigation, having begun at 35 DAS. The potential evapotranspiration rate of seedlings (ETP), in mm, and the irrigation time (TI), in seconds, were determined according to the equations:

$$ETp = \frac{40 \cdot M_{\theta cc} - M_{\theta current}}{\rho \cdot \pi \cdot D^2} \quad (1)$$

$$Ti = \frac{360 \cdot ETp \cdot A_{conteiner}}{1000 \cdot q} \quad (2)$$

Where: $M\theta_{cc}$ is the mass of container + seedlings + substrate on the moisture of the field capacity (g); $M\theta_{current}$ is the mass of the container + seedlings + substrate on current moisture (g); ρ is the specific mass of water at room temperature (approximately 1.0 g cm^{-3}); D is the diameter of the upper edge of the container (cm), and $A_{container}$ is the container area (cm^2), both at the level of the substrate, and q is the flow rate of the container (L h^{-1}).

The difference in mass ($M\theta_{cc} - M\theta_{current}$) of three containers of each type was measured daily, by means of digital scale with capacity of 10,000 g and precision of 1.0 g. After weighing, the refitting of the mass of water lost through evapotranspiration was done, returning the substrate to θ_{cc}.

The fertilization in the substrate consisted of applying, per seedlings, 1.0 g of ammonium sulfate, 45 and 140 DAS, and 1.0 g of fertilizer 20-11-15 + micronutrients, at 75 DAS, based on the chemical analysis of the substrate and the work of Pacheco (2008), on soil fertilization in seedlings of *Dipteryx alata* Vog., this species of the same botanical family of jatobazeiro. The calcium and part of sulfur and copper were supplied via leaf fertilization, through spray Bordeaux mixture to 30 and 120 DAS. The syrup was prepared in the proportion of 1.0 L of water, 4.0 g virgin lime and 4.0 g of copper sulphate. Any weeds were manually eliminated.

During the experimental period, the temperature and the relative humidity of the air were registered in datalogger, inside the protected environment. In the period from 80 to 200 days after sowing (DAS), four evaluations of height of seedlings (AM), diameter of the stem (DC) and number of leaves (NF), and three, leaf area (AF), masses of dry matter of roots (MSR) and of seedlings (MSM) were carried out, obtained by the sum of the MSR with the dry matter of the aerial part (MSPA), and the ratio MSR/ADM. The AF was determined by the method of the mass of leaf rectangles, according to Gondim et al. (2009).

3. RESULTS

The potential evapotranspiration (ETp) of jatobazeiro was greater in seedlings produced in citrovase regarding the vases, throughout the experimental period (Figure 1). The ETp was superior both in terms of daily (mm blade day^{-1}) and in terms of mass (g day^{-1}) of evaportranspired water, despite of presenting lower citrovase evaporative area (153.9 cm^2) than the vases (283.5 cm^2).

The largest ETp based on earth, in citrovase, is, in part, due to a greater volume of that container (4.0 L) in relation to the vases (3.1 L), since the greatest mass of substrate in the first, heated by the solar global radiation energy, presented daily larger differences of weighing and, consequently, greater ETp.

The types of containers had significant effects ($p<0.05$) or highly significant ($p<0.01$) over the seedling height and number of leaves, to 80, 120, 160 and 200 days after sowing (DAS), the diameter of the stem (DC) to 160 and 200 of the mass, leaf area, dry matter of

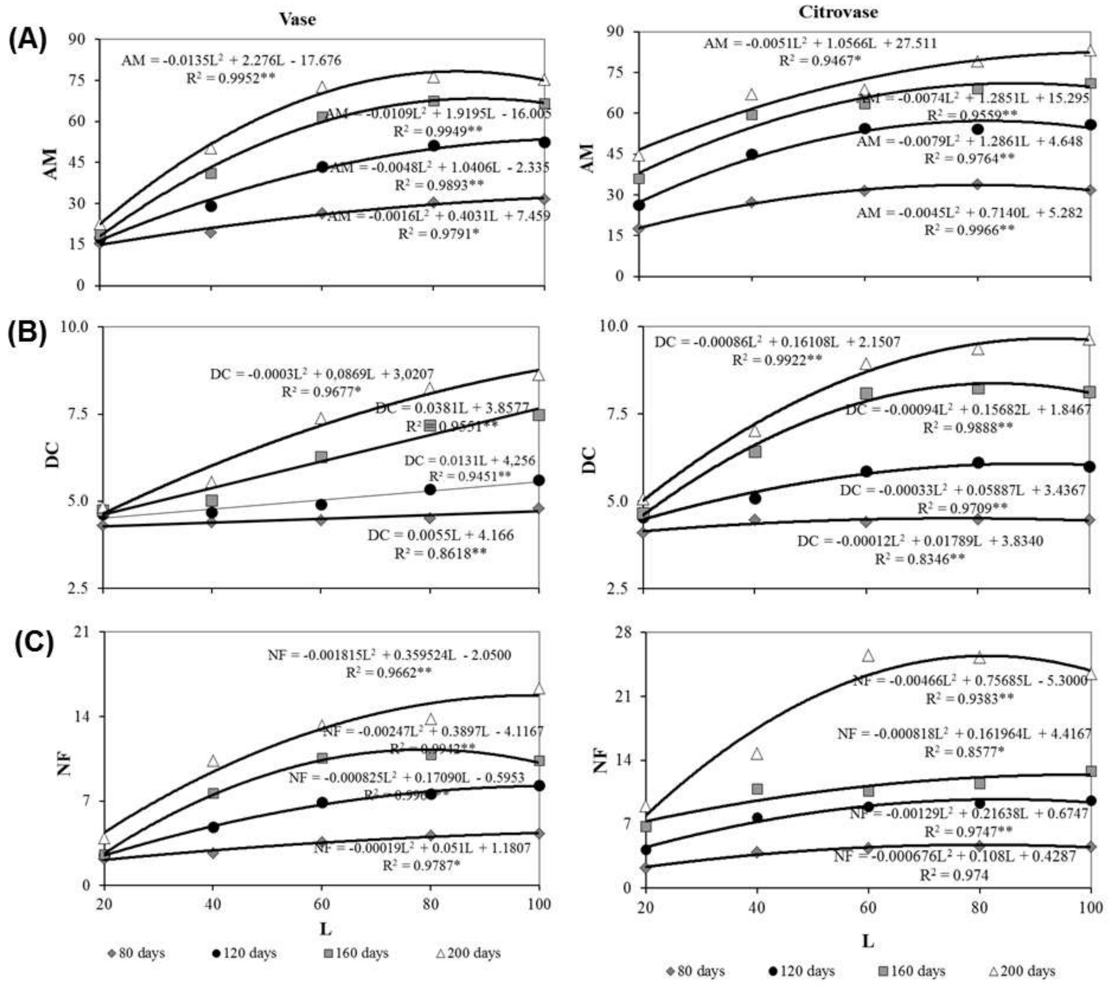

Figure 2 – Seedling height (AM, cm), stem diameter (DC, mm) and leaves number (NF) of jatoba seedlings in function of containers, irrigation levels (L, % ETp) and days after the sowing, grown under greenhouse.

Figura 2 – *Altura de muda (AM, cm), diâmetro de caule (DC, mm) e número de folhas (NF) do jatobazeiro em função de recipientes, lâminas de irrigação (L, % ETp) e dias após a semeadura, em casa de vegetação.*

roots and dry matter mass of seedlings, to 120, 160 and 200 days and the ratio of the masses of dry matter of roots and aerial part (MSR/MSPA), to 120 of, the 5% probability, by F test.

The irrigation blades influenced all the morphological parameters of the seedlings of jatobazeiro (AM, DC, NF, AF, MSR and MSM), regardless of age. All parameters were highly significant ($p<0.01$), being significant ($p<0.05$) the relationship MSR/MSPA TO 120 DAS. There was significant interaction between the type of container and blades for all parameters evaluated, with the exception of AF, at 160 and 200 days.

In the vases, the seedlings under irrigation blade 100% of the ETp, presented AM 31.6; 52.6; 66.6 and 75.5 cm, to 80, 120, 160 and 200 of, respectively, while in citrovase, the heights were 31.8; 55.9; 71.0 and 83.2 cm, these same ages (Table 2). At 200 DAS, the AM under the blade of 100%, in vase and citrovase, was 3.3 and 1.9 times, respectively, greater than in relation to blade 20%. The largest growth of AM occurred in phase of 80 to 120 of, in citrovases, in the absence of water restriction.

With relation to DC, higher values were observed in the blades of 80 and 100% of the ETp, on both the containers, reaching maximum values of 8.64 and 9.64 mm, in the vase and in citrovase, respectively, to 200 of (Figure 2B and Table 2). In both containers, the greatest growth of DC, took place in phase of 120 to 160 of irrigation on blades equivalent to 60, 80 and 100% of the ETp. Between the first (4.64 cm to 80 of) and the last evaluation (9.14 cm to 200 DAS), the average growth of DC (vase and citrovase) was approximately 97%, in the absence of water restriction (100% of irrigation blade), while in condition of *extreme deficit* (20% of the ETp), the growth was only 17.8% (4.96 - 4.21/4.21 x 100).

Larger number of leaves (NF) and leaf area (AF) were observed in the period of 160 200 DAS, especially in blades of 80 and 100% of the ETp, applied in citrovases. The maximum number of sheets observed was 16 and 23, respectively, in the vase and in citrovase, in seedlings with 200 DAS, submitted to refitting of 100% of the ETp, while in the most severe *water deficit* 20%) blade, these values were 4 and 9 sheets (Figure 2C). In vases under the blade of 60%, the AF increased by 3.34 (1582.8/472.6) times in the last 80 days of the experiment (120 to 200). The greatest increase of AF after 120 DAS, on both the containers, is due to, in part, the stage of development of jatobazeiro seedlings, and partly to the greater evapotranspiration, by reason of the greater weight of roots dry matter.

Up to 120 DAS, the seedlings in vases presented AF increased linearly in function of the irrigation blades. The AF maximum observed in this container, to 120 DAS, was 705.0 cm^2 $seedling^{-1}$, while the jatobazeiros in citrovase presented in this same age, maximum AF 859.4 cm^2 $seedling^{-1}$, under irrigation blade of 80% of the ETp (Figure 3A).

At 160 and 200 DAS, AF showed no significant interaction between containers and irrigation blades. The great blades in their respective ages, were estimated in 92.0% and 89.5% of the ETp, which result from AF maximum 1489.2 and 2104.6 cm^2 $seedling^{-1}$, regardless of the container. The most severe *water deficit* compromised considerably the AF, in both the recipients. It was observed wilting symptoms in seedlings irrigated to 20% of the ETp, mainly in the period from 11:00 am to 05:00 pm, in sunny days, and recovery of its turgidity at night after the irrigation.

The mass of dry matter of roots (MSR) in vases, at 120 DAS, showed linear response in function of the irrigation blades (Figure 3B) At 160 and 200 DAS the equation of 3rd degree showed a better adjustment to the data of the MSR within these containers, being the maximum of 11.9 g MSR $seedlings^{-1}$, estimated with blade of 92.0%, at 200 days. In the last 80 days of the experiment, the greatest increment of MSR within these containers was of 9.68 g $seedlings^{-1}$, this increase being observed in the blades of 80% and 100%. Now, with relation to citrovase, 120 DAS, the largest MSR was 3.2 g $seedling^{-1}$, at the absence of *water deficit*, while in the following stages, the great irrigation blades varied from 90.1% (160 DAS) to 88.8% (200 DAS), when the MSR achieved the value of 15.2 g $seedling^{-1}$.

The mass of seedlings dry matter (MSM) of jatobazeiro considerably reduced with the increase of water *deficit*, being all organs (roots, stems and leaves) affected. In the container of lower volume (vase), the levels of irrigation had increasing linear effect on the MSM, until 120 DAS; however, the equations of 2^{nd} and 3^{rd} degrees were significant at 160 and 200 DAS. At 200 DAS, the maximum production of MSM in this container was estimated at 34.0 g $seedling^{-1}$, with the blade of 93.0% of the ETp (Figure 3C).

Table 2 – Seedling height, stem diameter, leaves number, leaf area, roots dry matter mass, seedling dry matter mass and ratio of dry matter masses of roots and aerial part (MSR/MSPA) of jatoba seedlings, in function of age, containers and irrigation levels, in greenhouse.

Tabela 2 – *Altura de muda, diâmetro de caule, número de folhas, área foliar, massa de matéria seca de raízes e de muda e, relação das massas de matéria seca de raízes e parte aérea (MSR/MSPA) do jatobazeiro, em função da idade, recipientes e lâminas de irrigação, em casa de vegetação.*

Evaluated characteristic	Age (days)	Recipient	Irrigation blade (% ETp)					Average	DMS
			20	40	60	80	100		
Seedling height(cm)	80	Citrovase	17.59 a	27.18 a	31.46 a	33.80 a	31.79 a	28.36	2.46
		Vase	15.58 a	19.54 b	26.53 b	30.51 b	31.59 a	24.75	
		Average:	16.58	23.36	29.00	32.15	31.69	26.56	
	120	Citrovase	26.26 a	45.10 a	54.48 a	54.26 a	55.86 a	47.19	4.76
		Vase	17.60 b	29.20 b	43.47 b	51.37 a	52.64 a	38.86	
		Average:	21.93	37.15	48.98	52.82	54.25	43.02	
	160	Citrovase	36.07 a	59.49 a	63.63 a	68.91 a	71.04 a	59.83	6.24
		Vase	18.84 b	41.06 b	61.68 a	67.51 a	66.56 a	51.13	
		Average:	27.45	50.28	62.66	68.21	68.80	55.48	
	200	Citrovase	44.57 a	67.03 a	68.80 a	79.30 a	83.19 a	68.58	9.84
		Vase	22.74 b	50.42 b	72.61 a	76.35 a	75.47 a	59.52	
		Average:	33.66	58.72	70.71	77.82	79.33	64.05	
Stem diameter(mm)	80	Citrovase	4.10 b	4.47 a	4.42 a	4.50 a	4.47 b	4.39	0.18
		Vase	4.31 a	4.40 a	4.46 a	4.51 a	4.80 a	4.50	
		Average:	4.21	4.43	4.44	4.50	4.64	4.44	
	120	Citrovase	4.56 a	5.09 a	5.87 a	6.12 a	5.99 a	5.53	0.27
		Vase	4.63 a	4.69 b	4.92 b	5.35 b	5.61 b	5.04	
		Average:	4.60	4.89	5.40	5.74	5.80	5.28	
	160	Citrovase	4.66 a	6.42 a	8.10 a	8.24 a	8.13 a	7.11	0.55
		Vase	4.75 a	5.02 b	6.28 b	7.17 b	7.48 b	6.14	
		Average:	4.70	5.72	7.19	7.71	7.80	6.63	
	200	Citrovase	5.08 a	7.02 a	8.95 a	9.37 a	9.64 a	8.01	0.49
		Vase	4.84 a	5.55 b	7.40 b	8.26 b	8.64 b	6.94	
		Average:	4.96	6.29	8.17	8.82	9.14	7.48	
Number of leaves	80	Citrovase	2.21 a	3.92 a	4.38 a	4.63 a	4.55 a	3.94	0.31
		Vase	2.21 a	2.71 b	3.63 b	4.13 b	4.29 a	3.39	
		Average:	2.21	3.32	4.00	4.38	4.42	3.67	
	120	Citrovase	4.25 a	7.75 a	8.92 a	9.33 a	9.59 a	7.97	0.50
		Vase	2.50 b	4.84 b	6.88 b	7.63 b	8.30 b	6.03	
		Average:	3.38	6.30	7.90	8.48	8.94	7.00	
	160	Citrovase	6.75 a	10.92 a	10.67 a	11.50 a	12.83 a	10.53	1.51
		Vase	2.58 b	7.67 b	10.58 a	10.83 a	10.33 b	8.40	
		Average:	4.67	9.29	10.62	11.17	11.58	9.47	
	200	Citrovase	9.00 a	14.75 a	25.50 a	25.33 a	23.50 a	19.62	2.56
		Vase	3.92 b	10.33 b	13.25 b	13.83 b	16.33 b	11.53	
		Average:	6.46	12.54	19.38	19.58	19.92	15.58	
Leaf area (cm^2 $seedling^{-1}$)	120	Citrovase	189.0 a	585.9 a	746.1 a	859.4 a	855.8 a	647.2	78.2
		Vase	116.6 a	259.5 b	472.6 b	554.9 b	705.0 b	421.7	
		Average:	152.8	422.7	609.4	707.1	780.4	534.5	
	160	Citrovase	328.8	1101.9	1443.0	1728.8	1682.7	1257.0A	200.5
		Vase	130.7	499.8	1064.0	1190.4	1253.8	827.7 B	
		Average:	229.7	800.8	1253.5	1459.6	1468.2	1042.4	
	200	Citrovase	443.2	1523.7	2012.7	2439.7	2358.8	1755.6 A	316.1
		Vase	143.0	710.6	1582.8	1747.9	1735.2	1183.9 B	
		Average:	293.1	1117.1	1797.8	2093.8	2047.0	1469.8	

Continua...
Continue...

Table 2...
Tabela 2...

Mass of roots dry matter (g seedling^{-1})	120	Citrovase	0.63 a	1.74 a	2.53 a	2.81 a	3.16 a	2.17	0.47
		Vase	0.53 a	0.74 b	0.98 b	1.47 b	2.00 b	1.14	
		Average:	0.58	1.24	1.75	2.14	2.58	1.66	
	160	Citrovase	1.36 a	5.43 a	8.03 a	9.76 a	9.47 a	6.81	1.15
		Vase	0.71 a	1.64 b	4.15 b	6.62 b	7.15 b	4.05	
		Average:	1.03	3.54	6.09	8.19	8.31	5.43	
	200	Citrovase	1.97 a	8.45 a	12.52 a	15.44 a	14.62 a	10.60	1.94
		Vase	0.86 a	2.44 b	6.94 b	11.15 b	11.68 b	6.61	
		Average:	1.41	5.44	9.73	13.30	13.15	8.61	
Mass of seedling dry matter (g seedling^{-1})	120	Citrovase	2.98 a	7.47 a	10.17 a	10.84 a	11.88 a	8.67	1.39
		Vase	2.21 a	3.51 b	5.48 b	6.70 b	9.00 b	5.38	
		Average:	2.60	5.49	7.82	8.77	10.44	7.02	
	160	Citrovase	5.62 a	16.74 a	24.38 a	27.84 a	28.66 a	20.65	2.47
		Vase	2.66 b	7.13 b	15.11 b	19.68 b	21.96 b	13.31	
		Average:	4.14	11.93	19.75	23.76	25.31	16.98	
	200	Citrovase	7.79 a	24.31 a	36.00 a	41.75 a	42.38 a	30.44	4.06
		Vase	3.06 b	10.31 b	23.56 b	31.07 b	33.34 b	20.27	
		Average:	5.42	17.31	29.78	36.41	37.86	25.36	
Relation MSR/MSPA	120	Citrovase	0.26 b	0.30 a	0.33 a	0.35 a	0.36 a	0.32	0.05
		Vase	0.32 a	0.27 a	0.22 b	0.28 b	0.28 b	0.27	
		Average:	0.29	0.28	0.27	0.32	0.32	0.30	
	160	Citrovase	0.30 a	0.43 a	0.44 a	0.48 a	0.45 a	0.42	0.06
		Vase	0.36 a	0.29 b	0.32 b	0.43 a	0.42 a	0.37	
		Average:	0.33	0.36	0.38	0.46	0.44	0.39	
	200	Citrovase	0.33 a	0.53 a	0.54 a	0.59 a	0.53 a	0.50	0.09
		Vase	0.39 a	0.31 b	0.42 b	0.56 a	0.54 a	0.44	
		Average:	0.36	0.42	0.48	0.58	0.54	0.47	

Averages followed by the same letter in column, for the same morphological parameter and age, dot not differ among themselves, by the Tukey test, at 5% probability. DMS: Minimum significant difference

In citrovase, the maximum productions of MSM were estimated in 11.7, 28.8 and 42.8 g seedling^{-1}, with irrigation blades of 93.4%, 92.4% and 92.1%, at 120, 160 and 200 DAS, respectively.

The relationship MSR/MSPA was greater in seedlings of higher age, mainly due to the increase in mass of secondary roots. Cubic equations (to 160 and 200 DAS) and 4th degree (to 120 DAS) were significant and best adjusted to the data of the MSR/MSPA originated from the vase. Now, for the data from the citrovase , the linear equations (to 120 DAS) and quadratic (at 160 and 200 DAS) were significant at 1% (Figure 3D).

In the vase, the smaller relations MSR/MSPA were of 0.22; 0.28 and 0.31, estimated with blades of 58.2%, 39.7% and 35.6% of the ETp, at 120, 160 and 200 DAS, respectively. Larger blades that these have resulted in greater MSR/MSPA, however smaller blades also indicated higher MSR in detriment of the aerial part.

From 120 to 160 and from 160 to 200 DAS, there was greater increment of MSR than of MSPA, in all treatments. In citrovase, with the increase of the irrigation blades, larger volumes of humid substrate provided greater MSR, in detriment of the aerial part and, consequently, greater MSR/MSPA. The maximum value of this parameter was estimated in 0.59, at 200 DAS with the blade of 73.3% of the ETp.

With relation to containers, it was obtained greater AM in citrovase, especially in the blades of 40% and 20% of the ETp, in the last three evaluations (Table 2). However, there was no statistical difference of AM between containers when they were irrigated at 100% of the ETp.

As for the DC, the NF and MSR, citrovase propitiated better results than the vase, in the treatments of 40% to 100% of the ETp, in the last three evaluations. However, the replacement of 20% of the ETp did not promote statistical difference of the DC between containers.

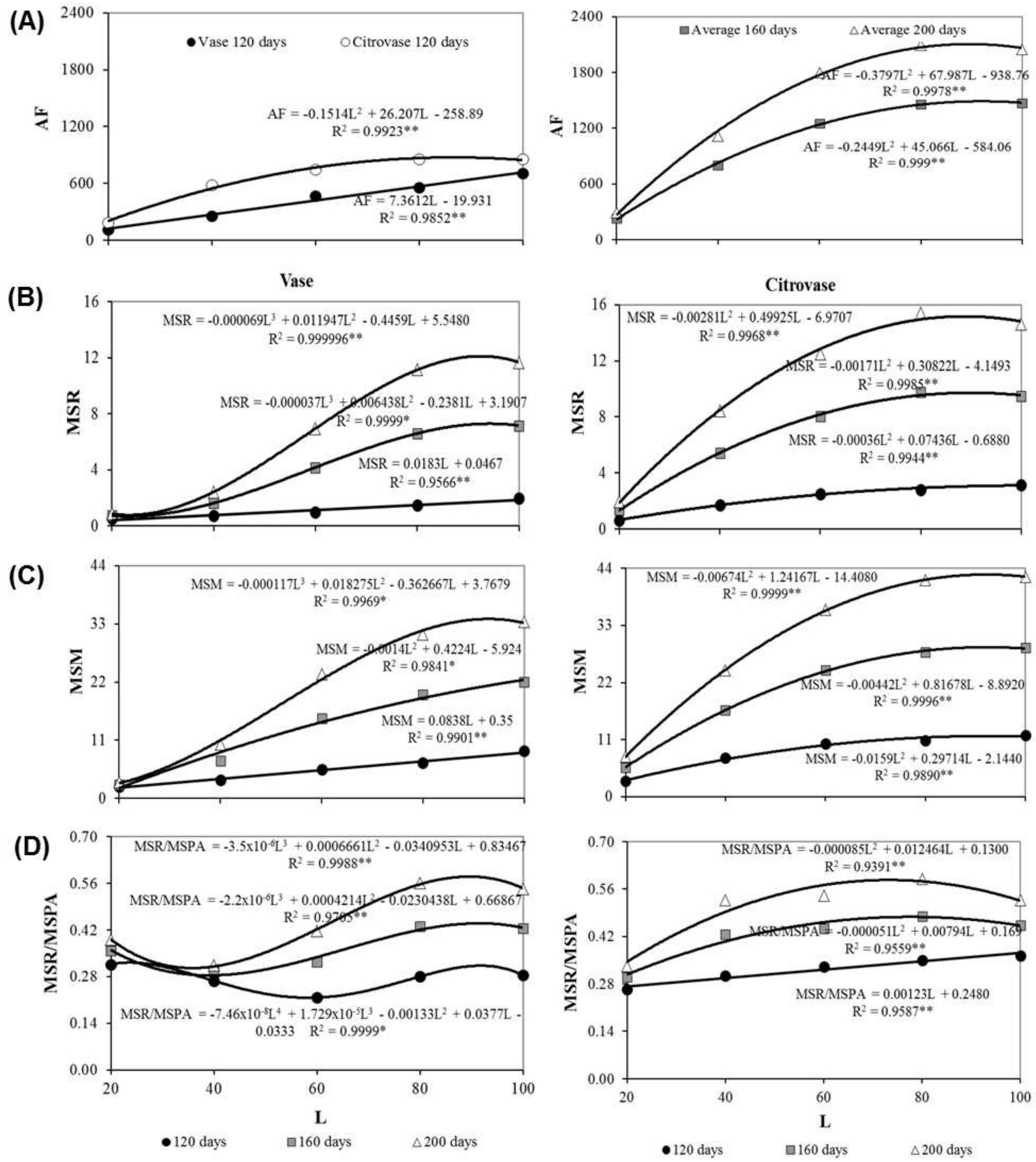

Figure 3 – Leaf area (AF, cm^2 $seedling^{-1}$), roots dry matter mass (MSR, g $seedling^{-1}$), seedling dry matter mass (MSM, g $seedling^{-1}$) and relationship among the masses of roots and aerial part (MSR/MSPA) of jatoba seedlings, in function of containers, irrigation levels (L, % ETp) and days after the sowing, grown under greenhouse.

Figura 3 *– Área foliar (AF, cm^2 $muda^{-1}$), massa de matéria seca de raízes (MSR, g $muda^{-1}$), massa de matéria seca de muda (MSM, g $muda^{-1}$) e relação entre as massas de raízes e da parte aérea (MSR/MSPA) do jatobazeiro, em função de recipientes, lâminas de irrigação (L, %ETp) e dias após a semeadura, em casa de vegetação.*

In all levels of irrigation applied, except the 20% at 120 DAS, the AF and MSP of seedlings in citrovase was statistically superior in relation to the vase, by the Tukey test, at 5% probability.

Jatobazeiros with four months of age, coming from citrovase, presented values of MSR/MSPA higher than those from the vase, the blades of 60%, 80% and 100% of the ETp, while in the blade of 20% the opposite occurred. Now, in seedlings of 160 and 200 of the citrovase was statistically superior only in the blades of 40% and 60%.

4. DISCUSSION

Major differences between the ETp of seedlings produced in the citrovase and in the vase, were observed mainly in days of higher temperatures. It is likely that this greater difference is due to the higher leaf area and dry matter mass of roots observed in citrovase, without ignoring the possibility of greater heating of the substrate in this container, since that the contact area of the substrate with its walls (1349 cm^2) was higher than the vase (801 cm^2). According to Oliveira et al. (2003), for each degree Celsius increase in soil temperature (in the range of optimum growth of plants), perspiration and water absorption amounting in approximately 10%, thus increasing the evapotranspiration.

In irrigation with deficit (blades of 20% and 40%), the largest AM in citrovase, to 120, 160 and 200 DAS, is due in particular to the largest volume of humid substrate, availability of nutrients and depth reached by wetting front advance, in relation to the vase, provided that it is more adequate to the development of the root system and the absorption.

The results of AM in function of the blades, are consistent with those obtained by Nascimento et al. (2011), once these authors have obtained seedlings of 62.6 cm height to 155 days of age (105 days after the beginning of the treatments), with the irrigation blade equivalent to 100% of the "capacity of pot' (CP). Nascimento et al. (2011) verified still that seedlings submitted to 25% of CP had reduction of height in 42.17%, in relation to the witness, this value being close to obtained at 160 DAS at this work with the blade of 20% of the ETp in citrovase, which has reduced the height in 47.8% in relation to the witness.

In condition of *water deficit* (80%, 60%, 40% and 20% of the ETp), reductions of DC of jatobazeiro were similar to those obtained by Nascimento et al. (2011). At 200 DAS, the reductions of DC were 2.8%; 7.2%; 27.2% and 47.3%, in citrovase, and 4.4%; 14.4%; 35.8% and 44.0%, in the vase, in their respective *water deficits*, in relation to the witness (blade of 100% of the ETp). Nascimento et al. (2011) obtained reductions of the DC, of 16.3%, 20.7% and 31.0%, in the treatments of 75%, 50% and 25% of the "capacity of pot" (CP), respectively, in relation to seedlings maintained at 100% of CP. The differences between results, are certainly due to differences in the environment and age of seedlings in both surveys, because these authors assessed the DC to 155 days after germination.

Regardless of the irrigation blade and the container used, the DC of jatobazeiro, at 120 DAS, was higher than that found by Leles et al. (1998), also in the house of vegetation. The lower DC obtained by these authors should probably have evaluated this parameter in seedlings of lower age at 110 DAS and in conditions of mild water *deficit*. At 200 DAS, the DC was consistent to the obtained by Carvalho Filho et al. (2003), to 180 DAS, in plastic bag of 15 x 20 cm.

The results of AF of this work are compatible with those of Nascimento et al. (2011), since that authors obtained AF of 758.6 cm^2 $seedling^{-1}$, to 155 days after germination, in water treatment of 100% of humidity in the "pot capacity" (CP). They still verified that the blade of 25% of CP reduced the AF in 70.1%, in relation to the witness, while in this study, the mean reduction of AF in the blade of 20% to 200 DAS, was 85.7%, in relation to the refitting of 100% of the ETp. According to Santos and Carlesso (1998), the reduction in AF is a prominent response of plants to water *deficit*. Significant reduction in AF was also observed in the agricultural crops, by Alves Junior et al. (2005), Paiva Sobrinho et al. (2011) and Ünlü et al. (2011), in plants of acid lime 'Tahiti', sunflower and cotton, respectively, when the fraction of water available in the soil was below the evapotranspirometric demand.

The MSM to 160 DAS, is superior than that obtained by Nascimento et al. (2011), in part due to differences in environments where the experiments were conducted. These authors obtained MSM 18.6 g $seedlings^{-1}$, in jatobazeiros with 155 days after germination, irrigated at 100% of θ_{cc}, in vases with 8.0 kg of soil, while in this experiment containers were used with the smallest quantity of substrate but, probably of greater availability of nutrients.

The higher relation MSR/MSPA, in seedlings o *H. courbaril* L. of higher age, is a mechanism of resistance to drought, also observed in other species, as *Arachis hypogaea* L. (Correia e Nogueira, 2004). To the extent that the seedlings are developed in a given volume of substrate, hydric demand becomes larger. For this reason, they are induced to develop the root system, for better access to water and, consequently is greater the absorption by radicelas.

5. CONCLUSIONS

1. Seedlings of *H. courbaril* developed better in citrovase than in vase, because of greater potential evapotranspiration that occurred in the first.

2. Irrigation blades of 90 to 100% of the ETp provide more vigorous seedlings of jatobazeiro.

3. The increase of the *water deficit* reduces all characteristics of jatobazeiro (AM, DC, AF e MSP), except the relationship MSR/ADM.

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