Handroanthus heptaphyllus MATTOS RESPONSE IN DIFFERENT VOLUMES OF SUBSTRATE AND BASE FERTILIZATION

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Resumo

Resposta de Handroanthus heptaphyllus Mattos em diferentes volumes de substrato e adubação de base. As espécies florestais nativas necessitam da adoção de práticas adequadas em viveiro, como a definição do volume de recipiente e adubação de base. Assim, este estudo teve como objetivo avaliar parâmetros morfológicos capazes de identificar o tamanho de recipiente e dose de fertilizante de liberação controlada (FLC) adequados à produção de mudas de *H. heptaphyllus*. O experimento foi conduzido em esquema fatorial 2x4, consistindo em dois tamanhos de recipiente (110 e 180 cm³) e quatro doses de FLC (0; 2.5; 5.0 e 7.5 g L^{-1} de substrato). Ao final do ciclo de produção das mudas, 180 dias após o semeio, mensurou-se a altura da parte aérea, diâmetro do coleto, massa seca (aérea, radicular e total), razão massa seca aérea/massa seca radicular, Índice de Qualidade de Dickson, e área foliar. Na condição deste estudo, a massa seca total demonstrou ser um parâmetro robusto para predizer sobre a qualidade de mudas de *H. heptaphyllus*. Recomenda-se o tubete de 180 cm³ e dose mínima de 7,0 g L^{-1} de FLC. A espécie *H. heptaphyllus* é nutricionalmente exigente, respondendo positivamente a altas doses de FLC.
Palavras-chave: Ipê-roxo; volume de recipiente; fertilizante de liberação controlada; morfologia.

Abstract

The native forest species require the adoption of appropriate practices in the nursery, such as the definition of the container volume and base fertilizer, to develop seedlings at lower cost. Thus, this study aimed to evaluate morphological parameters capable of identifying sizes of containers and controlled release fertilizers (CRF) rates more suitable for the production of *H. heptaphyllus* seedlings. The experiment was conducted in a 2x4 factorial design, consisting of two container sizes (110 and 180 cm³) and four doses of CRF (0; 2.5; 5.0 e 7.5 g L^{-1} of substrate). At the end of the seedling production cycle, 180 days after sowing, shoot height, stem diameter, dry mass (shoot, root and total), shoot dry mass/root dry mass ratio, Dickson Quality Index, and leaf area. In the condition of this study, a total dry mass demonstrated a robust parameter to predict about the quality of *H. heptaphyllus* seedlings. It is recommended the 180 cm³ tube and a minimum dose of 7.0 g L^{-1} of CRF. *H. heptaphyllus* species is nutritionally demanding, positively responding to high dose of CRF.
Keywords: Ipê-roxo; container volume; controlled release fertilizer; morphology.

INTRODUCTION

The constant exploitation of native forests, whether through agricultural expansion, extensive livestock farming or the direct use of wood, often illegally, leads to a decrease in forest cover, causing degradation and environmental imbalance (CALDEIRA *et al.*, 2013). In this sense, there is a greater demand for seedlings of native species, aiming to reduce this environmental liability by planting restoration and restoration of degraded areas.

The production of seedlings of environmental interest and timber trade species has required the development of research for the production of seedlings with adequate inputs and that provide the ideal characteristics to plants, ensuring success in the future afforestation (ROSSA *et al.*, 2013). For native tree species, there is a demand in relation to the elaboration of complete protocols on seedling production processes that include issues such as substrate composition, adequate luminosity, container volumes and fertilizations (STORCK *et al.*, 2016). One of the obstacles to production, especially for native species, is the varied behavior according to the inputs used. However, the nursery manager needs to establish the most appropriate management, defining what will enable him to obtain seedlings with adequate quality.

According to Gomes and Paiva (2011) the type of container and its dimensions (volume) influence both the quality and production costs, as well as the availability of water and nutrients to the seedlings. In addition, the adoption of substrate fertilization techniques has been identified as a relevant factor to increase the growth and quality of seedlings of forest species (MEZZOMO *et al.*, 2018; BERGHETTI *et al.*, 2019; TURCHETTO *et al.*, 2019).

To determine those characteristics the use of morphological parameters is needed, among which we can highlight height, stem diameter, height/stem diameter rate, shoot dry mass, dry root mass, leaf area and Dickson quality index (GOMES; PAIVA, 2011). The morphological parameters due to the easiness of measurement are the most used in the observation of the adequate growth of plants. Gonçalves *et al*. (2005) believes that a seedling produced in tubes with quality suitable for planting should have height between 20 and 35 cm and the stem diameter between 5 and 10 mm. The native forest species with slower initial growth, such as *Handroanthus heptaphyllus* Mattos may have different performance both in the nursery and in the field, and so they depend on specific study for their cultivation. Since field planting, according to Gasparin *et al*. (2014), allows to confirm and recommend techniques that favor the rapid growth of seedlings.

H. heptaphyllus, popularly known as ipê-roxo, is a native species from Brazil belonging to the Bignoniaceae family, which occurs from Bahia to Rio Grande do Sul States, being a deciduous plant, classified as a secondary secondary (CARVALHO, 2003). *H. heptaphyllus* has wide current and future economic use due to its wood characteristics, and it can be used in the manufacture of parquet floors, walking sticks, wheel axles and wagon poles, wooden gear teeth, in shipbuilding, dye for dyeing fabrics, among others, it still has environmental importance, standing out in mixed plantations, agroforestry systems, recovery of riparian forests, and in urban afforestation due to its scenic beauty, besides having medicinal application in tumor treatment, flu and as blood purifier (GRINGS; BRACK, 2011).

Considering the economic, social, environmental and landscape importance that gives multiple uses to *H. heptaphyllus*, this study and the definition of the most appropriate management techniques for the development of seedlings are justified, as well as the establishment of quality standards for the species. Therefore, it should be understood how the exposure of *H. heptaphyllus* plants to different containers and doses of basic fertilization alter the formation of seedlings in the nursery.

So, how does the choice of inputs occur, focusing on the size of the tube and fertilizer dose, for plants of native species? Thus, this study aimed to evaluate morphological parameters capable of identifying sizes of containers and controlled release fertilizers rates more suitable for the production of *H. heptaphyllus* seedlings.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse belonging to the Forestry and Forest Nursery Laboratory (29º43'14 "S and 53º43'15"W), from the Departamento de Ciências Florestais (DCFl), in a southern University. The region according to Köppen classification presents the 'CFA' (humid subtropical) kind of climate (ALVARES *et al.*, 2013), characterized by the average temperature of the coldest month between -3 and 18 °C and the hottest month above 22 °C, the average annual precipitation is 1,769 mm, with four distinct seasons.

The seeds used in the study came from eight trees located in deciduous seasonal forest fragments in the region of Santa Maria, RS (29º47'37"S and 53º40'01"W). The experiment was conducted in a 2x4 factorial design, consisting of two container sizes and four doses of base fertilizer, totaling eight treatments with four repetitions of each eight seedlings, randomly distributed.

The containers used were tapered tubes of polypropylene (Factor A) with volumetric capacity of 110 cm^3 and 180 cm^3. The containers were filled with commercial substrate, that have *Sphagnum* peat, 20% carbonized rice husk, expanded vermiculite, dolomitic limestone and gypsum in its formulation.

The substrate was mixed with base fertilizer at the time of preparation which was Factor B, represented by different controlled release fertilizer (CRF) doses with NPK formulation 15-09-12 + 2.3% S, 1% Mg + micronutrients (0.45% Fe, 0.2% Mo, 0.05% Cu and 0.06% Mn) in the dosage of 0 (control); 2.5; 5.0 and 7.5 g L^{-1} CRF of substrate. According to the manufacturer's technical specification, when placed in moist substrate at an average temperature of 21.1 °C, the release of all nutrients occurs in a period of 8 to 9 months.

The seeding was carried out directly in the tubes, placing two seeds per container, covering them with a thin layer of the same substrate and after that the trays were taken to the greenhouse. The emergency count started at 11 and ended at 30 days after seeding, considering as emerged seedlings the ones that presented visible cotyledons and leaf primordial. Later, a thinning was performed, eliminating the surplus seedlings, leaving only one per container (the strongest and most central). The seedlings remained in a greenhouse until day 180.

The experiment conducted in the greenhouse received daily irrigation carried out by a mobile bar of microsprinklers with water depth of 4 mm per day, with automatic operation at 8 a.m., 11 a.m., 2 p.m. and 5 p.m.

In addition to the base fertilizer, the topdressing began at day 30, which was performed every seven days, using a NPK fertilizer in the form of salt (9-45-15) at a dose of 5 g L^{-1} which has in its base formulation macro and micronutrients, among these boron (0.0088% B) and zinc (0.0025% Zn) that are not present in the CRF. The coverage fertilizer was dissolved in water and applied with use of backpack sprayer, early in the morning and after that a brief irrigation was performed to reduce excess fertilizer in order to avoid possible burning of the seedlings.

The evaluations were performed at day 180, by measuring the following characteristics from the eight central seedlings of each repetition: height (H) measure from the seedling base to the apical bud of the last leaf, with the aid of a millimeter ruler; and the stem diameter (SD) to the substrate level with a digital caliper, obtaining the H/SD relation. By the destructive method, the following parameters were obtained: leaf area (LA), shoot dry mass (SDM), root dry mass (RDM), total dry mass (TDM), SDM/RDM relation and the Dickson quality index (DQI), using one seedling per repetition, totaling 32 plants.

The seedlings were sectioned on the stem diameter, and the leaves of the main stem and branches were separated, which were initially used to determine the leaf area, setting them on a blank paper (A4 size) covered by transparent glass, using a millimeter ruler for scale. The samples were photographed using a digital camera brand Sony, DSC T-100 model, using a zoom 1.4 without flash. The root system was washed on the sieve (4 mm) to remove the substrate. The leaves were reserved to obtain the SDM with the rest of the shoot (stem and branches), stored in kraft paper bags and then subjected to oven drying at 60 °C to constant weight, which was followed by weighing in precision digital scale (0.001 g). Subsequently, the images were processed with the aid of the Image J program. The same drying and weighing procedure was carried to the root system to discover the RDM. The DQI was obtained by the formula described in Gomes and Paiva (2011).

The data were submitted to verification of normality and homogeneity of variances. Statistical analysis was performed with the aid of SISVAR software (FERREIRA, 2014), submitting the data to analysis of variance (ANOVA) and when the discrepancy between treatments by F test was found, we performed polynomial regression at 5% of error probability.

On having significance to the quadratic equations, it was determined the maximum dose of technical efficiency (MDTE), by the formula $X = -b1/2b2$, where X = point of maximum technical efficiency; b1 and b2 = equation coefficients. Besides that, the Pearson correlation (r) at 5% of significance between morphological variables was also held. The correlation can be classified as: $r = 0$ (no correlation), $0 < r < 0.3$ (weak); $0.3 \leq r < 0.6$ (regular); $0.6 \leq r < 0.9$ (strong); $0.9 \leq r < 1$ (strongly) and $r = 1$ (perfect) (CARGNELUTTI FILHO *et al*., 2010).

To assess the quality of the seedlings in the field, 20 plants with height attributes and stem diameter compatible with those obtained from the best treatment were selected, which were conducted in full sun. The trees were planted in an area annexed to the Forestry Laboratory and Nursery Forestry, DCFl, and they were put in pits of 30 cm of diameter and 35 cm deep (0.02 m^3). The cultivation was constituted in mowing, weeding, ant control and top dressing (30 and 180 days after planting, with NPK formulation 5-20-20). Evaluations of survival, height and stem diameter were performed bimonthly for one year after planting, using the descriptive statistics and graphical analysis field for growth behavior analysis.

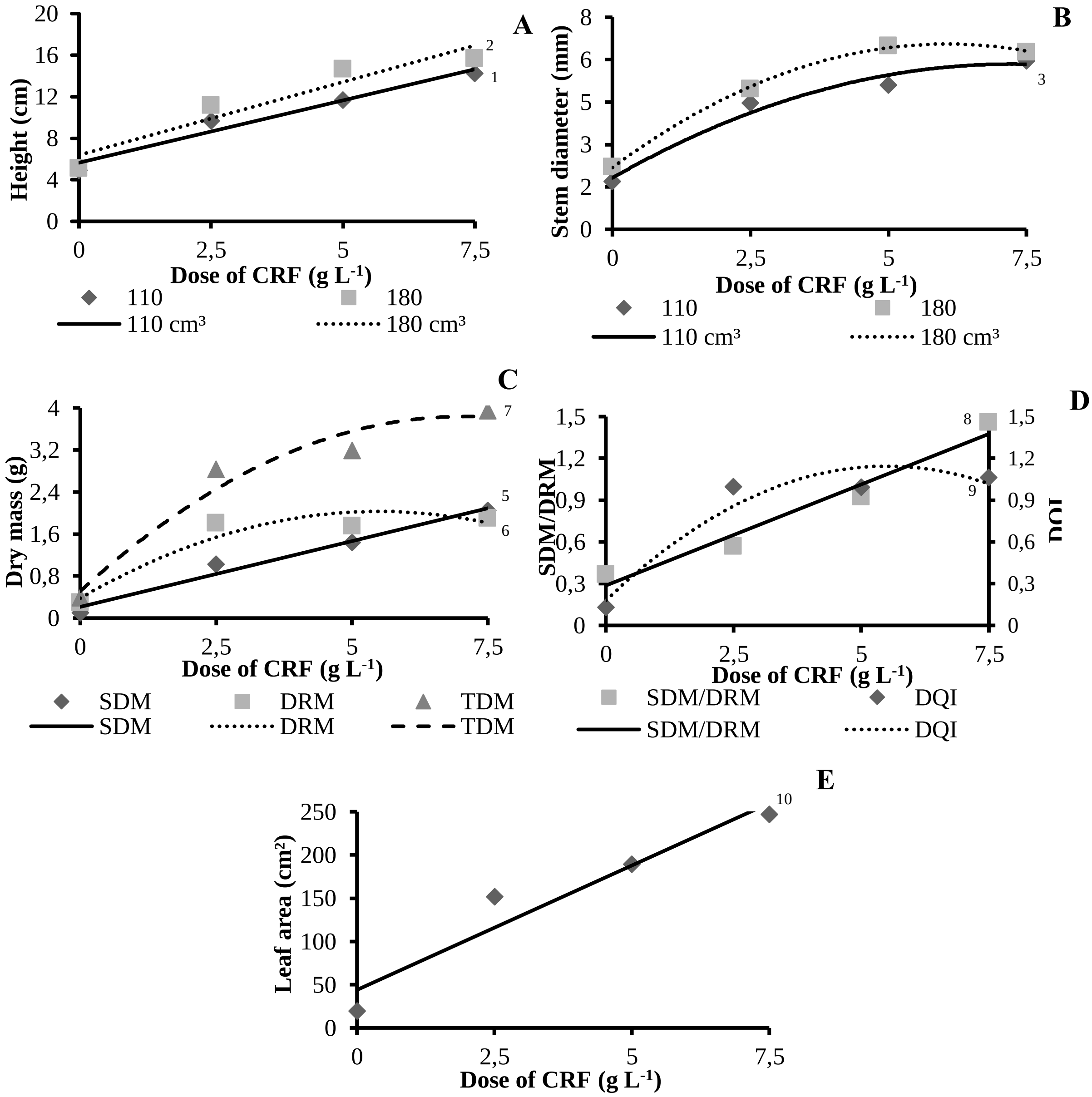
RESULTS

The seedling emergence of *H. heptaphyllus*, began at 11 days after sowing and showed 95.5% at 30 days (CV = 6.57%) (p>0.05). The growth of *H. heptaphyllus* seedlings in nurseries at day 180 for height and stem diameter showed a significant interaction between the container size and base fertilizer doses, with controlled release fertilizer (CRF) (p <0.05). However, for the shoot dry mass, root mass, shoot dry mass/dry root mass relation, Dickson quality index and leaf area, only the base fertilization factor was significant.

The development of the height (H) was crescent, with a linear behavior as the doses of CRF were increased, for both the 110 and the 180 cm^3 tubes. For both containers the dose of 7.5 g L^{-1} gave the highest averages (14.27 and 15.68 cm, respectively) at 180 days (Figure 1A).

In relation to stem diameter (SD), it is observed that *H. heptaphyllus* seedlings grew to a certain dosage, expressing a quadratic trend for the two container volumes analyzed (110 and 180 cm^3) (Figure 1B). It appears that the maximum dose of technical efficiency (MDTE) to the tubes of 110 and 180 cm^3 was, respectively, 7.2 and 6.1 g L^{-1}, which correspond to 5.85 and 6.55 mm SD. It is observed in Figure 2 that when the SD is under low dosage (up to 2.5 g L^{-1}), there is little difference in stem diameter values for the containers (p <0.05).

The shoot dry mass (SDM), root dry mass (RDM) and the total dry mass (TDM) showed an increasing behavior in relation to the dose of CRF, and the behavior for showed a linear pattern, similar to the height, and quadratic for RDM and TDM (Figure 1C). SDM was 2.05 g at the maximum dose, and RDM and TDM, respectively, with 2.03 and 3.84 g in the MDTE of 5.5 and 7.0 g L^{-1}. The shoot dry mass/root dry mass (SDM/RDM) relation of *H. heptaphyllus* seedlings grown in nurseries, resulted in a relation of 1.46 also obtained with the highest dose of CRF (7.5 g L^{-1}). The Dickson Quality Index (DQI) for *H. heptaphyllus* was positively related quadratically with doses of CRF (Figure 1D), MDTE of 5.5 g L^{-1} (IQD = 1.15), and that from this point of inflection, the DQI is influenced negatively. The leaf area (LA) presented linear increase behavior (Figure 1E), a trend also seen for other parameters such as H, SDM and SDM/RDM.



Polynomial regression equations: [1]H (110 cm³)= 5.64+1.2x; R^2=0.96; [2]H (180 cm³)=6.38+1.41x; R^2=0.91; [3]SD (110 cm³)=1.82+1.11x-0.08x²; R^2=0.97; MDET=7.2; [4]SD (180 cm³)=2.18+1.44x-0.12x²; R^2=0.99; MDET=6.1; [5]SDM=0.21+0.25x; R^2=0.98; [6]DRM=0.38+0.60x-0.05x²; R^2=0.91; MDET=5.5; [7]TDM=0.51+0.94x-0.07x²; R^2=0.96; MDET=7.0; [8]SDM/DRM=0.29+0.15x; R^2=0.96; [9]DQI=0.18+0.35x-0.03x²; R^2=0.93; MDET=5.5; [10]LA=43.93+28.79x; R^2=0.93.
H=altura (height); SD=diâmetro do coleto (stem diameter); SDM = massa seca aérea (shoot dry mass); RDM = massa seca radicular (root dry mass); TDM = massa seca total (total dry mass); DQI=Índice de Qualidade de Dickson (Dickson Quality Index) and LA=área foliar (leaf area); MDTE = máxima dose de eficiência técnica (maximum dose of technical efficiency).

Figura 1. Altura, diâmetro do coleto, massa seca (SDM, RDM, TDM), relação SDM/RDM, Índice de Qualidade de Dickson e área foliar de mudas de *Handroanthus heptaphyllus* Mattos em recipientes (110 e 180 cm³) e fertilizante de liberação controlada (CRF), aos 180 dias após o semeio em viveiro, Santa Maria, RS

Figure 1. Height, stem diameter, dry mass (SDM, RDM, TDM), relation SDM/RDM, Dickson Quality Index and leaf area of *Handroanthus heptaphyllus* Mattos seedlings in containers (110 and 180 cm³) and controlled release fertilizer (CRF), 180 days after sowing in nursery, Santa Maria, RS.

In addition to the analysis of the morphological parameters, using Pearson's correlation matrix (r), it is possible to infer and confirm the results. Thus, we sought to highlight as correlations with ≥ 0.75, which corresponds to a strong to perfect correlation, as can be seen in bold in Table 1.

It is noticed that the variable SD correlates strongly with H (r = 0.93). SDM and LA are strongly correlated with H and SD. Corroborating these requirements, LA correlates with MSA (0.97).

An TDM was the parameter that most correlated with other variables, having a magnitude of correlation with H (0.83), SDM (0.90), RDM (0.91) and LA (0.89). DQI is strongly correlated with RDM (0.99) and TDM (0.93), which can be ratified by the fact that these tests are part of their calculation (Table 1).

Tabela 1. Correlação de Pearson (r) dos parâmetros morfológicos de mudas de *Handroanthus heptaphyllus* Mattos em diferentes volumes de recipiente e doses de fertilizante de liberação controlada aos 180 dias após o semeio em viveiro, Santa Maria, RS.

Table 1. Pearson correlation (r) of the morphological parameters of *Handroanthus heptaphyllus* Mattos seedlings in different volumes of container and controlled release fertilizer doses at 180 days after sowing in the nursery, Santa Maria, RS.

Parameters	H	SD	SDM	RDM	LA	SDM/RDM	TDM	DQI
H	1							
SD	**0.93***	1						
SDM	**0.87***	**0.79***	1					
RDM	0.64*	0.55*	0.64*	1				
LA	**0.83***	**0.78***	**0.97***	0.67*	1			
SDM/RDM	0.52*	0.55*	0.59*	-0.05^{ns}	0.56*	1		
TDM	**0.83***	**0.74***	**0.90***	**0.91***	**0.89***	0.29^{ns}	1	
DQI	0.67*	0.63*	0.69*	**0.99***	**0.71***	0.03^{ns}	**0.93***	1

*significativo a 5% (significant a 5%); ns = não significativo (no significant); H = altura (height); SD = diâmetro do coleto (stem diameter); SDM = massa seca aérea (shoot dry mass); RDM = massa seca radicular (root dry mass); LA = área foliar (leaf area); relação (relation) SDM/RDM; TDM = massa seca total (total dry mass); DQI = Índice de Qualidade de Dickson (Dickson Quality Index)

The *H. heptaphyllus* seedlings led the field with height and average stem diameter, respectively, of 15.10 ± 2.99 cm and 6.23 ± 1.73 mm, demonstrated to respond efficiently to their development in the post-planting, with survival level of 95% and crescent increment in height of 81.51 cm and in stem diameter of 17.55 mm (Figure 2).

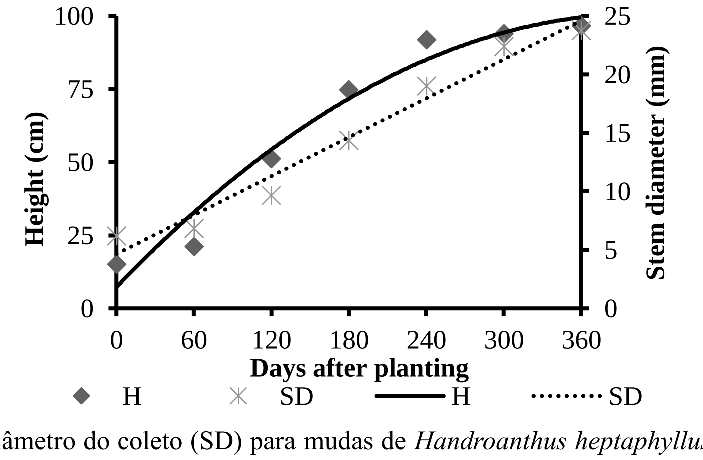


Figura 2. Altura (H) e diâmetro do coleto (SD) para mudas de *Handroanthus heptaphyllus* Mattos após 360 dias de plantio a campo, Santa Maria, RS.

Figure 23. Height (H) and stem diameter (SD) for *Handroanthus heptaphyllus* Mattos seedlings after 360 days planting on field, Santa Maria, RS.

DISCUSSIONS

The percentage of seedling emergence can be considered high, as it is a late secondary native species (GRINGS; BRACK, 2011). And also due to the fact that the seeds of *H. heptaphyllus* do not demonstrate a typical behavior of recalcitrant or orthodox seeds, having an intermediate tendency between the two classifications in relation to desiccation (TONETTO *et al*., 2015). The time observed for the start of the emergency is corroborated by Carvalho (2003), whose period comprises between 10 to 12 days.

The results indicate that, especially, the 180 cm³ container has the potential for the seedlings to continue increasing in height, allowing to infer that there is a close relationship between growth and available space. Similarly, the type of container influenced the growth of *Calophyllum brasiliense* Cambess and *Toona ciliata* M.

Roem. var. australis (F. Muell.) Bahadur seedlings, both responded significantly to the largest tube volumes (LISBOA *et al*., 2012). The height values measured for *H. heptaphyllus*, are below those suggested by Gonçalves *et al*. (2005), which are between 20 and 35 cm. However, it should be noted that the size did not represent an inadequate quality of the seedlings, not characterizing a limiting factor to the post-planting performance. Since, there was a significant increase in the aerial part, as was confirmed in Figure 2. Allied to this, it is noted that the period in which the nursery experiment was completed represented the most appropriate stage for planting in the region, as there is no need irrigation of these plants, that is, extending the stage of the nursery would provide greater investment in planting.

The highest growth in height, stem diameter, dry mass (shoot, root and total), shoot dry mass/root dry mass ratio, Dickson's Quality Index and leaf area (Figure 1) were observed when a higher dose of controlled release fertilizer (CRF), which showed the strong positive influence that the increase in CRF has on the growth of seedlings, which was also measured by Mezzomo *et al*. (2018), when studying *H. heptaphyllus* in higher concentrations of CRF. Turchetto *et al*. (2019) found greater growth in seedlings of *Balfourodendron riedelianum* (Engl.) Engl. in the highest concentrations of CRF, because there was a greater contact of the roots with the nutrients, resulting in a greater absorption and accumulation of nutrients in the plant organs, and thus, there was an increase in the metabolism of the plants' activity, allowing their greater growth. Likewise, Gasparin *et al*. (2014) observed greater development in the plants of *Cabralea canjerana* (Vell.) Mart at the highest CRF doses. Therefore, justifying the behavior observed in the plants of *H. heptaphyllus*.

When analyzing the SD, there was possibly greater investment by the species in the growth of the diameter of the collection. What may be a common characteristic for the family Bignoniaceae, since seedlings of *Tabebuia aurea* Manso Benth & Hook, also showed behavior similar to that observed in this study (DANTAS et *al*., 2018). The high SD values of the *H. heptaphyllus* seedlings are an interesting characteristic, since, according to Melo *et al*. (2018), seedlings with low stem diameters have difficulties to remain upright after planting, at the same time that plants with reduced SD and higher height are considered of inferior quality. Higher SD values express the best performance of the plant in the post-planting period (RITCHIE *et al*., 2010).

Regarding the shoot dry mass/root dry mass ratio, it is suggested that, under the conditions of the study, the species has prioritized a greater investment in the root than shoot. Meeting the measured values, Abreu *et al*. (2017) observed for the SDM/RDM ratio in *H. heptaphyllus* averages that ranged from 0.82 to 1.37. According to Caldeira *et al*. (2013), the SDM/RDM ratio is lower in environments with less fertility, and can be considered a strategy of the plant to remove the maximum nutrients in that condition.

Through the analysis of the DQI, it can be inferred this parameter can be a predictor in the evaluation of the adequate growth pattern of the species. The effect of higher doses of CRF in *H. heptaphyllus* seedlings, implies the best result observed for the DQI (0.18) (MEZZOMO *et al*., 2018). The DQI is an important indicator of seedling quality (GOMES; PAIVA, 2011).

The leaf area was influenced proportionally by the increase in the CRF doses, which is correlated to the nursery growth observed for *H. heptaphyllus*. Turchetto *et al*. (2019) infer that the growth response of seedlings submitted to different levels of fertilization is driven by changes in the leaf area of plants. The increase in the leaf area index is associated with increased light interception, which serves as the main promoter of increased biomass productivity (MEZZOMO *et al*., 2018).

It emphasizes the importance of analysis by the destructive method to describe the growth of *H. heptaphyllus*. Since, TDM correlated with most of the other variables studied (H, SD, SDM, RDM, LA and DQI), opting then for the use of this variable to decide on the container volume and the base fertilization dose for the growth of *H. heptaphyllus* seedlings. In this way, the combination of the 180 cm³ container plus the 7.0 g L^{-1} dose represents the most favorable condition for the species.

In areas where vegetative rest is imposed by low temperature, doses higher than 7.0 g L^{-1} of CRF can be a waste of resources if seedlings of H. heptaphyllus are carried out in the field at the appropriate time (late winter). An alternative for that would be to invest in larger quantities of *H. heptaphyllus* seeds, in view of the loss of their viability and to sow at the exit of the cold season, with storage in a dry and cold environment (TONETTO *et al*., 2015). That would possibly provide larger seedlings, due to the subsequent growth season of the winter, but the plants should be kept for a longer in the nursery, waiting for the appropriate time to plant.

CONCLUSIONS

- In the condition of this study, a total dry mass demonstrated a robust parameter to predict about the quality of *H. heptaphyllus* seedlings.
- It is recommended the 180 cm³ tube and a minimum dose of 7.0 g L^{-1} of controlled release fertilizer

(CRF).
- *H. heptaphyllus* species is nutritionally demanding, positively responding to high dose of CRF.

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