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PRODUCTION OF *DINIZIA EXCELSA* DUCKE (FABACEAE) SEEDLINGS SUBJECTED TO INCREASING DOSES OF CONTROLLED RELEASE FERTILIZER

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Abstract

Dinizia excelsa is one of the largest trees in the Amazon rainforest, with significant economic potential for the recovery of degraded areas. It is a key species for biodiversity and increased forest biomass. However, studies related to seedling production of this species are still scarce. In this study, we evaluated the production and quality of *D. excelsa* seedlings in response to the application of controlled-release fertilizer doses. The experimental design was completely randomized, applying different doses of Osmocote® (T1=0; T2=4.1; T3=8.2; and T4=12.3 g.dm^{-3}) with four replicates, using vermiculite and coconut fiber (1:1 v/v) as the substrate. We assessed the number of leaves and leaflets, shoot and root length, stem diameter, seedling height, shoot-to-stem diameter ratio, leaf area, dry mass of shoot, root, and total biomass. The data were subjected to analysis of variance and regression analysis. The seedlings responded positively to the use of Osmocote®, and starting from the 4.1 g.dm^{-3} dose, biomass accumulation showed better results, making it a recommended practice that allows cost savings in seedling production of this species.

Keywords: plant nutrition; Osmocote®; silviculture; seedling quality.

PRODUÇÃO DE MUDAS DE *DINIZIA EXCELSA* DUCKE (FABACEAE) SUBMETIDAS A DOSES CRESCENTES DE FERTILIZANTE DE LIBERAÇÃO CONTROLADA

Resumo

Dinizia excelsa é uma das maiores árvores da floresta amazônica, com grande potencial econômico para recuperação de áreas degradadas. Trata-se de uma espécie-chave para diversidade e aumento da biomassa florestal. Ainda são escassos os estudos relacionados à produção seminal de mudas da espécie. Nós avaliamos a produção e a qualidade de mudas de *D. excelsa* em resposta à aplicação de doses de adubo de liberação controlada. O delineamento adotado foi inteiramente casualizado, aplicando-se diferentes doses de Osmocote® (T1=0; T2=4.1; T3= 8.2 e T4=12.3 $g.dm^{-3}$) com quatro repetições, utilizando-se como substrato vermiculita e fibra de coco (1:1 v/v). Foram avaliados número de folhas e folíolos, comprimento da parte aérea e raiz, diâmetro do coleto, altura das mudas, relação comprimento da parte aérea e diâmetro do coleto, área foliar, massa seca da parte aérea, raiz e total. Os dados foram submetidos à análise de variância e regressão. As mudas responderam positivamente ao uso do adubo Osmocote® e a partir da dose 4.1 $g.dm^{-3}$ o acúmulo de biomassa apresentou melhores resultados, podendo ser recomendada, permitindo uma economia nos custos de produção seminal de mudas da espécie.

Palavras-chave: nutrição de plantas; Osmocote®; silvicultura; qualidade de mudas.

Introduction

Given the increasing need of recovering degraded ecosystems and the growing demand for forest implantations, it is essential understanding the culture of forest species, as well as improving technologies, and the technical and economic viability of projects focused on seedlings' seminal production (MENEGATTI *et al.*, 2017; AGUILAR *et al.*, 2020). Projects aimed at forest recovery processes, and at finding highly adaptable plant species, expand at similar pace, and it requires relying on studies about the development of high-quality seedlings (MEWS *et al.*, 2015).

It is essential investigating factors affecting plant development to help improving plant nursery techniques (TRAUTENMULLER *et al.*, 2017). However, the successful production of forest seedlings in nurseries is often limited by lack of information about species' nutritional demands. Thus, understanding them enables the production of better-quality seedlings capable of easily adapting to field environments, at higher survival rates (DUTRA *et al.*, 2016).

Fertilization practices promote seedling development and reduce the time plants spend in the nursery, thereby lowering production costs. The application of slow-release or controlled-release fertilizers provides a continuous availability of nutrients, avoiding the need for multiple applications of certain nutrient sources and reducing operational costs (BRITO *et al.*, 2018; GOMES *et al.*, 2020).

According to Rossa *et al.* (2015), Osmocote® is a controlled-release fertilizer used to produce seedlings in containers. It continuously supplies nutrients to plants for longer periods-of-time. This process decreases the likelihood of having nutrient deficiency during seedling formation and rules out the need of conducting split applications of other nutrient sources. Therefore, it helps reducing operation costs with seedling formation (MENDONÇA *et al.*, 2008, BRITO *et al.* 2018), besides being remarkably advantageous in comparison to other fertilization types (MARANA *et al.*, 2008; FELETTI, 2018).

Species *Dinizia excelsa* Ducke (Fabaceae), also known as *angelim-vermelho* (in Portuguese), is native to South America; in Brazil, it is mainly distributed in Acre, Amapá, Amazonas, Pará and Rondônia states. This species plays key role in increasing forest biomass; its wood is quite heavy and its apparent specific mass ranges from 0.95 to 1.00 $g.cm^{-3}$. It is resistant to fungi and termites, as well as intensively exploited for the domestic market focused on civil construction, shipbuilding and rustic furniture (MESQUITA *et al.*, 2009). From 2006 to 2016, it remained in the third position in the ranking of species accounting for the highest wood volume removed from Marajó region; it accumulated 332,605.1872 m^3 of wood volume exploited in logs (LIRA *et al.*, 2020).

It is essential optimizing the use of resources for seedling production in nursery environment, mainly for forestry companies that need to produce a large number of seedlings in a shorter period-of-time, at low cost and better-quality standards (MASSAD *et al.*, 2017). Thus, the aim of the current study was to assess the seedling production of forest species *D. Excelsa* in nursery environment based on using controlled-release fertilizer (CRF).

Materials and methods

1.1. Study site

The experiment was conducted based on 110-day follow-up period, in greenhouse environment, at the Agricultural Sciences Institute (ICA - Instituto de Ciências Agrárias) of Federal Rural University of Amazônia (UFRA – Universidade Federal Rural da Amazônia) (1°27’12.6” S; 48°26’33.5” W), Belém City - PA. Climate in the region is classified as humid tropical (Afi), based on Köppen’s classification; it is featured by high humidity rates, temperature ranging from 23 °C to 33 °C and abundant rainfall throughout the year - the rainiest period is observed between December and May, and the least rainy one takes place between June and November. Relative air humidity reaches 85% and annual rainfall accumulation reaches approximately 2,870 mm (ÁLVARES *et al.*, 2014).

1.2. Experiment conduction

The experiment followed a randomized blocks design, with four treatments and four repetitions. Treatments comprised four Osmocote® doses: T1 (0 $g.dm^{-3}$), T2 (4.1 $g.dm^{-3}$), T3 (8.2 $g.dm^{-3}$) and T4 (12.3 $g.\ dm^{-3}$). *D. excelsa* fruits were collected at the Germplasm Island, in Tucuruí County-PA. Subsequently, they were labeled and taken to the laboratory. After the seed processing procedure was over, lots only comprising mature and healthy seeds were formed.

Seeds were immersed in concentrated sulfuric acid (H_2SO_4), in glass petri dishes, to overcome dormancy; they were constantly stirred with glass rod, for 15 minutes, in order to standardize H_2SO_4's abrasive action. After the pre-established period was over, seeds were washed in running and distilled water for 5 minutes to enable full sulfuric acid removal (BRASIL, 2009).

Seedlings were grown in 290-ml tubes sterilized in vertical steel autoclave chamber (CS-75, Brazil) and filled with substrate comprising vermiculite and coconut fiber (1:1 V/V). They were irrigated every two days throughout the investigated period. Studies were conducted with other Amazonian tree species, under similar conditions (ALMEIDA; SANTIAGO, 2019).

1.3. Assessed parameters

Seedling development was assessed at the 110th experimental day, based on counting the number of leaves and leaflets. Shoot and root length (cm) were measured with the aid of millimeter ruler, from soil level up to plants' apical meristem, and from the end of the primary root to ground level, respectively. Plant height (cm) was based on the sum of seedlings' shoot and root length; stem diameter (mm) was measured with digital caliper.

Shoot length:stem diameter ratio was calculated by dividing shoot length value by stem diameter value; leaf area was measured with the aid of leaf area meter (LI-3100C AREA METER, EUA). After these assessments were over, seedlings were separated into shoot and root system, packed in paper bags and placed in forced ventilation oven, at 65 °C (± 3), until they reached constant weight. Subsequently, they were weighed on analytical scale (model M254AI; 0.0001g accuracy) to find shoot, root and total dry weight ($g.plant^{-1}$).

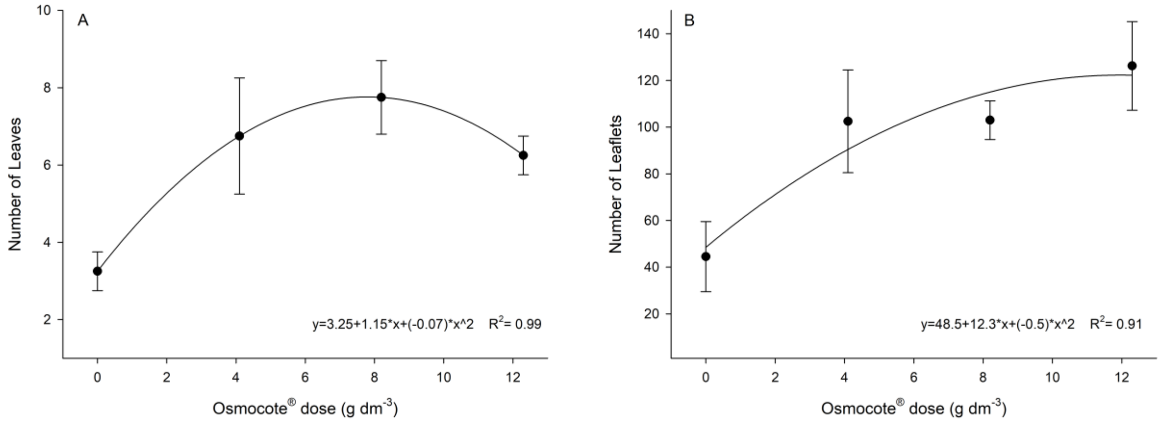
1.4. Statistical analysis

Data were subjected to log-logistic nonlinear regression analysis in Sigmaplot® software (version 13.0 for Windows, Systat Software Inc., Point Richmond, CA, USA).

Results and discussion

The initial development of the investigated species was influenced by the application of increasing controlled-release fertilizer doses. The analysis of variance allowed observing significant effects ($p \leq 0.05$) of OSMOCOTE® fertilizer on *D. excelsa* seedling production. The highest values recorded for parameters, such as number of leaves and number of leaflets, were observed for treatments corresponding to the application of 8.2 $g.dm^{-3}$ and 12.3 $g.dm^{-3}$ of Osmocote®, respectively (Figure 1).

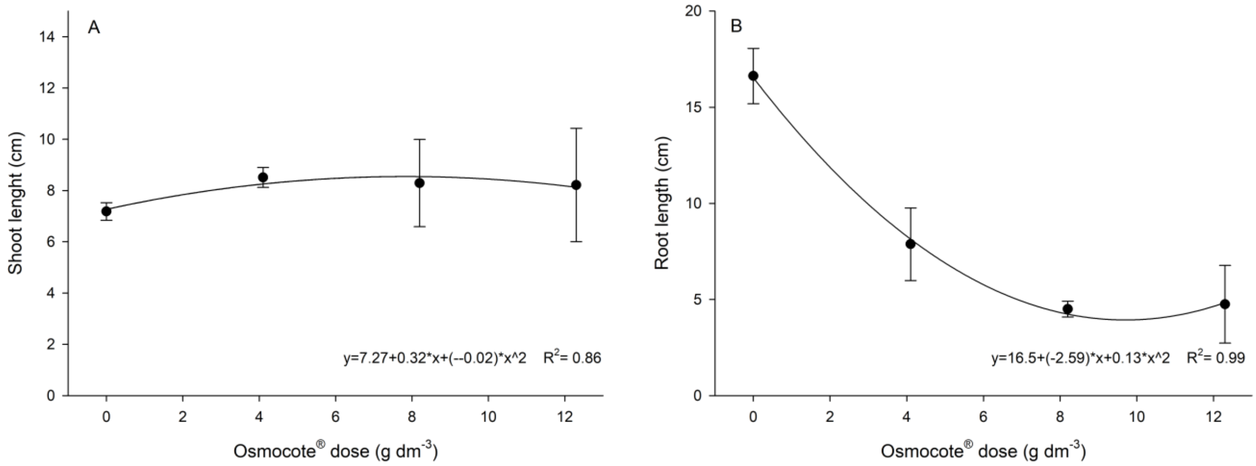
Figure 1. Number of leaves (A) and leaflets (B) in *D. Excelsa* seedlings subjected to OSMOCOTE® application.



This finding can be attributed to the fact that these formulations provide better seedling growth conditions due to nutrient supply on a regular basis, for a longer period-of-time. Thus, they meet the demand from the investigated species and, consequently, favor seedling development (AGUILAR *et al.*, 2020). Osmocote® fertilizer releases nutrients in a controlled manner. It is applied in the form of biodegradable organic resin capsules filled with nutrients. These capsules are subjected to osmotic pressure to enable slow and long-term active nutrient release in order to meet plants' metabolic needs (GIBSON *et al.*, 2019; SANTOS *et al.*, 2020).

On the other hand, this fertilizer may have had negative influence on morphological features, such as root length and there was no significant shoot length increase as fertilizer doses increased (Figure 2).

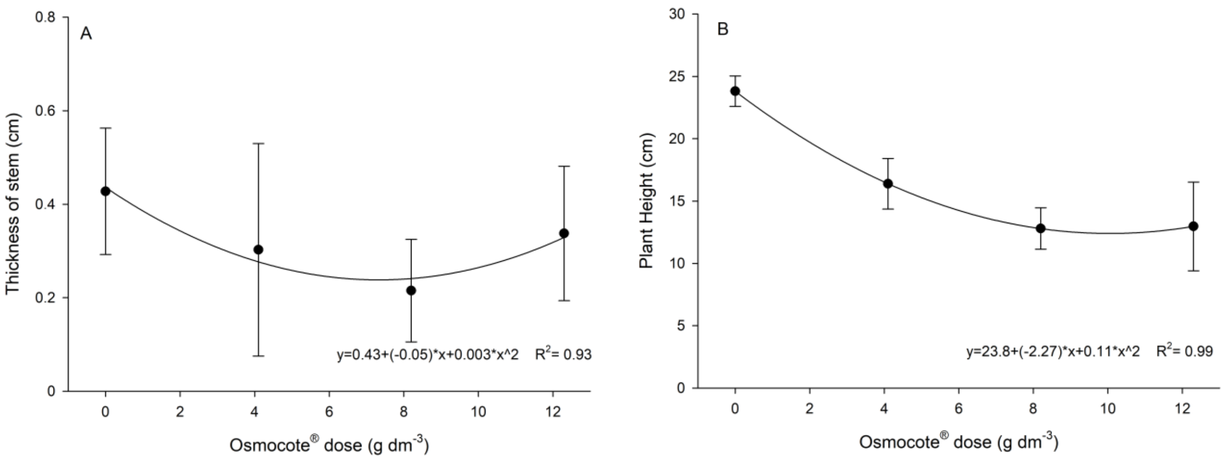
Figure 2. Root (A) and shoot (B) length in *D. excelsa* seedlings subjected to Osmocote® application.



The incidence of salts in the herein used fertilizer may have significantly affected plants' physiological behavior. Studies have shown that reduced plant growth and limited water absorption are the most common effects of salts on plants. This finding can explain the observed reduced transpiration and (consequently) initial seedling growth (DOWNTON *et al.*, 1985; DREW *et al.*, 1990; ELLI *et al.*, 2013).

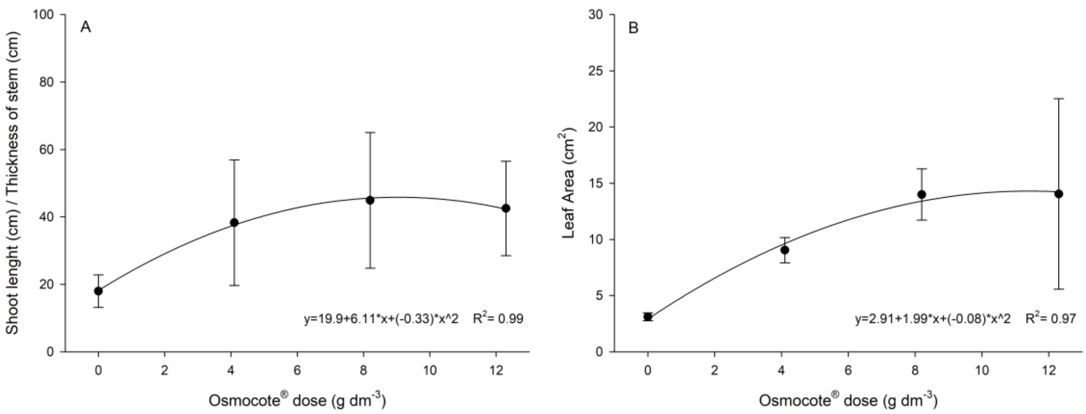
Based on Figure 3, using the controlled-release fertilizer did not increase plant height and stem diameter values in comparison to the control treatment, within the assessed period-of-time.

Figure 3. Thickness of stem (A) and plant height (B) in *D. excelsa* seedlings subjected to Osmocote® application.



Leaf area and shoot length: thickness of stem ratio were influenced by the adopted Osmocote® doses. They recorded increase by approximately 15 cm^2 and 20 cm^2, respectively, in comparison to the control (Figure 4).

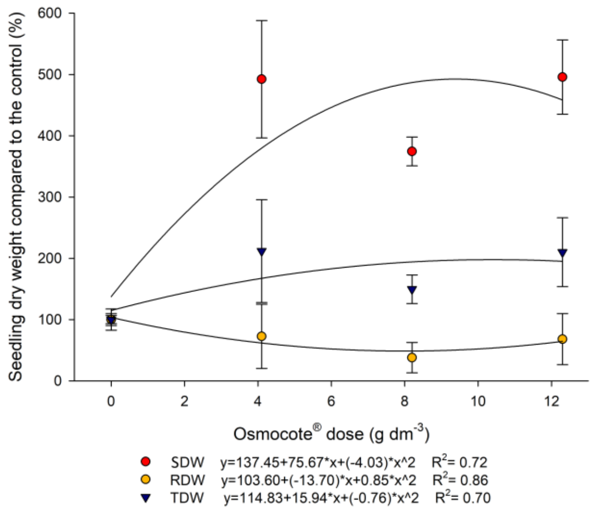
Figure 4. Shoot length: thickness of stem (A) and leaf area (B) in *D. excelsa* seedlings subjected to Osmocote® application.



One of the benefits provided by Osmocote®, in comparison to other fertilizers, lies on its slow nutrient-release mechanism, which allows seedlings to better use these nutrients during their formation process, as well as avoids losses due to leaching and volatilization (ELLI *et al.*, 2013; KATO *et al.*, 2018). Huett (1997) has proved Osmocote®'s efficiency when he noticed that the leaching of nutrients held by this fertilizer was lower than that observed for soluble fertilizers. These fertilizers, in association with high-quality substrate, can help reducing leaching- and volatilization-related losses, as well as shortening seedling formation time. Thus, they can be significantly advantageous for plants' production cycle, in comparison to often-used fertilizers. (STUP *et al.*, 2015).

Biomass accumulation in *D. excelsa* seedlings has changed as Osmocote® doses increased; thus, it presented quadratic behavior (Figure 5). This variable recorded maximum technical efficiency score. The best response observed for variables SDW, RDW and TDW - after fertilizer application - was recorded at doses of 4.1 gdm^{-3} and 12.3 $g.dm^{-3}$.

Figure 5. Biomass accumulation in *D. excelsa* seedlings subjected to Osmocote® application.



Biomass increase after slow-release fertilizer application was associated with nutrient supply to seedlings at proper amounts required at each plant development stage, since nutrient absorption is not constant throughout this cycle (MARANA *et al.*, 2008; KATO *et al.*, 2018). Shoot dry weight indicated rusticity; this variable is directly correlated to seedlings' survival and initial performance after planting, in the field. In addition, total biomass played significant role in plants' performance after they were transferred to the field, since it influenced their water and nutrient carrying and intake ability (ALMEIDA *et al.*, 2005; GOMES; PAIVA, 2006).

Conclusion

D. excelsa seedlings responded well to the use of Osmocote® controlled-release fertilizer. Plants subjected to treatments T2 and T4 (4.1 and 12.3 $g.dm^{-3}$, respectively) recorded the highest growth values and quality standards. Therefore, 4.1 $g.dm^{-3}$ of Osmocote® is the best fertilizer dose to produce *D. excelsa* seedlings, at nursery-permanence period of 110 days, based on mean values recorded for the maximum technical efficiency scores observed for total biomass accumulation, at lower cost.

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