

Controlled-release Fertilizer in the Production and Quality of *Acacia mangium* Seedlings

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ABSTRACT

In order to evaluate the use of controlled-release fertilizer in the production and quality of *Acacia mangium* seedlings, this experiment was conducted in randomized blocks, and treatments consisted of five levels (0, 2.5, 5.0, 7.5 and 10.0 kg m⁻³ of substrate) of Osmocote Plus® in six replicates. After 130 days of sowing, the production and quality variables of *Acacia* seedlings were analyzed. All production and quality variables, height/shoot ratio (HSH) and Dickson quality index (DQI) were influenced by the fertilizer doses. The greatest mean values of stem diameter, total height, shoot dry mass, root dry mass, the best HSH and the highest DQI, were obtained for doses ranging from 7.1 to 7.8 kg m⁻³ of substrate. The largest leaf area was obtained using a dose of 9.3 kg m⁻³ of substrate.

Keywords: fertilization, forest species, nursery.

1. INTRODUCTION

For the Brazilian economy, the increasing consumption of wood from planted forests represents a productive potential that mitigates the pressure exerted on native forests. Thus, exotic species of rapid growth, high production capacity and multiple uses have become viable alternatives in the country's forest sector (IBA, 2016).

Brazilian forestry is currently consolidated by extensive research and investments on *Eucalyptus* and *Pinus* species (Somavilla et al., 2014). However, other exotic species of great productive ability are limited to the little available information regarding the production of seedlings and some silvicultural aspects. This lack of information is because of its recent introduction to the country, in comparison to the aforementioned species, such as the *Acacia mangium* species (Tonini et al., 2010).

Brazil has approximately 160 thousand hectares of area planted with the *Acacia* genus (IBA, 2016). Of these, more than 25 thousand hectares are planted with *A. mangium* in savanna areas of Roraima, with a high prospective for commercially expanding its plantations (Barros et al., 2009). However, investments in genetic improvement, nutritional research and improvement in the productive system are necessary so that the formed forest stands express the true productive capacity of the species and the site.

A. mangium belongs to the Fabaceae family and is an exotic species native from Australia that has adapted to Brazilian soil and climate conditions. It presents relatively rapid growth, low nutritional requirements, tolerance to acid and compacted soils, as well as symbiotic interaction with nitrogen-fixing bacteria and arbuscular mycorrhizal fungi (Rossi et al., 2003; Tonini et al., 2010). Under optimal management conditions, it can present an average annual growth of 45m³ ha⁻¹ year⁻¹, similar to that of eucalyptus (Veiga et al., 2000), reason why it has been considered a promising species for the Brazilian forestry sector, and favoring its expansion to biomes such as the Brazilian Cerrado.

In order to achieve high productivity, attention must be paid to various silvicultural aspects that cover the use of techniques that favor producing good quality seedlings (Ceconi et al., 2007; Brondani et al., 2008). Therefore, allied to a substrate that presents adequate physical and chemical properties for seedlings formation,

soil enrichment with controlled-release fertilizer in adequate doses can reduce the formation time of the seedlings and losses by leaching and volatilization, favoring the use of available nutrients and allowing greater seedling development and quality in the nursery, and consequently reducing the mortality rate of the plants under establishment in the field (Simões et al., 2012; Stüpp et al., 2015; Menegatti et al., 2017).

The use of controlled-release fertilizers is a nutritional contribution technology for forest species (Rossa et al., 2015a). These fertilizers include soluble compounds in their interior (NPK and some micronutrients) surrounded by a semipermeable membrane that, depending on the temperature and humidity of the substrate, dilates and contracts, which causes the release of nutrients to be controlled and made available gradually, thereby maintaining constant levels of the essential elements for the seedlings throughout the growth period (Bennett, 1996; José et al., 2009).

Applying controlled-release fertilizer in *Eucalyptus grandis* seedling production provided better quality standards of seedlings compared to those obtained with the use of conventional fertilizer (Rossa et al., 2015b). For the seedling formation of *Anadenanthera peregrina* and *Schinus terebinthifolius*, Rossa et al. (2015a) verified that application of the controlled-release fertilizer provided significant gains in seedling growth when compared to the unfertilized plants. Somavilla et al. (2014) verified that the use of the same fertilizer provided an increase in all evaluated parameters for the production and quality of *Toona ciliata* seedlings. On the other hand, Stüpp et al. (2015) observed that the doses of controlled-release fertilizer influenced the initial growth of *Mimosa scabrella* seedlings; however, its positive effect was verified only up to a certain dose, and further on from this dose it became negative, verifying that excess of this fertilizer can hinder seedling growth.

Thus, the present study had the objective of evaluating the application of controlled-release fertilizer on the production and quality of *Acacia mangium* seedlings.

2. MATERIAL AND METHODS

The experiment was installed in September 2014 at the Federal University of Mato Grosso do Sul (UFMS) on the Campus of Chapadão do Sul, MS, Brazil, in a

greenhouse with lateral sombrite coating (50%) and humidity controlled by a micro sprinkler irrigation system.

The experimental design was in randomized blocks with five treatments of controlled-release fertilizer (Osmocote Plus® (15-09-12 + micro) with release of 3 to 4 months), at doses 0, 2.5, 5.0, 7.5 and 10 kg m⁻³ of substrate with six replicates. Each parcel consisted of 18 polyethylene bags with 8 × 12 cm dimension and volume 550 cm³ of *A. mangium* seedlings per container. The nutrient concentrations found in the Osmocote are: 15% of N, 9% of P₂O₅, 12% of K₂O, 1.3% of Mg, 5.9% of S, 0.02% of B, 0.05% of Cu, 0.46% of Fe, 0.06% of Mn, 0.02% of Mo and 0.05% of Zn.

A mixture of soil (*Typic Hapludult soil*), sand and cow manure was used as substrate for seedling formation in the volumetric ratio of 2:1:1. Mixing the substrate components as well as homogenizing the fertilizer doses into the substrate was carried out using a concrete mixer for a period of approximately 10 minutes.

Prior to the sowing, *A. mangium* seeds were disinfested with 3% sodium hypochlorite for two minutes. Next, dormancy was interrupted using hot water immersion (100 °C) for one minute. Three seeds were used per container for sowing, and thinning was carried out after the seedlings reached 3 to 4 cm in height, leaving only the most vigorous and central seedling in each container.

After 130 days of sowing, three medium height seedlings were selected per plot, in which the stem diameter (StD) and the total height (TH) were measured using a digital caliper and a graduated ruler, respectively. After evaluation in the nursery, the selected seedlings were then taken to the Forest Engineering Laboratory of the UFMS and sectioned into roots and shoots per sample. The shoot part was separated into stem and leaves, and the leaves were used to determine the leaf area of each tree/sample using a CI-203CA Bioscience leaf area meter. The roots were washed in running water over a sieve and subsequently placed to dry together with the shoot in a forced circulation oven at 65 °C for 48 hours in order to determine the root (RDW) and shoot dry weight (SDW) per seedling. The seedlings' quality was obtained according to: height/diameter ratio (HDR), height/shoot ratio (HSR), shoot/root

ratio (SRR), and the Dickson quality index (DQI) (Dickson et al., 1960).

Data were submitted to analysis of variance and the F test at 5% probability. In cases of significant differences between treatments, polynomial regression analysis was performed where the equations were defined by the F test when they reached a significance level of 5% probability.

3. RESULTS AND DISCUSSION

All seedling production variables analyzed were influenced by the Osmocote Plus® dose tested. Increasing doses of controlled-release fertilizer provided significant increases in stem diameter, total height, leaf area, root dry weight and shoot dry weight compared to the unfertilized *A. mangium* seedlings. However, a reduction in the seedling gain was observed after a specific dose, which varied according to the evaluated parameters.

The best diameter development (2.77 mm) was achieved with the dose of 7.77 kg m⁻³ of substrate, while the smallest diameter (1.87 mm) was observed for unfertilized seedlings (Figure 1a). Thus, the application of this dose corresponded to a 48% increase in seedling diameter. A similar result was observed by Somavilla et al. (2014) using the same fertilizer and formulation (15-09-12) for *Toona ciliata* seedlings, in which the best dose for diameter growth was 7.50 kg m⁻³ of substrate, while the smallest diameters were found for unfertilized seedlings. Diameter is the most relevant parameter among the evaluated variables to indicate seedling quality, since it presents a high degree of relationship with DQI (Binotto, 2007).

The height development of *A. mangium* seedlings had a similar behavior to that of the diameter variable, with the best response being found for the dose of 7.06 kg m⁻³ of substrate (30.41 cm), and with the smallest height (20.55 cm) being observed for the unfertilized seedlings (Figure 1b), representing an increase of approximately 48% in height. These results are similar to the observation made by Rossa et al. (2015a) on the significant gains in seedling height compared to unfertilized plants. In another study comparing conventional fertilization with controlled-release fertilizer, Rossa et al. (2015b) found that all the seedlings of *Eucalyptus grandis* that received doses of controlled-release fertilizer reached higher heights than those that received conventional

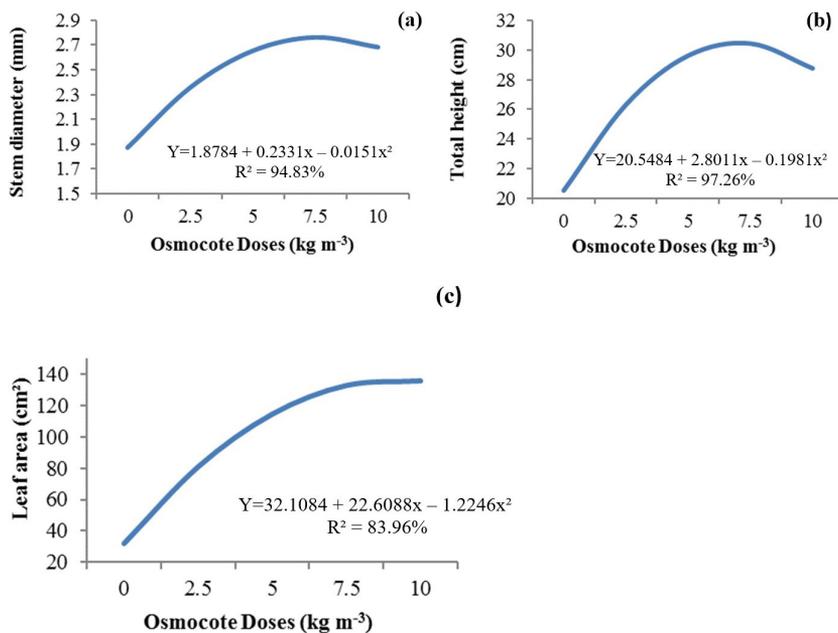


Figure 1. Stem diameter (mm) (a), total height (b), and leaf area (cm²) (c) of *Acacia mangium* regarding the application of controlled-release fertilizer doses.

fertilization, emphasizing the importance of a continuous availability of nutrients during the seedling formation period. This reinforces the observation from Zhang (2007), who emphasizes the use of controlled-release fertilizer for optimizing the usage of the available nutrients through the possible reduction of leaching losses and volatilization, thereby favoring plant growth.

Following the same behavior, the leaf area (cm²) per *A. mangium* seedling increased with the application of increasing doses of Osmocote Plus[®] up to the dose of 9.23 kg m⁻³ of substrate (135.73 cm²) (Figure 1c). Therefore, a greater leaf area value is related to a greater photosynthetic area, propitiating an increase in photoassimilate production for the seedlings, having great importance for the formation of good quality seedlings and for its vigorous establishment in the field (Santos et al., 2014).

It is observed that among the production variables, leaf area (cm²) presented better development in response to the higher level of fertilization 9.23 kg m⁻³ of substrate, differing from the other results obtained ranging from 7.06 to 7.77 kg m⁻³ of substrate. According to Elli et al. (2013), the morphological and physiological characteristics of each organ of the seedlings may comprise a different fertilization level for each one.

For shoot (SDW) and root dry weight (RDW), the use of increasing doses of Osmocote Plus[®] provided increases in the fertilized seedlings' development, reaching the maximum dry mass values of 1.50 g (SDW) and 0.40 g (RDW) with the doses of 7.62 and 7.54 kg m⁻³ of substrate, respectively (Figures 2a and 2b). Somavilla et al. (2014) observed the same behavior for *Toona ciliata* seedlings related to the controlled-release fertilizer dose for this species, where the highest values were obtained using 8.8 kg m⁻³ of substrate for shoot and root dry weight production at 150 days after fertilization.

By analyzing the quality indices of seedlings, we found that doses of 7.52 and 7.78 kg m⁻³ of substrate provided the best results for the HSR and DQI variables, respectively (Figures 3a and 3b). For forest species, Hunt (1990) established that seedling quality indexes (HSR and DQI) should be less than 10 and greater than 0.2, so that the seedlings present good quality and high survival after planting, respectively. However, Binotto (2007) points out that it is necessary to establish tests for DQI calibration for each forest species of interest. Moreover, the same author reports that diameter has a high relation with DQI; thus, doses that allow greater development

in stem diameter of the seedlings will favor better seedling quality. Although the highest DQI value was less than 0.20 in the present study, the dose that provided this value (7.78 kg m⁻³ of substrate) was the same found for the best diameter development (7.77 kg m⁻³ of substrate), thus indicating a good quality standard.

No statistical difference was found for the use of the controlled-release fertilizer for the HDR and SRR variables (Figures 4a and 4b). However, the absence of significant difference should not be seen as a negative factor, since it indicates the occurrence of an efficient dry mass distribution pattern between the seedlings' organs (Dutra et al., 2012).

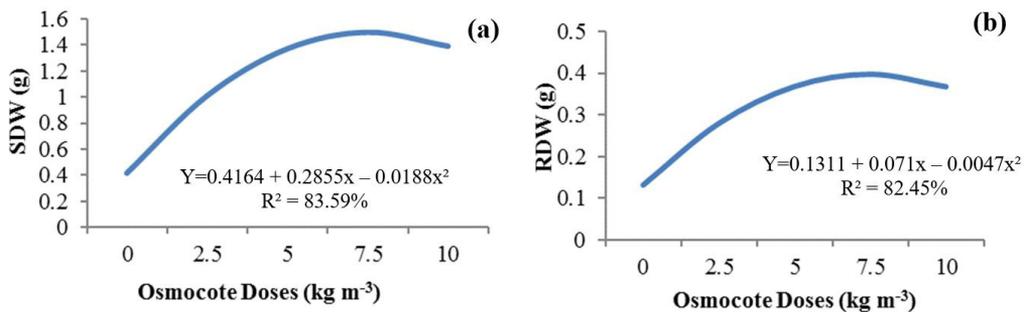


Figure 2. Shoot dry weight (a) and root dry weight (b) of *Acacia mangium* regarding the application of controlled-release fertilizer doses.

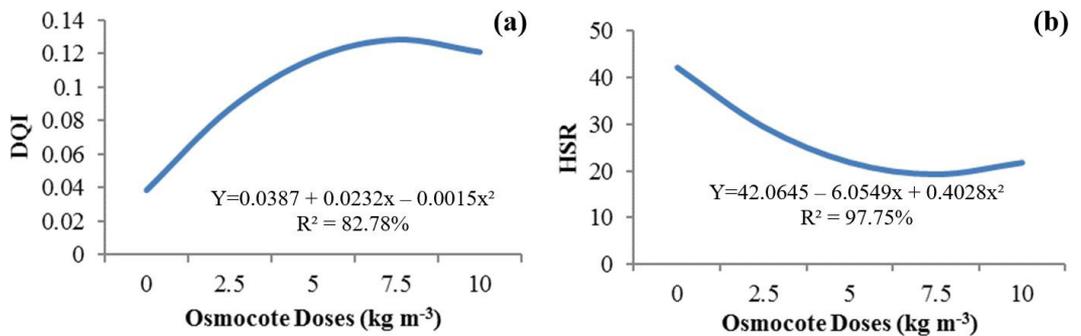


Figure 3. Dickson Quality Index (DQI) (a) and height/shoot dry weight ratio (HSR) (b) of *Acacia mangium* regarding the application of controlled-release fertilizer doses.

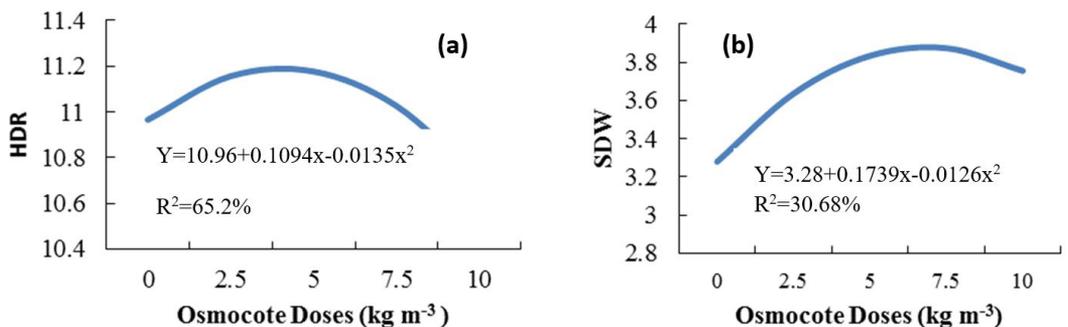


Figure 4. Height/diameter ratio (a) and shoot dry weight ratio (b) of *Acacia mangium* regarding the application of controlled-release fertilizer doses.

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