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Effect of hydrogel doses in the quality of *Corymbia citriodora* Hill & Johnson seedlings

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ABSTRACT: The aim of this study was to evaluate the influence of different hydrogel doses incorporated into the substrate in the production of lemon-scented gum seedlings (*Corymbia citriodora*). The design was entirely randomized with 5 treatments (0, 1, 2, 3 and 4 g L^{-1} hydrogel doses) and 5 repetitions. Therefore, seedlings were produced (via seeds) in 55 cm^3 tubes, with different doses of hydrogel incorporated into the substrate. At 120 days after sowing, the seedlings quality was evaluated by: shoot height, stem diameter, shoot, root and total dry mass and Dickson quality index. The data were submitted to regression analysis of variance for orthogonal polynomials ($\alpha = 0.05$), being selected the corresponding equation for the highest degree of regression that was significant ($p < 0.05$). Only the shoot and total height and dry mass showed significant responses to the hydrogel doses. The intermediate dose (2 g L^{-1}) promoted the best quality to seedlings, providing increments greater than 10% for all variables. Thus, the incorporation of the hydrogel to the substrate contributes to increased growth and quality standard of *Corymbia citriodora* seedlings.

Keywords: hydroretentive polymer, forest-tree nurseries, eucalyptus.

Efeito de doses do hidrogel na qualidade de mudas de *Corymbia citriodora* Hill & Johnson

RESUMO: O objetivo deste estudo foi avaliar a influência de diferentes doses do hidrogel, incorporado ao substrato, na produção de mudas de eucalipto citriodora (*Corymbia citriodora*). Foi considerado o delineamento inteiramente casualizado com 5 tratamentos (0, 1, 2, 3 e 4 g L^{-1} doses do hidrogel) e 5 repetições. Para tanto, foram produzidas mudas (via sementes) em tubetes de 55 cm^3, com diferentes doses do hidrogel incorporado ao substrato. Aos 120 dias após a semeadura, a qualidade das mudas foi avaliada por: altura da parte aérea, diâmetro do coleto, massas secas, da parte aérea, das raízes e total e índice de qualidade de Dickson. Os dados foram submetidos à análise de variância da regressão por polinômios ortogonais ($\alpha = 0{,}05$), sendo selecionada a equação correspondente à regressão de mais alto grau que foi significativa ($p < 0{,}05$). Apenas a altura e as massas secas da parte aérea e total apresentaram respostas significativas às doses do hidrogel. A dose intermediária (2 g L^{-1}) foi a que promoveu melhor qualidade às mudas, proporcionando incrementos superiores a 10% para todas as variáveis analisadas. Dessa forma, a incorporação do hidrogel ao substrato contribui para o maior crescimento e padrão de qualidade de mudas de *Corymbia citriodora*.

Palavras-chave: polímero hidroretentor, viveiros florestais, eucalipto.

1. INTRODUCTION

Eucalyptus, due to its adaptation to different climate and soil conditions and diversification of the use of its wood, has been used in forest plantations, contributing to reduce environmental pressure on native forests. In Brazil, according to the Brazilian Forest Service (SFB, 2015), in 2014, the area of planted forests exceeded 9.3 million ha, especially the eucalyptus species, which represent 74.23% of this total. Among these species, there is the lemon-scented gum (*Corymbia citriodora* (Hook.) K.D.Hill & L.A.S. Johnson), whose cultivation has been expanded in Brazil year after year (MORAIS et al., 2010).

The success of a forest planting depends on the choice of the ideal species for each site, the goal of planting and mainly quality of seedlings to be planted, which in addition to withstand the adverse field conditions, should be able to develop and externalize their growth potential (WENDLING; DUTRA, 2010), which makes replanting an indispensable practice, given the small mortality rate in the field (ROCHA et al., 2013).

The production of seedlings with superior quality is the result of a combination of genetic materials adapted to the planting site and the use of efficient techniques in the production cycle of seedlings in nursery (DAVIDE; FARIA, 2008), which raises demand for the development of technologies that involve reduction of production costs in nurseries and the good performance of seedlings in the field (BERNARDI et al., 2012).

A technique that has recently been used in seedling production is the use of agricultural hydroretentive polymers, also known as hydrogels. It is a synthetic polyacrylamide product with large retention and water storage capacity (AZEVEDO et al., 2002; NAVROSKI et al., 2015a), and when incorporated into the soil, it increases the availability of water and nutrients to the plants, acting as soil conditioners (CAMARA et al., 2011; BERNARDI et al., 2012).

Most studies with hydrogel refers to its use in planting seedlings in the field, both in reforestation, as in the recovery of degraded areas. Recent studies have also shown the beneficial effect of using this product in the substrate for the production of seedlings of certain forest species, such as *Corymbia citriodora* (Bernardi et al, 2012), *Eucalyptus dunnii* (Navroski et al., 2015ab), *Pinus greggii* (MALDONADO-BENITEZ et al., 2011) and *Handroanthus ochraceus* (Mews et al., 2015). In this sense, the present study was conducted to evaluate the influence of different hydrogel doses incorporated into the substrate in the production of *Corymbia citriodora* seedlings.

2. MATERIAL AND METHODS

2.1. Study location

The experiment was conducted in the period from June to October (dry season) 2013, in the *Via Verde Florestal* nursery, located in the coordinates 16º12'31" S and 48º44'26" W, in the town of Abadiania, State of Goias, Brazil. The climate, according to Koppen classification, is Aw, characterized by having a well-defined dry season (five to seven months) and a wet season, with rains and annual precipitation ranging from 1300 to 2000 mm. The average temperatures oscillate from 22 to 26° C.

2.2. Seedlings production system

The seedlings were grown in 55 cm³ conical plastic tubes, filled with Agroflox Trimix commercial substrate®. This substrate is composed of vermiculite, carbonized rice hulls, and coconut fiber (1:1:1) and has 90-170 kg m^{-3} density, particles with diameters between 0.15 and 8.0 mm and a minimum capacity of 60% water retention. Prior to filling the tubes, researchers incorporated into the substrate the basis fertilization (1.0 kg of Yoorin Master 1 + 0.5 kg of Super simple phosphate + 4 L of the syrup of the mixture of nutrients (MAP, potassium chloride, Yoorin Mg, ammonium sulfate, magnesium sulfate, boric acid, manganese sulfate, copper sulfate, zinc sulfate, sodium molybdate and ferrilene for each100 L of substrate) and different doses of the forth Gel® hydrogel (copolymer of potassium polyacrylate), in its dry form.

Three to five *Corymbia citriodora* seeds per pot were seeded. The trays containing the tubes were placed in a greenhouse with 50% shading, with three daily irrigations through micro-sprinklers, remaining under these conditions for 30 days, time needed for germination to become uniform. After this period, manually thinning was performed so as to keep only one seedling per tube, the stronger and most centralized. Soon after, they were transferred to the growth area in full sun, in screen suspended benches. At this stage, irrigation was made by sprinklers with empirically determined daily irrigation depth, based on temperature, relative humidity and intensity of the winds. During the experiment, rain gauges were used, which found that the water depth ranged from 12 to 20 mm per day. Coverage fertilization was performed every 15 days, in full sun, according to what is adopted in the nursery. The amount applied was 10 L of nutrient solution to each 1536 tubes. The growth fertilizer formulation was: 2.0 Kg of MAP, 0.5 kg of KCl, 2.8 kg of single superphosphate, 0.8 kg of ammonium sulfate, 30.0 g of magnesium sulfate, 40.0 g of boric acid, 10.0 g of copper sulfate, 30 g of zinc sulfate and 20.0 g of ferrilene for 1,000 L of water. Seedlings remained under these conditions until 120 days after sowing, when their growth and quality were evaluated.

2.3. Evaluation of growth and quality of seedlings

The quality of the seedlings under different hydrogel doses was evaluated using the variables: shoot height (H, in cm), stem diameter (D, in mm), shoot dry mass (SDM), root dry mass (RDM) and total dry mass (TDM) and the Dickson quality index (DQI = TDM/(H/D+SDM/RDM)) (DICKSON et al., 1960). The shoot height was obtained with the aid of a ruler, measuring from the lower of the seedling to the apical bud. The stem diameter was measured with the aid of a digital caliper with a precision of 0.01 mm, in the height of the substrate. The dry mass weights were determined after washing the root to remove the substrate, and seedlings were sectioned at the height of the stem, to separate the root system from the shoot, with subsequent drying in an oven at 75 ° C until obtaining a constant dry mass by weighing in analytical balance with a precision of 0.001 g (BÖHM, 1979).

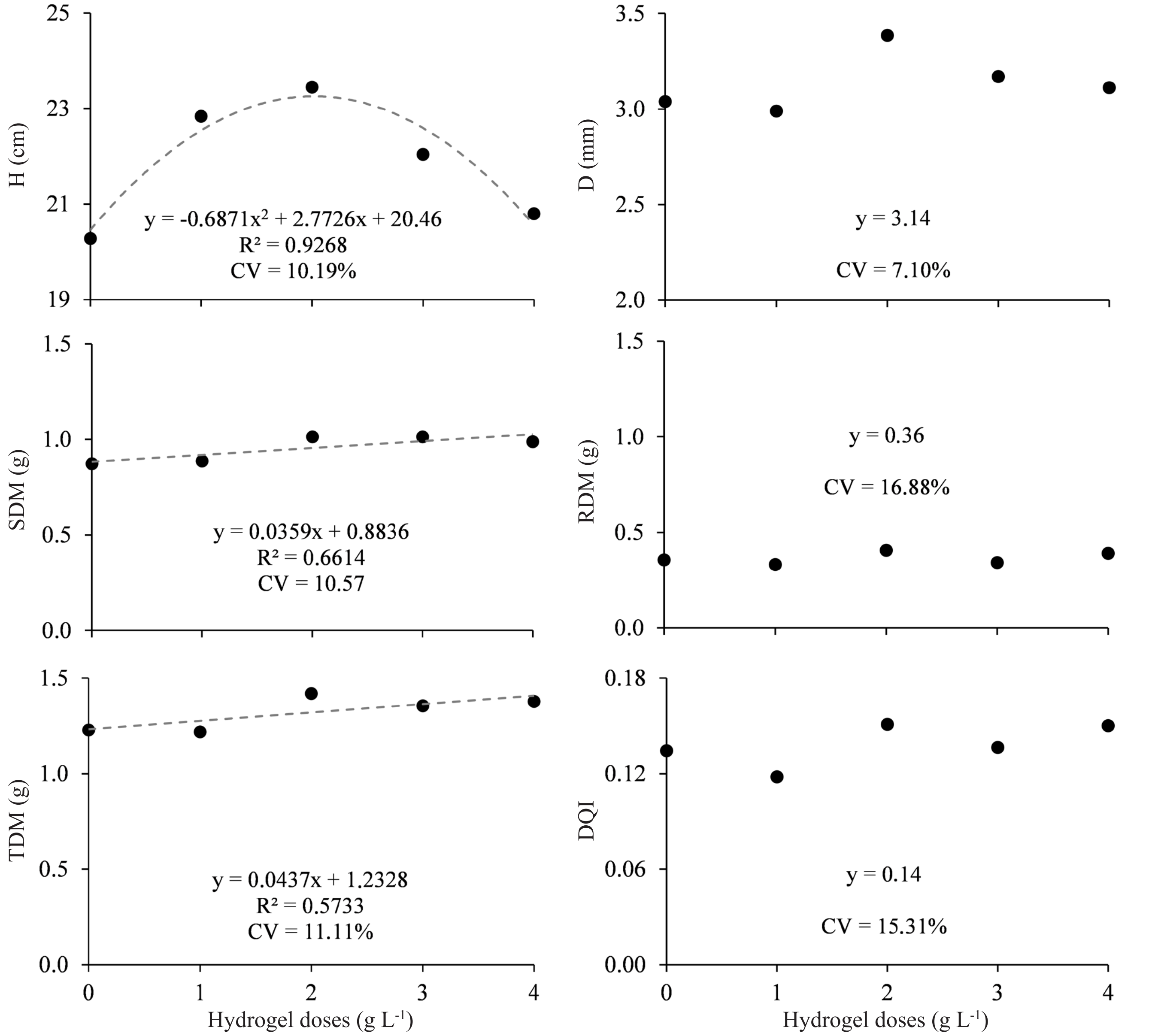
It was used a completely randomized design with 5 treatments (hydrogel doses: 0, 1, 2, 3 and 4 g of hydrogel per liter of substrate) with five replications composed of 10 seedlings each, totaling 250 seedlings. After verifying the homogeneity and normality, data were submitted to regression analysis of variance of orthogonal polynomials ($\alpha = 0.05$), and the corresponding equation to the highest grade regression which was significant was selected ($p < 0.05$). Analyses were performed using the Assistat 7.7 beta software (SILVA; AZEVEDO, 2002). Complementarily, the relative difference between treatments that used hydrogel and the control treatment (without hydrogel) was evaluated.

3. RESULTS AND DISCUSSION

The variables showed different responses as for the hydrogel doses incorporated into the substrate (Figure 1). The use of hydrogel provided a significant effect on the variables H ($p = 0.0179$), DSM ($p = 0.0205$) and TDM ($P = 0.0481$), whereas for D ($p = 0.0858$), RDM ($p = 0.2998$) and DQI ($p = 0.1207$) this effect was not verified.

The variable H showed quadratic behavior, with the point of culmination estimated at dose of 2 g L^{-1}, and from this dose, the values tended to decrease; it is worthy highlighing out that the maximum dose provided similar values to the control treatment. Nevertheless, SDM and TDM showed increasing linear behavior, having their values increased as the hydrogel doses increased.

When evaluating the relative difference between treatments with hydrogel and the control treatment (without hydrogel) (Figure 2), it appears that the dose of 2 g L^{-1} provided the best performance for all variables, with increases above 10%, including those in which the significant effect of using hydrogel has not been verified. The variables that had the greatest



Where: H = shoot height, D = stem diameter; SDM = shoot dry mass; RDM = root dry mass; TDM = total dry mass; DQI = Dickson quality index; and CV = Coefficient of variation. Points represent the averages and lines represent the estimated values by the regression.

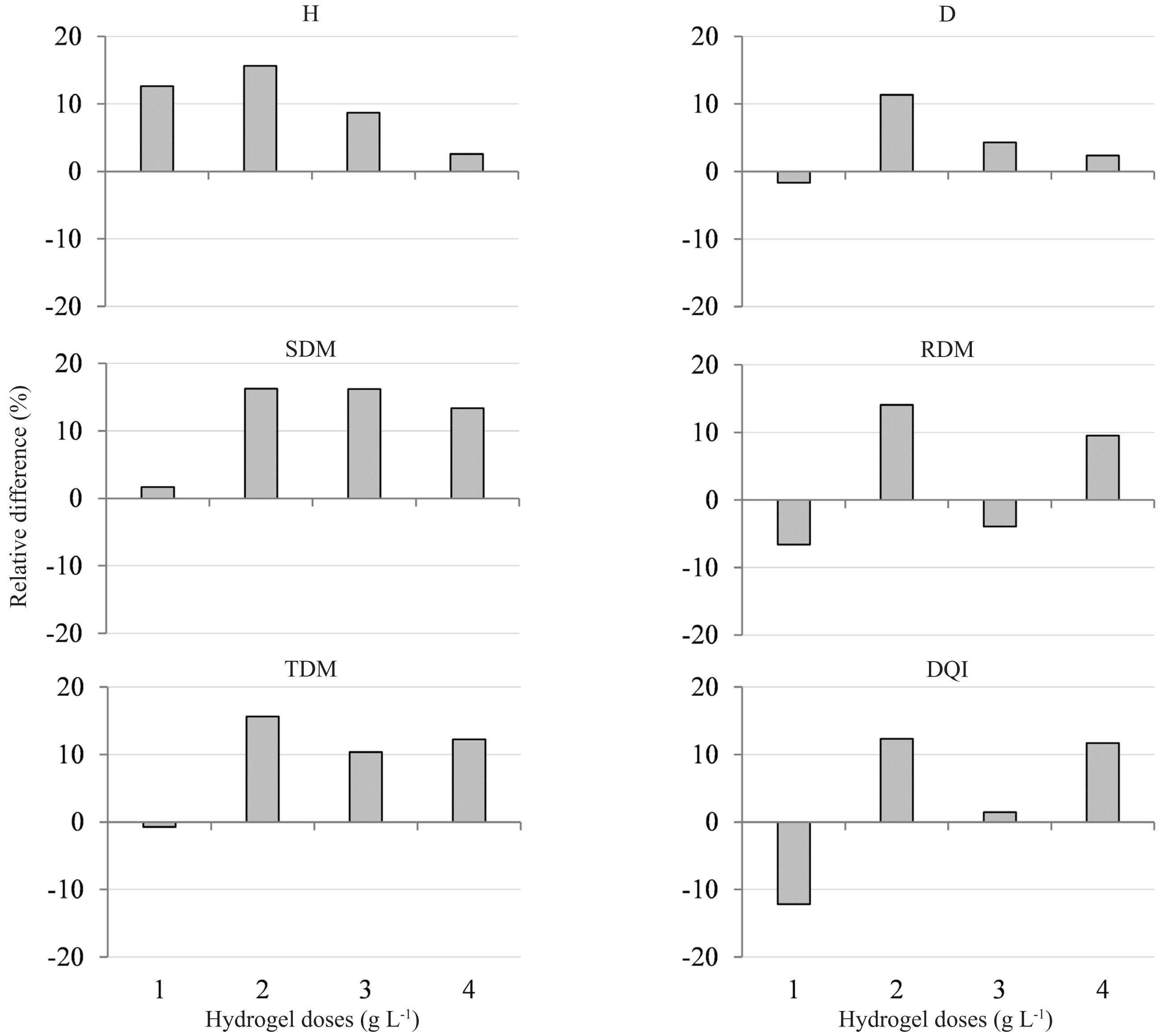
Figure 1. Variables behavior for different hydrogel doses in *Corymbia citridiodora* seedlings 120 days after sowing.

Figura 1. Comportamento das variáveis em relação às diferentes doses do hidrogel em mudas de *Corymbia citridiodora*, 120 dias após a semeadura.

influence of this treatment were H (15.63%), SDM (16.24%) and TDM (15.62%).

The results of this study corroborate with other studies in the literature, in which the hydrogel provided greater development and quality of seedlings of different tree species. Bernardi et al. (2012) evaluated the growth of lemon-scented gum seedlings (*Corymbia citriodora*) as for to the use of hydrogel (0 and 6 g L^{-1}) and fertilizer doses, and they found a positive effect with the use of hydrogel (increase of 22.99% for shoot height and 23.12% for the diameter), compared to seedlings produced without the addition of the product, in the same fertilization. These authors also found that the use of this product allows a reduction of at least 20% of routine fertilization, used by the merchantable nursery. Besides, Navroski et al. (2015a) observed increased content of macronutrients in the shoots of eucalyptus (*Eucalyptus dunnii*) seedlings (stem + leaves) after the addition of hydrogel. In turn, Navroski et al. (2015b) observed a reduction in irrigation with the incorporation of hydrogel to the substrate (3 g L^{-1}) in the production of *Eucalyptus dunnii* seedlings.

However, Navroski et al. (2015b) warn that the use of higher irrigation water can dispense with the use of hydrogel, as in this case its presence may adversely influence the quality of the seedlings due to the excessive amount of water in the substrate. Furthermore, it is important to note that the use of excessive doses of hydrogel may also affect the nutritional status of the seedlings, since it alters the pH of the substrate and thus affects the absorption of some micronutrients, reducing their development (BERNARDI et al. 2012; NAVROSKI et al, 2015a). Although Sousa et al. (2013) have not found differences in relation to the parameters related to the shoot of 'angico vermelho' (*Anadenanthera peregrina*) seedlings produced with different doses of hydrogel (0 to 8 g L^{-1}), they have found that doses greater than 4 g L^{-1} have negatively influenced the root dry mass and total dry mass,



Where: H = shoot height, D = stem diameter; SDM = shoot dry mass; RDM = root dry mass; TDM = total dry mass; and DQI = Dickson quality index.

Figure 2. Relative difference of the averages of the variables in relation to the control group (without hydrogel).

Figura 2. Diferença relativa das médias das variáveis em relação ao tratamento controle (sem hidrogel)

affecting the formation of the root system and hence the quality of the seedlings.

The results of this study indicate that the use of hydrogel in the production of *C. citriodora* seedlings is promising because it contributes to the further growth and improves the quality of seedlings produced. The bigger growth of seedlings produced with the intermediate dose 2 g L^{-1} of hydrogel may be related to lower water deficit suffered by seedlings. Once irrigation is performed empirically and based on the response of plants to environmental conditions, the use of hydrogel allows greater water retention on the substrate, optimizing irrigation and reducing the effects of drought.

4. CONCLUSIONS

The incorporation of hydrogel to the substrate at a dose of 2 g L^{-1} contributes to the further growth and quality standard of *C. citriodora* seedlings.

It is important to note that the effects of the hydrogel use may vary according to the particular needs of each species or genetic material and management practices adopted by forest nurseries.

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