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Use of a water-retaining polymer in the cultivation substrate of palmito-juçara (*Euterpe edulis Mart.*)

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ABSTRACT

Over the years, the natural landscape of Atlantic forest has undergone significant changes. Inventories carried out by the Fundação SOS Mata Atlântica and by the National Institute for Space Research (SOS Mata Atlântica and INPE, 2017), showed that 83.7% of the São Paulo territory initially covered by this biome has already been transformed into pasture, monoculture and other uses. This intensive exploration resulted in extensive degraded areas, resulting from abandonment after the loss of the productive capacity of the soil. For the recovery of physical and chemical characteristics and the reduction of soil loss due to erosive processes, forest species are planted. During planting and in the first weeks of plant growth, the lack or excess of water can limit development. In this case, an alternative used is to add water-retaining polymers to the soil that have the ability to increase water retention. This study evaluated the effect on the growth of Palmito-Juçara (Euterpe edulis Mart) seedlings of different doses of water-retaining polymer incorporated into the growing substrate, with watering on five consecutive days and with alternating watering for a period of three months in a nursery. The experiment started when the seedlings presented 220 days after sowing. The juçara plants were grown in plastic bags filled with 850 g of substrate composed of a mixture of peat, carbonized rice husk, horse manure, chicken manure, tanned bovine manure, mineral fertilizer and dolomitic limestone. To study the effect of the hydro-retaining polymer, the following doses of a polyacrylic potassium copolymer were added to the dry substrate: D0 = without adding the polymer to the substrate (control); D2 = 2g of polymer; D3 = 3 g of polymer; D4 = 4 g of polymer; and, D5 = 5 g of polymer. Each dose was combined with two irrigation regimes, watering for five consecutive days or alternating, in a 5 x 2 factorial arrangement, with 15 repetitions, totaling 150 experimental plots in a randomized block design. The transplanting of the seedlings to the bags took place in April 2019 and every 30 consecutive days, five individuals were collected from each dose and each type of irrigation (50 experimental plots / collection), that is, 3 collections (250 days, 280 days and 310 days after sowing). In each collection, the length of the leaves and the root system, the diameter of the stem, the height of the plant, the dry mass of the aerial part, the dry mass of the root and the total dry mass were measured. After checking the normality of the data and the homoscedasticity of the variances, analyses of variances were performed (ANOVA, $p < 0.05$) and the differences between the means were compared using the Tukey test ($p < 0.05$). The analysis of the results showed significant differences between the irrigations, with greater growth for the variables of leaf length, stem diameter, plant height and dry mass of the aerial part in the initial period of development of juçara plants. In the condition of irrigation in five consecutive days, the highlight was for dose D3 and, in alternate watering, for dose D5.

Keywords: cultivation substrate, *Euterpe edulis* Mart, water-retaining polymer.

Uso de polímero hidroretentor no substrato de cultivo do palmito juçara (*Euterpe edulis* Mart.)

RESUMO

Ao longo dos anos, a mata atlântica vem sofrendo significativas alterações da paisagem natural. Inventários realizados pela Fundação SOS Mata Atlântica e pelo Instituto Nacional de Pesquisas Espaciais (SOS Mata Atlântica and INPE, 2017), apontaram que 83,7% do território paulista inicialmente coberto por esse bioma já foi transformado em pastagens, monocultura e outros usos. Essa intensiva exploração resultou em extensas áreas degradadas, decorrentes do abandono após a perda da capacidade produtiva do solo. Para a recuperação das características físicas e químicas e da diminuição da perda de solo por processos erosivos, realiza-se o plantio de espécies florestais. Durante a realização do plantio e nas primeiras semanas de crescimento das plantas, a falta ou o excesso de água podem limitar seu desenvolvimento. Neste caso, uma alternativa utilizada consiste em adicionar ao solo polímeros hidroretentores que tem a capacidade de elevar a retenção de água. O objetivo geral deste estudo foi avaliar o efeito de diferentes doses de polímero hidroretentor incorporadas ao substrato de cultivo com regas diárias e alternadas no crescimento de mudas de Palmito-Juçara (*Euterpe edulis* Mart.) por um período de 3 meses em viveiro. O experimento teve início quando as mudas apresentaram 220 dias pós-semeadura. As plantas de juçara foram cultivadas em sacos plásticos preenchidos com 850 g de substrato composto por uma mistura de turfa, casca de arroz carbonizada, esterco de cavalo, esterco de galinha, esterco bovino curtido, fertilizante mineral e calcário dolomítico. Para o estudo do efeito do polímero hidroetentor, foram adicionadas ao substrato seco as seguintes doses de um copolímero poliacrílico de potássio: D0 = sem adição do polímero ao substrato (testemunha), D2 = 2 g de polímero, D3 = 3 g de polímero, D4 = 4 g de polímero e D5 = 5 g de polímero. Cada dose foi combinada a dois regimes de irrigação, rega diária ou alternada, em um arranjo fatorial 5 x 2, com 15 repetições, totalizando 150 parcelas experimentais em um delineamento em blocos casualizados. O transplantio das mudas para os sacos aconteceu em abril de 2019 e a cada 30 dias consecutivos se realizou a coleta de cinco indivíduos de cada dose e de cada tipo de rega (50 parcelas experimentais/coleta), ou seja, 3 coletas (250 dias, 280 dias e aos 310 dias pós-semeadura). Em cada coleta foram realizadas as medidas do comprimento das folhas e do sistema radicular, do diâmetro do caule, da altura da planta, da massa seca da parte aérea, da massa seca da raiz e da massa seca total. Verificada a normalidade dos dados e a homocedasticidade das variâncias foram realizadas as análises das variâncias (ANOVA, $p<0,05$) e as diferenças entre as médias foram comparadas pelo teste de Tukey ($p<0,05$). As análise dos resultados evidenciaram diferenças significativas entre as regas com maior crescimento para as variáveis comprimento das folhas, diâmetro do caule, altura da planta e massa seca da parte aérea no período inicial de desenvolvimento das plantas de juçara, sendo que na condição de rega diária, o destaque foi para a dose D3 e, na rega alternada, foi para a dose D5.

Palavras-chave: *Euterpe edulis* Mart, polímero hidroretentor, substrato de cultivo.

1. INTRODUCTION

Over the years, the natural landscape of Atlantic forest has undergone significant changes in. Inventories carried out in 2016 by the Fundação SOS Mata Atlântica and the National Institute for Space Research (INPE) show that 83.7% of the São Paulo territory initially covered by this biome has already been transformed into pasture, monoculture and other uses.

This intensive exploration resulted in extensive degraded areas, resulting from abandonment after the loss of the productive capacity of the soil or from improper management. For the recovery of physical and chemical characteristics and the reduction of soil loss through erosive processes, forest species are planted (Silva *et al.*, 2011).

In the state of São Paulo, all methods of intentional human intervention in degraded ecosystems that aim to facilitate the natural process of ecological succession must use native species, either by total planting or interspersed with woody, perennial or exotic long-cycle species. In short, native species are those that occur within their natural range (São Paulo, 2014).

Forest restoration aims to recover and/or preserve areas impacted by man-made damage to ecosystems, aiming to recreate sustainable communities and restore stability and natural biological integrity. A biodiversity crisis represents the biggest challenge that humans have ever faced; however, conservation biology in the short term and restoration ecology in the long term form the basis of a late attempt to mitigate this disaster (Engel and Parrota, 2003; Young, 2000).

Forest restoration is very costly, so the search for less expensive alternatives is important. As stated by Barbosa *et al.* (2013), it is possible to reduce costs with the use of seedlings in containers of different sizes, such as tubes that optimize the transport of species, enabling and encouraging the restoration processes in degraded areas with the use of native species.

For this reason, there has been a growing need for the production of forest seedlings at reduced costs that resist environmental adversities in the field, with the success of planting depending on factors such as variations in soil attributes and supplying the water needs of plants. During planting, and in the first weeks of plant growth, the lack or excess of water can limit development. (Bernardi *et al.*, 2012; Buzetto *et al.*, 2002; Amaro Filho *et al.*, 2007; Dranski *et al.*, 2013).

It is also difficult to find seedlings of various native species in nurseries, which affects the propagation of those species and their use in restoring forest areas (Fonseca *et al.*, 2017).

In this case, an alternative that has been used is to add to the soil products, such as hydro-absorbent polymers (hydrogels), that have the ability to increase water retention in the soil (Vale *et al.*, 2006).

This can be seen in the results of Fonseca *et al.* (2017), who demonstrated that planting seedlings of native species with hydrogel in the driest season of the year showed a 15% lower mortality than those seedlings planted without the use of the polymer.

Knowledge of the benefits of using polymers in the development of a native plant species of the Atlantic Forest biome, more specifically the Palmito-Juçara (*Euterpe edulis* Mart.), will facilitate large-scale application, perhaps meeting the growing demand for forest species for reforestation projects the water requirements of plants. This would in turn reduce the frequency of irrigation and increase the resistance of seedlings in the field during the dry season.

Thus, this study evaluated the effect of different doses of water-retaining polymer incorporated into the growing substrate with irrigation for five consecutive days and with alternating irrigation on the growth of Palmito-Juçara (*Euterpe edulis* Mart.) seedlings, for a period of 3 months in a nursery.

The specific objectives were to evaluate the growth of Palmito-Juçara seedlings (*Euterpe edulis* Mart.) subjected to different doses of water-retaining polymer and different irrigation, in order to analyze whether these factors influence the growth of the seedlings.

2. MATERIALS AND METHODS

2.1. Characterization of the study area.

The experiment was carried out in the screened greenhouse of Viveiro Manacá, a nursery specialized in native forest seedlings of the Atlantic forest, located at Rodovia Floriano Rodrigues Pinheiro, km 06 in Taubaté-SP, with geographical coordinates 23º0'30.86'' S and 45º38'22,93'' O.

According to the Köppen classification, the region's climate is tropical in altitude, with dry winters and hot, rainy summers. The average annual temperature is 21.7°C, varying between 15.6°C and 27.8°C, with an average annual rainfall of 1,347.6 mm (CEPAGRI, 2018).

The municipality of Taubaté is in the Atlantic Forest biome, with its original vegetation cover consisting of Secondary Seasonal Semi-deciduous Forest, Ombrophilous Dense Forest, Savanna and, to a greater extent, Secondary Vegetation of Ombrophilous Dense Forest (Cohidro, 2014; Instituto Florestal, 2010).

Located in the Paraíba do Sul River Basin, in addition to the Paraíba do Sul River, the territory of Taubaté has as main water bodies the rivers Una and Itaim (Cohidro, 2014).

As for the pedological formation, Taubaté has its central region located on Red-Yellow Argisol and its north and south regions located on Red-Yellow Latosol (IAC, 2018).

2.2. Species selection and seedling production

The choice of the Palmito-Juçara plant species (*Euterpe edulis* Mart.) considered the growth cycle factors and the commercial and environmental importance of this plant for the ecosystem. The seedlings were donated by Viveiro Manacá, together with the Municipality of Taubaté.

According to information provided by the nurseryman, the seeds that originated the seedlings were harvested directly from bunches of several pre-selected healthy matrices randomly distributed among natural populations in the municipality of Tremembé (SP), and were not just from a single plant.

The harvested bunches completed their ripening, and the fruits were subsequently detached from the bunches and scarified or, as popularly known, pulped. This process consisted of rubbing the fruits with the palm of the hand against grains of sand, leaving only the seeds ready for sowing.

The seeds were soaked in water and then placed over an area of the nursery covered with shade canvas for a week. After some time, the seeds were again immersed in water at room temperature, where they remained for twelve hours with an hourly water change, in order to avoid fermentation.

When ready, the seeds were sown with a proper seeder in the nursery at a depth of approximately 2 to 3 centimeters. After 23 days, the seedlings were transplanted, being placed in rigid polyethylene tubes with volumetric capacity of about 290 cm^3 and stored in plastic trays suspended 90 cm from the ground.

2.3. Experimental assembly and design

The experiment started when the seedlings presented 220 days after sowing. During this period, the seedlings were irrigated for five consecutive days by sprinkling in two fractions of 20 minutes, except on rainy days. The transplanting of the tubes into the bags with substrate took place in April 2019 and seedling growth was monitored over the subsequent three months until July 2019.

The substrate used was composed of a mixture with amounts of approximately 20 kg peat, 10 kg of carbonized rice husk with horse manure, 5 kg of tanned bovine manure, 0.2 kg of mineral fertilizer (simple superphosphate, 18% P_2O_5 and 10-12% S) and 0.4 kg of dolomitic limestone.

After proportioning in accordance with the common use of the nursery, the mixture was left to rest for twenty days, being moistened with water before use.

For transplanting, polyethylene packages (black bags) were used for seedlings of 9 cm x

20 cm, which were filled homogeneously with 850 g of moist substrate.

The hydro-absorbent polymer used in the experiment was the branched Potassium Polyacrylic Copolymer (trademark FORTH ®), available in agricultural houses or at large resellers of agricultural products.

The polymer was mixed with the substrate in doses of 0 g, 2 g, 3 g, 4 g and 5 g, that is:

- D0 = 850 g of substrate (control)
- D2 = 2 g polymer + 850 g substrate
- D3 = 3 g of polymer + 850 g of substrate
- D4 = 4 g of polymer + 850 g of substrate
- D5 = 5 g polymer + 850 g substrate

Such doses were selected according to the manufacturer's recommendation for using the product, and when it was found that doses greater than 5 grams expel part of the substrate from the planting package.

The seedlings were transplanted from the tube to the packages filled with the moist substrate and water-retaining polymer, placing one plant per package that was identified according to the number of the planting sequence and the dose used.

Each dose was combined with two irrigation regimes, watering for five consecutive days or alternating watering, in a 5 x 2 factorial arrangement, with 15 repetitions, totaling 150 experimental plots in a randomized block design.

Seedling irrigation was carried out by sprinkling in two fractions of 20 minutes and occurred in two ways: watering for five consecutive days or alternating, except for rainy days.

Watering was carried out only on weekdays, with watering for five consecutive days occurring from Monday to Friday and alternating watering consisting of alternating one-day shifts, that is, on three days of the week (Monday, Wednesday and Friday).

To avoid the influence of excessive lighting, the seedlings were placed in the greenhouse at Viveiro Manacá, which is covered with a shade screen and produces a shading level of approximately 50%, not avoiding the influence of rain.

2.4. Studied variables

The study variables of Euterpe edulis Mart. were leaf length (CF), root system length (CR), stem diameter (DC), plant height (HP), shoot dry matter (MSPA), root dry mass (MSR) and total dry mass (MST).

The length of the leaves, as well as the length of the roots and the height of the plant, were measured using a measuring tape graduated in centimeters. The stem diameter, in turn, was determined using a digital caliper with an accuracy of 0.01 cm. The dry matter masses were determined after washing the parts of the plant that were dried in an oven for 72 hours at a temperature regulated at 70°C (Gomes *et al.*, 2002).

The evaluations of the variables were carried out monthly, that is, at 250, 280 and 310 days after sowing, with the collection of 5 individuals of each dose and each type of irrigation, totaling 50 seedlings evaluated per collection.

For each collection performed, the species that were still alive were counted and the dead species, with dry leaves or without leaves, were discarded.

The number of species in mortality was noted to monitor the survival rate throughout the experiment.

2.5. Statistical design and analysis

For each variable, a previous assessment of data normality, independence of errors and homoscedasticity was carried out, and subsequent analysis of variance, ANOVA ($p < 0.05$). The differences between the means were compared by the Tukey test at the level of 5% of significance, considering the doses of polymer D0, D2, D3, D4 and D5, the age of the plant (250, 280 and 310 days after sowing) and the irrigation regime (5 consecutive days). The analyses were performed using the software "Statistical Analysis System" (SAS) through its "General Linear Models Procedure" (PROC GLM).

3. RESULTS AND DISCUSSION

In addition to the analyses carried out with the surviving seedlings, five dead plants were counted and discarded in the first month of collection, four of which referred to irrigation for five consecutive days and doses 2 g (D2 - number 07), 3 g (D3 - number 07), 4 g (D4 - number 01) and 5 g (D5 - number 14); and only one referred to alternate irrigation and dose 4 g (D4 - number 13). It is noted that there was no pattern in the deaths.

The following table illustrates results that showed significance considering polymer doses D0, D2, D3, D4 and D5, plant age at 250, 280 and 310 days after sowing and the five consecutive days or alternate irrigation regime (Table 1).

Table 1. Summary of the results of the analysis of variance and the TuKey Test with 95% confidence level.

Condition	Diameter	Length		Height	Dry mass		
	Stalk (DC)	Sheets (CF)	Roots (CR)	Plants (HP)	Aerial part (MSPA)	Root (MSR)	Total (MST)
Plant age	280	280	-	280	280	250	250
Polymer dose	3	3	-	3	3	2	2
Irrigation regime	5D irrigation	5D irrigation	-	5D irrigation	5D irrigation	Alternating irrigation	Alternating irrigation

Source: Autor, 2020.

The results of stem diameter (DC), leaves (CF) and plant height (HP), as well as for dry shoot weight (MSPA) in the period of 280 days post-germination with irrigation on five consecutive days and doses of 3g of water-retaining polymer mixed with the growing substrate of Palmito-Juçara seedlings (Euterpe edulis Mart.) pointed out significant effects for the different irrigation and polymer doses, as well as for the interaction between these factors (irrigation x dose).

It was observed, that even with lower numbers than those reached by irrigation on five consecutive days with doses of 3g of polymer, in the same period of 280 days, the alternate irrigation showed a steady and gradual growth of the stem diameter (DC), of the leaves (CF) and plant height (HP), as well as for the dry mass of the aerial part (MSPA), reaching the highest value in the dose of 5g of water-retaining polymer.

Although in the root factor (CR) the analysis did not show significant differences for the irrigation and polymer doses, or the occurrence of interaction between them, it was noted that for the period of 250 days, the alternate irrigation had a positive influence on the dry mass of the root (MSR). This may indicate that the large availability of water influenced the low growth of the roots.

Analyzing the total dry mass (MST), it was observed that in the period of 250 days alternating irrigation showed the best growth, while at 280 days, irrigation for five consecutive days was highlighted.

It is interesting to note that in the 310-day period, none of the variables tested, namely leaf length (CF) and root length (CR), stem diameter (DC), plant height (HP), dry mass of the aerial part (MSPA), dry root weight (MSR) and total dry weight (MST) showed the Palmito-Juçara seedlings (Euterpe edulis Mart.) performed well, thus showing an evolution in the periods of 250 and 280 days and a decay in the 310 days.

There are studies like the one by Marques *et al.* (2013), which found benefits in the use of hydrogel in coffee trees, and that of Santos *et al.* (2015), which found that hydrogel positively increases the probability of success in planting lettuce; however, based on the results of this experiment, it is possible to find similarity with the planting of Euterpe edulis only up to the period of 250 days, which showed significant evolution of stem diameter (DC), leaves (CF) and plant height (HP) using polymer.

In the case of tree forest species, Fonseca *et al.* (2017) demonstrated in their studies that seedlings of native species of Tapirira guianensis Aubl., Genipa americana L., Cedrela fissilis Vell., Hymeneae courbaril L., Handroanthus serratifolius (AH Gentry) S. Grose and Inga cylindrica (Vell.) Mart. planted with hydrogel in the driest season of the year presented a 15% lower mortality than seedlings planted without the use of the polymer.

According to Marques *et al.* (2013), the dry mass of aerial part by dry mass of root was higher in irrigated treatments. Comparing with the results of these experiments, it can be concluded that, although the dry root mass (MSR) has been positively influenced in alternate irrigation, there was no significant difference in the dry mass ratio of aerial part to dry mass of root in the treatments carried out with Euterpe edulis.

For Navroski *et al.* (2016), the residence time of Eucalyptus dunnii seedlings in nurseries can be reduced by applying doses between 2 and 4 g.L-1 of hydrogel to the substrate, due to the product's ability to increase growth and seedling quality. The same recommendation can be seen in this experiment involving Euterpe edulis in which significant differences were found in the evolution of seedlings up to the 250-day post-germination period.

Likewise Azevedo (2014) concluded that the hydride retention polymer incorporated into the substrate in the production of clonal seedlings of Eucalyptus spp allows to optimize the use of water in a forest nursery. Compared with this work, the results showed that it is possible to optimize the use of water for planting Euterpe edulis by means of alternate irrigation, in the period of 280 days post-germination and use of the 5g dose of water-retaining polymer.

According to Mews (2014), the seedlings of Handroanthus ochraceus, H. impetiginosus and Myracrodruon urundeuva were positively influenced by the growth and the quality of the plants due to the use of different doses of the hydro-absorbent polymer associated with the nitrogen top dressing, which differs from the present research, which did not use fertilization, and the statistical analysis showed significant differences in the evolution of Euterpe edulis seedlings only in stem diameter (DC), leaves (CF) and plant height (HP) up to 280 days post-germination.

Regarding the species survival rate, Bogarim (2014) concluded that the use of hydrogel in planting native seedlings of Cambuí-Amarelo (Myrciaria floribunda), Jenipapo (Genipa americana) and Jatobá (Hymenaea courbaril var. Stilbocarpa) is viable because it retains the water necessary for plants in the period of scarcity. In comparison to this research, the five deaths occurred in the first month of collection and all referred to some hydrogel treatment (D2, D3, D4, D5 - irrigation for five consecutive days and D4 - alternate irrigation), and subsequently, the plants were subjected to different irrigation periods and there was no further loss.

In the study of the effects of the water-retaining polymer associated or not with organic matter when planting in a field of coffee seedlings cultivar Catuaí (Vale *et al.*, 2006), it is concluded that in the evaluations of stem diameter, plant height, number of branches plagiotropic and number of nodes in the plagiotropic branches, the planting systems had a significant effect; however, the doses of organic matter and polymer did not affect the initial development of the plants. This result is similar to that obtained in the present study, since the evaluations of the evolution of stem diameter (DC), leaves (CF) and plant height (HP) up to the period of 280 days post-germination using irrigation in five consecutive days showed significant differences in treatments with doses of 3g of water-retaining polymer.

According to Borelli (2016), the evaluation of the effect of doses of water-retaining polymer on the productivity and quality of the irrigated radish crop showed a significant response regarding the number of leaves, root diameter, length of the aerial part and the root, fresh weight and dry weight of the aerial part and the root, and an absence of influence only on the pH parameter. This result differs from the present study with regard to the root length, as no significant differences were found in the evolution of this factor for *Euterpe edulis* seedlings with the use of the water-retaining polymer; however, a positive influence was noted in the period of 250 days with alternate watering in the dry root mass (MSR).

A result similar to that obtained by the present study in the 310-day post-germination period was observed in the evaluation of the survival rate and the initial growth of thirty native tree species in containers with three distinct volumes with and without the use of hydrogel in planting (Barbosa, 2011) which concluded that the polymer did not interfere in the establishment or growth of seedlings in the different treatments.

4. CONCLUSIONS

It is concluded that the use of different doses of the hydro-absorbent polymer incorporated into the substrate and associated with alternating irrigation for five consecutive days presents significant differences in the seedlings of *Euterpe edulis* Mart. in nursery conditions.

The greatest growth for the variables leaf length (CF), stem diameter (DC), plant height (HP) and shoot dry mass (MSPA) was observed in the period of 280 days post-germination, in the condition of irrigation for five consecutive days. The highlight was the dose D3 of water-retaining polymer and, in alternate irrigation, it was the dose D5.

With this, it is possible to obtain results similar to *Euterpe edulis* Mart seedlings. with 12 months growth in just 9 months of development, in addition to achieving a 40% reduction in water consumption, saving time and water.

5. REFERENCES

AMARO FILHO, J. *et al.* Amostragem e variabilidade espacial de atributos físicos de um latossolo vermelho em Mossoró, RN. **Revista Brasileira de Ciência do Solo**, v. 31, p. 415-422, 2007. http://dx.doi.org/10.1590/S0100-06832007000300001

AZEVEDO, G. T. de O. S. **Produção de mudas clonais de Eucalyptus Spp. com polímero hidroretentor incorporado ao substrato**. 2014. 60f. Dissertação (Mestrado em Ciências Florestais) – Universidade de Brasília, Brasília, 2014.

BARBOSA, T. C.; RODRIGUES, R. R.; COUTO, H. T. Z. Tamanhos de recipientes e o uso de hidrogel no estabelecimento de mudas de espécies florestais nativas. **Hoehnea**, v. 40, n. 3, p. 537-556, 2013. https://doi.org/10.1590/S2236-89062013000300013

BARBOSA, T. C. **Tamanhos de recipientes e o uso de hidrogel no estabelecimento de mudas de espécies florestais nativas**. 2011. Dissertação (Mestrado em Ciências) – Universidade de São Paulo, São Paulo, 2011.

BERNARDI, M. R. *et al.* Crescimento de mudas de E. Corymbia citriodora em função do uso de hidrogel e adubação. **Cerne**, v. 18, n. 1, p. 67-74, 2012. https://doi.org/10.1590/S0104-77602012000100009

BOGARIM, E. P. A. **Uso de hidrogel no desenvolvimento de espécies nativas, visando aplicação em áreas degradas**. 2014. 48 f. Dissertação (Mestrado em Ciência e Tecnologia Ambiental) - Universidade Federal da Grande Dourados, Dourados, 2014.

BORELLI, A. B. **Aplicação de polímero hidroretentor na cultura do rabanete irrigado via gotejamento superficial e subsuperficial**. 2016. 51 f. Tese (Doutorado em Produção vegetal) - Universidade Federal de Grande Dourados, Dourados, 2016.

BUZETTO, F. A.; BIZON, J. M. C.; SEIXAS, F. Avaliação de polímero adsorvente à base de acrilamida no fornecimento de água para mudas de Eucalyptus urophylla em pós-plantio. **Circular Técnica IPEF**, n. 195, 2002.

CENTRO DE PESQUISAS METEOROLÓGICAS E CLIMÁTICAS APLICADAS À AGRICULTURA. **Clima dos municípios paulistas**: Taubaté. Available at: https://www.cpa.unicamp.br/outras-informacoes/clima-dos-municipios-paulistas.html Access: 17 May 2018.

CHAIMSOHN, F. P.; CHIQUETTO, N. C. Construção do marco legal para a produção de açaí de juçara: contribuições da “Oficina interestadual sobre legislação, comercialização e marketing para exploração de frutos da palmeira juçara”. **Revista Conexão UEPG**, v. 9, n. 2, p. 244-253, 2013.

CHU, E. Y.; DUARTE, M. L. R.; TREMACOLD, C. R. **Uso da Casca de Arroz Carbonizada como Substrato para Micorrização de Mudas de Três Cultivares de Pimenteira-do-Reino**. Belém: Embrapa, 2007. 18 p.

CONSULTORIA, ESTUDOS E PROJETOS LTDA; ASSOCIAÇÃO PRÓ-GESTÃO DAS ÁGUAS DA BACIA HIDROGRÁFICA DO RIO PARAÍBA DO SUL. **Plano integrado de recursos hídricos da bacia hidrográfica do rio Paraíba do Sul e planos de ação de recursos hídricos das bacias afluentes**. São Paulo, 2014.

DEAN, W. **A ferro e fogo**: a história e a devastação da Mata Atlântica brasileira. São Paulo: Companhia das Letras, 1996.

DRANSKI, J. A. L. *et al.* Sobrevivência e crescimento do pinhão-manso em função do método de aplicação e formulações de hidrogel. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 17, n. 5, p. 537–542, 2013. http://dx.doi.org/10.1590/S1415-43662013000500011

ENGEL, V. L.; PARROTA, J.A. Definindo a restauração ecológica: tendências e perspectivas mundiais. *In*: KAGEYAMA, P. Y.; OLIVEIRA, R. E.; MORAES, L. F. D.; ENGEL, V. L.; GANDARA, F. B. (Ed.). **Restauração ecológica de ecossistemas naturais**. Botucatu: FEPAF, 2003. Cap. 1. p. 3-26.

FADINI, R. F.; FLEURY, M.; DONATTI C. I.; GALETTI M. Effects of frugivore impoverishment and seed predators on the recruitment of a keystone palm. **Acta Oecologica**, v. 35, n. 2, p. 188-196, 2009. https://doi.org/10.1016/j.actao.2008.10.001

FONSECA, A. A.; BACKES, A. R.; ROSENFIELD, M. F.; OVERBECK, G. E.; MÜLLER, S. C. Avaliação da regeneração natural em área de restauração ecológica e mata ciliar de referência. **Ciência Florestal**, v. 27, n. 2, p. 521-534, 2017. https://doi.org/10.5902/1980509827733

FONSECA, L. *et al.* Viabilidade do Hidrogel na Recuperação de Cerrado sensu stricto com Espécies Nativas. **Floresta e Ambiente**, v. 24, n. e20160227, 2017. https://doi.org/10.1590/2179-8087.022716

FUNDAÇÃO SOS MATA ATLÂNTICA; INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS. **Atlas dos remanescentes florestais da mata atlântica – período 2015-2016**. São Paulo, 2017.

GOMES, J. M.; COUTO L.; LEITE, H. G.; XAVIER, A.; GARCIA, S. L. R. Padrões morfológicos na avaliação da qualidade de mudas de Eucalyptus grandis. **Revista Árvore**, v. 26, n. 6, 2002. https://doi.org/10.1590/S0100-67622002000600002 INSTITUTO AGRONOMICO (SP). **Solos do estado de São Paulo**. 2018. Available at: http://www.iac.sp.gov.br/solossp/ Access: 26 May 2018.

INSTITUTO FLORESTAL (SP). **Inventário Florestal da Vegetação Natural do Estado de São Paulo**. 2010. Available at: http://www.iflorestal.sp.gov.br/sifesp/inventario.html Access: 13 May 2018.

MARQUES, P. A. A.; CRIPA, M. A. M.; MARTINEZ, E. H. Hidrogel como substituto da irrigação complementar em viveiro telado de mudas de cafeeiro. **Ciência Rural**, v. 43, n. 1, p. 1-7, 2013. https://doi.org/10.1590/S0103-84782012005000129

MEWS, C. L. **Crescimento de mudas de espécies arbóreas nativas em viveiro em função da incorporação de polímero hidroretentor ao substrato e adubação nitrogenada**. 2014. 66f. Dissertação (Mestrado em Ciências Florestais) - Departamento de Engenharia Florestal, Universidade de Brasília, Brasília, 2014.

NAVROSKI, M. C. **Hidrogel como condicionador de substrato para produção de mudas de Eucalyptus dunnii Maiden**. 2013. 224 f. Tese (Doutorado em Recursos Florestais e Engenharia Florestal) - Universidade Federal de Santa Maria, Santa Maria, 2013.

SÃO PAULO (Estado). Secretaria do Meio Ambiente. Resolução SMA de n° 32, de 03 de abril de 2014. Estabelece as orientações, diretrizes e critérios sobre restauração ecológica no Estado de São Paulo, e dá providências correlatas. **Diário Oficial [do] Estado de São Paulo**, seção I, p. 36-37, 05 Apr. 2014.

SÃO PAULO (Estado). Secretaria Meio Ambiente; FUNDAÇÃO PARA CONSERVAÇÃO E A PRODUÇÃO FLORESTAL DO ESTADO DE SÃO PAULO. **Restauração Florestal**: da semente a muda. São Paulo: SMA, 2004.

SANTOS, H. T. dos *et al.* Cultivo de alface em solos com hidrogel utilizando irrigação automatizada. **Engenharia Agrícola**, v. 35, n. 5, p. 852-862, 2015. http://dx.doi.org/10.1590/1809-4430-eng.agric.v35n5p852-862/2015

SILVA, A. H.; PEREIRA, J. S.; RODRIGUES, S. C. Desenvolvimento inicial de espécies exóticas e nativas e necessidade de calagem em área degradada do Cerrado no triângulo mineiro (Minas Gerais, Brasil). **Agronomia Colombiana**, v. 29, n. 2, p. 287-292, 2011.

SILVA, A. L. B. B.; SILVA, E. O. da. **Conhecendo Materiais Poliméricos**. Cuiabá: Universidade Federal de Mato Grosso/Grupo de Pesquisa em Novos Materiais, 2003.

SILVEIRA, E. R.; DURIGAN, G. Recuperação de matas ciliares: estrutura da floresta e regeneração natural aos dez anos em diferentes modelos de plantio na Fazenda Canaçu, Tarumã, SP. *In*: VILAS BOAS, O.; DURIGAN, G. (Orgs.). **Pesquisas em conservação e recuperação ambiental no Oeste Paulista**: resultados da cooperação Brasil/Japão. São Paulo: Páginas & Letras, 2004. p. 325-347.

VALE, G. F. R.; CARVALHO, S. P.; PAIVA, L. C. Avaliação da eficiência de polímeros hidroretentores no desenvolvimento do cafeeiro em pós-plantio. **Coffee Science**, v. 1, n. 1, p. 7-13, 2006.

YOUNG, T. P. Restoration ecology and conservation biology. **Biological Conservation**, v. 92, 2000. https://doi.org/10.1016/S0006-3207(99)00057-9