Revista
ÁRVORE
ISSN 1806 – 9088

Scientific Article

CUTTING OF *Eucalyptus camaldulensis* TREE AIMING VEGETATIVE RESCUE OF SELECTED GENOTYPES IN SEMIARID CONDITIONS

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ABSTRACT

Eucalyptus camaldulensis is suitable for cultivation in semiarid conditions due to its resistance to long periods of water deficit. Considering their excellent silvicultural performance, the selected genotypes will represent an excellent alternative for future plantings in drought conditions. However, cloning superior genotypes is accomplished by vegetative propagation of mature trees and requires juvenile or rejuvenated material for rooting. The objective of this work was to evaluate the cutting of *Eucalyptus camaldulensis* aiming vegetative rescue of selected genotypes in semiarid conditions, through the action of the auxins IBA (indole-3-ylbutyric acid) and IAA (indoleacetic acid) in the adventitious rooting of cuttings. The four genotypes were selected at five years old. The trees were cut down 20 cm above the ground at the beginning of the rainy season. The experiments were conducted in 2022, adopting the experimental design in randomized blocks. In the first collection of shoots, the influence of IBA was evaluated. In the second collection, the impact of IAA on rooting was evaluated at concentrations of 0 (control), 2000, and 6000 mg.L^{-1}. The survival of the stump was 100%, producing an average of 30 shoots in the first collection and 40 shoots in the second collection. In the shoots from the second collection, this rate was higher than 50%, with emphasis on the G4 genotype with 80% of rooting. The auxins IAA and IBA contributed little to the increase in rooting (between 12% and 7%, respectively). The genotypes showed a higher percentage of adventitious rooting and a lower percentage of oxidation in the propagules from the second collection. Genotypes conducted in environments with water deficit produce propagules with lower rooting rates, increasing with the improvement of water conditions in the environment where the coppicing is conducted.

Keywords: Vegetative propagation; Auxins; Coppicing; Clonal forestry

How to cite:
Costa, L. J. da, Silveira, G. V. dos S., Silva, C., Scatolino, M. V., & Araujo, P. C. D. (2024). Cutting of *Eucalyptus camaldulensis* tree aiming vegetative rescue of selected genotypes in semiarid conditions. *Revista Árvore, 48*(1). https://doi.org/10.53661/1806-9088202448263769

Revista ÁRVORE
ISSN 1806 – 9088

ESTAQUIA DE ÁRVORES DE *Eucalyptus camaldulensis* VISANDO O RESGATE VEGETATIVO DE GENÓTIPOS SELECIONADOS EM CONDIÇÕES SEMIÁRIDAS

RESUMO – *Eucalyptus camaldulensis* apresenta aptidão para cultivo em condições semiáridas, por sua resistência a longos períodos de déficit hídrico. Levando em consideração o seu ótimo desempenho silvicultural, os genótipos selecionados certamente representarão uma excelente alternativa para futuros plantios em condições de seca. Contudo, a clonagem de genótipos superiores é realizada pela propagação vegetativa de árvores maduras, e requer material juvenil ou rejuvenescido para enraizamento. O objetivo deste trabalho foi avaliar a estaquia de *Eucalyptus camaldulensis* com vistas o resgate vegetativo de genótipos selecionados em região semiárida, testando a ação das auxinas AIB (ácido indol-3-ilbutírico) e AIA (ácido indolacético) no enraizamento adventício das estacas. Os quatro genótipos foram selecionados aos cinco anos. A decepa das árvores foi realizada a 20 cm acima do solo, no início do período chuvoso. Os experimentos foram conduzidos no ano de 2022, adotando-se o delinemaneto experimental em blocos ao acaso. Na primeira coleta das brotações, avaliou-se a influência do AIB e na segunda coleta avaliou-se a influência do AIA no enraizamento, nas concentrações de 0 (controle), 2.000 e 6.000 mg.L-1. A sobrevivência das cepas foi de 100%, produzindo em média 30 brotações na primeira coleta e 40 brotações na segunda coleta. Nas brotações da segunda coleta esse índice foi superior a 50%, com destaque para o genótipo G4 com 80% de enraizamento. As auxinas AIA e AIB pouco contribuíram para o aumento do enraizamento (entre 12% e 7%, respectivamente). Em todos os genótipos foi observado maior percentual de enraizamento adventício e menor percentual de oxidação nos propágulos da segunda coleta. Genótipos conduzidos em ambientes com déficit hídrico produzem propágulos com menores índices de enraizamento, havendo incremento com a melhoria das condições hídricas do ambiente de condução das cepas.

Palavras-Chave: Propagação vegetativa; Auxinas; Decepa; Silvicultura clonal

1. INTRODUCTION

Exploiting native woody forest species to meet the demand for wood products has increasing pressure on the vegetation of Brazilian biomes. The Caatinga biome supplies 80% of the market for firewood and charcoal in the semiarid region (IBGE, 2020; Figueiredo, 2018; Silva et al., 2021).

The production of wood from commercial forests in the Northeast region is mainly limited to eucalyptus plantations located, with representation, in the South of Bahia and Maranhão (IBA, 2020). There is a need to select genotypes adapted to high temperature and water deficit conditions, accentuated by global warming and planting in regions with thermal and water stress (Langstroff et al., 2021). Among the species with adaptive and productive potential for these production conditions, *Eucalyptus camaldulensis* stands out (Moraes et al., 2007).

Eucalyptus camaldulensis is a species that demonstrates adaptability to semiarid regions due to its resistance to long periods of water deficit (Moraes et al., 2007; Costa et al., 2015; Vijayaraghavan & Sivakumar, 2017), being propagated through cuttings (Nair et al., 2021; Muthulakshmi et al., 2021), mini-cuttings (Bindumadhava et al., 2011), and micropropagation (Rani & Raina, 1998; Shanthi et al., 2015; Avelar et al, 2020).

Cutting is considered one of the main techniques used in the vegetative propagation of forest species of the eucalyptus in clonal forestry, being a method used for commercial purposes. The vegetative propagation of forest species by cuttings has been limited by a series of factors, such as the lack of efficient methods for rejuvenating adult material, techniques for managing the propagation environment, presence of oxidizing phenolic compounds, genotype of the propagule donor plant, phycological and nutritional condition of the vegetative propagule donor plant (Dias et al., 2015; Stuepp et al., 2015a; Zem et al., 2015; Pereira & Peres, 2016).

The cutting technique associated with the vegetative rescue of adult matrices in the field contributes to the multiplication of superior trees within forest genetic improvement programs (Badilla, Xavier & Murillo, 2016; Avelar et al, 2020; Santos Junior et al., 2021; Souza et al., 2022). Among the techniques for the vegetative rescue of matrices, the induction of epicormic shoots through coppicing the matrix plant has been widely used for the cloning and multiplication of selected genotypes (Avelar et al, 2020; Lima et al., 2020; Engel et al ., 2019; Badilla, Xavier & Murillo, 2016; Dias et al., 2015). This technique is used to reinvigorate vegetative propagules with better physiological quality and use younger propagules for adventitious rooting (Almeida, Xavier & Dias, 2007; Teleginski et al., 2018; Pereira et al., 2017). Vigorous and more juvenile propagules are more conducive to adventitious rooting, favoring the production of seedlings using the cutting technique (Souza et al., 2022).

The cutting rooting process involves three phases: induction, initiation, and expression of histogenesis (Ilczuc & Jacygrad, 2016; Pacurar, Perrone & Bellini, 2014; Zhang et al., 2017). Factors that affect the rooting of woody cuttings include growth regulators, substrate, storage of cuttings, health, age of the mother plant, youthfulness, and environmental conditions, such as temperature, humidity, and light (Pio et al., 2005; Xavier, Wendling & Silva, 2013; Bernardes et al., 2020; Barbosa et al., 2020). Endogenous factors interfere with the success of adventitious rooting, with auxin essential for root induction and initiation (Gomes et al., 2022; Nascimento et al., 2022). Different auxins, such as IBA (indole-3-ylbutyric acid) and IAA (indoleacetic acid), have been tested to verify their role in inducing adventitious rooting (Sousa et al., 2024).

Given the above, this work aimed to evaluate the cutting of *Eucalyptus camaldulensis* trees for vegetative rescue of selected genotypes in semiarid conditions, testing the IBA and IAA auxins in the adventitious rooting of cuttings.

2. MATERIAL AND METHODS

2.1 Experimental material

Eucalyptus camaldulensis matrices trees were rescued on the experimental farm belonging to the Federal University of Semi-arid Region (UFERSA) in Mossoró, Rio Grande do Norte, Brazil. The region has a climate classification, according to Köppen, of the BSwh' type (Borges et al., 2015), characterized as dry and very hot, with an annual average precipitation of 788 mm and an average temperature of 28°C, concentrated between February and May. In this sense, the trees were cut down (coppicing) in February, at the beginning of the rainy season. *Eucalyptus camaldulensis* trees were selected in a 5-year species test, considering survival and growth in height and diameter. After selecting the trees, crowning took place 15 days before cutting, in a radius of 50 cm around the selected matrices, and was carried out by manual weeding, thus avoiding weed competition. Next, 200 g of NPK 10-30-12 was applied to the projection of the tree canopy (Dias, 2015).

2.2 Vegetative rescue of *Eucalyptus camaldulensis* matrices

The matrices were rescued by cutting down (coppicing) four trees 20 cm above the ground with an automatic saw (Figure 1A). After 40 days of cutting, the epicormic shoots originating from the stumps were collected (Figure 1B), and cuttings were subsequently made to evaluate adventitious rooting. The number of shoots was quantified in collections at 40 (first collection) and 80 (second collection) days after cutting down the adult trees.

2.3 Vegetative propagation by cuttings

After 40 and 80 days of cutting down the trees, the shoots were collected in the morning and stored in Styrofoam boxes containing water at room temperature (26 ºC). The shoots were taken to the UFERSA Forest Biotechnology Laboratory. The cuttings were made 10 cm high, with a 75% reduction in leaf area, keeping 2 pairs of leaves on the cuttings. The propagules were distributed in tubes of 55 cm³ filled with the commercial substrate Carolina Soil® (peat, vermiculite, limestone, retention capacity of 315% m/m, electrical conductivity: 1.0 mS/cm, dry density: 145 kg /m³, pH: 5.50, maximum humidity: 60% m/m). With shoots collected 40 days after cutting, the influence of IBA on the rooting of propagules was evaluated (experiment 1). On the other hand, with the shoots collected 80 days after cutting, the effect of IAA was tested (experiment 2). The cuttings had their bases (2 cm) immersed for 10 s in IBA or IAA solution at concentrations of 0 (control, distilled water), 2000, and 6000 mg.L^{-1}, in the liquid formulation, dissolved in hydroxide of potassium (KOH) at 1 mol.L^{-1} and diluted in deionized distilled water. The cuttings were transferred to a climate-controlled greenhouse,

Figure 1. Vegetative rescue of *Eucalyptus camaldulensis*: A) stump; and B) shoots after 40 days of cutting. Source: Author

Figura 1. Resgate vegetativo de *Eucalyptus camaldulensis*: A) cepa; e B) brotações após 40 dias da decepa. Fonte: Autor

with a temperature between 26 ºC and 30 ºC and humidity above 80%. Thirty days after staking, the following were evaluated: percentage of propagule oxidation, percentage of base swelling, percentage of cuttings with calluses, average root size (larger than 0.5 cm), rooting rate, average number of roots, and average survival.

2.4 Statistical analysis

The experimental design used for the two experiments was completely randomized blocks, arranged in a 4 x 3 factorial scheme (4 genotypes: G1, G2, G3 and G4; and three doses of IBA or IAA: 0, 2000 and 6000 mg L^{-1}), in three replications and ten cuttings per plot. The data were submitted to tests for homogeneity (Breusch-Pagan) and normality (Shapiro-Wilk) of variances, then evaluated by analysis of variance (ANOVA). The averages were compared using the Tukey test at a 5% probability level. For all analyses, the statistical software Sisvar 5.6 (Ferreira, 2014) was employed.

3. RESULTS

The variance analysis conducted revealed significant interaction ($p < 0.05$) between genotypes and propagules collection after 40 (collection 1) and 80 (collection 2) days of coppicing. In general, cutting down the trees induced the emission of shoots in all genotypes (Figure 2). To evaluate the number of shoots in the different genotypes, two collections of shoots were carried out on the tree stumps. Genotypes G1 and G3 presented the lowest average number of shoots in collection 1, producing 30 shoots. However, genotypes G2 and G4 in the first collection showed superior results, above 40 sprouts per stump. In the second collection of shoots, there was no statistical difference between the genotypes ($p>0.05$); each genotype presented an average of more than 40 shoots per strain. At the same time, comparing the production of propagules of the stumps between the two collections, genotypes G1, G2, and G4 showed greater shoot production in collection 2. However, genotype G2 did not reveal a significant difference in shoot production in the two collections.

To analyse the influence of the different types of auxin on the adventitious rooting of selected genotypes of *Eucalyptus camaldulensis*, the effects of IBA and IAA on the adventitious rooting of cuttings collected at 40 and 80 days after coppicing, respectively, were tested in two independent experiments. There was no significant differences among the interaction IBA doses and genotypes ($p > 0.05$). However, it was observed that the lowest percentages regarding callogenesis (10%) were found for genotypes G1 and G2, which did not differ from each other (Figure 3A). On the other hand, genotypes G3 and G4

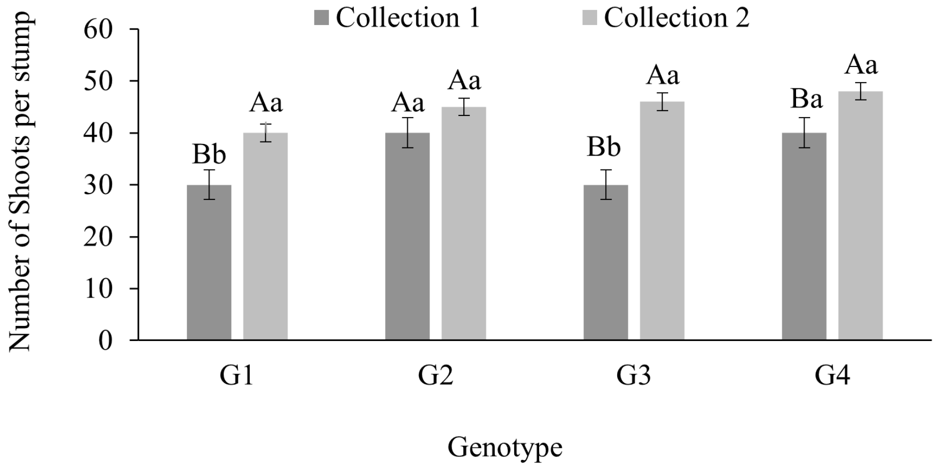

Figure 2. Emission of shoots from stumps of genotypes G1, G2, G3, and G4 of *Eucalyptus camaldulensis* after 40 (collection 1) and 80 (collection 2) days of coppicing. Capital letters compare the same genotype in different collections, and lowercase letters compare genotypes within the same collection

Figura 2. Emissão de brotações das cepas dos genótipos G1, G2, G3 e G4 de *Eucalyptus camaldulensis* aos 40 (coleta 1) e 80 (coleta 2) dias após a decepa. Letras maiúsculas indicam comparação do mesmo genótipo nas diferentes coletas e letras minúsculas comparam os genótipos dentro de uma mesma coleta

showed superior results (15%). Genotypes G2, G3, and G4 did not show statistical differences in oxidation, standing out with the highest percentage (30%). Therefore, the lowest average was observed in genotype G1, with 20% oxidation of propagules (Figure 3B). Regarding the presence of non-reactive propagules, genotypes G1 and G2 showed the highest percentage (20%), with the lowest percentages observed to genotypes G3 and G4 (5%) (Figure 3C). Interestingly, these differences do not interfere with adventitious rooting, the variance analysis conducted revealed an absence of significant interaction ($p > 0.05$) between the four genotypes regarding to rooting.

Callus formation at the cuttings base showed a significant increase concerning the IBA concentrations applied (Table 1). However, for non-reactive explants, a decreasing average was observed when IBA was applied. In summary, compared to the application of IBA, the control treatment presented significant number of recalcitrant propagules to adventitious roots, showing a lower callus formation and a high non-reactive propagules. Thus, the application of IBA increase adventitious rooting, promoting a significantly number of rooted cuttings (Table 1).

We investigated the effect of IAA on the adventitious rooting of propagules collected at 80 days. No influence of IAA on the genotypes response to rooting was observed. However, it was observed for the callogenesis that genotypes 1 and 2 presented equal averages (10%), while genotypes G3 and G4 demonstrated lower percentages, 5% and 0%, respectively (Figure 4A). Propagule oxidation showed no significant difference in genotypes G1, G2, and G3 (10%). However, genotype G4 stood out for not presenting oxidized propagules (Figure 4B), nor non-reactive explants (Figure 4C), and presenting the highest rooting rate, 80% (Figure 4D).

Analyzing the influence of IAA on adventitious rooting, the results showed similar responses to those previously observed for applying IBA (see Table 1). The application of IAA increase the number of rooted cuttings (Figure 5).

Finally, we analyzed only the controls (without auxin application) from the IAA and the IBA experiments to determine the effect of propagule collections on adventitious rooting. In this context, rooting and oxidation stood out. The propagules from the second collection showed a higher percentage of rooting and a lower percentage of oxidation

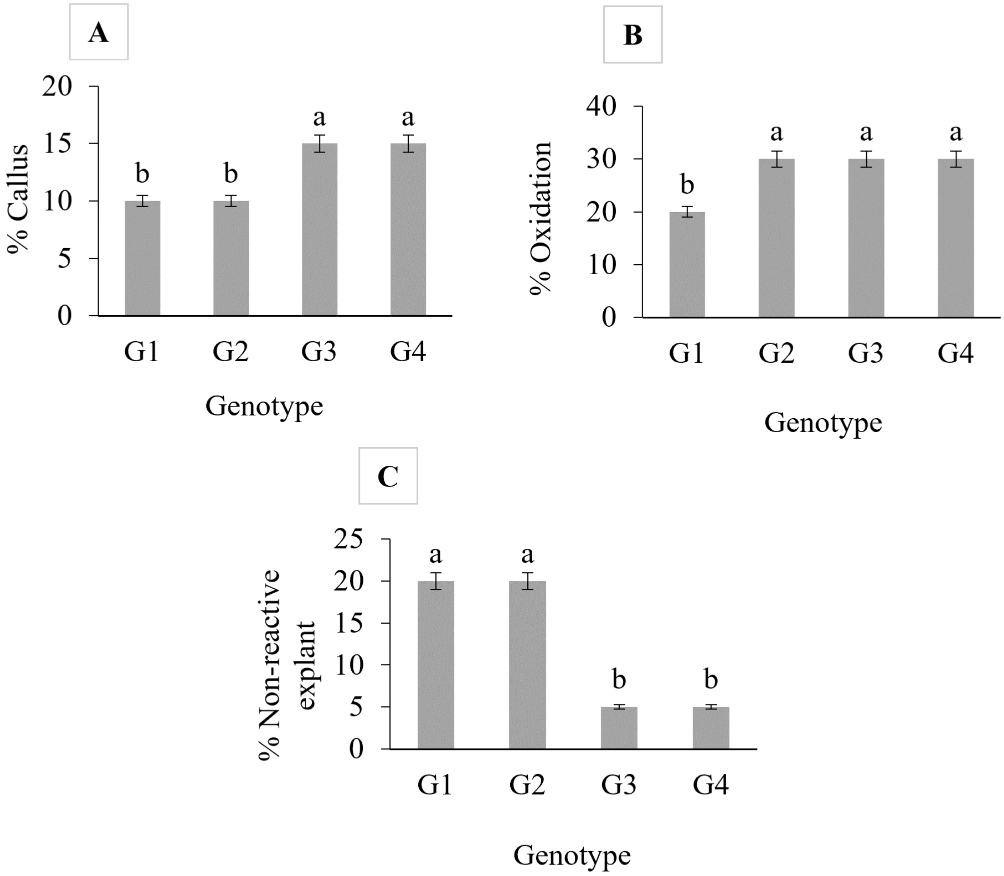

Figure 3. Percentages of callus (A), oxidation (B), and non-reactive explant (C) of propagules collected 40 days after coppicing in different genotypes of *Eucalyptus camaldulensis* with the application of acid-indole-3-butyric (IBA) in the cuttings. Average with equal lowercase letters do not differ using the Tukey test (p<0.05)

Figura 3. Porcentagens de Calo (A), oxidação (B) e explante não reativo (C) de propágulos coletados após 40 dias da decepa em diferentes genótipos de *Eucalyptus camaldulensis* com a aplicação de acido-indol-3-butirico (AIB) nas estacas. Médias com letra minúscula igual não diferem entre si, pelo teste de Tukey (p<0.05)

Table 1. Percentages of callus (A), non-reactive explant (B), and Rooting (C) in *Eucalyptus camaldulensis* cuttings subjected to different concentrations of IBA

Tabela 1. Porcentagens de calo (A), explante não reativo(B); e (C) enraizamento em estacas de *Eucalyptus camaldulensis* submetidas as diferentes concentrações de AIB

IBA (ppm)	Callus (%)	Non-reactive explant (%)	Rooting (%)
0 (control)	5 B (9.13)	20 A (10.41)	25 B (14.18)
2.000	10 AB (13.24)	12.5 B (9.07)	32.5 A (12.55)
6.000	15 A (12.40)	10 B (13.60)	30 A (11.47)

Means followed by different letters, considering the column, are different according to the Tukey test (p<0.05). Values in parentheses represent the coefficient of variation in percentage.

Médias seguidas de letras diferentes, considerando a coluna, são diferentes de acordo com o teste de Tukey (p<0.05). Valores em parênteses representam o coeficiente de variação em porcentagem

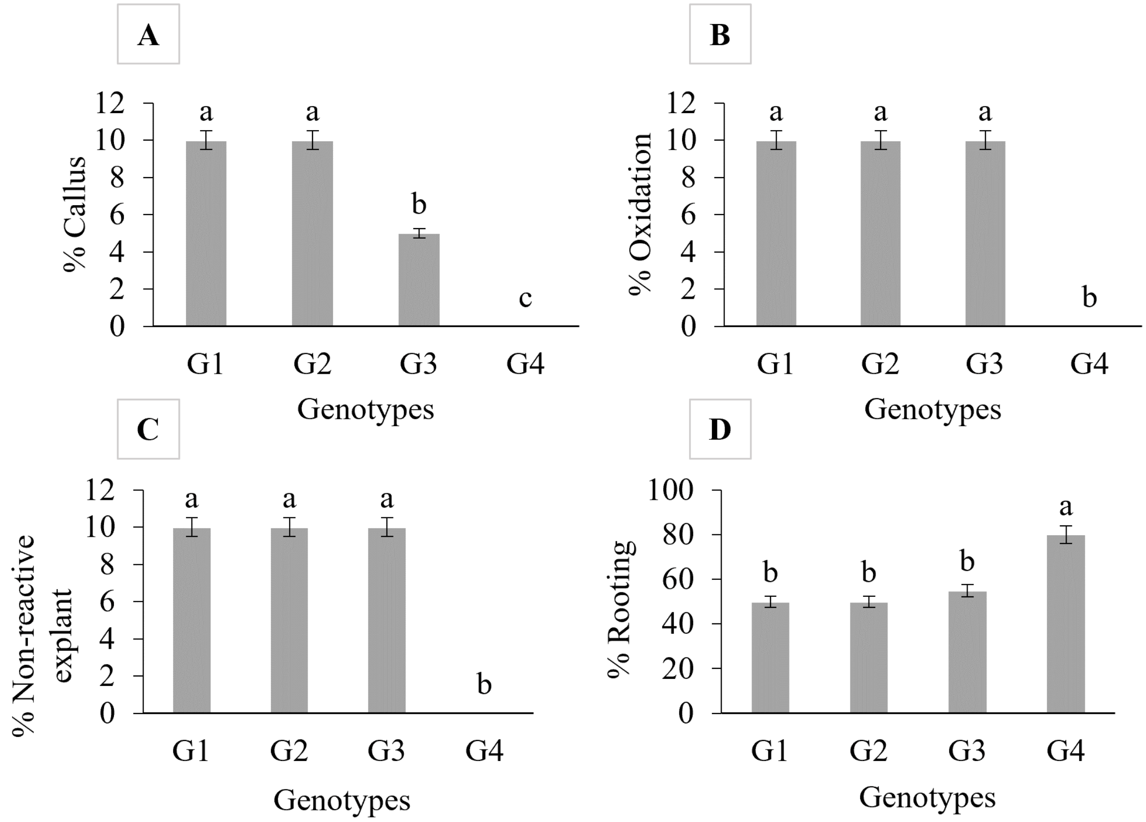

Figure 4. Percentages of callus (A), oxidation (B), non-reactive explant (C), and rooting (D) of *Eucalyptus camaldulensis* propagules after application of IAA auxin. Averages followed by the same lowercase letter do not differ using the Tukey test (p<0.05)

Figura 4. Porcentagens de calo (A), oxidação (B), explante não reativo (D) e enraizamento (E) de propágulos de *Eucalyptus camaldulensis* após a aplicação da auxina AIA. Médias seguidas de uma mesma letra minúscula não diferem entre si. Teste de Tukey (p<0.05)

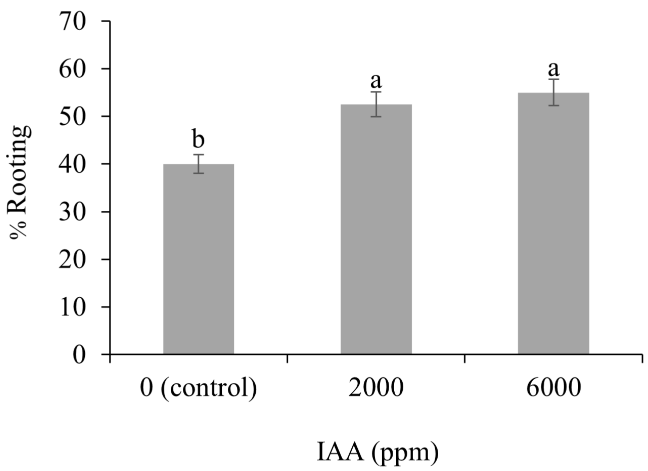

Figure 5. Percentage of rooting in *Eucalyptus camaldulensis* cuttings, subjected to treatment with different concentrations of IAA

Figura 5. Porcentagem de enraizamento em estacas de *Eucalyptus camaldulensis*, submetidas a tratamento com diferentes concentrações de AIA

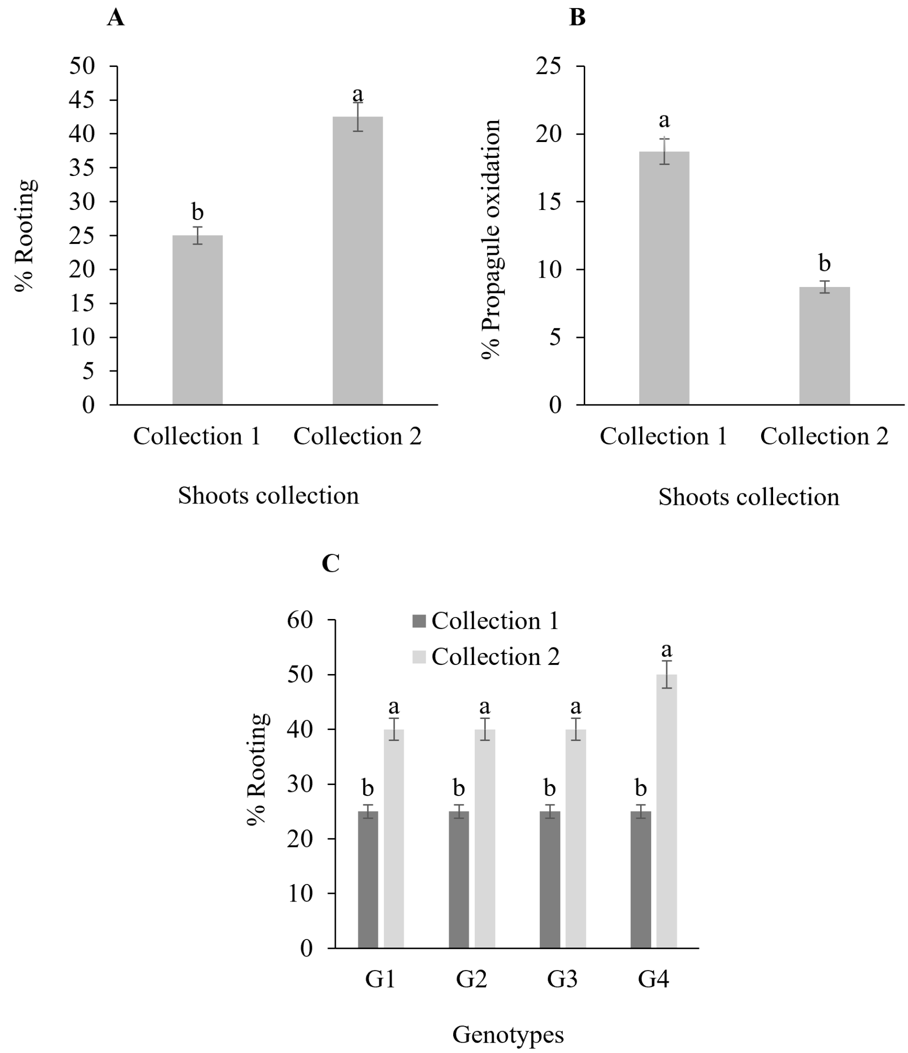

Figure 6. Percentages of rooting (A) and oxidation (B) of *Eucalyptus camaldulensis* propagules were collected at 40 (collection 1) and 80 (collection 2) days after coppicing. Percentages of rooting (C) of four genotypes of *Eucalyptus camaldulensis* considering the propagules collection 1 and collection 2. Averages followed by the same lowercase letter, comparing different propagule collections, do not differ using the Tukey test ($p<0.05$)

Figura 6. Porcentagens de enraizamento (A) e oxidação (B) de propágulos de *Eucalyptus camaldulensis* coletados aos 40 (coleta 1) e 80 (coleta 2) dias após a decepa. Porcentagem de enraizamento (C) de quatro genótipos de *Eucalyptus camaldulensis* considerando a coleta 1 e a coleta 2 de propágulos. Médias seguidas de uma mesma letra minúscula, comparando diferentes coletas de propágulos, não diferem entre si pelo teste de Tukey ($p<0.05$)

(Figure 6A-B). Remarkably, genotypes G1, G2, and G3 increased 60% in the rooting index when comparing the first with the second collection. At the same time, for genotype G4, the increase in the rooting index was 100% between the two collections (Figure 6C).

4. DISCUSSION

Coppicing is a procedure used to reinvigorate the vegetative propagules of adult trees and, through the emission of epicormic shoots, allows the rescue of selected matrices (Wendling, Trueman & Xavier, 2014). In the present study, we used *Eucalyptus camaldulensis* to evaluate the role of coppicing in reinvigoration in this species. In this sense, the emission of shoots was observed in all stumps, resulting in a survival rate of 100% for the individuals analyzed. For other species of the same genus, high efficiency has been observed in the emission of shoots after coppicing. However, in the species *E. camaldulensis*, *E. propinqua, E. cloeziana, E. pellita, E. tereticornis, E. microcorys,* and *E. maculata*, 85% of the stumps produced shoots while stumps of *E. urophylla* and *E. pilularis* obtained 100% emission of epicormic shoots (Higa and Sturion, 1991).

The vegetative rescue of adult trees is influenced by several factors, such as the technique used for reinvigoration, physiological condition, the chronological age of the mother plant, the ontogeny of the propagules, the genotype of the mother plant, and environmental factors (Xavier, Wendling & Silva, 2021). We demonstrate that coppicing is a reinvigoration technique that can induce epicormic shoots for the vegetative rescue of selected genotypes of *Eucalyptus camaldulensis*. The results are consistent with previous studies suggesting that coppicing efficiently induces juvenile shoots with good physiological conditions (Dias et al., 2015; Shanthi et al. 2015; Souza et al., 2022). Coppicing of the selected tree is the primary technique to revert tissues to their juvenile state, increasing the adventitious rooting percentage of cuttings (Baccarin et al., 2015; Fonseca et al., 2021).

Coppicing was carried out on *Eucalyptus camaldulensis* trees selected in a plantation located in a semiarid region. In this sense, the trees were cut at the beginning of the rainy season to promote the emission of shoots with high vigor. However, in the first collection of propagules, genotypes G1 and G3 emitted fewer shoots than genotypes G2 and G4. In the literature, the difference in shoot productivity between parent plants of the same species has been related to the genetic capacity of each parent to form shoots (Wendling, Trueman & Xavier, 2014; Dias et al., 2015; Bernardes et al., 2020; Souza et al., 2022).

In the second collection of propagules, genotypes G1, G3, and G4 showed a similar response and produced significantly more shoots than in the first collection. Here, evidence is provided that genotypes respond differently to acclimatization, influencing shoot production. The matrices, in the dry period, undergo physiological adjustments and morphological changes to acclimate to water deficit (Ezzine et al., 2023; Niemczyk et al., 2023). In this case, in genotypes G2 and G4, the residual effect of water stress on shoot production appears to be smaller than in genotypes G1 and G3, demonstrating that genotypes G2 and G4 are more acclimatized to dry environments or can more quickly reverse the effects of water stress, which resulted in more propagules of these genotypes in the first collection.

In the second shoot collection, a more remarkable aptitude for the emission of epicormic shoots in the stumps is notable compared to the first shoot collection. The emission of epicormic shoots in stumps is related to different factors, such as genetic, ontogenic age, chronological age, physiological vigor, hormonal balance, and environmental factors, such as nutritional and water condition of the stumps (Meier, Saunders & Michler, 2012; Souza et al., 2022). These factors can influence the activation of the dormant buds at the tree's base (Wendling, Trueman & Xavier, 2014). Thus, considering that the stumps in the second collection had better nutritional and water conditions due to the concentration of rain in the period, added to the physiological effect of the cutting carried out in the first collection, they favored an increase in the number of propagules in the second collection of shoots.

In the propagules from the first collection, despite the differences observed between the genotypes in the percentages of callus, oxidation, and reactivity of the explant, these changes were insufficient to stimulate distinct adventitious rooting in the four genotypes tested. Thus, the effect of physiological vigor and maturation of propagules from the first collection is predominant for the low adventitious rooting of the different genotypes.

In this sense, the application of IBA auxin tended to lead to a significant increase in the rooting index. Corroborating this observation, other studies have demonstrated that auxin application stimulates and accelerates adventitious rooting (Stuepp et al., 2017; Rasmussen et al., 2015; Díaz-Sala, 2021; Souza et al., 2022), increasing the quality and uniformity of the root system (Pijut, Wowste & Michler, 2011; Díaz-Sala, 2021). However, for *Eucalyptus camaldulesis* it was previously observed that the plants showed efficient rooting behavior without any hormone treatment (Bindumadhava et al., 2011).

Evaluating the propagules from the second collection of the four genotypes subjected to different doses of IAA, the G4 genotype stood out for not showing callogenesis, oxidation, and non-reactive explants. However, it was the genotype with the highest rate of adventitious rooting. The absence of a callus in the propagules of this genotype indicates that the formation of adventitious roots occurs directly, without the need to form an external callus for root emission (Hartmann et al., 2011). The process of callus formation may be related to the concentrations of regulators used, as well as indicating tissue maturation (Stuepp et al., 2015b; Pecegueiro et al., 2022).

All explants of the G4 genotype were reactive to adventitious rooting, with rooted or swollen propagules being observed. Furthermore, the genotype did not present oxidized propagules, as observed in the first experiment, indicating that the cuttings presented physiological and ontogenetic conditions conducive to adventitious rooting in the second collection of propagules. Thus, the G4 genotype has a high potential for adventitious rooting when the physiological conditions of the propagules are optimal. The potential for adventitious rooting formation varies among genotypes due to genetic effects or environmental influences (Wendling, Trueman & Xavier, 2014; Bernardes et al., 2020).

In addition to the genotype factor, adventitious rooting is influenced by the juvenileness and physiological characteristics of the propagules. In this sense, it is possible to associate that the propagules from the second collection are more vigorous as they have better water, nutritional, and hormonal conditions, produce a higher sugar and carbohydrate content, and have a lower quantity of oxidizing compounds, such as reactive oxygen and phenols (Niemczyk et al., 2023). All this information supports the hypothesis that after the rainy season, plants are still recovering from the oxidative stress generated in the dry season for acclimatization. This hypothesis was corroborated by a higher percentage of oxidation and lower rooting rates in the first collection of propagules. However, after recovery from stress, plants respond positively to rooting, this response being genotype-dependent. These results suggest that the rooting competence is not only influenced by the genotype, but it could be due to the differences in environmental factors, such as temperature and hydrological status of the mother tree, ontogenetic aging of the cuttings, or a combination of all the factors. Endogenous or environmental regulators may successfully modify the cell-maturation and differentiation processes toward adventitious root formation (Díaz-Sala, 2020). In addition, the reserve substances in the stem, mainly carbohydrates, which will supply the necessary energy for rhizogenesis, are available, allowing the development of branches and roots (Hartmann et al., 2011).

It is well known that climatic factors have a fundamental and direct influence on the rhizogenic process, as well as on the survival of cuttings (Pereira et al., 2018). Several studies evaluating the influence of seasonality on the rooting of cuttings proved this hypothesis (Ferreira et al., 2010; Pereira et al. 2018; Nascimento et al., 2022). However, these findings do not rule out the possibility that another factor regulates adventitious root formation. Cutting the shoots on the stumps, for example, may also have positively influenced the adventitious rooting of the propagules from the second collection. Successive cutting induces reinvigoration (reduced physiological age) and rejuvenation (reduced ontogenetic age) of propagules, even recovering the rooting potential in recalcitrated genotypes (Wendling et al., 2014). When the tissues are more juvenile, the adventitious rooting will be greater.

Further, the vegetative rescue of *Eucalyptus camaldulensis* mother plants subjected to prolonged periods of drought will result in a lower rooting rate and fewer propagules for the stumps compared to periods of high water availability. The recovery of the rooting potential and induction of shoots in the stumps does not occur immediately after the cessation of water stress, requiring a period for metabolic and physiological regulation of the stumps. The increase in rooting and reduction in the oxidation of propagules from the second collection of shoots corroborates this.

5. CONCLUSION

Cutting of *Eucalyptus camaldulensis* is an efficient technique for vegetative rescue of selected genotypes in semiarid conditions. Genotypes grown in environments with long periods of water deficit have lower cuttings rooting rates, with this potential increasing with improved water conditions in the environment where the stumps are grown and with the auxin application.

AUTHOR CONTRIBUTIONS

Costa, L. J. da: Methodology, Validation, Investigation, Writing; Silveira, G. V. dos S. and Silva, C.: Investigation, Validation; Scatolino, M. V.: Visualization, English Translation - Original Draft; Araujo, P. C. D.: Conceptualization, Methodology, Validation, Writing - Review & Editing, Supervision.

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