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Rescue techniques and vegetative propagation of *Eucalyptus benthamii* Maiden & Cambage

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SILVICULTURE

ABSTRACT

Background: The *Eucalyptus* genus is globally important for wood and non-wood product supply due to its fast growth, high productivity, and resistance to biotic and abiotic stresses. *Eucalyptus benthamii* is notably cultivated in subtropical regions, such as southern Brazil, due to its frost tolerance. However, the species exhibits low efficiency in adventitious rooting when propagated through clonal techniques. This study aimed to assess vegetative rescue techniques with different stump heights for *E. benthamii* and evaluate the effect of indolebutyric acid (IBA) 2024 on cutting rooting and seedlings development.

Results: The first trial was conducted in the field using a 2x3 factorial design to compare two stump heights (15 cm and 90 cm) and three collection intervals. The number of shoots and total cuttings were analyzed across three shoot height classes. The stump 15 cm, especially in the second collection (111 days after rescue), produced the highest number of shoots (73.7 shoots stump^{-1}). The second trial, carried out in a nursery, assessed rooting responses to IBA concentrations (0, 1500, 3000, and 4500 mg L^{-1}) in cuttings from both rescue techniques (stump 15 cm and 90 cm). IBA significantly improved cutting survival, rooting rate, and root development.

Conclusion: The stump at 15 cm was the most effective for shoot and cutting production in the field for vegetative rescue. Furthermore, an IBA concentration of 2800 mg L^{-1} is recommended for improving adventitious rooting and seedling production of *E. benthamii.*

Keywords: Adventitious rooting. Seedling production. Indolebutyric acid. Cutting propagation. Clonal forestry.

HIGHLIGHTS

1. The 15 cm stump rescue technique increased shoots and cutting yield in *E. benthamii.*
2. The 90 cm stump cutting rescue showed no significant vegetative propagation gains.
3. The 2800 mg L^{-1} IBA dose improved survival, rooting, and root growth in field cuttings.
4. Stump sprouting for vegetative rescue in the field is limited to few collections.

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INTRODUCTION

The commercial forest segment has been successful in the Brazilian and global economy with the planting of clones and interspecific hybrids of the *Eucalyptus* genus, becoming the preference of companies and investors due to its adaptability, high productivity, and versatility in the use of wood (FAO, 2025; IBÁ, 2024). In addition, advanced management techniques and genetic improvement have increased production efficiency, making the sector even more attractive.

Eucalyptus benthamii Maiden & Cambage is a species used for reforestation in subtropical climate regions, mainly where frequent and severe frosts occur, such as in southern Brazil (Silva et al., 2022). The species can tolerate low temperatures and presents economic benefits, such as producing wood for pulp, firewood, and charcoal (Bush et al., 2023). Originally from Australia, *E. benthamii* occurs in the coastal region of the New South Wales state, predominating in places with Cfb climate (Dooren et al., 2025).

Despite the several advantages, the species has low adventitious rooting when subjected to vegetative propagation, including its interspecific hybrids (Brondani et al., 2012; Gatti et al., 2025). This limits the advances in forest breeding programs and mass multiplication in nurseries, requiring improvements in the production process (Griebeler et al. 2024), which begins with the vegetative rescue of superior trees in the field.

This stage is characterized by inducing the emission of epicormic shoots to form cuttings with juvenile characteristics suitable for adventitious rooting. To obtain juvenile material, shoot induction is usually performed at the base of the trees, near the collar region (Davies et al., 2018). According to Tomar et al. (2023), the clearcutting technique is the most used, showing success for most species of the *Eucalyptus* genus, due to the high production of shoots for cuttings. Other superior tree rescue methodologies can be used, such as girdling and semi-girdling at the base of the trunk, grafting, pruned branches, and induction of basal shoots by fire (Shmakov et al., 2024). The height of stump cutting can influence the rescue process, according to the species, and factors such as tree age, climate condition, collection interval and size of the shoots influence the seedling production by vegetative propagation.

The use of phytoregulators in cuttings has been frequent in most forest species, with the aim to increase the percentage of adventitious rhizogenesis, morphological quality, and uniformity of the roots, thus reducing the seedling production cycle (Nascimento et al., 2022). Indolebutyric acid (IBA) is an auxin widely used in forest species (Gibson et al., 2021; Hilgert et al., 2021). However, there will be differences in concentration and form of application depending on the species (Loconsole et al., 2022; Vielba et al., 2020), requiring protocols to standardize the use of IBA according to the genetic material. The seedling production by cutting collected from stump in the field aims to clone superior trees to use in genetic breeding program, for mass multiplication in commercial nursery the mini-cutting technique is used, which generally does not require auxin.

Therefore, this study aimed to evaluate the effect of vegetative rescue technique with different stumps heights, collection time and concentrations of IBA on the adventitious rooting of cuttings and the quality of *E. benthamii* seedlings, propagated by material rescued from the field.

MATERIAL AND METHODS

Collection site

The plant material was collected in the municipality of Tapes, RS (Figure 1), from a progeny test where a *Eucalyptus benthamii* clone was used, belonging to the CMPC – Celulose Riograndense company, established in October 2013 (latitude 30° 56′ 39′ South, longitude 51° 51′ 41.1′ West, altitude 126 m). The climate in the region is Cfa (humid subtropical), according to the Köppen climate classification (Alvares et al., 2013).

Vegetative rescue

The vegetative rescue experiment was designed completely randomized in a 2x3 factorial scheme (stump height x shoot collection intervals). The rescue technique used consisted of cutting the stump at different heights: clearcutting the tree at 15 cm (stump 15 cm) and 90 cm from the ground (stump 90 cm), leaving 15 cm of bark for both techniques (Figure 2A-D). The stump 15 cm was selected based on previous studies reporting positive sprouting in *Eucalyptus* due the greater juvenility at the tree base (Davies et al., 2018; Costa et al., 2024), whereas 90 cm stump was adopted under the hypothesis that taller stumps may retain greater nutrient reserves available for shoot emergence and cutting root (Engel et al., 2019). A topsoil layer near the tree collar (radius of approximately 30 cm) was also removed to induce shoot production in both techniques (Figure 2A - D). Five replicates of single tree plot were used, totaling ten trees.

The trees were cut in August 2020 with the use of a chainsaw. The first shoot collection was conducted in November (85 days after cutting trees). The second and third collections were conducted in December (interval between collections of 26 and 21 days, respectively). The variables analyzed were the total number of shoots (TNS) produced per stump, the diameter of the shoots, and the total number of cuttings per stump. The shoots were divided into height classes: class I (5-10 cm), class II (>10-30 cm), and class III (>30 cm). Meteorological data of mean temperature and precipitation for the study site were obtained from the meteorological station belonging to the company, located 52 km from the study area (Figure 3).

Effect of IBA on rooting of cuttings and seedling production of *E. benthamii*

The second experiment was conducted in a completely randomized design, in a 4x2 factorial scheme.

The levels of factor "A" corresponded to the concentrations of IBA hydroalcoholic solution (zero, 1500, 3000, and 4500 mg L^{-1}) and factor "B" to the vegetative rescue techniques (stump 15 cm and stump 90 cm), totaling eight treatments. Five replicates of 12 cuttings per treatment were used in the seedling production phase. The study was conducted in the Forest Nursery of the CMPC – Celulose Riograndense company, located in Horto Florestal Barba Negra, municipality of Barra do Ribeiro, RS (latitude 30°20'33.63" South, longitude 51°14'42.29" West). The climate of the region is the same as previously described. The epicormic shoots were packaged and transported immediately after each collection, placed in plastic containers lined with paper towels moistened in water. The containers with the shoots were placed inside a thermal box with ice for transport to the nursery. The cuttings used were from Class II shoots, made with a pair of leaves, with a reduction of 50% of the leaf area, and an average length of 10 ± 2 cm, discarding the material from the apical position.

The cuttings were immersed in distilled water (control treatment) and the IBA hydroalcoholic solution for 10 seconds. After the procedure, they were planted at two centimeters of depth in a commercial substrate composed of *Sphagnum* peat and vermiculite with base fertilization, consisting of a mixture of controlled-release fertilizer (NPK 19:06:10), simple superphosphate, and PG Mix®, at a dosage of 1.5 kg m^{-3} of substrate. The tubes used for seedling production were polypropylene with a volume of 50 cm^3, placed on plastic trays and an automated greenhouse with intermittent misting for 45 days. After this stage, the rooted cuttings were taken to the growth and hardening area, remaining until 120 days. Fogger nozzles were used for irrigation, triggered at set periods according to the day's environmental condition, maintaining the air's relative humidity above 80% (Figure 4).

The following variables were analyzed: survival percentage, calogenesis, cuttings with leaves, rooting, and morphological attributes in the hardening phase. The percentage of survival cutting was determined by those that were turgid after 30 days of planting. The percentage of cuttings with leaves was evaluated considering the presence of the remaining pair of leaves or the formation of new leaves in the survival phase (30 days) and rooting (45 days). The percentage of calogenesis and rooting were also evaluated at 45 days after cutting. The cuttings with a visible root system in the lower part of the tube and/or induction of radial beginnings at the base of the cutting with at least 1 mm in length were classified as

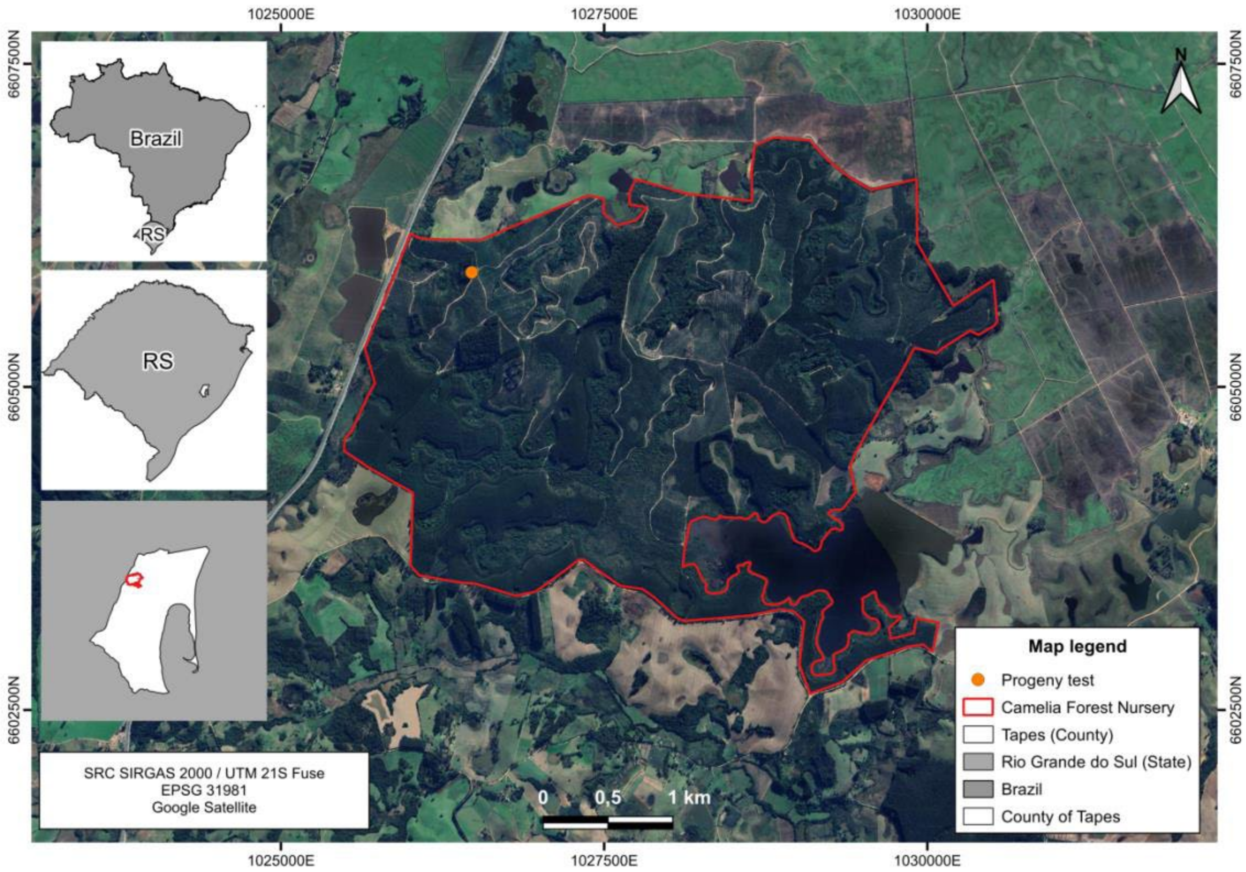

Figure 1: Location map of *Eucalyptus benthamii* trees rescued in the field for shoot collection and vegetative propagation. Tapes, RS.

Figure 2: Vegetative rescue of *Eucalyptus benthamii* trees through clearcutting of the tree at 15 (stump 15 cm) (A-B) and 90 cm (stump 90 cm) (C-D) from the soil surface.

rooted. The percentage of calogenesis and rooting were calculated based on the total number of planted cuttings. The treatments were analyzed only with the data obtained from the second collection, since the first and third collections presented practically null results.

The morphological attributes of the cuttings evaluated were stem diameter (SD), shoot height (H), number of roots emitted by cuttings (NR), root length (RL), shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM = SDM + RDM), and Dickson's quality index. The SD and H were measured using a digital caliper (accuracy of 0.01 mm) and a millimeter ruler, respectively. After the measurements, the cuttings were sectioned into the root system and aerial part. Drying was conducted in a forced air circulation oven (65 ºC) until reaching constant weight, followed by weighing using an analytical scale (0.001 g). Morphological attributes were evaluated at 120 days using material from the second collection.

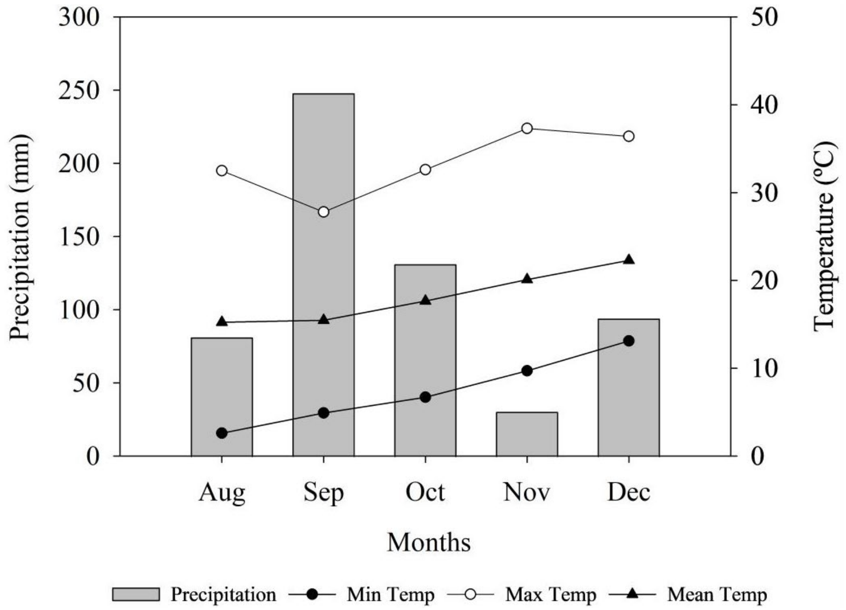

Figure 3: Minimum, maximum, and mean monthly temperature (ºC) and monthly precipitation (mm) recorded during the experiment, Tapes, RS, Brazil.

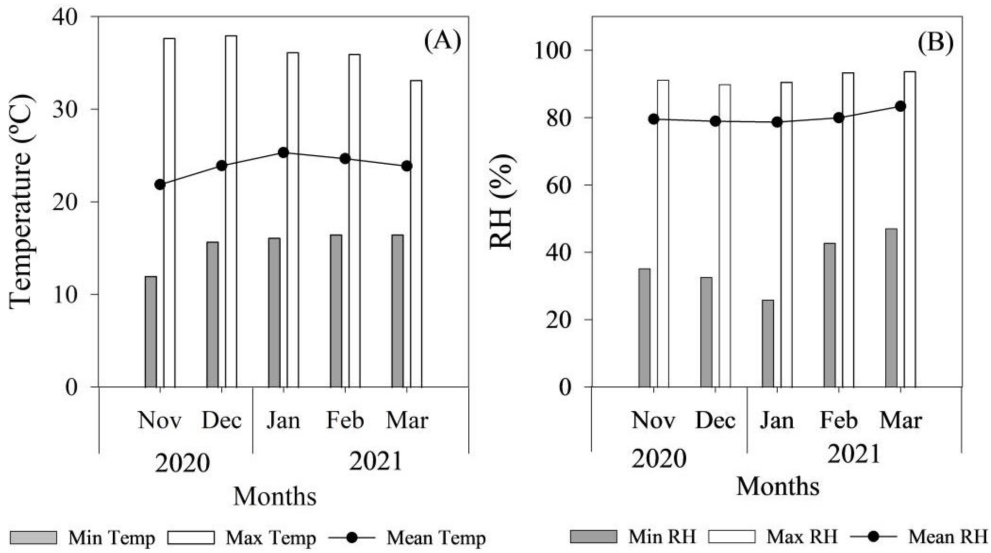

Figure 4: Minimum, maximum and mean temperature (A) and relative humidity (RH) of the greenhouse during the study period. Barra do Ribeiro, RS, Brazil.

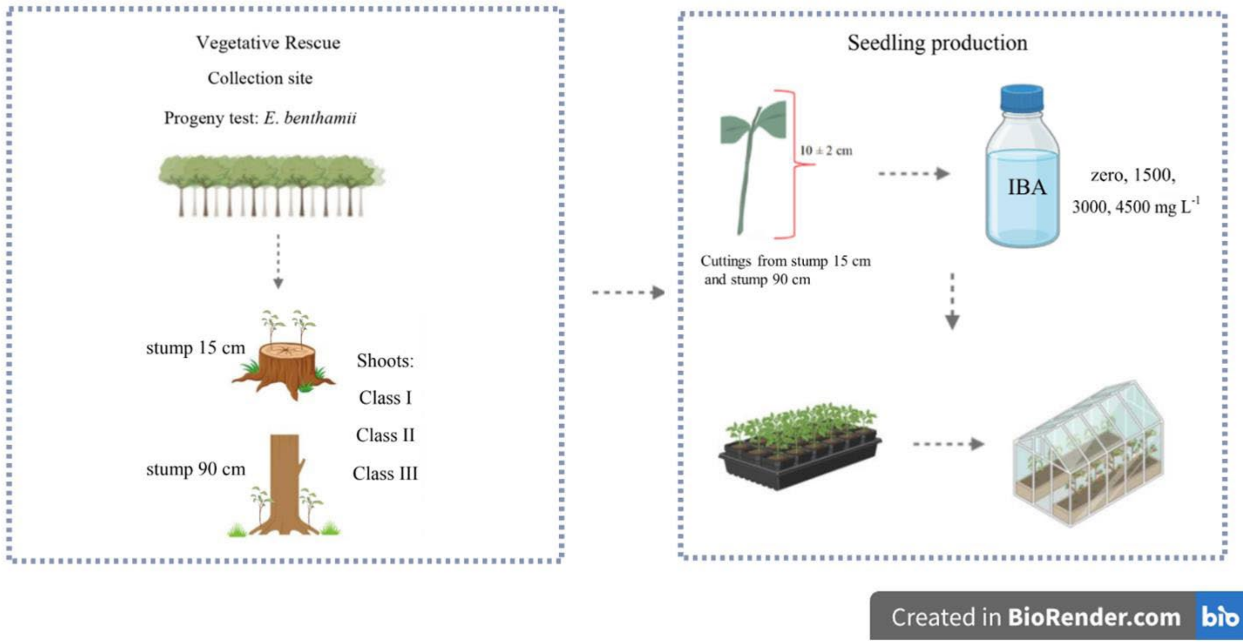

Figure 5: Schematic representation of the workflow of activities carried out throughout the experiment.

Statistical analyses

Data from both experiments was submitted for analysis testing the normality of residuals and homogeneity of variance by the Shapiro-Wilk and Bartlett tests, respectively. Data that did not meet the assumptions was transformed by the Box-Cox method and, subsequently, the analysis of variance was performed. When a significant difference was found, the means were compared using the Tukey test at a 5% probability of error ($p<0.05$) for qualitative factors (collection and rescue technique) and regression analysis for IBA concentrations ($p<0.05$). The maximum technical efficiency dose (MTED) was calculated for the variables that presented quadratic behavior. Pearson's correlation (r) was also applied to the studied variables. All analyses were performed using the R (R Core Team, 2019) and RStudio statistical software with the support of ExpDes.pt (Ferreira et al., 2021) and Metan (Olivoto, 2021) packages.

RESULTS

A significant isolated effect ($p<0.05$) of the collections in the production of shoots from classes I and II was found in the first experiment. The production of class I shoots was higher in the third collection (21.9 shoots stump^{-1}) (Figure 6-A), while in class II, the second collection showed a higher mean (50.5 shoots stump^{-1}) (Figure 6-B). A significant interaction occurred ($p<0.05$) between the factors studied for the class III shoots. The second collection and the rescue technique with the clearcutting of the stump at 15 cm resulted in a production of 43.4 shoots stump^{-1} (Figure 6-C). An isolated effect was observed ($p<0.05$) for the factor total number of shoots. The second collection and stump 15 cm rescue presented superior results, 93.4 and 73.7 shoots stump^{-1}, respectively (Figure 6-D). The clearcutting 15 cm resulted in an increase of 27.5 p.p (percentage points) in shoot production compared to stump 90 cm (Figure 6-D). The interval between collections also influenced shoot productivity. The third collection had a higher mean of shoots from class I than the others (Figure 6A) due to the shorter period (21 days) between collections and the highest average temperature in this period (summer), Figure 3. The second collection showed a higher average of class II shoots, which were favorable for preparing cuttings, because they were less lignified and had adequate length. Shoots larger than 30 cm were discarded due to increased tissue lignification, and their use in vegetative propagation is not recommended.

Regarding the stem diameter of the shoots, there was only a difference ($p<0.05$) for class I in the first and third collections, which showed higher means (1.6 mm) compared to the second collection (1.3 mm), not differing from each other (Figure 7-A). There was no variation ($p>0.05$) for class II and III shoots, with means of 2.13 and 2.37 mm, respectively. The significant effect was observed only for the collection ($p<0.05$) regarding the total number of cuttings per stump. The second collection denoted a higher production of cuttings suitable for staking (Figure 7-B).

In relation to the seedling production phase, there was an isolated effect ($p<0.05$) of the IBA concentration factor for percentage of survival for cuttings and rooting (Figure 8A-B). A quadratic effect was observed with an MTED estimate of 2300 mg L^{-1} IBA for survival (98.6%) and 2475 mg L^{-1} for rooting (51.2%). The percentage of calogenesis and cuttings with leaves were not significant ($p>0.05$). The mean callogenesis was 9.79%, and cuttings with leaves were 90.8% at 30 days and 47.1% at 45 days after staking.

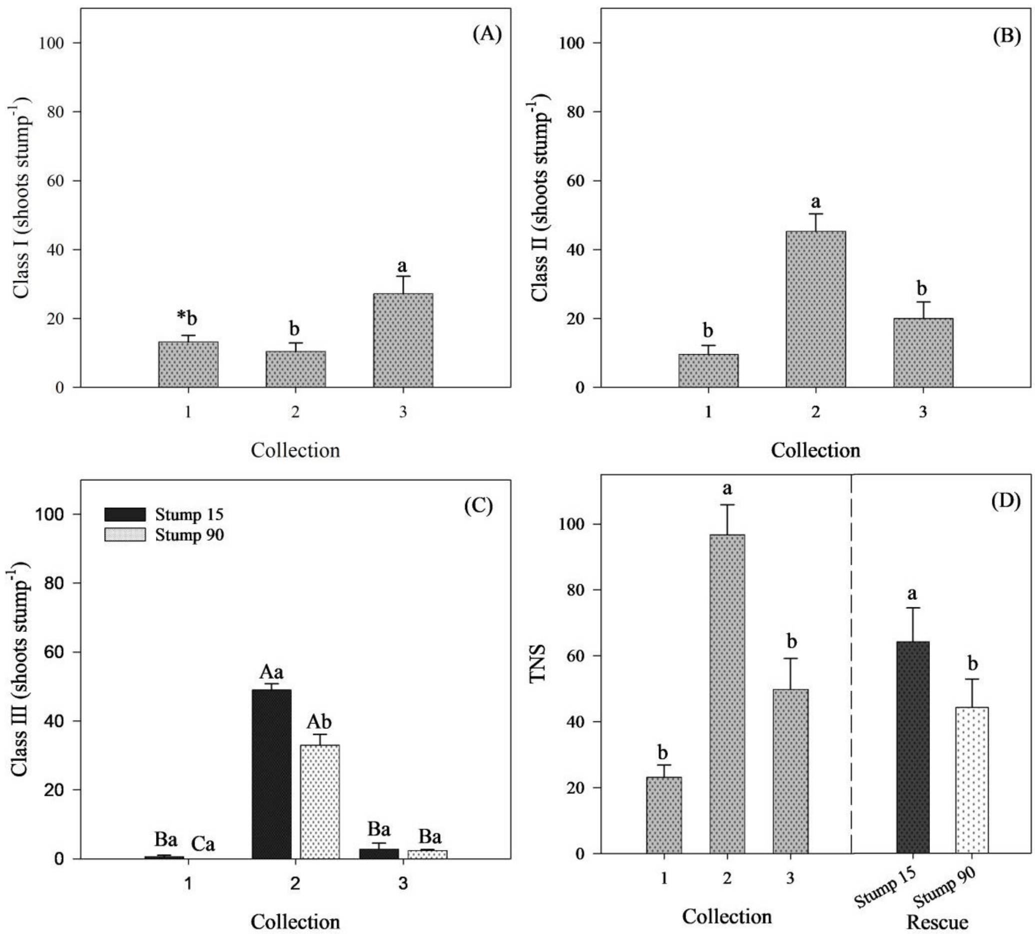

Figure 6: Mean of shoots produced by different height classes, I (A), II (B), and III (C), and total number of shoots per stump (TNS) (D) in the evaluation of different rescue techniques and collection intervals in *Eucalyptus benthamii*. *Means followed by the same uppercase and lowercase letters do not differ statistically by the Tukey test at 5% probability. Vertical bars indicate standard error.

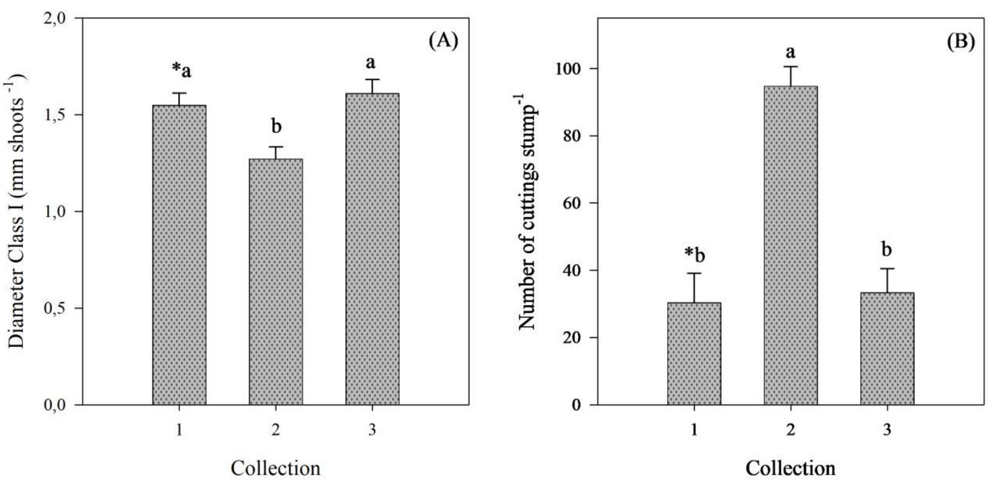

Figure 7: Mean of stem diameter of class I shoots (A) and total number of cuttings per stump (B) of *Eucalyptus benthamii* at three intervals of shoot collections in the field. *Means followed by the same letter do not differ by the Tukey test at 5% probability. Vertical bars indicate standard error.

Pearson's correlation showed a positive correlation (p<0.001) between the percentage of rooting with cuttings with leaves (0.9), calogenesis and cuttings with leaves (0.81), and the percentage of cuttings with leaves with the survival of the cuttings at 30 days (0.68) (Figure 9).

The morphological attributes in the hardening phase was a significant isolated effect for both study factors (p<0.05) for the cuttings' root length. Cuttings from the stump 15 cm showed a higher mean (14.48 cm), compared to stump 90 cm (12.71 cm) (Figure 10-A). A quadratic behavior was observed for the IBA factor, with MTED of 3500 mg L^{-1} (15.6 cm) (Figure 10-B). The stem diameter showed an isolated effect (p<0.05) of the rescue technique factor, with stump 15 cm showing superior results (2.09 mm) compared to stump 90 cm (1.90 mm) (Figure 10-C). The height, SDM, RDM, TDM, number of roots, and Dickson quality index were not significant, with means of 13.36 cm, 0.21 g, 0.07 g, 0.28 g, 3.76 roots, and 0.03, respectively. The mean of MTED based on the MTEDs presented by survival percentage, rooting, and root length was 2800 mg L^{-1} of IBA.

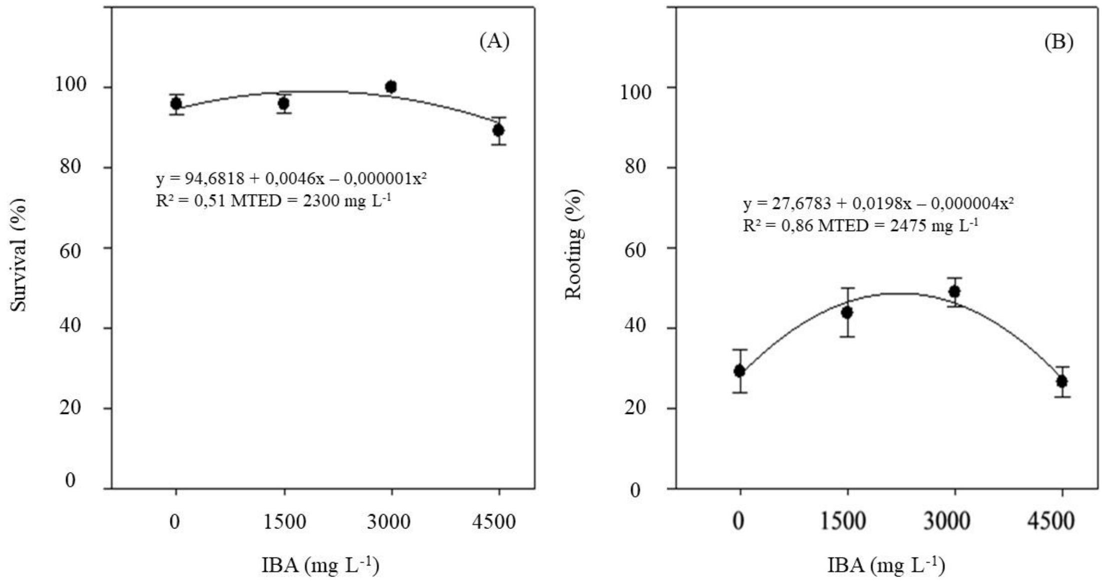

Figure 8: Percentage of survival (A) and rooting (B) of *Eucalyptus benthamii* cuttings subjected to different concentrations of indolebutyric acid (IBA). Vertical bars indicate standard error.

Figure 9: Pearson's correlation matrix for the variables evaluated in *Eucalyptus benthamii* from different vegetative rescue techniques and IBA concentrations. Variables: survival percentage – 30 days (Sur%), callogenesis (Call%), rooting (Root%), cuttings with leaves in the survival phase - 30 days – SurL%), cuttings with leaves in the rooting phase - 45 days (RootL%) *significant at 0.05; **significant at 0.01; ***significant at 0.001.

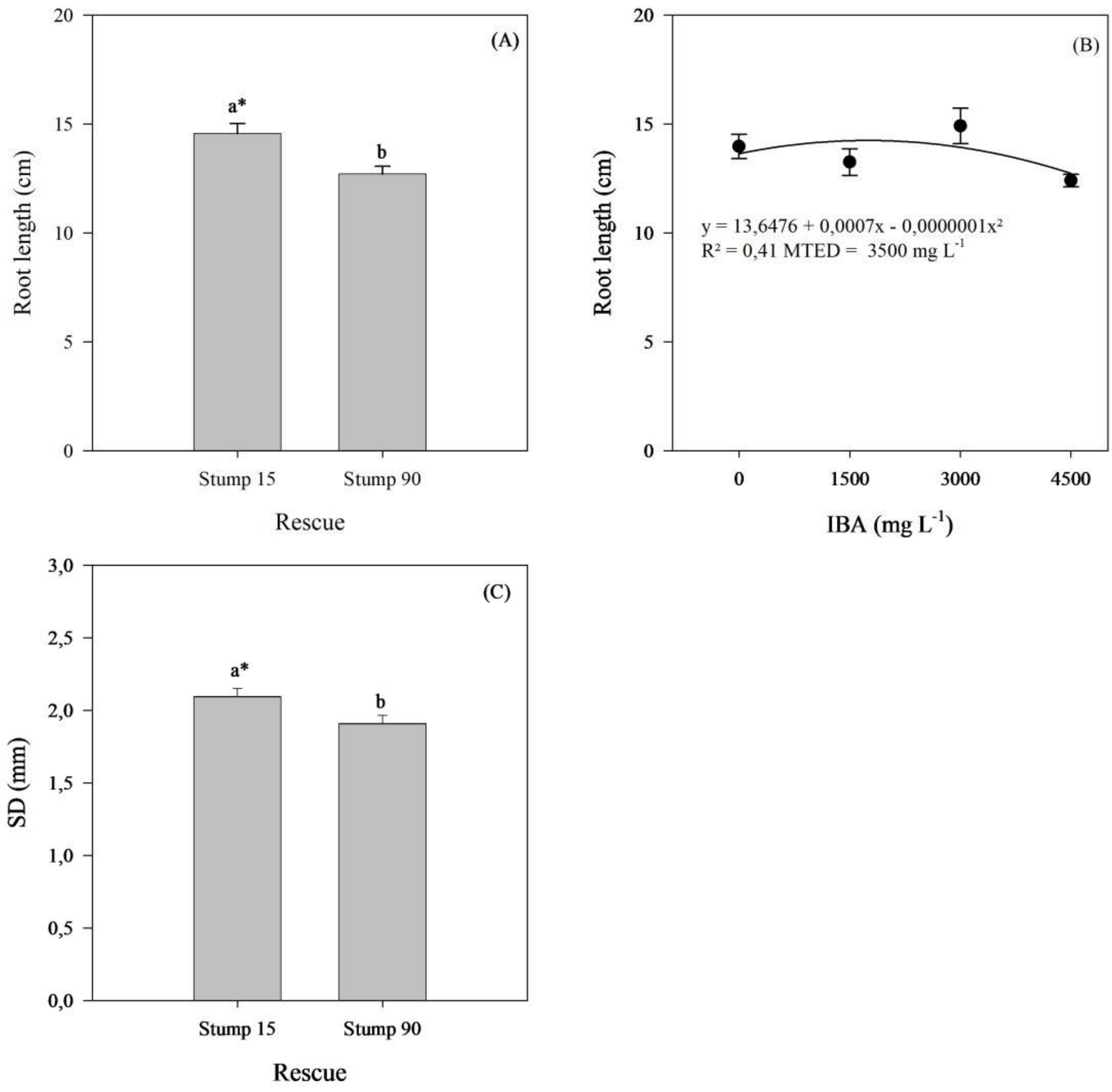

Figure 10: Root length (A-B) and stem diameter (SD) (C) of *Eucalyptus benthamii* cuttings submitted to different vegetative rescue techniques and IBA concentrations. *Means followed by the same letter do not differ by the Tukey test at 5% probability. Vertical lines over the bars indicate standard error.

DISCUSSION

We verified that the stump 15 cm was the most efficient technique for the vegetative rescue of *Eucalyptus benthamii* (Figure 6C-D). This clearcutting allowed considerable production of epicormic shoots and seedlings with superior morphological quality (Figure 10). An experiment conducted with the clearcutting of 244 trees of *E. benthamii* showed an 87.3% regrowth capacity (Graça et al., 1999), corroborating with the data from the present study, demonstrating the efficiency of clearcutting and soil removing as a rescue technique for the species. Soil compaction and the accumulation of litter around the stump can make the shoot emission difficult. Therefore, removing this layer improves aeration and exposes a larger area of the stump to the light incidence, resulting in a greater emission of epicormic shoots. Additionally, Davies et al. (2018) and Xavier et al. (2021) highlighted that shoots collected from the basal portions of the tree, such as those produced by stump sprouting, are generally more responsive to rooting. This greater rooting potential is mainly attributed to the juvenile physiological condition of basal shoots, which favor the formation of adventitious roots (Faria et al, 2023). Therefore, the efficiency observed with the stump 15 cm technique can also be explained by the enhanced rooting capacity of these basal shoots, further supporting its suitability for the vegetative rescue and propagation of *E. benthamii*.

The vegetative rescue method with stump 90 cm showed lower production of shoots and cuttings compared to stump 15 cm (Figure 6C-D), demonstrating the low efficiency of this technique. According to Sakai et al. (1997), cutting the tree at lower heights can compromise the emission of shoots due to the low availability of reserve substances in the parent plant. In this context, research conducted with *Acacia mearnsii* showed that 1.20 m and 2 m heights, with the use of tourniquet technique, resulted in a greater number of shoots compared to lower cutting heights (0.30, 0.40, and 0.60 m) (Engel et al., 2019). However, this response was not observed in the present study.

The lower production of shoots in the first collection of both rescue techniques (Figure 6-D) may be due to the dormancy of the buds after the application of vegetative rescue methods, considering that the trees were cut in August, during the winter season, taking 85 days for the first shoot collection (November/spring). Considering this context, in a study evaluating rescue techniques with *Persea willdenovii* Kosterm., the highest number of shoots was obtained from the third and fourth collections (January and February, in the summer) (Andrade et al., 2022). Similar results were found for *Toona ciliata* var. *australis* (F. Muell.) Bahadur, in which the highest production of epicormic shoots occurred in the second collection (December/summer) (Pereira et al., 2015). In our study, the greater production of shoots was observed in the second collection, with a subsequent drop, showing no regrowth after the third collection and, consequently, stump mortality. The increase in mean temperature after the first collection (Figure 3) also contributes to higher shoot production, despite the stump survival being limited to a few collections.

The season of year when the vegetative rescue is conducted affects shoot production, as trees undergo different growth cycles throughout the periods. Plants are in the active growth phase during the spring and summer, producing new shoots and leaves (Carloni et al., 2025; Davies et al., 2018). This is the most suitable period for collecting shoots, since they are most vigorous and have the greatest potential for rooting cuttings. Trees growth slows during the autumn and winter as they enter a dormant period, making the rescue process difficult (Negri et al., 2025), increasing the risk of frost in subtropical regions. In our study, the collection was conducted in November and December (spring season), a period recommended for collecting shoots aimed vegetative rescue.

According to Moura and Guimarães (2003), it is recommended to avoid collecting larger (> 30 cm) and lignified shoots for cuttings roots of *Eucalyptus* spp. Materials with higher lignification change the carbon/nitrogen ratio, which can negatively impact adventitious rooting (Bannoud and Bellini, 2021). This condition may represent a physical barrier to root formation, hindering the onset and growth of the root primordium. In addition, it acts as a chemical barrier, due to the increased level of tissues maturation, reducing the levels of auxins in plant tissues by peroxidase degradation (Davies et al., 2018).

The 26-day interval between the first and second collections is adequate for collecting viable epicormic shoots for preparing cuttings, according to the local climatic characteristics (Figure 3). However, the study period occurred during the spring and summer, when plants are in vegetative growth (Davies et al., 2018), allowing the production of shoots at shorter intervals. The period between collections can be longer during autumn and winter due to lower temperatures, which reduce plants' physiological and metabolic functions (Taiz and Zeiger, 2024) and possibly cause sprout mortality.

Regarding the stem diameter of shoots, a significant difference between the collections was observed only for class I (Figure 7-A). The ideal diameter for cuttings varies according to the species (Yeager, 2020). In the case of *Eucalyptus* spp., cuttings with diameters up to 5 mm are recommended to promote greater rooting and to avoid excessive lignification of the material (Cooper et al., 1994). Therefore, the shoots from class II used to produce cuttings in the present study, with an average diameter of 2.13 mm, are within the ideal range to make cutting for clonal propagation. Shoots with larger diameters should, nevertheless, be avoided when making cuttings due to greater lignification of the material, compromising the adventitious rhizogenesis.

The survival values of the cuttings were high in the our trial using different concentrations of IBA, with a mean of 98.6% at a dose of 2300 mg L^{-1} (Figure 8-A). According to Davies et al. (2018), high cutting survival rates indicate adequate greenhouse environmental conditions (humidity, temperature, and light), which may favor root induction. Regardless of the rescue technique, the rooting observed in the cuttings was 51.2% with an MTED of 2475 mg L^{-1} of IBA (an increase of 22.7 p.p. in relation to the control) (Figure 8-B). When evaluating *E. camaldulensis* cuttings from vegetative rescue through shallow cutting of superior trees, was observed an average of 32.5% rooting using 2000 mg L^{-1} of IBA (Costa et al. 2024). The concentration and application form of IBA vary according to the species and clone studied (Oğuztürk et al., 2025; Sekhukhune and Maila, 2024; Vennila et al., 2022), requiring the use mainly in cuttings collected directly from the field. In the present study, we recommend 2800 mg L^{-1} of IBA (MTED) based on the best results of survival, rooting, and growth of *E. benthamii* seedlings.

The permanence of leaves on the cuttings is another essential factor for the success of vegetative propagation by cuttings, observing a positive correlation with the survival, callogenesis, and rooting of the *E. benthamii* (Figure 9). Auxins are synthesized in the apical meristems and transported from the apex to the base of the plant, promoting the formation of lateral and adventitious roots, in addition to the carbohydrates produced by photosynthesis, essential in the formation of the root system (Adem et al., 2024; Hou et al., 2025; Jan et al., 2024).

The stump 15 cm technique influenced the morphological attributes, root length and stem diameter (Figure 10-A and C), of the seedlings evaluated at 120 days. In addition, the application of indolebutyric acid showed the importance for root length (Figure 10-B), inducing a better development of adventitious roots. The root system quality is an important variable for the successful development of trees in the field. A plant with a well-developed root system can adapt better to environmental variations, capturing water and nutrients more efficiently, in addition to resisting environmental stresses, such as falling trees due to the strong wind. Furthermore, Baccarin et al. (2015), when applying the girdling rescue technique (20 cm above ground level and 20 cm in width) to twenty selected adult *E. benthamii* trees, obtained an average rooting of 18.7% under greenhouse conditions, which was lower than that achieved with the stump 15 cm technique combined with IBA application (51.2%), demonstrating the higher efficiency of the vegetative rescue method employed in the present study.

Vegetative propagation of *E. benthamii* still represents a challenge for commercial seedling production, showing low rooting rates even when the mini-cutting propagation technique is employed, despite the intensive management of the mini-garden and the cultural practices applied to the mini-stumps. Brondani et al. (2008), evaluating three hybrids' clones of *E. benthamii* × *E. dunnii* under a mini-cutting system, obtained 43.2% rooting at an estimated dose of 4421.9 mg L^{-1} IBA. Furthermore, in another study with mini-cutting of the same three *E. benthamii* × *E. dunnii* clones, Brondani et al. (2012) reported rooting percentages of 44.4% to 66.7% when using 2000 mg L^{-1} of IBA. In addition, Brondani et al. (2010) observed in mini-cutting rooting ranging from 30.32% to 55.45% with IBA concentrations between 4000 and 6000 mg L^{-1}. Griebeler et al. (2024), testing the use of a mini-tunnel in a clonal mini-garden of *E. benthamii*, achieved a rooting percentage of 62.5%, demonstrating that environmental management of the seedling production places can improve physiological responses.

The results obtained in the present study contribute to the vegetative rescue of *E. benthamii* genotypes in the field, providing propagative material with higher quality, uniformity, and rooting rates, which may significantly support the subsequent stages of the clonal seedling production process, as mini-cutting process, which is used for massal propagation of *Eucalyptus* spp. in a commercial forest nurseries.

CONCLUSIONS

Vegetative rescue in *E. benthamii* with clearcutting, leaving a stump with 15 cm of high, and removing a surface layer of soil, significantly increases the production of shoots in the field and cuttings for vegetative propagation. This technique also provides the development of seedlings with a greater root length and stem diameter.

The 26-day interval between collections in the summer provides the best results in shoots production and cuttings, depending on the local climatic conditions. We recommend the use of 2800 mg L^{-1} of IBA hydroalcoholic solution to improve cutting survival, rooting, and root development in the seedlings production.

DATA AVAILABILITY

The datasets supporting the conclusions are included in the article.

AUTHORSHIP CONTRIBUTION

Project Idea: EG

Funding: EG

Database: EG

Processing: HCS; EG; AMG;

Analysis: HCS; AMG; HAB

Writing: HCS; EG; AMG; OPS; NP; HAB; MMA

Review: HCS; EG; AMG; OPS; NP; MMA

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