Propagation Strategies for Native Species in Forest Restoration: Efficiency of Substrates and Hormonal Treatments

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Abstract

Background: Forest restoration using native species has spurred interest in optimizing seedling production to enhance survival and competitiveness in degraded areas. Larger seedlings are advantageous but often cost-prohibitive, emphasizing the need for efficient propagation methods. Vegetative propagation, particularly through cuttings, offers a viable solution for species with limited seed availability. However, research on substrate suitability and rooting performance in Cerrado species remains limited. Methods: This study evaluated the propagation potential of Miconia albicans, Croton urucurana, and Solanum paniculatum using apical cuttings treated with or without indole-3-butyric acid (IBA). Cuttings were grown in Cerrado soil and sand substrates within polyethylene bags under controlled conditions for 208 days. Rooting and leaf sprouting were assessed biweekly. Statistical analyses were performed using Chi-square tests and Tukey's test at a 95% confidence level. Results: Substrate type did not significantly influence the rooting or sprouting success of the species. Solanum paniculatum demonstrated superior adaptability, achieving consistent rooting, shoot growth, and leaf production without IBA application, irrespective of substrate type. Conversely, Miconia albicans and Croton urucurana showed limited rooting success and no leaf production. The cost-effective method using polyethylene bags proved efficient for propagating S. paniculatum. Conclusion: Solanum paniculatum emerged as a robust candidate for vegetative propagation, suitable for ecological restoration projects, while further refinement is needed for Miconia albicans and Croton urucurana. The findings underscore the potential of simple, low-cost propagation methods to support forest restoration and sustainable nursery practices, particularly for small-scale producers.

Keywords: Forest restoration, Asexual propagation, Native species, Substrate efficiency, Solanum paniculatum Significance

Significance | This study identifies cost-effective propagation techniques for Solanum paniculatum, optimizing forest restoration efforts with minimal resource dependency.

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Introduction

Forest restoration initiatives employing native species have spurred discussions regarding the optimal size of seedlings for planting. Seedling size directly influences survival and competitiveness in the field, particularly against aggressive grasses. Larger seedlings, provided they possess well-formed roots, are expected to have a higher survival rate in degraded areas due to their enhanced vigor and resource acquisition potential. However, larger seedlings necessitate higher costs, stemming from increased substrate use, space requirements in nurseries, and elevated transport expenses, which collectively diminish planting efficiency (Ferraz & Engel, 2011). These factors underline the need for economically viable and

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efficient strategies to produce high-quality seedlings, particularly for small- and medium-scale rural producers who are primary stakeholders in forest restoration (Cunha et al., 2005). The vegetative propagation of Cerrado species, despite its potential, remains understudied. Interest in asexual propagation methods, such as cuttings, has grown as they offer promising results for the production of robust seedlings. This approach is particularly advantageous for species that struggle with seed production, enabling the propagation of genetically uniform individuals suitable for reforestation projects. Although this method may reduce genetic diversity in some cases, it is a viable solution for regenerating degraded ecosystems (Sano et al., 2008; Oliveira & Ribeiro, 2013).

A critical factor in successful seedling production is the choice of substrate and its compatibility with the species' requirements. For native plants, research on the specific germination and emergence conditions remains limited. Substrate selection must account not only for technical suitability but also for local availability and cost-effectiveness to ensure accessibility for small-scale nursery operations (Bao et al., 2014; Cunha et al., 2005).

In this study, three native species—*Miconia albicans*, *Croton urucurana*, and *Solanum paniculatum*—were selected for their ecological relevance in degraded area recovery. These species were chosen due to their adaptability to local environmental conditions, their role in supporting local fauna, and their seed dispersal mechanisms. They represent distinct ecological functions, contributing to the stability and diversity of restored ecosystems.

1.1 Species Overview

Croton urucurana Baill. (Euphorbiaceae), commonly known as "Sangra d'água," is a pioneer species found in semideciduous broadleaf forests, often in swampy and humid terrains. It reaches heights of 7–14 m and is well-suited for mixed plantations in riparian restoration projects. Its fruits exhibit explosive dehiscence, classifying it as an autocoric species (Calegari et al., 2013; Lorenzi, 2002).

Miconia albicans Steud. (Melastomataceae), known as "White Leaf" or "Maria-branca," is a characteristic shrub of Cerrado ecosystems. It grows up to 2.5 m tall and is commonly found at forest edges. This species has a zoocoric dispersal mechanism, primarily mediated by birds and small mammals, making it valuable for enhancing biodiversity in restoration projects (Siqueira, 1988; Neri et al., 2005; Approbato & Godoy, 2006; Souza & Lorenzi, 2012).

Solanum paniculatum L. (Solanaceae), commonly referred to as "Jurubeba," is a thorny shrub reaching approximately 2 m in height. It is native to most of Brazil and thrives in degraded lands, pastures, and roadsides, particularly in the Cerrado biome. Its fruits are predominantly dispersed by bats and birds, aligning with its zoocoric dispersal strategy (Lorenzi, 2000; Nunes & Araújo, 2003; Sampaio, 2013).

1.2 Study Objective

Given the ecological significance of these species, the objective of this study was to develop efficient propagation protocols for producing seedlings of *Miconia albicans*, *Croton urucurana*, and *Solanum paniculatum*. This involved investigating the induction of rooting and foliar sprouting in cuttings as a means to support forest restoration efforts, particularly in degraded areas. By addressing propagation challenges, this research aims to contribute to sustainable practices in native species cultivation and ecological recovery.

2. Material and methods

2.1 Study Area

The study was conducted at Instituto São Vicente (20°23'16.80"S, 54°36'36.30"W), situated at an altitude of 661 m in the Lagoa da Cruz region, Campo Grande, Mato Grosso do Sul, Brazil. The site is approximately 10 km from the city center and encompasses a total area of 191 hectares, of which 20 hectares are designated as a legal reserve. The area includes 30 hectares dedicated to agricultural activities such as corn, bean, soybean, and arrowroot cultivation. Additionally, the site supports livestock farming, including sheep, goats, horses, cattle, pigs, and aquaculture in fish tanks.

2.2 Collection and Preparation of Cuttings

Apical cuttings measuring approximately 15 cm in length were collected from five individual plants of *Miconia albicans*, *Croton urucurana*, and *Solanum paniculatum*. A bevel cut was made at the basal end of each cutting, and the leaves were removed. Voucher specimens of the species were prepared, identified, and deposited at the Herbarium CGMS of the Federal University of Mato Grosso do Sul under accession numbers CGMS 51397, CGMS 51398, and CGMS 51399.

The cuttings were planted in 20 × 30 cm polyethylene bags containing 180 mL of water to create a mini greenhouse, sealed with a knot at the top (Figure 1).

2.3 Experimental Design

The experiment involved two primary treatments. In the first treatment (T1), indole-3-butyric acid (IBA) was applied at a concentration of 0.5% to the basal ends of the cuttings, while the second treatment (T2) served as a control without IBA application. Each treatment was tested on two substrate types: Cerrado soil and sand. The experimental setup comprised a total of 120 cuttings, with 10 replicates for each combination of treatment and substrate. Before initiating the experiment, chemical analyses were conducted to assess the composition of the substrates used (Table 1).

To evaluate the outcomes, two parameters were assessed: rooting, measured as the number of cuttings that developed roots, and leaf production, determined by counting the number of leaves per cutting. Observations for rooting and leaf sprouting were made every 15 days without disturbing the root systems inside the

Figure 1. Apical cuttings of *Solanum paniculatum*. (A) no use of regulator (B), 15 days after treatment (C) with phytoregulator (IBA), (D) after 15 days of treatment with IBA and (E) container used for treatments.

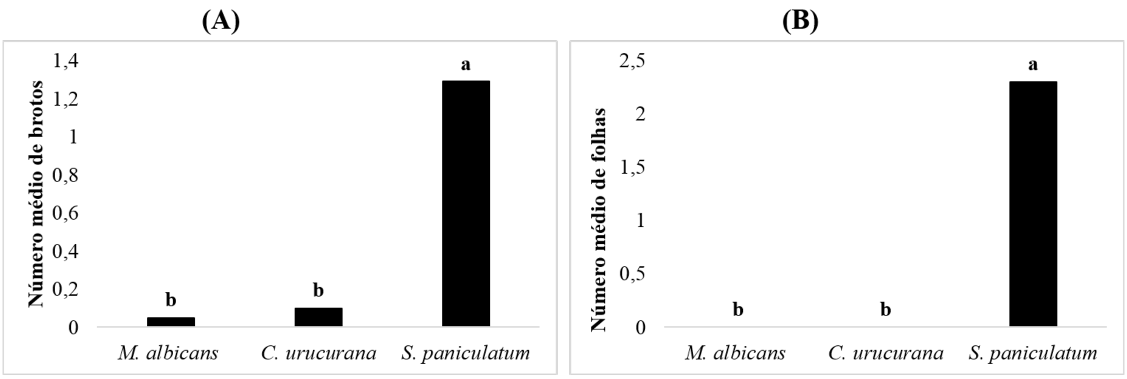

Figure 2. Average number of buds (A) and average number of leaves (B) of *Miconia albicans, Croton urucurana* and *Solanum paniculatum* cuttings. Test Tukey, $p < 0.05$.

Table 1. Chemical characteristics of the soil used in the production of seedlings.

Chemical Characteristic *	Land of Savannah Cerrado	Sand
pH – H_2O (1:2,5)	7,51	6,73
pH – $CaCl_2$ (1:2,5)	6,95	5,30
MO (g/kg)	22	20
P (mg/dm^3)	6,62	2,74
K ($cmol_c/dm^3$)	0,08	-
Ca ($cmol_c/dm^3$)	1,30	-
Mg ($cmol_c/dm^3$)	0,4	0,2
Al ($cmol_c/dm^3$)	-	-
H + Al ($cmol_c/dm^3$)	3,20	2,60
T ($cmol_c/dm^3$)	5	2,8
V%	35,7	7,1

* Soil chemical analysis performed by the Laboratory of Soils and Nutrition of Plants of Fazenda Escola / UCDB. P and K: Mehlichl; MO: Colorimetry; Ca, Mg and Al: 1M KCl; H + Al: Calcium Acetate pH 7.00.

Table 2. Root length cuttings *Miconia albicans*, *Croton urucurana* and *Solanum paniculatum*, with or no phytoregulator IBA.

Species	Com AIB *		Sem AIB *	
	Média	Variância	Média	Variância
M. albicans	0 b	0,71 b	0 b	0,71 b
C. urucurana	0 b	0,71 b	0 b	0,71 b
S. paniculatum	0,53 a	0,97 a	1,58 a	1,33 a

* Means followed by the same letter in the column do not differ statistically from each other, by the Tukey test $P < 0.05$. CV (%) = 30.70

polyethylene bags. This process was maintained for a total observation period of 208 days.

2.4 Statistical Analysis

Data were analyzed using SISVAR statistical software (Ferreira, 2000). Non-parametric Chi-square tests (Zar, 1999) were performed to compare treatments within and across species. When significant differences were detected, the means were further compared using Tukey's test at a 95% confidence level. This statistical approach ensured robust comparisons across treatments and species over the observation period.

3. Results

The type of substrate—Cerrado soil or sand—did not significantly affect the establishment of *Miconia albicans*, *Croton urucurana*, and *Solanum paniculatum* (Table 1). Regardless of the application of indole-3-butyric acid (IBA) as a propagation aid, all species showed bud formation, with *S. paniculatum* exhibiting the highest percentage of bud development. Leaf production varied significantly among the species, as shown by Tukey's test at a 5% level of significance. *Solanum paniculatum* had a mean of 2.3 leaves per cutting, whereas no leaves were observed in cuttings of *M. albicans* and *C. urucurana* (Figure 2).

Rooting was also significant between the species with or without the application of IBA (Table 2). Notably, *S. paniculatum* consistently demonstrated shoot, leaf, and root emission, independent of the substrate and uninfluenced by IBA application.

4. Discussion

The results align with findings from previous studies that explored substrate suitability and rooting in various plant species. Bao et al. (2014) reported that sand, soil, and a mix of soil, sand, and manure were unsuitable for seedling emergence in some plants, such as *Carica papaya* L., particularly when using various container types like polyethylene bags and polystyrene trays. Similar to their findings, this study observed no significant differences in seedling establishment between Cerrado soil and sand substrates for *M. albicans*, *C. urucurana*, and *S. paniculatum*. This indicates that both substrates can be effectively used for the propagation of these species.

The choice of economical and efficient propagation methods, such as the use of transparent polyethylene bags with only 180 mL of water, demonstrated a reduction in both time and cost for asexual propagation. This method proved advantageous for *S. paniculatum*, enabling rapid seedling production while minimizing expenses related to water, substrates, and phytoregulators. Da Silva et al. (2009) similarly suggested that transparent polyethylene bags serve as efficient containers for seedling development, requiring minimal water usage.

For rural producers and nurserymen, cost reduction in seedling production is crucial. Carvalho et al. (2013) highlighted that nurseries producing 400,000 coffee seedlings spend an average of $4,000 per month on irrigation. The use of minimal water per seedling, as demonstrated in this study, represents a significant economic advantage. Additionally, containers made of materials like expanded polystyrene and polypropylene are commonly used for seedling production (Filgueira, 2008), but simpler and cheaper alternatives like polyethylene bags can achieve similar results for certain species.

In terms of rooting and sprouting, *S. paniculatum* showed remarkable adaptability. Root, shoot, and leaf development occurred without the application of IBA, a finding consistent with studies on other species. For example, Hernández et al. (2013) observed minimal influence of IBA on the vegetative propagation of *Cariniana estrellensis* cuttings. Similarly, Santos et al. (2011) found that species like *Cestrum laevigatum* and *Salix humboldtiana* could root successfully without IBA. Oliveira and Ribeiro (2013) also noted that IBA application failed to enhance rooting in *Euplassa inaequalis*.

The success of rooting in *S. paniculatum* without IBA might be attributed to its inherent physiological characteristics. Rooting in plant cuttings depends on factors like the physiological condition of the parent plant, the presence of carbohydrates, and environmental conditions such as substrate type and water availability (Hartmann et al., 2002; Hess, 1969). The cuttings of *M. albicans* and *C. urucurana* collected during the vegetative period exhibited no rooting, likely due to insufficient carbohydrate reserves necessary for auxin-mediated root formation (Fachinello et al., 1994; Hartmann et al., 2002).

The collection timing for cuttings is critical. Hartmann et al. (2002) emphasized the importance of collecting cuttings during dormancy when photoassimilates are abundant. Ohland et al. (2009) found that cuttings collected in August without IBA treatment rooted better than those collected at other times, underscoring the role of collection timing. However, *S. paniculatum* exhibited rooting irrespective of the collection season, a trait also observed in species like *Bambusa vulgaris* (Gasparetto et al., 2013).

The effectiveness of IBA varies significantly across species. Stuepp et al. (2013) reported that *Melaleuca alternifolia* cuttings showed no significant differences in rooting regardless of branch position or IBA concentration. On the other hand, Ohland et al. (2009) demonstrated that specific IBA concentrations could enhance rooting in *Ficus carica* under certain conditions. The lack of rooting in *M. albicans* and *C. urucurana* despite IBA application might be due to species-specific requirements or insufficient carbohydrate reserves at the time of collection.

The findings of this study align with observations from other woody species, where rooting is influenced by environmental and physiological factors rather than solely by IBA application. Fachinello et al. (2005) noted that cuttings collected during periods of active growth, such as spring and summer, root more readily than those collected during winter when lignification is higher. This could explain the low rooting success in *M. albicans* and *C. urucurana* cuttings, as their physiological state might not have been optimal for rooting.

For species like *S. paniculatum*, the ability to root and sprout leaves without external hormonal aid highlights its potential as a robust candidate for ecological restoration and nursery production. Hartmann et al. (2002) suggested that for species with inherent rooting ability, the use of substrates like sand or soil can further enhance propagation success without the need for costly phytoregulators.

Additionally, successful propagation through cuttings can significantly reduce dependency on seeds, particularly for species with low seed production or poor germination rates (Oliveira & Ribeiro, 2013). This method is especially beneficial for reforestation projects aiming to restore degraded areas with native species.

5. Conclusion

The study demonstrated that *Solanum paniculatum* exhibits high potential for asexual propagation due to its ability to root, sprout, and develop leaves independently of substrate type or IBA application. While *Miconia albicans* and *Croton urucurana* showed limited rooting success, the findings suggest that refining propagation techniques, such as optimizing cutting collection timing and improving carbohydrate reserves, may enhance their propagation outcomes. Cost-effective methods, like the use of polyethylene bags with minimal water, were shown to be viable alternatives for large-scale seedling production. These findings provide valuable insights for the sustainable propagation of native species and their application in ecological restoration and commercial nurseries.

Author contributions

E.G. contributed to the conceptualization and data collection for the study. J.N.R. supervised the research, guided the methodology, and provided critical revisions to the manuscript. F.A.C. was involved in data interpretation and assisted in drafting and reviewing the manuscript.

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Competing financial interests

The authors have no conflict of interest.

References

Approbato, A. U., & Godoy, S. A. P. (2006). Survey of diaspores in Cerrado areas in the Municipality of Luiz Antônio, SP. Hoehnea, 33(3), 385–401.

Bao, F., Lima, L. B., & Luz, P. B. (2014). Morphological characterization of branch, seeds and seedlings of Matayba guianensis Aubl. and seedling production in different containers and substrates. Tree Review, 38(1), 63–71.

Calegari, L., Martins, S. V., Campos, L. C., Silva, E., & Gleriani, J. M. (2013). Evaluation of soil seed bank for forest restoration in Carandaí, MG. Revista Árvore, 37(5), 871–880.

Carreira, R. C. (2004). Germination in seeds of Miconia albicans (Sw.) Triana and Miconia rubiginosa (Bonpl.) DC. Melastomataceae, from the cerrado of Mogi Guaçu, SP. Master's dissertation.

Carvalho, C. H. S., Paiva, A. C. R. S., Silva, E. Q., & Custodio, A. A. (2013). Cost of production of clonal Arabica coffee seedlings produced by somatic embryogenesis. Technical Circular, 3. Brasília, DF.

Cunha, A. O., Andrade, L. A., Bruno, R. L. A., Silva, J. A. L., & Souza, V. C. (2005). Effects of substrates and vessel sizes on seedling quality of Tabebuia impetiginosa (Mart. Ex D.C.) Standl. Revista Árvore, 29(4), 507–516.

Da Silva, E. A., Maruyama, W. I., de Oliveira, A. C., & Dógenes, M. B. (2009). Effect of different substrates on the production of mangabeira seedlings (Hancornia speciosa). Revista Brasileira de Fruticultura, 31(3).

Dos Santos, J. P., Davide, A. C., Teixeira, L. A. F., Melo, A. J. S., & Melo, L. A. (2011). Rooting of woody cuttings of forest species. Hoehnea, 17(3), 293–301.

Facchinello, J. C., Hoffmann, A., & Santos, A. M. (1994). Amoreira-preta, raspberry, and blueberry: Small fruits for the south of Brazil. In Brazilian Fruit Congress, 13, Salvador (Vol. 3, pp. 989–990). Brazilian Society of Fruticulture.

Fachinello, J. C., Hoffmann, A., & Nachtigal, J. C. (2005). Propagation of fruit plants. Brasília, DF: Embrapa.

Ferraz, A. V., & Engel, V. L. (2011). Effect of tubet size on seedling quality of Hymenaea courbaril L. var. stilbocarpa (Hayne) Lee et Lang., Tabebuia chrysotricha (Mart. Ex DC.) Sandl., and Parapiptadenia rigida (Benth.) Brenan. Tree Review, 35(3), 413–423.

Ferreira, D. F. (2000). Statistical analysis through SISVAR (System for Analysis of Variance) for Windows version 4.0. In Annual Meeting of the Brazilian Region of the International Society of Biometry, 45, São Carlos (pp. 255–258). UFSCar.

Filgueira, F. A. R. (2000). New manual of olericultura: Modern agrotechnology in the production and commercialization of vegetables. Minas Gerais: UFV.

Garcia, J., Jacobson, T. K. B., Farias, J. G., & Boaventura, R. F. (2008). Effectiveness of methods to increase the germination rate of Solanum paniculatum L. seeds. Pesquisa Agropecuária Tropical, 38, 223–226.

Gasparetto, G. A., Davalo, M. J., & Rondon, J. N. (2013). Decreased production and acclimatization time of two bamboo species under greenhouse conditions. Biotemas, 26(1), 17–23.

Guimarães, M. A., Garcia, M. F. N., Damasceno, L. A., & Viana, C. S. (2012). Production of cocona and jurubeba seedlings in different types of containers. Horticultura Brasileira, 30(4), 720–725.

Hartmann, H. T., Kester, D. E., Davies, F. T. Jr., & Geneve, R. L. (2002). Plant propagation: Principles and practices (7th ed.). New Jersey: Prentice Hall.

Hernandez, W., Xavier, A., Paiva, H. N., & Wendling, I. (2013). Vegetative propagation of the pink jequitibá (Cariniana estrellensis (Raddi) Kuntze) by cuttings. Tree Review, 37(5), 955–967.

Hess, C. E. (1969). Internal and external factors regulating root initiation: Root growth. London: Butterworths.

Lorenzi, H. (2000). Weeds of Brazil - Terrestrial, aquatic, parasitic and toxic (3rd ed.). Nova Odessa: Plantarum Institute.

Lorenzi, H. (2002). Brazilian trees: A manual for identification and cultivation of native tree plants in Brazil (4th ed., Vol. 1). Nova Odessa: Plantarum Institute.

Neri, A. V., Campos, E. P., Duarte, T. M., Neto, J. A. A. M., Silva, A. F., & Valente, G. E. (2005). Regeneration of native woody species under Eucalyptus plantation in the Cerrado area of the Paraopeba National Forest, MG, Brazil. Acta Botanica Brasilica, 19(2), 369–376.

Nunes, A. P. M., & Araujo, A. C. (2003). No genotoxicity of stevioside in E. coli. In X Week of Scientific Initiation of UERJ, Rio de Janeiro (p. 15).

Ohland, T., Worse, E., Chagas, E. A., Barbosa, W., Kotz, T. E., & Daneluz, E. (2009). Rooting of apical cuttings of 'Roxo de Valinhos' fig tree as a function of the collection time and IBA. Ciência e Agrotecnologia, 33(1), 74–78.

Oliveira, M. C., & Ribeiro, J. F. (2009). Rooting of cuttings of Euplassa inaequalis (Pohl) Engl. of gallery forest in different seasons of the year. Bioscience Journal, 25(2).