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HIANKA KAROLLINY DOS SANTOS DANTAS ARAUJO

***Eugenia klotzschiana*: importância agroecológica e crescimento de mudas para
conservação e domesticação**

Ilha Solteira - SP

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PROGRAMA DE PÓS-GRADUAÇÃO EM AGRONOMIA

HIANKA KAROLLINY DOS SANTOS DANTAS ARAUJO

***Eugenia klotzschiana*: importância agroecológica e crescimento de mudas para
conservação e domesticação**

Dissertação apresentada à Universidade Estadual Paulista (UNESP), Faculdade de Engenharia, Ilha Solteira, para obtenção do título de Mestre em Agronomia.

Área de Concentração: Sistemas de Produção.

Orientador: Prof. Dr. Antonio Flávio Arruda Ferreira

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IMPACTO POTENCIAL DESTA PESQUISA

O estudo do crescimento de mudas apresenta-se como uma estratégia relevante para a conservação e a valorização de espécies frutíferas nativas do Cerrado, especialmente aquelas ainda pouco exploradas do ponto de vista agrônomo, como é o caso da *Eugenia klotzschiana* O. Berg, popularmente conhecida como pera-do-cerrado. Essa espécie encontra-se entre as frutíferas nativas mais vulneráveis do bioma, resultado direto do avanço da degradação ambiental, da fragmentação de habitats e da escassez de informações técnicas sobre seu manejo e propagação, fatores que juntos dificultam sua conservação e restringem seu aproveitamento econômico, alimentício e ornamental. Diante desse cenário, a geração de conhecimento sobre o estado da arte, o crescimento inicial e o estabelecimento de mudas torna-se essencial, pois viabiliza a produção de indivíduos sadios em menor tempo, os quais podem subsidiar ações de reintrodução em áreas degradadas e programas de restauração ecológica. Além disso, compreender os aspectos fisiológicos envolvidos no desenvolvimento das mudas contribui para a formação de bancos de germoplasma, ferramenta indispensável à manutenção da variabilidade genética da espécie. Esse conjunto de conhecimentos favorece não apenas estudos futuros sobre ecologia e melhoramento genético, mas também fortalece estratégias de domesticação, reduzindo, assim, o risco de extinção da *Eugenia klotzschiana* e ampliando seu potencial de uso sustentável.

POTENTIAL IMPACT OF THIS RESEARCH

Studying seedling growth is essential for conserving and valorizing native fruit species from the Cerrado, especially underexplored species such as *Eugenia klotzschiana* O. Berg, popularly known as pera-do-cerrado. This species is among the biome's most vulnerable native fruit trees. This is a direct consequence of advancing environmental degradation, habitat fragmentation, and a lack of technical information regarding its management and propagation. Collectively, these factors hinder conservation efforts and limit its economic, nutritional, and ornamental utility. In this context, generating knowledge on the current state of research, as well as on initial growth and seedling establishment, is essential. It enables the production of healthy plants in less time, supporting reintroduction efforts in degraded areas and ecological restoration programs. Understanding the physiological aspects of seedling development also aids in the creation of germplasm banks, an indispensable tool for maintaining the species' genetic diversity. This body of knowledge facilitates future studies on ecology and genetic

improvement, strengthens domestication strategies, reduces the risk of extinction for *Eugenia klotzschiana*, and expands its potential for sustainable use.

CERTIFICADO DE APROVAÇÃO

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Dedico este trabalho aos meus avós:
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“As raízes do estudo são amargas, mas seus frutos
são doces.” - Aristóteles

RESUMO

A pera-do-cerrado (*Eugenia klotzschiana* O. Berg) é uma frutífera nativa do Cerrado com significativo potencial alimentar, medicinal e econômico, porém ainda pouco explorada do ponto de vista agrônomo. A degradação progressiva do bioma e a carência de técnicas eficientes de propagação limitam sua conservação e domesticação. Esta dissertação objetivou investigar a importância agroecológica da espécie, sintetizar conhecimento sobre suas técnicas de propagação e conservação, e desenvolver protocolos para produção de mudas de alta qualidade. O trabalho foi estruturado em uma revisão sistemática seguindo diretrizes PRISMA, sintetizando oito publicações sobre usos tradicionais, propagação e conservação da espécie. Os resultados evidenciaram crescimento nas publicações entre 2020-2024, porém identificaram lacunas significativas em técnicas eficientes de propagação, particularmente devido à recalcitrância das sementes. Além disso, também foi realizada uma pesquisa experimental em delineamento fatorial 3×5 , avaliando três telas de sombreamento (fotosseletiva vermelha, termorreletora e monofilamento preto) combinadas com cinco doses de fertilizante de liberação controlada (0, 16, 24, 32 e 40 g vaso⁻¹). Aos 120 dias após o transplante, foram mensuradas trocas gasosas, crescimento, biomassa e desenvolveu-se um Índice de Qualidade de Muda (IQM_PC) baseado em análise multivariada. A tela termorreletora proporcionou superior desempenho fisiológico, atingindo taxa fotossintética máxima de 9,58 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ na dose de 20,28 g vaso⁻¹, com elevada eficiência do uso da água e crescimento estrutural robusto. Foi identificada faixa ótima de adubação entre 17-21 g vaso⁻¹, com máxima eficiência técnica em 18⁻¹9 g vaso⁻¹, resultando em mudas de alta qualidade (IQM_PC = 57,79). Doses superiores induziram estresse salino manifesto por redução em condutância estomática, transpiração e fixação de carbono. O IQM_PC demonstrou-se ferramenta robusta. Análises multivariadas confirmaram que qualidade de muda é determinada primariamente por crescimento estrutural e acúmulo de biomassa, não por eficiência fisiológica instantânea. A plasticidade morfofisiológica das mudas foi evidenciada pela capacidade de adaptar respostas fisiológicas e alocação de biomassa conforme condições luminosas e nutricionais. Por fim, recomenda-se a produção de mudas de *E. klotzschiana* sob tela termorreletora (35% sombreamento) associada a 18⁻¹9 g vaso⁻¹ de fertilizante de liberação controlada 15-09⁻¹2 em substratos de 280 mL. Os resultados consolidam a base científica necessária à domesticação e produção de mudas da espécie, oferecendo um modelo replicável para outras frutíferas nativas do Cerrado. A dissertação demonstra ser possível conciliar conservação da biodiversidade com desenvolvimento econômico sustentável, contribuindo para valorização e preservação de patrimônio genético único e ameaçado.

Palavras-chave: pera do Cerrado; Cerrado, qualidade de mudas; telas de sombreamento, fertilização de liberação controlada; propagação de espécies nativas; conservação.

ABSTRACT

The pera-do-cerrado (*Eugenia klotzschiana* O. Berg) is a fruit-bearing species native to the Cerrado biome with significant nutritional, medicinal, and economic potential, yet it remains underexplored from an agronomic perspective. Progressive biome degradation and a lack of efficient propagation techniques limit its conservation and domestication. This dissertation aimed to investigate the species' agroecological importance, synthesize knowledge regarding its propagation and conservation techniques, and develop protocols for high-quality seedling production. The work was structured as a systematic review following PRISMA guidelines, synthesizing eight publications on the species' traditional uses, propagation, and conservation. Results showed an increase in publications between 2020 and 2024 but identified significant gaps regarding efficient propagation techniques, particularly due to seed recalcitrance. Additionally, an experimental study was conducted using a 3×5 factorial design, evaluating three types of shade netting (red photosensitive, heat-reflecting, and black monofilament) combined with five doses of controlled-release fertilizer (0, 16, 24, 32, and 40 g pot⁻¹). At 120 days after transplanting, gas exchange, growth, and biomass were measured, and a Seedling Quality Index (IQM_PC) was developed based on multivariate analysis. The heat-reflecting netting yielded superior physiological performance, achieving a maximum photosynthetic rate of 9.58 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ at a dose of 20.28 g pot⁻¹, alongside high water-use efficiency and robust structural growth. An optimal fertilization range of 17–21 g pot⁻¹ was identified, with maximum technical efficiency at 18–19 g pot⁻¹, resulting in high-quality seedlings (IQM_PC = 57.79). Higher doses induced salt stress, manifested by a reduction in stomatal conductance, transpiration, and carbon fixation. The IQM_PC proved to be a robust tool. Multivariate analyses confirmed that seedling quality is determined primarily by structural growth and biomass accumulation, rather than by instantaneous physiological efficiency. The seedlings' morphophysiological plasticity was evidenced by their ability to adjust physiological responses and biomass allocation according to light and nutritional conditions. Finally, the production of *E. klotzschiana* seedlings is recommended using heat-reflecting netting (35% shading) combined with 18–19 g pot⁻¹ of 15-09-12 controlled-release fertilizer in 280 mL substrate volumes. These results consolidate the scientific foundation required for the domestication and seedling production of this species, offering a replicable model for other native Cerrado fruit trees. The dissertation demonstrates the feasibility of reconciling biodiversity conservation with sustainable economic development, thereby contributing to the valorization and preservation of a unique and threatened genetic heritage.

Keywords: pera do Cerrado; Cerrado, seedling quality; shade nets; controlled-release fertilization; native species propagation; conservation.

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2. TRADITIONAL USES, PROPAGATION, AND CONSERVATION OF *EUGENIA KLOTZSCHIANA*: AN UNDERSTUDIED FRUIT TREE FROM THE BRAZILIAN CERRADO

ABSTRACT

This study evaluated traditional uses, propagation methods, and conservation strategies of *Eugenia klotzschiana* to support its sustainable management and preservation amid the broader context of Cerrado degradation. A systematic literature review following PRISMA guidelines was conducted using Scopus, Web of Science, and Google Scholar, alongside manual searches, considering studies published up to December 2024. Eight selected articles addressed conservation, traditional uses, medicinal potential, seed propagation, and vegetative techniques, including *in vitro* cultivation. Despite significant nutritional, medicinal, and ecological potential, the species faces challenges due to recalcitrant seeds and limitations in vegetative propagation methods. The reviewed studies emphasize developing efficient propagation protocols and sustainable management practices, such as germplasm banks and reintroduction programs. Without intervention, wild *E. klotzschiana* populations could decline by 30% over 20 years due to habitat loss and climate change, highlighting increasing extinction risks. Its decline indicates on going Cerrado degradation. While highly relevant to biodiversity and local communities, *E. klotzschiana*'s conservation is hindered by propagation and management challenges. Integrating traditional knowledge, research, and conservation strategies is essential. This integration fosters a collaborative adaptive co-management model between local communities and scientists—a cyclical process of monitoring, learning, and adjusting to ensure long-term sustainability and socioeconomic benefits.

Keywords: Myrtaceae; Cerrado; Ethnobotany; Recalcitrant seeds, *In vitro* culture, Germplasm banks; Extinction risk assessment.

2.1 INTRODUCTION

Eugenia klotzschiana O. Berg. is recognized for its significance in both nutritional and biological conservation contexts. This species possesses notable food and medicinal properties, highlighting its value to local communities and traditional populations. In addition to its use as a food source through fruit consumption, it contains bioactive compounds with potential health benefits, supporting its classification as a nutraceutical resource. Furthermore, ‘*Pera-do-Cerrado*’, as it is commonly known, serves as a representative species of regional biodiversity and contributes substantially to the maintenance of the ecosystems in which it occurs (Carneiro *et al.*, 2017a; Carneiro *et al.*, 2017b).

Propagation and conservation practices for *Eugenia klotzschiana* are of significant interest to researchers, farmers, and traditional communities due to its socioeconomic and ecological potential. As noted by Barbosa, Costa, and Sanches (2024), the recognition and

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

3. RELAÇÃO ENTRE TELAS DE SOMBREAMENTO E DOSES DE FERTILIZANTE DE LIBERAÇÃO CONTROLADA NAS TROCAS GASOSAS E NO CRESCIMENTO DE MUDAS DE PERA-DO-CERRADO

RESUMO

A produção de mudas de qualidade é essencial para o sucesso de cultivos comerciais e projetos de restauração de espécies nativas. A pera-do-cerrado (*Eugenia klotzschiana* O. Berg) é uma frutífera nativa do Cerrado com limitado conhecimento científico sobre suas técnicas de propagação. Este trabalho avaliou a plasticidade morfofisiológica de mudas de pera-do-cerrado em resposta a três telas de sombreamento (fotosselativa vermelha, termorrefletora e monofilamento preto) e cinco doses de fertilizante de liberação controlada (0, 16, 24, 32 e 40 g vaso⁻¹). O experimento foi conduzido em delineamento inteiramente casualizado com esquema fatorial 3 × 5. Aos 120 dias após o transplântio, foram mensurados: trocas gasosas (fotossíntese, transpiração, condutância estomática, concentração interna de CO₂), parâmetros de crescimento (diâmetro do caule, número de folhas, comprimento da parte aérea e do sistema radicular, biomassas secas) e desenvolvimento de um Índice de Qualidade de Mudas (IQM_PC) baseado em análise multivariada. Os resultados demonstraram que a tela termorrefletora proporcionou o melhor desempenho fisiológico, atingindo taxa fotossintética máxima de 9,58 µmol CO₂ m⁻² s⁻¹ na dose de 20,28 g vaso⁻¹, com elevada eficiência do uso da água e crescimento. A tela fotosselativa vermelha induziu elevada eficiência intrínseca do uso da água (52,20), porém com menor acúmulo de biomassa. O monofilamento preto limitou o desempenho fotossintético e fisiológico, apesar de promover alongamento do sistema radicular. Uma faixa ótima de adubação foi identificada entre 17 e 21 g vaso⁻¹, com máxima eficiência técnica em 18,72 g vaso⁻¹, resultando em mudas de alta qualidade (IQM_PC = 57,79). Além disso, doses elevadas induziram estresse salino, reduzindo condutância estomática, transpiração e fixação de carbono. O IQM_PC, integrador de seis variáveis morfo métricas via componentes principais, demonstrou-se uma ferramenta robusta para avaliação objetiva da qualidade, explicando 63,39% da variância total. Recomenda-se a produção de mudas de *E. klotzschiana* sob viveiros com tela termorrefletora e substrato com 18-19 g vaso⁻¹ de fertilizante 15-09-12, obtendo mudas de elevada qualidade.

Palavras-chave: *Eugenia klotzschiana*, qualidade de mudas, radiação luminosa, nutrição mineral, Cerrado

ABSTRACT

Producing high-quality seedlings is essential for the success of commercial crops and native species restoration projects. *Eugenia klotzschiana* O. Berg (known as "pera-do-cerrado") is a fruit-bearing species native to the Cerrado, yet scientific knowledge regarding its propagation techniques remains limited. This study evaluated the morphophysiological plasticity of *E. klotzschiana* seedlings in response to three types of shade netting (red photosensitive, thermoreflective, and black monofilament) and five rates of controlled-release fertilizer (0, 16, 24, 32, and 40 g pot⁻¹). The experiment followed a completely randomized design with a 3 × 5 factorial arrangement. At 120 days after transplanting, the following were measured: gas exchange (photosynthesis, transpiration, stomatal conductance, internal CO₂ concentration), growth parameters (stem diameter, number of leaves, shoot and root system lengths, dry biomass), and the development of a Seedling Quality Index (IQM_PC) based on multivariate analysis. The results showed that the thermoreflective netting yielded the best physiological performance, achieving a maximum photosynthetic rate of 9.58 μmol CO₂ m⁻² s⁻¹ at a fertilizer rate of 20.28 g pot⁻¹, alongside high water-use efficiency and growth. The red photosensitive netting induced high intrinsic water-use efficiency (52.20) but resulted in lower biomass accumulation. The black monofilament netting limited photosynthetic and physiological performance, despite promoting root system elongation. An optimal fertilization range was identified between 17 and 21 g pot⁻¹, with maximum technical efficiency at 18.72 g pot⁻¹, resulting in high-quality seedlings (IQM_PC = 57.79). Furthermore, high doses induced salt stress, reducing stomatal conductance, transpiration, and carbon fixation. The IQM_PC, an integrator of six morphometric variables via principal component analysis, proved to be a robust tool for objective quality assessment, explaining 63.39% of the total variance. Producing *E. klotzschiana* seedlings in nurseries equipped with heat-reflecting netting and using a substrate containing 18–19 g pot⁻¹ of 15-09-12 fertilizer is recommended to obtain high-quality seedlings.

Keywords: *Eugenia klotzschiana*, seedling quality, light radiation, mineral nutrition, Cerrado

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