



## CAN ORGANIC MULCHINGS BE AN ALTERNATIVE METHOD FOR CONTROLLING WEED COMPETITION IN ECOSYSTEM RESTORATION?

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### ABSTRACT

**Introduction:** The Atlantic Forest, a highly threatened biome, suffers from the presence of exotic grasses that compromise restoration efforts by competing with native species. Although herbicide use is common, it poses environmental and health risks. As an alternative, mulching can help manage weed competition.

**Objective:** The objective of this study was to evaluate the effect of castor bean (*Ricinus communis* L.) and brachiaria straw (*Urochloa decumbens* (Stapf) R.D. Webster) mulching on weed competition in an area undergoing ecological restoration.

**Method:** Seedlings of six native forest species were planted in beds prepared with two types of management (circular crowning and half-moon) and three mulching treatments (straw, castor bean, and straw + castor bean). After four months, competing plants were collected to determine aboveground dry mass (ADM), obtained by drying in a forced-air oven (65 °C, 72 h) and expressed in g/m<sup>2</sup>. Data were analyzed using the non-parametric Kruskal-Wallis test followed by Dunn-Bonferroni post-hoc ( $p < 0.05$ ).

**Results and Discussion:** Weed competition was significantly influenced by the type of mulching ( $p < 0.05$ ). Crowning presented the highest ADM of competing plants, making it the least effective in controlling weed competition. Treatments with straw recorded the lowest ADM, highlighting their efficacy. Castor bean was not effective due to low coverage and greater degradation. The half-moon reduced ADM by 3.5 times compared to crowning, removing part of the seed bank and exposing more compacted soils.

**Research Implications:** This study provides important insights for the sustainable management of weed competition in ecological restoration projects. Its results can guide practices in environmental conservation, agroecology, and vegetation management policies, promoting alternative techniques more aligned with sustainability principles.

**Originality/Value:** The study stands out for comparatively evaluating different management practices (crowning and half-moon) combined with mulching types in the context of ecological restoration, an interaction that is still little explored, particularly for the half-moon. Its results contribute to the literature by offering sustainable alternatives to herbicide use.

**Keywords:** Atlantic Forest, Exotic Species, Castor Bean, *Ricinus Communis*, Brachiaria, *Urochloa Decumbens*.

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## OS MULCHINGS ORGÂNICOS PODEM SER UM MÉTODO ALTERNATIVO PARA O CONTROLE DA MATOCOMPETIÇÃO NA RESTAURAÇÃO DE ECOSISTEMAS?

### RESUMO

**Introdução:** A Mata Atlântica, altamente ameaçada, sofre com a presença de gramíneas exóticas, que comprometem a restauração ao competir com espécies nativas. O uso de herbicidas, embora comum, gera riscos ambientais e à saúde. Como alternativa, a cobertura morta (*mulching*) pode auxiliar no manejo da matocompetição.

**Objetivo:** O objetivo deste estudo foi avaliar o efeito da cobertura morta de mamona (*Ricinus communis* L.) e da palha de capim-braquiária (*Urochloa decumbens* (Stapf) R.D. Webster) sobre a matocompetição em uma área em processo de restauração ecológica.

**Metodologia:** Foram plantadas mudas de seis espécies florestais nativas em berços preparados com dois tipos de manejo (coroamento circular e meia-lua) e três tratamentos de *mulching* (palha, mamona e palha + mamona). Após quatro meses, as plantas competidoras foram coletadas para determinação da massa seca da parte aérea (MSA), obtida por secagem em estufa de circulação forçada de ar (65 °C, 72 h) e expressa em g/m<sup>2</sup>. Os dados foram analisados pelo teste não paramétrico de Kruskal-Wallis seguido do post-hoc de Dunn-Bonferroni ( $p < 0,05$ ).

**Resultados e Discussão:** A matocompetição foi influenciada significativamente pelos tipos de *mulching* ( $p < 0,05$ ). O coroamento apresentou a maior MSA de plantas competidoras, sendo o menos eficiente no controle da matocompetição. Tratamentos com palha registraram as menores MSA, evidenciando sua eficácia. A mamona não se mostrou eficiente devido à baixa cobertura e maior degradação. A meia-lua reduziu a MSA em 3,5 vezes em relação ao coroamento, removendo parte do banco de sementes e expondo solos mais compactados.

**Implicações da Pesquisa:** Esta pesquisa oferece *insights* importantes para o manejo sustentável da matocompetição em projetos de restauração ecológica. Seus resultados podem orientar práticas de conservação ambiental, agroecologia e políticas de manejo de vegetação, promovendo técnicas alternativas mais alinhadas aos princípios de sustentabilidade.

**Originalidade/Valor:** O estudo se destaca por avaliar comparativamente diferentes manejos (coroamento e meia-lua) associados a tipos de *mulching* no contexto da restauração ecológica, uma interação ainda pouco explorada, especialmente no caso da meia-lua. Seus resultados contribuem para a literatura ao oferecer alternativas sustentáveis ao uso de herbicidas.

**Palavras-chave:** Mata Atlântica, Espécies Exóticas, Mamona, *Ricinus Communis*, Capim-Braquiária, *Urochloa Decumbens*.

## ¿PUEDEN LOS *MULCHINGS* ORGÁNICOS SER UN MÉTODO ALTERNATIVO PARA EL CONTROL DE LA MATOCOMPETENCIA EN LA RESTAURACIÓN DE ECOSISTEMAS?

### RESUMEN

**Introducción:** La Mata Atlántica, altamente amenazada, se ve afectada por la presencia de gramíneas exóticas que comprometen la restauración al competir con especies nativas. Aunque el uso de herbicidas es común, genera riesgos ambientales y para la salud. Como alternativa, la cobertura de mulch puede ayudar en el manejo de la matocompetencia.

**Objetivo:** El objetivo de este estudio fue evaluar el efecto del *mulching* de ricino (*Ricinus communis* L.) y de la paja de pasto braquiaria (*Urochloa decumbens* (Stapf) R.D. Webster) sobre la matocompetencia en un área en proceso de restauración ecológica.

**Método:** Se plantaron plántulas de seis especies forestales nativas en camas preparadas con dos tipos de manejo (coronamiento circular y media luna) y tres tratamientos de *mulching* (paja, ricino y paja + ricino). Después de cuatro meses, se recolectaron las plantas competidoras para determinar la masa seca aérea (MSA), obtenida mediante secado en estufa de circulación forzada de aire (65 °C, 72 h) y expresada en g/m<sup>2</sup>. Los datos se analizaron mediante la prueba no paramétrica de Kruskal-Wallis seguida del post-hoc de Dunn-Bonferroni ( $p < 0,05$ ).



**Resultados y Discusión:** La matocompetencia se vio significativamente influenciada por los tipos de *mulchings* ( $p < 0,05$ ). El coronamiento presentó la mayor MSA de plantas competidoras, siendo el menos eficiente en el control de la matocompetencia. Los tratamientos con paja registraron las menores MSA, evidenciando su eficacia. El ricino no fue eficiente debido a la baja cobertura y mayor degradación. La media luna redujo la MSA 3,5 veces en relación con el coronamiento, removiendo parte del banco de semillas y exponiendo suelos más compactados.

**Implicaciones de la investigación:** Esta investigación proporciona importantes conocimientos para el manejo sostenible de la matocompetencia en proyectos de restauración ecológica. Sus resultados pueden orientar prácticas de conservación ambiental, agroecología y políticas de manejo de la vegetación, promoviendo técnicas alternativas más alineadas con los principios de sostenibilidad.

**Originalidad/Valor:** El estudio se destaca por evaluar comparativamente diferentes manejos (coronamiento y media luna) asociados a tipos de *mulchings* en el contexto de la restauración ecológica, una interacción aún poco explorada, especialmente en el caso de la media luna. Sus resultados contribuyen a la literatura al ofrecer alternativas sostenibles al uso de herbicidas.

**Palabras clave:** Mata Atlántica, Especies Exóticas, Ricino, *Ricinus Communis*, Pasto Braquiaria, *Urochloa Decumbens*.

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## 1 INTRODUCTION

The Atlantic Forest is considered one of the global hotspots for biodiversity conservation, as it is one of the most biodiverse ecosystems on the planet and, at the same time, is extremely threatened (Cruz *et al.*, 2018). It is estimated that only about 12.5% of its original forest cover remains (Barretto & Catharino, 2022). In addition, the presence of exotic grasses, usually associated with the conversion of areas into pastures, can compromise the recovery actions of these environments due to competition with native species (Mantoani & Torezan, 2023).

Several studies have reported the impacts of exotic grasses on the establishment of native species (Chemin *et al.*, 2025; Rabelo *et al.*, 2023; Ruas *et al.*, 2024). In this context, herbicides have been widely used in the management of invasive species, because they are considered economically viable (Assis *et al.*, 2021). However, the use of chemical treatments raises concerns about the contamination of water resources, the impacts on non-target organisms, the poisoning of workers (Weidlich *et al.*, 2020) and, in the short term, the commitment of seedlings of native species (Mantoani & Torezan, 2023).

Thus, alternative methods for the management of macrocompetition are necessary, such as the use of different soil covers, called *mulching*. *Mulchings* act as a barrier to germination, since invasive grasses are generally photoblastic positive due to the small size of their seeds



(Silva & Vieira, 2017). Additionally, *mulching* can provide a reduction in soil temperature and erosion, increase in soil moisture, increase soil fauna richness and promote nutrient cycling (El-Beltagi *et al.*, 2022).

Given the need to promote alternative methods for the control of competing species, this study aimed to evaluate the effect of mulch of castor bean (*Ricinus communis* L.) and brachiaria grass straw (*Urochloa decumbens* (Stapf) R.D. Webster) on competition in an area undergoing ecological restoration.

## 2 METHODOLOGY

### 2.1 STUDY AREA

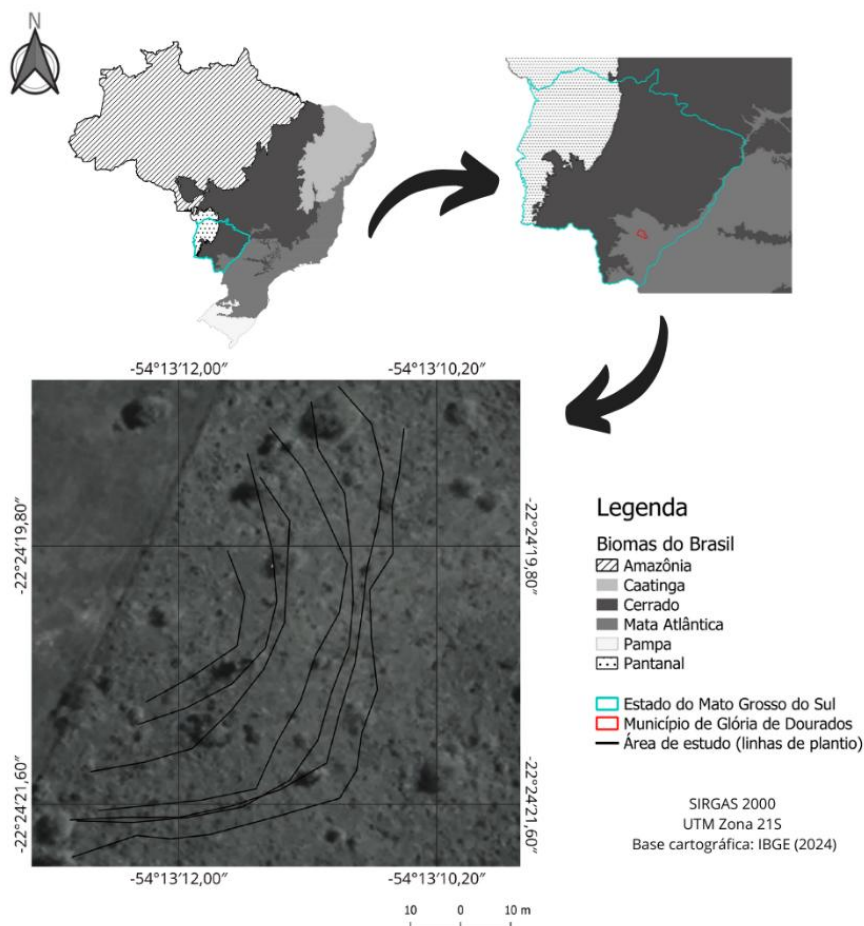
The experiment was conducted in an area in the process of restoration, located in the Municipal Natural Park of Glória de Dourados (PNMGD), in the municipality of Glória de Dourados, Mato Grosso do Sul (MS), at coordinates 22°24'21.60"S and 54°13'10.20"W (Figure 1).

The study area is located in the Atlantic Forest biome, in a forest formation of the Semideciduous Seasonal Forest type (IBGE, 2012). The regional climate is classified, according to Köppen, as Cwa (humid subtropical), characterized by dry winters and rainy summers, with average temperatures below 18 °C in the coldest month and above 22 °C in the warmest month (Da Silva *et al.*, 2022).



**Figure 1**

*Location of the study area in the municipality of Glória de Dourados, Mato Grosso do Sul.*



Source: Elaborated from data from the Brazilian Institute of Geography and Statistics - IBGE (2024).

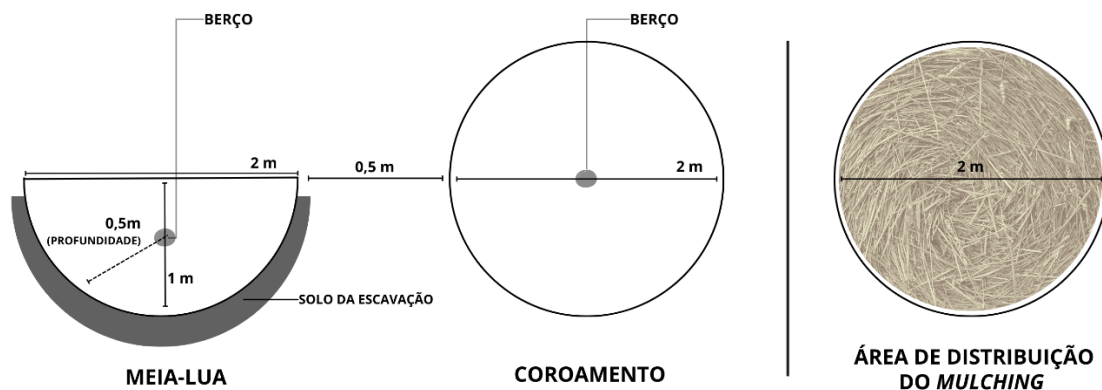
## 2.2 EXPERIMENTAL DESIGN

For the restoration of the area were planted seedlings of six native forest species: *Schinus terebinthifolia* Raddi, *Genipa americana* L., *Jacaratia spinosa* (Aubl.) A.DC., *Triplaris americana* L., *Sapindus saponaria* L. and *Enterolobium contortisiliquum* (Vell.) Morong. The preparation of the cribs included two managements (circular crowning and half-moon), with spacing of 0.5 m between treatments, and three types of *mulching* (straw, castor bean and straw + castor bean), according to the dimensions presented in Figure 2.



**Figure 2**

*Half-moon dimensions, crowning and mulching used in the experiment.*



The straw was obtained from the brachiaria grass (*Urochloa decumbens* (Stapf) R.D. Webster), obtained by soil gradation and applied in a layer of 30 cm thick. The *mulching* of castor bean (*Ricinus communis* L.) consisted of the ground aerial part: in the exclusive treatments of castor bean a wheelbarrow per cradle ( $\sim 0.028 \text{ m}^3$ ) was applied and, in the treatments with straw + castor bean, half of this volume ( $\sim 0.014 \text{ m}^3$ ). The *mulchings* were distributed in a circular area of 2 m in diameter around each seedling. Before the installation of the experiment, the area was graded for the control of competing species.

The experimental design was completely randomized (DIC), composed of the following treatments: T1 - Half moon; T2 - Crowning; T3 - Half moon + straw; T4 - Crowning + straw; T5 - Half moon + castor bean; T6 - Crowning + castor bean; T7 - Half moon + straw + castor bean; T8 - Crowning + straw + castor bean. Each treatment had five replicates per species.

### 2.3 SAMPLING OF MATOCOMPETITION

The evaluation of macrocompetition was carried out four months after the installation of the experiment, in September 2024. For field sampling, a metal circle of galvanized wire was positioned around each seedling, 2 m in diameter, precisely delimiting the area of the treatments. All individuals within the circle were considered competing plants, except the species planted in the restoration process. The collection was performed manually.

Subsequently, the competing plants were sent to the laboratory to determine the dry mass of the aerial part (MSA). The material was packed in paper envelopes of known mass and dried in an oven of forced air circulation at  $65^\circ\text{C}$  for 72 hours until it reached constant mass, and then weighed on a semi-analytical precision scale, according to the procedure described by



De Souza *et al.* (2002). The MSA was expressed per unit area ( $\text{g/m}^2$ ), obtained by the ratio between the dry mass of the sample (g) and the area of the sampling circle ( $3.14 \text{ m}^2$ ), according to the formula:

$$\text{MSA (g/m}^2\text{)} = \frac{\text{Massa seca da amostra (g)}}{\pi \cdot r^2} \quad (1)$$

where:

MSA ( $\text{g/m}^2$ ) = dry shoot mass of competing vegetation by area

$\pi = 3.14$

$r$  = radius of the sampling circle (m), where  $r = 1$

## 2.4 STATISTICAL ANALYSIS

All analyses were conducted in R software, version 4.3.1 (R Core Team, 2023). The MSA data ( $\text{g/m}^2$ ) of the competing plants were evaluated for normality (Shapiro-Wilk) and homoscedasticity (Levene). In the absence of normality, even after transformation, the nonparametric Kruskal-Wallis test was applied, followed by Dunn's post-hoc with Bonferroni correction ( $p < 0.05$ ), using the "statix" package (Kassambara, 2023).

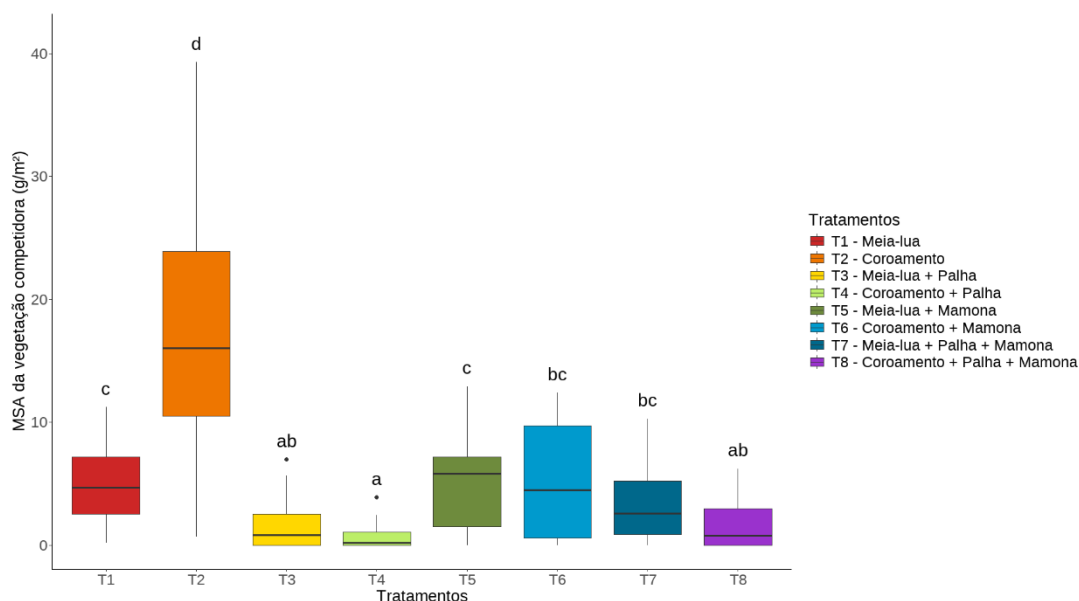
## 3 RESULTSS AND DISCUSSÕES

The total sampled area was approximately  $754 \text{ m}^2$ . Mato competition was significantly influenced by the different types of *mulchings*, with statistical differences between some treatments ( $p < 0.05$ ) (Figure 3). The crowning (T2) presented the highest SAM ( $\text{g} / \text{m}^2$ ) of competing plants, differentiating from the others and demonstrating to be the least efficient treatment for the control of competition. Similar results were reported by Böhlenius and Övergaard (2015), who found less effectiveness of manual methods of vegetation control compared to mulch with polypropylene plastic.



**Figure 3**

Aerial dry mass ( $\text{g/m}^2$ ) of competing plants per treatment. Treatments with the same letter do not differ (Kruskal-Wallis followed by Dunn-Bonferroni,  $p < 0.05$ ).



In contrast, the treatment with crown and straw (T4) presented the lowest MSA ( $\text{g/m}^2$ ) of competing plants, with an average of  $0.66 \text{ g/m}^2$ . Other straw treatments were also among those that registered the lowest MSA values, such as straw and castor bean crowning (T8) and half-moon with straw (T3), with averages of  $1.63 \text{ g/m}^2$  and  $1.64 \text{ g/m}^2$ , respectively. These results reinforce the efficiency of straw as *mulching* in reducing macrocompetition and are in line with findings in the literature.

Francisco *et al.* (2022), who also used *Urochloa decumbens* straw as *mulching*, reported an 80.6% reduction in the presence of exotic grasses compared to control. Similarly, El-Metwally *et al.* (2022), when evaluating different types of coverage, found that *mulching* with peanut straw was the most effective, with effects comparable to the herbicide oxadiargyl. Therefore, the use of straw *mulching* is configured as an ecological alternative for the control of macrocompetition, since it prevents the incidence of light in the soil and, consequently, reduces the germination of seeds of competing plants (El-Beltagi *et al.*, 2022).

The results showed that the use of a competing species, *U. decumbens*, as *mulching* did not promote increased macrocompetition, unlike expected. In general, coatings containing seeds, such as straw, can favor the germination of competing plants (Prem *et al.*, 2020). Therefore, the *mulching* of *U. decumbens* may also have exerted intraspecific allelopathic effects, that is, interfering with the germination and development of individuals of the species itself.



Although the interspecific allelopathic effects (between different species) of this grass are already well documented in agricultural cultivars (Rodrigues *et al.*, 2012) and native species (Barbosa *et al.*, 2008), there is also evidence of intraspecific competition (Martins *et al.*, 2018). Thus, in addition to acting as a physical barrier to germination, *mulching* may be associated with chemical barriers resulting from the release of allelochemicals.

Oliveira *et al.* (2014) observed that the reduction of macrocompetition by the use of *U. ruziziensis* cover suggests that the inhibitory effects may be more chemical than physical in nature, since there was no significant difference in macrocompetition with the increase in the level of mulch. In contrast, Francisco *et al.* (2022) indicated that there is an ideal *mulching* height of *U. decumbens*, located between 21 and 37 cm.

On the other hand, the castor bean was not efficient in the control of competing species, since the treatment with half-moon associated with castor bean (T5) does not differ from the treatment with isolated half-moon (T1). Thus, the application of this coverage is not recommended for the management of competition due to unfavorable cost-benefit ratio.

The low effectiveness may be related to the height of the applied layer, which made it more susceptible to burial, as well as to the greater degradation of the material observed during the experiment. In addition, unlike straw, which has openings allowing seeds from the dispersion to penetrate and remain in greater depth without exposure to light, the castor bean *mulching* keeps the newly arrived propagules on the surface, acting only as a physical barrier on the seed bank of the area.

The MSA ( $\text{g/m}^2$ ) of competing plants was approximately 3.5 times lower in the treatment with half-moon (T1) compared to crowning (T2), with averages of  $4.79 \text{ g/m}^2$  and  $16.8 \text{ g/m}^2$ , respectively. The excavation of the half-moon (0.5m deep) may have removed part of the seed bank of the competitors. In addition, it exposed more compacted soil layers, since compaction tends to intensify with depth (Sartor *et al.*, 2020), reducing the development of competing plants due to the physical impediment to root penetration (Da Silva, 2021). Therefore, in the absence of *mulchings*, the handling by half-moon proves to be more effective in controlling macrocompetition than circular crowning.

In the present study, although the competing vegetation of the area was predominantly composed of *U. decumbens*, the identification of the competing species was not performed, so additional investigations are needed to evaluate the efficiency of the coverages in the control of different species. Studies indicate that large-leaved ruderal grasses and grasses have different responses according to the type of *mulching* used (Abouziena *et al.*, 2015), and that exotic grasses tend to present competitive superiority over native grasses (Duell *et al.*, 2021).



Finally, *mulchings* can be inorganic, such as plastic films, or organic, from plant and animal matter (El-Beltagi *et al.*, 2022). However, organic *mulchings* are an ecologically viable alternative for the control of macrocompetition, as observed in this study, in addition to favoring the establishment and survival of seedlings in ecological restoration projects (Francisco *et al.*, 2022).

#### 4 CONCLUSION

Mulching of *U. decumbens* straw proved to be efficient in the control of competing species, unlike *mulching* of castor bean (*R. communis*), which showed less effectiveness. Thus, it is recommended the use of *U. decumbens* straw *mulching* as an ecologically viable alternative for the management of macrocompetition in ecological restoration projects. In addition, in the absence of *mulching*, the management of half-moon is recommended, since it was about 3.5 times more efficient in controlling macrocompetition than circular crowning.

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