

## Efficiency of Cardboard Crowning on the Suppression of Invasive Alien Grasses

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### Abstract

Invasive exotic grasses are among the biggest obstacles to the success of reforestation projects. The aim of this study was to evaluate the efficiency of the crowning with cardboard in suppressing the grasses *Urochloa humidicola* and *Megathyrsus maximus* aiming its use in reforestation areas. A field experiment was installed in a completely randomized design with two treatments consisted of crowning with cardboard and without crowning (control). The crowning with cardboard caused a progressive reduction of the biomass and was effective in causing senescence of both grasses in 80% or more of the crowning area between 20 and 50 days after the crowning (F test;  $p < 0,05$ ). These results demonstrate the effectiveness and potential of using the crowning with cardboard to control alien grass species in reforestation areas. This method brings as an innovation the possibility of placing cardboard directly on the grass after mowing, allowing greater simplicity and lower operating cost.

**Keywords:** grasses suppression, reforestation, weed competition.

### 1. INTRODUCTION AND OBJECTIVES

The main objective of planting natural forests in Brazil is to restore forest ecosystems, previously suppressed, in areas of permanent preservation and legal reserve of rural properties, as determined by the Brazilian Forest Code (Law 12.651, of May 25, 2012). These areas are generally pasture areas, usually dominated by exotic grasses that are difficult to eliminate and replace with a biodiverse and multi-stratified forest vegetation (Dias *et al.*, 2013). Several African grasses brought to Brazil and used as fodder have spread over large areas and alter the evolution of native species by competition for essential resources (water, light, nutrients and space) or allelopathy (Martins *et al.*, 2007; Santos *et al.*, 2019ab). Notorious examples in Brazil include Molasses grass (*Melinis minutiflora*) in tropical savanna (Hoffmann *et al.*, 2004; Rossi *et al.*, 2014), Palisade signalgrass (*Urochloa brizantha*) in savanna (Gorgone-Barbosa *et al.*, 2015), Signalgrass

(*Urochloa decumbens*) in tropical forest/savanna (Silvério *et al.*, 2013) and Guinea grass (*Megathyrsus maximus*) in tropical forest and grassland (Dias *et al.*, 2013).

Control of fast-growing exotic grass species is one of the main management practices necessary in the initial stages of reforestation in tropical environments, since these grasses can reduce the growth of the trees and impede forest regeneration (Silva, 2012; Resende & Leles, 2017). Therefore, active control interventions are necessary, usually in the form of mechanical, chemical and/ or bioherbicide control (Lake & Minter, 2018; Benites *et al.*, 2020). While these control methods can be effective, they require follow-up applications, and thus, can be exorbitantly expensive (Resende & Leles, 2017; Quirion *et al.*, 2018). In Rio de Janeiro state, southeast Brazil, reforestation costs per hectare of Atlantic Forest can exceed US\$ 6.500,00, due to the necessary three-year maintenance period for planted areas, including 8 to 12 interventions, involving crowning of seedlings and mowing (Leles *et al.*, 2015). These

operations are frequently neglected due to either difficulty with access or to the high costs involved, often leading to reforestation failure (Toledo *et al.*, 1996; Wittenberg & Cock, 2001; Monquero *et al.*, 2011; Santos *et al.*, 2019).

In this sense, crowning seedlings with cardboard has been proposed as an efficient and low-cost alternative for controlling weed competition in reforestation areas (Martins *et al.*, 2004; Palhares *et al.*, 2011; Gonçalves *et al.*, 2018; Silva *et al.*, 2018; Benites *et al.*, 2020). Cardboard is expected to inhibit seed germination and also lead to the senescence and death of undesirable existing vegetation, in order to control competition. However, these previous studies have not evaluated the feasibility of placing cardboard directly on the grass, a situation in which the need for crowning with a hoe would be avoided prior to planting or before cardboard crowning after planting. Thus, this study aimed to evaluate the effectiveness of the direct crowning with cardboard in the suppression of *Urochloa humidicola* and *Megathyrsus maximus*, two species of forage grasses usually found in reforestation areas in the Atlantic Forest biome.

## 2. MATERIAL AND METHODS

### 2.1. Study area and species

The experiment was conducted in an area of approximately 6 hectares, belonging to Embrapa Agrobiologia, located in Seropédica municipality, Rio de Janeiro state (UTM 23K 635182 E, 7483547 S), meant for reforestation with native species. Two sites were selected based on the presence of different forage invasive grasses (Poaceae) as follows: Site 1: *Urochloa humidicola* (Rendle) Morrone and Zuloaga (Koronivia grass), and Site 2: *Megathyrsus maximus* (Jacq.) B.K.Simon and S.W.L.Jacobs (Guinea grass). These species have survival mechanisms that make them very aggressive due to the high production capacity of seeds of high viability and longevity, which can germinate in different types of soil with high or low fertility. These species can still reproduce vegetatively and have a great capacity to regenerate their clumps, once cut. *M. maximus*, was accidentally introduced to Brazil from slave ships, serving as beds for slaves (Nagano *et al.*, 2011). They are aggressive and resistant species, dispersing easily, significantly interfering with infested crops. Without control, they can replace native species and, with the soil covered, it is very difficult to grow new trees (Silva, 1969; Ammond & Litton, 2012; Dias *et al.*, 2016; Mantoani *et al.*, 2016).

The soil of the area is classified as Haplic Planosol (soil fertility analysis of the area: pH = 5.9; total carbon = 1%; Al = 0 cmol<sub>c</sub>.dm<sup>-3</sup>; H+Al = 2.8 cmol<sub>c</sub>.dm<sup>-3</sup>; Ca = 2 cmol<sub>c</sub>.dm<sup>-3</sup>; Mg = 1 cmol<sub>c</sub>.dm<sup>-3</sup>; K = 91 mg L<sup>-1</sup>; P = 5.7 mg L<sup>-1</sup>;

N = 0.1%). The soil texture is sandy, with approximately 15% clay. The relief of the place is slightly wavy, tending to flat in some places, between 24 m and 38 m of altitude. The area remained fallow for at least 30 years, having suffered burnings and periodic grazing. There is no record of previous crops in the area. The climate of the region is Aw, characterized by a dry season in winter (especially from June to September) and a humid one in summer. The records of the municipality of Seropédica between January 2009 and December 2013 indicate an annual rainfall of 1,370 mm, with average monthly temperatures ranging from 16 °C to 36 °C and an annual average around 24 °C. The annual mean relative air humidity in the same period was 81% (INMET, 2014). The maximum temperature and amount rainfall during the study months (September 2015 to January 2016) ranged between 37.7°C and 40.9°C and between 95.2 mm and 207.2 mm respectively (<https://bdmep.inmet.gov.br/>).

### 2.2. Design and conduction of experiments

The grasses at the experimental sites were mowed one week before the experiments were set up. The experiment was set up in a completely randomized design with 5 replications and plots subdivided over time. The treatments consisted of crowning with cardboard (Cardboard) and a control, without crowning (Control). The position of the experimental plots (“crowns”) was marked with bamboo stakes, simulating a seedling (Figure 1). The installing of the experiments at each site was in september 2015. In the cardboard treatment, the crowning was performed with B wave kraft cardboard sheets of 50 x 50 cm containing a cut from the edge to the center made with a box cutter. The cardboard was placed directly on the grass, without prior weeding.

To fix the cardboard to the soil, 4 staples made from galvanized wire with a 2.77 mm gauge and 20 cm in length, folded in a “U” shape, were used. The use of four staples for fixing the four cardboard ends, including a fifth at the place where the stylet cut was performed, improve the cardboard efficiency in containing the grass growth. No chemical treatment was performed on the cardboard used in this study. In the control treatment, no type of intervention was performed after mowing, causing the grass to develop under normal conditions without any type of impediment. In each site, 25 experimental units (crowns) were placed for each treatment.

### 2.3. Monitoring of Biomass and Grass Senescence

Samples of grass biomass in the crown area were carried out in at zero, 35, 75 and 120 days after the installation of the experiment in the field. For sampling, a square mold with an

area of 0.25 m<sup>2</sup> (area equivalent to the area of the cardboard crown) was used. In the control treatments (without crown) the mold was placed on the soil, with bamboo, the marker of each sample unit, in the center. In crowning treatments, the cardboard was removed before placing the mold. In each sample unit, delimited by the mold, all grass (alive or senescent) was collected with the help of pruning shears. The procedure was repeated in five sample units of each treatment per sampling date at each site. The collected material was weighed fresh and subsequently dried in a forced circulation oven at 65 °C for 72 hours and weighed again to obtain the dry grass mass. The results were expressed in vegetation biomass per m<sup>2</sup>, being calculated by dividing the dry weight

of each sampling point by 0.25. The senescence level of the grass crowned with cardboard was assessed visually and classified according to the following scale: (1) green grass, with no sign of senescence in more than 80% of the crown area, (2) yellowish or partially desiccated grass in more than 80% of the crown area; (3) grass dried out or in the process of decomposition in more than 80% of the crown area (Figure 1).

## 2.4. Data analysis

The data obtained at each site were analyzed independently. The dry biomass data were analyzed on each collection date using the t test at a 5% significance level to compare the two treatments.



**Figure 1.** General views of the experimental sites with *Urochloa humidicola* (A) and *Megathyrsus maximus* (B). Bamboo poles were used to simulate seedlings in the field.

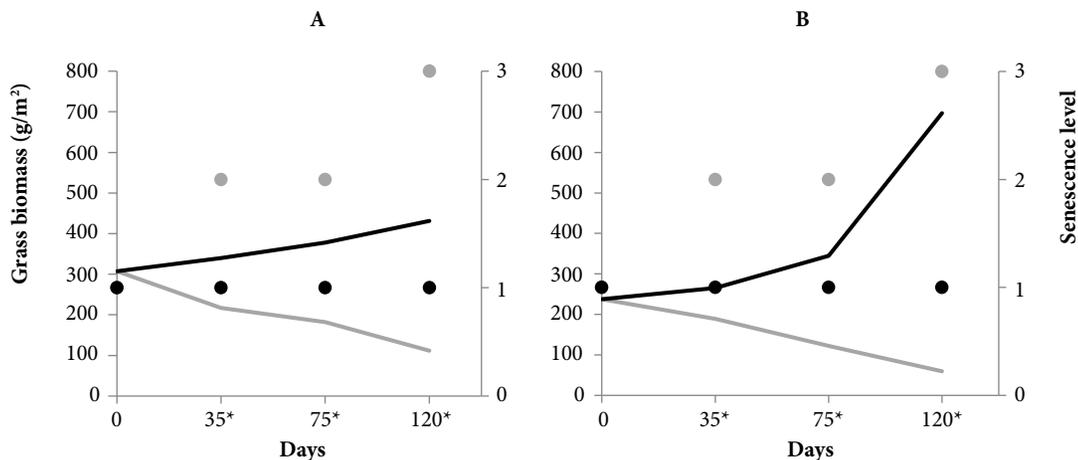
## 3. RESULTS AND DISCUSSION

The biomass of both grasses studied showed a significantly lower value under cardboard, compared to the control, throughout the monitoring period ( $p < 0.05$ ; Figure 2). At 120 days after the installation of the study, the biomass of *U. humidicola* under the cardboard was approximately 100 g/m<sup>2</sup>, approximately 33% of that found at the time of installing the cardboard, while in the control the biomass of the grass reached 425 g/m<sup>2</sup>. For *M. maximus*, this effect was even greater with the biomass under the cardboard being reduced to approximately 50 g/m<sup>2</sup> about 20% in relation to the moment of the cardboard placement, while the control reached 700 g/m<sup>2</sup> of biomass (Figure 2). The senescence process of invasive grasses under the cardboard were already at level 2 since the first evaluation (35 days after crowning), and reached level 3 in the last evaluation (120 days after crowning), showing itself to be desiccated or undergoing decomposition in more than 80% of the crown area (Figure 3).

Lower light availability for the soil unfavors the spread, germination and sprouting of invasive grasses because

they are highly intolerant to shading (Pereira *et al.*, 2012). Under intense shading, when virtually all light is blocked, the photosynthetic mechanism is compromised, leading to senescence and death of the plant. Therefore, the sunlight blocked by the cardboard, once placed directly over the weeds, caused the loss of biomass and the senescence of both grass species as we identified here.

Several previous studies have shown the efficiency of cardboard crowning to control exotic grasses in reforestation projects. Silva *et al.* (2018) showed, through photo documentation, that cardboard was effective at controlling *Urochloa humidicola* growth up to a year after its placement on the ground. Gonçalves *et al.* (2018) succeeded in controlling *Andropogon bicornis* with cardboard crowning in a reforestation in Seropédica, RJ, while Benites *et al.* (2020) also succeeded in controlling *Urochloa decumbens* (Stapf) R.D. Webster and *Paspalum notatum* Flüggé (Poaceae) using the same method in the Cerrado of the Mato Grosso do Sul state. However, in all those studies the weeds were crowned with hoe before placing the cardboard, which involves additional labor costs.



**Figure 2.** Amount of biomass (lines) and senescence level (dots) of *Urochloa humidicola* (A) and *Megathyrsus maximus* (B). Gray dots and lines refer to the cardboard treatment while black dots and lines to the control. Asterisk after each sampling time means that the treatments differed by the t test ( $p < 0.05$ ).



**Figure 3.** Senescence levels 2 (A) and 3 (C) for *U. humidicola* and senescence levels 2 (B) and 3 (D) for *M. maximus* as a result of the cardboard crowning. Photos A and B were taken 35 days after crowning, and photos C and D 120 days after crowning.

The importance of controlling grasses in reforestation projects aims to obtain greater growth and survival gains for tree species (Ammond & Litton, 2012; Dias *et al.*, 2016; Mantoani & Torezan, 2016; Santos *et al.*, 2019). Gonçalves *et al.*

(2018) demonstrated that manual crowning of seedlings can be replaced by crowning with cardboard without hindering growth and with the benefit of reducing seedling mortality. In another study, the survival rate and growth of seedlings of

a Cerrado native tree species (*Dipteryx alata* Vog.) did not differ between crowning with cardboard or hoe, but cardboard treatment resulted in better weed control (Benites *et al.*, 2020).

Cardboard can be also effective in controlling soil temperature affecting plant growth over time (Benites *et al.*, 2020), since many nutrients essential for its development are only released at certain temperature ranges (Gasparin *et al.*, 2005). A strong effect of cardboard mulching on soil temperature was noted on days with high air temperatures, which proved up to 15 °C lower in the 0 to 10 cm deep layer compared to bare soil (hoe crowning) areas (Silva *et al.*, 2018). This cardboard effect may have consequences on seedlings development under field conditions, given that it improves the soil environment for rooting due, for instance, to less water loss and more favorable conditions for biological activity.

One of the greatest benefits of crowning seedlings with cardboard can be related to the lower cost of operation compared to traditional manual crowning, although the quality of the cardboard and the volume of rainfall in the area can increase these costs (Dias *et al.*, 2019). In a study carried out in a riparian forest in the Atlantic Forest biome, the use of cardboard cut the working time in half (Palhares, 2011). Other studies have also shown significant reductions in operating costs with the use of cardboard for crowning. Benites *et al.* (2020) showed costs 20% lower for crowning with cardboard compared to traditional crowning with hoe. The material and labor costs used for crowning with cardboard were 43% lower than the costs of manual crowning with a hoe over a year (Gonçalves *et al.*, 2017). The cost of cardboard can be further reduced if the purchase is made of reused material from packaging of market products or even pizza boxes.

Our results showed that the crowning with cardboard can be carried out directly on the grasses, making it possible to eliminate the manual crowning operation prior to placing the cardboard. According to Gonçalves *et al.*, (2018), the cost for hoe crowning before placing the cardboard in the field represent about 20% of the total budget for the crowning operation with cardboard in the first year. Therefore, the findings of this study can further enhance the attractiveness to the adoption of the cardboard crowning technique, considering the crowning operation a large part of the reforestation budget.

The development of low-cost techniques for reforestation actions subsidizes the implementation of the National Plan for the Recovery of Native Vegetation in Brazil, facilitating the expansion of its scale. This plan aims to present strategies to motivate and implement reforestation in the next 20 years (Brazil 2017). The benefit of cardboard may be more related to the reduction of crowning maintenance frequency to avoid competition with invasive alien grasses and, owing to its conspicuity, facilitating the recognition of seedlings

during maintenance actions and also, being a cheap and environmentally viable technique owing to its biodegradability.

In this study, the use of cardboard, placed directly over the weeds, was effective in suppressing the growth and cause the senescence of two invasive grasses (*U. humidicola* and *M. maximus*). This fact was verified by the loss of biomass and / or by the visual analysis that showed loss of vigor, yellowing and death of the grasses over the evaluation period. It is imperative to use four staples (or any similar apparatus) for fixing the cardboard when the crowning is performed directly on the newly mowed grass. The results of the present study reinforce the potential of using cardboard to control invasive grasses during forest reforestation initiatives, and bring as an innovation the possibility of placing cardboard directly on grasses after mowing, allowing greater simplicity and lower cost of operation.

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