Floresta e Ambiente 2018; 25(3): e20160261
https://doi.org/10.1590/2179-8087.026116
ISSN 2179-8087 (online)

Original Article

Silviculture

Use of Cardboard Disks for Crowning Seedlings in Reforestation

Felipe Ferreira da Silva[1], Alexander Silva de Resende[2], Thainá Alves dos Santos[1], Guilherme Montandon Chaer[2]

[1]Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica/RJ, Brasil
[2]Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA Agrobiologia, Seropédica/RJ, Brasil

ABSTRACT

The present study aimed to evaluate the effect of chemopreventive or water-repellent substances on the durability of cardboard disks used to crown forest tree species. The experiment presented a randomized block design with four repetitions and four sampling times (63, 133, 260 and 365 days) and was installed in Seropedica, RJ, in an area with *Urochloa humidicola*. Bamboo poles were used to simulate seedlings in the field and define the position of the experimental units. The treatments consisted of *in natura* cardboard, or treated with $CuSO_4$ solution, pinus shellac, $CuSO_4$ + pinus shellac, $CuSO_4$ + Sika®, pinus shellac + Sika®, and a second control with manual crowning. The cardboard crowning was effective at suppressing grass growth over all periods evaluated, independent of the treatment. After a year in the field, the cardboard disks treated with $CuSO_4$ solution presented higher physical integrity with only 25% mass loss, against 60% mass loss in the control. The cardboard crowning also reduced soil temperature at the crown area by up to 15 °C in the 0 to 10 cm layer, in comparison with manual crowning. The results of this study indicate that the cardboard crowning method is efficient and has the potential to reduce the cost of weed control in reforestation.

Keywords: weed competition; mulching; recovery of degraded areas.

1. INTRODUCTION

Weed control is an essential practice to ensure the success of reforestation with native species in areas dominated by fast-growing grasses. Weed competition consists of competition for water, sunlight and nutrients between tree species, especially during the initial growth stage, and weeds, particularly fast-growing grasses (Silva et al., 2000). Weeds may still have an allelopathic effect on forestry species, host pests and pathogens and increase the risk of fire (Pitelli, 1987; Toledo et al., 2000).

In reforestation, invading plants are primarily controlled by crowning and mowing operations, or by chemical weeding with herbicides. The use of herbicides in multi-specific reforestation sites is restricted due to potential environmental risks and a lack of information regarding the effect that herbicides can have on recovering plant species. In parallel, mowing and crowning practices present significant labor requirements and consequently, increase the cost of reforestation (Leles et al., 2015). In Rio de Janeiro state, reforestation costs per hectare can exceed R$ 30.000,00, 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). Thus, these operations are frequently neglected, due to either difficulty with access or to the high costs involved, often leading to reforestation failure (Monquero et al., 2011).

Mulching is another weed control technique widely adopted in agriculture. It consists of placing a mowed organic material layer on the ground (eg., leaves, sawdust, straw, etc.) or a plastic film in the soil surface, forming a physical barrier which limits solar radiation at ground level and inhibits seed germination and seedling growth (Streck et al., 1994). This inhibition also occurs through soil thermal and hydric amplitude retraction that affects seed dormancy and germination (Taylorson & Borthwick, 1969; Fenner, 1980). Besides the decrease in seed germination, vegetable mulch reduces vegetative vigor (leaf chlorosis, tillering reduction and stunting roots) leading to seedling mortality (Sarrantonio & Gallant, 2003). Other benefits of mulching are reduced soil water evaporation, holding moisture in the soil for longer periods, and a reduced temperature amplitude within the soil profile, particularly near the surface (Gasparim et al., 2005).

Earlier studies have evaluated the use of cardboard as mulch for weed control in tree species (Martins et al., 2004; Palhares, 2011). The technique is based on the placement of cardboard disks or polygonal plates (typically quadrangular) of cardboard that can range from 40 to 100 cm in diameter containing a seedling in the center to form a crown. In a process similar to mulching, the cardboard inhibits weed seed germination and/or leads to the collapse of already pre-existing plants.

The first report was made by Martins et al. (2004), who evaluated the use of copper sulphate treated cardboard as an alternative to traditional crowning (performed with a hoe) in *Bactris gasipaes* Kunth. Results showed that plants covered with cardboard had a higher growth index compared to the traditional crowning, which frequently damages the superficial root system of the species. Recently, Palhares (2011) demonstrated that the use of cardboard as an alternative to traditional crowning was beneficial in a riparian reforestation site in the Mata Atlântica, reducing labor time by 50%.

No previous study has considered the longevity of cardboard in the field or pretreatment methods that aim to effectively increase weed control time. Therefore, this study sought to evaluate the durability of cardboard under field conditions, treated or not with different preservative substances, and to evaluate the method efficiency in suppressing *Urochloa humidicola*. Concomitantly, it aimed to evaluate the effect of cardboard mulching on soil temperature.

2. MATERIAL AND METHODS

2.1. Area description and experiment design

The experiment was installed on October 2013 in an area adjacent to Embrapa Agrobiologia, located at Seropedica, RJ (Figure 1). The predominant vegetation consisted of *Urochloa humidicola* (Rendle) Morrone & Zuloaga and the soil was classified as haplic Planosol. The climate is Aw type according to Koppen classification. The average temperature is 23.5 °C and annual precipitation is 1354 mm.

The experiment had a randomized block design with seven treatments, four repetitions and four sampling times. The treatments consisted of chemoprotective and

Figure 1. View of the experimental area. Before installation, the whole area was mown and cardboard disks with 25 cm radius were placed at a spacing of 1 m x 1 m. Bamboo poles were used to simulate the seedlings and fix the position of the cardboard disk.

water-repellent products applied on the cardboard disks, prior to being placed in the field, in order to evaluate their effect on decomposition rate. The treatments were cardboard *in natura* (T1); cardboard treated with copper sulphate solution ($CuSO_4$) (T2) or shellac (T3) or $CuSO_4$ + shellac (T4) or $CuSO_4$ + Sika® (T5) or shellac + Sika® (T6). The seventh treatment (T7) was manual crowning with a hoe.

The $CuSO_4$ solution was prepared following the recommended concentration mixture preparation used in the preservation of fence posts by sap replacement techniques, using 6.50 g of boric acid, 13.76 g of copper sulphate and 0.25 mL of acetic acid per liter of distilled water (Galvão, 1975). The potassium dichromate proposed in the formulation by Galvão (1975) was excluded because of its toxicity and high carcinogenic potential. The cardboard was then immersed in the $CuSO_4$ solution, previously poured in 55 cm x 70 cm plastic trays.

The shellac ("national shellac" or "pine shellac") consists of a resin extracted from pine knots typically used as varnish for wood or metal. It was diluted at a ratio of 150 g per liter of alcohol, according to manufacturer's recommendations, and applied to the cardboard with foam rollers. The product used as waterproofing additive for mortars, the Sika® was diluted in water at 1/9 ratio (Sika/water) and applied to the cardboard as with the $CuSO_4$ solution. In the T4 and T6 treatments, $CuSO_4$ and Sika® were firstly applied to the second product, respectively. In treatment T5, $CuSO_4$ was applied before the Sika®. Prior to the treatment arrangement, the experiment site was mown. Using spacing of 1 x 1 m, manual crowning was performed with a hoe in a radius of approximately 25 cm. In this study, Kraft/B wave type cardboard disks, used in the assembly of pizza boxes, were used with an approximate dimension of 0.5 x 0.5 m. At the center of each crown, a bamboo pole simulating the plant position was placed. The cardboard was cut at its center with a razor and placed in the ground and fixed with a bamboo pole at the center (Figure 1). In each line, the bamboo poles were tied with nylon thread in order to avoid its displacement by wind action. After the experiment installation, any additional weed-control operations were performed, including treatments such as traditional crowning. This allowed a maximum growth expression by the grasses at the experimental site, only limited by treatments with cardboard as mulch.

Prior to being placed in the field, all cardboard disks were weighed to obtain *in natura* net weight and subsamples were dried in an oven at 65 °C for 72 hours to obtain mean moisture percentage. Mass loss in cardboard disks was monitored through destructive samples on days 63, 133, 260 and 365.

Soil temperature was taken using a soil thermometer containing with stainless steel probe. Measurements were performed in a period no greater than 40 minutes in parcels for treatments T1 (*in natura* cardboard) and T7 (manual crowning). Measuring time was fixed at 13:00 hours for nonconsecutive days during the 2013/2014 summer. Temperatures were taken at depths from 0 to 10 cm with the thermometer probe at a position equivalent to half the covered area.

Mass residue and soil temperature data were submitted to analysis of variance followed by Dunnett's test for multiple comparison with a control (MCC) using $p < 0.1$. Treatment, evaluation date and block were considered as variation sources, as well as interactions between treatment and evaluation date. The software used was the S-Plus 8.0 (InsightfulCorp).

During the experiment, weekly photo documentation was made of the treatments T1 (*in natura* cardboard) and T7 (manual crowning) in a single block for the visual monitoring of the effectiveness of cardboard in controlling Brachiaria growth. In the evaluation of each plot, a photo was taken from over the cardboard crown (1 m above the ground) and another from under the crown, in this case, carefully lifting the cardboard and returning it to its original position afterward.

3. RESULTS AND DISCUSSION

3.1. Mass loss of cardboard in the field

During all evaluations, treatments containing shellac (T3) and shellac + Sika (T6) showed statistically similar results for mass loss compared to control (T1) (Figure 2). At day 365, mass loss of the cardboard of these treatments varied from 42 to 60%. The Shellac + $CuSO_4$ (T4) treatment had the lowest mass loss compared to control from the first evaluation until day 260. However, by day 365 this treatment did not differ from the control (T1). Instead, in the $CuSO_4$ (T2) and $CuSO_4$ + Sika® (T5) treatments, the residual mass percentage was always superior compared to control (T1) ($p < 0.1$). The $CuSO_4$ (T2) and $CuSO_4$ + Sika® (T5) treatments presented 75% residual mass, on the last sampling date (365 days), in comparison with 40% for *in natura* cardboard (Figure 2).

The best result in terms of residual mass obtained in treatments containing $CuSO_4$ may be associated with the anti-fungal action of this substance suppressing cardboard decomposition by this organism group. Copper sulphate is widely used in agriculture for leaf disease control and in wooden fence post treatments, possessing a known antifungal action (Lopes, 2002).

In spite of the good result observed on treatment T5 ($CuSO_4$ + Sika®), its similarity with that containing $CuSO_4$ indicates that the retarding decomposition effect has been caused by the presence of copper sulphate alone, therefore, its interaction with Sika® is not recommended. Sika® alone or together with shellac showed no effect on cardboard longevity (T6; Figure 2). Consequently, applying Sika® as a cardboard treatment is not justified. The same reasoning may be applied to shellac.

Other studies that evaluate the decomposition rate of cardboard treated with different substances and placed on the ground were not found. However, Martins et al. (2004), when performing an experiment testing $CuSO_4$ treatments on cardboard for mulch in pupunha (*Bactris gasipaes* Kunth.) seedlings, observed that this was effective in weed control for at least a year, in addition to resulting in a higher seedling growth rate compared to the manual crowning treatment.

3.2. Soil temperature in the covered area

Independent of application of chemoprotective substance, cardboard mulch reduced soil temperature in the layer from 0 to 10 cm depth under the covered area by 4.5 °C on average, compared to crowning (Figure 3). On days of high maximum air temperature (above 35 °C), soil temperature under the cardboard-covered area achieved a reduction of 15 °C.

The soil temperature reduction observed by placement of cardboard is supported by the findings of studies using mulch. A review carried out by Streck et al., (1994) reports that several types of mulch, such as opaque plastic, vegetable residues and paper, decreased the soil thermal amplitude, lowering maximum temperature and

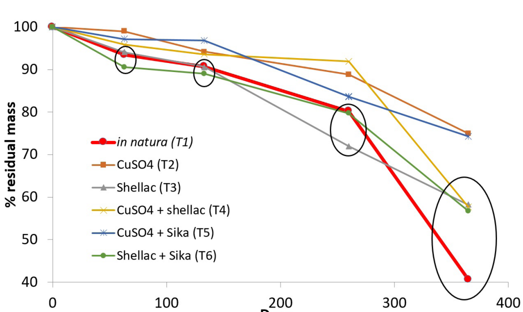

Figure 2. Residual mass percentage of cardboard disks after 365 days in the field. At each sampling date, points inside the ellipse do not differ from control by the Dunnett's test for multiple comparison to a control, at 10% significance.

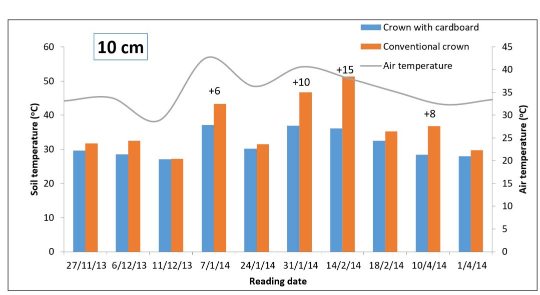

Figure 3. Air and soil temperature at the crown position at a depth of 0 to 10 cm. Difference between treatments is shown in °C above the conventional crowning bar, when there was significant interaction between reading date and soil temperature.

raising minimal temperatures. Gasparim et al. (2005), evaluating temperature in the soil profile using two mulch densities and bare soil, reported that independent of the density adopted, mulching lowered temperature in the soil profile, by at least 2 °C. In a study comparing no-tillage versus conventional planting systems, Sidiras & Pavan (1986) observed lower temperatures in no-tillage using permanent mulch.

Bragagnolo & Mielniczuck (1990) reported that mulch maintenance with crop residues at ground surface, combined with minimum tillage, dissipate part of the solar radiation through reflection. Thus, coverage prevents sunlight from promoting seed germination of weeds and causing water loss through evaporation, preventing soil temperatures reaching harmful levels for crop development.

3.3. Efficiency of cardboard in suppressing Urochloa humidicola

Photo documentation proved that cardboard mulch, independent of the treatment, was effective at controlling *Urochloa humidicola* growth up to a year after its placement on the ground (Figure 4). The covered area remained free of weeds (Figures 4E and 4H), in spite of the intense grass growth at 180 and 365 days

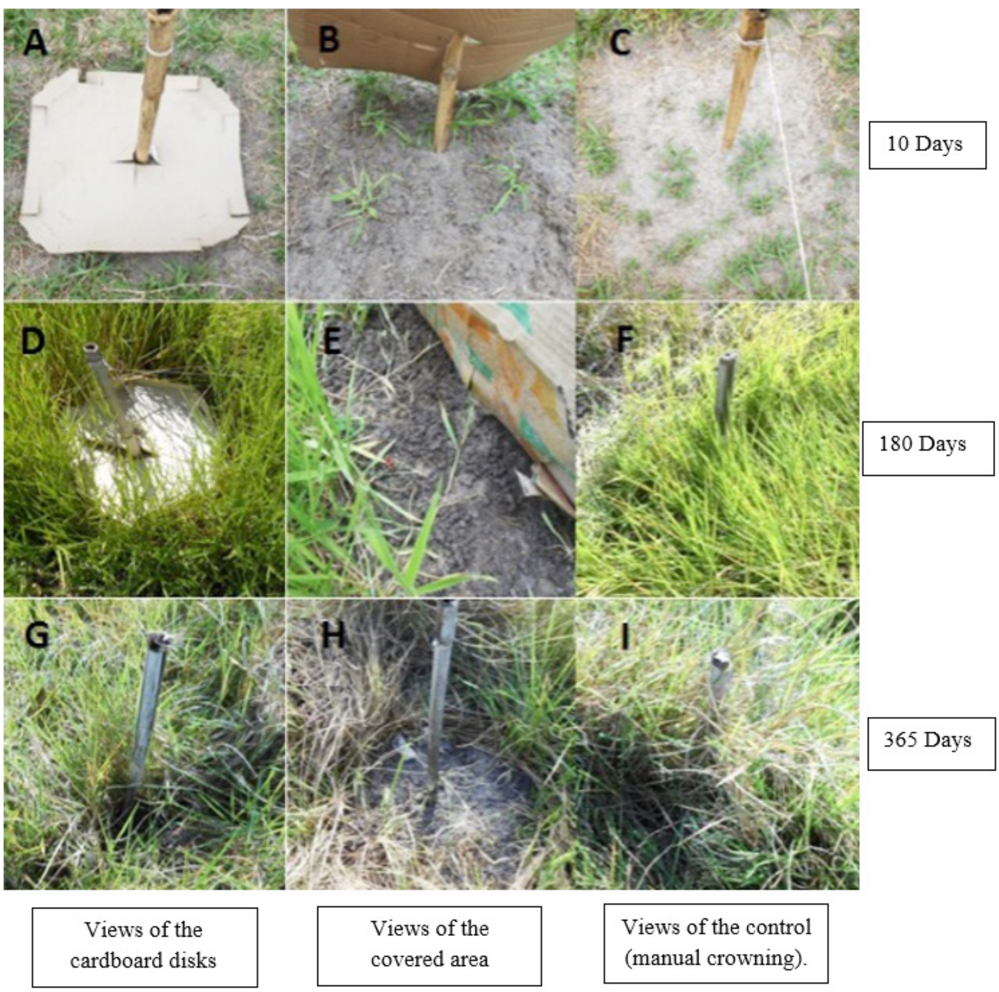

Figure 4. Photo documentation of cardboard mulching (A, D, G), under the cardboard disk (B, E, H) and in the control without cardboard (C, F, I). Lines and columns, each formed by 3 photos, represents respectively readings at 10, 180 and 365 days, and the different photo documented scenarios: views of the cardboard disks, views of the area covered by the cardboard and views of the manual crowning at time zero. The complete control of the grass in the crown area at 365 days (H) is notable, in spite of the apparent dominance of the grass before removing the cardboard (G).

after mowing (Figures 4D and 4G). On the other hand, figures 4F and 4I display vigorous grass growth in the crowned area of the control treatment (no cardboard) at 180 and 365 days after mowing.

The results indicate great potential for use of cardboard disks as plant mulch in reforestation, especially of native species, where herbicide use is restricted. It should be noted that the use of cardboard, even when not treated, maintains a weed-control effect for up to one year. Due the experimental design adopted in this study, considering destructive samples, we were not able to determine the total longevity (or effectiveness) of the cardboard disks for all treatments. However, it is clear that under these study conditions, the cardboard maintains a weed-control effect for a period exceeding one year, especially when treated with copper sulphate, considering its physical integrity and consistent suppression of grasses observed up to 365 days. Different to what was done in this study, $CuSO_4$ may be sprayed directly onto the cardboard, aiming to reduce application time and labor costs in the operation. Moreover, the $CuSO_4$ has low toxicity, low cost and is easily accessible on the market.

It should be noted that there are different cardboard types available on the market, with variations including wall-layer type (simple, double, etc), origin (Kraft and recycled), wave type (A, B, C or E) and quality of the adhesive used in the assembly of layer components (Rodrigues et al., 2014). Certainly, each variation would have a different decomposition rate under field conditions. Therefore, additional studies are required to determine the qualitative effects of cardboard longevity as mulch. It should be noted that all variables influencing the organic matter decomposition rate inherent in the reforestation site (eg., climate, soil quality, macro and microfauna activity, etc.) should have influenced cardboard decomposition also, and consequently, its effective protection lifetime.

The use of cardboard as mulch may significantly lower weed-control costs, given that it may eliminate or extensively reduce the need for manual crowning of seedlings, one of the most expensive operations, economically and physically. However, studies should be conducted to evaluate cardboard mulch effect on the growth and survival of native plant species, where the technique will be applied. The results of this and prior studies using other mulches suggest reducing soil thermal amplitude and water evaporation can improve the rooting system and thus, favor seedling growth and development. These factors, on the other hand, may potentially favor the emergence of pests or diseases, conditions that need to be observed in future studies.

4. CONCLUSIONS

Cardboard proved effective in controlling weed competition, independent of the chemical treatment applied, for at least one year. The copper sulphate treatment was effective at reducing the cardboard decomposition rate, which may increase its effective durability.

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. This effect may have consequences on seedlings development under field conditions, given that it improves the soil environment, promoting a better environment for rooting due, for instance, to less water loss and more favorable conditions for biological activity.

SUBMISSION STATUS

Received: 20 july, 2016
Accepted: 27 oct., 2017

CORRESPONDENCE TO

Alexander Silva de Resende
EMBRAPA Agrobiologia, BR 465, Km 07,
CEP 23891-000, Seropédica, RJ, Brasil
email: alexander.resende@embrapa.br

REFERENCES

Bragagnolo N, Mielniczuck L. Cobertura do solo por palha de trigo e seu relacionamento com a temperatura e umidade do solo. *Revista Brasileira de Ciência do Solo* 1990; 14(3): 369-374.

Fenner M. Germination tests of thirty-two East African weed species. *Weed Research* 1980; 20(3): 135-138. http://dx.doi.org/10.1111/j.1365-3180.1980.tb00058.x.

Galvão APM. *Processos práticos para preservar a madeira*. Piracicaba: ESALQ; 1975. 29 p.

Gasparim E, Ricieri RP, Silva SL, Dallacort R, Gnoatto E. Temperatura no perfil do solo utilizando duas densidades de cobertura e solo nu. *Acta Scientiarum Agronomy* 2005; 27(1), 107-115.

Leles PSS, Oliveira Neto SN, Alonso JM. Restauração florestal em diferentes espaçamentos. In: Leles PSS, Oliveira SN No, editores. *Restauração Florestal e a Bacia do Rio Guandu*. Seropédica: Editora Rural; 2015. 156 p.

Lopes C. *Efeito do sulfato de cobre e de zinco no controle da população de fungos e bactérias do solo que causam intemperismos em arenitos de prédios históricos na Lapa - PR*. Curitiba: DSEA-AG-UFPR; 2002.

Martins EG, Neves EJM, Santos AF, Ferreira CA. *Papelão tratado: alternativa para controle de plantas daninhas em plantios de pupunheira (Bactris gasipaes* Kunth*)*. Colombo: EMBRAPA Florestas; 2004. 4 p. Comunicado Técnico.

Monquero PA, Penha AS, Orzari I, Hirata ACS. Seletividade de herbicidas em mudas das espécies nativas – *Acacia polyphylla, Enterolobium contortisiliquum* (Fabaceae), *Ceiba speciosa* e *Luehea divaricata* (Malvaceae). *Planta Daninha*. *Viçosa* 2011; 29(1): 159-168.

Palhares AO. *Contribuição para recuperação de matas ciliares: uso de papelão em substituição à capina de coroamento, no plantio e condução de mudas florestais*. São Paulo: IPT; 2011.

Pitelli RA. Competição e controle de plantas de plantas daninhas em áreas agrícolas. *IPEF* 1987; 4(12): 25-35.

Rodrigues D, Chagas R, Aguiar FEC. Importância da qualidade do adesivo na produção de papelão corrugado. *O Papel* 2014; 4: 59-61.

Sarrantonio M, Gallant ER. The role of cover crops in North American cropping systems. *Journal of Crop Production* 2003; 8(1-2), 53-74. https://doi.org/10.1300/J144v08n01_04.

Sidiras, N.; Pavan, M.A. Influência do sistema de manejo na temperatura do solo. *Revista Brasileira Ciência do Solo* 1986; 10(3), 181-184.

Silva W, Silva AA, Sediyma T, Freitas RS. Absorção de nutrientes por mudas de duas espécies de eucalipto em resposta a diferentes teores de água no solo e competição com plantas de *Brachiaria brizantha. Ciência e Agrotecnologia* 2000; 24(1): 147-159.

Streck NA, Schneider FM, Buriol GA. Modificações físicas causadas pelo Mulching. *Revista Brasileira Agrometeorologia* 1994; 2, 131-142.

Taylorson RB, Borthwick HA. Light filtration by foliar canopies: significance for light-controlled weed seed germination. *Weed Science* 1969; 17(1): 48-51.

Toledo REB, Victoria FR, Alves PLC, Pitelli RA, Cadini MTD. Efeitos da faixa de controle do capim-braquiaria (*Brachiaria decumbens*) no desenvolvimento inicial de plantas de eucalipto. *Planta Daninha* 2000; 18(3): 383-393.