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FLAMETHROWER APPLICATION TIME IN WEED CONTROL[1]

Tempo de Aplicação de Lança-Chamas no Controle de Plantas Daninhas

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ABSTRACT - In the organic system, one of the biggest obstacles faced by the farmer is the management and control of weeds. In this context, the use of heat treatment with fire may be seen as an interesting alternative, because of its characteristic of not leaving chemical residues in the soil and water. The objective was to evaluate the effect of the time of application of the flamethrower in weed control as compared to manual control and mechanical methods. The experiment was arranged in a randomized block design with four replications and seven treatments, totaling 28 plots with dimensions of 1.0 x 1.0 m. The treatments consisted of five application times for the flamethrower (0, 5, 10, 15 and 20 s m^{-2}) and two types of weeding (manual and mechanical). Infestation percentage, fresh and dry weight assessments of the remaining weeds in each plot were made. The application of 10 s m^{-2} for the flamethrower was efficient in controlling weeds in early stage of development and it can be used as an alternative to mechanical and manual weeding, in weed control.

Keywords: thermal control, liquefied petroleum gas, thermodegradation.

RESUMO - No sistema orgânico, um dos maiores entraves enfrentados pelo agricultor é o manejo e controle de espécies daninhas. Nesse contexto, o uso do tratamento térmico com fogo pode ser visto como uma alternativa interessante, dada sua característica de não deixar resíduos químicos no solo e na água. O objetivo deste trabalho foi avaliar o efeito do tempo de aplicação do lança-chamas no controle de plantas daninhas, em comparação aos métodos de controle manual e mecânico. O experimento foi disposto em delineamento de blocos casualizados, com quatro repetições e sete tratamentos, totalizando 28 parcelas experimentais com dimensões de 1,0 x 1,0 m. Os tratamentos foram constituídos por cinco tempos de aplicação do lança-chamas (0, 5, 10, 15 e 20 s m^{-2}) e dois tipos de capina (manual e mecânica). Foram feitas avaliações de porcentagem de infestação e da massa da matéria fresca e seca das plantas daninhas remanescentes em cada parcela. A aplicação de 10 s m^{-2} de lança-chamas mostrou-se eficiente em controlar as plantas daninhas em estádio inicial de desenvolvimento, podendo ser utilizada como alternativa às capinas mecânicas e manual no controle das plantas daninhas.

Palavras-chave: controle térmico, gás liquefeito de petróleo, termodegradação.

INTRODUCTION

The term weed may be understood as all plants whose advantages have not yet been discovered, or as any plant that interferes with human objectives, or that grows in undesired locations (Burin & Fuentes, 2015).

In the organic system, the term spontaneous plants is used to replace the term *weeds*, due to the several benefits they offer for the ecological balance of the system. However, due to the impossibility of using conventional herbicides, their management and control must be cautiously made, since,

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in several cases, they cause significant productivity losses (Souza & Rocha, 1998; Souza & Resende, 2014). One of the major obstacles faced by farmers when converting their crops is the management of weeds (Brighenti & Brighenti, 2009). In this context, using thermal treatment with fire in cultivated areas may be seen as an important alternative for organic producers, considering its characteristic of not leaving chemical residues in the soil and the water (Bond et al., 2007). Initially, the physical control method with high temperatures was highly used by organic agricultural producers in Europe, which may not use the conventional defensive substances (Silva, 2008a).

The use of fire to control weeds was commonly adopted in the United States for yearly crops, such as cotton and sorghum, between the decades of 1930 and 1960. From this period on, the thermal control technique for weeds was gradually abandoned, due to the increase in the fossil fuel prices and the emergency of selective herbicides for several crops (Seifert & Snipes, 1998). However, the thermal control of weeds became expressive once again during the 1980's and 1990's, mainly across those who practice organic agriculture, in several European countries, due to the legal prohibition to use any chemical intervention in their crops (Bond & Grundy, 2001).

Currently, there are two fundamental types of equipment used for the thermal control of weeds: using a flame of approximately 1,900 °C, with a spraying nozzle, or using an invisible 900 °C flame, through an infrared spray. Both pieces of equipment use liquefied petroleum gas (LPG) or propane/butane mixtures as fuel and one of their characteristics is that they do not damage the treated area. As restated by Hatcher & Melander (2003), the disadvantage is still the high cost and consumption of fossil fuels.

Heat apparently acts on the plant by coagulating the protoplasm on the cells of the leafs and stem. According to Ascard (1997), the lethal thermal point that causes the death of the leaf varies from 55 to 94 °C, and the lethal exposure time that would cause the death of the tissues varies from 0.07 to 0.13 s. Heat not only kills the aerial part, but also the upper part of the radicular system, due to the translocation of toxic sub-products resulting from the thermodegradation of components of the aerial part.

The efficiency of the thermal control varies according to the vegetal species to be controlled. The tolerance or not of a certain species depends of the presence of bristles or protective waxes, lignification, the hydric condition of the plant and its capacity to sprout again (Ascard, 1995).

According to Ascard (1995), plants may be divided into four different groups according to their sensitivity to physical control using flames: highly sensitive plants, with thin leafs and no type of protection on their growth points; easy-to-control plants, with some type of protection on their growth points; tolerating plants, with high capacity to sprout again and which may only the controlled during their initial developmental phases; and highly tolerating plants, due to their creeping growth habit and extremely protected growth points, therefore, they cannot be reached by the thermal treatment. Usually, highly tolerating plants are not controlled with only one fire application, regardless of their developmental stage.

According to Virbickaite at al. (2006), the thermal control of annual weeds is 22.5% more efficient than the mechanical method. However, for perennial weeds, the mechanical method is 32% more efficient. The use of a flamethrower may be seen as a technique to control weeds during the pre-emergency stage of crops, before sowing (Rasmussen, 2003), and during the post-emergency stage for tomatoes and cabbage (Wszelaki et al., 2007).

The thermal control also shows positive results when used for a different objective than weed control. According to Silva (2008a), the desiccation of potato branches using flamethrowers is an alternative to chemical control, in which it is possible to desiccate the branches e leafs using the heat of the flame produced by specific burners. In the USA, flaming machines are used to control the Colorado potato beetle; in that case, heat may be effective both for the adult insect and to reduce the eggs.

Marchi et al. (2005), assessing the use of flamethrowers to control weeds on an aquatic environment, when planted on soil vases, observed that all sequential applications offered a reduction of over 90% in the production of dry biomass of *E. crassipes* and *B. subquadripara*, concluding that the physical control by applying the flame is an alternative to manage weeds in aquatic environments.

In that sense, the objective of this paper was to assess the effect of the application time of the flamethrower to control weeds, in comparison to the manual and mechanic control methods.

MATERIAL AND METHODS

The work was conducted central-mountain region of the State of Espírito Santo, at an altitude of 950 m, in the municipality of Domingos Martins. This region has an average of the maximal temperatures over the hottest months between 26.7 and 27.8 °C, and an average of the minimal temperatures over the coldest months between 8.5 and 9.4 °C, with average annual rainfall of 1,800 mm.

The experiment was arranged at a randomized block design with four repetitions and seven treatments, totaling 28 experimental plots with dimensions of 1.0 x 1.0 m. The treatments constituted of five flamethrower application times (0, 5, 10, 15 e 20 s m^{2}) and two weeding types (manual and mechanical types).

The treatments were applied on 08/13/2014 on the respective plots, which were infested by weeds from the following species: *Bidens pilosa, Digitaria sanguinalis, Euphorbia heterophylla, Galinsoga quadriradiata, Oxalis* spp. and *Sonchus oleraceus* on the initial development stage, with the first pair of real leafs completely expanded. To apply the treatment with the flamethrower, a flamethrower with nozzle was used, with an outflow of 1 kg h^{-1} of gas, coupled to a LPG gas flask with capacity for 13 kg. The mechanical weeding treatment was conducted with the help of a hoe and, for the manual treatment, the weeds were manually eliminated.

Five days after applying the treatments, assessments were made as to the infestation percentage, fresh matter, and dry matter weight of weeds in each plot. In order to assess the infestation, four samplings by plot were taken, through digital photograph, obtained with a digital Sony cyber-shot DSC-W350 camera, with 14.1 megapixels, placed at 1.00 m from the ground. The images were processed using the SISCOB® computing system from Embrapa Instrumentação Agropecuária, measuring the soil coverage percentage of the remaining weeds, in each digital photography, and the result was expressed as a percentage of week infestation. In order to assess the fresh and dry matter weight, all weeds from the plot were collected, weighted and dried on a greenhouse with forced air circulation at 65 °C, and they were weighted again. As to the assessed characteristics, it was observed that errors showed ($p>0.05$), normal distribution according to Lilliefors' test and variance homogeneity according to the tests by Cochran and Bartlett.

The application times for the flamethrower were subjected to regression analysis. The means across the treatment times for the 10 s m^{-2} flamethrower, manual, and mechanical weeding were compared according to Tukey's test ($p>0.05$), using the statistical analysis program SAEG, according to Ribeiro Júnior & Melo (2009).

RESULTS AND DISCUSSION

Figures 1, 2 and 3 show, respectively, the fresh matter weight, dry matter weight, and infestation percentage data for weeds due to the application time of the flamethrower. It was observed that the data adjusted significantly to the cubic model and that, from the flamethrower time of 10 s m^{-2}, no reduction of the fresh and dry matter weight and infestation percentage values was found; due to this reason, this value was used for comparison purposes with the other methods used. This flamethrower time reduced the fresh matter weight to 41.09 g m^{-2}, the dry matter weight to 6.72 g m^{-2}, and the infestation percentage to 9.49%, in relation to the absence of flamethrower; these values correspond to a reduction of 94.47, 92.02 and 86.69%, respectively.

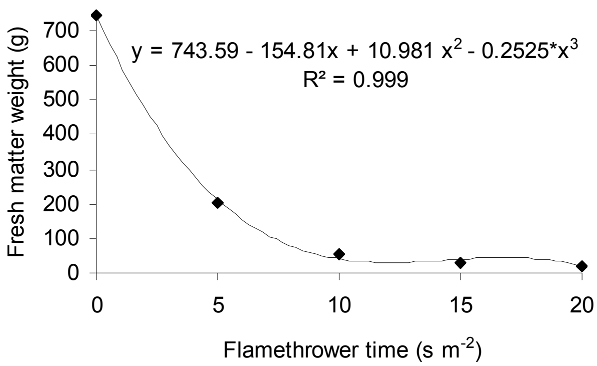

Figure 1 - Fresh matter weight of weeds in relation to the flamethrower application time.

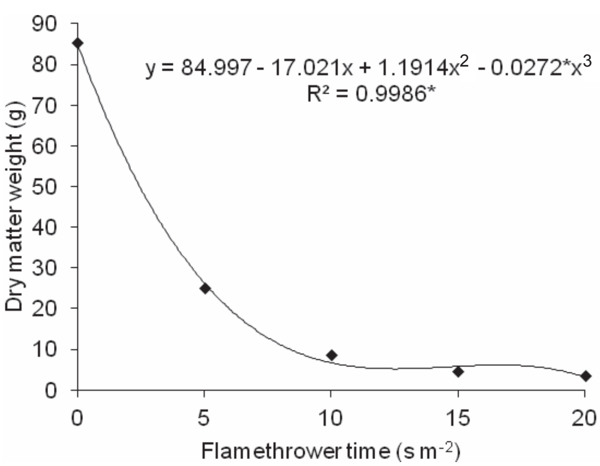

Figure 2 - Dry matter weight of weeds in relation to the flamethrower application time.

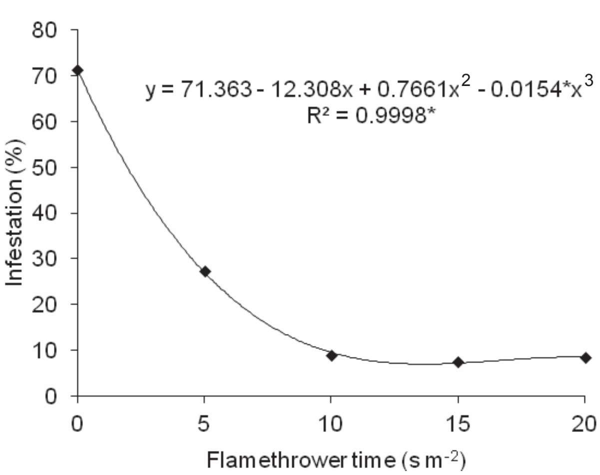

Figure 3 - Percentage of weed infestation in relation to the flamethrower application time.

Marchi et al. (2005), evaluating the use of a flamethrower to control weeds on an aquatic environment on soil-filled vases, observed that the highest percentage reductions of dry matter weight were obtained for *Brachiaria subquadripara*, with doses of 2,226, 1,113 and 556 kg ha^{-1} of LPG, offering reductions of 77.6, 74.2 and 78.3%, respectively. This result was different than the one observed on this paper, in which, with a dosage of 27.7 kg ha^{-1} of LPG, equivalent to 10 s m^{-2} of application of the flamethrower, a reduction of 92% on the dry matter weight of weeds could be obtained. This difference may be explained due to the discrepancy among the weed species and their phenologic stage.

Ascard (1995), comparing the response of different weeds subjected to several dosages of propane for thermal treatment, observed that it was necessary to use dosages of 10-40 kg ha^{-1} to reach 95% of control on the number of plants from species that were sensitive during the stage with 0-4 real leafs; while plants with 4-12 leafs required 40-150 kg ha^{-1}.

Silva (2008b), when testing direct radiation flamethrowers to control two large-leaf species, black-jack (*Bidens pilosa*) and morning glory (*Ipomea triloba*), and two thin-leaf species, signal grass (*Brachiaria decumbens*) and guinea grass (*Panicum maximum*), observed a high efficiency of the treatments both for large-leaf plants, getting to 100% in the case of black-jack, and for the other plants, which showed injuries that assure the control efficiency.

Rahkonen & Vanhala (1993), studying the application of different doses of thermal treatment to a community of plants constituted by *Chenopodium album*, *Matricaria inodora* and *Phleum pratense*, verified that *M. inodora* showed lower injury levels when compared to two other species, which culminated on greater vigor to sprouting again and fast occupation of the room left by more sensitive species. With a competitive edge, *M. inodora* produced a larger quantity of dry matter, when compared to an area that was not subjected to thermal treatment.

The reduced efficiency to control weeds after the thermal treatment with a flamethrower application time of 5 s m^{-2} may be due to the lack of contact of the heat from the flame with the plant or to a tolerance of the plants to heat. The contact between the heat and the plant depends on the heat emission technique used, the structure of the plant and the presence of humidity on the surface of the several structures of the plant (Leroux et al., 2001). Tolerance is due to the presence of protective layers, such as bristles and waxes, lignification, water content and the capacity to sprout again of plants (Laguë et al., 2001).

Ascard (1995) comments that plants treated with a single dose of the flame are exposed for a short period to heat and, for that reason, only the tissues that are more exposed may be initially ruptured. A second application of the flame after an interval of one week may reach the tissues that are more protected and, consequently, offer more control efficiency when compared to a single application. This author also suggests that the second application of the flame may be made as soon as the plant begins to sprout again, with the purpose of completely exhausting its biochemical reserves.

Table 1 shows that the means across the treatments of manual weeding, mechanical weeding and flamethrower time of 10 s m^{-2} showed no significant differences for the fresh matter, dry matter and infestation percentage features. This result clearly indicates that an application time of 10 s m^{-2} for the flamethrower is sufficient to replace the physical control through weeding, whether mechanically or manually.

The application of the flamethrower for 10 s m^{-2} was efficient to control weeds on an initial developmental stage, assuring a reduction of 92.02 and 86.69% for dry matter weight and infestation percentage, respectively.

Table 1 **-** Means of the green weight, dry weight and infestation percentage characteristics

Treatment	Fresh matter (g)	Dry matter (g)	Infestation (%)
Manual weeding	78.43 a	13.24 a	15.21 a
Hoe weeding	65.93 a	12.41 a	10.08 a
Flamethrower - 10 s m^{-2}	53.18 a	8.55 a	8.91 a
Mean	65.84	11.40	11.40

Means followed by the same letter vertically do not differ according to Tukey's test at 5% probability.

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