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Utilização de herbicidas na cultura de *Crotalaria ochroleuca G.Don*

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ABSTRACT
In areas where crotalaria are implanted, weed species may occur, which require adequate management for their control, as they may be competitive with the crop. In view of the above, this work aims to understand the action of herbicides in the control of the viola string in the crotalaria culture. The work was carried out in a greenhouse with a completely randomized design, in a 4x3 factorial scheme, using four herbicides: Sulfentrazone; Flumioxazin; Amicarbazone and Diclosulam, interacting with four concentrations: 25; 50; 75; 100% of the recommended dose plus a control group with no herbicide and with four replications, totaling 52 plots. All herbicides used, even at doses below that recommended by the manufacturer, did not show selectivity to the crotalaria culture. The Diclosulan molecule kept seedlings alive until the seventh day of germination or twelfth day after sowing. With only 68% of the dose of any molecule, it was possible to kill 100% of the crotalaria seedlings.

Keywords: Green manure, Sulfentrazone, Flumioxazina, Amicarbazone, Diclosulam

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RESUMO
Nas áreas onde são implantadas as crotalárias podem ocorrer espécies de plantas daninhas, algumas espécies requerem manejo adequado para o seu controle, pois pode apresentar uma competitividade com a cultura. Diante do exposto, este trabalho tem como objetivo conhecer a ação de herbicidas no controle da corda de viola na cultura da crotalária. O trabalho foi realizado em casa de vegetação com o delineamento inteiramente casualizado, em esquema fatorial de 4x3 sendo quatro herbicidas sendo eles: Sulfentrazone; Flumioxazina; Amicarbazone e Diclosulam, interagindo com quatro concentrações, ou seja: 25; 50; 75; 100% da dose recomendada acrescido um grupo controle com ausência de herbicida e com quatro repetições, totalizando 52 parcelas. Todos os herbicidas utilizados, mesmo em doses abaixo do recomendado pelo fabricante não mostrou seletividade a cultura da crotalária. A molécula Diclosulan manteve plântulas vivas até o sétimo dia de germinação ou décimo segundo dia após a semeadura. Com apenas 68% da dose de qualquer molécula foi possível matar 100% das plântulas de crotalária.

Palavras-chave: Adubo verde, Sulfentrazone, Flumioxazina, Amicarbazone, Diclosulam

1 INTRODUCTION

The use of crotalaria (*Crotalaria ochroleuca* G. Don) crop rotation provides improvements in the physical, chemical and biological characteristics of the soil. Due to its pivoting root system, this plant has a high recycling capacity for nutrients, as it extracts these minerals in the deeper layers of the soil, where they are exported to the more superficial layers after the decomposition of its dry mass. It is an annual legume that has a rustic and aggressive growth, in addition to having interesting properties in the control of nematodes (Braz *et al*., 2016).

In areas where crotalaria are implanted, weed species may occur, thus, although crotalaria can be used to control these invaders, some species require adequate management for their control, as they may be competitive with the crop (Timossi *et al*., 2011). The viola string stands out among these weed species, as it has a climbing habit, which conditions the species to a different ecological niche, resulting in the difficulty of developing crotalaria (Severino *et al*., 2006a).

This interference depends on several factors, such as: the size of the weeds, population density and their phenological stage (Carvalho *et al*., 2011). In the advanced stages of development, the viola string can release its seeds, which have a large amount of reserve in the endosperm, which provides its germination even in the final stages of other cultures. With the expansion of its branches on the host plant, it starts to negatively interfere due to the competition for nutrient and mainly for light, affecting the photosynthetic rate, in addition to making it difficult in the cultural treatments, mainly in the harvest. The application of phyto-regulators exogenously can influence even the germination of seeds, which can even those of the weed (Silva *et al*., 2009; Severino *et al*., 2006b; Rodrigues *et al*., 2020).

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The control of weeds is a fundamental practice in cultural treatments, making the use of specific herbicides makes it an important strategy in decision making to minimize the population of these plants. Therefore, the choice of the appropriate doses of these products presents a limiting factor for their use, since the purpose is the control of the weed and the reduction of its action on the crotalaria culture. (Braz *et al*., 2016; Timossi *et al*., 2011).

Given the above, this work aims to learn about the use of herbicides in the culture of *Crotalaria ochroleuca* G. Don.

2 MATERIAL AND METHODS

Implementation of the experiment and design

An experiment was installed at the Faculty of Agricultural and Technological Sciences (Unesp) campus of Dracena, State of São Paulo, in a greenhouse with a 5 meter high ceiling, covered with plastic light-diffusing film 1000 microns thick and its sides surrounded with Sombrite® type screen with 50% light pass. A completely randomized design was used, in a 4x3 factorial scheme with four herbicides: Sulfentrazone; Flumioxazin; Amicarbazone and Diclosulam, interacting with four concentrations, that is: 25; 50; 75; 100% of the recommended dose plus a control group with no herbicide and with four replications, totaling 52 plots.

The plots were composed of plastic pots with a capacity of seven liters. The soil used was classified according to Embrapa (2013) and the following chemical attributes were determined: P, K, Ca, and Mg, using the ion exchange resin method, pH in $CaCl_2$; organic matter by calorimetry; H + Al with SMP buffer solution; Al in KCl (Raij *et al*., 2001). The plots were fertilized according to Raij *et al*. (1996).

Fifty crotalaria seeds were sown, at a depth of three centimeters, then the herbicides were applied with their respective doses, with the help of a pressurized pump with constant pressure with application of 150 L ha^{-1}, using a fan-type nozzle without air induction.

Development assessments

At 15 days after sowing, crotalaria germination rates (% BW) and survival (% LPC) were determined; given in percent and determined by the equation:

Equation1:

$$\%\mathrm{GC} = \frac{GS}{NS} \times 100$$

Equation2:

$$\%\mathrm{LPC} = \frac{L}{NS} \times 100$$

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Where: GS = germinated seedlings or L = live seedlings and NS is the total number of seeds.

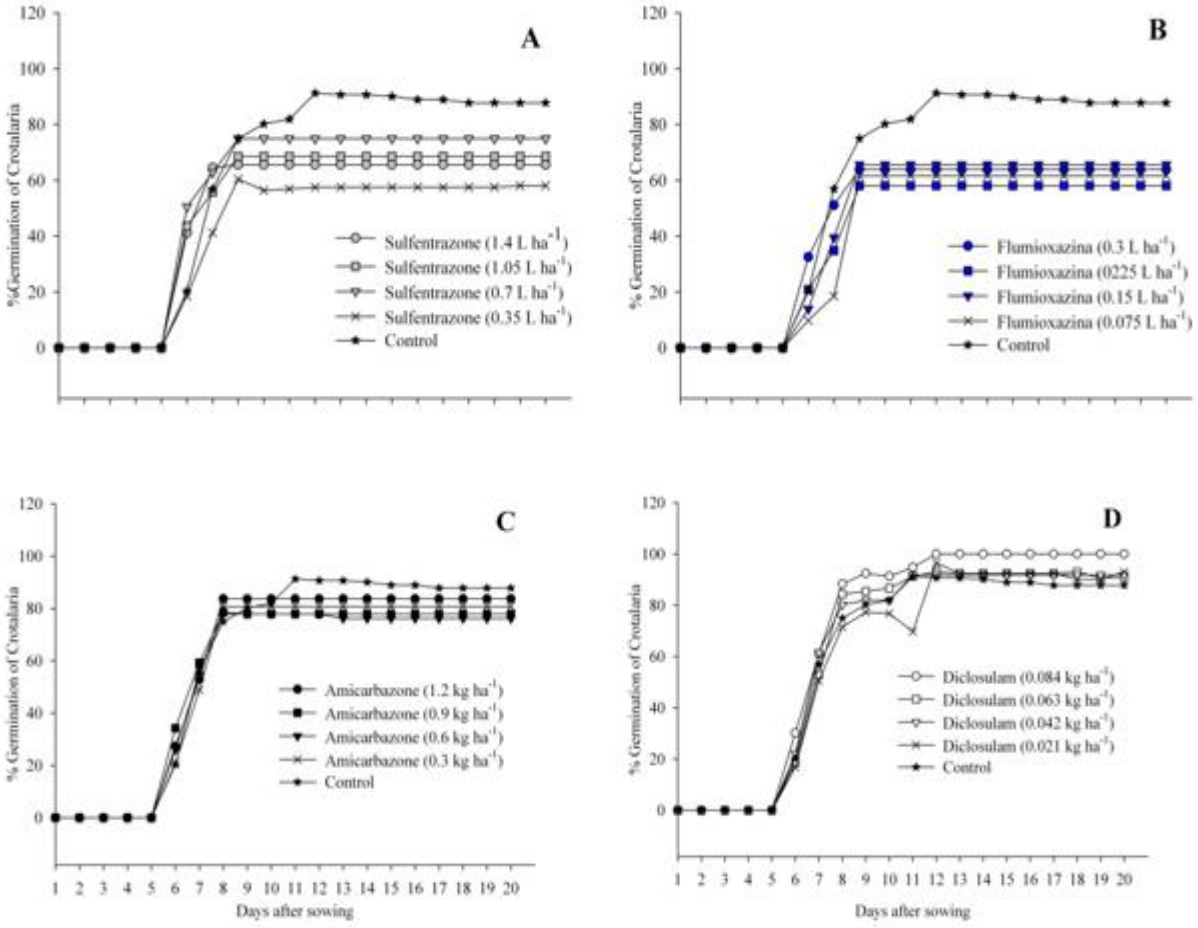
Statistical analysis

All variables were subjected to the F test ($p<0.05$) and were subjected to regression analysis for the doses of each herbicide, in which their models were tested: linear; quadratic and cubic. Tukey's average test was also applied at 5% probability for herbicides (Banzatto and Kronka, 2013). The statistical program was used Assistat 7.7 (Silva and Azevedo, 2016).

3 RESULTS AND DISCUSSION

It was observed that the crotalaria showed a start of germination after the sixth day of sowing, denoting that regardless of the herbicide molecules the germinative behaviors of the culture were similar as shown in Figure 1.

Figure 1. Percentage of crotalaria germination and showing germination behavior during the experimental period. Andradina, 2019.



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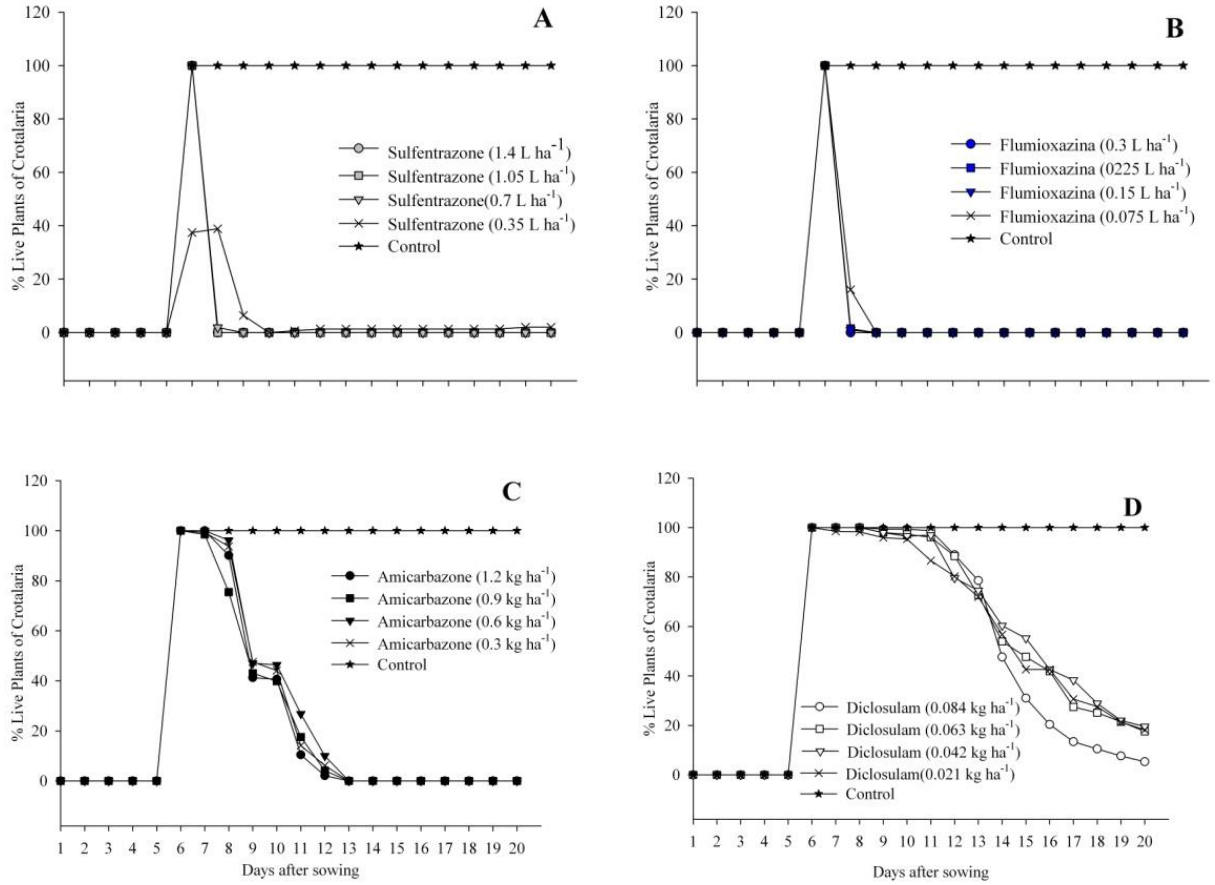
However, it was observed that the percentage of crotalaria germination was impaired when there was an increase in the concentration of the Sulfentrazone and Flumioxazin molecule, as shown in Figure 1A and B. This implies that these molecules already interfere in the germination of the culture even before the emergence, because it showed an average of 65% germination.

The Amicarbazone and Diclosulam molecules showed less interference in the germinative process of crotalaria, since the average germinations were 85%. The difference between the actions of the different herbicide molecules on the crotalaria culture is notorious, since, in Figure 2, the Sulfentrazone molecule, at a concentration of 25% of the recommended dose, still presented live plants within 7 to 8 days. On the other hand, the molecule Flumioxazin, even in lower concentrations of the recommended dose, has already presented a mortality of 100% in the culture of the crotalaria, as shown in Figure 2B.

Figure 2. Percentage of live crotalaria plants showing the action of herbicides on the crop. Andradina, 2019.



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The crotalaria seedlings started to die after the third day of germination, that is, only after the ninth day of sowing when the Amicarbazone molecule was used regardless of the applied dose as shown in Figure 2C, while the action of the Diclosulam molecule started only after the seventh day emergency or twelfth day after sowing, as seen in Figure 2D.

It was observed in isolation among the factors of herbicide molecules where Diclosulam was the one with the highest percentage of crotalaria germination (% BF), statistically equaling with Amicarbazone, as shown in Table 1.

Table 1. Average values of the percentage of crotalaria germination (% GC) and percentage of live crotalaria plants (% LPC) after the action of herbicides.

Herbicides (H)	%GC	%LPC
Sulfentrazone	71.58bc	21.34c
Flumioxazina	64.75c	20.46c
Amicarbazone	77.28ab	41.26b
Diclosulam	84.41a	71.23a
MSD	7.48	4.38
CV%	12.01	13.59
OA	74.51	38.57
p value of (H)	<0.0001**	<0.0001**
p value of (D)	<0.0001**	<0.0001**
p value of HxD	0.1180Ns	<0.0001**

DMS: Minimum significant difference. CV: Coefficient of variation. OA: Overall average. F: value of F in the analysis of variance; Ns p=0.05; *0.01≤p<0.05; **p<0.01. Equal averages within the column do not differ statistically. Tukey's test was applied at 5% probability.

Table 2 shows the analysis of variances of the factor regressions of herbicide doses applied to the crotalaria crop. Was the linear response in the molecules Amicarbazone and Diclosulam is notorious.

Table 2. Analysis of variance of the regressions of the percentage of crotalaria germination (%GC) and percentage of live crotalaria plants (%LPC); after the action of the herbicides, where the models were tested: linear, quadratic and cubic.

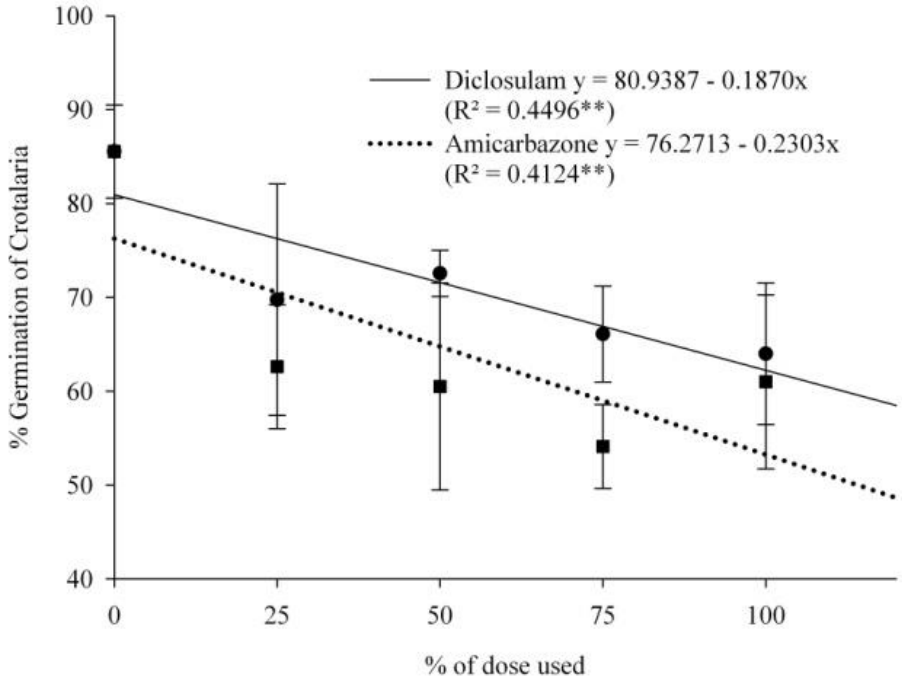
Herbicide		%GC	%LPC
Sulfentrazone	p value	0.4386NS	0.001**
	Regression	Ns	Q
Flumioxazina	p value	0.1008NS	0.001**
	Regression	Ns	Q**
Amicarbazone	p value	0.0011**	0.001**
	Regression	L	Q
Diclosulam	p value	0.0017**	0.0047**
	Regression	L	Q

Ns-p>=0.05; *0.01≤p<0.05; **p<0.01. L: 1st degree polynomial. Q: 2nd degree polynomial.

This response can be well seen in Figure 3, in which it is shown that the increase in the concentration of doses showed a decrease in the percentage of germination. It was not possible to

make an analysis for this variable in the Sulfentrazone and Flumioxazin molecules due to the mortality of the crotalaria seedlings in a few days as pointed out in Figure 2A and B.

Figure 3: Regressions of the percentage of germination of sunnheme after the application of Diclosulam and Amicarbazone. Andradina, 2019.



Diclosulan are herbicides of the chemical group Triazolpyrimidines and act as pre-emergents of residuals in the soil, inhibit the enzyme acetolactate synthase (ALS) and the synthesis of amino acids, mainly in the route of amino acids such as leucine, valine and isoleucine, which also act to inhibit cell division, causing accumulation of acetohydroxybutyrate and decreasing the flow of assimilates. This set of effects leads to death-sensitive plants, initially presenting symptoms such as leaf border and yellow leaf blade and red or purple ribs.

Amicarbazone are herbicides of the chemical group Triazolinone, which act as pre-emergents of residuals in the soil, inhibit the flow of electrons in photosystem II, and, with that, photosynthesis. There is a reduction in the photosynthetic rate due to the interruption in the flow of electrons, causing a low production of energy, which, consequently, triggers the synthesis of carbohydrates and sugars, leading the plant to death, after exposure to its to this herbicide molecule, which causes symptoms of chlorosis of the ribs, at the edges and later on the entire leaf (Roman *et al*., 2005; Carvalho., 2017; Marchi *et al*., 2008).

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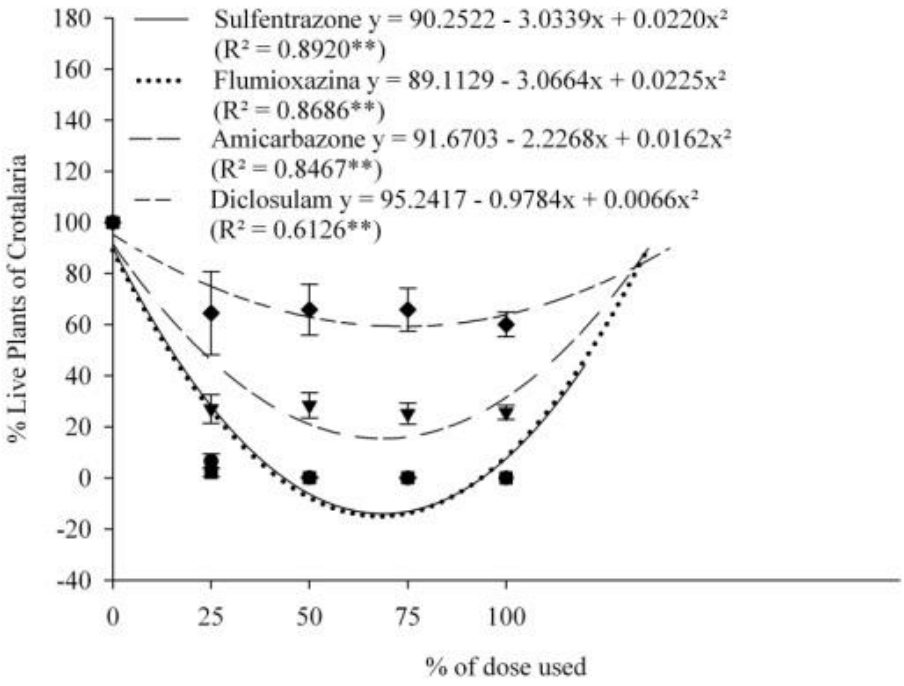
An interaction was observed between the factors studied, as shown in Table 2. In Figure 4, the quadratic responses of all analyzed molecules are observed.

Figure 4. Regression of percentage of live plants of crotalaria after application of herbicides. Andradina, 2019.



The maximum crotalaria mortality point for the Sulfentrazone molecule was 68.95% of the recommended dose, whereas in the Flumioxazin molecule it was 68.14%; for the Amicarbazone molecule, it was 68.72 and 74.12% for Diclosulam. This implies that even with approximately 68% of the recommended dose of each herbicide, 100% of crotalaria plants already occur.

The action of the molecules of the herbicides Sulfentrazone and Flumioxazina are herbicides of the chemical group Triazolinone and N-phenyl-phthalimides act as a pre-emergent of residuals in the soil, and inhibit the enzyme protoporphyrinogen oxidase (PROTOX) that starts to destroy cell membranes. This occurs due to the accumulation of Protoporphyrogen and Protoporphyrin group IX, which leads to the destruction of cell membranes, triggering tissue necrosis and plant death, especially in the initial phase of seedlings (Roman *et al*., 2005; Carvalho, 2017; Marchi *et al*., 2008).

4 CONCLUSION

All herbicides used, even at doses below that recommended by the manufacturer, did not show selectivity to the crotalaria culture.

The Diclosulan molecule kept seedlings alive until the seventh day of germination or twelfth day after sowing.

With only 68% of the dose of any molecule, it was possible to kill 100% of the crotalaria seedlings.

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