REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

SELECTIVITY OF RESIDUAL HERBICIDES USED IN SUGARCANE CROPS FOR *CROTALARIA* SPECIES

SELETIVIDADE DE HERBICIDAS RESIDUAIS USADOS EM CANA-DE-AÇÚCAR PARA ESPÉCIES DE CROTALÁRIA

Renan Cantalice de Souza
Universidade Federal de Alagoas – UFAL, Brasil
Orcid: https://orcid.org/0000-0001-9022-3360
E-mail: renan.souza@ceca.ufal.br

Leandro Lima Casado dos Santos
Universidade Federal de Alagoas – UFAL, Brasil
Orcid: https://orcid.org/0000-0002-7011-5837
E-mail: leandro.casado@ceca.ufal.br

Hilda Rafaella da Silva Santos
Universidade Federal de Alagos – UFAL, Brasil
Orcid: https://orcid.org/0000-0003-3893-125X
E-mail: hilda.santos@ceca.ufal.br

Mariângela Gomes Pereira
Universidade Federal de Alagoas – UFAL, Brasil
Orcid: https://orcid.org/0009-0007-3780-8432
E-mail: mariangela.pereira@ceca.ufal.br

Ana Rosa de Oliveira Farias
Universidade Federal de Alagoas – UFAL, Brasil
Orcid: https://orcid.org/0000-0002-1593-5293
E-mail: ana.farias@ceca.ufal.br

Antônio Barbosa da Silva Júnior
Universidade Federal de Alagoas – UFAL, Brasil
Orcid: https://orcid.org/0000-0002-2513-7471
E-mail: antonio.barbosa@ceca.ufal.br

Submetido: 10 ago. 2023
Aprovado: 23 out. 2023.
Publicado: 21 nov. 2023.

E-mail para correspondência:
renan.souza@ceca.ufal.br

Abstract: The use of herbicides for desiccation and with residual effect in sugarcane crops increases the spectrum of weed control, reducing the early interference of weeds in crops. *Crotalaria* species are commonly used for certain purposes, including weed suppression, but herbicides need to be applied to provide a better establishment ofthespecies. Given the above, the objective of this study was to determine the tolerance of *Crotalaria* species to pre-emergence herbicides used in sugarcane through dose-response curves, establishing the safest doses to be used. Greenhouse assays were conducted at the Campus of Engineering and Agricultural Sciences of the Federal Universityof Alagoas (CECA/UFAL), located in Rio Largo – AL. The experimental units consisted of recipients with a capacity of 500 ml filled with médium to heavy texture soil. Seeds of *Crotalaria ochroleuca* and *Crotalaria spectabilis* were sown directly in the recepients. Five herbicides were used in the experiment: flumioxazin (Flumyzin®), metsulfuron-methyl (Zartan®), clomazone (Reactor®), 2,4-D + picloram (Norton®) andisoxaflutole (Provence®). The experimental design was completely randomized in a 2 x 5 factorial arrangement, with four replications. The factors were two species of *Crotalaria* (*C. ochroleuca* and *C. spectabilis*) and five doses of herbicides (0; 50; 100; 200; and 400% of the dose recommended for sugarcane crops). One experimente was performed for each herbicide. A visual control evaluation was performed: 0% indicated the total absence of symptomsand 100% indicated the death of the plant. At the end of the experiment, the plants were collected for assessment of shoot and root dry mass. The experimental data weren submitted to analysis of variance using the SISVAR software and a non-linear regression model of the logistic type with 3 parameters was fit to the data. The results obtained showed that the herbicides clomazone and methsulfuron-methyl are safe for *C. spectabilis*, but *C. ochroleuca* tolerated doses below that recommended by the manufacturer. The species *C. spectabilis* and *C. ochroleuca* have moderate tolerance to the herbicide flumioxazin. The herbicide isoxaflutole is safe only for *C. spectabilis* and the herbicide 2,4-D + picloram is not recommended for any of the two species.

Keywords: Crop rotation. Pre-emergent herbicides. Dose-response.

Resumo: A utilização de herbicidas em cana-de-açúcar para dessecação e com efeito residual, aumentam o espectro do controle de plantas daninhas, reduzindo a interferência precoce destas com a cultura. Associado, o uso de espécies de crotalárias é comumente empregado para determinados fins, dentre eles, a supressão de plantas daninhas, no entanto, a aplicação de herbicidas é necessária para proporcionar um melhor estabelecimento da espécie. Diante do exposto, o objetivo do trabalho foi determinar a tolerância de espécies de crotalárias aos herbicidas pré-emergentes utilizados em cana-de-açúcar através de curva de doses-resposta.. O ensaio foi conduzido em casa de vegetação no Campus de Engenharias e Ciências Agrárias da Universidade Federal de Alagoas (CECA/UFAL), localizado em Rio Largo – AL. As unidades experimentais foram constituídas por copos com capacidade para 500 ml, sendo utilizado solo de textura média, onde as sementes das espécies de *Crotalaria Ochroleuca* e *Crotalaria Spectabilis* foram semeadas diretamente nos recipientes. O experimento caracterizou-se pelo uso de cinco herbicidas, assim definidos:flumioxazina (Flumyzin®), metsulfurom-metílico (Zartan®), clomazona (Reator®), 2,4-D + picloram (Norton®) eisoxaflutol (Provence®). Utilizou-se o delineamento inteiramente casualizado em esquema fatorial 2x5, com quatro repetições.Os fatores foram duas espécies de crotalárias (*C. Ochroleuca* e *C. Spectabilis*) e cinco doses dos herbicidas (0; 50; 100; 200 e 400% da dose recomendada para a cultura da cana-de-açúcar). Para cada herbicida foi realizado um experimento. Foi realizada avaliação visual de controle, onde 0% representava ausência total de sintomas e 100% morte da planta. Ao término do experimento, foram realizadas a coleta das plantas para a massa seca de parte aérea e raiz. Os dados experimentais foram submetidos à análise de variância utilizando-se o *software* SISVAR e posteriormente foram ajustados ao modelo de regressão não-linear do tipo logístico com 3 parâmetros. Os resultados obtidos demonstraram que os herbicidas clomazona e metsulfurom-metílico são seguros para *C. spectabilis*, enquanto que, para *C. ochroleuca* a tolerância é abaixo da dose recomendada pelo fabricante. As espécies de *C. spectabilis* e *C. ochroleuca* possuem tolerância moderada ao herbicida flumioxazina. O herbicida isoxaflutol é seguro apenas para *C. spectabilis* e o herbicida 2,4-D + picloram não é recomendado para ambas as espécies.

Palavras-chave: Rotação de culturas.Pré-emergentes. Dose-reposta.

Introduction

Crop rotation was one of the first sustainable practices to emerge in agriculture, optimizing the use of nutrient sand reducing pest sand pathogen volume [(1)]. Green manureis a potential fertilizer because it increases the organic carbon present in the soil, improving soil fertility and microbial activity [(2)]. *Crotalaria* species at different stages of growth are considered allelopathic plants useful for weed control, significantly reducing weed coverage [(3,4,5)].

Crop rotation and application of legume green manures are implemented in sugarcane crops in Brazil because these practices do not interfere with crop sprouting and prevent the propagation of weeds. It is also indicated in the renewal of sugarcane fields and the cost is considered low (6). There are also benefits in terms of crop yield. The cultivation of legumes such as *Crotalaria juncea* results in greater nitrogen accumulation, promoting increases in stalk and sugar production (7). *Crotalaria ochroleuca*, in turn, is important in crop rotation to reduce nematode populations (8) and *C. spectabilis* promotes greater total soil porosity and aggregate stability (9).

Desiccation of ratoons, one of the practices used in sugarcane cultivation, is fundamental for the renewal of sugarcane fields and crop succession (10). In turn, the desiccation of weeds contributes to the incorporation of a large amount of plant residues, increasing soil fertility and aeration, ultimately facilitating the distribution of water through the soil profile and promoting a favorable environment for the development of sugarcane roots (11).

Desiccation operations with residual effect increase the spectrum of weed control, especially at the beginning of the crop cycle, thus avoiding early interference (12). The level of weed control depends on the herbicide used, its residual effect, and the season in which it is applied (13).

Although *Crotalaria* species are efficient for weed management in sugarcane crops, the application of herbicides in desiccation is necessary to provide a better establishment of the species. It is important, thus, to evaluate the tolerance of these species to herbicides in order to establish the safest doses to be used (14). Given the above, the objective of this study was to determine the tolerance of *Crotalaria* species to pre-emergence herbicides used in sugarcane crops through dose-response curves.

Methodology

The assay was conducted in a greenhouse at the Campus of Engineering and Agricultural Sciences of the Federal University of Alagoas (CECA/UFAL), in Rio Largo – AL (09°28’ 02” S; 35°49’ 43” W; 127 m), in the Coastal Tablelands (‘TabuleirosCosteiros’) region.

Five herbicides were used in theexperiment: flumioxazin (Flumyzin® from the company Sumitomo), metsulfuron-methyl (Zartan® from the company UPL OpenAg), clomazone (Reactor®), 2,4-D + picloram (Norton® from the company Nortox), and isoxaflutole (Provence® from the company Bayer). The experimental design was completely randomized in a 2 x 5 factorial arrangement, with four replications. The factors were two species of

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

Crotalaria (*C. ochroleuca* and *C. spectabilis*) and five doses of herbicides (0; 50; 100; 200; and 400% of the dose recommended for sugarcane crops).

The experimental units consisted of with a capacity of 500 ml filled with sieved soil of medium texture. The seeds of the two species were sown directly into the recipients. The herbicides were applied using a CO_2 pressurized backpack sprayer equipped with bars containing two Adia 110.02 flat-fan spray nozzles and using a constant pressure of 200 KPa to provide a spray solution volume corresponding to 120 $L.ha^{-1}$.

The application of the herbicide treatments took place 30 days prior to the sowing of *Crotalaria* species, simulating the applications carried out along with desiccation in sugarcane crops. Thinning was performed at 60 days after application (DAA) of the herbicides and 30 days after sowing the species, leaving only one plant per recipients. After applying the treatments, a visual control evaluation was performed: 0% indicated total absence of symptoms and 100% indicated the death of the plant. At the end of the period of 90 days after sowing and 120 DAA, the plants were collected for assessment of shoot and root dry mass. We decided to present only the curves generated at 120 DAA, so that the herbicides could be fully absorbed by the plants.

The experimental data were submitted to analysis of variance using the SISVAR software [(15)] and a non-linear regression model of the logistic type with 3 parameters was fit to the data [(16)] (eq. 1).

$$y = \frac{a}{\left[1 + \left(\frac{x}{b}\right)^{c}\right]}$$

Where:

y = percentage of control

x = dose of the herbicide;

a, *b* and *c* = curve parameters; *a* is the difference between the maximum and minimum points of the curve, *b* is the dose that provides the percentage of 50% of the response of the variable, and *c* is the slope of the curve.

To define the doses required for optimal control, the control percentages of 50, 80 and 90% were calculated. The values were obtained from the equations generated from the dose-

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

response curves and they represent the dose of the herbicides ($g.ha^{-1}$) for 50, 80 and 90% control, respectively [17].

Results and Discussion

A significant interaction term was found in the analysis of variance. Table 1 indicates the parameters *a*, *b*, and *c* and the lethal doses that caused 50, 80, and 90% of mortality in the species.

Table 1 - Parameters of the logistic equation used to describe the percentagem of control of *Crotalaria* species at 120 DAA of pre-emergence herbicides.

Herbicide	Species	*A*	*B*	*C*	$R^{(2)}$	LD50	LD80	LD90
Flumioxazin	*C. ochroleuca*	105.2	54.8	117.6	0.79	56.12g	90.51g	107.62g
	C. spectabilis	105.0	52.5	106.3	0.82	50.63g	83.68g	100.18g
2,4-D + picloram	*C. ochroleuca*	78.8	0.02	0.3	0.85	2.15g	IDM*	IDM
	C. spectabilis	100.0	0.01	0.4	1.00	2.97g	3.13g	3.23g
Isoxaflutole	*C. ochroleuca*	120.8	112.1	258.9	0.77	164.9g	250.8g	284.29g
	C. spectabilis	97.9	2.1	45.5	0.99	34.17g	36.49g	37.98g
Clomazone	*C. ochroleuca*	2.8	0.00	3.0	0.37	IDM	IDM	IDM
	C. spectabilis	96.4	1.5	2.6	0.92	29.45g	54.54g	72.11g
Metsulfuron -methyl	*C. ochroleuca*	81.2	0.4	0.8	0.95	0.17g	0.43g	IDM
	C. spectabilis	63.2	1.1	2.5	0.70	0.70g	IDM	IDM

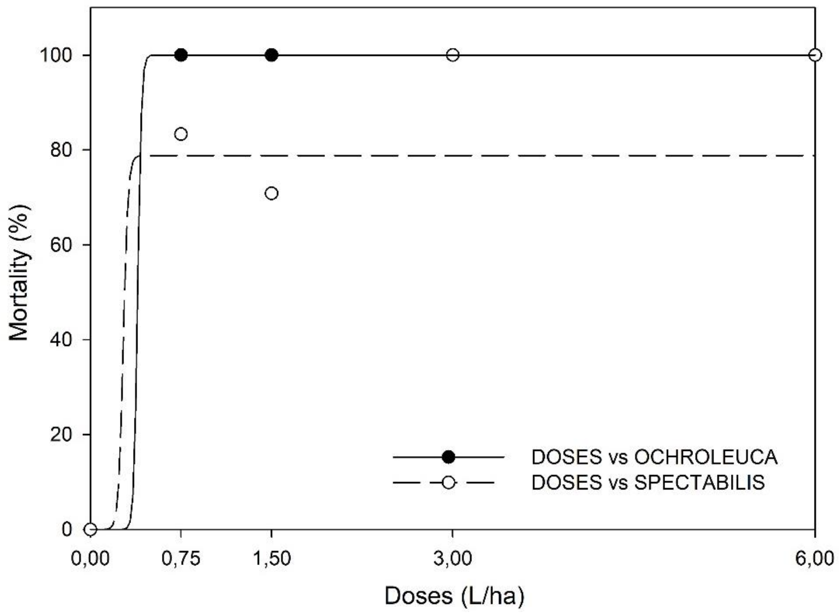
* Impossibleto Determine by the Method (IDM)

For the herbicide 2,4-D + picloram, the mortality of the species *C. ochroleuca* was reached at doses lower than the commercial dose recommended by the manufacturer, that is, the species is not tolerant to the herbicide at any dose tested. The mortality of *C. spectabilis* did not reach 100% at the doses of 0.75 and 1.5 L/ha, but rather rangedf rom 60 to 80% of the control; a dose of 3 L/ha, which corresponds to 200% of the recommended commercial dose, was required to obtain total mortality (Figure 1). Post-emergence application of 2,4-D + picloram in species of Fabaceae, such as beans, caused high phytointoxication and reduced

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

plant height and consequently dry mass, being, therefore, unsuitable for use in this species [18].

Figure 1 – Percentage of mortality of *Crotalaria* species at 120 DAA of2,4-D + picloram at increasing doses.



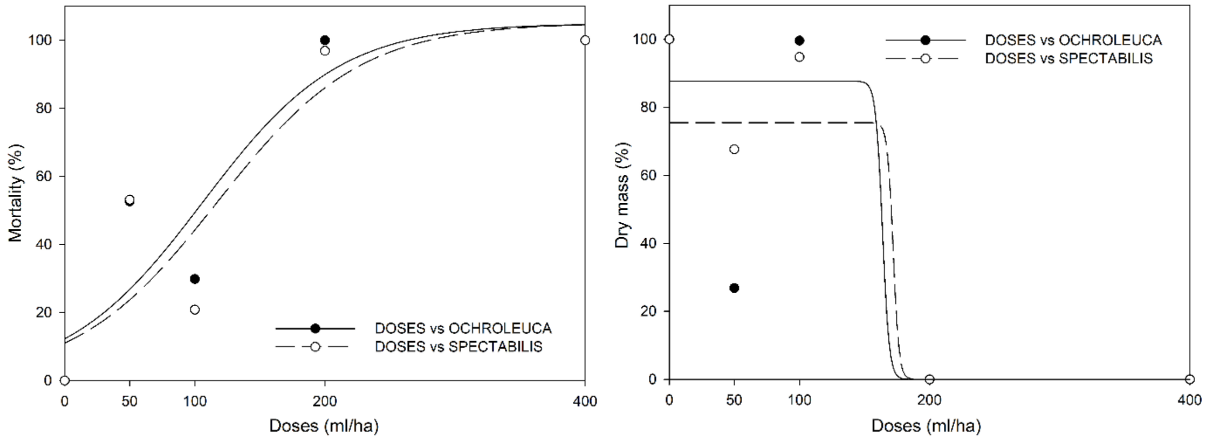
The herbicide flumioxazin caused nearly 100% mortality in *Crotalaria* species at a dose of 200 ml/ha. Between the doses of 50 and 100 ml/ha, whichis the dose recommended by the manufacturer, the control ranged from 100% to 50% mortality in the species *C. ochroleuca* and *C. spectabilis* (Figure 2). The amount of 56.12 g of the comercial product, which is very close to the commercial dose, was necessary to obtain the LD50, and it was necessary to increase the dosage to cause 100% mortality of the species. This indicates that the species have a moderate tolerance to this herbicide. The use of different doses Applied pre-emergence to C. juncea using the herbicides saflufenacil and indaziflam found that both herbicides cause phytotoxicity and reduced plant biomass at all tested doses. These variables were influenced by sowing times, indicating the species' sensitivity to these herbicides [19].

At the recommended commercial dose of flumioxazin, the dry mass value (%) was close to that of the control with out herbicide in the two species. A notable decrease was found at the doses of 200 and 400 ml/ha, which represent 200% and 400% of the commercial dose, respectively (Figure 2). The herbicides atrazine, oxadiazon, mesotrione, and the mixture

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

atrazine + flumioxazin + carfentrazone-ethyl, interfere distinctly in *C. spectabilis*. The previously mentioned herbicides are not selective when applied post-emergence [20].

Figure 2 - Percentage of mortality and dry mass of *Crotalaria* species at 120 DAA of flumioxazin at increasing doses.

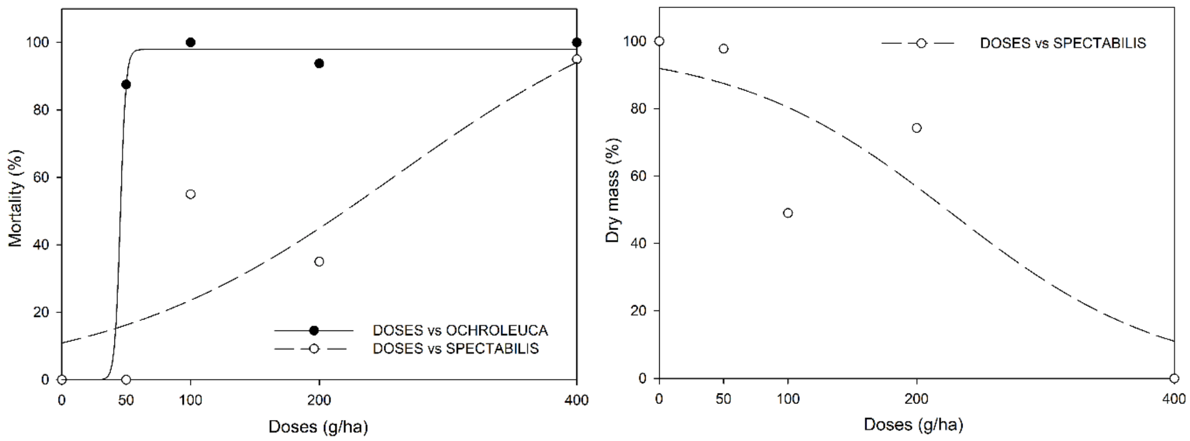


The doses of 50 and 100 g/ha of theherbicide isoxaflutole caused more than 80% and 100% mortality, respectively, in thespecies *C. ochroleuca*. In *C. spectabilis*, nearly 100% mortality occurred When the dose of 400 g/ha was used (Figure 3). Therefore, the herbicide is safe only for *C. spectabilis* at a dose of 200 g/ha, but it is not recommended for *C. ochroleuca*, since the speciesis not tolerant to this herbicide at any dose tested. In mung bean, a plant morphologically similar to Crotalaria, the use of isoxaflutol as a pre-emergent for controlling Chloris virgata causes damage to the crop and reduces its field emergence rate, consequently decreasing the likelihood [21].

In terms of dry mass (%), the species *C. ochroleuca* did not fit the curve, since the species presented high susceptibility to the molecule studied, as can be seen in the control variable. In turn, the dry mass accumulation of *C. spectabilis* was close to 80% compared to the control at the dose of 200 g/ha, which is equivalent to 200% of the commercial dose, thus showing that the species has tolerance to this herbicide (Figure 3).

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

Figure 3 - Percentage of mortality and dry mass of *Crotalaria* species at 120 DAA of isoxaflutole at increasing doses.

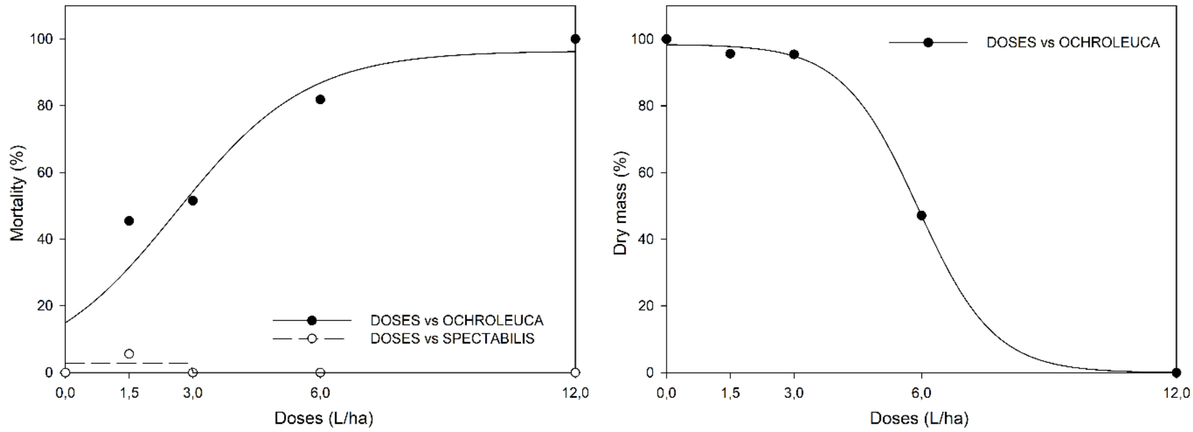


In the case of the herbicide clomazone, nearly 100% mortality of *C. ochroleuca* occurred at the dose of 12.0 L/ha, and the dose of 1.5 L/ha, below the dose recommended by the manufacturer, was safer (Figure 4). The species *C. spectabilis* showed high tolerance even to high doses of the herbicide; thus, the use of clomazone is recommended for production systems in which *C. spectabilis* is used as a source of green manure. Green manure improves nitrogen management, increasing the decomposition of organic matter [22].

The accumulation of dry mass of the species *C. ochroleuca* was very close to the control at doses of 1.5 and 3 L/ha. There was a reduction close to 50% of the relative dry mass at the dose of 6 g, which is equivalent to 200% of the commercial dose. This indicates that the dry mass of *C. ochroleuca* increases despite high doses of the herbicide (Figure 4). The species *C. spectabilis* did not fit the proposed logistic model with three parameters, what is explained by the low mortality, because *C. spectabilis* demonstrated high tolerance to the herbicide and, thus, a dose-response curve was not generated and the accumulation of dry mass was not different from the control.

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

Figure 4 – Percentage of mortality and dry mass of *Crotalaria* species at 120 DAA of clomazone at increasing doses.

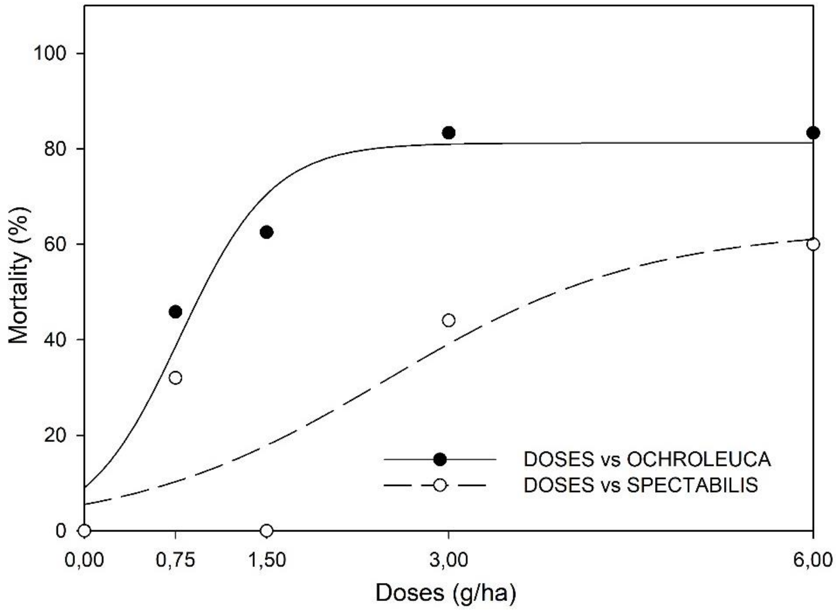


A mortality of 100% was not obtained in any of the two species when metsulfuron-methyl was used. *Crotalaria spectabilis* was less susceptible to the herbicide, with a mortality of approximately 60% with the maximum dose tested (6.0 g/ha). The dose of 1.5 g/ha recommended by the manufacturer was the most suitable for the species, since it did not cause death (Figure 5).

Studies on the selectivity of post-emergence herbicides imazamox, bentazon, pyrithiobac-sodium, flumiclorac, and the mixtures imazamox + bentazon, clethodim + quizalofop applied to C. spectabilis, find that the herbicides imazamox and flumiclorac are selective and can be used for weed control in crops with *C. spectabilis*, whereas the herbicide pyrithiobac-sodium, despite belonging to the same chemical group as imazamox, did not exhibit selectivity (23).

In the case of *C. ochroleuca*, the dose of 3 g/ha of metsulfuron-methyl promoted a mortality of 80% (Figure 5). The Nicossulfuron, classified in the chemical group of ALS inhibitors (Acetolactate Synthase Enzyme), just like the Methyl Metsulfuron analyzed in this study, was selective for *C. spectabilis* in a post-emergence application study using the herbicides nicossulfuron and bentazon (24). Thus, the dose of 0.75 g/ha, below that recommended by the manufacturer, is the most advisable for application in the desiccation of *C. ochroleuca*, aiming at the establishment of the species.

Figure 5 – Percentage of mortality of *Crotalaria* species at 120 DAA of metsulfuron-methyl at increasing doses.



For metsulfuron-methyl and 2,4-D + picloram, it was not possible to determine the dry mass Variable using the proposed model.

Conclusion

The herbicides clomazone and methsulfuron-methyl are safe for *C. spectabilis*, while *C. ochroleuca* showed tolerance below the dose recommended by the manufacturer.

The species *C. spectabilis* and *C. ochroleuca* have moderate tolerance to the herbicide flumioxazin.

The herbicide isoxaflutole is safe for *C. spectabilis*, but not for *C. ochroleuca.*

The herbicide 2,4-D + picloram is not recommended for any of the two species.

Referências

1 Dias T, Dukes A, Antunes PM. Accounting for soil biotic effects on soil health and crop productivity in the design of crop rotations. J Sci Food Agric [Internet]. 10 fev 2014;95(3):447-54. https://doi.org/10.1002/jsfa.6565.

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

2 Maitra S, Zamam A, Mandal TK, Palai JB. Green manures in agriculture: A review. J of Pharmacognosy and Phytochemistry [Internet]. 2018;7(5):1319-1327.

3 Bundit A, Ostlie M, Prom-U-Thai C. Sunn hemp (Crotalaria juncea) weed suppression and allelopathy at different timings. Biocontrol Sci Technol [Internet]. 8 fev 2021;31(7):694-704. https://doi.org/10.1080/09583157.2021.1881446.

4 Cherr CM, Scholberg JM, McSorley R. Green Manure Approaches to Crop Production: A Synthesis. Agron J [Internet]. Mar 2006;98(2):302-19. https://doi.org/10.2134/agronj2005.0035.

5 Skinner EM, Díaz-Pérez JC, Phatak SC, Schomberg HH, Vencill W. Allelopathic Effects of Sunnhemp (Crotalaria juncea L.) on Germination of Vegetables and Weeds. HortScience [Internet]. Jan 2012;47(1):138-42. https://doi.org/10.21273/hortsci.47.1.138.

6 Ambrosano EJ, Trivelin PC, Cantarella H, Ambrosano GM, Schammass EA, Guirado N, Rossi F, Mendes PC, Muraoka T. Utilization of nitrogen from green manure and mineral fertilizer by sugarcane. Sci Agricola [Internet]. Dez 2005;62(6):534-42. https://doi.org/10.1590/s0103-90162005000600004.

7 Ambrosano EJ, Cantarella H, Ambrosano GM, Schammas EA, Dias FL, Rossi F, Trivelin PC, Muraoka T, Sachs RC, Azcón R. Produtividade da cana-de-açúcar após o cultivo de leguminosas. Bragantia [Internet]. 2011;70(4):810-8. https://doi.org/10.1590/s0006-87052011000400012.

8 Leandro HM, Asmus GL. Rotação e sucessão de culturas para o manejo do nematoide reniforme em área de produção de soja. Cienc Rural [Internet]. Jun 2015;45(6):945-50. https://doi.org/10.1590/0103-8478cr20130526.

9 Moraes, LAA; Filho, JT; Melo, TR. Different managements in conventional sugarcane reform in sandy soils: effects on physical properties and soil organic carbon. Rev Brasileira de Ciência do Solo [Internet]. 2022;46. https://doi.org/10.36783/18069657rbcs20220017.

10 Timossi PC, Durigan JC. Manejo de convolvuláceas em dois cultivares de soja semeada diretamente sob palha residual de cana crua. Planta Daninha [Internet]. 2006;24(1):91-8. https://doi.org/10.1590/s0100-83582006000100012.

11 Moraes ER, Mageste JG, Lana RM, Torres JL, Domingues LA, Lemes EM, Lima LC. Sugarcane Root Development and Yield under Different Soil Tillage Practices. Rev Bras Cienc Solo [Internet]. 2019;43. https://doi.org/10.1590/18069657rbcs20180090.

12 Jaremtchuk CC, Constantin J, Oliveira Júnior RS, Biffe DF, Alonso DG, Arantes JG. Efeito de sistemas de manejo sobre a velocidade de dessecação, infestação inicial de plantas daninhas e desenvolvimento e produtividade da soja. Acta Sci Agron [Internet]. 6 out 2008;30(4). https://doi.org/10.4025/actasciagron.v30i4.5297.

13 Ronchi CP. Association of chemical and mechanical weed control methods during the pre-harvest of coffee crops. Planta Daninha [Internet]. 2020;38. https://doi.org/10.1590/s0100-83582020380100079.

REVISTA CIENTÍFICA FAEMA
ISSN 2179-4200
DOI: http://dx.doi.org/10.31072

14 Cerqueira DC, Ferreira VM, Souza RC, Araújo Neto JC, Silva VS, Almeida FF. Management of Soil Mulch in Weed Suppression and Sugarcane Productivity. J Agric Sci [Internet]. 10 jul 2018;10(8):125. https://doi.org/10.5539/jas.v10n8p125.

15 Ferreira, DF. Sisvar: a computer statistical analysis system. Ciência e agrotecnologia. 2011;35:1039-1042.

16 Streibig, JC. Herbicide bioassay. Weed Research.1988;28(6):479-484.

17 Christoffoleti PJ, Borges A, Nicolai M, Carvalho SJ, López-Ovejero RF, Monquero PA. Carfentrazone-ethyl aplicado em pós-emergência para o controle de Ipomea spp. e Commelina benghalensis na cultura da cana-de-açúcar. Planta Daninha [Internet]. 2006; 24(1):83-90. https://doi.org/10.1590/s0100-83582006000100011.

18 Fernandes CPC, Braz AJBP, Procópio SO, Dan HA, Braz GBP, Barroso ALL, Menezes CCE, Simon GA, Braz LBP. Seletividade de herbicidas registrados para uso em pré e pós-emergência na cultura da cana-de-açúcar ao feijoeiro-comum. Rev Trópica [Internet]. 2012;5(3):8-21.

19 Torres AB, Meneghin SP, Ribeiro NM, Santos HV, Schedenffeldt BF, Monqueiro PA. Saflufenacil and indaziflam herbicide effects on agricultural crops and microorganisms. Afr J Agric Res [Internet]. 19 abr 2018;13(16):872-85. https://doi.org/10.5897/ajar2018.13067.

20 Dias RC, Mendes KF, Gonçalves CG, Melo CAD, Teixeira MFF, Silva DV, Reis MR. Seletividade inicial de herbicidas aplicados em pós-emergência da crotalária. Rev Bras Herbic [Internet]. 10 mar 2017;16(1):76. https://doi.org/10.7824/rbh.v16i1.517.

21 Mahajan, G, Chauhan, BS. Evaluation of preemergent herbicides for Chloris virgata control in mungbean. Plants [Internet]. 2021;10 (8):1632. https://doi.org/10.3390/plants10081632.

22 Tariq M, Ali H, Hussain N, Nasim W, Mubeen M, Ahmad S, Hasanuzzaman M. Fundamentals of crop rotation in agronomic management. Agronomic Crop [Internet]. 2019; 1: 545-559. https://doi.org/10.1007/978-981-32-9151-5_24.

23 Braz GBP, Oliveira Júnior RS, Constantin J, Takano HK, Godinho FB. Selectivity of herbicides applied in post-emergence of showy crotalaria. Rev Caatinga [Internet]. Dez 2016;29(4):918-26. https://doi.org/10.1590/1983-21252016v29n417rc.

24 Nogueira CHP, Correia NM, Gomes LJP, Ferreira PSH. Selectivity of bentazon andnico sulfuron in Crotalaria spectabilis inter cropped with maize culture. Rev Caatinga [Internet]. Jun 2019;32(2):381-9. https://doi.org/10.1590/1983-21252019v32n211rc.

doi 10.31072/rcf.v14i2.1362