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Selectivity of herbicides applied in pre-emergence in chia crop

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ABSTRACT: Seeds of chia (*Salvia hispanica* L.) are known worldwide for the benefits in human nutrition. However, from the agricultural point of view, weed interference is one of the main limitations in this crop, and restricted basic information about the management with herbicides. The aim of this work was to evaluate the selectivity of herbicides applied in pre-emergence of chia crop (*S. hispanica*). It was carried out an experiment in the field at the Universidade Estadual do Centro-Oeste, Guarapuava - PR, using randomized complete block design, with ten treatments and four replications. The treatments applied in the pre-emergence of chia were constituted by the herbicides: sulfentrazone (100, 200, 400 and 800 g ha^{-1}), oxyfluorfen (720 g ha^{-1}), s-metolachlor (1920 g ha^{-1}), flumioxazin (50 g ha^{-1}), diclosulan (25 g ha^{-1}), trifluralin (1800 g ha^{-1}) and a control without application. Oxyfluorfen, s-metolachlor, flumioxazin and diclosulan were not selective for application in chia crop in pre-emergence, unlike trifluralin, which showed high selectivity. Sulfentrazone presented viability only at the dose of 100 g ha^{-1}.

Key words: intoxication; *Salvia hispanica* L.; sulfentrazone; triluralin; yield

Seletividade de herbicidas aplicados em pré-emergência na cultura da chia

RESUMO: Sementes de chia (*Salvia hispanica* L.) são conhecidas mundialmente pelos benefícios na nutrição humana. Entretanto, do ponto de vista agrícola, a interferência das plantas daninhas é uma das principais limitações nessa cultura, sendo ainda restritas informações básicas sobre o manejo com herbicidas. O trabalho teve como objetivo avaliar a seletividade de herbicidas aplicados em pré-emergência da cultura da chia (*S. hispanica*). Um experimento foi desenvolvido a campo em Guarapuava - PR, utilizando delineamento experimental de blocos casualizados, com dez tratamentos e quatro repetições. Os tratamentos foram constituídos pelos herbicidas: sulfentrazone (100, 200, 400 e 800 g ha^{-1}), oxyfluorfen (720 g ha^{-1}), s-metolachlor (1920 g ha^{-1}), flumioxazin (50 g ha^{-1}), diclosulan (25 g ha^{-1}), trifluralin (1800 g ha^{-1}) e uma testemunha sem aplicação. Oxyfluorfen, s-metolachlor, flumioxazin e diclosulan não foram seletivos para aplicação em pré-emergência na cultura da chia, ao contrário do trifluralin que apresentou alta seletividade. Sulfentrazone apresentou viabilidade apenas na dose de 100 g ha^{-1}.

Palavras-chave: intoxicação; *Salvia hispanica* L; sulfentrazone; trifluralin; produtividade

Introduction

Chia (*Salvia hispanica L.*) is an annual herbaceous plant, belonging to the Lamiaceae family. It has high nutritional value, containing substances such as omega 3 and 6, antioxidants, dietary fiber and proteins (Peiretti & Gai, 2009). The chia crop cultivation can reach up to two meters in height and achieve an average yield of 250 g of seeds per plant (Coelho & Salas-Mellado, 2014). Despite it being a photoperiod sensitive species and also considered as a short-day (Jamboonsri et al., 2012), in Brazil it has adapted to different locations, where the temperature, altitude and precipitation conditions meet the crop cultivation requirements (Migliavacca et al. 2014, Freitas et al., 2016).

The western Paraná and northwest Rio Grande do Sul regions began to invest in chia cultivation in the latest harvests, having good results from it, despite the lack of information regarding their nutritional requirements, difficulties related to the harvest and to the seeds commercialization (Migliavacca et al., 2014), as well as on the weeds management (Pozo, 2010).

Thus, the control of weeds becomes necessary, mainly due the high pressure that may occur at the beginning of the chia crop development, which can severely affect the yield and quality of the final product (Karkanis et al., 2018). According to Ayerza & Coates (2006), the critical period of the competition between chia and weeds extends up to 45 days after emergence (DAE), after which the crop provides shade for the soil, hindering the infestation development in the area. Therefore, it becomes relevant to control weed infestation at the beginning of the crop cycle, since the initial development of chia is slow (Coates, 2011; Miranda, 2012).

In this matter, among the options for the weeds seed bank management would be the use of herbicides applied in the crop pre-emergence, since chia has a low competitive capacity at its development beginning.

For the decision-making in the herbicide choice, the technical and economic aspects must be taken into account, such as the efficiency, selectivity for the crop, residual effect, application window, control spectrum and the costs involved (Nascimento, 2016). It is also worth noting that, unlike other crops belonging to the Lamiaceae family, also considered as with insufficient phytosanitary support (*minor crop*), such as peppermint (*Mentha piperita*), Japanese mint (*Mentha arvensis*), flax (*Linum usitatissimum*) and sage (*Salvia officinalis*), chia has no record of safe herbicides for use in the weed control (Karkanis et al., 2018).

Field-level information regarding the herbicide selectivity is still scarce and insufficient for the chia crop cultivation, thus requiring researches and studies that report about weed management in a more detailed form.

Therefore, the aim of this work was to evaluate the selectivity of the chia crop cultivation to the action of herbicides applied in pre-emergence, under the edaphoclimatic conditions of Guarapuava - PR.

Material and Methods

The experiment was conducted in an experimental of the Midwestern State University – UNICENTRO, CEDETEG *Campus*, located in Guarapuava-PR at the coordinates 25°23’07.5’’ S 051°29’45.4’’ W and 1024 m of altitude. The experimental area soil was classified as typical dystrophic Bruno Latosol (Haplustox), with clayey texture (Embrapa, 2013), presenting composition, regarding its physical-chemical analysis, of: pH of 5.0 in $CaCl_2$; 4.39 $cmol_c$ cm^{-3} of $H^+ + Al^{+3}$ content, 2.8 $cmol_c$ dm^{-3} of Ca^{+2}, 1.5 $cmol_c$ dm^{-3} of Mg, 0.18 $cmol_c$ dm^{-3} of K^+, 2.8 mg dm^{-3} of P (Mehlich), with 47.0 g dm^{-3} of C, as well as 490, 270 and 240 g kg^{-1}, of clay, silt and sand, respectively.

The predominant climate of the region was classified by Köeppen-Geiger as the subtropical humid mesothermic Cfb type, with cool summers, winters with frequent and severe frosts, and absence of a dry season. The average annual precipitation is between 1.600 and 1.800 mm (Iapar, 2014). In Figure 1, the meteorological data regarding the execution period of the work is verified (from 12/23/2016 to 05/23/2017).

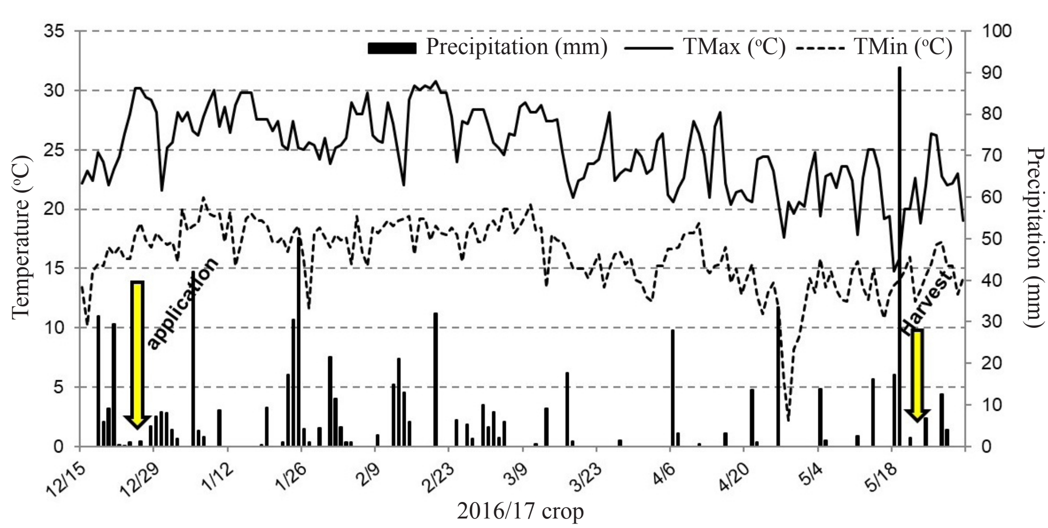

Figure 1. Daily maximum and minimum temperatures (°C) and precipitation (mm) data during field conduction of the experiment. Guarapuava-PR, 2017.

The experimental design used was the randomized block design with ten treatments and four replicates. The treatments used in crop pre-emergence were consisted of the following herbicides: sulfentrazone (100, 200, 400 and 800 g ha^{-1}; Boral 500 SC®), oxyfluorfen (720 g ha^{-1}; Galigan 240 EC®), s-metolachlor (1920 g ha^{-1}; Dual Gold®), flumioxazin (50 g ha^{-1}; Flumyzin 500®), diclosulan (25 g ha^{-1}; Spider®), trifluralin (1800 g ha^{-1}; Trifluralina Nortox Gold®), and a control group without application, which was weekly manually weeded over the entire crop cycle.

The chia sowing was manually carried out on 12/23/2016, using a 0.5 m spacing between lines and a 160.000 plant ha^{-1} population, as well as a 250 kg ha^{-1} base fertilization of the 08-20-20 formulation (NPK) and 60 kg ha^{-1} of urea, twenty days after emergence (DAE) of the crop. The experimental units were represented by plots with total area of 10.0 m² (2.5 x 4.0 m), where 0.5 m of the edges and lateral lines were disregarded in the evaluations.

The applications were carried out with a CO_2 pressurized backpack sprayer with four TTI110.02 tips, at 210 KPa pressure, 3.6 km h^{-1} displacement velocity, which constituted a 200 L ha^{-1} application rate. The meteorological conditions at the time of application (from 9:30 a.m. to 10:00 p.m.) were recorded with a portable digital thermo-hygro-anemometer, which typified an average temperature of 23.8 °C, relative humidity of 64.3% and winds with 2.2 km h^{-1} speed.

The experiment was periodically weeded, thus avoiding interference from weed infestation on all treatments, in order to verify individually just the crop selectivity to the herbicides. The evaluated crop characteristics were: stand (plant no. m^{-1}), represented by the number of chia plants emerged at 14, 21 and 28 DAE; plants height (cm), considering the distance from the soil to the last fully expanded leaf insertion at 21, 35, 49 DAE and at the beginning of the reproductive phase (R1); leaf chlorophyll content (SPAD index), with the aid of a portable chlorophyll meter (Minolta SPAD-502) at 21, 35 and 49 DAE; number of ramifications (NR), dry mass of the aerial part (MSPA) and the roots (MSRA), all carried out at the beginning of the reproductive phase (R1); and the production components: inflorescence number (NINF), inflorescence length (CINF), flower number per inflorescence (NF/I), mass of 100 grains (P100G) and crop grain yield (PROD - kg ha^{-1}), all obtained through the weighing on an precision balance.

The data were submitted to variance analysis by the F test and the results compared by the Scott-Knott clustering test at 5.0% probability.

Results and Discussion

The results, in general, showed a reduction in the stand and height of plants for all treatments in relation to the control group without application at 14, 21 and 28 days after emergence (AED) (Table 1). For these variables, the damage intensity was lighter in the groupings formed by trifluralin and sulfentrazone at the 100 g ha^{-1} dose, severe for sulfentrazone at 200; 400 and 800 g ha^{-1} doses, and entirely harmful for the grouping consisting of oxyfluorfen, s-metolachlor, flumioxazin and diclosulan.

Trifluralin, despite having statistically reduced the crop stand, was the one that less affected the emergence of chia plants, followed by the lower doses of sulfentrazone (100 and 200 g ha^{-1}) (Table 1). Rojas (2013) also reported that trifluralin and linuron did not cause damage in the chia crop development, as well as reduction in the grain yield, in addition of providing efficient weed control. On the opposite way, the other herbicides oxyfluorfen, s-metolachlor, flumioxazin and diclosulan fully inhibited the emergence of chia plants, being then characterized as non-selective for the crop cultivation.

In this aspect, it is important to note that besides chia seeds being small and sowed superficially, the edaphoclimatic conditions such as soil texture and excessive precipitation may favor the phytotoxic action of the chloroacetamide (s-metolachlor) and dinitroanilines (trifluralin) in the emergency phase, reducing the crop stand.

Unlike trifluralin, which acts inhibiting cellular division and elongation in plants, and has a low leaching potential

Table 1. Stand and height of the chia crop cultivation at 14, 21, 28, 35, 49 DAE (Days After Emergence) and the beginning of flowering (R1), submitted to pre-emergence herbicide application. Guarapuava/PR, 2017.

Herbicides (dose g ha^{-1})	Stand (plant no. m^{-1})			Height (cm)			
	14 DAE	21 DAE	28 DAE	21 DAE	35 DAE	49 DAE	(R1)
1. Control without application	8.8 A	9.0 A	9.3 A	18.3 A	45.3 A	61.4 A	111.0 A
2. sulfentrazone (100)	5.0 C	7.0 B	7.5 C	16.6 B	41.6 B	59.0 B	105.6 B
3. sulfentrazone (200)	2.3 D	4.5 C	5.0 D	14.9 C	39.1 C	52.0 D	100.1 C
4. sulfentrazone (400)	1.3 E	2.3 D	2.8 E	13.4 D	36.3 D	38.1 E	84.0 D
5. sulfentrazone (800)	0.3 F	1.3 E	1.8 F	9.0 E	21.6 E	33.3 F	75.0 E
6. oxyfluorfen (720)	0.0 F	0.0 F	0.0 G	0.0 F	0.0 F	0.0 G	0.0 F
7. s-metolachlor (1920)	0.0 F	0.0 F	0.0 G	0.0 F	0.0 F	0.0 G	0.0 F
8. flumioxazin (50)	0.0 F	0.0 F	0.0 G	0.0 F	0.0 F	0.0 G	0.0 F
9. diclosulan (25)	0.0 F	0.0 F	0.0 G	0.0 F	0.0 F	0.0 G	0.0 F
10. trifluralin (1800)	7.5 B	8.5 A	8.5 B	15.5 C	41.4 B	57.4 C	108.5 A
Fcal	226.6*	231.5*	277.5*	824.5*	3136.2*	2861.6*	2510.7*
CV (%)	17.89	14.98	13.08	6.29	3.23	3.40	3.51

- Means followed by the same letter in the lines do not differ from each other by the clustering test of Scott-Knott ($p \geq 0.05$). * = significant ($p < 0.05$) e ^{NS} = significant ($p \geq 0.05$).

due to its high adsorption to the soil, the sulfentrazone has an action mechanism based on the inhibition of the PROTOX (protoporphyrinogen oxidase) enzyme, causing peroxidation of lipids from the cell membranes and interference in the chlorophyll biosynthesis, with moderate mobility and low soil adsorption (Roman et al., 2007; Oliveira Jr. et al., 2011; Rodrigues & Almeida, 2011). This fact may be a possible explanation for the death of chia plants due low selectivity of the higher sulfentrazone concentrations, especially when the application was held in pre-emergence, soon after the crop sowing.

For the plant height evaluation, it was observed a vegetative suppression for all treatments that received sulfentrazone applications at 21, 35, 49 DAE and at the beginning of flowering (R1), as well as for trifluralin, except for the last evaluation (Table 1). For sulfentrazone, the 100 and 200 g ha^{-1} doses were the ones that less affected the height of the chia plants until the beginning of flowering (R1), differing statistically from 400 and 800 g ha^{-1}, where the reduction was about 24 and 32%, respectively. However, in terms of selectivity, the chia height may not be positively associated with the yield, especially when grown under long-day development conditions (Baginsky et al., 2016), in accordance with how this work was developed.

Specifically for trifluralin and sulfentrazone at the 100 g ha^{-1} dose, even though the reduction of the chia plants stand and height were less severe, it is still highlighted that the condition of less densified and smaller plants can provide competitiveness for environment resources such as space, light, water, and nutrients. On the contrary, in a study developed by Rodrigues (2016) with seeding densities of the chia crop cultivation in the state of Ceará, the author observed that the density reduction of the crop resulted in a height increase of the plants.

Regarding the chlorophyll content in the leaves of chia (SPAD index), a significant reduction was only observed at 21 DAE for 200, 400 and 800 g ha^{-1} of sulfentrazone in relation to the control group without application, in the order of 6, 12 and 10%, respectively (Table 2). However, it is worth noticing that for the lowest dose of sulfentrazone (100 g ha^{-1}) and trifluralin there was no reduction of this variable. At 35 and 49 DAE no statistical differences were observed between sulfentrazone and trifluralin treatments, which contained emerged chia plants, in response relation to the weeded control group.

The photosynthetic efficiency of the plants is related to the process of converting light radiation into chemical energy, in which chlorophylls are directly involved (Taiz & Zeiger, 2016). Therefore, it is possible to affirm for the studied conditions that the herbicide trifluralin, an inhibitor of tubulin polymerization in the plant root mitosis (Roman et al., 2007; Rodrigues & Almeida, 2011), did not interfere in the physiological activity regarding the maintenance of the chia leaves chlorophyll content. However, this variable may have been affected by sulfentrazone, at the concentrations higher than 200 g ha^{-1}, considering that after 21 DAE there was recovery of the crop. The sulfentrazone herbicide reduces photosynthetic activity in susceptible plants due to the lower synthesis of chlorophylls and heme compounds in the chloroplasts (Vidal et al., 2014), and as the oxidative stress increases according to the light exposure time, the thylakoids are damaged and lose their photosynthetic capacity (Tripathy et al., 2007).

Regarding the number of ramifications (NR) per plant of the chia crop, it was observed in the R1 stage that only trifluralin did not influence this variable. For sulfentrazone the levels of NR reduction were in the order of 7, 8, 12 and 20%, respectively, for the 100, 200, 400 and 800 g ha^{-1} doses (Table 2).

With these results, it is noted that the NR reduction of chia was not proportional to the stand and height reductions. This fact may have occurred due to the greater space available for the growth and development of the plants that have managed to emerge, being it an intrinsic characteristic of species that have the branching ability. However, although there was no NR increase in chia for the herbicide treatments, this crop when strategically established in low plant population can

Table 2. Chlorophyll content of the leaves, number of ramification (NR), dry matter of the aerial part (MSPA) and dry mass of roots (MSRA) of chia crop cultivation submitted to pre-emergence herbicide application at 21, 35 and 49 DAE (Days After Emergence), as well as number of ramification (NR), dry mass of the aerial part (MSPA) and roots (MSRA) at the flowering beginning (R1). Guarapuava/PR, 2017.

Herbicides (dose g ha^{-1})	Chlorophyll content (SPAD Index)			NR	MSPA	MSRA
	21 DAE	35 DAE	49 DAE		(R1)	
1. Control without application	33.0 A	33.8 A	32.8 A	10.3 A	261.8 A	185.5 B
2. sulfentrazone (100)	31.6 A	33.9 A	32.9 A	9.6 B	262.7 A	209.4 A
3. sulfentrazone (200)	30.7 B	33.7 A	32.5 A	9.5 B	265.3 A	217.0 A
4. sulfentrazone (400)	29.0 C	33.8 A	33.3 A	9.1 C	145.6 B	135.2 C
5. sulfentrazone (800)	29.5 C	33.8 A	32.3 A	8.2 D	100.3 C	64.8 D
6. oxyfluorfen (720)	0.0 D	0.0 B	0.0 B	0.0 E	0.0 D	0.0 E
7. s-metolachlor (1920)	0.0 D	0.0 B	0.0 B	0.0 E	0.0 D	0.0 E
8. flumioxazin (50)	0.0 D	0.0 B	0.0 B	0.0 E	0.0 D	0.0 E
9. diclosulan (25)	0.0 D	0.0 B	0.0 B	0.0 E	0.0 D	0.0 E
10. trifluralin (1800)	32.3 A	33.5 A	32.6 A	10.1 A	256.2 A	211.7 A
Fcal	1467.7*	9737.9*	3311.4*	1349.3*	172.1*	189.9*
CV (%)	4.50	1.74	2.99	4.72	14.61	14.01

- Means followed by the same letter in the lines do not differ from each other by the clustering test of Scott-Knott ($p \geq 0.05$). * = significant ($p < 0.05$) e ^{NS} = significant ($p \geq 0.05$).

increase its ramifications and, consequently, the grain yield (Miranda, 2012).

Trifluralin (1800 g ha^{-1}) and the two lowest sulfentrazone doses (100 and 200 g ha^{-1}) did not differ from the control group without application, for the variables dry mass of the aerial part (MSPA) and of the roots (MSRA) of chia plants (Table 2). However, for 400 and 800 g ha^{-1} of sulfentrazone, the levels of MSPA reduction in relation to the control group without application were 44 and 61%, respectively. For the MSRA, the reduction for both herbicides in relation to the control group without application was in the order of 27 and 65%, respectively. In addition to this, it is important to reinforce that only trifluralin and the lower doses of sulfentrazone had an increase in the MSRA of the chia plants in relation to the control group without application, probably due the result of the recovery from the chemical stress caused by these herbicides action. Karkanis et al. (2018) also mentioned a low selectivity of the chia crop cultivation for pre-emergence application of linuron (900 g ha^{-1}), pendimethalin (1137 g ha^{-1}) and, mainly oxyfluorfen (600 g ha^{-1}) herbicides, where it was found a significant reduction in height and MSPA, as well as the photosynthetic activity of plants, in a work developed in two locations in Greece.

For the variables inflorescence number (NINF), inflorescence length (CINF) and flower number per inflorescence (NF/I), no statistical differences were observed between treatments with trifluralin and sulfentrazone at the lowest doses (100 and 200 g ha^{-1}) and the control group without application (Table 3).

The NINF is directly related to the productivity of the chia crop cultivation. For this variable, sulfentrazone at 400 and 800 g ha^{-1} doses caused a reduction of 30 and 57%, respectively. However, for the mass of 100 grain (P100G) no statistical difference was observed in relation to the control group for the trifluralin and sulfentrazone, at all doses studied. This result corroborates with those obtained by Rojas (2013), using trifluralin (2500 g ha^{-1}) and pendimethalin (3030 g ha^{-1}) in pre-emergence. Thus, it is possible to affirm that the chia grain formation is not influenced by the application of up to 800 g ha^{-1} of sulfentrazone and trifluralin (1800 g ha^{-1}), under the studied edaphoclimatic conditions (Table 3).

In relation to the yield (PROD) of the chia crop cultivation, only trifluralin and sulfentrazone treatments at the lowest dose (100 g ha-1) were verified as selective and did not cause a statistical reduction in the yield when compared to the control group without application (Table 3).

Recent researches have shown that the trifluralin application in pre-emergence did not cause damage to the chia crop, allowing both unchanged growth and grains yield (Migliavacca et al., 2014). In contrast to this, the 200, 400 and 800 g ha^{-1} sulfentrazone concentrations promoted a progressive yield reduction with damages around 40, 84 and 94%, respectively (Table 3). Thus, the 200 g ha^{-1} sulfentrazone dose, regardless of not reducing the NINF, CINF, F/I and P100G of the chia plants that managed to survive the pre-emergence application, was sufficient in rendering a reduction in the number of emerged plants (stand), and consequently, in grain yield reduction.

With these preliminary results, it was possible to affirm that the only applicable treatments at field level in the studied conditions, with a reliable recommendation to the farmer, would be the trifluralin (1800 g ha^{-1}) and the lowest sulfentrazone dose (100 g ha^{-1}). For sulfentrazone, it is important to point out that 100 g ha^{-1} may not be sufficient to control the weeds seed bank in a reasonable timely manner, since this dose is practically five times lower than the recommended one for the same use modality in the soybean crop cultivation (Rodrigues & Almeida, 2011).

Still regarding the weed control, it is important to establish the early management of the infestation while still in the seed bank in the area, since the chia crop cultivation presents a slow initial development (Coates, 2011; Miranda, 2012). In this context, the combination, in a tank mix, of trifluralin (1800 g ha^{-1}) with 100 g ha^{-1} of sulfentrazone would have potential

Table 3. Inflorescence number (NINF), inflorescence length (CINF), flower number per inflorescence (NF/I), as well as the mass of 100 grains (P100G) and grain yield (PROD) of the chia crop cultivation under pre-emergence application of herbicides. Guarapuava/PR, 2017.

Herbicides (dose g ha^{-1})	NINF (plant no.$^{-1}$)	CINF (cm)	NF/I (no.)	P100G (g)	PROD (kg ha^{-1})
1. Control without application	87.8 A	7.5 A	187.8 A	0.142 A	1147.A
2. sulfentrazone (100)	85.4 A	7.5 A	186.8 A	0.146 A	1067 A
3. sulfentrazone (200)	82.2 A	7.4 A	184.6 A	0.141 A	686 B
4. sulfentrazone (400)	61.2 B	6.2 B	130.3 B	0.138 A	185 C
5. sulfentrazone (800)	37.9 C	5.8 B	100.4 C	0.137 A	64 D
6. oxyfluorfen (720)	0.0 D	0.0 C	0.0 D	0.000 B	0 E
7. s-metolachlor (1920)	0.0 D	0.0 C	0.0 D	0.000 B	0 E
8. flumioxazin (50)	0.0 D	0.0 C	0.0 D	0.000 B	0 E
9. diclosulan (25)	0.0 D	0.0 C	0.0 D	0.000 B	0 E
10. trifluralin (1800)	84.7 A	7.6 A	185.4 A	0,142 A	1187 A
Fcal	834.3*	331.1*	2164.8*	1121.3*	231.7*
CV (%)	6.40	9.58	3.90	5.14	15.95

- Means followed by the same letter in the lines do not differ from each other by the clustering test of Scott-Knott ($p \geq 0.05$). * = significant ($p < 0.05$) e ^{NS} = significant ($p \geq 0.05$).

to improve the residual effect on the control of the weeds seed bank in the soil. Beyond that, in relation to the culture selectivity for the trifluralin + sulfentrazone association, it is also possible to envisage the possibility of positive effects from its use, even with higher doses than the studied, but only provided that a larger interval between the application window and the sowing of the crop was established.

In a general way, the results indicate potential pre-emergence use of trifluralin and sulfentrazone in the chia crop cultivation, but further studies are still needed to optimize the best options of dosage and intervals between application and sowing, under different edaphoclimatic conditions.

Conclusions

The oxyfluorfen, s-metolachlor, flumioxazin and diclosulan herbicides, in their respective studied doses, were not selective for the pre-emergence application in the chia sowing, in contrast to trifluralin, which presented acceptable selectivity for the crop cultivation.

Sulfentrazone was selective for the chia crop only with 100 g ha^{-1}, but the results indicated feasibility and potential use for chia crop cultivation, requiring further studies for a better adjustment of the dose and the interval between the application and sowing.

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