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Article

Selectivity of Iodosulfuron-Methyl to Oat Cultivars

Seletividade de Iodosulfuron-Methyl para Cultivares de Aveia

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ABSTRACT - Weeds are among the main constraints to high grain yield on hexaploid oat (*Avena sativa*), but there are few herbicides registered for weed control on this cereal crop. The objectives of this study were to evaluate the impact of the iodosulfuron-methyl on grain yield of elite oat cultivars and investigate the mechanism of oat tolerance to this herbicide. A field experiment conducted in 2012 demonstrated there was no difference on grain yield between cultivars URS Guará and URS Guria, when iodosulfuron-methyl was used up to 4.5 g ha^{-1}. Likewise, experiments from 2013 have demonstrated that iodosulfuron-methyl, at 5 g ha^{-1}, did not affect the oat grain yield of the genotype UFRGS 14, but affected it on the cultivars URS Guará and URS Guria. In 2014, the oat grain yield of five cultivars, including URS Guará, URS Guria and UFRGS 14 was reduced by iodosulfuron-methyl even at only 2.5 g ha^{-1}. The activity of the ALS enzyme, extracted from oat plants, was sensitive to iodosulfuron-methyl. The increment of the iodosulfuron-methyl effect on oat plants treated with herbicide-detoxification inhibitors (malathion + chlorpyrifos), or the reduction of the herbicide efficacy in plants sprayed with the stimulator of detoxification (mefenpyr-diethyl), suggest that iodosulfuron-methyl degradation is the mechanism involved on its selectivity to oat plants.

Keywords: *Avena sativa*, detoxification, tolerance, acetolactate synthase inhibitor.

*RESUMO - As plantas daninhas estão entre os principais problemas para o alto rendimento de grãos em aveia hexaploide (**Avena sativa**), mas existem poucos herbicidas registrados para o controle de plantas daninhas nessa cultura de cereais. Os objetivos deste estudo foram avaliar o impacto do iodosulfuron-methyl no rendimento de grãos de cultivares de aveia elite e investigar o mecanismo de tolerância de aveia a esse herbicida. Um experimento de campo, realizado em 2012, demonstrou que não houve diferença no rendimento de grãos entre os cultivares URS Guará e URS Guria quando iodosulfuron-methyl foi utilizado até 4,5 g ha^{-1}. Da mesma forma, experimentos realizados em 2013 demonstraram que iodosulfuron-methyl, na dose de 5 g ha^{-1}, não afetou o rendimento de grãos de aveia do genótipo UFRGS 14, porém o fez nos cultivares URS Guará e URS Guria. Em 2014, o rendimento de grãos de aveia de cinco cultivares, incluindo URS Guará, URS Guria e UFRGS 14, foi reduzido em iodosulfuron-methyl mesmo com apenas 2,5 g ha^{-1}. A atividade da enzima ALS, extraída a partir de plantas de aveia, era sensível a iodosulfuron-methyl. O incremento do efeito do iodosulfuron-methyl em plantas de aveia tratada com inibidores de herbicida de desintoxicação (malathion + chlorpyrifos) ou a redução da eficácia do herbicida em plantas pulverizadas com o estimulador de desintoxicação (mefenpyr-diethyl) sugerem que a degradação de iodosulfuron-methyl é o mecanismo envolvido na sua seletividade em plantas de aveia.*

Palavras-chave: *Avena sativa*, detoxificação, tolerância, inibidor da acetolactato sintase.

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INTRODUCTION

Oat (*Avena sativa*) is an important cereal crop in Mediterranean type environments. This species is used as a cover crop to protect the soil in minimum-tillage systems and as food, both for humans (grains) and livestock (direct grazing, grain, silage or hay). One of the determining factors to reach high grain yields is the appropriate weed management (Cargnin et al., 2006). Chemical control is the main option for weed management, but there is limited number of active ingredients registered as selective for *A. sativa*. For instance, in Canada and in the USA there are twelve active ingredients registered for weed control in this crop (Saskatchewan, 2015), whereas in Brazil there are only two compounds (Brasil, 2016).

The benefits of the herbicides that inhibit the enzyme acetolactate synthase (ALS) include the broad spectrum of weed species controlled, the low rates for weed control, and the low mammalian toxicity (Yu and Powles, 2014). Iodosulfuron-methyl is a sulfonylurea recommended for weed control in wheat, triticale, rye and barley (Kramer et al., 2012). There is limited information about the selectivity of this herbicide to the cultivated hexaploid oat, but it is recommended to control wild oats and *Avena strigosa* (Brasil, 2016). However, the literature indicates the tolerance of oat cultivar to several ALS inhibitors (Fischer et al., 1999; Cargnin et al., 2006). For instance, the herbicides thifensulfuron + tribenuron (ALS inhibitors) did not reduce grain yield on eight oat cultivars (Fischer et al., 1999). Similarly, metsulfuron-methyl, at a dose of 4 g ha^{-1}, did not affect the oat grain yield on plants from the cultivars UPF 18, UPF 19 and UFRGS 19 (Cargnin et al., 2006).

The major mechanism involved in the tolerance of ALS inhibitors on crops is the herbicide detoxification or degradation in the plants (Yu and Powles, 2014). There are direct and indirect methods to identify whether herbicide metabolism is involved in crop tolerance. Direct methods involve chromatography to evaluate the decomposition of the herbicide and/or the formation of the metabolites (Hosseini et al., 2011; Yu and Powles, 2014). Indirect methods may involve the use of inhibitors of herbicide detoxification, such as malathion and chlorpyrifos (Kaspar et al., 2011; Beckie et al., 2012), or the use of stimulators of herbicide metabolization, also called crop safener (Bunting et al., 2004).

The objectives of this study were to evaluate the impact of iodosulfuron-methyl on grain yield of elite oat cultivars and to investigate the mechanism of oat tolerance to the herbicide.

MATERIALS AND METHODS

Crop grain yield on field experiments

In the years 2012 to 2014, field experiments were carried out at the Agronomy Experimental Station of Federal University at Rio Grande do Sul (RS), located at Eldorado do Sul, RS, Brazil (30^{o} 06' 12'' S and 51^{o} 40' 14'' W). The soil of the area is classified as Rhodic Paleudult (Ultisol), with 34% clay. The experimental design used in the experiments was a randomized block, with treatments organized in a factorial design with four replications. The first experiment was conducted from June to October 2012, where one factor included the oat cultivars (URS Guria and URS Guará), and the other factor was iodosulfuron-methyl rates (Hussar® 50 g kg^{-1}) (1, 2, 2.75, 3.5 and 5 g ha^{-1}). The second experiment was carried out from June to November 2013 and included five oat cultivars (UFRGS 14, UFRGS 18, URS Taura, URS Guria and URS Guará) and seven doses of iodosulfuron-methyl (0, 2.5, 5, 10, 15, 20 and 30 g ha^{-1}). The third field experiment was conducted from July to November 2014; based on the results from the previous years, the factors included oat cultivars and seven iodosulfuron-methyl rates, which differed according to the sensitivity of the oat genotypes to the herbicide. For the sensitive oat cultivars (URS Taura and URS Corona), the herbicide doses were: 0, 0.5, 1, 2.5, 5, 7.5 and 10 g ha^{-1}. For the tolerant oat cultivars (URS Guará, URS Guria and UFRGS 14), the herbicide doses were: 0, 2.5, 5, 10, 20, 35 and 50 g ha^{-1}. In this third experiment, the cultivar URS Corona was included in the group of sensitive cultivars after preliminary results.

The experiment of 2012 was conducted under soil tilling and the plots consisted of five rows (3.0 meter long), spacing 0.20 m between rows and 0.40 m between plots. In 2013 and 2014, the crop was cultivated under "no-till" system and the same plot size and distribution. In all experiments the seeding rate was 350 seeds m^{-2}. Base fertilization was done during sowing time, according to soil analysis. Urea was applied twice as a top-dress fertilizer, at 20 and 35 days after emergence, adding up at total of 70 kg ha^{-1} of nitrogen. In the 2012 experiment, iodosulfuron-methyl was sprayed when the plants had 3-4 leaves; whereas in 2013 and 2014 experiments, the plants had 4-5 leaves (early tillering growth stage). The equipment used to spray the herbicide was a backpack sprayer pressurized with CO_2, at 200 kPa, with nozzles type 110.02 XR and spray volume equivalent to 200 L ha^{-1}. In each treatment, the adjuvant Dash® at 0.5% was added.

In the experiment of 2012, the grain yield was determined using the yield components (plant density, number of seeds per plant, seed weight), whereas in the experiments conducted in 2013 and 2014, the grain yield was determined after harvesting the total area of the experimental unit with a mechanical combine (Wintersteiger Classic ST).

Identification of tolerance mechanisms

ALS enzyme activity

Young oat leaves from the cultivar URS Taura were collected and frozen in liquid nitrogen. After the ALS enzyme extraction, according to the method described by Gerwick et al. (1993), the herbicide sensitivity assay was conducted in microcentrifuge tubes, using 500 µL of a solution containing iodosulfuron-methyl. The final concentrations of iodosulfuron-methyl herbicide were 0 (100 enzyme activity), 5, 25 and 50 µM. For the positive control treatment (equivalent to 100% of ALS activity), it was used 500 µL distilled water. For the negative control treatment (equivalent to 0% of the ALS enzyme activity), it was used 250 µL of H_2SO_4 at 1.8 N concentration. In each tube, it was added 500 µL of the enzyme extract, which were incubated for a period of 90 min at 37 °C and the final product of this reaction was acetolactate. After this period, the reactions were stopped with 250 µL of 1.8 N H_2SO_4. All treatments were performed with three replications.

On the previous reaction, a second incubation for 15 min at 60 °C was performed after addition of 700 µL of a 2 N sodium hydroxide solution containing creatinine naphthol at 0.25%. This reaction leads to the formation of a colored complex containing acetoin, which through a calibration curve allows to determine the herbicide sensitivity. The amount of acetoin was determined by absorbance readings on a spectrophotometer (Shimadzu UV-1800) at 535 nm. The ALS activity values were expressed in enzyme unit per mg (U mg^{-1}), where one unit of ALS is defined as the amount of enzyme able to produce 0.1 absorbance unit per minute, expressed as a function of total protein concentration (specific activity). The protein content was determined by the Bradford method (1976).

The results of inhibition of the ALS enzyme activity were converted to percentage values, considering as 100% the activity in the absence of the herbicide. After the analysis of variance, a regression between the enzymatic activity and the herbicide concentration was performed using the software Sigma-plot 11.0.

Effect of detoxification inhibitors and herbicide antidote (safener)

In 2014, two greenhouse experiments were conducted to evaluate either the effect of inhibitors of herbicide degradation or of herbicide antidote on the iodosulfuron-methyl efficacy on oat plants. The experiment with inhibitors of herbicide degradation consisted of three factors: two oat cultivars (URS Guará and URS Guria), seven iodosulfuron-methyl doses (Hussar® 50 g kg^{-1}) (0, 0.5, 1.0, 2.5, 5.0, 10.0 and 20.0 g a.i. ha^{-1}), and two conditions of detoxification inhibitor (without and with). The inhibitors of herbicide degradation consisted of the mixture of malathion (Malathion 500 CE®, 500 g L^{-1}), at 1.000 g $ha^{-1}$of active ingredient and chlorpyrifos (Lorsban®, 480 g L^{-1}), at 1.125 g ha^{-1} of active ingredient (Fischer et al., 2000; Beckie et al., 2012).

For the experiment with the herbicide antidote (safener), only plants of the cultivar 'URS Guria' were used. The treatments included the same seven doses of iodosulfuron-methyl described above and two conditions of antidote (with and without). The antidote was mefenpyr-diethyl (SIGMA, 99, 9%), at a rate of 15 g ha^{-1}.

On both experiments, the spray solution included the adjuvant ASSIST® (0.5% v/v) and either detoxification inhibitor or antidote were sprayed approximately three hours before the herbicide application. The plants were grown in 500 mL plastic pots containing substrate (Ultisol soil:sand:potting substrate at the ratio of 3:1.5:1) and the NPK fertilizer 12-20-10 at a dose of 0.125 g per pot. Seven days after seedling emergence, excess plants were removed leaving only two plants per pot. The application of the products was performed when the plants were at the three-leave growth stage. The chemicals were applied in a spray chamber with one 80.02E nozzle, pressurized at 200 kPa with compressed air, and delivering spray volume equivalent to 200 L ha^{-1}. The iodosulfuron-methyl was associated with the adjuvant Dash® (0.5% v/v).

At 28 days after the herbicide application, the plant height (distance between the base of the stem to the tip of the last expanded leaf) was evaluated. Plant height data was converted into a percentage value compared to untreated plants.

Statistical analysis

For all field experiments, the data were submitted to the analysis of variance using the software Winstat. When interaction of factors was detected, the data were submitted to regression analysis between the dependent variable and the herbicide rate using the software Sigma-plot 11.0. Data were adjusted to linear models (simple and quadratic), logistic, exponential and hyperbolic decay regression models. The adopted regression model considered the equation with lowest value of mean square of the residue. The regression equation was used to estimate herbicide rate that reduced 50% the value of the dependent variables (D_{50}).

RESULTS AND DISCUSSION

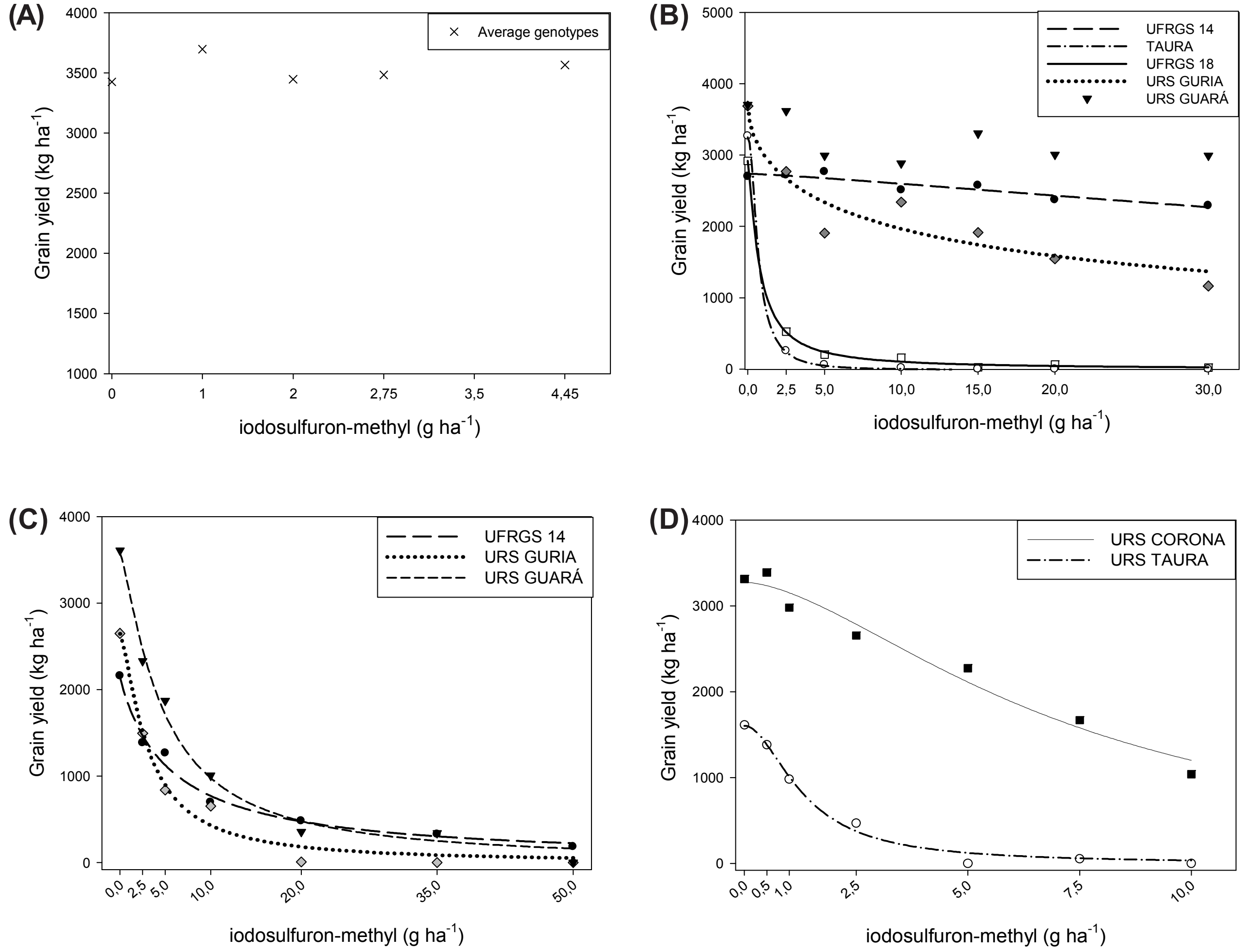
Crop grain yield on field experiments

On the experiment from 2012, there was no effect of iodosulfuron-methyl rate on oat grain yield on either genotype (URS Guará and URS Guria) (Figure 1A). This experiment considered herbicide rates up to the maximum registered on the label (5 g ha^{-1}) and the environmental conditions throughout the crop growing cycle was very favorable for plant growth. Because the grain yield this year was estimated based on the yield components, it is speculated it super-estimated the total amount harvested.

On the experiment of 2013, the herbicide rate was increased up to 6-fold the label dose, thus, significant interaction ($p<0.01$) between genotype and doses was observed. The effect of the herbicide on the crop grain yield revealed that plants of cultivars UFRGS 18 and URS Taura were more sensitive to iodosulfuron than the other ones (URS Guará, URS Guria and UFRGS 14), even at the rate of 2.5 g ha^{-1}. In contrast, plants of the genotype UFRGS 14 showed limited impact of the herbicide on the grain yield, even at the maximum herbicide rate tested (Figure 1B and Table 1). No model could be adjusted between herbicide rate and the crop grain yield for the cultivar URS Guará, suggesting iodosulfuron-methyl did not affect the grain yield of this genotype, even at the highest dose tested (Figure 1B and Table 1).

On the experiment of 2014, severe reductions on the crop grain yield were observed for all cultivars (Figure 1C and 1D). On the group of iodosulfuron-methyl tolerant cultivars, there was a grain yield reduction, even at the rate of 2.5 g ha^{-1} (Figure 1C). On the herbicide-sensitive oat cultivar group, URS Taura showed a grain yield reduction, even when iodosulfuron-methyl was applied at 1.0 g ha^{-1} (Figure 1D). The cultivar URS Corona showed a smaller decrease in grain yield compared to URS Taura (Figure 1D). The behavior of URS Corona was similar to cultivar URS Guará, which was expected because they are sister lines.

Overall, the oat plants demonstrated some symptoms of herbicide injury on assessments performed up to one month after spray (data not shown). However, on the experiments conducted in the years 2012 and 2013, the plants recovered from these initial symptoms compared to 2014 (especially considering cultivars URS Guará and URS Guria, present in all field experiments). But, the 2014 results indicated that none of the cultivars were tolerant to iodosulfuron-methyl at a dose up to 5 g ha^{-1} (label rate for the wheat crop) (Brasil, 2016).



The least significant differences for comparing grain yield means between oat cultivars, within herbicide doses, is 550.3 kg ha^{-1} in B and 347.8 kg ha^{-1} in C and D. Equations on Table 1.

Figure 1 - Grain yield (kg ha^{-1}) of oat plants in response to different doses of iodosulfuron-methyl evaluated in the years of 2012 (A), 2013 (B) and 2014 (C and D).

Table 1 - Parameters of equations[(1)] between iodosulfuron-methyl rates and grain yield from several oat cultivars

Cultivar	Regression equation parameters			[(4)]R^2	[(5)]p
	Year of 2013				
	A	b	X_0		
UFRGS 14	2738.26 (63.36)***	1.22 (0.52)[(2)]*[(3)]	109.48 (63.79)^{ns}	0.81**	0.015
UFRGS 18	3266.46 (4.25)***	2.15 (0.09)***	0.80 (0.04)***	0.99***	<0.01
URS Taura	2916.69 (39.02)***	1.28 (0.17)***	0.75 (0.15)***	0.99***	<0.01
URS Guria	3677.28 (318.56)***	0.60 (0.20)**	12.59 (4.99)*	0.85***	<0.01
URS Guará	3720.93 (258.44)***	0.32 (0.31)^{ns}	1958.34 (8795.17)^{ns}	0.39^{ns}	0.163
	Year of 2014				
UFRGS 14	2147.90 (93.28)***	0.98 (0.11)***	5.53 (0.79)***	0.98***	<0.01
URS Corona	3274.15 (127.08)**	1.65 (0.36)**	7.18 (0.69)***	0.96***	<0.01
URS Taura	1603.13 (76.37)***	1.89 (0.26)***	1.33 (0.14)***	0.99***	<0.01
URS Guria	2645.60 (152.44)***	1.39 (0.27)***	3.07 (0.48)***	0.98***	<0.01
URS Guará	3578.80 (154.69)***	1.28 (0.15)***	4.67 (0.54)***	0.98***	<0.01

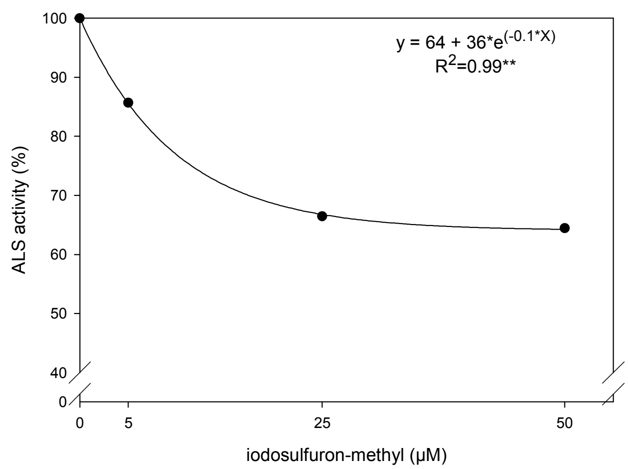
[(1)] Logistic equation of three parameters $Y= a/(1+(x/X_0)^b)$. [(2)] Numbers in parentheses correspond to standard error of the parameter estimates. [(3)] The level of significance of the 't' test is represented as follows: * 10%; ** 5% and ***1%; ns indicates not significant. [(4)] Coefficient of determination of the model. [(5)] Probability of the significance of the equation by the t test.

There are at least two explanations for the change of performance of the oat plants recovery from iodosulfuron injury, detected among the three years of field investigation. First, oats in Brazil are cultivated during winter-spring and it seems that higher temperature conditions during the crop growth cycle helped the plants to recover from the injury. Second, air moisture and temperature in 2014 were highly conducive for crown rust development, requiring more fungicide sprays, thus decreasing herbicide degradation abilities by the plants. Indeed, in experiments conducted in 2014, there were three applications of the fungicide tebuconazole. In the literature, there is evidence of the inhibitory effects of the triazole fungicides on the herbicide detoxification enzymes, especially from the cytochrome P450 complex (Parker et al., 2011; Koch et al., 2013).

Identification of tolerance mechanisms

There was an exponential decay (three parameters) between the activity of the ALS enzyme and iodosulfuron-methyl concentration. The herbicide concentration of 50 µM reduced the activity of this enzyme by 40% (Figure 2). This result indicates the ALS enzyme of the oat plants is sensitive to iodosulfuron-methyl herbicide. On the literature, wheat (*Triticum aestivum*) plants tolerant to ALS inhibitors have shown similar ALS enzyme sensitivity to the herbicides, indicating that another mechanism is likely to be involved on the tolerance to the chemical (Koeppe et al., 1997).

The next step of the research was to evaluate whether herbicide detoxification was involved on the oat plant tolerance to iodosulfuron-methyl using two indirect methods: inhibitors of herbicide detoxification and herbicide antidote. The oat plant height (average from the two cultivars URS Guará e URS Guria) differed between the two conditions of herbicide-detoxification inhibitor (with and without). When the herbicide was used alone, the rate needed for 50% reduction (D_{50}) of plant height was 12.4. However, when the herbicide-detoxification inhibitors were used, the D_{50} was 0.36 (Figure 3A, Table 2). In other words, in the presence of the herbicide-detoxification inhibitors, the amount of iodosulfuron-methyl needed to achieve D_{50} was 34.5-fold lower than the observed without the inhibitors (Table 2). This result strongly supports the hypothesis that herbicide detoxification is the mechanism responsible, at least in part, for the iodosulfuron-methyl selectivity to oat plants.

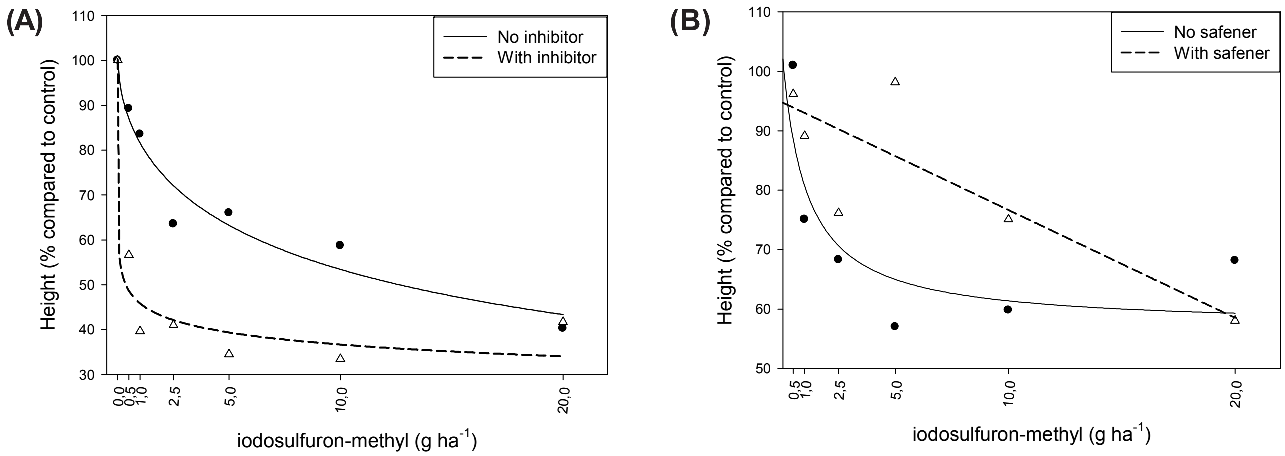


** indicates p = 0.013.

Figure 2 - ALS enzyme activity under different concentrations of iodosulfuron.

On the literature, studies performed with other ALS-inhibiting herbicides and organophosphate insecticides were also used as indirect evidence of detoxification as a mechanism of crop tolerance (Kaspar et al., 2011; Beckie et al., 2012). Sunflower lines (*Helianthus annuus*), naturally tolerant to ALS-inhibiting herbicides, became sensitive to imazamox (an ALS inhibitor) when applied with malathion (Kaspar et al., 2011). Biotypes of *Avena fatua* tolerant to the herbicide flucarbazone (an ALS inhibitor) became sensitive when treated with malathion (Beckie et al., 2012).

In the absence of the herbicide antidote, the oat plant height decreased exponentially with the increase of iodosulfuron-methyl rate. However, in the presence of the antidote, the increment of herbicide rate decreased linearly the oat plant height (Figure 3B). These results also support the hypothesis that herbicide detoxification is the mechanism of iodosulfuron tolerance in oat plants. In the literature, mefenpyr-diethyl was demonstrated to increase the synthesis and activity of the enzymes glutathione-S-transferase (GST) in wheat (*Triticum aestivum*) (Taylor et al., 2013). These enzymes are responsible for the detoxification of several herbicides



Data was evaluated 28 days after herbicide spray. The least significant differences (LSD) to compare plant height, relative to control, with and without detoxification inhibitor, at the same herbicide rate, is 15.1%; and to compare plant height, relative to control, with and without herbicide antidote, at the same herbicide rate, is 24%. Equations on Table 2.

Figure 3 - Oat plant height (% compared to control) in response to iodosulfuron-methyl herbicide: (A) with and without detoxification inhibitors (malathion + chlorpyrifos) (data is the average of two oat cultivars); (B) with and without antidote (the safener mefenpyr).

Table 2 - Estimation of the parameters to the equations describing the effect of inhibitor of herbicide detoxification and of antidote and iodosulfuron-methyl rates on the average plant height of oat cultivars, evaluated at 28 days after application treatments

Treatment	Equation	Regression equation parameters			Yo	(11)TF	(12)R^2	(13)p
		a	b	(10)X_0				
NI (1)	Log.(5)	100.50 (5.49)(8)***(9)	0.58 (0.13)***	12.44 (3.73)**	-	34.5	0.92***	<0.01
H + I (i)(2)	Log.	100.09 (6.99)***	0.17 (0.09)ns	0.36 (0.59)ns	-	-	0.91***	<0.01
NS(3)	Hip.(6)	46.78 (11.02)6**7	1.03 (0.89)ns	-	57.00 (7.98)***	-	0.73**	0.033
H + S (4)	Linear(7)	-1.82 (0.51)**	-	-	94.80 (4.41)***	-	0.66**	0.016

(1) NI= No inhibitor (herbicide alone). (2) H= iodosulfuron-methyl; and Inhibitor (I) = insecticides malathion+chlorpyrifos. (3) NS= No safener (herbicide alone). (4) H= iodosulfuron-methyl; and safener (S) = mefenpyr-diethyl. (5) Logistic equation of three parameters $Y= a/(1+(x/X_0)^b)$ (6) Decreasing hyperbolic equation of three parameters $Y=Y_0+(a*b)/(b+x)$. (7) Linear regression equation $Y= Y_0 + ax$. (8) Values in parentheses correspond to standard error of the parameter estimates. (9) The level of significance of the 't' test is represented as follows: * 10%; ** 5% and ***1%; ns indicates not significant. (10) Iodosulfuron-methyl dose which reduces by 50% the height in the logistic equation. (11) TF = tolerance factor = the average of two cultivars, X_{0H}/X_{0H+I}. (12) Coefficient of determination of the model. (13) Significance probability of the equation by the *t* test.

(Carvalho et al., 2009). A direct way to confirm the hypothesis that the herbicidal degradation is involved in the mechanism of selectivity iodosulfuron-methyl to oat plants consists of chromatograph monitoring of the herbicide and the formation of its metabolites on sensitive and tolerant plant cultivars (Askew and Wilcut, 2002; Yu and Powles, 2014).

The results of these experiments support the hypothesis that tolerance to iodosulfuron-methyl in oat is conferred by the ability of plants to detoxify the herbicide. Also, oat tolerance to iodosulfuron-methyl is greatly affected by the environmental conditions, especially by the air temperature (Vidal et al., 2017). High air temperature tends to increase the oat tolerance to the herbicide. This fact is promising when one considers the development of oat cultivars to warmer parts of Brazil. This research also highlights that the association of herbicide with certain insecticides and fungicides can decrease the selectivity of iodosulfuron-methyl to oat crop. We suggest efforts should be made to avoid applying certain insecticides and fungicides on the crop to prevent grain yield inconsistencies through the years. Also, to prevent yield losses from diseases, it would be wise to grow oat cultivars that are resistant to major diseases, especially crown and stem rust, which are quite destructive. But, these cultivars are not always available, thus, it is important to identify all the insecticides and fungicides that could affect the herbicide detoxification on tolerant cultivars.

In summary, oat crop tolerance to iodosulfuron-methyl herbicide depends on the environment, the cultivars and the doses used. Under no environmental stresses, the oat cultivars UFRGS 14 and URS Guará were tolerant to iodosulfuron-methyl at the dose of 5 g ha^{-1}. The oat cultivar UFRGS 18 and URS Taura are sensitive to iodosulfuron-methyl. The ALS enzyme extracted from the oat plants is sensitive to iodosulfuron-methyl. Indirect evidence (detoxification inhibitors and herbicide antidote) suggests that herbicide degradation is the mechanism involved in the tolerance of oat cultivars to iodosulfuron-methyl.

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