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Article

Selectivity of Iodosulfuron-Methyl Association with ACCase Inhibitors and 2.4-D in Wheat and Barley Crops

Seletividade da Associação do Herbicida Iodosulfuron-Methyl com Inibidores de Accase E 2,4-D nas Culturas de Trigo e Cevada

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ABSTRACT - This research aimed to assess the selectivity of treatments involving the commercial formulations tank mixtures of iodosulfuron-methyl with herbicides ACCase inhibitors (fenoxaprop-p-ethyl and clethodim) and synthetic auxins (2.4-D), applied in post-emergence of wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) crops. Three experiments were conducted in the field, during the 2014 crop year. A randomized complete block design was used with 11 treatments and five replications. Treatments consisted of (g ha^{-1}): 1) iodosulfuron-methyl (6.5), 2) fenoxaprop-p-ethyl (82.5), 3) fenoxaprop-p-ethyl + clethodim (55 + 54); 4) 2.4-D (335), 5, 6 e 7) iodosulfuron-methyl + fenoxaprop-p-ethyl (6.5 + 82.5; 6.5 + 110 and 6.5 + 165), 8) iodosulfuron-methyl + fenoxaprop + clethodim (6.5 + 55 + 54), 9) iodosulfuron + fenoxaprop-p-ethyl + 2.4-D (6.5 + 110 + 335), 10) iodosulfuron-methyl + fenoxaprop-p-ethyl + clethodim + 2.4-D (6.5 + 82.5 + 72 + 335) and 11) check without weeds. Associations of iodosulfuron-methyl + fenoxaprop-p-ethyl (6.5 + 82.5; 6.5 + 110 and 6.5 + 165 g ha^{-1}) associations, as well as of iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D (6.5 + 110 + 335 g ha^{-1}) were selective for BRS Campeiro and BRS Gralha azul wheat cultivars and did not feature symptoms of intoxication and significant losses in grain yield and hectoliter weight, when compared to the treatment with no application. For BRS Brau barley cultivar, only iodosulfuron-methyl + fenoxaprop-p-ethyl associations, in doses of 6.5 + 82.5 and 6.5 + 110 g ha^{-1} were feasible for selectivity. Clethodim addition in iodosulfuron-methyl + fenoxaprop-p-ethyl or iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D associations caused negative effects for wheat and barley crops. Commercial formulation of iodosulfuron-methyl (Hussar™) resulted in protection for damage effects of fenoxaprop-p-ethyl (Podium EW™) for studied crops.

Keywords: *Triticum aestivum*, *Hordeum vulgare*, intoxication, tank mixtures

*RESUMO - A pesquisa teve como objetivo avaliar a seletividade de tratamentos envolvendo a mistura em tanque de formulações comerciais de iodosulfuron-methyl com herbicidas inibidores da ACCase (fenoxaprop-p-ethyl e clethodim) e auxinas sintética (2,4-D), aplicados em pós-emergência das culturas do trigo (**Triticum aestivum**) e cevada (**Hordeum vulgare**). Três experimentos foram conduzidos em campo, durante a safra agrícola de 2014. O delineamento experimental utilizado foi o de blocos casualizados, com 11 tratamentos e 5 repetições. Os tratamentos foram constituídos por (g ha^{-1}): 1) iodosulfuron-methyl (6,5), 2) fenoxaprop-p-ethyl (82,5), 3) fenoxaprop-p-ethyl + clethodim (55,0 + 54,0); 4) 2,4-D (335,0); 5, 6 e 7) iodosulfuron-methyl + fenoxaprop-p-ethyl (6,5 + 82,5, 6,5 + 110,0 e 6,5 + 165,0); 8) iodosulfuron-methyl + fenoxaprop-p-ethyl + clethodim (6,5 + 55,0 +*

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54,0); 9) iodosulfuron-methyl + fenoxaprop-p-ethyl + 2,4-D (6,5 + 110,0 + 335,0); 10) iodosulfuron-methyl + fenoxaprop-p-ethyl + clethodim + 2,4-D (6,5 + 82,5 + 72,0 + 335,0); e 11) testemunha capinada. As associações de iodosulfuron-methyl + fenoxaprop-p-ethyl (6,5 + 82,5, 6,5 + 110,0 e 6,5 + 165,0 g ha^{-1}), assim como de iodosulfuron-methyl + fenoxaprop-p-ethyl + 2,4-D (6,5 + 110,0 + 335,0 g ha^{-1}), foram seletivas para os cultivares de trigo BRS Campeiro e BRS Gralha Azul, não apresentando sintomas de intoxicação e perdas significativas na produtividade e no peso hectolitro dos grãos. Para a cevada BRS Brau, apenas as associações de iodosulfuron-methyl + fenoxaprop-p-ethyl, nas doses de 6,5 + 82,5 e 6,5 + 110,0 g ha^{-1}, foram viáveis em relação à seletividade. A adição de clethodim nas associações de iodosulfuron-methyl + fenoxaprop-p-ethyl ou iodosulfuron-methyl + fenoxaprop-p-ethyl + 2,4-D teve efeitos negativos para as culturas de trigo e cevada. A formulação comercial de iodosulfuron (Hussar™) proporcionou proteção aos efeitos deletérios do fenoxaprop-p-ethyl (Podium EW™) para as culturas estudadas.

Palavras-chave: *Triticum aestivum*, *Hordeum vulgare*, intoxicação, mistura em tanque.

INTRODUCTION

Wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) production is mostly found in the southern region of Brazil, and the states of Parana and Rio Grande do Sul account for, respectively, 90.4% and 97.2% of planted area, and 87.1% and 98.5% of national production (Conab, 2016). The use of winter cereal cultivation has been a fundamental practice for some regions of southern Brazil, in succession of crops along with summer crops (Santos et al., 2010).

Among winter cereals, wheat and barley crops stand out in winter crops in the Guarapuava-PR region, as they are part of the succession of crops and provide extra yield to the producer in the winter season. Normally, in this region, black oats or white oats are planted in advance to cover the soil in subsequent sowing of corn, while soybeans are sown after harvesting barley and wheat.

Regarding management practices, estimates of losses in winter grain yield due to weed coexistence are inaccurate, since the level of competition of infestations varies according to the aggressiveness of species, population density, duration of competition and environmental conditions (Vargas and Roman, 2005; Vargas et al., 2008; Agostinetto et al., 2008; Gherekhloo et al., 2010). In general, weed control in wheat and barley in Brazil is mainly carried out with application of post-emergence herbicides inhibitors of ALS enzyme (acetolactate synthase) and metsulfuron-methyl (Ally™) suitable for infestations species of Magnoliopsidas class, and iodosulfuron-methyl (Hussar™), for control of Liliopsidas class, such as oat and ryegrass, plus some Magnoliopsidas (Rodrigues and Almeida, 2011).

Recently, the combination of iodosulfuron-methyl + fenoxaprop-p-ethyl herbicides in the tank has been used empirically by farmers from Rio Grande do Sul and Paraná as a management option with a single application of difficult-to-control Magnoliopsida and Liliopsida species, such as ryegrass and black oats. Such a tank mix is only feasible for some winter crops due to the *safener* (chemical protection) present in the formulation of iodosulfuron-methyl, called mefenpyr-diethyl (Cataneo et al., 2013), which is capable of protecting the crop Wheat from the deleterious and phytotoxic effects of fenoxaprop-p-ethyl. These substances can be applied separately, for example in the treatment of seeds of the crops in question, or even be used directly in the formulation of some herbicides (Abu-Qare and Duncan, 2002; Galon et al., 2011).

Unlike fenoxaprop-p-ethyl formulations sold in Brazil, in other countries there is a commercial formulation of fenoxaprop-p-ethyl with mefenpyr-diethyl *safener,* reported in some studies the selectivity of this herbicide for wheat crops and rice, As well as the high efficiency in the control of weed species of the Liliopsida class (Awan et al., 2006, Yasin, 2011, Fahad et al., 2013 and Mehmood et al., 2014).

Thus, this study aimed to assess the selectivity of the mixture, commercial formulations tank iodosulfuron-methyl + fenoxaprop-p-ethyl applied post-emergence alone or in combination with other herbicides, in crops of wheat (*T. aestivum*) and barley (*H. vulgare*).

MATERIAL AND METHODS

The work was carried out in the field, with three experiments, the first two in Guarapuava-PR (experiments 1 and 2), in the coordinates of latitude 25º23'06.9" S, longitude 051º29'37.8" W and 1,055 meters in altitude; and a third experiment in Palmeirinha-PR (experiment 3), in the coordinates of 25º15'48.4" S, 051º35'11.1" W and 1,058 m of altitude.

Soil physical and chemical analysis for the Guarapuava-PR samples from 0 to 20 cm deep, had the following composition: pH in $CaCl_2$ de 5,7; organic matter of 28.2 g dm^{-3}; H + Al^{+3}, Mg^{+2}, Ca^{+2}, K^+ and P (Mehlich), respectively, of 0.2, 2.6, 6.4, 0.29 and 11.1 mg dm^{-3}; as well as 510, 230 and 260 g kg^{-1} of clay, silt and sand, respectively. In Palmeirinha-PR, the physical and chemical soil analysis showed pH in $CaCl_2$ de 5.0; MO of 43.6 g dm^{-3}; H + Al^{+3}, Mg^{+2}, Ca^{+2}, K^+ and P (Mehlich), respectively, of 0.0, 1.6, 4.3, 0.63 and 14.2 mg dm^{-3}; as well as 500, 220 and 280 g kg^{-1} of clay, silt and sand, respectively. The soil of both locations is classified as typical dystrophic Bruno Latosol, clay texture (Embrapa, 2013).

The climate of the region is classified as humid mesothermic subtropical Cfb (Köppen, 1948), with fresh summers, winters with severe and frequent frost, not having defined dry season. Mean annual maximum temperature is 23.5 ºC, and the mean annual minimum temperature is 12.7 ºC (Comissão Sul Brasileira de Pesquisa de Trigo e Triticale,, 2014). Figure 1 shows the meteorological data regarding the period of the work, as well as the sowing and application times of the three experiments.

The experimental design was made with randomized blocks with 11 treatments and 5 replicates. The treatments are depicted in Table 1. The experimental units presented dimension 3 x 6 m (18 m^2), the six - axis being evaluated, disregarding 0.5 m and the ends of the wings portions (useful area 13.3 m^2).

Seeds of cultivar BRS Brau (experiment 1 - barley), BRS Campeiro (experiment 2 - wheat) and BRS Gralha Azul (experiment 3 - wheat) were cultivated on 07/04/2014, 07/28/2014 and 08/07/2014, respectively, using spacing of 17 cm between rows and about 220 viable seeds m^{-2} as wheat sowing technical recommendations for the Southern Brazil (Comissão Sul Brasileira de Pesquisa de Trigo e Triticale, 2014). The amount of fertilizer used in the experiments seeding was 350 kg ha^{-1} formulated 8-20-20 (NPK) and top dressing of 100 kg ha^{-1} urea (45% nitrogen).

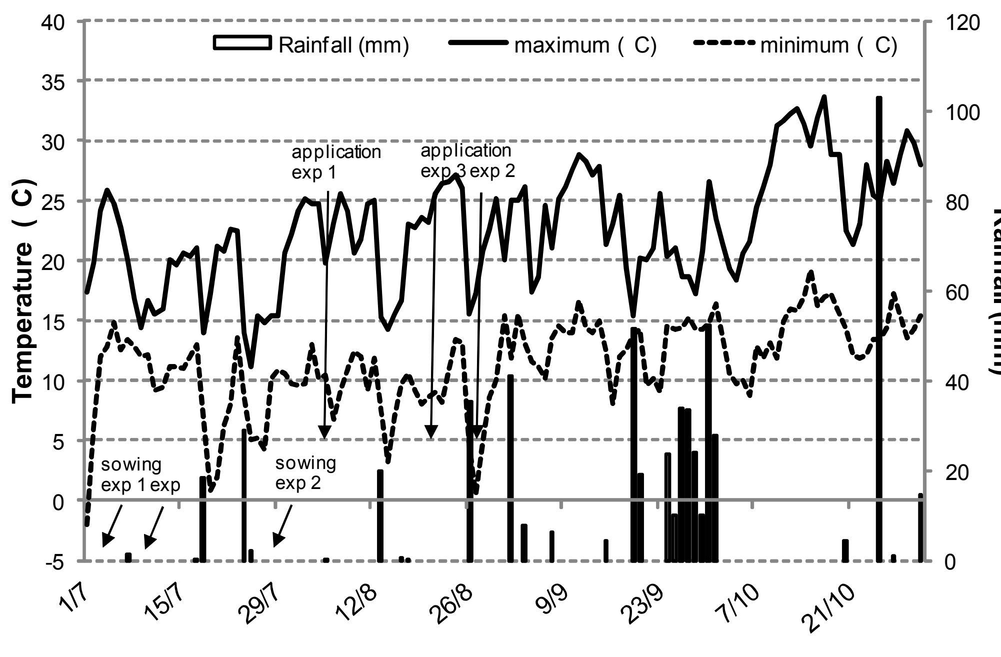

Figure 1 - Meteorological data for the period of development of evaluations in experiments with barley (experiment 1) and wheat (experiments 2 and 3). Guarapuava-PR, 2014.

Table 1 **-** Treatments used in experiments of wheat and barley in Guarapuava-PR and Palmeirinha-PR, 2014

Treatment (common herbicide names)	Rate ($g\ ai\ ha^{-1}$ or $g\ ae\ ha^{-1}$)	Rate ($g\ ha^{-1}$ or L pc)
IOD (1)(5)	6.5	130.0
PHE (2)	82.5	0.75
CLE FEN+(3) (5)	55.0+54.0	0.5+0.225
2.4D (4) (5)	335.0	0.50
IOD+FEN (5)	6.5+82.5	130+0.75
IOD+FEN (5)	6.5+110.0	130+1.0
IOD+FEN (5)	6.5+165.0	130+1.5
IOD+PHE+CLE (5)	6.5+55.0+54.0	130+0.5+0.225
IOD+PHE+2.4D (5)	6.5+110.0+335.0	130+1.0+0.5
IOD+PHE+2,4 - D+CLE (5)	6.5+82.5+72.0+335.0	130+0.75+0.3+0.5
Weeding witness	-	-

(1) iodosulfuron-methyl = Hussar™; (2) fenoxaprop-p-ethyl = Podium EW™; (3) clethodim = Select EC 240™; (4) 2.4-D = DMA 806 BR™; (5) plus adjuvant treatments of soybean oil methyl ester = Aureo™ 0.5 L cp ha^{-1}.

At the moment of application, the wheat and barley crops were at the phenological stage 2.1, characterized by the pitching stage, constituting the main one plus a single one, according to the scale proposed by Zadoks et al. (1974).

Applications of treatments were made using a knapsack sprayer pressurized CO_2 equipped with four tips TTi 110.02 (Teejet™ manufacturer) spaced 0.5 m and 0.5 m high culture in working pressure 210 kPa travel speed of 3.6 km h^{-1} and application rate of 200 L $ha^{-1.}$

Meteorological conditions in the applications were recorded with a portable digital anemometer at the beginning and end of the application of the treatments of experiment 1, performed on 06/08/2014 from 9:25 a.m. to 10:45 a.m., all presented, on average, relative humidity, temperature and wind speeds, respectively, from 73.5 to 71.7% from 18.9 to 19.6 °C and 1.0 to 1.5 km h^{-1}. In experiment 2, the application was performed on 08/27/2014 from 10:05 a.m. to 10:55 a.m., when the mean relative air humidity, temperature and wind speed were 70.8 to 69.3%, 10.4 a 10.9 °C 2.6 km and 1.0 h^{-1}, respectively. In the experiment 3, the beginning and the end of the application of the treatments, performed on 08/22/2014 between 12:15 a.m. and 1:10 p.m., recorded relative air humidity, temperature and wind speed, respectively, from 63.5 to 59.8% 18.5 to 20.3 °C and 1.5 to 2.9 km h^{-1}.

The three experiments were kept free of reinfestation and weed interference throughout the crop cycle, by means of weeding and manual withdrawals for all treatments.

To control pests, there was no need to apply insecticide, unlike diseases held an application of the fungicide tebuconazole + trifloxystrobin (0.6 L cp ha^{-1} methylated oil with 0.25% v/v) during the tillering and stem elongation, and in addition, during the bolting with tebuconazole + trifloxystrobin (0.6 L cp ha^{-1} methylated oil with 0.25% v/v) propiconazole and (0.3 L cp ha^{-1} methylated oil with 0.25% v/v).

The evaluated characteristics were the intoxication (%) of the wheat and barley cultures, through a scale of visual notes (SBCPD, 1995), in which 0% corresponded to the absence of injuries and 100% to the death of the plants; chlorophyll content (SPAD) leaves using a portable Minolta Chlorophyll™ model; And plant height (cm) at 7, 14, 28 and 49 days after application (DAA). In addition, morphological characteristics were also analyzed: ear length and number of spikelets per spike, in a sample of ten ears collected in the plot area; and agronomic characteristics: weight hectolitre (kg hL^{-1}) being determined as the Rules for Seed Analysis (Brazil, 2009) and grain yield (kg ha^{-1}) with humidity adjusted to 130 g kg^{-1}.

Data were then submitted to analysis of variance by the F test, and the means were compared by the Scott-Knott statistical grouping test ($p \leq 0.05$).

RESULTS AND DISCUSSION

For barley, it was observed that only the associations iodosulfuron-methyl + fenoxaprop-p-ethyl, at doses of 6.5 and 82.5 + 6.5 + 110 g ha^{-1} were selective for cultivating BRS Brau, not characterizing symptoms of intoxication in any of the evaluation periods, as well as reduction in productivity and pH of the grains (Table 2). However, although iodosulfuron-methyl + fenoxaprop-p-ethyl in the dose 6.5 + 165 g ha^{-1} + iodosulfuron-methyl and fenoxaprop-p-ethyl + 2.4-D at a dose of 6.5 + 110 + 335 g ha^{-1} have not caused toxicity in culture, caused a significant reduction in all agronomic traits.

Moreover, it is also important to note that were observed in visual injuries BRS Brau isolated subjected to application of iodosulfuron-methyl (6.5 g ha^{-1}). These results differ from those reported by Vargas and Roman (2005) and Galon et al. (2014), using the cultivars BRS 225, Criollo and MN610, where it is detected in distinction poisoning intensity levels with iodosulfuron application at a dose of 5.0 g ha^{-1}. According to Galon et al. (2014), the distinct characteristics of the barley genotypes, as well as the physico-chemical characteristics of each herbicide, will confer greater or lesser tolerance of the crop.

Regarding the morphoagronomic characteristics of barley, the grain yield results of the BRS Brau cultivar indicated safety in the use of iodosulfuron-methyl + fenoxaprop-p-ethyl only in the doses of 6.5 + 82.5 and 6.5 + 110 g ha^{-1}, since the only associations were not significantly different from the control without application (Table 2). However, it is important to note that, regarding morphological characteristics of ear length (COESP) and number of spikelets per spike (NESP), these associations of iodosulfuron-methyl + fenoxaprop-p-ethyl had similar behavior to that of iodosulfuron-methyl alone, Which were lower than the control without application, but did not imply reduction of grain yield. Galon et al. (2014), using 5 g ha^{-1} iodosulfuron-methyl, have been reported no reduction in components spike length number of heads, and number of total grain barley culture.

The addition of clethodim in the association of iodosulfuron-methyl + fenoxaprop-p-ethyl or iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D was not viable in terms of selectivity aspects for barley cultivation, with high levels (COESP), number of spikelets per ear (NESP) and grain yield (PROD). Thus, it is evident that the mefenpyr-diethyl *safener* present in iodosulfuron-methyl formulation was able to protect the culture of barley from the deleterious effects of phytotoxic and fenoxaprop-p-ethyl, but did not exercise the same protection for clethodim.

These results indicate that only combinations of the commercial formulations of iodosulfuron-methyl + fenoxaprop-p-ethyl or iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D were selective for barley culture. It is noteworthy that the herbicide fenoxaprop-p-ethyl is not registered for use in this crop in Brazil (Rodrigues and Almeida, 2011).

For wheat cultivars, BRS Campeiro and BRS Gralha Azul cultivars showed lower levels of insults compared to BRS Brau barley cultivars, and no symptoms were observed for the associations of iodosulfuron-methyl + fenoxaprop-p-ethyl, as well as only mild phytotoxic symptoms due to the application of iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D only for BRS Gralha Azul (Table 3).

Importantly, the toxicity was not observed when performed wheat cultivars application iodosulfuron-methyl (6.5 g ha^{-1}) alone, as well as the lower tolerance was found BRS Campeiro the herbicide fenoxaprop-p-ethyl (82.5 g ha^{-1}), in relation to BRS Gralha Azul. These results corroborate those of Rubin et al. (2012), which reported no symptoms of intoxication to iodosulfuron-methyl (5.0 g ha^{-1}) in Ivory wheat cultivar, but differ from those described by Santos et al. (2015), who verified symptoms of chlorosis in the cultivars Quartzo and BRS Tangará. According to Vargas and Fleck (1999) and Hartwig et al. (2008), there is genetic variability in wheat for tolerance to herbicides inhibiting the enzymes ACCase and ALS, respectively. Therefore, this shows that the genetic constitution of the cultivar can determine variation in tolerance or susceptibility to these herbicides, as well as to their associations.

Cataneo et al. (2013) reported that the combination of fenoxaprop-p-ethyl with the *safener* mefenpyr-diethyl increased lipid content in four wheat cultivars in relation to fenoxaprop-p-ethyl alone. According to these authors, the *safener* of the protective action in wheat crop is related to the increase in the lipid content in the plant, which results in increased cuticle composition and plasma membrane. Hess and Weller (2000) stated that the increase of these components can reduce the translocation of fenoxaprop-p-ethyl in the wheat crop, making it tolerant to this herbicide. Belfry and Sikkema (2015) described as excellent the tolerance of four wheat cultivars submitted to the application of a commercial formulation of fenoxaprop-p-ethyl + mefenpyr-diethyl.

Table 2 **-** Intoxication of shoot of barley cultivar BRS Brau (exp. 1) at 7, 14, 28 and 49 days after application (DAA) and agronomic traits: ear length (COESP), number of spikelets per spike (NESP), grain yield (PROD) and hectoliter weight (PH). Guarapuava-PR, 2014

Treatment	Rate (g ai ha^{-1} or g ae ha^{-1})	Intoxication (%)				Morphoagronomic characteristics			
		7 DAA	14 DAA	28 DAA	49 DAA	COESP (cm)	NESP	PROD (kg ha^{-1})	PH (kg^{-1} hL)
IOD (1)(5)	6.5	0.0 E	0.0 E	0.0 E	0.0 E	6.4 B	9.6 B	2468 B	58.0 A
PHE (2)	82.5	7.8 B	72.8 B	91.0 B	86.3 B	3.3 F	9.0 C	426 E	58.1 A
CLE FEN+(3) (5)	55+54	15.0 A	89.0 A	100.0 A	100.0 A	0.0 G	0.0 F	0 F	0.0 C
2.4D (4) (5)	335	0.0 E	0.0 E	0.0 E	0.0 E	6.0 C	9.5 B	2677 A	58.1 A
IOD+FEN (5)	6.5+82.5	0.0 E	0.0 E	0.0 E	0.0 E	5.9 C	9.6 B	2507 A	58.2 A
IOD+FEN (5)	6.5+110	0.0 E	0.0 E	0.0 E	0.0 E	5.8 C	9.4 B	2655 A	57.5 B
IOD+FEN (5)	6.5+165	0.0 E	0.0 E	0.0 E	0.0 E	5.3 D	9.2 C	2473 B	56.8 B
IOD+PHE+CLE (5)	6.5+55+54	3.0 D	40.3 D	45.3 D	42.5 D	3.7 E	8.5 D	701 D	58.2 A
IOD+PHE+2.4D (5)	6.5+110+335	0.0 E	0.0 E	0.0 E	0.0 E	6.3 B	9.7 B	2420 B	57.5 B
IOD+PHE+2,4 - D+CLE (5)	6.5+82.5+72+3350	5.0 C	53.5 C	71.0 C	65.8 C	3.9 E	7.4 E	911 C	56.8 B
Weeding witness	-	0.0 E	0.0 E	0.0 E	0.0 E	7.3 A	10.8 A	2823 A	58.2 A
F_{cal}	-	241.3*	195.2*	4740.0*	1342.1*	163.5*	336.9*	239.8*	2634.4*
VC (%)	-	22.24	21.13	4.26	8.08	6.55	3.77	7.58	1.29

(1) iodosulfuron-methyl = Hussar™; (2) fenoxaprop-p-ethyl = Podium EW™; (3) clethodim = Select EC 240™; (4) 2.4-D = DMA 806 BR™; (5) plus adjuvant treatments of soybean oil methyl ester = Áureo™ 0.5 L cp ha^{-1}. Means followed by the same lowercase letters in the columns do not differ from each other by the Scott-Knott test grouping ($p \leq 0.05$)* = significant; NS = not significant.

Table 3 **-** Intoxication of shoots of wheat cultivar BRS Campeiro (exp. 2) and BRS Gralha azul (exp. 3) at 7, 14, 28 and 49 days after treatment (DAT) the treatments alone or herbicides in combination. Guarapuava-PR and Palmeirinha-PR, 2014

Treatment	Rate (g ai ha^{-1} or g ae ha^{-1})	Intoxication (%)							
		Exp. 2 (BRS Campeiro)				Exp. 3 (BRS Bluegrass)			
		7 DAA	14 DAA	28 DAA	49 DAA	7 DAA	14 DAA	28 DAA	49 DAA
IOD (1)(5)	6.5	0.0 D	0.0 D	0.0 E	0.0 E	0.0 D	0.0 F	0.0 E	0.0 E
PHE (2)	82.5	9.2 B	12.2 B	40.2 B	51.8 B	8.8	16.6 D	19.4 D	21.2 D
CLE FEN+(3) (5)	55+54	27.6 A	42.6 A	85.6 A	90.6 A	5.6 B	74.6 A	88.2 A	90.2 A
2.4D (4) (5)	335	0.0 D	0.0 D	0.0 E	0.0 E	0.0 D	0.0 F	0.0 E	0.0 E
IOD+FEN (5)	6.5+82.5	0.0 D	0.0 D	0.0 E	0.0 E	0.0 D	2.2 E	0.0 E	0.0 E
IOD+FEN (5)	6.5+110	0.0 D	0.0 D	0.0 E	0.0 E	0.0 D	0.0 F	0.0 E	0.0 E
IOD+FEN (5)	6.5+165	3.8 C	0.0 D	0.0 E	0.0 E	0.0 D	0.0 F	0.0 E	0.0 E
IOD+PHE+CLE (5)	6.5+55+54	3.4 C	9.2 C	30.2 C	40.6 C	3.4 C	47.6 C	51.6 C	53.2 C
IOD+PHE+2.4D (5)	6.5+110+335	0.0 D	0.0 D	0.0 E	0.0 E	3.0 C	3.8 E	1.2 E	0.6 E
IOD+PHE+2,4 - D+CLE (5)	6.5+82.5+72+3350	3.4 C	8.8 C	18.8 D	23.4 D	3.0 C	67.6 B	82.2 B	83.8 B
Weeding witness	-	0.0 D	0.0 D	0.0 E	0.0 E	0.0 D	0.0 F	0.0 E	0.0 E
F_{cal}	-	342.9*	749.1*	4204.8*	6961.6*	127.1*	1337.9*	1916.3*	3416.3*
VC (%)	-	23.10	15.83	5.92	4.34	27.02	9.28	8.10	6.05

(1) iodosulfuron-methyl = Hussar®; (2) fenoxaprop-p-ethyl = Podium EW™; (3) clethodim = Select EC 240™; (4) 2.4-D = DMA 806 BR™; (5) plus adjuvant treatments of soybean oil methyl ester = Aureo™ 0.5 L cp ha^{-1}. Means followed by the same lowercase letters in the columns do not differ from each other by the Scott-Knott test grouping ($p \leq 0.05$)* = significant; NS = not significant.

For the variable height of plants (4), only BRS Campeiro wheat showed significant reductions until the evaluation of 49 DAA, when submitted to associations of the herbicides iodosulfuron-methyl + fenoxaprop-p-ethyl and iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D. On the contrary, significant reductions in plant height were also observed in all cultivars at all epochs when fenoxaprop-p-ethyl + clethodim, iodosulfuron-methyl + fenoxaprop-p-ethyl + clethodim and iodosulfuron-methyl + fenoxaprop-p-ethyl + clethodim + 2.4-D.

As for the chlorophyll content, it was observed that in both experiments there was a significant reduction of this variable when the iodosulfuron-methyl + fenoxaprop-p-ethyl and iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D until the 28 DAA, not interfering with the 49 DAA (Table 4). It is noteworthy that for the BRS Gralha Azul, only treatments with mixtures involving the association of clethodim and iodosulfuron-methyl + fenoxaprop-p-ethyl (6.5 + 165 g ha^{-1}) could not match the chlorophyll content to that of the control without herbicide application at 49 DAA. For the cultivar BRS Campeiro, only the association of fenoxaprop-p-ethyl + clethodim significantly differed the chlorophyll content at 49 DAA, compared to the control without application.

Table 4 **-** Height of plants and chlorophyll content of wheat cultivar BRS Campeiro (exp. 2) and BRS Gralha azul (exp. 3) at 7, 14, 28 and 49 days after application (DAA) of treatment with isolates herbicides or in association. Guarapuava-PR and Palmeirinha-PR, 2014

Treatment	Rate (g ai ha^{-1} or g ae ha^{-1})	Height (cm)							
		Exp. 2 (BRS Campeiro)				Exp. 3 (BRS Bluegrass)			
		7 DAA	14 DAA	28 DAA	49 DAA	7 DAA	14 DAA	28 DAA	49 DAA
IOD [1][5]	6.5	21.4^{C}	24.0^{D}	54.5^{A}	68.3^{B}	42.6^{A}	53.3^{B}	80.2^{A}	83.8^{A}
PHE [2]	82.5	22.7^{B}	25.0^{C}	44.0^{D}	50.9^{G}	41.2^{A}	54.8^{A}	74.9^{A}	71.9^{B}
CLE FEN+ [3][5]	55+54	19.6^{D}	20.8^{E}	36.1^{E}	44.6^{H}	32.8^{B}	27.2^{C}	55.9^{C}	56.6^{D}
2.4D [4][5]	335	23.8^{A}	26.9^{B}	54.5^{A}	67.5^{B}	43.5^{A}	55.3^{A}	81.8^{A}	83.7^{A}
IOD+FEN [5]	6.5+82.5	22.1^{B}	25.8^{C}	49.6^{B}	65.6^{C}	41.8^{A}	56.1^{A}	78.5^{A}	84.1^{A}
IOD+FEN [5]	6.5+110	21.3^{C}	25.2^{C}	48.0^{C}	66.4^{C}	41.2^{A}	54.9^{A}	79.7^{A}	83.8^{A}
IOD+FEN [5]	6.5+165	20.9^{C}	24.3^{D}	44.7^{D}	62.6^{D}	40.1^{A}	54.2^{A}	80.3^{A}	83.9^{A}
IOD+PHE+CLE [5]	6.5+55+54	20.2^{D}	25.7^{C}	45.5^{D}	54.2^{F}	35.7^{B}	23.0^{D}	62.6^{B}	64.1^{C}
IOD+PHE+2.4D [5]	6.5+110+335	21.8^{C}	23.5^{D}	54.3^{A}	67.6^{B}	43.5^{A}	55.3^{A}	79.9^{A}	83.5^{A}
IOD+PHE+2,4 - D+CLE [5]	6.5+82.5+72+3350	21.3^{C}	26.7^{B}	43.6^{D}	60.7^{E}	34.9^{B}	27.3^{C}	63.1^{B}	63.7^{C}
Weeding witness	-	23.7^{A}	30.4^{A}	58.5^{A}	70.7^{A}	44.4^{A}	55.0^{A}	80.4^{A}	83.8^{A}
F_{cal}	-	8.3*	25.4*	113.5*	315.6*	7.7*	1282.7*	22.3*	433.9*
VC (%)	-	4.74	4.21	2.69	1.70	7.87	1.81	5.84	1.47
		Chlorophyll content (SPAD)							
IOD [1][5]	6.5	31.1	32.0^{B}	32.7^{B}	33.7^{A}	32.1^{B}	32.5^{B}	33.4^{A}	32.9^{A}
PHE [2]	82.5	31.3	27.7^{D}	26.5^{E}	33.0^{A}	31.5^{B}	32.1^{B}	32.6^{B}	33.2^{A}
CLE FEN+ [3][5]	55+54	31.0	22.0^{E}	10.2^{F}	7.1^{B}	24.3^{E}	24.8^{E}	21.3^{D}	17.9^{E}
2.4D [4][5]	335	31.6	32.0^{B}	33.0^{B}	33.1^{A}	32.1^{B}	32.5^{B}	33.0^{A}	33.4^{A}
IOD+FEN [5]	6.5+82.5	31.6	31.3^{B}	32.9^{B}	32.8^{A}	31.4^{B}	32.3^{B}	33.3^{A}	33.1^{A}
IOD+FEN [5]	6.5+110	31.3	32.0^{B}	33.1^{B}	32.8^{A}	31.9^{B}	32.8^{B}	32.8^{B}	32.5^{A}
IOD+FEN [5]	6.5+165	31.4	32.3^{B}	32.9^{B}	32.5^{A}	27.5^{C}	30.8^{C}	31.9^{B}	31.1^{B}
IOD+PHE+CLE [5]	6.5+55+54	31.5	27.2^{D}	28.7^{D}	32.0^{A}	25.6^{D}	27.6^{D}	25.3^{C}	23.4^{D}
IOD+PHE+2.4D [5]	6.5+110+335	31.4	31.8^{B}	32.8^{B}	33.0^{A}	31.9^{B}	32.3^{B}	32.8^{B}	33.0^{A}
IOD+PHE+2,4 - D+CLE [5]	6.5+82.5+72+3350	31.3	28.6^{C}	30.7^{C}	32.6^{A}	28.1^{C}	27.6^{D}	25.4^{C}	25.3^{C}
Weeding witness	-	32.4	33.2^{A}	34.3^{A}	33.9^{A}	34.7^{A}	33.7^{A}	33.5^{A}	33.2^{A}
F_{cal}	-	1.3^{NS}	98.9*	982.5*	523.3*	58.8*	71.1*	201.2*	390.4*
VC (%)	-	2.86	2.50	1.65	2.50	3,12	2.44	2.22	1.99

[1] iodosulfuron-methyl = Hussar™; [2] fenoxaprop-p-ethyl = Podium EW™; [3] clethodim = Select EC 240™; [4] 2.4-D = DMA 806 BR™; [5] plus adjuvant treatments of soybean oil methyl ester = Aureo™ 0.5 L cp ha^{-1}. Means followed by the same lowercase letters in the columns do not differ from each other by the Scott-Knott test grouping ($p \leq 0.05$)* = significant; ^{NS} = not significant.

Regarding the agronomic characteristics of grain yield (PROD) and hectoliter weight (PH), the associations of iodosulfuron-methyl + fenoxaprop-p-ethyl did not differ significantly from the control without application in the two evaluated cultivars (Table 5). However, for spike length (COESP) and number of spikelets per spike (NESP), the cultivar BRS Gralha Azul was distinguished because it did not differ from the control when submitted to the associations of iodosulfuron-methyl + fenoxaprop-p-ethyl, iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D and iodosulfuron-methyl isolated, unlike BRS Campeiro, in which for all variables, all herbicidal treatments caused a significant reduction in relation to the control. Similarly, Mahmood et al. (2013) reported high selectivity for wheat from the ready-mixed fenoxaprop-p-ethyl + mefenpyr-diethyl wheat, mainly in relation to the number of tillers, plant height, ear length, number of grains per ear, weight of thousand Grain and productivity.

Table 5 - Morphoagronomic characteristics of length spike (COESP) and number of spikelets per spike (NESP), grain yield (PROD) and weight hectolitre (PH) of wheat cultivars BRS Campeiro (exp. 2) and BRS Gralha azul (exp. 3) submitted to treatments with herbicides alone or in combination. Guarapuava-PR and Palmeirinha-PR, 2014

Treatment	Rate (g ai ha^{-1} or g ae ha^{-1})	Morphoagronomic characteristics							
		Exp. 2 (BRS Campeiro)				Exp. 3 (BRS Bluegrass)			
		COESP (cm)	NESP	PROD (kg ha^{-1})	PH (kg^{-1} hL)	COESP (cm)	NESP	PROD (kg ha^{-1})	PH (kg^{-1} hL)
IOD (1)(5)	6.5	11.1 B	11.7 B	3012 A	73.5 A	14.5 A	15.8 A	4575 A	75.0 B
PHE (2)	82.5	7.8 C	10.6 C	1327 C	73.0 A	12.6 C	13.8 B	3657 B	75.1 B
CLE FEN+(3) (5)	55+54	7.5 C	10.3 C	823 C	71.8 C	10.6 D	12.6 B	1006 D	72.6 D
2.4D (4) (5)	335	11.4 B	12.1 B	2857 A	70.7 D	14.5 A	14.7 B	4363 A	74.2 C
IOD+FEN (5)	6.5+82.5	11.3 B	12.2 B	2920 A	73.0 A	15.0 A	13.9 A	4582 A	75.9 A
IOD+FEN (5)	6.5+110	11.1 B	12.0 B	2970 A	73.3 A	14.9 A	15.0 A	4612 A	75.6 A
IOD+FEN (5)	6.5+165	11.1 B	12.0 B	2761 A	73.0 A	14.7 A	14.8 A	4376 A	75.6 A
IOD+PHE+CLE (5)	6.5+55+54	10.4 B	10.0 C	1868 B	72.3 B	13.8 B	11.2 C	2564 C	73.1 D
IOD+PHE+2.4D (5)	6.5+110+335	11.0 B	12.3 B	3050 A	70.4 D	14.8 A	14.9 A	4717 A	73.3 D
IOD+PHE+2,4 - D+CLE (5)	6.5+82.5+72+3350	10.9 B	11.4 B	2047 B	72.7 B	13.6 B	12.8 B	2869 C	74.5 B
Weeding witness	-	12.1 A	14.5 A	3197 A	73.5 A	14.8 A	16.7 A	4912 A	75.8 A
F_{cal}	-	32.42*	21.73*	22.03*	17.4*	17.6*	6.05*	25.56*	28.29*
VC (%)	-	5.42	4.97	15.62	0.82	5.13	10.00	14.02	0.65

(1) iodosulfuron-methyl = Hussar™; (2) fenoxaprop-p-ethyl = Podium EW™; (3) clethodim = Select EC 240™; (4) 2.4-D = DMA 806 BR™; (5) plus adjuvant treatments of soybean oil methyl ester = Aureo™ 0.5 L cp ha^{-1}. Means followed by the same lowercase letters in the columns do not differ from each other by the Scott-Knott test grouping ($p \leq 0.05$)* = significant; NS = not significant.

The associations between the iodosulfuron-methyl + fenoxaprop-p-ethyl herbicides did not significantly interfere in the PH of the wheat cultivars BRS Campeiro (experiment 2) and BRS Gralha Azul (experiment 3), which had a type III and II classification, respectively, according to Wheat Technical Regulation (Brasil, 2010). In addition, the iodosulfuron-methyl + fenoxaprop-p-ethyl + 2.4-D, as well as iodosulfuron-methyl and 2.4-D isolated treatments were also not significantly different from the control without application only for the characteristic grain yield, showing also to be selective, but may negatively influence the industrial quality of the grains.

Given the above, the results of this study indicate that the commercial formulation of iodosulfuron-methyl herbicide (Hussar™) provided protection and selectivity for the deleterious effects of fenoxaprop-p-ethyl, when used in tank - mix the wheat crop and barley, may be considered an alternative tool for the management of weeds of these winter cereals. However, it is also important to note that the *safener* mefenpyr-diethyl, iodosulfuron-methyl present in the formulation did not provide protection and selectivity on wheat and barley crops when used in combination with clethodim + fenoxaprop-p-ethyl.

Further studies on productivity and grain quality of other cultivars under distinct edaphoclimatic conditions are still required for the safer use of iodosulfuron-methyl + fenoxaprop-p-ethyl in wheat and barley crops.

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