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Flumioxazin selectivity to wheat[1]

Seletividade do flumioxazin ao trigo

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Abstract - The chemical control of weeds is an important management to keep high productivity in the wheat crop. Due to the scarceness of registered products for the crop, the goal of this work was to evaluate the selectivity of the flumioxazin herbicide to wheat, applied in post-emergence. The experiment was conducted on the field and the used experimental design was the randomized block one, with four replications. The treatments were applied on stage V3 of the wheat crop and consisted in six flumioxazin doses: 0, 10, 20, 30, 40, 50 g ha^{-1}. Evaluations were performed on SPAD index, intoxication and weed control on day 15, 21, 28 and 35 after application. At the end of the experiment, 109 days after seeding, plants were tracked to determine the one thousand grain weight, hectoliter weight and grain productivity. The obtained results showed that in spite of causing an up to 20% SPAD index and up to 34% intoxication reduction in the highest applied dose, flumioxazin provided selectivity to the wheat crop, since it did not interfere in the other evaluated variables, mainly in grain productivity.
Keywords: doses; herbicide; productivity; *Triticum aestivum*

Resumo - O controle químico de plantas daninhas é um importante manejo para se manter a alta produtividade na cultura do trigo. Devido à escassez de produtos registrados para a cultura, objetivou-se avaliar a seletividade do herbicida flumioxazin ao trigo, aplicado em pós-emergência. O experimento foi realizado a campo e o delineamento experimental utilizado foi de blocos ao acaso, com quatro repetições. Os tratamentos foram aplicados no estádio V3 da cultura do trigo e consistiram de seis doses de flumioxazin: 0, 10, 20, 30, 40, 50 g ha^{-1}. Foram realizadas avaliações de índice SPAD, de intoxicação e de controle de plantas daninhas aos 15, 21, 28 e 35 dias após a aplicação. Ao final do experimento, 109 dias após a semeadura, as plantas foram trilhadas para determinação do peso de mil grãos, peso hectolitro e produtividade de grãos. Os resultados obtidos mostraram que apesar de causar redução do índice SPAD de até 20% e intoxicação de até 34% na maior dose aplicada, o flumioxazin proporcionou seletividade à cultura do trigo por não interferir nas demais variáveis avaliadas, principalmente na produtividade de grãos.
Palavras-chaves: doses; herbicida; produtividade; *Triticum aestivum*

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Introduction

Weed management in the wheat crop during the critical period of interference prevention is fundamental, because without controlling weeds, the growth and development of the crop may be affected, mainly by the competition for water, light and nutrients, reducing grain productivity (Cenci et al., 2013). Wheat grain productivity was reduced by 37.5% by the interference of weeds during the whole crop cycle, with a prevalence of the *Raphanus raphanistrum* species, also causing reductions in the number of reproductive tillers per plant, in the ear length, in the number of spicules per wheat ear and in the plant height (Silva et al., 2016).

The chemical control of weeds in the wheat crop is widely used for its convenience, higher operation yield and effectiveness over extensive areas. However, there are few registered active ingredients for post-emergence application on wheat crop (MAPA, 2017). Therefore, flumioxazin may be an interesting alternative to control weeds in wheat in this application modality.

Flumioxazin is registered for applications in weed pre- and post-emergence in the soybean, pinus and eucalyptus crop; in post-emergence in cotton, coffee, citrus, bean and maize crops; and in weed pre-emergence in onion, garlic, potato and sugarcane crops; it is effective in controlling dicots and some monocots (MAPA, 2017). This herbicide presents reduced leaching (Alister et al., 2008), half-life between 12.9 and 17.9 days (Ferrell and Vencill, 2003), effective control of weeds that are resistant to ALS- and triazine-inhibitor herbicides (Taylor-Lovell et al., 2001) and high adsorption to soil colloids (Ferrell et al., 2005), which allows its use in dry, semi-humid and humid seasons of the year, with low risk of environmental impact. It is a product with a contact action and action mechanism based on the inhibition of the PROTOX enzyme (Matsumoto, 2002).

Over the last three decades, the effectiveness in controlling weeds in the main crops with agronomic importance in Brazil has progressed due to the selectivity of herbicides to the crops (Hartwig et al., 2008), which is a measure of the different responses of crop and weed tolerance to an herbicide treatment (Oliveira Jr. e Inoue, 2011). Some factors, such as application period, dose, phenological stage of the crop, environmental conditions, position of the product in relation to the crop seeds or genetic tolerance of the species may interfere in the selectivity to the different herbicides (Oliveira Jr. and Inoue, 2011). Studies highlighted that flumioxazin selectivity to peanut (*Arachis hypogaea* L.) (Grichar et al., 2013), to sorghum (*Sorghum bicolor* L. Moench) (Grichar, 2006), both in applications in pre-emergence of the crop, and to sunflower (*Helianthus annuus* L.) in post-emergence of the crop (Jursík et al., 2011).

In literature, there were no reports on flumioxazin application to control weeds in the wheat crop. Flumioxazin selectivity to wheat would allow the use extension of the product to the crop and would increase herbicide options for the rotation and management of weeds in post-emergence. Due to the scarceness of registered products for the crop, the goal of this work was to evaluate the selectivity of the flumioxazin herbicide to wheat, applied in post-emergence.

Material and Methods

The experiment was conducted on the field, succeeding the cultivation of potato, in an experimental area located in the city of Rio Paranaíba - Minas Gerais state, whose coordinates are 19°12’21”S and 46°10’05”O, with an altitude of 1140 m. The climate, according to the international Köppen classification is Aw type, defined as tropical with dry season. The soil is classified as Red-Yellow Latosol, with a very clayey texture.

The sowing of the Sintonia cultivar was performed by broad casting, with a density of 330 seeds m^{-2} on day 05/29/2015. There was no fertilizing, since it was a fertile area that received consistent fertilizations during the previous cultivation. In the top-dressing, 250 kg ha^{-1} of the NPK 23-00-18 formula were applied. When plants were about 25-35 cm tall, there was an application of ethyl-trinexapac (Moddus®, CE, 250 g L^{-1} de a.i., Syngenta) in the dose of 0.5 L ha^{-1}.

The used experimental design was the randomized block one with four replications. Treatments were applied on stage V3 of the wheat crop, 11 days after sowing (DAS) and consisted in six flumioxazin doses (Flumyzin 500, WP, 500 g kg^{-1} a.i., Sumitomo Chemical Co. Ltda): 0, 10, 20, 30, 40, 50 g ha^{-1}. Plots were 2.0 m wide and 12 m long, making up 24 m^2. The usable area of plots consisted in four central meters, disregarding 0.5 m on the sides and four meters from each edge, totalizing 4 m².

Treatment applications were performed with a CO_2 pressurized backpack sprayer, equipped with a 1.5 m bar containing three spraying 110.02 "fan" nozzles (0.5 m between them), working pressure of 2 bar, providing an application volume equivalent to 200 L ha^{-1}, at 50 cm from the target.

The irrigation management was performed via central pivot, according to the water need of the crop for the Alto Paranaíba region. The management of pests and diseases was performed according to the recommendations for the irrigated wheat crop (Fornasieri Filho, 2008).

Evaluations of the SPAD index (Soil Plant Analysis Development) were performed on 15, 21, 28 and 35 days after application (DAA), among which the first three evaluations were standardized to be performed on the third fully expanded leaf of the crop, counted from top to base, and the fourth evaluation occurred on the flag leaf. Plant intoxication and weed control were evaluated in the same periods. The SPAD index was measured with a portable chlorophyll meter (CFL1030 model, FALKER®) and the visual evaluations of the intoxication symptoms of wheat plants was based on a scale where 0% did not indicate injuries and 100% represented plant death, according to the methodology proposed by SBCPD (1995).

The mechanized harvest of the crop in each plot was performed on 09/15/2015, 109 DAS, harvesting the usable area of each plot. Plants were tracked to determine the one thousand grain weight, the hectoliter weight and the grain productivity, subsequently corrected to 13% moisture.

The hectoliter weight was obtained with a hectoliter scale with one-liter capacity, in duplicate, and the results were expressed in kg hL^{-1}, according to the methodology described in the Rules for Seed Analysis (BRASIL, 2009). The one thousand grain weight was obtained by manually counting eight replications of one hundred grains, weighed on an analytical scale and converted to one thousand grains (BRASIL, 2009).

Data were submitted to analysis of variance ($P<0.05$). When the doses effect was significant, the regression analysis was performed. The choice of the model was based on the significance of the regression coefficients, in the biological phenomenon and in the determination coefficient.

Results and Discussion

Flumioxazin affected the SPAD index of wheat leaves, which was reduced by the increase of herbicide doses in all evaluation periods (Figure 1A). This is due to the action mechanism of the herbicide, inhibiting the PROTOX enzyme, which acts on the biosynthesis of chlorophyll. This herbicide causes the accumulation of protoporphyrin IX which, with light and molecular oxygen, generates reactive species of oxygen, responsible for the destruction of cell membranes, causing desiccation and necrosis of the tissues (Matsumoto, 2002).

The SPAD index is a technique that analyzes, in real time, the intensity of leaf green, which presents a significant correlation with the chlorophyll content (Marquard and Tipton, 1987). In addition, this index has been used in various researches as an additional tool to evaluate the intoxications caused by herbicides (Brighenti, 2012; Arantes et al., 2013; França et al., 2016). Thus, the increase in flumioxazin doses promoted higher intensity of necrosis symptoms of the foliar tissue, which caused a reduction in the green intensity on leaves in all evaluation periods (Figure 1A). Moreover, since flumioxazin is basically a contact product, with the growth of the plant new leaves without symptoms were launched, reducing proportionally the area affected by the herbicide.

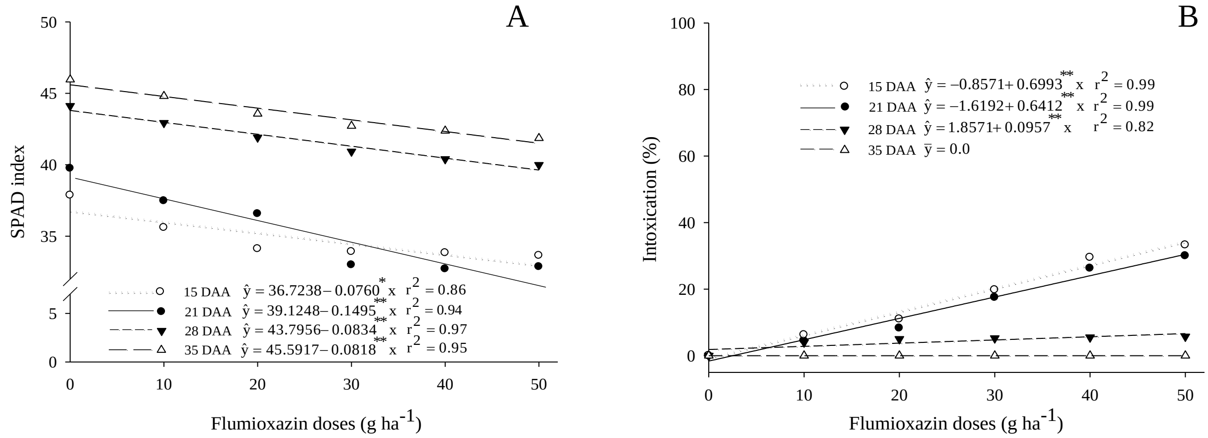

Figure 1. SPAD index (A) and Intoxication (B) of wheat plants according to the application of growing doses of flumioxazin in post-emergence. Rio Paranaíba (MG), 2015.

The intoxication of the crop by the herbicide was reduced over time (Figure 1B). On day 15 and 21, the intoxication increased linearly with the increase of the doses, reaching a maximum of 34.11 and 30.4%, respectively. Inoue et al. (2014) reported that starting from day 14 DAA, the doses of oxyfluorfen and flumioxazin caused low intoxication in the physic nut crop. Symptoms of intoxication were also evaluated on eucalyptus plants when treated with flumioxazin + sulfentrazone, in the doses of 100 + 500 g ha^{-1}, with an intoxication of 71.25% until day 15 DAA; however, on day 30 DAA, the intoxication level decreased to 10% (Tibúrcio et al., 2012). Júrisk et al. (2011) observed, one week after the application, intoxication varying from 17 to 24% caused by flumioxazin (30 g ha^{-1}) in sunflower plants, with a progressive reduction after two and three weeks (less than 10%). In this work, as time went by, the intoxication caused by the action of flumioxazin also decreased, due to the recovery of plants, as it is possible to observe in the evaluations performed on day 28 and 35 DAA (Figure 1B). In addition to the low intoxication level in wheat, weed control on the area was effective, remaining above 95% regardless of the evaluation period (data not presented), because of the quick soil covering provided by the used seed density and the broad casting.

One of the great influence variables used in the classification and commercialization of wheat is the hectoliter weight, since the higher the weight, the higher the income given to flour and, later, the better the quality given to the product (Ormond et al., 2013). In this work, the hectoliter weight of wheat was not changed, remaining with a constant value of 81.787 kg hL^{-1}, in spite of the growing doses of flumioxazin (Figure 2). In other crops, the application of herbicides did not change the hectoliter weight as well; therefore, it did not affect the quality of the grains, as for example, in the crops of grain sorghum with the application of the herbicides triazine and chloroacetanilide (Martins et al., 2006) and of white oats with the application of metsulfuron and bentazon (Cargnin et al., 2006).

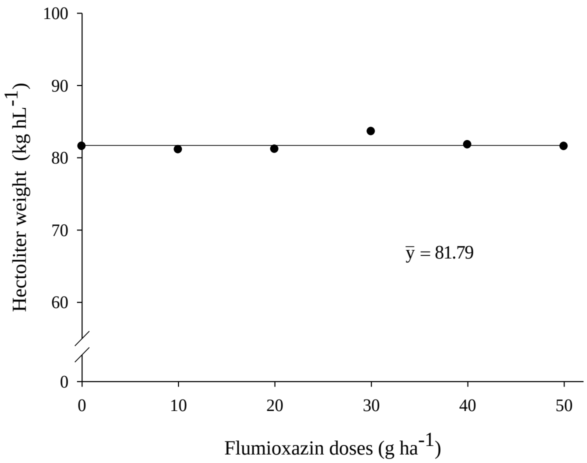

Figure 2. Hectoliter weight of wheat grains according to the application of growing doses of flumioxazin in post-emergence. Rio Paranaíba (MG), 2015.

The one thousand grain weight was not changed by the increase in flumioxazin doses, maintaining the average of 6.76 g (Figure 3). The same behavior was verified in the mung bean (Vigna Radiata) crop submitted to the application of flumioxazin at the 52.5 g ha^{-1} dose, during the period of summer-fall (Fontes et al., 2001).

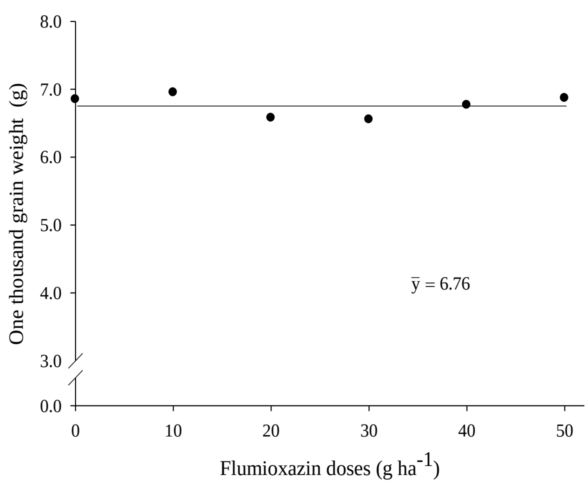

Figure 3. One thousand grain weight according to the application of growing doses of flumioxazin in post-emergence. Rio Paranaíba (MG), 2015.

The application of herbicides in post-emergence on the wheat crop, such as metsulfuron-methyl + clodinafop propargil (2.4 + 36 g ha^{-1} a.i.), 2.4-D + clodinafop propargil (806 + 36 g ha^{-1} a.i.) and iodosulfuron-methyl (5 g ha^{-1} a.i.) also did not cause a decrease in the discussed variable (Paula et al., 2011). In spite of causing a slight injury on the leaves, the weight of sunflower seeds from the cultivars Heliaroc and Alexandra was not affected by the application of 30 g ha^{-1} of flumioxazin in port-emergence (Jurísk et al., 2011).

As for the wheat productivity, no significant difference was observed among the tested doses (Figure 4), presenting an average of 5.3 t ha^{-1}, regardless of the applied dose. A similar behavior occurred for the soybean crop, where the application of flumioxazin at the dose of 25 g ha^{-1} did not change the height of plants, the accumulation of dry matter of the aerial part, the number of grains per pod and the grain productivity per plant (Correia et al., 2008).

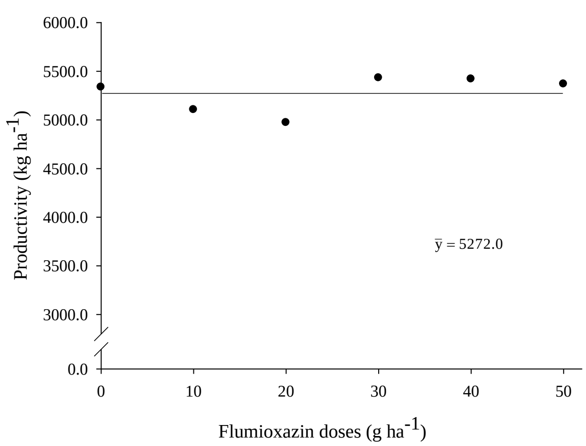

Figure 4. Wheat productivity according to the application of growing doses of flumioxazin in post-emergence. Rio Paranaíba (MG), 2015.

In the pearl millet crop, the application of 50 g ha^{-1} of flumioxazin was not able to change the height of plants or the grain yield of the crop (Dan et al., 2011). Four peanut cultivars did not have their productivity changed by the application of flumioxazin in pre-emergence at doses of 53, 107 and 214 g ha^{-1} (Grichar et al., 2013).

The tolerance of cotton to flumioxazin applied in post-emergence was observed and related with the absorption, translocations and differential metabolism of the product on the plant (Price et al., 2004). In addition to these selectivity mechanisms, wheat's response to the herbicide may be involved with the super-expression of the PROTOX enzyme or the compartmentalization of the molecule, which must be investigated. The results found in the present work demonstrate that, in spite of the changes in the SPAD index and the presence of visual leaf intoxication symptoms (<34%), the herbicide did not affect the other variables in the crop, which highlights the selectivity of flumioxazin to wheat.

Conclusions

Flumioxazin presents usage potential in post-emergence on the wheat crop.

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