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Toxicity by metsulfuron-methyl in the establishment of the soybean crop submitted to seed treatment

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Palavras-chave

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Keywords
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Resumo
Different management strategies and products can be adopted for weed control and seed treatment. This study evaluated the effect of metsulfuron-methyl application on the establishment of soybean (*Glycine max Merril. L*) at two herbicide application times and in response to micronutrient and amino acid seed treatment. The soybean seeds, cultivar Nidera 5909, were submitted to the following treatments: control (without treatment); amino acid; micronutrient 1 (a product containing amino acids from seaweed, cobalt, and molybdenum) and micronutrient 2 (a product containing amino acids from seaweed). The sowing periods occurred 15 days after the herbicide application or immediately after its application. We evaluated the emergence of seedlings at seven and 14 days after sowing (DAS), and the dry matters of roots and shoots at 14 and 21 DAS. The metsulfuron-methyl affected the seedling emergence at seven days after the sowing in seed treated with micronutrient 1 immediately after the herbicide application. At 21 DAS, a reduction in the dry mass of seedling roots was observed, which sowing occurred immediately after the application of the herbicide. The application of metsulfuron-methyl at sowing may damage the establishment and performance of soybean seedlings. Therefore, it is important to carry out sowing respecting the period of carryover effects from the herbicide, in order to prevent phytotoxicity symptoms to the soybean crop.

Toxidez por metsulfurom-metílico no estabelecimento da cultura da soja submetida ao tratamento de sementes
Diferentes estratégias de manejo e produtos podem ser utilizadas para o controle de plantas daninhas e o tratamento de sementes. Este trabalho avaliou o efeito da aplicação de metsulfurom-metílico no estabelecimento da cultura da soja (--), em duas épocas de aplicação do herbicida e em resposta ao tratamento de sementes com micronutrientes e aminoácidos. As sementes de soja, cultivar Nidera 5909, foram submetidas aos seguintes tratamentos: testemunha (sem tratamento); aminoácido (Amino Seed Raiz); micronutriente 1 (produto contendo aminoácidos de algas marinhas, cobalto e molibdênio) e micronutriente 2 (produto contendo aminoácidos de algas marinhas). A semeadura ocorreu 15 dias após a aplicação do herbicida e imediatamente após a sua aplicação. Nós avaliamos a emergência de plântulas aos sete e 14 dias após a semeadura (DAS); e a matéria seca de raiz e parte aérea, aos 14 e aos 21 DAS. O metsulfurom-metílico afetou a emergência das plântulas aos sete dias após a semeadura em sementes tratadas com micronutriente 1 e semeadas imediatamente após a aplicação do herbicida. Aos 21 DAS, observou-se redução na massa seca de raízes das plântulas, cuja semeadura ocorreu imediatamente após a aplicação do herbicida. A aplicação de metsulfuron-metil na semeadura pode prejudicar o estabelecimento e o desempenho de plântulas de soja. Nesse sentido, é importante realizar a semeadura respeitando o período do efeito residual do herbicida, a fim de prevenir sintomas de fitotoxicidade na cultura da soja.

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Introduction

The soybean crop has undoubted economic importance in Brazil, being the main agricultural product exported. In order to achieve high yield, different product technologies have been used to increase soybean yield. Among the various factors that affect crop performance, weed competition has been reported as one of the factors that can significantly reduce grain yield (SILVA et al., 2009). Depending on the weed infestation, the interference in the reduction of grain yield can vary from 73% to 92.5% (SILVA et al., 2009). This influence of weed on yield, associated with the soybean cultivation area, estimated at 32,2 million hectares in 2015; point to the soybean culture as the largest consumer of pesticides in Brazil (570,060,129.90 liters of pesticides), with emphasis on the herbicides Ggyphosate, 2,4-D, and atrazine (PIGNATI et al., 2017).

In addition to the excessive use of herbicides, successive applications of herbicides with the same mechanisms of action have caused weed resistance (RIZZARDI; SILVA, 2014). The main cases of resistance are related to soybean culture and the mechanism of action of inhibiting the enzyme acetolactate synthase ALS (CRUZ et al., 2020). Among the weeds, Conyza spp. has been reported as an important resistant weed (CRUZ et al., 2020). In wheat, one of the strategies for their control is the association of metsulfuron-methyl with glyphosate, either pre-sowing, or post-emergence at any stage of the crop, with a 30-day grace period (AGOSTINETTO, 2015). The use of metsulfuron-methyl has also been reported for white oat and ryegrass in winter pastures (DALAZEN; CRUZE; MACHADO, 2015), and in pre-sowing of soybeans to control the Conyza bonariensis resistant to the glyphosate (PAULA et al., 2011).

The application of the metsulfuron-methyl herbicide in winter crops should be carried out at least 60 days before soybean sowing, due to the low decomposition of the active ingredient in dry and low-temperature environments (VARGAS; GAZZIERO, 2009). In this sense, when the period between herbicide application and soybean sowing is disregarded, toxicity symptoms can be observed in soybeans plants in succession. In soybean, necrosis (brownish colour) of the node that connects the leaf petiole to the stem occurs, followed by the appearance of brown colour in the marrow and the death of the apical buds, along with the shoots of the lateral buds and the inhibition of root growth (BIANCHI, 2009). These symptoms occur due to the inhibition of the enzyme acetoacetate synthase (ALS), responsible for the synthesis of three branched-chain amino acids: valine, leucine, and isoleucine (AGROFIT, 2019; SILVA; SILVA, 2007).

In addition to weed control strategies, soybean management also includes seed treatment. Fungicides, insecticides and polymers (DECARLI et al., 2019) are commonly applied to seeds. Besides these, micronutrients (SFREDO; OLIVEIRA, 2010) and amino acids (TEIXEIRA et al., 2017) may be applied to improve crop performance. Thus, this study analyzed the effect of metsulfuron-methyl application on the establishment of soybean crops (*Glycine max Merrill L.*), for two herbicide application times and in response to micronutrient and amino acid seed treatment.

Material and methods

The study was conducted at the experimental area of the Instituto Federal de Ciência e Tecnologia do Rio Grande do Sul, Campus Ibirubá, during the period from May to June 2013. The experimental design used was a factorial scheme (4 seed treatments × 2 periods of herbicide application), with four repetitions in randomized blocks. Soybean seeds (cultivar Nidera 5909) were submitted to the following seed treatments: control (without treatment), amino acids (Amino Seed Raiz), and micronutrient 1 (a product containing amino acids from seaweeds and Cobalt and Molybdenum) and micronutrient 2 (a product containing amino acids from seaweeds). Doses of 1.2 mL kg^{-1} of the commercial products were applied on the seed through a water syrup. The seeds were sown in two conditions: (1) fifteen days after the application of herbicide and (2) immediately after the application of the herbicide. The dose of herbicide (metsulfuron-methyl) applied on soil was equivalent to 4 g ha^{-1}, and in proportion to the area of pots. After sowing, the experiment was inspected daily, and the pots irrigated two to three times a week, according to the soybean requirement.

Experimental units were composed of plastic pots, 30 cm in diameter and approximately 20 cm in height. Pots were filled with soil–Oxisol (SOIL SURVEY STAFF, 2014), characterized by being in the layer of 0–10 cm and with pH 5.7, 6.6 $cmol_c$ dm^{-3} Ca, 1.7 $cmol_c$ dm^{-3} Mg, 68.2 mg dm^{-3} P-Melhich, 276 mg dm^{-3} K, 3% organic matter and 47% clay. In each pot, twenty-five soybean seeds were sown at 3 cm depth.

Seedling emergence was evaluated at seven and 14 days after sowing (DAS). For this evaluation, we counted the seedlings with cotyledons 2 cm above the level of the soil. At 14 and 21 DAS, we collected among 10-13 and ten seedlings, respectively, for the determination of root and shoot dry mass. The seedlings were washed and placed in a forced circulation air oven at a temperature of 65.5°C until reaching a constant weight. The dry mass of seedlings was express in grams per seedling.

Analysis of variance was performed to verify the significance of the treatments and times of herbicide application. When significant, means were compared by the Tukey test (5%), with the ExpDes.pt package in R (FERREIRA; CAVALCANTI; NOGUEIRA, 2013).

Results and discussion

The metsulfuron-methyl affected the emergence of seedlings seven days after the sowing (DAS) in seed treated with micronutrient 1 immediately after the herbicide application (p = 0.00625). Control seeds also presented a decrease in seedling emergence immediately after the herbicide application; however, no difference was observed between the metsulfuron-methyl applications fifteen days prior to the sowing. Subsequently, at 14 DAS, seed treatment and herbicide application did not affect the seedling emergence (Table 1).

Table 1- Emergence of soybean seedlings, at seven and 14 days after sowing (DAS), at two times of application of metsulfuron-methyl and in response to the treatment of seeds with micronutrients and amino acids.

Seed treatment	7 DAS		14 DAS	
	Herbicide application			
	15 days pre-sowing	Sowing	15 days pre-sowing	Sowing
Control	7.5 Aa	4.2 Aab	22.8 ^{ns}	23.5 ^{ns}
Amino acid	4.2 Aa	8.2 Aa	22.5	24.2
Micronutrient 1	9.5 Aa	1.2 Bb	23.2	24.5
Micronutrient 2	6.0 Aa	9.0 Aa	23.5	23.3
CV (%)	53.92		7.59	

^{ns} No significant effect .

Means followed by the same lowercase letter in the column and upper case in the row did not differ by the Tukey test (p< 0.05).

Source: Prepared by the authors, 2020.

The low seedling emergence at seven DAS occurred in seed treated with micronutrient containing amino acids from seaweeds, Co, and Mo. Despite the importance of cobalt to the symbiotic fixation process (MARCONDES; CAIRES, 2005), and the molybdenum in biochemical reactions, as a cofactor of enzymes (SFREDO; OLIVEIRA, 2010), Co and Mo may have caused the decrease of seedling emergence. Besides the association with the herbicide application, the micronutrient may have been toxic. Studies showed that the application of 3.4 g ha^{-1} of Co on seed decreased the grain yield by 5%, and the application of Mo did not affect the number and mass of nodules, the dry mass of the aerial part, the plant height, and some yield components (MARCONDES; CAIRES, 2005). Moreover, Dörr et al. (2018) showed that the seed treatment with amino acid did not have a positive effect on seed germination and seedling length, and increasing doses of amino acids may have a negative effect on soybean seed vigor. On the other hand, the use of amino acids via seed treatment associated with the foliar application can prevent undesirable effects (yellow flashing) of herbicide, as glyphosate on glyphosate-resistant (GR) soybeans (ZOBIOLE et al., 2010).

There was no significant influence of seed treatment on root and shoot dry mass (Table 2). The herbicide metsulfuron-methyl negatively affected the dry mass of roots in seedlings sowed immediately after its application ($p = 0.03065$), as was also observed for seedling emergence at seven DAS. The dry mass of roots decreased approximately 21% in the sowing immediately after the herbicide application. Among the symptoms caused by metsulfuron-methyl, the inhibition of cell division and elongation of the roots and young leaf cells have been reported soon after application of the herbicide (BIANCHI, 2009). This effect could be observed at 21 DAS when the dry mass of roots was reduced because of the herbicide application (Figure 1). Santos et al. (2009) also observed a negative effect of the herbicide metsulfuron-methyl on the dry mass of roots and aerial part of corn hybrids, mainly when the sowing was carried out on the same day of the herbicide application. However, at 30, 60, and 90 days after the application, the effect of the herbicide, applied in doses of 3.6 g.ha^{-1} and 7.2 g.ha^{-1} decreased (Santos et al., 2009), but not entirely due to the herbicide half-life, which varies from 30 to 120 days (ZANINI et al., 2009).

Table 2 - Shoot and root dry mass of soybean seedlings, at 14 and 21 days after sowing (DAS), at two times of application of metsulfuron-methyl and in response to the treatment of seeds with micronutrients and amino acids.

Treatment	Shoot dry mass (g $plant^{-1}$)		Root dry mass (g $plant^{-1}$)	
	14 DAS	21DAS	14 DAS	21 DAS
		Seed treatment		
Control	0.0329 ns	0.0578 ns	0.0134 ns	0.0353 ns
Amino acid	0.0407	0.0758	0.0136	0.0358
Micronutrient 1	0.0403	0.0575	0.0144	0.0344
Micronutrient 2	0.0314	0.0566	0.0131	0.0381
		Herbicide application		
15 days pre-sowing	0.0364 ns	0.0671 ns	0.0142 ns	0.0398 a
Sowing	0.0379	0.0567	0.0131	0.0316 b
CV (%)	22.82	37.29	15.34	28.18

ns No significant effect .

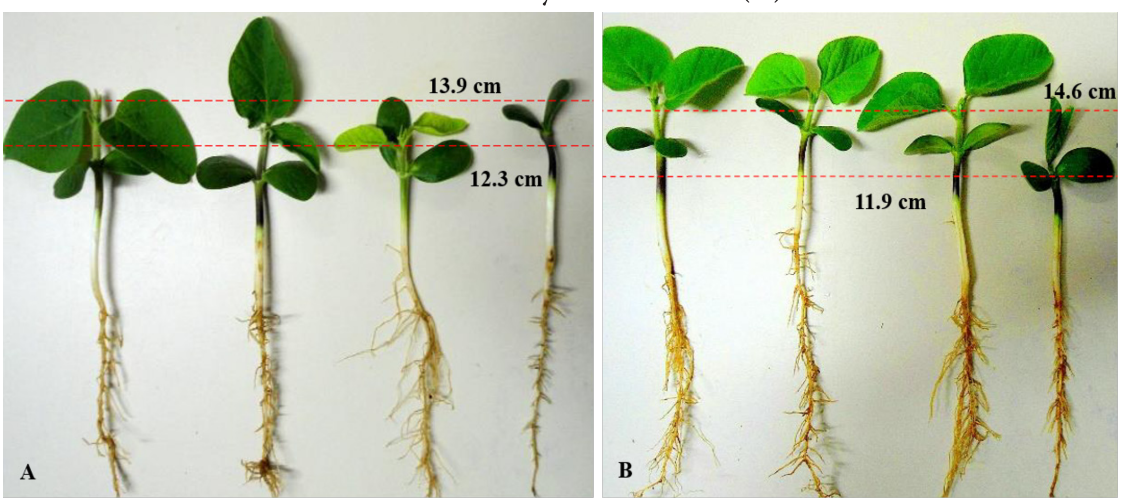
Means followed by the same letters in the column do not differ significantly by the Tukey test ($p < 0.05$).

Source: Prepared by the authors, 2020.

The phytotoxicity of metsulfuron-methyl herbicide depends on the soil properties (SILVA; SILVA, 2007) and the period between its application and the sowing. This herbicide has lower adsorption on clay and higher adsorption in organic matter (VENCILL, 2002), and residues of metsulfuron-methyl bound previously to the soil matrix may be again released and cause damage to rotation or substitution crops (YE; SUN; WUB, 2003). Thus, in soils with adequate water availability and microbial degradation, the higher leaching potential reduces the persistence of herbicides in soil (CARVALHO et al., 2015). The herbicide degradation rate can be accelerated with high temperatures, and its mobility can be increased at pH values of more than six (BIANCHI, 2009; EUROPEAN FOOD SAFETY AUTHORITY, 2015).

The herbicide metsulfuron-methyl, from the chemical group of sulfonylureas, is used in the control of the pre-emergence and post-emergence of dicot weeds (broad leaves). With systemic action, it is rapidly absorbed through the leaves and roots, with translocation throughout the plant. It is selective and recommended for crops of irrigated rice, rice, white oats, black oats, coffee, sugar cane, barley, wheat, and triticale (AGROFIT, 2019). This herbicide has not registered for use in soybean crops, due to phytotoxicity; and for this reason, it has shown effectiveness in controlling soybean volunteer plants (LIMA et al., 2011).

Figure 1- Soybean seedlings at 21 DAS. Seeds were treated with amino acids or micronutrients and sowing immediately after the application of the herbicide metsulfuron-methyl (A), and fifteen days after the application of herbicide (B). In this evaluation, sowing immediately after the application of the herbicide reduced the dry mass of roots (A).



Source: Prepared by Rotta (2020), and edited by the authors, 2020.

Conclusion

The application of metsulfuron-methyl at the sowing damages the establishment and performance of soybean seedlings. Thus, it is important to carry out sowing respecting the period of the carryover effect from the herbicide, in order to prevent phytotoxicity symptoms in the soybean crop.

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