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Residual Activity of 2,4-D Amine on Soybean Plant Development

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ABSTRACT

The objective of this research was to evaluate the residual effect of 2,4-D amine on the initial development of soybean plants after its application on the soil at different times before sowing. The experiment was conducted in a greenhouse during the months from April to June 2013, at State University of Mato Grosso do Sul. The experimental design was completely randomized, with four replications. The treatments consisted of eight application times of herbicide 2,4-D amine, seven (3, 6, 9, 12, 15, 18 and 21 days) before sowing, a treatment during sowing (0) and a control treatment (no herbicide application). The dose used was 1080 g i.a. ha^{-1}. It were evaluated he following variables: percentage of emergency, plant height, stem diameter, fresh mass of shoot, fresh mass of roots, dry mass of shoot, dry mass of roots, nodular activity and toxicity. The soybean sowing at time or three days after application of 2,4-D amine causes reduction in the crop development as a result of this residual effect of this herbicide and should occur at least six days after application of this herbicide.

Key words: *Glycine max* (L.) Merrill, herbicide, toxicity

INTRODUCTION

In recent years, large amounts of herbicides have been highlighted in obtaining high productivity by to be an effective and economically viable alternative (Inoue *et al*., 2011). In this way, it is common to use of broad-spectrum herbicides after the cultivation of off-season or in fallow areas for weed control. This operation is the basis of the crop success, because if properly conducted, will provide an efficient control of important weeds which may cause problems in the crop course, thus affecting productivity and product quality (Silva *et al*., 2011).

2,4-D amine (2,4-dichlorophenylacetic acid) is a growth regulator herbicide which has a similar effect to auxin hormone (Ashton and Crafts, 1973). Phenoxy compounds, being salts or esters of high molecular weight and low volatility, constitute it phenoxyacetic acid derivatives. When it applied in low doses cause effects in distant points where it reached the plant due to its translocation capacity (Rodrigues and Almeida, 2005; Procopio *et al*., 2009).

2,4-D amine is selective for narrow leaves of plants having greater toxicity to broadleaf species, widely used in no-tillage, especially in combination with other herbicides, like glyphosate, in weed desiccation before soybean sowing (Silva *et al*., 2011). This selectivity occurs by physiological mechanisms possibly because in dicotyledonous this synthetic auxin is not metabolized as quickly as the endogenous auxin, while monocotyledonous can quickly inactivate synthetic auxin by conjugation (Taiz and Zeiger, 2013).

The chemical structure of 2,4-D amine allows its molecules persist in the soil, leaving toxic residues or not to the successor crop (Inoue *et al*., 2011). This may be favorable

for providing residual control during desiccation for the soybean sowing, on the other hand may cause toxicity to the crop. However, this feature has caused concern to farmers who practice crop rotation, especially those who grow winter maize in succession to soybean. The persistence in soil of 2,4-D amine herbicide is considered short to medium, not exceeding four weeks residual period in clay soils and warm climate when applied in commercial dosages (Silva *et al*., 2011).

When the residual effect of the herbicides in the soil is determined by biological methods, using as an indicator a sensitive plant, the evaluation of the time of this product in activity is possible (Guevara, 1998). In addition to assessing its environmental impact, it is possible to estimate the time that can remain in the soil and affect sensitive crops, in a succession of crop rotation system or (Blanco *et al*., 2010). Thus, the aim of the study was to evaluate the residual effect of 2,4-D amine on the initial development of soybean plants after its application on the soil at different times before sowing.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse during the months from April to June 2013, at Universidade Estadual de Mato Grosso do Sul, localized in the municipality of Aquidauana, MS, transition region between Savanna (or Cerrado) and Pantanal biomes (20°28' S and 55°48' W) with an altitude of 170 m. The soil was classified as Ultisol dystrophic of sandy texture, with the following chemical features: pH (H_2O) = 4.3, OM (g dm^{-3}) = 1.0, P (mg dm^{-3}) = 0.0, Ca = 0.5 $cmol_c$ dm^{-3}, Mg = 0.4 $cmol_c$ dm^{-3}, K = 0.8 $cmol_c$ dm^{-3}, Al = 1.4 $cmol_c$ dm^{-3} and H+Al = 3.2 $cmol_c$ dm^{-3}.

The plastic greenhouse in arcs in which the trial was conducted, has galvanized steel structure with 6.40 m wide by 18.00 m in length, with a height under the gutter of 4.0 m. The cover is transparent polyethylene film 150 µm, thermal reflector screen 50% under the film with monofilament screen locks of 50%.

The experimental design was completely randomized, with four replications. The treatments consisted of eight application times of herbicide 2,4-D amine, seven (3, 6, 9, 12, 15, 18 and 21 days) before sowing, a treatment during sowing (0) and a control treatment (no herbicide application). The dose used was 1080 g i.a. ha^{-1}.

The trial was conducted in polyethylene pots with a capacity of 7 L. The soil used was sieved to eliminate stones and clods, being performed subsequently liming, with dolomitic limestone at a dose of 2,11 t ha^{-1}. The fertilization was performed with NPK fertilizer (02-20-20), calculated based on volume of soil used and the dose of 300 kg ha^{-1}.

The soybean cultivar used was BRS 317. At the time of sowing was carried out inoculation of the same with commercial product BioSoja, which has in its composition *Bradyrhizobium japonicum*. Dose used was doubled regarding to the recommended dose (200 mL) due the soil to be of first crop. It were sown five seeds per pot at a depth of 5 cm and subsequently carried out the controlled irrigation of 10 mm per pot.

The pulverization of the herbicide 2,4-D amine was done by a CO_2 pressurized backpack sprayer with spray flow rate of 200 L ha^{-1}. The spray bar was made up of four corners XR 11002 VS, spaced 0.5 m and positioned at 0.5 m in height relative to the soil surface of pots.

The residual activity of 2,4-D amine was measured every 2 days after emergence, using the following variables for evaluation: percentage of emergency (%), height (cm), collar diameter (mm), fresh mass of shoot (g), fresh mass of roots (g), dry mass of shoot (g), dry mass of roots (g), nodular activity and visual toxicity of soybean with scores from 0-5, wherein 0-corresponds to no symptoms of intoxication, 1-represents 1-25% symptom; 2-26 to 50%, 3-51 to 75%, 4-76 to 99% and 5-corresponds to death of the plant. For nodular activity was done counting the number of nodules present in the roots and the number of active nodules.

Data was submitted to analysis of variance and means compared by Tukey's test at 5% probability with statistical program Sisvar (Ferreira, 2011).

RESULTS AND DISCUSSION

Soybean plants were most affected at 0 Days Before Sowing (DBS) in all variables. There was a lower percentage of emergence when 2,4-D was applied at 0 and 3 DBS (Table 1). These results are in agreement with Silva *et al*. (2011), who when assessing the residual effect of different doses (502,5 and 1.005 g i.a. ha^{-1}) of 2,4 on the soil in six different application times (0, 3, 5, 7, 10 and 14 days before sowing), observed that the emergence of the plants was impaired when 2,4-D was applied on the largest studied dose (1.005 g i.a. ha^{-1}) at the time of sowing.

The toxicity of soybean was mainly observed at 0, 3 and 6 days before sowing, decreasing this number as it increased day of applying before sowing (Table 1). The visual symptoms of toxicity observed were wrinkled leaves and petioles epinasty. Such symptoms were also observed by Silva *et al*. (2011), Deuber and Novo (2006), Rodrigues and Almeida (2005), Constantin *et al*. (2000) and Guevara (1998) in their researches checking the residual activity of 2,4-D amine on the soil.

With increasing the interval between the application of 2,4-D amine and soybean seeding there was a decrease of symptoms of toxicity and this fact is of great interest because it reduces potential risk of environmental contamination and provides the area for sensitive crop sowing in a relatively short time. The results confirmed the recommendations made by Silva *et al*. (2011), Deuber and Novo (2006), Rodrigues and

Table 1: Emergence and toxicity of soybean plants depending on the days of application of 2,4-D amine on the soil

		Treatments (Days of application before sowing)							
Variables	Control	0	3	6	9	12	15	18	21
EM (%)	52^{ab}	4.0^{c}	36.0^{b}	68.0^{a}	68.0^{a}	72.0^{a}	72.0^{a}	64.0^{a}	80.0^{a}
TX (%)	0^{c}	48.0^{a}	44.6^{a}	16.0^{ab}	2.0^{b}	4.0^{b}	6.0^{b}	2.0^{b}	0.0^{c}

Equal lowercase letters on the line do not differ statistically by the Tukey's test at 5% probability, EM: Emergence, TX: Toxicity

Table 2: Height and collar diameter of soybean plants at 30 days after emergence depending on the days of application of 2,4-D amine on the soil

		Treatments (Days of application before sowing)							
Variables	Control	0	3	6	9	12	15	18	21
PH (cm)	15.91^{a}	2.5^{c}	7.6^{b}	15.1^{a}	14.9^{a}	16.1^{a}	16.0^{a}	17.1^{a}	16.4^{a}
CD (mm)	3.32^{ab}	0.7^{c}	2.3^{b}	3.6^{a}	3.5^{ab}	3.4^{ab}	3.5^{a}	3.9^{a}	3.6^{a}

Equal lowercase letters on the line do not differ statistically by the Tukey's test at 5% probability, PH: Plant height, CD: Collar diameter

Table 3: Fresh and dry mass of shoot and roots of plants depending on the days of application of 2, 4-D amine on the soil for soybean crop implantation

		Treatments (Days of application before sowing)							
Variables	Control	0	3	6	9	12	15	18	21
Roots									
FM (g)	15.9^{b}	0.7^{d}	5.64^{c}	14.9^{b}	14.9^{b}	16.4^{ab}	15.0^{ab}	14.0^{b}	18.5^{a}
DM (g)	1.6^{ab}	0.1^{c}	0.62^{c}	1.2^{bc}	1.8^{ab}	1.7^{ab}	1.4 b^{c}	1.4^{abc}	2.6^{a}
Shoot									
FM (g)	6.7^{a}	0.4^{c}	2.6^{b}	8.2^{a}	6.1^{a}	8.0^{a}	7.7^{a}	8.2^{a}	8.2^{a}
DM (g)	1.4^{b}	0.1^{d}	0.5^{c}	1.7^{a}	1.4^{b}	1.7^{a}	1.7^{a}	1.8^{a}	1.8^{a}

Equal lowercase letters on the line do not differ statistically by the Tukey's test at 5% probability, FM: Fresh mass, DM: Dry mass

Table 4: Number of nodules present in soybean roots and number of active nodules depending on the days of application of 2,4-D amine on the soil for soybean crop implantation

		Tratamentos (Days of application before sowing)							
Variables	Control	0	3	6	9	12	15	18	21
NN	5.8^{ab}	0.4^{c}	4.0^{b}	6.8^{ab}	8.2^{a}	9.2^{a}	3.8^{ab}	6.4^{ab}	7.0^{ab}
NAN	5.8^{ab}	0.4^{c}	2.6^{b}	6.8^{ab}	8.0^{a}	9.0^{a}	3.6^{ab}	6.4^{ab}	7.4^{ab}

Equal lowercase letters on the line do not differ statistically by the Tukey's test at 5% probability, NN: No. of nodules, NAN: No. of active nodules

Almeida (2005), Constantin *et al*. (2000), Guevara (1998), Flury *et al*. (1995), Morre *et al*. (1984) and Scheel and Sandermann Jr. (1981) for the use of 2,4-D amine in no-till system and must be expected at least 10 days between application and soybean seeding.

Application of 2,4-D at 0 and 3 DBS significantly reduced the height and collar diameter of soybean plants (Table 2). Silva *et al*. (2011) evaluating the same active ingredient, also found the same effects obtained in this study with residual effect up to 3 DBS to soybean. These results indicate that desiccation with 2,4-D, held over a period of at least six days before sowing, will not present residual effect on the size and collar diameter of soybean plants.

Application of 2,4-D amine near to soybean sowing (0 and 3 DBS) caused the lower values of fresh and dry mass of roots and fresh and dry mass of shoot (Table 3). At the other extreme, the application at 21 DBS caused the greatest values of these variables, possibly by effective weed control. According to Rodrigues and Almeida (2005), Constantin *et al*. (2000), Guevara (1998), Flury *et al*. (1995), Morre *et al*. (1984) and Scheel and Sandermann Jr. (1981) 2,4-D amine applied near sowing of broad-leaved causes drastic cambium strangulation due to inhibition of the main branch elongation, which results in decreased growth.

Similarly to other variables, the number of nodules present in soybean roots and the number of active nodules were smaller when the application of 2,4-D amine was near sowing (0 and 3 DBS) (Table 4). With soybean seeding as from 6 days after application of 2,4-D amine there is no reduction of these variables and the highest values were observed at 9 and 12 DBS.

These results are in agreement with Deuber and Novo (2006), who evaluated the possible effects of diclosulam and flumetsulam herbicides on the development and nodulation of soybean IAC-19 and noted that the number of nodules on the roots is reduced when the application of herbicides on the soil is carried out near the sowing.

CONCLUSION

The soybean sowing at time or three days after application of 2,4-D amine causes reduction in the crop development as a

result of this residual effect of this herbicide and should occur at least six days after application of this herbicide.

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