Original Article

SELECTIVITY OF HERBICIDES IN NATIVE FOREST SPECIES OF CERRADO

SELETIVIDADE DE HERBICIDAS EM ESPÉCIES FLORESTAIS NATIVAS DO CERRADO

Deisy Micaelli Sousa Santos POLINI[1]; Cristiane Gonçalves MENDOÇA[1]; Paulo Eduardo TEODORO[2*]

1. Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Aquidauana, Aquidauana, MS, Brazil;
2. Universidade Federal de Mato Grosso do Sul, Campus de Chapadão do Sul, Chapadão do Sul, Ms, Brazil. eduteodoro@hotmail.com

ABSTRACT: A aggravating problems in forest management is weed interference, which is a factor that modifies adaptation and reduces plant growth. The use of herbicides is an indispensable practice to mitigate these effects in reforestation areas. This study aimed to evaluate the selectivity of glyphosate and imazapyr in native plants of the Brazilian Cerrado, such as: *Schinus terebinthifolia* (Anacardiaceae), *Peltophorum dubium* (Fabaceae) and *Handroanthus albus* (Bignoniaceae). The trial was carried out in a greenhouse at Unit of Aquidauana/UEMS. Experimental design was completely randomized, with seven treatments and five replications. Selectivity of the herbicides in the seedlings of these species was evaluated at 7, 14, 21, 28 and 60 days after application (DAA) of the herbicides, by means of a percentage scale of notes, where 0% corresponds to no injury and 100% corresponds to plant death. At the same time, for the weed control evaluation, visual analysis was also performed at 7, 14, 21, 28 and 60 DAA of the herbicides, where 100% was considered plant death and 0% no injury to weed. Imazapyr herbicide, when applied in the initial post-emergence in its lower level, it is selective to the tree species, but in the other concentrations it can affect differently the survival of them. Glyphosate herbicide was the least selective to the tree species in its different concentrations, causing phytotoxic effects with changes in the seedlings morphology. The results of this study could help in the integrated management of weeds and contribute to the efficient herbicide use in planting forest species in the Cerrado.

KEYWORDS: *Schinus terebinthifolia*. *Peltophorum dubium*. *Handroanthus albus*. Imazapyr. Glyphosate.

INTRODUCTION

Cerrado is considered one of the most extensive biomes of Brazil, with around 200 million hectares, mostly concentrated in the Midwest (KLINK; MACHADO, 2005). It is present in 15 states and in the Federal District, having a great diversity of phyto-physiognomic forms. The vegetation is characterized by sparse trees of small to medium size and tortuosity in their stems (EITEN, 2001; MARIMON JUNIOR; HARIDASAN, 2005). It is present in 15 states and in the Federal District, having a great diversity of phyto-physiognomic forms. The vegetation is characterized by sparse trees of small to medium size and tortuosity in their stems (FELFILII et al. 2002).

Natural regeneration of sub-forests is closely dependent on the establishment of native species for conservation purposes. Therefore, the importance of natural regeneration studies as a way of facilitating the recovery of the forest cover is evident (REZENDE et al., 1994). One of the aggravating problems in the forest management is the weeds interference due to the reduction in the adaptation and growth of the plants (CHRISTOFFOLETI; NICOLAI, 2016). In this sense, the use of herbicides is an indispensable practice to mitigate these effects (SILVA et al., 2000). The most used method for weed control is herbicide selectivity, which represents a differential response of several plant species to a given herbicide (OLIVEIRA JUNIOR et al., 2011). The most used herbicides in reforestation areas with native species are the glyphosate and imazapyr (GONÇALVES et al., 2003).

However, the use of other active principles can prevent the emergence of resistant species, as well as to increase the farmer's options to choose the defensive to be used. Currently, herbicide selectivity trials on tree species are focused on Eucalyptus and Pinus crops as they are most used in reforestation areas (MONQUERO et al., 2011). Therefore, the need for researches on weed control in reforestation areas with native tree species is clear (DOUST et al., 2008; MACHADO et al., 2013). Thus, identifying herbicides selective to native species would allow the use of more practical methods for controlling invasive plants and would facilitate the use of these species in commercial plantations or agroforestry systems (BRANCALION et al., 2009).

Recently, several researches have been conducted with the aim of clarifying the chemical management practices of existing weeds in Cerrado

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(TEODORO et al., 2015; GILO et al., 2016; SANTO et al., 2017). Thus, this study aimed at assessing the selectivity of glyphosate and imazapyr in native seedlings present in Cerrado, such as *Schinus terebinthifolia* (Anacardiaceae), *Peltophorum dubium* (Fabaceae) and *Handroanthus albus* (Bignoniaceae).

MATERIAL AND METHODS

The trial was carried out in a greenhouse at State University of Mato Grosso do Sul, Unit of Aquidauana, in 2014 (20˚28'S, 55˚40'W and average altitude of 174 m). In this study, seedlings of *Schinus terebinthifolia* (Anacardiaceae), *Peltophorum dubium* (Fabaceae) and *Handroanthus albus* (Bignoniaceae) were used. Seedlings were collected in the region and conducted in plastic containers with a capacity of 400 mL.

Experimental plot consisted of a plant transplanted at the initial stage of development (20 cm to 30 cm in height) on Bioplant® substrate composed by coconut fiber and powder and pH between 6.0-6.5. For determining the control, we collected soil infested by weeds from areas with a history of infestation. This soil was placed in containers of 400 ml for the seeds from the bank seeds germinate and represent the weeds. The main species identified were: *Cyperus rotundus L., Commelina benglhalensis L., Acanthospermum australe*, *Bidens pilosa* L., *Pluchea sagittalis* (lam.) Cabrera (LORENZI, 2014).

We divided this study into 4 groups, each group corresponding to a native species of the Cerrado: Group I (*Schinus terebinthifolia*), Group II (*Peltophorum dubium*), Group III (*Handroanthus albus*) and Group IV (weeds), according to the species, so the seedlings were evaluated. In each group, a completely randomized design with five replications was used. The treatments used are shown in Table 1.

Table 1. Treatments used, levels and time of application. Aquidauana - MS, 2014.

Herbicide (active ingredient)	Levels (L p.c./ha)	Time of application
Imazapyr	1.0	Post emergency
Imazapyr	2.0	Post emergency
Imazapyr	4.0	Post emergency
Glyphosate	2.0	Post emergency directed
Glyphosate	4.0	Post emergency directed
Glyphosate	6.0	Post emergency directed
Control	---	---

Herbicides used were glyphosate (Nortox) and imazapyr (Garden Clean 2.5SC). For the application of herbicides in each group was used pressurized costal spray with CO_2, equipped with 6 spray nozzles TEEJET 110.02, with spray consumption of 200 L ha^{-1} in total area for imazapyr. The application of the glyphosate herbicide was directed and sought to reach only the weeds, avoiding contact of the product with the plant, which was protected with a plastic canvas in order to avoid any contact with herbicide. Average temperatures during the application were 28.1°C and 27.8°C, Wind speed 6.4 km/h and humidity 35%, which are considered appropriate for this operation. The seedlings were relocated back to the greenhouse after 24 hours of herbicide application.

The herbicides selectivity in the seedlings and evaluating weed control was evaluated by the percentage of intoxication on plants at 7, 14, 21, 28 and 60 days after application (DAA), using a percentage scale of notes in which 0% corresponds to no injury and 100% to plant death (ALAM, 1974).

Data were submitted to analysis of variance and comparison of means by the Tukey test at 5% of probability. The percentage of intoxication of plants variables were submitted to the $\sqrt{x}$ transformation. The analyzes were performed with Sisvar software (FERREIRA, 2011).

RESULTS AND DISCUSSION

The means of phytotoxicity at 7, 14, 21, 28 and 60 DAA of plants of *Schinus terebinthifolia* are shown in Table 2. Imazapyr herbicide at 4 L ha^{-1} caused greater visual damage in all assessment periods. The use of this treatment occurred from 14 DAA and resulted in the death of some plants at 21 DAA at the highest dose (Figure 1). With intoxications from 21-30, 31-40 and 41-50%, Tuffi-Santos et al. (2007) report that a reduction in the volume of timber of 18, 26 and 48%, respectively, may occur in eucalyptus. As for glyphosate, phytotoxicity levels were lower, differing from the study carried out by Duarte et al. (2006), who

verified high phytotoxicity levels from 21 DAA of application in *Myracrodruon urundeuva.*

Table 2. Phytotoxicity evaluation of imazapyr and glyphosate according to ALAM scale (1974) on *Schinus terebinthifolia (Anacardiaceae)* in different evaluation periods after application. Aquidauana-MS, 2014.

Treatment	7 DAA	14 DAA	21 DAA	28 DAA	60 DAA
Control	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
Imazapir1	22.00 ab	32.00 ab	39.00 ab	44.00 ab	41.00 b
Imazapir2	24.00 ab	31.00 ab	37.00 b	46.00 ab	51.00 b
Imazapir4	42.00 a	60.00 a	78.00 a	84.00 a	88.00 a
Glyphosate2	24.00 ab	26.00 b	34.00 b	39.00 b	42.00 b
Glyphosate4	7.00 b	11.00 b	17.00 b	19.00 b	28.00 b
Glyphosate6	12.00 b	22.00 b	36.00 b	44.00 ab	53.00 ab
F calculated	8.52*	14.64*	19.06*	23.78*	33.58*

*: significant at 5% probability by F test; Means followed by equal letters in the same column do not differ by Tukey test at 5% probability.

Figure 1. Visual damage in seedlings of *Schinus terebinthifolia* (A) and leaves of *Schinus terebinthifolia* with necrosis (B).

In *Handroanthus albus* seedlings (Table 3), both herbicides caused significant damage, despite the tolerance of the species to the lowest glyphosate level.The Imazapyr herbicide can be considered selective to the seedlings of *Handroanthus albus* in its lower dosage, since, even when chlorosis occurred,, it did not inhibit the emission of new leaves or plant recovery. However, imazapyr at 4 L ha^{-1} caused phytotoxicity to seedlings of *Handroanthus albus* in all assessment periods. Christoffoleti et al. (1998) observed that imazapyr is completely selective for *Pinus* spp., that tolerates applications before and after transplanting, whose doses provide longer residual weed control. Monquero et al. (2011) also verified that this herbicide was selective in *Ceiba speciosa* seedlings and *Luehea divaricata,* however, in its higher level, it caused phytotoxicity with necrosis and deformation of leaves and shoots but did not inhibit the plant development.

It is possible to observe in Table 4 that there was no difference between treatments at 7 DAA and 14 DAA, indicating a longer period for absorption and metabolization of the herbicides used in *Peltophorum dubium*. The Imazapyr herbicide caused phytotoxicity at its higher level regardless of the assessment period, but it was favorable to the growth of the *Peltophorum dubium* seedlings, which indicates a lower level of intoxication in the them. According to Brancalion et al. (2009), this very same effect occurred with the setoxidim herbicide in seedlings of *Senna multijuga* and *Guazuma ulmifolia* Lam. Monquero et al. (2011) also verified that the leaves of *Kielmeyera lathrophyton* were damaged but gradually recovered as they grew older. From 21 DAA, the seedlings showed more intense toxicity symptoms as the herbicide level was doubled. This result was observed by Gonçalves et al. (2011) in *Jatropha curcas* L. and by Alves et al. (2000) in the maize (*Zea mays* L.) crop, where the treatments with glyphosate caused phytotoxicity as the herbicide level was doubled.

Table 3. Phytotoxicity evaluation of imazapyr and glyphosate according to ALAM scale (1974) on *Handroanthus albus* (Bignoniaceae) in different evaluation periods after application. Aquidauana-MS, 2014.

Treatment	7 DAA	14 DAA	21 DAA	28 DAA	60 DAA
Control	0.00 b	0.00 b	0.00 c	0.00 c	0.00 c
Imazapir1	4.40 ab	12.00 a	30.00 ab	32.00 b	26.00 b
Imazapir2	0.00 b	9.00 a	12.00 b	17.00 b	23.00 b
Imazapir4	16.00 a	22.00 a	53.00 a	68.00 a	72.00 a
Glyphosate2	3.40 ab	7.00 a	9.00 bc	11.00 b	11.00 b
Glyphosate4	4.00 ab	7.00 a	11.00 bc	15.00 b	24.00 b
Glyphosate6	5.00 ab	17.00 a	25.00 ab	36.00 ab	31.00 b
F calculated	3.95*	9.79*	9.53*	18.66*	21.25*

*: significant at 5% probability by F test. Means followed by equal letters in the same column do not differ by Tukey test at 5% probability.

Table 4. Phytotoxicity evaluation of imazapyr and glyphosate according to ALAM scale (1974) on *Peltophorum dubium* (Fabaceae) in different evaluation periods after application. Aquidauana-MS, 2014.

Treatment	7 DAA	14 DAA	21 DAA	28 DAA	60 DAA
Control	0.00	0.00	0.00 b	0.00 b	0.00 b
Imazapir1	1.40	2.00	5.40 ab	0.00 b	14.00 ab
Imazapir2	0.00	13.00	18.00 a	28.00 a	30.00 a
Imazapir4	0.00	2.00	6.00 ab	8.00 ab	12.00 ab
Glyphosate2	2.40	3.00	4.00 ab	6.00 ab	8.00 ab
Glyphosate4	2.00	3.00	5.40 ab	7.00 ab	12.00 ab
Glyphosate6	2.00	8.00	14.00 b	18.00 a	22.00 a
F calculated	1.06^{ns}	2.69^{ns}	3.42*	3.17*	4.37*

^{ns} e *: not significant and significant at 5% probability by F test, respectively. Means followed by equal letters in the same column do not differ by Tukey test at 5% probability.

Symptoms of selectivity with glyphosate in seedlings are the yellowing of meristems that progress to necrosis and death. However, only symptoms such as spotting and necrosis were observed in young leaves (AMARANTE JÚNIOR et al., 2002). There was a difference between treatments for weeds control at all evaluation periods (7, 14, 21, 28 and 60 DAA) (Table 5).

Table 5. Weed control evaluation with imazapyr and glyphosate herbicides according to ALAM scale (1974) in different evaluation periods after application. Aquidauana-MS, 2014.

Treatment	7 DAA	14 DAA	21 DAA	28 DAA	60 DAA
Control	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
Imazapir1	3.20 c	18.20 b	24.00 b	27.00 bc	32.00 bc
Imazapir2	18.20 b	27.00 b	33.00 b	34.00 bc	36.00 bc
Imazapir4	34.00 ab	47.00 ab	45.00 ab	56.00 ab	58.00 ab
Glyphosate2	33.00 ab	37.00 ab	48.00 ab	52.00 b	58.00 ab
Glyphosate4	30.00 ab	40.00 ab	46.00 ab	56.00 ab	62.00 ab
Glyphosate6	50.00 a	70.00 a	78.00 a	88.00 a	84.00 a
F calculated	17.07*	16.70*	18.17*	24.41*	23.74*

*: significant at 5% probability by F test. Means followed by equal letters in the same column do not differ by Tukey test at 5% probability.

Among the evaluated treatments, the highest glyphosate level presented satisfactory control with 84% at 60 DAA, differing from the control and imazapyr at levels 1 and 2. However, control levels were still not satisfactory for reducing weeds interference, both the imazapyr as to glyphosate herbicide, since according to ALAM scale (1974) the level with effectiveness considered excellent would be around 91 to 100%.

CONCLUSION

Imazapyr herbicide, when applied in the initial post-emergence in its lower level, it is selective to the tree species, but in the other concentrations it can affect differently the survival of them. Glyphosate herbicide was the least selective to the tree species in its different concentrations, causing phytotoxic effects with changes in the seedlings morphology.

RESUMO: Um dos problemas mais agravantes no manejo florestal é a interferência que as plantas daninhas podem causar no desenvolvimento e crescimento das plantas. O uso de herbicidas é uma prática indispensável para atenuar esses efeitos em áreas de reflorestamento. Este trabalho teve como objetivo avaliar a seletividade dos herbicidas glyphosate e imazapyr em mudas de espécies nativas do Cerrado brasileiro, tais como: *Schinus terebinthifolia* (Anacardiaceae), *Peltophorum dubium* (Fabaceae) e *Handroanthus albus* (Bignoniaceae). O experimento foi conduzido em Casa de Vegetação, na Unidade Universitária de Aquidauana/UEMS. O delineamento experimental utilizado foi o inteiramente casualizado, com sete tratamentos e cinco repetições. A seletividade dos herbicidas nas mudas destas espécies foi avaliada aos 7, 14, 21, 28 e 60 dias após aplicação (DAA) dos herbicidas, por meio de uma escala percentual de notas, em que 0% corresponde a nenhuma injúria e 100% corresponde a morte da planta. Paralelamente, para a avaliação do controle das plantas daninhas também foi realizada analise visual aos 7, 14, 21, 28 e 60 dias após aplicação (DAA) dos herbicidas, através da avaliação visual de controle, onde 100% consideram-se morte da daninha e 0% nenhuma injúria à planta daninha. O herbicida imazapyr aplicado em pós-emergência inicial em sua menor dosagem é seletivo as espécies arbóreas, mas em maiores concentrações pode afetar sua sobrevivência de forma diferenciada nas espécies. O herbicida glyphosate foi o menos seletivo às espécies arbóreas em suas diferentes concentrações, causando intoxicações às mudas com alterações em sua morfologia. Os resultados deste trabalho podem auxiliar no manejo integrado de plantas daninhas e contribuir para o uso eficiente de herbicidas em plantios de espécies florestais no cerrado.

PALAVRAS-CHAVES: *Schinus terebinthifolia*. *Peltophorum dubium*. *Handroanthus albus*. Imazapyr. Glyphosate.

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