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Article

SELECTIVITY OF HERBICIDES TO NATIVE TREE SPECIES IN BRAZIL

Seletividade de Herbicidas a Espécies Arbóreas Nativas do Brasil

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ABSTRACT - Weeds are one of the main obstacles in the recovery of degraded areas. This research aimed to study the selectivity of herbicides on *Trema micrantha* (Jamaican nettletree), *Schinus molle* (Peruvian peppertree), and *Apuleia leiocarpa* (garapeira) seedlings. An experiment was installed in Junqueirópolis and another in Jaboticabal/SP, Brazil. The experimental design used was completely randomized design with four replications. Treatments consisted of clethodim + fenoxaprop-p-ethyl (50 + 50 g a.i. ha^{-1}), sethoxydim (184 g a.i. ha^{-1}), quizalofop-p-ethyl (75 g a.i. ha^{-1}), nicosulfuron (50 g a.i. ha^{-1}), fluazifop-p-butyl (125 g a.i. ha^{-1}), fomesafen (225 g a.i. ha^{-1}), haloxyfop-methyl (48 g a.i. ha^{-1}), bentazon (720 g a.i. ha^{-1}), chlorimuron-ethyl (15 g a.i. ha^{-1}), and control without herbicide. The analyzed characteristics were stem diameter, plant height, and phytointoxication at 7, 14, 21, 28, 35, and 42 days after herbicide application (DAA), in addition to shootdry matter accumulation in seedlings at the end of the study. Nicosulfuron and chlorimuron-ethyl caused intoxication in all the studied tree species. In Jaboticabal, these herbicides impaired the initial growth of Jamaican nettletree seedlings, while no herbicide delayed its initial development in Junqueirópolis.A similar result was obtained regarding dry matter accumulation for garapeira in both cities. The herbicides clethodim + fenoxaprop-p-ethyl and sethoxydim decreased dry matter accumulation in Peruvian peppertree plants in Jaboticabal and Junqueirópolis, respectively, thus not being recommendedtheir use for these species.

Keywords: tree species, phytointoxication, *Schinus mole*, *Apuleia leiocarpa*, *Trema micrantha*.

RESUMO - As plantas daninhas são um dos principais entraves na recuperação de áreas degradadas. O objetivo deste trabalho foi estudar a seletividade de herbicidas sobre mudas de ***Trema micrantha*** *(candiúba),* ***Schinus molle*** *(aroeirinha) e* ***Apuleia leiocarpa*** *(garapeira). Foi implantado um experimento no município de Junqueirópolis-SP e outro em Jaboticabal/SP. O delineamento experimental usado foi inteiramente casualizado com quatro repetições. Os tratamentos utilizados foram (50 + 50 g i.a. ha^{-1}): clethodim + fenoxaprop-p-ethyl, sethoxydim (184 g i.a. ha^{-1}), quizalofop-p-ethyl (75 g i.a. ha^{-1}), nicosulfuron (50 g i.a. ha^{-1}), fluazifop-p-butyl (125 g i.a. ha^{-1}), fomesafen (225 g i.a. ha^{-1}), haloxyfop-methyl (48 g i.a. ha^{-1}), bentazon (720 g i.a. ha^{-1}), chlorimuron-ethyl (15 g i.a. ha^{-1}) e controle sem herbicida. As características analisadas foram: diâmetro de caule, altura de plantas e fitointoxicação aos 7, 14, 21, 28, 35 e 42 dias após a aplicação (DAA) dos herbicidas, além do acúmulo de massa seca na parte aérea das mudas ao final do estudo. O nicosulfuron e o chlorimuron-ethyl causaram intoxicação em todas as espécies arbóreas estudadas. Em Jaboticabal, estes mesmos herbicidas prejudicaram o crescimento inicial das plantas de candiúba, enquanto em*

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Junqueirópolis nenhum herbicida retardou o desenvolvimento inicial desta espécie. Resultado semelhante foi obtido quanto ao acúmulo de matéria seca para a espécie garapeira em ambos os municípios. Também houve redução de matéria seca em plantas de aroeirinha quando da utilização dos herbicidas (clethodim + fenoxaprop-p-ethyl) e sethoxydim, em Jaboticabal e Junqueirópolis, respectivamente, o que não permite recomendar estes herbicidas para estas arbóreas.

Palavras-chave: plantas arbóreas, fitointoxicação, *Schinus mole*, *Apuleia leiocarpa*, *Trema micrantha*.

INTRODUCTION

A recent analysis estimated that Brazil has about 21 million hectares of native vegetation deficit in permanent preservation and legal reserve areas (Soares Filho et al., 2014). As a result, sectors of society together with relevant government agencies are engaged in actions that encourage rural entrepreneurs to conserve and recover their degraded biomes over the years. In this fact lies the importance of creating mechanisms that accelerate the recovery process of degraded areas.

One of the factors that may contribute toalower advance in the development of newly recovered areas is the presence of weeds that colonize remaining areas of native vegetation and also compete for resources essential for the development of tree species, which contributes to an ecological imbalance (Cornish and Burgin, 2005; Hooper et al., 2005). The main challenge for the recovery of a degraded area is the weed control, mainly the species *Urochloa decumbens* (Pivello et al., 1999).

The most adequateand fast weed control method for extensive recovery areas of native tree vegetation is the chemical (Peter and Harrington, 2009). Studies with different herbicides to control weeds in areas of recovery of native vegetation is a new researchline since the use of glyphosate has some limitations, as it is efficient only when the application is directed at the target.

Many herbicides and native species have not yet been evaluated. Herbicides with known selective action for some crops have been studied as an attempt to improve weed control methods in reforestation areas, although there is still limited information on the potential damages that the use of these products can bring to native species development (Brancalion et al., 2009).

Several natural vegetation recovery projects may be unviabledue to the interference caused by the presence of weeds. Therefore, weed control is one of the main challenges for recovering a degraded area, in which the use of mechanical and manual control becomes costly.

Thus, this study aimed to evaluate the selectivity of herbicides applied in post-emergence on the development of three native tree species of Brazil at different locations.

MATERIAL AND METHODS

The study was carried out in two distinct regions. The first experiment was conducted in Jaboticabal/SP, located at 21°15’17" S and 48°19’20" W, with an altitude of 605 m. The second experiment was carried out in Junqueirópolis-SP, located at 21°30’53" S and 51°26’01" W, with an altitude of 421 m.

Each experimental unit consisted of a plastic pot with a 5.0 L capacity filled with the soils of each region: a dystroferric Red Argisol in Junqueirópolis and a Red-Yellow Latosol in Jaboticabal (Embrapa, 2013). Both soils were mixed with coconut shell-basedsubstrate at a ratio of 3:1 (substrate: soil), in addition to 1.4 g of NPK (04-14-08) per pot. Topdressing fertilization was performed with potassium nitrate at a dose of 400 mg per experimental unit at 30 days after seedling transplanting.

The studied native tree species were garapeira (*Apuleia leiocarpa* Spruce ex Benth.), Peruvian peppertree (*Schinus molle* L.), and Jamaican nettletree (*Trema micrantha* L. Brume) from a nursery for seedling production located in Rosana/SP. The experimental design was a completely randomized design with four replications. Treatments consisted of the application of nine herbicides: clethodim + fenoxaprop-p-ethyl (50 + 50 g a.i. ha^{-1}) + mineral oil Assist (0.5% v/v), sethoxydim (184 g a.i. ha^{-1}), quizalofop-p-ethyl (75 g a.i. ha^{-1}), nicosulfuron (50 g a.i. ha^{-1}), fluazifop-p-butyl (125 g a.i. ha^{-1}), fomesafen (225 g a.i. ha^{-1}), haloxyfop-methyl (48 g a.i. ha^{-1}), bentazon (720 g a.i. ha^{-1}), chlorimuron-ethyl (15 g a.i. ha^{-1}), and control without herbicide.

The first experiment was conducted in Jaboticabal and herbicide application was performed on August 12, 2015, at 60 days after transplanting seedlings with 30 to 40 cm high to pots. A CO_2-pressurized backpack sprayer, equipped with a boom with two flat spray tips Teejet 11002VS and at a pressure of 200 kPa and spray solution consumption of 200 L ha^{-1}. Wind speed was 3.0 km h^{-1}, with an RH of 63% and air temperature of 27 °C. Plants were maintained in a plastic greenhouse with irrigation whenever necessary.

The second experiment was carried out in Junqueirópolis and herbicide spraying on seedlings of native species occurred on September 23, 2015, at 70 days after transplanting seedlings with 35 to 40 cm high. Sprayer equipment and its regulation were identical to that performedinthe first experiment, but with a wind speed of 2.5 km h^{-1}, RH of 48%, and air temperature of 29 °C at the application time. Plants were maintained under a lath house covered by a shading screen, which received sprinkler irrigation and precipitation that totaled 649.5 mm from the transplant to the last data collection.

Visual evaluations of phytointoxication were carried out at 7, 14, 21, 28, 35, and 42 days after herbicide application (DAA) through a percentage score scale, where 0 represents no visual injury caused by herbicides and 100 corresponds to plant death (SBCPD, 1995). Plant height was measured using a measuring tape and considering the distance from the ground to the apex of the highest plantleaf. Stem diameter was obtainedusing a digital caliper by measuring the stemfrom two centimeters at the ground level. The increment in plant height and stem diameter was obtained from the difference of the means observed at 42 DAA and the means observed at applicationtime.

At the end of the evaluations (at 42 DAA), plant shoots were collected and the dry matter was obtained by drying them in a forced circulation oven at 65 °C until constant weight. The results were submitted to analysis of variance by the F test, and the means were compared by the Student t test ($p>0.05$).

RESULTS AND DISCUSSION

Garapeira (*Apuleia leiocarpa*)

Jaboticabal

Table 1 shows that only two active ingredients stood out by providing moderate symptoms of toxicity. The herbicide bentazon caused symptoms of intoxication in the plants from 21 DAA, which were more intense at 28 DAA. Also, fomesafen led to more severe visual injuries at 14 DAA and provided visual symptoms of intoxication in garapeira plants at all evaluatedtimes.

The ACCase-inhibiting herbicides did not provide any level of visual intoxication in plants of this tree species. Herbicides from this class are a great alternative for efficient control of grasses in areas of forest recovery since their mechanism of action allows eudicotyledonous plants not to present any visual injuries because theyhave the heterodimeric enzyme ACCase in plastidsbecause the herbicide binds only to the heterodimeric enzyme present in grasses. The other herbicides caused slight injuries in garapeira plants (Table 1).

When investigating herbicide action on plants, theincrement in height and dry matter of garapeira plants were similar to those observed in plants without treatment application. No herbicide restricted the increment of stem diameter of garapeira, including those that caused visual intoxication (Table 2).

Symptoms of intoxication and lack of reduction of seedling development are signals that the selectivity of the tested herbicides in native forest species is due to the metabolism of the active principles, which progressively reduces their toxic action and does not delay the normal development of plants (Brancalion et al., 2009).

Differences were only observed between some herbicides, but similar to the control (Table 2).

Table 1 **-** Percentage of intoxication of *Apuleia leiocarpa* (garapeira) at different evaluation times after the application of several herbicides. Jaboticabal, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.(1)	4.0 b	3.5 b	2.0 cde	0.0 c	0.0 b	0.0 c
2. Fluazifop-p-butyl	0.0 c	0.0 b	0.0 e	0.0 c	0.0 b	0.0 c
3. Sethoxydim(2)	0.0 c	0.0 b	0.0 e	0.0 c	0.0 b	0.0 c
4. Quizalofop-p-ethyl	2.2 b	3.0 b	1.2 de	0.0 c	0.0 b	0.0 c
5. Fomesafen	14.2 a	29.5 a	25.5 a	15.7 ab	11.2 a	8.0 ab
6. Haloxyfop-methyl	0.0 c	0.0 b	0.0 e	0.0 c	0.0 b	0.0 c
7. Nicosulfuron	2.5 b	5.0 b	6.2 c	5.7 bc	2.7 a	2.2 abc
8. Bentazon	0.0 c	0.0 b	19.2 b	23.7 a	16.0 a	9.0 a
9. Chlorimuron-ethyl	2.5 b	4.7 b	5.0 cd	6.7 bc	2.7 b	1.5 bc
F Treatment	103.2**	47.9**	84.9**	16.5**	11.2**	6.3**
CV (%)	31.49	53.37	30.83	73.2	96.97	124.86
LSD	2.21	6.45	4.82	10.06	8.39	6.84

Means followed by the same letter in the column do not differ from each other by Student t test ($p>0.05$). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Table 2 **-** Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Apuleia leiocarpa* (garapeira) at 42 days after application. Jaboticabal, SP, 2015

Treatment	Height	Stem diameter	Dry matter
	(cm)	(mm)	(g)
1.Clethodim + fenox.(1)	10.0 abc	0.5	4.0 ab
2. Fluazifop-p-butyl	15.5 ab	0.8	7.5 a
3. Sethoxydim(2)	8.0 bc	0.9	2.7 ab
4. Quizalofop-p-ethyl	9.0 abc	0.7	2.4 ab
5. Fomesafen	3.2 c	0.6	4.1 ab
6. Haloxyfop-methyl	19.7 a	0.8	5.4 ab
7. Nicosulfuron	10.0 abc	1.1	4.6 ab
8. Bentazon	10.0 abc	0.5	4.1 ab
9. Chlorimuron-ethyl	8.5 bc	0.4	2.1 b
10. Control	8.7 abc	0.6	2.5 ab
F Treatment	3.81**	0.84ns	2.42*
CV (%)	44.46	67.38	53.29
LSD	11.02	1.17	5.12

Means followed by the same letter in the column do not differ from each other by Student t test ($p>0.05$). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Junqueirópolis

The intoxication of garapeira plants caused by different herbicidesof the experiment carried out in Junqueirópolis-SP is shown in Table 5. Only the herbicides clethodim + fenoxaprop-p-ethyl and quizalofop-p-ethyl caused visual symptoms at 7, 14, and 21 DAA. The herbicides fomesafen, nicosulfuron, and chlorimuron-ethyl provided intoxication throughout the evaluation period. Visual symptoms of intoxication were registered at 21 DAA in garapeira plants that received the application of bentazon (Table 3).

One of the characteristics of the herbicide fomesafen is the presence of visual symptoms of intoxication such as chlorosis in leaf tissues, with subsequent recovery of these symptoms without affecting plant development (Silva et al., 2014).

The application of different herbicides did not influence the development of garapeira plants. Growth parameters such as increment in plant height and stem diameter and dry matter accumulation were not influenced by treatments (Table 4).

Table 3 **-** Percentage of intoxication of *Apuleia leiocarpa* (garapeira) at different evaluation times after the application of several herbicides. Junqueirópolis, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.(1)	2.0 b	2.2 b	1.0 c	0.0 c	0.0 c	0.0 b
2. Fluazifop-p-butyl	0.0 c	0.0 b	0.0 c	0.0 c	0.0 c	0.0 b
3. Sethoxydim(2)	0.0 c	0.0 b	0.0 c	0.0 c	0.0 c	0.0 b
4. Quizalofop-p-ethyl	1.2 bc	2.2 b	1.2 c	0.0 c	0.0 c	0.0 b
5. Fomesafen	7.5 a	15.2 a	13.5 a	8.0 ab	5.2 ab	3.2 ab
6. Haloxyfop-methyl	0.0 c	0.0 b	0.0 c	0.0 c	0.0 c	0.0 b
7. Nicosulfuron	1.2 bc	3.2 b	2.7 c	2.7 c	2.0 bc	1.0 b
8. Bentazon	0.0 c	0.0 b	9.7 b	12.0 a	7.5 a	5.2 a
9. Chlorimuron-ethyl	1.0 bc	2.0 b	2.2 c	3.5 bc	1.5 bc	0.7 b
F Treatment	58.63**	35.71**	67.19**	17.95**	9.03**	5.89**
CV (%)	43.17	58.37	35.00	70.37	101.53	135.44
LSD	1.48	3.85	2.82	4.88	4.36	3.67

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Table 4 **-** Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Apuleia leiocarpa* (garapeira) at 42 days after application. Junqueirópolis, SP, 2015

Treatment	Height	Stem diameter	Dry matter
	(cm)	(mm)	(g)
1. Clethodim + fenox.(1)	14.3	2.4	7.3
2. Fluazifop-p-butyl	9.4	1.3	5.0
3. Sethoxydim(2)	7.9	2.0	7.2
4. Quizalofop-p-ethyl	14.3	1.6	11.5
5. Fomesafen	16.3	1.6	8.0
6. Haloxyfop-methyl	13.7	1.3	7.8
7. Nicosulfuron	3.2	1.4	4.0
8. Bentazon	7.2	1.9	5.7
9. Chlorimuron-ethyl	8.4	1.1	5.6
10. Control	18.5	1.2	5.0
F Treatment	2.07^{ns}	1.19^{ns}	2.02^{ns}
CV (%)	58.73	46.51	44.97
LSD	16.08	1.80	7.50

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Peruvian peppertree (*Schinus molle*)

Jaboticabal

Peruvian peppertree plants did not undergo any visual symptoms of intoxication with the application of the herbicides clethodim + fenoxaprop-p-ethyl, fluazifop-p-butyl, sethoxydim, and haloxyfop-methyl. The herbicides chlorimuron-ethyl, fomesafen, nicosulfuron, and bentazon caused visual injuries in plants at all evaluated times, except for chlorimuron-ethyl and fomesafen, which provided symptoms of intoxication that disappeared at the last evaluated period (42 DAA) (Table 5).

Brighenti and Muller (2014) observed no symptoms of intoxication in African mahogany with the application of chlorimuron-ethyl. Oliveira Júnior et al. (2011) pointed out that selectivity to herbicidescan be obtained by means of physiological and morphological differences between plant species, which may explain the different results found between Peruvian peppertree and African mahogany.

Regarding the main effects of treatments on growth parameters evaluated in plants of Peruvian peppertree, the herbicides did not influence in the increment of plants height and stem diameter (Table 6). Only the herbicide clethodim + fenoxaprop-p-ethyl affected dry matter accumulation, being not recommended its use for thisspecies. Also, there were no symptoms of injury caused by this herbicide in all the evaluated period.

Brighenti and Muller (2014) reported that nicosulfuron application in African mahogany and Australian cedar at a dose of 40 g ha^{-1} presented slight and medium symptoms of intoxication at 14 and 21 DAA, respectively, with a lower dry matter accumulation in Australian cedar plants. In our study, nicosulfuron (50 g ha^{-1}) provided visual toxicity from 7 to 42 DAA in Peruvian

Table 5 - Percentage of intoxication of *Schinus molle* (Peruvian peppertree) at different evaluation times after the application of several herbicides. Jaboticabal, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.[1]	0.0 c	0.0 c	0.0 d	0.0 d	0.0 d	0.0 c
2. Fluazifop-p-butyl	0.0 c	0.0 c	0.0 d	0.0 d	0.0 d	0.0 c
3. Sethoxydim[2]	0.0 c	0.0 c	0.0 d	0.0 d	0.0 d	0.0 c
4. Quizalofop-p-ethyl	0.0 c	4.7 b	6.5 bc	5.5 bc	3.5 c	0.0 c
5. Fomesafen	12.7 a	13.7 a	16.7 a	10.2 a	4.7 c	0.0 c
6. Haloxyfop-methyl	0.0 c	0.0 c	0.0 d	0.0 d	0.0 d	0.0 c
7. Nicosulfuron	6.0 b	8.7 b	10.2 b	8.2 ab	8.2 b	3.7 b
8. Bentazon	5.2 b	8.0 b	8.2 bc	11.0 a	10.5 a	7.2 a
9. Chlorimuron-ethyl	4.7 b	7.0 b	3.2 cd	2.5 cd	1.0 d	0.0 c
F Treatment	26.39**	29.06**	29.23**	45.71**	97.98**	62.43**
CV (%)	53.96	39.79	43.88	33.14	25.87	53.39
LSD	4.10	4.44	5.22	3.28	1.91	1.55

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Table 6 - Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Schinus molle* (Peruvian peppertree) at 42 days after application. Jaboticabal, SP, 2015

Treatment	Height	Stem diameter	Dry matter
	(cm)	(mm)	(g)
1. Clethodim + fenox.[1]	10.0	2.2	12.7 b
2. Fluazifop-p-butyl	14.0	2.1	16.5 ab
3. Sethoxydim[2]	20.0	2.5	21.2 ab
4. Quizalofop-p-ethyl	18.5	2.5	25.3 ab
5. Fomesafen	25.2	2.6	21.3 ab
6. Haloxyfop-methyl	14.5	2.3	26.4 a
7. Nicosulfuron	15.2	2.7	25.4 ab
8. Bentazon	13.0	1.6	18.1 ab
9. Chlorimuron-ethyl	12.7	3.1	22.6 ab
10. Control	17.0	3.1	26.9 a
F Treatment	1.64	0.96^{ns}	3.13**
CV (%)	42.44	37.90	24.48
LSD	16.40	2.28	12.80

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

peppertree plants, but without significant reduction in relation to the control. Burnet et al. (1993) stated that plant tolerance to the application of protox-inhibiting herbicides, such as nicosulfuron, may occur due to the formation of metabolites that modify the conformation of the herbicide molecule, making it non-toxic, such as in transformations of N-demethylation of the chlorimuron molecule, which occurs in resistant *Lolium rigidum*.

Junqueirópolis

Clethodim + fenoxaprop-p-ethyl, fluazifop-p-butyl, haloxyfop-methyl, and sethoxydim did not induce visual injury symptoms to Peruvian peppertree plants at the evaluated periods (Table 7).

Nicosulfuron and bentazon provided plant intoxication at all evaluations (Table 7). Bentazon selectivity is due to the fast metabolism in tolerant plants, forming the glycosyl radical, which probably occurred in this species. The selectivity of this herbicide may be related to the fastmolecule metabolization into non-toxic forms, which prevents plant death (Rodrigues and Almeida, 2011). The herbicides quizalofop-p-ethyl, fomesafen, and chlorimuron-ethyl caused visual injuries in Peruvian peppertree plants up to 35 DAA; at 42 DAA, these insults no longer existed.

Table 7 **-** Percentage of intoxication of *Schinus molle* (Peruvian peppertree) at different evaluation times after the application of several herbicides. Junqueirópolis, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.[1]	0.0 c	0.0 d	0.0 d	0.0 c	0.0 e	0.0 c
2. Fluazifop-p-butyl	0.0 c	0.0 d	0.0 d	0.0 c	0.0 e	0.0 c
3. Sethoxydim[2]	0.0 c	0.0 d	0.0 d	0.0 c	0.0 e	0.0 c
4. Quizalofop-p-ethyl	1.2 bc	2.0 cd	3.7 bc	3.5 b	1.2 cd	0.0 c
5. Fomesafen	6.2 a	7.5 a	7.2 a	5.5 a	2.0 c	0.0 c
6. Haloxyfop-methyl	0.0 c	0.0 d	0.0 d	0.0 c	0.0 e	0.0 c
7. Nicosulfuron	2.5 b	4.5 b	5.5 ab	4.2 ab	4.0 b	1.5 b
8. Bentazon	2.5 b	4.2 bc	4.0 bc	5.5 a	5.5 a	3.7 a
9. Chlorimuron-ethyl	2.2 b	3.5 bc	1.5 cd	1.2 c	0.7 de	0.0 c
F Treatment	32.22**	26.43**	19.96**	44.63**	66.72**	47.7**
CV (%)	44.32	43.43	50.71	32.97	32.71	63.88
LSD	1.72	2.49	2.94	1.74	1.16	0.88

Means followed by the same letter in the column do not differ from each other by Student t test ($p>0.05$). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

No herbicide reduced the increment in plant height and stem diameter, as well as dry matter accumulation. Thus, all the herbicides promoted selectivity in the initial development of Peruvian peppertree plants under the conditions of Junqueirópolis (Table 8). Oliveira et al. (2008) observed that the application of haloxyfop-methyl in cedar seedlings did not affect stem height and dry matter.

Jamaican nettletree (*Trema micrantha*)

Jaboticabal

For Jamaican nettletree plants, the herbicides nicosulfuron and chlorimuron-ethyl provided symptoms of severe visual injuries higher than 80% at the end of the evaluation period (Table 9). A gradual increase of injuries was observed in plants throughout the evaluations up to 35 DAA. The characteristics of symptoms caused by the use of these herbicides were leaf yellowing, followed by the death of apical bud in some plants. Plants that present symptoms of injuries due

Table 8 **-** Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Schinus molle* (Peruvian peppertree) at 42 days after application. Junqueirópolis, SP, 2015

Treatment	Height	Stem diameter	Dry matter
	(cm)	(mm)	(g)
1. Clethodim + fenox.[1]	18.0	3.8	34.0
2. Fluazifop-p-butyl	17.4	2.8	20.8
3. Sethoxydim[2]	14.3	2.8	19.6
4. Quizalofop-p-ethyl	17.8	3.8	40.6
5. Fomesafen	19.4	2.8	26.9
6. Haloxyfop-methyl	10.7	3.3	30.9
7. Nicosulfuron	7.2	3.2	22.0
8. Bentazon	12.5	1.7	25.3
9. Chlorimuron-ethyl	6.1	3.3	26.8
10. Control	14.4	2.9	33.6
F Treatment	1.64^{ns}	1.04^{ns}	1.13^{ns}
CV (%)	52.31	37.94	44.8
LSD	17.42	2.8	30.34

Means followed by the same letter in the column do not differ from each other by Student t test ($p>0.05$). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Table 9 **-** Percentage of intoxication of *Trema micrantha* (Jamaican nettletree) at different evaluation times after the application of several herbicides. Jaboticabal, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.[1]	2.2 c	1.7 d	2.7 c	0.0 c	0.0 c	0.0 c
2. Fluazifop-p-butyl	0.0 c	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c
3. Sethoxydim[2]	0.0 c	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c
4. Quizalofop-p-ethyl	0.0 c	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c
5. Fomesafen	22.7 a	49.7 b	53.2 b	54.2 b	48.2 b	41.0 b
6. Haloxyfop-methyl	0.0 c	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c
7. Nicosulfuron	12.7 b	33.2 c	65.0 a	76.2 a	82.7 a	81.0 a
8. Bentazon	0.0 c	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c
9. Chlorimuron-ethyl	13.2 b	52.9 a	72.0 a	85.2 a	86.7 a	85.0 a
F Treatment	84.82**	318.56**	185.17**	140.3**	109.91**	88.02**
CV (%)	32.39	17.13	21.82	25.94	29.8	33.9
LSD	4.36	6.52	11.13	14.79	17.15	18.55

Means followed by the same letter in the column do not differ from each other by Student t test ($p>0.05$). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

to these herbicides do not develop, have the apical bud affected, and may eventually die (Rodrigues and Almeida, 2011).

The same behavior in this species was observedfor fomesafen application, but the maximum visual symptoms (54%) were observed only up to 28 DAA, with a subsequent reduction in injuries until the last evaluation (Table 9). The commercial mixture of the herbicide clethodim + fenoxaprop-p-ethyl promoted slight symptoms (2.7%) of toxicity in plants from 7 to 21 DAA, but injuries disappeared from 28 DAA (Table 9). Fluazifop-p-butyl, haloxyfop-methyl, sethoxydim, and bentazon did not visually affect Jamaican nettletree plants during the experimental period (Table 9).

The herbicides haloxyfop-methyl, sethoxydim, quizalofop-p-ethyl, and fluazifop-p-butyl positively influenced the increment in plant height (Table 10). In addition, the other herbicides did not affect the growth of Jamaican nettletree plants. The selectivity imposed by ACCase-

Table 10 **-** Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Trema micrantha* (Jamaican nettletree) at 42 days after application. Jaboticabal, SP, 2015

Treatment	Height (cm)	Stem diameter (mm)	Dry matter (g)
1. Clethodim + fenox.[1]	3.7 cd	2.9	7.3 bc
2. Fluazifop-p-butyl	11.2 ab	1.7	13.3 a
3. Sethoxydim[2]	15.2 a	1.7	13.3 a
4. Quizalofop-p-ethyl	12.7 a	2.1	12.9 a
5. Fomesafen	3.2 d	1.4	7.4 bc
6. Haloxyfop-methyl	12.2 a	1.9	9.2 abc
7. Nicosulfuron	2.2 d	1.3	4.7 c
8. Bentazon	7.5 bc	2.3	11.5 ab
9. Chlorimuron-ethyl	3.5 cd	1.6	4.4 c
10. Control	6.2 cd	2.5	11.4 ab
F Treatment	30.39	0.97^{ns}	9.43**
CV (%)	21.95	52.50	23.34
LSD	4.13	2.51	5.39

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). [1] Fenoxaprop-p-ethyl. [2] Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; [ns] Not significant.

inhibiting herbicides may be related to the enzymatic insensitivity, which is the result of a large part of the studies directed to the tolerance of plants to herbicides belonging to this group (Volenberge and Stoltenberg, 2002; Prado et al., 2004).

Chlorimuron-ethyl and nicosulfuron provided a reduction in dry matter accumulation (Table 10). These herbicides caused intense injuries to plants, which can evidence the deleterious effect in this parameter. Brighenti and Muller (2014) studied the tolerance of African mahogany with the use of chlorimuron-ethyl and observed no visual symptoms of toxicity. However, these authors noted the presence of intoxications and consequent reduction in dry matter accumulation in Australian cedar.

The other herbicides did not affect the growth and development of Jamaican nettletree plants. In this case, their application can be recommended for the initial development of this tree species.

Junqueirópolis

In all visual evaluations of intoxication, clethodim + fenoxaprop-p-ethyl, bentazon, fluazifop-p-butyl, sethoxydim, haloxyfop-methyl, and quizalofop-p-ethyl did not provide any visual injury in Jamaican nettletree plants (Table 11).

The degree of visual injury caused by the herbicides nicosulfuron and chlorimuron-ethyl was lower in the first evaluation at 7 DAA, increasing gradually over the evaluated periods. Fomesafen induced progressive visual injuries from 7 to 21 DAA, with a subsequent decrease from 28 DAA (Table 11). One of the possible explanations for the recovery of this species to the symptoms of fomesafen without affecting its development is the lack of herbicide translocation to new sprouts and the action of glutathione S-transferase (GST) enzymes, which detoxify the herbicide (Andrews et al., 2005; Kilinc et al., 2011).

None of the herbicides reduced plant height and stem diameter, as well as dry matter accumulation (Table 12), including the treatments with the herbicides fomesafen, chlorimuron-ethyl, and nicosulfuron, which caused moderate to severe visual damagesto plants. Andrei (2009) stated that some plant species mightexhibit symptoms of intoxication, but the development is normal againonce the product is deactivated, with no deleterious result for the affected plant species. It may explain the observed injuries of these herbicides, which did not affect the growth and development of Jamaican nettletree plants in Junqueirópolis.

Table 11 **-** Percentage of intoxication of *Trema micrantha* (Jamaican nettletree) at different evaluation times after the application of several herbicides. Junqueirópolis, SP, 2015

Treatment	Days after herbicide application					
	7	14	21	28	35	42
1. Clethodim + fenox.(1)	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
2. Fluazifop-p-butyl	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
3. Sethoxydim(2)	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
4. Quizalofop-p-ethyl	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
5. Fomesafen	15.0 a	24.7 a	35.5 b	29.0 c	27.2 c	25.0 c
6. Haloxyfop-methyl	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
7. Nicosulfuron	14.2 a	25.5 a	47.7 a	53.7 a	62.5 a	68.0 b
8. Bentazon	0.0 b	0.0 b	0.0 c	0.0 d	0.0 d	0.0 d
9. Chlorimuron-ethyl	14.7 a	25.2 a	31.7 b	39.7 b	56.2 b	73.0 a
F Treatment	184.51**	302.74**	480.53**	575.17**	1042.55**	1300.88**
CV (%)	22.09	17.24	14	13.07	9.96	9.21
LSD	2.56	3.44	4.25	4.23	3.84	4.04

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Table 12 **-** Effects of different herbicides on the increment in height, stem diameter, and shoot dry matter accumulation of *Trema micrantha* (Jamaican nettletree) at 42 days after application. Junqueirópolis, SP, 2015

Treatment	Height	Stem diameter	Dry matter
	(cm)	(mm)	(g)
1. Clethodim + fenox.(1)	18.4	1.1	6.1
2. Fluazifop-p-butyl	16.8	0.9	7.2
3. Sethoxydim(2)	13.2	2.1	9.3
4. Quizalofop-p-ethyl	13.3	1.1	11.9
5. Fomesafen	19.0	1.5	6.6
6. Haloxyfop-methyl	8.3	2.5	6.5
7. Nicosulfuron	6.0	1.3	7.2
8. Bentazon	15.0	1.8	6.3
9. Chlorimuron-ethyl	3.6	1.5	10.9
10. Control	8.2	2.3	8.9
F Treatment	1.9	2.6ns	1.17ns
CV (%)	63.96	41.23	46.69
LSD	18.83	1.60	9.15

Means followed by the same letter in the column do not differ from each other by Student t test (p>0.05). (1) Fenoxaprop-p-ethyl. (2) Addition of 0.5% v/v of Assist. ** Significant at 1%; * Significant at 5%; ns Not significant.

Brancalion et al. (2009) reported that symptoms of intoxication and lack of reduction of seedling development are signals that the selectivity of the tested herbicides to native forest species is due to the metabolism of active principles, which progressively reduces their toxic action and not delays the normal plant development. It may explain the visual injuries of these herbicides, which did not affect the growth and development of Jamaican nettletree plants in Junqueirópolis.

None of the studied species underwent a reduction of increment in height and stem diameter, besides dry matter accumulation, with sethoxydim application. Brancalion et al. (2009) studied the selectivity of sethoxydim in several tree species andobserved that this herbicide favored seedling growth, indicating the vigorous potential of this molecule.

The three species evaluated in both cities showed that the ACCase-inhibiting herbicides clethodim + fenoxaprop-p-ethyl, fluazifop-p-butyl, sethoxydim, haloxyfop-methyl, and quizalofop-p-ethyl provided, in general, an intoxication index from none to veryslight, in addition to absence in the inhibition of growth and development of the analyzed tree species, culminating in selectivity to plants, except for clethodim + fenoxaprop-p-ethyl in Jaboticabal for Peruvian peppertree plants.

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