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HERBICIDE SELECTIVITY IN TROPICAL ORNAMENTAL SPECIES[1]

Seletividade de Herbicidas em Espécies Ornamentais Tropicais

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ABSTRACT - This study evaluated the selectivity of herbicides applied post-emergence on ornamental plants of *Alpinia purpurata*, *Strelitzia reginae* and *Heliconia psittacorum*. The study was conducted in two seasons. The experimental design was completely randomized with four replications. The treatments were: fluazifop-p-butyl (87.5 g ha^{-1}), quizalofop-p-ethyl (75.0 g ha^{-1}), sethoxydim (184.0 g ha^{-1}), quinclorac (375.0 g ha^{-1}), chlorimuron-ethyl (15.0 g ha^{-1}), clethodim + fenoxaprop-p-ethyl (37.5 + 37.5 g ha^{-1}), bentazon (720.0 g ha^{-1}), fomesafen (225.0 g ha^{-1}), and a control without any herbicide. In general, all tested herbicides and doses were selective for the three studied species. Although plants of *A. purpurata* and *H. psittacorum* have shown symptoms of phytotoxicity, recovery occurred with subsequent satisfactory visual appearance at the end of the evaluations. However, the *S. reginae* plants showed the smallest dry mass values when the sethoxydim and quizalofop-p-ethyl herbicides were sprayed.

Keywords: *Alpinia purpurata*, *Strelitzia reginae*, *Heliconia psittacorum*, *phytotoxicity*, *landscaping*.

RESUMO - O objetivo deste trabalho foi avaliar a seletividade de herbicidas aplicados em pós-emergência sobre plantas ornamentais de ***Alpinia purpurata****,* ***Strelitzia reginae*** *e* ***Heliconia psittacorum****. O estudo foi conduzido em duas épocas. O delineamento experimental utilizado foi inteiramente casualizado com quatro repetições. Os tratamentos foram: fluazifop-p-butyl (87,5 g ha^{-1}), quizalofop-p-ethyl (75,0 g ha^{-1}), sethoxydim (184,0 g ha^{-1}), quinclorac (375,0 g h^{-1}), chlorimuron-ethyl (15,0 g ha^{-1}), clethodim + fenoxaprop-p-ethyl (37,5+37,5 g ha^{-1}), bentazon (720,0 g ha^{-1}), fomesafen (225,0 g ha^{-1}) e uma testemunha sem aplicação de herbicida. De modo geral, todos os herbicidas e doses testadas foram seletivos para as três espécies estudadas. Ressalta-se que, apesar de as plantas de* ***A. purpurata*** *e* ***H. psittacorum*** *terem apresentado sintomas visuais de fitotoxicidade inicial, houve recuperação, com aspecto visual posterior satisfatório ao final das avaliações; contudo, para as plantas de* ***S. reginae*** *registraram-se as menores quantidades de massa seca quando houve a aplicação dos herbicidas sethoxydim e quizalofop-p-ethyl.*

Palavras-chave: *Alpinia purpurata*, *Strelitzia reginae*, *Heliconia psittacorum*, fitotoxicidade, paisagismo.

INTRODUCTION

Brazil has the potential to become a major producer of ornamental plants, mainly in relation to tropical species, considering the large genetic diversity and the favorable climate for their production. The tropical floriculture also gains space in the national flower production, due to favorable aspects for the commercialization, such as post-harvest durability and resistance to transportation, in addition to beauty, the colors and peculiar shapes of tropical flowers (Loges et al., 2005; Castro, 2010). Among the main tropical ornamental plants, some highlights are ostrich plume (*Alpinia purpurata*, strelitzia (*Strelitzia reginae*) and parrot's beak (*Heliconia psittacorum*).

Ostrich plume is a plant that may be explored both for gardening and for the production of cut flowers (Lorenzi and Souza, 2008). Its use as a cut flower has grown substantially over the last years, due to

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the durability and exuberance of its inflorescences, in addition to the possibility of continuous blooming throughout the year (Lamas, 2002).

Strelitzia, also known as bird of paradise, is grown on several parts of the world. This plant also is prominent on gardens, and it is an important choice for landscaping (Jainag et al., 2011). In the case of parrot's beak, currently distributed across all tropical regions of the world, its culture became popular as a cut flower and for landscaping, due to the exotic appearance of its inflorescences and the major color and shape variation (Berry and Kress, 1991; Santos et al., 2006).

One of the factors that may compromise the development and, in turn, the production of tropical flowers is the presence of weeds on its culture environment, since, in addition to competing for nutrients, water and light, these plants may contribute for an inadequate appearance of the flowers, as well as change the local landscape.

Manual hoeing is one of the most commonly used methods to control weeds in areas with flower cultures, whether in parks or even in gardens, which makes it unfeasible in extensive areas. The chemical control of these weeds, with the use of herbicides, becomes a management alternative, which may show great results, above all, during the most critical periods of the flower development (Freitas et al., 2007).

Within this context, for a successful use of herbicides, it is important to know about the selectiveness of the cultivated plants to the herbicide to be used on the area, that is, the herbicide must control the weeds but not affect the quality and quantity of the parts of the culture with economic interest (Velini et al., 2000).

Studies on the use of herbicides on ornamental cultures are scarce in the literature, which makes it necessary to know about the selectiveness of some herbicides with attested efficiency to control weeds on tropical ornamental species of economic interest. Therefore, the objective of this study was to evaluate the selectiveness of some herbicides applied post-emergence on ostrich plume, strelitzia and parrot's beak plants.

MATERIAL AND METHODS

Pots with volumetric capacity for 20 L were used, containing a mix of soil and humus at a proportion of 2:1 (v/v). The used soil was Red-Yellow Latosol (Embrapa, 2013) with the following physical characteristics: clay (18.9%), silt (3.6%) and sand (77.5%). Each pot constituted one experimental unit. Only one seedling was transplanted in each pot, which were kept by the sun and irrigated when necessary.

On both experiments, the experimental design was completely randomized with four replications. The tested treatments were: fluazifop-p-butyl (87.5 g ha^{-1}), quizalofop-p-ethyl (75.0 g ha^{-1}), sethoxydim (184.0 g ha^{-1}), quinclorac (375.0 g ha^{-1}), chlorimuron-ethyl (15.0 g ha^{-1}), clethodim + fenoxaprop-p-ethyl (37.5+37.5 ha^{-1}), bentazon (720.0 g ha^{-1}) and fomesafen (225.0 g ha^{-1}), in addition to a control with no application of herbicides.

At the time of application of the treatments, the plants had the following heights (first time/second time): ostrich plume (28 to 33 cm/40 to 50 cm), strelitzia (50 to 75 cm/35 to 60 cm) and parrot's beak (37 to 46 cm/30 to 44 cm).

The application of the herbicide treatments was conducted through a CO_2 pressurized backpack sprayer, maintained at a constant pressure of 200 kPa, equipped with a Teejet XR 11002VS nozzle bar, with spacing of 0.50 m from each other, at 0.50 m of the target, with spray consumption of 200 L ha^{-1}. The environmental conditions at the time of application, on both times, were: relative humidity of 56% and 60%, temperature of 23 °C and 25.6 °C and wind speed of 3 and 5 km h^{-1}, respectively.

Visual phytointoxication evaluations were conducted at 7, 14, 21, 28, 35 and 42 DAA (days after application) for strelitzia and parrot's beak plants, and, for ostrich plume, the evaluations were conducted up to 49 DAA (on the first study), through a percentage scale of grades, from 0% to 100%, in which 0 represents no injuries and 100, the death of the plants (SBCPD, 1995). During those periods, the growth rate of the plants was also evaluated, with the help of a measuring tape, measuring the plant from its base, close to the soil, up to the tip of the higher leaf of the plant on the application day and at the end of the study (growth rate = final height – initial height); at the end of the study, the shoot dry mass of the plants was also evaluated; the plants were cut close to the soil, and the material was collected and kept on an forced-air circulation oven at 65 °C, until a constant dry mass was reached.

Initially, the results obtained for the height of the plant and shoot dry mass, as well as the phytotoxicity scores were individually analyzed in each period, for the three species. After the individual analyses, it was observed whether the relationship among the residual mean squares and the periods were lower than 7, for a further joint analysis of the experiments. This was possible only for the strelitzia and parrot's beak, since they show the same evaluation days in each experiment from each period. Afterwards, the data were subjected to analysis of variance through the F test, and the means were compered trough the t test (p>0.05), with the help of the statistical program AgroEstat (Barbosa and Maldonado Jr., 2015).

RESULTS AND DISCUSSION

As to the phytointoxication analysis of ostrich plume plants, only the individual analysis during the first period was conducted (Table 1), since, during the second period, no visual injury to the ostrich plume plants was observed, making it impossible to conduct a joint analysis of the data.

Table 1 shows that the ostrich plume plants showed mild symptoms of injury across all tested treatments since the first evaluation, and the herbicide bentazon offered greater phytotoxicity during that period. Throughout the evaluations, at 14, 21 and 28 DAA, the phytotoxicity symptoms remained similar, and only from the evaluation conducted at 35 DAA accentuated reductions occurred across all tested treatments.

It is noteworthy that at 42 DAA, the herbicides fluazifop-p-butyl, quizalofop-p-ethyl, sethoxydim and clethodim + fenoxaprop-p-ethyl did not cause any more injuries to the ostrich plume plants, at 49 DAA, all herbicides no longer affected the plants visually. On plants from the same family as ostrich plume, such as ginger (*Zingiber officinale*), the post-emergence application of herbicides fluazifop-p-butyl, quizalofop-p-ethyl, clethodim and fenoxaprop-p-ethyl did not cause the phytointoxication of the young culture (Suwanrak et al., 1999).

For parrot's beak plants, visual symptoms of phytointoxication were recorded on both studied times. At 7 and 14 DAA, it was not

Table 1 - Effect of different herbicides applied post-emergence on ostrich plume plants on the visual phytointoxication percentage. Botucatu/SP, 2012/2013

Treatment	Dose	Phytointoxication (%)						
	(g ha^{-1})	7 DAA[1/]	14 DAA	21 DAA	28 DAA	35 DAA	42 DAA	49 DAA
Fluazifop-p-butyl	87.5	1.5 c	1.8 b	1.8 b	1.5 c	1.3 cd	0.0 b	0.0
Quizalofop-p-ethyl	75	2.3 bc	2.8 b	2.8 b	1.8 c	1.0 d	0.0 b	0.0
Sethoxydim	184	2.5 bc	2.5 b	2.0 b	2.3 bc	1.5 cd	0.0 b	0.0
Quinclorac	375	2.0 bc	2.0 b	2.5 b	3.8 b	2.3 bc	1.5 a	0.0
Chlorimuron-ethyl	15	3.0 b	3.3 b	2.5 b	3.8 b	2.8 b	0.3 b	0.0
Clethodim + fenox.[2/]	37.5+37.5	2.5 bc	2.5 b	1.8 b	2.0 bc	1.5 cd	0.0 b	0.0
Bentazon	720	6.0 a	7.3 a	7.3 a	7.0 a	4.0 a	1.8 a	0.0
Fomesafen	225	2.5 bc	2.5 b	2.5 b	3.3 bc	2.3 bc	1.3 a	0.0
F		7.3 **	10.52 **	10.46 **	8.4 **	5.4 **	17.4 **	-
VC (%)		36.5	35.3	38.9	39.2	40.8	62.0	-
LSD		1.48	1.57	1.63	1.8	1.23	0.54	-

Means followed by the same letter, on the columns, are not statistically different from each other according to the t test (p>0.05). ** significant at 1% of probability. [1/]Days After the Application. [2/]Commercial mix (clethodim + fenoxaprop-p-ethyl).

possible to conduct the joint analysis of both experiments, since, at 7 DAA, o the second period (2013/2014), a score of zero was assigned to all tested treatments, making the joint analysis unfeasible; at 14 DAA, the individual analysis was also conducted, since the mean square of the residue (MSresidue = 12.78) was higher than 7 (Barbosa and Maldonado Jr., 2015).

At 7 DAA, the experiment from the first period (2012/2013) showed significance (p>0.01) among the treatments, and the herbicides that caused higher phytointoxications, in descending order, were: fomesafen, bentazon, quinclorac and clethodim + fenoxaprop-p-ethyl. At 14 DAA, it was observed, for the first period, that the same herbicides from the previous evaluation, except for quinclorac, offered higher phytointoxication, and, during the second period (2013/2014), the same herbicides that caused visual symptoms of injuries during the first period, plus fluazifop-p-butyl, sethoxydim and chlorimuron-ethyl, also caused injuries to the plants (Table 2).

On the evaluations conducted at 21 DAA, on both periods, the joint analysis of the experiments was conducted (MSresidue = 3.70). The interaction of the treatments and the periods was significant, and the herbicides fomesafen and bentazon behaved differently on the studied times. On the other evaluations, a reduction was recorded on the phytointoxication symptoms, however, the same behavior from the fomesafen and bentazon herbicides remained on the evaluations at 28 DAA (MSresidue = 1.69) and 35 DAA (MSresidue = 1.16). However, at the end of the experiments (42 DAA), on both times, a score of zero was assigned to the visual phytointoxication symptoms, that is, the visual aspect of these ornamental plants was not affected (Table 2).

As to strelitzia, no visual symptoms of phytointoxication were observed caused by the herbicide treatments in none of the studies, and a score of zero was assigned in all evaluations. Possibly, the reduced injuries and even the lack of phytointoxication symptoms on the parrot's beak and strelitzia plants may be associated to the large amounts and diversity of waxes deposited on the leaf blade of both species, which may offer a surface that is even more hydrophobic to the sprayed solution, making it harder for the droplets to remain on the leaves, in addition to reducing the herbicide absorption (Meusel et al., 1994).

Table 2 - Effect of different herbicides applied post-emergence on parrot's beak plants on the visual phytointoxication percentage on both studied periods. Botucatu/SP, 2012/2013 and 2013/2014

Treatment	Dose	Phytointoxication (%)					
		7 DAA[1/]		14 DAA		21 DAA	
	(g ha^{-1})	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Fluazifop-p-butyl	87.5	0.00 d	0.0	3.25 c	2.00 a	3.50 cA	3.00 aA
Quizalofop-p-ethyl	75	2.00 d	0.0	4.00 c	0.75 bc	3.50 cA	2.75 abA
Sethoxydim	184	0.00 d	0.0	3.50 c	2.00 a	2.50 cA	3.00 aA
Quinclorac	375	6.25 bc	0.0	3.25 c	0.00 c	2.50 cA	2.00 abA
Chlorimuron-ethyl	15	1.00 d	0.0	3.00 c	1.00 abc	2.25 cA	3.00 aA
Clethodim + fenox.[2/]	37.5+37.5	3.00 cd	0.0	4.50 bc	1.25 ab	3.25 cA	2.75 abA
Bentazon	720	6.50 b	0.0	7.75 b	1.00 abc	6.00 bA	2.00 abB
Fomesafen	225	14.25 a	0.0	16.25 a	1.00 abc	12.25 aA	1.00 bB
F Treatment (T)		17.32 **	-	13.43 **	3.58 **	0,48 ns	
F Time (E)		-	-	-	-	2.07 ns	
F TxE		-	-	-	-	16.69 **	
VC (%)		56.1	-	43.5	61.5	38.8	37.0
LSD		3.37	-	3.60	1.01	1.96	

To be continued ...

Table 2 - Continued...

Treatment	Dose	Phytointoxication (%)					
		28 DAA[1/]		35 DAA		42 DAA	
	($g\ ha^{-1}$)	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Fluazifop-p-butyl	87.5	2.00 cA	2.00 abA	1.25 bA	1.00 aA	0.0	0.0
Quizalofop-p-ethyl	75	2.75 cA	1.75 abA	1.25 bA	1.00 aA	0.0	0.0
Sethoxydim	184	2.00 cA	3.00 aA	1.00 bA	1.25 aA	0.0	0.0
Quinclorac	375	1.50 cA	1.25 bA	0.50 bA	0.50 aA	0.0	0.0
Chlorimuron-ethyl	15	1.75 cA	2.75 aA	0.75 bA	1.00 aA	0.0	0.0
Clethodim + fenox.[2/]	37.5+37.5	2.25 cA	2.25 abA	1.25 bA	1.25 aA	0.0	0.0
Bentazon	720	4.25 bA	2.25 abB	2.25 aA	1.00 aB	0.0	0.0
Fomesafen	225	7.75 aA	1.00 bB	3.00 aA	0.50 aB	0.0	0.0
F Treatment (T)		0.52 ^{ns}		0.69 ^{ns}		-	-
F Time (E)		1.25 ^{ns}		1.95 ^{ns}		-	-
F TxE		14.4 **		5.32 **		-	-
VC (%)		34.82	39.88	42.93	59,63	-	-
LSD		1.33		0.82		-	

Means followed by the same letter, lowercase on the columns and uppercase on the rows, within each evaluation period, are not statistically different from each other according to the t test ($p>0.05$). ** significant at 1% of probability. ^{ns} non-significant. [1/]Days After the Application. [2/] Commercial Mix (clethodim + fenoxaprop-p-ethyl).

As to the growth rate of the different studied species, only parrot's beak and strelitzia, across the studied times, showed a relationship for the mean square of the residue that was lower than 7, that is, 5.92 and 4.69, respectively. According to the analysis of variance conducted for parrot's beak, only a seasonal effect occurred, meaning that, regardless of the time in which the application of the tested treatments was conducted, the growth rate is not affected by the evaluated herbicides (Table 3). For strelitzia, there was an interaction of the time and the tested herbicides, considering that, during the first period, the quinclorac herbicide offered an increase in height of 116% in relation to the control, with no application of herbicides; however, this behavior did not occur during the second period (Table 3). Probably, the increase on the height of strelitzia and ostrich plume plants was caused by the growth regulating effect produced by quinclorac, since it is known that small doses of this herbicide may change the action of quinolinecarboxylic acid, stimulating the production of ethylene, and that, in some plants, this hormone promoted the growth of stems, responsible for the growth regulating effect (Meusel et al., 1994; Lin et al., 2009; Lee et al., 2011)

For ostrich plume, it was not possible to conduct the joint analysis of the experiments, since, during the first period (2012/2013), the study was conducted up to 49 DAA and, on the second period (2013/2014), up to 42 DAA; therefore, it is recommended that the individual analysis of the periods is conducted for this species (Barbosa and Maldonado Jr., 2015). According to the analysis of variance for this species, there was no difference in growth after the application of the herbicides on both times (Table 3).

Table 4 shows the dry masses of the three species on both studied times. Both parrot's beak and strelitzia plants did not show a residual mean square lower than 7: 18.4 and 8.82, respectively, not allowing the joint analysis of the experiments. This fact shows that, regardless of the application time of the tested herbicides, there were no changes in the behavior of the dry mass accumulation on these species (Table 4).

The parrot's beak and strelitzia plants did not suffer significant reductions on their dry mass with the application of the herbicides on the first period (2012/2013); during the second period, this behavior was not similar on both species. For parrot's beak, the fomesafen herbicide significantly increased

Table 3 **-** Effect of different herbicides applied post-emergence, on parrot's beak, strelitzia and ostrich plume plants, on the height growth rate on both studied periods. Botucatu/SP, 2012/2013 and 2013/2014

Treatment	Dose	Growth Rate (cm)					
		parrot's beak		strelitzia		ostrich plume	
	(g ha^{-1})	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Fluazifop-p-butyl	87.5	10.25	2.45	3.25 cA	4.00 aA	6.90	2.12
Quizalofop-p-ethyl	75	9.52	1.80	2.75 cA	2.00 aA	6.25	4.62
Sethoxydim	184	10.50	3.45	5.00 bcA	4.00 aA	4.75	5.37
Quinclorac	375	10.25	4.12	9.75 aA	3.00 aB	8.75	3.50
Chlorimuron-ethyl	15	5.35	3.62	3.50 cA	1.33 aA	4.50	2.50
Clethodim + fenox.[1/]	37.5+37.5	7.20	4.12	3.75 bcA	3.00 aA	8.00	4.00
Bentazon	720	11.27	3.80	4.00 bcA	2.33 aA	3.75	5.25
Fomesafen	225	7.07	4.30	6.50 bA	2.67 aA	5.00	1.75
Control	-	7.12	3.45	4.50 bcA	3.33 aA	5.00	4.62
F Treatment (T)		0.67^{ns}		1.29^{ns}		0.99^{ns}	0.98^{ns}
F Time (E)		42.23 **		6.98 *		-	-
F TxE		1.13^{ns}		2.48 *		-	-
LSD		6.13	2.52	2.78		5.0	3.98

Means followed by the same letter, lowercase on the columns and uppercase on the rows, within each evaluation period, are not statistically different from each other according to the t test (p>0.05). ** significant at 1% of probability. ^{ns} non-significant. [1/] Commercial mix (clethodim + fenoxaprop-p-ethyl).

Table 4 **-** Effect of different herbicides applied post-emergence, on parrot's beak, strelitzia and ostrich plume plants, on the shoot dry mass accumulation on both studied times. Botucatu/SP, 2012/2013 and 2013/2014

Treatment	Dose	Dry Mass (g)					
		parrot's beak		strelitzia		ostrich plume	
	(g ha^{-1})	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Fluazifop-p-butyl	87.5	24.7	9.7 cd	70.6	28.3 bc	21.1	20.9
Quizalofop-p-ethyl	75	23.3	8.2 d	54.5	21.7 cd	24.2	17.9
Sethoxydim	184	19.6	8.8 cd	62.5	16.3 d	24.8	19.2
Quinclorac	375	17.4	13.1 b	56.5	27.1 bc	27.7	18.9
Chlorimuron-ethyl	15	26.4	10.9 bc	58.5	30.2 ab	24.6	20.9
Clethodim + fenox.[1/]	37.5+37.5	19.4	9.9 cd	48.4	33.9 ab	24.8	16.5
Bentazon	720	22.1	9.6 cd	55.6	25.8 bc	29.8	19.8
Fomesafen	225	25.8	16 a	53.7	32.4 ab	25.3	19.9
Control	-	26.3	10.9 bc	72.3	36.9 a	25.9	23.1
F		0.81^{ns}	7.81 **	0.84^{ns}	4.73 **	0.57^{ns}	0.44^{ns}
VC (%)		32.5	16.0	29.2	20.7	25.3	29.0
LSD		10.7	2.5	25.1	8.4	9.3	8.3

Means followed by the same letter, on the columns, are not statistically different from each other according to the t test (p>0.05). ** significant at 1% of probability. ^{ns} non-significant. [1/] Commercial mix (clethodim + fenoxaprop-p-ethyl).

the dry mass at 46.8%, in comparison to the control, and the quizalofop-p-ethyl herbicide reduced the dry mass in 25%, in relation to the control. For the strelitzia plants, also during the second period, the fluazifop-p-butyl, quizalofop-p-ethyl, sethoxydim, quinclorac and bentazon herbicides offered reductions of 24%, 41%, 55%, 26.5% and 30%, respectively. In the case of the production of cut flowers, it is not possible to correlate these dry mass reductions and the quality of the inflorescences. For ostrich plume plants, no significant differences were observed as to the dry mass accumulation on both studied periods (Table 4).

Under the conditions in which the study was conducted, all herbicides, at the tested doses, were selective for the three studied species. The initial phytointoxication of the parrot's beak and ostrich plume plants did not affect their ornamentation at the end of the study. However, special attention must be given to the strelitzia and parrot's beak plants, since, upon the application of the sethoxydim and quizalofop-p-ethyl herbicides, they showed a lower dry mass accumulation. This fact creates some concern, considering the diverging results on both studies and the lack of information in the literature as to how much this dry mass reduction could affect the quality of the harvested product.

In the absence of herbicide records for this branch of horticulture, whose production increases every year, further studies are necessary to better understand the effect of the different molecules available on the market for the most promising species, in addition to making more weed management options available on this area.

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