Revista Ceres
ISSN: 0034-737X
ISSN: 2177-3491
Universidade Federal de Viçosa

Correia, Núbia Maria; Carvalho, Agnaldo Donizete Ferreira de
Post-emergence selectivity of metribuzin to carrot
Revista Ceres, vol. 65, no. 4, July-August, 2018, pp. 314-320
Universidade Federal de Viçosa

DOI: 10.1590/0034-737X201865040003

Available in: http://www.redalyc.org/articulo.oa?id=305257968003

How to cite
Complete issue
More information about this article
Journal's homepage in redalyc.org

Scientific Information System Redalyc
Network of Scientific Journals from Latin America and the Caribbean, Spain and Portugal
Project academic non-profit, developed under the open access initiative

This is an open access article under the CC BY licence Creative Commons

Post-emergence selectivity of metribuzin to carrot

Núbia Maria Correia[1], Agnaldo Donizete Ferreira de Carvalho[1]*

10.1590/0034-737X201865040003

ABSTRACT

When selecting a weed chemical treatment (herbicide, product mixtures, dose, or application timing), an important issue to consider is its selectivity to the crop of commercial interest. The objective of this study was to evaluate the selectivity of the herbicide metribuzin to carrot plants as a function of genotype, dose, and plant growth stage at the time of application. Two experiments were carried out, one in a greenhouse and another in the field. The greenhouse experiment was arranged in a completely randomized, 5 x 2 x 3 factorial design, with four replications. Metribuzin doses (0, 72, 96, 144, and 192 g ha^{-1}) were sprayed on plants with 2-3 and 4-5 true leaves of the cultivars Maestro, BRS Planalto, and Verano. Cultivar Maestro was cultivated in the field in a 2 x 5 factorial experiment in randomized complete block design, with four replications. Carrot plants, at two stages of development (2 and 5 true leaves), were sprayed with the same doses of metribuzin applied in the greenhouse experiment. Metribuzin, regardless of application time and dose tested, was selective for cultivars BRS Planalto and Verano (greenhouse) and Maestro (both greenhouse and field), without reduction in quality and yield of roots.

Keywords: phytotoxicity; *Daucus carota* L.; tolerance.

RESUMO

Seletividade do herbicida metribuzin para cenoura quando pulverizado em pós-emergência

A escolha do tratamento químico (herbicida, associações de produtos, dosagem ou época de aplicação) deve considerar a sua seletividade para a cultura de interesse econômico. Por isso, objetivou-se estudar a seletividade do herbicida metribuzin para plantas de cenoura, em função do genótipo, dosagem do produto e estádio de desenvolvimento das plantas no momento da aplicação. O trabalho englobou a realização de dois experimentos, um em casa de vegetação e outro em campo em área de produção comercial. Em casa de vegetação, o delineamento experimental foi o inteiramente casualizado, em esquema fatorial 5 x 2 x 3, com quatro repetições. O metribuzin (nas dosagens 0, 72, 96, 144 e 192 g ha^{-1}) foi pulverizado em plantas com 2-3 e 4-5 folhas verdadeiras das cultivares Maestro, BRS Planalto e Verano. Em campo, foi instalado um experimento com a cultivar Maestro, no delineamento de blocos ao acaso, em esquema fatorial 2 x 5, com quatro repetições. As plantas de cenoura, em dois estádios de desenvolvimento (2 e 5 folhas verdadeiras), foram pulverizadas com as mesmas dosagens de metribuzin do experimento em casa de vegetação. O herbicida metribuzin, independentemente da época de aplicação ou da dosagem testada, foi seletivo para as cultivares BRS Planalto e Verano (em casa de vegetação) e Maestro (em casa de vegetação e campo), não ocasionando depreciação na qualidade e na produtividade das raízes.

Palavras-chave: fitointoxicação; *Daucus carota* L.; tolerância.

Submitted on April 04th, 2017 and accepted on July 10th, 2018.

[1] Embrapa Hortaliças, Brasília, Distrito Federal, Brazil. nubia.correia@embrapa.br; agnaldo.carvalho@embrapa.br

* Corresponding author: nubia.correia@embrapa.br

INTRODUCTION

One of the biotic factors responsible for reduction in the yield and quality of carrot roots is the occurrence of weeds, reaching up to 100% of losses (Coelho *et al.*, 2009; Zagonel *et al.*, 1999; Swanton *et al.*, 2010). Besides reducing the yield and quality of the harvested product, weeds serve as a host for insects, nematodes, and disease (Alvarez & Hutchinson, 2005; Boydston *et al.*, 2008).

Herbicide application has been an alternative for weed control in carrot. However, despite its many advantages, chemical control requires a series of precautions to be followed in order to ensure satisfactory results, such as to select correctly the product and dose, technology of application, and edaphoclimatic conditions. The herbicide selectivity to the crop also must be evaluated and taken into account, as it is the basis of the success of weed chemical control in crop production (Oliveira Jr. & Inoue, 2011).

Selectivity is a measure of the differential response of several plant species to a given herbicide. The greater the difference between the tolerance of the crop and the tolerance of the weed, the safer the application (Oliveira Jr. & Inoue, 2011). This characteristic is not always attributed to the herbicide itself, but to the dose applied and the growth stage of the plants. Soil, climate, and adjuvants may also change the selectivity level and sometimes the sensitivity varies with the genetic material (Alterman & Jones, 2003).

The main hindrance to herbicide use in carrot in Brazil is the few products registered for the crop - only five, so far (Agrofit, 2018; Rodrigues & Almeida, 2011). Of these, three (clethodim, fenoxaprop-p-ethyl, and fluazifop-p-butyl) are recommended for post-emergence application, one for pre-emergence (trifluralin), and one (linuron) for pre-or post-emergence. Four (clethodim, fenoxaprop-p-ethyl, fluazifop-p-butyl, and trifluralin) are recommended for the control of monocotyledonous species mainly and only one (linuron) for the control of eudychotyledons (Agrofit, 2018; Rodrigues & Almeida, 2011). There is a lack of herbicides for the control of eudychotyledonous weed (broad leaves) in the carrot crop, either before or after emergence. Therefore, most Brazilian carrot producers use the herbicide metribuzin to complement the control of these species by linuron. In other countries, metribuzin is also used as an alternative to linuron and prometryn (Jensen *et al.*, 2004).

Metribuzin inhibits the electron transport in photosystem II at the photochemical stage of photosynthesis. It belongs to the chemical group triazinones and has the chemical name 4-amino-6-tert-butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one. Metribuzin is registered for the control of pre-emergence or post-emergence weed in asparagus, potato, coffee, sugarcane, cassava, soybean, tomato, and wheat, with doses from 144 to 1,920 g ha^{-1} (Rodrigues & Almeida, 2011). In commercial carrot production, doses from 96 to 144 g ha^{-1} are sprayed once or twice until the crop canopy covers de soil. At these doses, metribuzin has no residual effect in the soil, acts in post-emergence and does not inhibit the emergence of new weed.

From the foregoing, therefore, the study considers the hypothesis that the selectivity of the herbicide metribuzin to carrot crop depends on the spraying dose, plant growth stage, and the genetic material. It aims to evaluate the selectivity of metribuzin to carrot, as a function of genotype, dose of application, and growth stage at the time of application.

MATERIAL AND METHODS

Two experiments were carried out: one in a greenhouse in the Experimental Field Sector of EMBRAPA Hortaliças, Brasília, DF, Brazil and, another in a commercial carrot production area of in the municipality of Cristalina, GO, Brazil.

The greenhouse experiment was arranged in a completely randomized, 5 x 2 x 3 factorial design, with four replications, from March 26 to July 9, 2015. The herbicide metribuzin, at the doses 0, 72, 96, 144 and 192 g ha^{-1} was sprayed on plants with 2-3 and 4-5 true leaves of the cultivars Maestro, BRS Planalto, and Verano.

The carrot cultivars were selected based on possible genetic differences among them. Maestro and Verano are hybrids currently in great use in the Winter and Summer crops, respectively. BRS Planalto is an open pollinated cultivar derived directly from cultivar Brasília, which was the main carrot cultivar grown in Summer in Brazil.

The commercial product used in both experiments has 480 g L^{-1} of metribuzin in the form of Suspension Concentrate (SC), and toxicological class III (moderately toxic).

Each experimental unit consisted of a 5 L plastic pot filled with substrate. The mixture soil, sand, and vegetable compost was used as substrate in the ratio of 3:1:1, respectively. Twenty carrot seeds were evenly distributed over the soil surface and incorporated up to 2 cm deep. Later, thinning was carried out to keep two plants per pot.

Each pot was placed in a plastic pot of larger diameter and without holes to maintain the water regime of the plots. The soil moisture was controlled daily, and the water was replaced in the bigger pots whenever necessary.

The herbicide was applied in post-emergence, using a backpack CO_2 pressurized sprayer equipped with two flat jet nozzles TTI 110015, maintaining a constant pressure of 2.8 kgf cm^{-2}, spaced 0.5 m and with a spray volume

Table 1: Leaf number, date, time, soil characteristics, and climate conditions at the time of herbicide application in greenhouse and field experiments of carrot tolerance to herbicide metribuzin

Location	Leaf number	Date	Time	Temperature (°C)		Relative air humidity (%)	Wind speed (km h^{-1})	Cloud cover (%)	Humidity
				Air	Soil				
Greenhouse	2-3	04/28	7:55-8:25	23.9-25.0	22.5-22.5	72-68	0	0	Moistured
	4-5	05/12	7:50-8:25	18.8-20.4	18.5-20.5	87-86	0	0	Moistured
Field	2	08/06	8:40-9:05	20.0-21.0	15.5-16.5	56-50	5.0-4.5	0	Moistured
	5	08/24	8:30-8:55	24.0-24.3	19.5-20.5	46-44	5.2	0	(1) Moistured 5-10 cm

(1) Dry soil on the surface (0 to 5 cm).

equivalent to 200 L ha^{-1}. Table 1 shows the carrot growth stages, date, time, and soil and climate conditions at the time of the greenhouse and field applications.

Possible visual symptoms of phytotoxicity were evaluated at 7, 14, and 28 days after herbicide application (DAA), by grading with a 0 - 100% scale, where zero is the absence of visual injuries, and 100 is the plant death (SBCPD, 1995).

At 105 days after sowing, the plants were removed from the pots and separated into shoots and roots. The roots were weighed to obtain the fresh matter of root per plant, and had the length and diameter measured. The height and fresh matter of the shoots were also determined.

In the field, an experiment was conducted with cultivar Maestro, from July 06 to November 11, 2015. The area is located between 16º13’20.1’’ S latitude and 47º28’06.7’’ W longitude, with 988 m altitude. According to the classification of Köeppen, the climate of the region is tropical humid (type Aw), with dry winter (Cardoso *et al.*, 2014). The soil of the experimental area is representative of the region, classified as heavy-clay Dark Red Latosol, with granulometric composition containing 690 g kg^{-1} clay, 268 g kg^{-1} silt, and 42 g kg^{-1} sand; and organic matter content of 2.7 dag kg^{-1}.

The experiment was arranged in a 2 x 5 factorial in randomized complete block design, with four replications. Carrot plants, at two stages of development (2 and 5 true leaves), were sprayed with five doses of the herbicide metribuzin (0, 72, 96, 144, and 192 g ha^{-1}).

Carrot was sown on 1.4 m wide beds spaced 0.4 m apart. Mechanized seeding distributed seeds in three triple rows (0.1 m between single rows) and the triple rows were spaced 0.4 m apart. For starter fertilization, 2,000 kg ha^{-1} of the NPK formulation 03-35-06 was applied. After carrot emergence, cover fertilization of 57 kg ha^{-1} K_2O was carried out in the form of potassium chloride at 35, 45, 60, and 75 days after sowing.

The plots consisted of 1.4 m wide (three triple rows) and 2.0 m long, with the three central triple rows (1.0 m length making 1.4 m^2) as harvest area.

The herbicide was applied using a backpack CO_2 pressurized sprayer equipped with three flat jet nozzles TTI 110015, maintaining a constant pressure of 2.8 kgf cm^{-2}, spaced 0.5 m and with a spray volume equivalent to 200 L ha^{-1}.

All the plots were kept weed-free up to carrot harvest, removing by hand escapes from the chemical control and all weeds in the treatment without herbicide (zero dose).

Possible injuries observed in carrot plants were evaluated at 15, 30, and 45 days after herbicide application (DAA), by grading with a 0 - 100% scale, where zero is the absence of visual injuries, and 100 is the plant death (SBCPD, 1995).

All roots from the harvest area were hand picked, sorted into commercial and discard, counted, and weighed to determine the amount of root fresh matter per plot. Production was estimated as t ha^{-1} and the amount of commercial, discard, and total roots (commercial + discard) as thousand units ha^{-1} (thou un ha^{-1}). Roots classified as discard showed diameter below 3.5 cm, deformation, green shoulder, cracks, or insect attack.

Data from production and amount of commercial and discard roots per plot were used to calculate the fresh matter of commercial and discard root per plant. Shoot fresh matter of 10 plants (kg), length (cm), and diameter (mm root^{-1}) of ten roots were also calculated.

The data obtained in each experiment were analyzed by the F test of the analysis of variance. The significant effects of the treatments or their interaction were compared by the Tukey test at 5% of probability or by polynomial fit to data. The statistical program Sisvar (Ferreira, 2011) was used for the analyses.

RESULTS AND DISCUSSION

In the greenhouse experiment, the application of metribuzin on 2-3 leaf plants caused slight visual injuries (up to 3%) to the cultivars Maestro and BRS Planalto, but only at 7 DAA, since the symptoms were not observed at 14 DAA (Tables 2 and 3). However, the 4-5 leaf plants of the three cultivars showed no visible damage. In this regard, Jensen *et al.* (2004) reported that phytotoxicity symptoms caused by metribuzim (280 g ha^{-1}) in carrot depended on the cultivar and the growth stage of the plants at the time of application. After 3 leaves, the visual injuries were very slight or did not occur, but from the cotyledonary stage to 2 true leaves, the lesions were more severe. In turn, Bellinder *et al.* (1997) found no correlation between the carrot tolerance to metribuzin and the increase in leaf number, since the results were variable and transient.

The low or nil visual phytotoxic action of metribuzin reflected on plant development of the three cultivars, because the herbicide did not affect any trait evaluated (Table 2). However, the cultivars differed in relation to fresh matter and length of roots, fresh matter and shoot height. In this sense, plants of Verano and BRS Planalto had greater root and shoot growth than the cultivar Maestro (Table 4). Still, these results did not depend on the metribuzin dose or the application time. These are, then, differences among the genetic materials studied.

In the field experiment, metribuzin, irrespective of the dose (up to 192 g ha^{-1}) and the plant growth stage (2 and 5 leaves), did not cause visual phytotoxicity and did not compromise yield and the amount of commercial and discard roots, root diameter and fresh matter of shoot and

Table 3: Phytotoxicity (%) of three carrot cultivars sprayed at 2-3 and 4-5 leaf stages, based on the average of five metribuzin doses (0, 72, 96, 144, and 192 g ha^{-1})

Cultivar	Leaf number	
	2-3	4-5
	Phytotoxicity (%)	
Maestro	2.50 b B[(1)]	0.00 a A
BRS Planalto	3.00 b B	0.00 a A
Verano	0.00 a A	0.00 a A
DMS (in row)	1.79	
DMS (in column)	2.16	

[(1)] Based on Tukey's test at 5% probability: means followed by small letters in the columns compare the cultivars within each stage of development, and capital letters in the rows compare the stages within each cultivar.

Table 2: F test of analysis of variance for phytotoxicity at 7 and 14 days after application (DAA) of the herbicide metribuzin, root fresh matter, root length and diameter, shoot fresh matter, and shoot height of three carrot cultivars sprayed at two growth stages (2-3 and 4-5 leaves) with five doses of the herbicide

Source of variation	Phytotoxicity		Root			Shoot	
	7 DAA	14 DAA	Fresh matter	Length	Diameter	Fresh matter	Heigth
Cultivar	3.15*	0.64	13.99**	13.62**	0.23	7.64**	4.92**
Time	12.31**	2.57	8.61	6.36	1.18	1.07	11.79
Dose	1.69	1.14	0.62	1.25	0.64	1.09	0.56
Cultivar x time	3.15*	0.64	1.18	0.26	0.44	0.11	0.20
Cultivar x dose	1.12	0.82	1.07	0.75	1.84	0.74	1.62
Time x dose	1.69	1.14	0.43	0.41	1.03	1.14	0.36
Culivar x time x dose	1.12	0.82	0.93	1.57	1.00	0.49	0.39
CV (%)	31.28	68.13	19.21	11.60	8.22	24.88	7.74
Overall mean	(%)		(g plant^{-1})	(cm)	(mm)	(g plant^{-1})	(cm)
	0.92	0.25	73.41	13.56	29.18	31.63	52.92

**, * Significant at 1% and 5% probability levels, respectively, by the F test of the analysis of variance.

ns Non-significant by the F test of the analysis of variance.

root per plant. These findings corroborate the results of the greenhouse experiment and other studies. Pacanoski *et al.* (2014) observed that pre-emergence metribuzin (350 g ha^{-1}) caused no visual damage to the plants and yield losses in carrot cv. Nantes. In another study, metribuzin (280 g ha^{-1}) application to 3 to 5-leaf plants was selective to cultivars Dominator and Caro-Choice, with no damage to root yield (Jensen *et al.*, 2004). The same result occurred in Brazil, where metribuzin, sprayed on 3-leaf plants was selective to cv. Nantes, with doses up to 432 g ha^{-1} (Pessoa Carneiro *et al.*, 2017).

Significant effect was found of metribuzin doses on root length and the interaction time x dose on yield and amount of discard roots (Tables 5 and 6). When the herbicide was applied at the second true leaf stage, there was no significant difference between metribuzin doses for yield and amount of discard roots (Figure 1). However, at the 5-leaf stage, these characteristics decreased linearly with increase in the herbicide dose. These results are positive, because these roots are discards and their reduction in the field is recommended, with consequent increase in commercial roots, even though in this work we found no increase in yield and quantity of commercial roots with the increase in metribuzin. In addition, root length varied with increasing metribuzin doses (polynomial fit to data), the length increased up to 144 g ha^{-1}, but decreased at the highest dose.

The hypothesis that the selectivity of the herbicide metribuzin to carrot is related to the spraying dose, the plant growth stage, and the genetic material was not

Table 4: Root fresh matter and root length, shoot fresh matter and shoot height of three carrot cultivars sprayed at 2-3 and 4-5 leaf stages, based on the average of five metribuzin doses (0, 72, 96, 144, and 192 g ha^{-1})

Cultivar	Root		Shoot	
	Fresh matter (g plant^{-1})	Length (cm)	Fresh matter (g plant^{-1})	Height (cm)
Maestro	63.89 b[(1)]	27.82 b	51.35 b	12.59 b
BRS Planalto	79.47 a	32.55 a	54.17 a	13.68 a
Verano	76.86 a	34.51 a	53.22 ab	14.42 a
DMS	7.52	4.19	2.18	0.84

[(1)] Means followed by the same letter in the column are not significantly different by the Tukey test at 5% probability.

Tabela 5: Test F of the analysis of variance for yield and amount of marketable and unmarketable roots, and total roots (commercial + discard) of carrot cv. Maestro, depending on the dose and time of metribuzin application

Source of variation	Root yield			Root amount		
	Commercial	Discard	Total	Commercial	Discard	Total
Time	0.12 ^{ns}	0.23 ^{ns}	0.02 ^{ns}	0.01 ^{ns}	0.50 ^{ns}	0.20 ^{ns}
Dose	0.65 ^{ns}	1.69 ^{ns}	1.49 ^{ns}	1.10 ^{ns}	1.41 ^{ns}	1.32 ^{ns}
Time x dose	0.65 ^{ns}	5.21**	1.09 ^{ns}	0.64 ^{ns}	3.84*	1.31 ^{ns}
CV (%)	10.50	17.83	7.89	11.34	19.21	9.35
Overall mean	(t ha^{-1})			(thou. uni. ha^{-1})		
	54.02	14.95	68.97	476.11	251.25	727.36

$^{**, *}$ Significant at 1% and 5% probability levels, respectively, by the F test of the analysis of variance.

^{ns} Non-significant by the F test of the analysis of variance ($p \geq 0.05$).

Table 6: Test F of analysis of variance for fresh matter of commercial and discard roots per plant, root diameter and root length of carrot cv. Maestro and fresh matter of shoot of ten plants, depending on the dose and time of metribuzin application

Source of variation	Root fresh matter per plant		Root diameter	Root length	Shoot fresh matter
	Commercial	Discard			
Time	0.43 ^{ns}	0.19 ^{ns}	0.18 ^{ns}	0.01 ^{ns}	0.20 ^{ns}
Dose	0.34 ^{ns}	0.54 ^{ns}	1.16 ^{ns}	5.02**	2.28 ^{ns}
Time x dose	0.06 ^{ns}	0.29 ^{ns}	2.26 ^{ns}	0.42 ^{ns}	3.64 ^{ns}
CV (%)	7.12	15.52	4.88	4.61	15.36
Overall mean	(g)		(mm)	(cm)	(kg)
	113.82	60.46	28.72	19.12	0.25

** Significant at the 1% probability level by the F test of the analysis of variance.

^{ns} Non-significant by the F test of the analysis of variance ($p \geq 0.05$).

supported by the present study at doses up to 192 g ha^{-1}, since the growth of cultivars Maestro, BRS Planalto, and Verano was not inhibited by the herbicide. This result was confirmed in the field for cultivar Maestro. However, metribuzin at higher doses can cause severe phytotoxicity symptoms to carrots, depending on the genotype, and affect plant growth (Jensen *et al.*, 2004). The differential tolerance among cultivars to metribuzin can be attributed to differences in the metribuzin metabolism rate to the polar metabolite β-D-N-glucoside (Falb & Smith, 1987; Smith *et al.*, 1989) during the early growth stages, which may disappear with increasing number of leaves (Stephenson *et al.*, 1976; Jensen *et al.*, 2004).

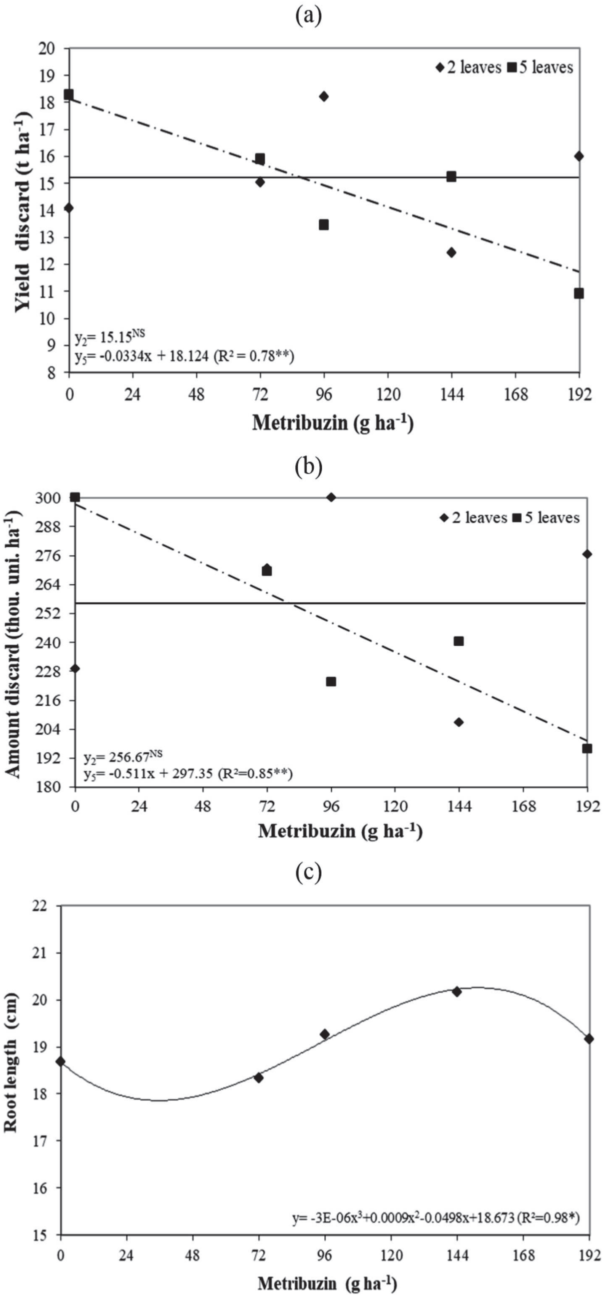

Figure 1: Yield (a) and amount (b) of discard roots of carrot cv. Maestro sprayed with the herbicide metribuzin at the doses 0, 72, 96, 144, and 192 g ha^{-1} at 2 and 5 leaf stages, and root length (c), all as a function of herbicide doses.

CONCLUSION

The herbicide metribuzin sprayed at the 2 to 5-leaf growth stages of carrot at doses up to 192 g ha^{-1} was selective to the cultivars Maestro, BRS Brasília, and Verano.

ACKNOWLEDGEMENTS

The authors want to thank Agrícola Wehrmann and HF manager Eng. Agr. Luciano Brito, who lent the areas for implementation of the field experiment.

REFERENCES

AGROFIT (2018) Ministério da Agricultura, Pecuária e Abastecimento. Consulta de produtos formulados, 2018. Disponível em: <http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons> Acessado em: 27 de julho de 2018.

Alterman MK & Jones AP (2003) Herbicidas: Fundamentos fisiológicos y bioquímicos del modo de acción. Santiago, Ediciones Universidad Católica del Chile. 333p.

Alvarez JM & Hutchinson PJS (2005) Managing hairy nightshade to reduce potato viruses and insect vectors. Outlooks on Pest Management Journal, 16:249-252.

Bellinder RR, Kirkwyland JJ & Wallace RW (1997) Carrot (*Daucus carota*) and weed response to linuron and metribuzin applied at different crop stages. Weed Technology, 11:235-240.

Boydston RA, Mojtahedi H, Crosslin JM, Brown CR & Anderson T (2008) Effect of hairy nightshade (*Solanum sarrachoides*) presence on potato nematode, disease, and insect pests. Weed Science, 56:151-154.

Cardoso MR, Marcuzzo FF & Barros JR (2014) Classificação climática de Köppen-Geiger para o estado de Goiás e Distrito Federal. Acta Geográfica, 8:40-55.

Coelho M, Bianco S & Carvalho LB (2009) Interferência de plantas daninhas na cultura da cenoura (*Daucus carota*). Planta Daninha, 27:913-920.

Falb LN & Smith AE (1987) Metribuzin metabolism in soybeans: partial characterization of the polar metabolites. Pesticide Biochemistry and Physiology, 27:165-172.

Ferreira DF (2011) Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia, 35:1039-1042.

Jensen KIN, Doohan DJ & Specht EG (2004) Response of processing carrot to metribuzin on mineral soils in Nova Scotia. Canadian Journal of Plant Science, 84:669-676.

Oliveira Jr RS & Inoue MH (2011) Seletividade de herbicidas para culturas e plantas daninhas. In: Oliveira Jr RS, Constantin J & Inoue MH (Ed.) Biologia e manejo de plantas daninhas. Curitiba, Omnipax. p.243-262.

Pacanoski Z, Týr S & Veres T (2014) Effects of herbicides and their combinations in carrots production regions in the Republic of Macedonia. Herbologia, 14:47-60.

Pessoa Carneiro GDO, Silva GS, Barbosa AR, Silva DV & Reis MR (2017) Selectivity of metribuzin in postemergence of culture of carrot. Planta Daninha, 35:01-06.

Rodrigues BN & almeida FLS (2011) Guia de herbicidas. 6ª ed. Londrina, Edição dos autores. 697p.

Smith AE, Phatak SC & Emmatty DA (1989) Metribuzin metabolism by tomato cultivars with low, medium, and high levels of tolerance to metribuzin. Pesticide Biochemistry and Physiology, 35:284-290.

SBCPD - Sociedade Brasileira da Ciência das Plantas Daninhas (1995) Procedimentos para instalação, avaliação e análise de experimentos com herbicidas. Londrina, SBCPD 42p.

Stephenson GR, Mcleod JE & Phatak SC (1976) Differential tolerance of tomato cultivars to metribuzin. Weed Science, 24:161-165.

Swanton CJ, O'Sullivan J & Robinson DE (2010) The critical weed-free period in carrot. Weed Science, 58:229-233.

Zagonel J, Reghin MY & Venâncio WS (1999) Controle pós-emergente de plantas daninhas em cenoura. Horticultura Brasileira, 17:69-71.