Spray temperature and spray volume influence on the efficacy of carfentrazone-ethyl and saflufenacil to control morning-glory

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ABSTRACT

The objective of this research was to relate the response of *Ipomoea hederifolia* and *Ipomoea quamoclit* with the variation of spray temperature and spray volume of carfentrazone-ethyl and saflufenacil. Two pot-experiments were carried out to relate the spray temperatures (10, 20, and 30 °C) and spray volumes (150, 200, and 250 L ha⁻¹) with the plant dry mass accumulation after application of 2 mL ha⁻¹ and 0.5 g ha⁻¹ of the labeled herbicide with carfentrazone-ethyl (Aurora®) and saflufenacil (Heat®). Fourteen days after application, shoot dry mass was determined. Data were expressed in relation to the herbicide-free check and submitted to linear regression analysis. Increasing 10 L ha⁻¹ in spray volume reduces 1.34% of the dry mass of both species, by using carfentrazone-ethyl, and 2.32% and 1.93% of the dry mass of *I. hederifolia* and *I. quamoclit*, respectively, by using saflufenacil. In addition, increasing 1 °C in spray temperature reduces 0.22% and 0.35% of the dry mass of *I. hederifolia* and *I. quamoclit*, respectively, by using carfentrazone-ethyl, and 0.56% and 0.30% of those species, respectively, by using saflufenacil. The efficacy of carfentrazone-ethyl and saflufenacil to control *I. hederifolia* and *I. quamoclit* is dependent on both spray temperature and spray volume. The use of spray temperature next to 30 °C and spray volume next to 250 L ha⁻¹ can provide a better control of those species.

Keywords: PPO inhibitors, herbicides, spray characteristics.

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INTRODUCTION

Morning-glory species (*Ipomoea* spp.) commonly infest agricultural areas in Brazil (Kuva et al. 2007, Ferreira et al. 2011, Giancotti et al. 2014), providing indirectly interference on the crop productivity by machinery blocking during mechanical harvesting, in addition to the direct interference on crops by competition for environmental resources (Carvalho et al. 2009, Carvalho et al. 2014). Among several morning-glory species, *Ipomoea hederifolia* and *Ipomoea quamoclit* have been two of the major weeds occurring in sugar cane, soybean, maize, and other crops (Agostineto et al., 2015). To control morning-glory species, herbicides inhibiting the enzyme protoporphyrinogen oxidase (PPO) such as carfentrazone-ethyl and saflufenacil, are been recommended (MAPA 2014a,b).

The application of pesticides under inadequate spray conditions affects the efficacy of the agrochemicals on controlling pests (Nicolai and Christoffoleti 2014). In this way, spray volume and spray temperature can play an important role on the efficacy of herbicides to control weeds, as observed by Downer et al. (1998), Galon et al. (2007), Cunha et al. (2010), Campos et al. (2011), among others. Thus, the objective of this research was to relate the response of *I. hederifolia* and *I. quamoclit* with the variation of spray temperature and spray volume of carfentrazone-ethyl and saflufenacil.

MATERIAL AND METHODS

Two pot-experiments were carried out to study the role of spray temperature and spray volume on the efficacy of carfentrazone-ethyl and saflufenacil to control morning-glory. In both experiments, young plants of *I. hederifolia* and *I. quamoclit* grew during October and December 2014 in 5-L pots filled with a mixture of soil and organic substrate in a 4:1 proportion (v:v). Before sowing, 2 g of NPK (5-20-10) and 3 g of urea were applied. After sowing, plants were daily irrigated with 150 mL of water. Two plants grew in each pot and the pots were maintained under environmental conditions during the experiment (that are repeated twice for each experiment).

In the experiment on spray temperature, treatments consisted of a 2x3 factorial scheme, where we tested two morning-glory species (*I. hederifolia* and *I. quamoclit*) and three spray volumes (150, 200, and 250 L ha⁻¹), maintaining a herbicide-free check, arranged in a completely randomized design with four replicates.

In the experiment on spray volume, treatments consisted of a 2x3 factorial scheme, where we tested two morning-glory species (*I. hederifolia* and

I. quamoclit) and three spray temperatures (10, 20, and 30 °C), maintaining a herbicide-free check, arranged in a completely randomized design with four replicates.

For both experiments, 2 mL ha⁻¹ and 0.5 g ha⁻¹ of the labeled herbicide, respectively for carfentrazone-ethyl (Aurora®, 400 g ai L⁻¹, FMC, Brazil) and saflufenacil (Heat®, 700 g ai kg⁻¹, Basf, Brazil), were sprayed using a CO₂-pressurized sprayer equipped with flat plan nozzles (TeeJet, 80.02, USA). The herbicide doses were determined in previous experiments (Agostineto et al. 2015), choosing sub-lethal doses causing differences on the plant-response.

Fourteen days after herbicide application, plants were cut off close to soil and dried for 96 h in a forced air oven at 60 °C. After drying, plant material was weighted in an analytical balance (0.001 g) for dry mass determination.

Data were submitted to linear regression analysis performed by using SigmaPlot® (Systat, version 10.0, USA).

RESULTS

Spray volume. The ANOVA was not significant ($P > 0.05$) to plant species, indicating that both *I. hederifolia* and *I. quamoclit* responded similarly to carfentrazone-ethyl spraying when spray volume was increased. Therefore, just one equation provided the relation between the increasing of spray volume and the effect on the decreasing of dry mass of both species (Figure 1). According to the equation, increasing 10 L ha⁻¹ in spray volume reduces 1.34% of the dry mass, indicating that high spray volume provide higher efficacy of carfentrazone-ethyl to control both species.

Figure 1. Relation between the percentage of dry mass of *Ipomoea hederifolia* and *Ipomoea quamoclit*, compared to a herbicide-free check, and the spray volume applied with carfentrazone-ethyl (Aurora®, 400 g ai L⁻¹, FMC, Brazil). Vertical lines indicate the standard error of the mean of four replicates.

The ANOVA was significant ($P < 0.05$) to plant species, indicating that *I. hederifolia* and *I. quamoclit* responded differently to saflufenacil spraying when spray volume increased, so that two equations were required to provide the relation between the increasing of spray volume and the effect on the decreasing of dry mass of both species (Figure 2). According to the equation, increasing 10 L ha⁻¹ in spray volume reduces 2.32% and 1.93% of the dry mass of *I. hederifolia* and *I. quamoclit*, respectively, indicating that high spray volume provide higher efficacy of saflufenacil to control morning-glory species and this augmenting provides a better control of *I. quamoclit* in the same way that *I. quamoclit* is better controlled than *I. hederifolia* using this herbicide.

Figure 2. Relation between the percentage of dry mass of *Ipomoea hederifolia* and *Ipomoea quamoclit*, compared to a herbicide-free check, and the spray volume applied with saflufenacil (Heat®, 700 g ai kg⁻¹, Basf, Brazil). Vertical lines indicate the standard error of the mean of four replicates.

Spray temperature. The ANOVA was significant ($P < 0.05$) to plant species, indicating that *I. hederifolia* and *I. quamoclit* responded differently to carfentrazone-ethyl spraying when spray temperature increased, so that two equations were required to provide the relation between the increasing of spray temperature and the effect on the decreasing of dry mass of both species (Figure 3). According to the equation, increasing 1 °C in spray temperature reduces 0.22% and 0.35% of the dry mass of *I. hederifolia* and *I. quamoclit*, respectively, indicating that high spray temperature provide higher efficacy of saflufenacil to control morning-glory species and this augmenting provide a better control of *I. hederifolia* than *I. quamoclit* in spite of *I. hederifolia* is better controlled than *I. quamoclit* using this herbicide.

The ANOVA was significant ($P < 0.05$) to plant species, indicating that *I. hederifolia* and *I. quamoclit* responded differently to saflufenacil spraying when spray temperature increased, so that two equations

were required to provide the relation between the increasing of spray temperature and the effect on the decreasing of dry mass of both species (Figure 4). According to the equation, increasing 1 °C in spray temperature reduces 0.56% and 0.30% of the dry mass of *I. hederifolia* and *I. quamoclit*, respectively, indicating that high spray temperature provide higher efficacy of saflufenacil to control morning-glory species and this augmenting provides a better control of *I. hederifolia* than *I. quamoclit* in the same way that *I. hederifolia* is better controlled than *I. quamoclit* using this herbicide.

Figure 3. Relation between the percentage of dry mass of *Ipomoea hederifolia* and *Ipomoea quamoclit*, compared to a herbicide-free check, and the spray temperature applied with carfentrazone-ethyl (Aurora®, 400 g ai L⁻¹, FMC, Brazil). Vertical lines indicate the standard error of the mean of four replicates.

Figure 4. Relation between the percentage of dry mass of *Ipomoea hederifolia* and *Ipomoea quamoclit*, compared to a herbicide-free check, and the spray temperature applied with saflufenacil (Heat®, 700 g ai kg⁻¹, Basf, Brazil). Vertical lines indicate the standard error of the mean of four replicates.

DISCUSSION

By using non-lethal doses of carfentrazone-ethyl and saflufenacil, we observed that the increase of both

spray volume and spray temperature provide a better control of *I. hederifolia* and *I. quamoclit*. In spite of not being the objective of applying herbicides to control weeds, the use of non-lethal doses, in this research, did not interfere with the effect of the spray volume and the spray temperature due to be a threshold dose between the surviving of the plant death. If higher doses were used, plants could be rapid killed and the desired effect of treatments, probably, were masked.

Studies of Campos et al. (2011), testing two spray volumes (200 and 400 L ha⁻¹) and three herbicides (glyphosate, paraquat+diuron, and glufosinate), they concluded that there was the highest efficacy using spray volumes lower than 200 L ha⁻¹ and, in general, spray volumes higher than 400 L ha⁻¹ are not recommended as well as lower than 100-150 L ha⁻¹. According to Galon et al. (2007), for contact herbicides, there is generally needed high spray volumes, as observed in this research, since herbicide efficacy is dependent on the covering of leaf surface; while systemic herbicides can be sprayed at plant shoot by using low spray volume.

Spray volume required to an efficient post-emergence control, according to King and Oliver (1992), is dependent on the target weeds, or even the plant age/stage, the herbicide, and the environmental conditions at the time of spraying. Under some situations, the use of adequate management and under specific environmental conditions, reduced spray volumes can be used with an efficient control of weeds (Devlin et al. 1991). However, changes on physico-chemical properties of herbicides have to be considered, can causing negative effects on herbicide penetration and absorption (Willis 1984, Fawcett et al. 1987).

Spray temperature, as well as spray volume, can influence on physico-chemical properties of herbicides (as viscosity, pH, electrical conductivity, and so on), in addition to solubilize epicuticular waxes, facilitating the penetration of some herbicides and, as a consequence, spray herbicide and efficacy of control are improved (Cunha et al. 2010). Downer et al. (1998) report the influence of spray temperature on physico-chemical properties of herbicides affecting on herbicide efficacy due to the effect on the potential of spray drift. Therefore, in all those cases, an adequate use of both spray volume and spray temperature can improve the control of weeds.

CONCLUSION

The efficacy of carfentrazone-ethyl and saflufenacil to control *I. hederifolia* and *I. quamoclit* is dependent on both spray temperature and spray volume. The use of spray temperature next to 30 °C and spray volume

next to 250 L ha⁻¹ can provide a better control of those species.

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RESUMO

Temperatura e volume de calda influenciam na eficácia de carfentrazone-ethyl e saflufenacil para controle de corda-de-violão. O objetivo desta pesquisa foi relacionar a resposta de *Ipomoea hederifolia* e *Ipomoea quamoclit* com a variação na temperatura da calda e no volume de calda de carfentrazone-ethyl e saflufenacil. Dois experimentos em vasos foram conduzidos para relacionar as temperaturas da calda (10, 20 e 30 °C) e os volumes de calda (150, 200 e 250 L ha⁻¹) com o acúmulo de massa seca das plantas após a aplicação de 2 mL ha⁻¹ e 0,5 g ha⁻¹ de herbicida comercial com carfentrazone-ethyl (Aurora®) e saflufenacil (Heat®). Quatorze dias após a aplicação, a massa seca da parte aérea foi determinada. Os dados foram expressos em relação à testemunha sem aplicação de herbicida e submetidos à análise de regressão linear. O aumento de 10 L ha⁻¹ no volume de calda reduziu em 1,34% a massa seca de ambas as espécies, usando carfentrazone-ethyl, e 2,32% e 1,93% da massa seca de *I. hederifolia* e *I. quamoclit*, respectivamente, usando saflufenacil. Além disso, o aumento de 1 °C na temperatura da calda reduziu em 0,22% e 0,35% a massa seca de *I. hederifolia* e *I. quamoclit*, respectivamente, usando carfentrazone-ethyl, e 0,56% e 0,30% da massa seca dessas espécies, respectivamente, usando saflufenacil. A eficácia de carfentrazone-ethyl e saflufenacil para o controle de *I. hederifolia* e *I. quamoclit* é dependente da temperatura da calda e do volume de calda. O uso de temperatura da calda próxima a 30 °C e volume de calda próximo a 250 L ha⁻¹ pode acarretar em melhor controle de ambas as espécies.

Palavras-chave: Inibidores de PROTOX, herbicidas, características da calda.