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EFFECT OF THE APPLICATION OF SUPPOSEDLY ANTAGONISTIC HERBICIDES ON RICE PLANTS SUSCEPTIBLE TO ACCASE INHIBITORS

EFEITO DA APLICAÇÃO DE HERBICIDAS SUPOSTAMENTE ANTAGÔNICOS SOBRE PLANTAS DE ARROZ SUSCETÍVEIS A INIBIDORES DA ENZIMA ACCASE

Renan Souza Silva[a], Edinalvo Rabaioli Camargo[a], Marcus Vinicius Fipke[a], André Andres[b], José Alberto Noldin[c], Nelson Diehl Kruse[d], Luis Antonio de Avila[a]*

[a]Departamento de Fitossanidade, Universidade Federal de Pelotas, Rio Grande do Sul, Brasil. [b]Estação Experimental Terras Baixas, Empresa Brasileira de Pesquisa Agropecuária, Rio Grande do Sul, Brasil. [c]Estação Experimental de Itajaí, Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina, Santa Catarina, Brasil. [d]Departamento de Defesa Fitossanitária, Universidade Federal de Santa Maria, Rio Grande do Sul, Brasil.

***Autor correspondente**: laavilabr@gmail.com.

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ABSTRACT

The control of weedy rice has been widely studied in weed science. However, gene flow from Clearfield rice (CL) to weedy rice has damaged the efficiency of the CL production system. A new rice crop that is resistant to ACCase inhibitor herbicides will be launched in the next year on the market, representing another tool for managing weedy rice in irrigated rice crops. In addition to using this tool, there is a need to increase the spectrum of herbicide treatments to control the diversity of weed species in irrigated rice crops. This study aimed to elucidate the effect of latifolicidal herbicides on the graminicide action of quizalofop on cultivated rice as an indicator plant in the simulation of weedy rice. An experiment was carried out in a greenhouse at the Epagri – Experimental Station of Itajaí, Santa Catarina, Brazil. There was a reduction in the efficiency of rice control for all evaluated doses of quizalofop associated with 2,4-D.

RESUMO

O controle do arroz-daninho tem sido foco de pesquisas na área de herbologia. Contudo, a ocorrência de fluxo gênico do arroz Clearfield (CL) para a espécie daninha tem resultado em perda na eficiencia do sistema de produção CL. Uma nova cultivar de arroz, resistente a herbicidas inibidores da ACCase, será lançada no mercado e se constitui em mais uma ferramenta para o manejo do arroz-daninho em lavouras de arroz irrigado. Aliada a essa ferramenta, existe a necessidade de aumento no espectro dos tratamentos herbicidas para o controle da diversidade de espécies de plantas daninhas infestantes nas lavouras de arroz irirgado. O objetivo deste estudo foi elucidar o efeito de herbicidas latifolicidas na ação graminicida do quizalofop sobre o arroz cultivado como planta indicadora na simulação de arroz-daninho. Foi realizado um experimento, em casa de vegetação na Epagri-Estação Experimental de Itajaí (SC). Os resultados obtidos indicam que houve redução da eficiência de controle do arroz em todas as doses avaliadas das associações de quizalofop com 2,4-D.

1. Introduction

The presence of weeds in irrigated rice crops is one of the main factors that limits productivity (AGOSTINETTO et al., 2010, MATZENBACHER et al., 2013). Weed species that cause the most considerable productivity losses include weedy rice (*Oryza sativa*) (MENEZES et al., 2013) and barnyard grass (*Echinochloa* spp.) (AGOSTINETTO et al. 2010).

The use of rice genotypes resistant to imidazolinone herbicides (Clearfield® System) provides an efficient alternative for the selective control of weedy rice and other species associated with rice cultivation (MARCHESAN et al., 2011; SOUSA; BACARIN; PINTO, 2012; MENEZES et al., 2013).

Provisia™ is an ACCase inhibitor-resistant rice technology that can complement the Clearfield® technology in suppressing grassy weeds (ANDRADE et al., 2018; CAMACHO; WEBSTER; LINSCOMBE, 2019). The potential adoption of ACCase inhibitor-resistant rice cultivars in Brazil requires studies on the possible synergistic or antagonistic effects resulting from mixing ACCase inhibitor herbicides with other action mechanisms. Possible synergisms may include a reduction of the chemical load in the environment (RITZ; STREIBIG, 2014), as well as more effective weed control.

Studies have also shown the antagonistic effects of herbicide interactions on weed control. Abit et al. (2011) obtained better control of large crabgrass (*D. sanguinalis*), giant foxtail (*Setaria faberi*), and green foxtail (*Setaria viridis*) when using a mixture of quizalofop with latifolicides than they did when using quizalofop applied alone. A review by Damalas (2004) noted that antagonism has been the most common interaction reported for latifolicides, resulting in reduced effectiveness among graminicides.

This study aimed to evaluate the effect of latifolicidal herbicides on the graminicide action of quizalofop on cultivated rice (*Oryza sativa*) as an indicator plant for weedy rice.

2. Material and methods

The experiment was conducted in a greenhouse from September to November 2016. Initially, pilot experiments were conducted to define the dose-response curves based on assumptions of possible antagonistic effects. Rice plants belonging to the SCS118 Marques cultivar were administered a mixture of quizalofop (Targa 50 EC, 50 g a.i. L^{-1}, Arysta Lifesciences) with 2,4-D (DMA, 806 g a.i. L^{-1}, Dow Agrosciences) herbicides to verify whether antagonistic, synergistic, or additive interaction would occur.

The experimental units consisted of pots containing 0.5 kg of soil. The experimental design was completely randomized, with 39 treatments consisting of quizalofop and 2,4-D herbicides applied alone or mixed in a tank using the concentrations indicated in Table 1. Rice seeds (*O. sativa*) of the SCS116 Satoru cultivar, which is susceptible to quizalofop, were sown to obtain four plants per pot after thinning. The herbicide treatments were applied when the rice plants had approximately three fully expanded leaves. Application was performed using a CO_2 pressurized sprayer equipped with 11003 fan-type nozzles at an application rate of 150 L ha^{-1}. Sprinkling was performed in the absence of wind, with an average temperature of 25°C and relative humidity of 55%. Daily irrigation ensured that the rice plants had suitable water availability throughout the trial period. Visual evaluation was performed on the 29th day after application (DAA) of herbicides using a rating scale from 0 to 100%, in which 0 represented the absence of symptoms and 100% the death of all plants. On the 29th DAA, the plants were cut at the height of the soil, and the dry mass of the aerial part was determined. Data variance was analyzed using the F test, and means were compared using the Tukey test at a 5% significance level.

Table 1. Dose-response curves (DRC) of quizalofop in association with 2,4-D. Itajaí, Santa Catarina, Brazil, 2016.

	Dose-response curve		
	DRC1	DRC2	DRC3
	2,4-D (g e.a. ha^{-1})		
	0.00	167.5	335
Quizalofop (g i.a. ha^{-1})	0	0	0
	18.75	18.75	18.75
	37.5	37.5	37.5
	75	75	75
	150	150	150
	300	300	300
	600	600	600
	DRC4	DRC5	DRC6
	Quizalofop (g i.a. ha^{-1})		
	0	18.75	37.5
2,4-D (g e.a. ha^{-1})	670	670	670
	1340	1340	1340
	2010	2010	2010
	2680	2680	2680

3. Results and discussion

This study demonstrated changes in the effect of quizalofop since the quizalofop deposited in the leaf cuticle competed for absorption into leaves with the 2,4-D herbicide (Figures 1 and 2). The auxin mimicker acts as a physical barrier to the ACCase inhibitor. This reduces the space available for the two products to penetrate the cuticle, where crystalline epicuticular waxes are arranged irregularly, with the result that the absorption of one herbicide is obstructed by the presence of the other (TAIZ et al., 2017). The herbicide phytotoxicity on the plants of the SCS116 Satoru cultivar increased with increasing concentrations of quizalofop and 2,4-D.

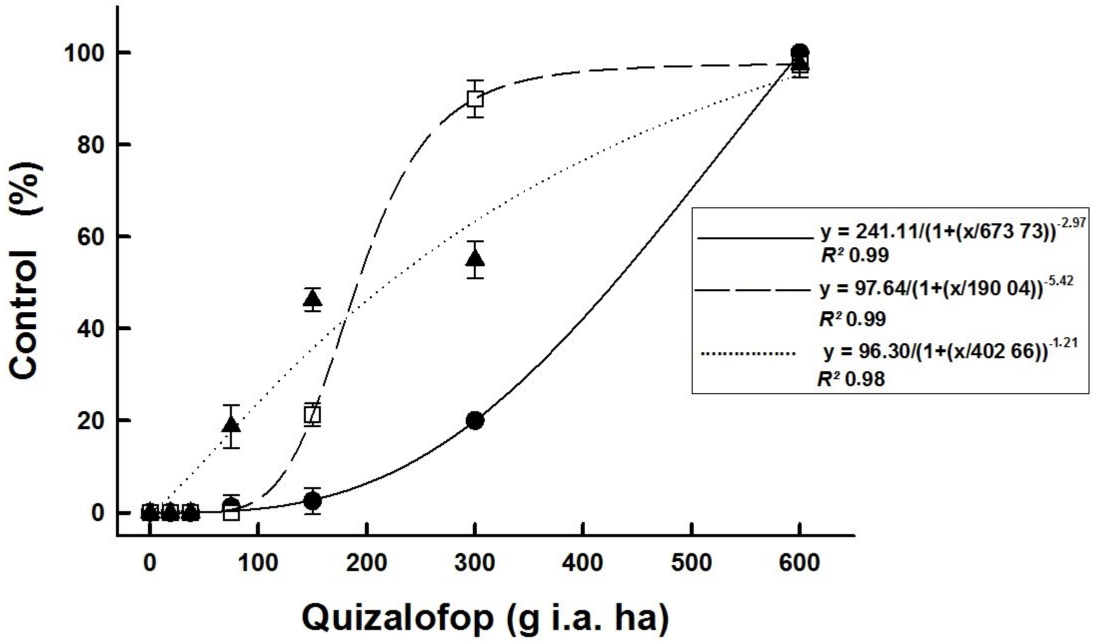
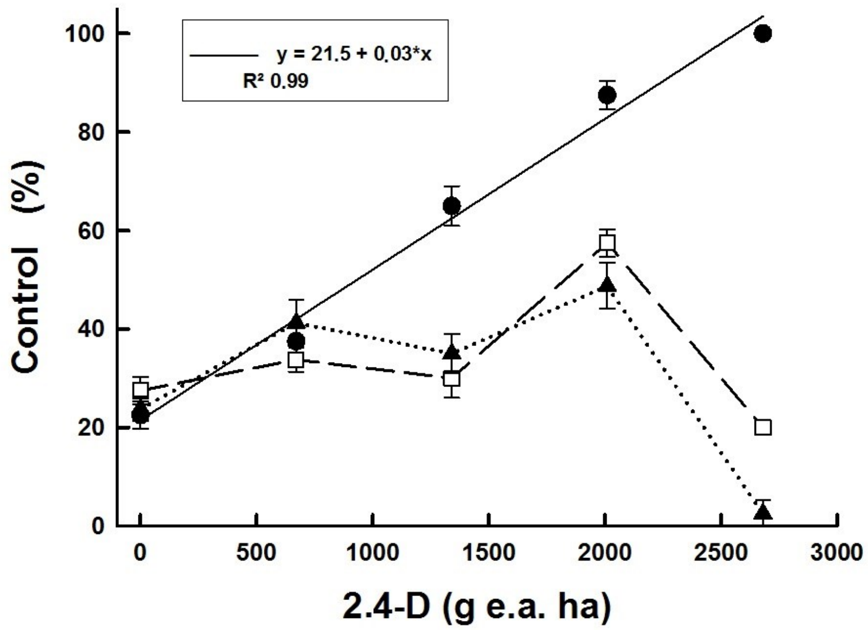


Figure 1. Control evaluation (%) of the SCS116 Satoru cultivar in response to different doses of quizalofop applied alone or in association with 2,4-D on the 29th day after application. Itajaí, Santa Catarina, Brazil, 2016. 2,4-D concentrations: • = 0.0x; □ =0.25x; ▲ =0.5x.



(B)

Figure 2. Control evaluation (%) of the SCS116 Satoru cultivar in response to different doses of 2,4-D applied alone or in association with quizalofop on the 29th day after application. Itajaí, Santa Catarina, Brazil, 2016. Quizalofop concentrations: • = 0.0x; □ = 0.25x; ▲ = 0.5x.

There was no antagonistic interaction between these herbicides since 2,4-D did not affect the control rate with increasing concentrations of quizalofop (Figure 3). Figure 4 shows a reduction in the loss of dry mass with increasing concentrations of 2,4-D, a result in line with several previous studies (BARNES; OLIVER, 2004). According to these authors, combining aryloxyphenoxypropionates with herbicides used to control broadleaf weeds typically results in antagonistic reactions. The timing is also crucial since the late application of 2,4-D can have different phytotoxicity effects in comparison to early applications.

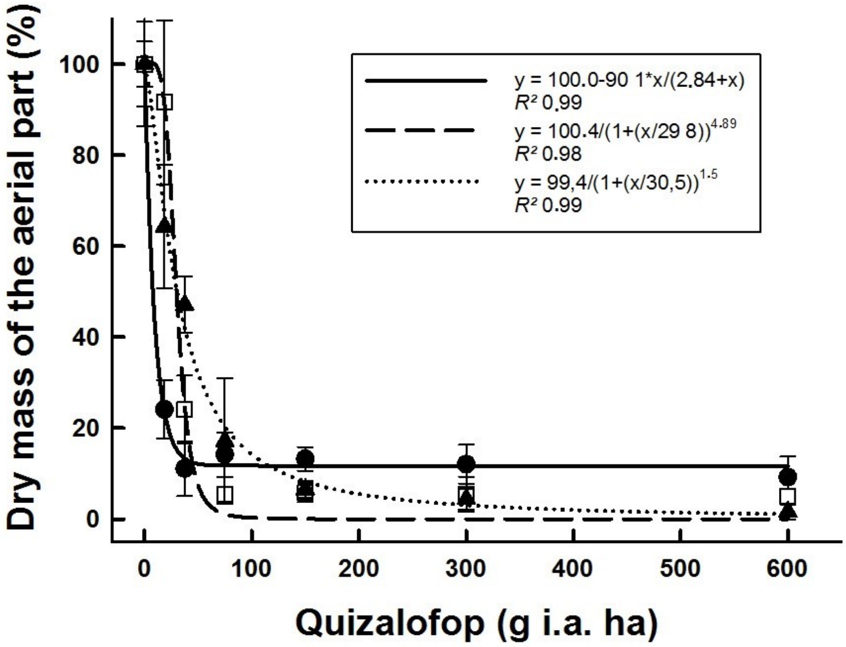


Figure 3. Dry mass of the aerial part (%) of the SCS116 Satoru cultivar in response to different doses of quizalofop applied alone or in association with 2,4-D on the 29th day after application. Itajaí, Santa Catarina, Brazil, 2016. 2,4-D concentrations: • = 0.0x; □ = 0.25x; ▲ = 0.5x.

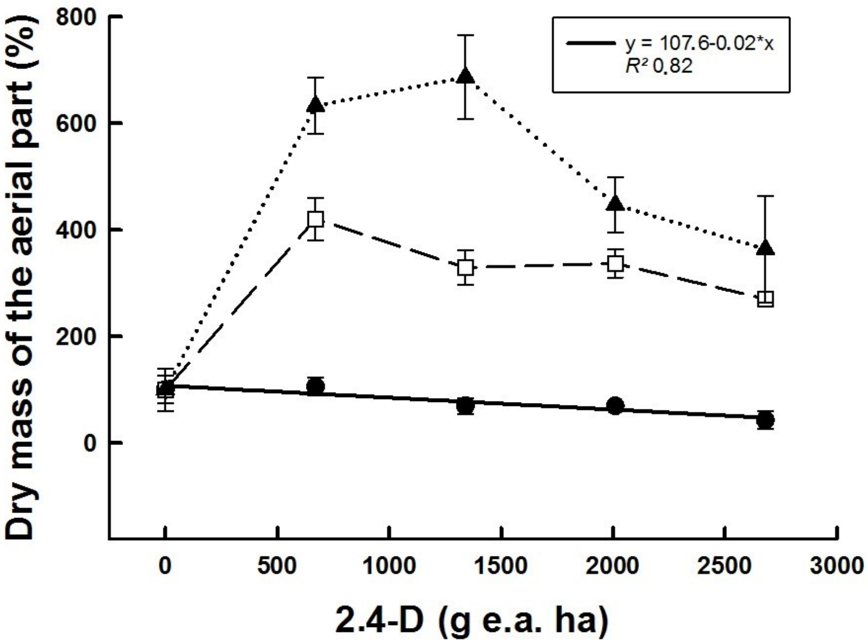


Figure 4. Dry mass of the aerial part (%) of the SCS116 Satoru cultivar in response to different doses of 2,4-D applied alone or in association with quizalofop on the 29th day after application. Itajaí, Santa Catarina, Brazil, 2016. Quizalofop concentrations: • = 0.0x; □ = 0.25x; ▲ = 0.5x.

Amine formulations have more considerable phytotoxicity effects on irrigated rice than 2,4-D ester applications, with average damage reductions of 37% and 62% for 800 and 1200 g ha^{-1} doses, respectively (NOLDIN, 2002). However, they are the strongest indicators of the existence of the antagonistic effect of 2,4-D on quizalofop. Previous studies (BLACKSHAW et al., 2006) reached similar results to ours when using other aryloxyphenoxypropionate herbicides applied in association with auxin mimickers. According to Abit et al. (2011), the results observed in this study suggest an antagonism between 2,4-D and quizalofop-p-ethyl, resulting in a decrease in the conversion of the quizalofopethyl to the acid form when in the presence of the auxin mimicker, thus decreasing the translocation of the ACCase inhibitor. This, in turn, suggests an increase in the detoxification rate and the synthesis level of competitor fatty acids.

4. Conclusion

There was a reduction in the efficiency of quizalofop when it was associated with 2,4-D in most of the concentrations used, applied on irrigated rice.

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