Revista Brasileira de Herbicidas, v.11, n.1, p.42-48, jan./abr. 2012 (ISSN 2236 - 1065)
www.rbherbicidas.com.br

Residual activity of ACCase inhibitor herbicides applied at pre-sowing of corn crop[1]

Atividade residual de herbicidas inibidores da enzima ACCase aplicados em pré-semeadura do milho

Vitor Spader[2]; Édina Cristiane Pereira Lopes[2]; Eliseu Geraldo dos Santos Fabbrin[2]; Cristina Gonçalves Mendonça [3]; Adelino Pelissari[3]

Abstract - The aim of this work was to determine residual activity of ACCase inhibitor herbicides applied at pre-sowing of corn crop. The experimental design was completely randomized blocks with four replications in a split-plot scheme, where the factor time interval (seven and two days prior to corn sowing) was the plot and herbicide treatments were the sub-plot: 1. check without application; 2. tepraloxydim (80 g ha^{-1}); 3. tepraloxydim (100 g ha^{-1}); 4. clethodim (72 g ha^{-1}); 5. clethodim (96 g ha^{-1}); 6. quizalofop-P-tefuryl (96 g ha^{-1}) and 7. quizalofop-P-tefuryl (120 g ha^{-1}). Evaluated variables were: visual phytotoxicity at 07, 14, 21 and 28 days after crop emergence, plant height, number of ears per plant, number of grains per ear, weight of thousand seeds and grain yield. All treatments proved to be selective to corn when applied prior to sowing crop period.

Keywords: selectivity, management, weeds, carryover.

Resumo - O objetivo do trabalho foi determinar a atividade residual dos herbicidas inibidores de ACCase, aplicados em pré semeadura da cultura do milho. O delineamento foi o de blocos ao acaso, com quatro repetições em esquema de parcelas subdivididas, onde o fator intervalo de tempo (sete e dois dias da semeadura do milho) foi colocado na parcela e os tratamentos herbicidas na sub-parcela: 1. testemunha sem aplicação; 2. tepraloxidim (80 g ha^{-1}); 3. tepraloxidim (100 g ha^{-1}); 4. cletodim (72 g ha^{-1}); 5. cletodim (96 g ha^{-1}); 6. quizalofop-P-tefuril (96 g ha^{-1}) e 7. quizalofop-P-tefuril (120 g ha^{-1}). As variáveis avaliadas foram: fitotoxicidade visual aos 07, 14, 21 e aos 28 dias após a emergência do milho, estatura de planta, número de espigas por planta, número de grãos por espiga, peso de mil sementes e o rendimento de grãos. Todos os tratamentos se mostraram seletivos ao milho, quando aplicados anteriormente à semeadura da cultura.

Palavras-chave: seletividade, manejo, plantas daninhas, carryover.

---

[1]Recebido para publicação em 10/07/2011 e aceito em 02/02/2012.
[2]Doutorando pelo Programa de Pós-Graduação em Agronomia, Universidade Federal do Paraná, vspader@agraria.com.br
[3]Professor (a) do Programa de Pós-Graduação em Agronomia - Produção Vegetal - Departamento de Fitotecnia e Fitossanidade pela Universidade Federal do Paraná.

Introduction

The cultivation system of direct sowing on straw is widely used in agricultural areas of southern Brazil, and its viability depends on the availability and use of efficient herbicides for desiccation of plants used to cover soil and weeds prior to crop sowing. The most used desiccant herbicide for no-till systems is glyphosate. It is a total action herbicide with broad spectrum which controls mono and dicotyledonous, annual and perennial plants (Rodrigues & Almeida, 2005). It also presents low environmental impact and reduced cost as compared to other herbicides or control methods.

Glyphosate inhibits the enzyme enol-pyruvylshikimate-phosphate synthase (EPSPs) and blocks the synthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophan resulting in plant death (Vidal, 1997). Common symptoms observed after glyphosate application are leaf chlorosis followed by necrosis. Other leaf symptoms are: wrinkling or malformations, especially in the areas of resprouting, and necrosis of meristems as well as rhizomes and stolons of perennial plants (Yamada & Castro, 2004).

The intensive use of a herbicide molecule increases the probability of selection of resistant weed biotypes (Powles & Holtum, 1994). Indeed, 22 species of glyphosate-resistant weeds have already been documented around the world, and in Brazil five cases have been confirmed so far (Heap, 2011). If appropriate actions are not taken with the aim of preventing the proliferation of these species and the selection of other resistant species, this issue may compromise the no-tillage system as glyphosate is essential for system sustainability and the infestation of cultivated areas with resistant biotypes can endanger the use of this herbicide.

The first glyphosate-resistant species documented in Brazil was the Italian ryegrass (*Lolium multiflorum*) (Roman et al., 2004). Currently there are reports of glyphosate-resistant biotypes of Italian ryegrass in several regions from the South of Brazil (Vargas et al., 2006; Spader et al., 2010).

The use of Italian ryegrass as forage in areas with crop-livestock integration is quite common in Southern Brazil mainly due to its high nutritional quality for animals as well as its ability to resprout after grazing, which represents a considerable potential for forage production (Pellegrini et al., 2010).

Most areas used for growing Italian ryegrass as forage in winter are cultivated with corn or soybean during summer. Thus, at the end of the grazing period and prior to sowing of summer crops, it is necessary to desiccate ryegrass plants. In this case the presence of glyphosate-resistant biotypes is more evident and very common in those regions.

The use of other herbicides registered for desiccation such as paraquat is not enough when applied alone since it is a contact herbicide (Vidal, 2007) and therefore does not prevent ryegrass plants from resprouting after treatment. However, the application of ACCase inhibitor herbicides in combination with glyphosate or in sequential application with paraquat have been an efficient alternative to control glyphosate-resistant ryegrass biotypes (Vargas et al., 2006; Spader et al., 2008; Spader et al., 2010), although they are still not registered with the use purpose of desiccation at pre-sowing of crops.

Indeed ACCase inhibitor herbicides are in general systemic and efficient for controlling annual and perennial grass at post emergence (Vidal, 2007). Nevertheless little information is available in literature showing the residual behavior of these herbicides on susceptible crops such as corn and wheat. Knowing the behavior of ACCase inhibitor herbicides in soil combined with information of effectiveness on glyphosate-resistant Italian ryegrass biotypes might be useful for the companies owning these molecules and government agencies in the search for records to position these herbicides for desiccation at pre-sowing of crops. Furthermore, this information comes as an extremely important tool for farmers who use the no-tillage system mainly in Southern Brazil.

Given the information above, this study was aimed at determining the residual activity of ACCase inhibitor herbicides applied at pre-sowing for corn.

Material and methods

The study was conducted at the *Fundação Agrária de Pesquisa Agropecuária – FAPA*, located at 25° 33' S, and 51° 29' W, with approximately 1,100 meters of altitude in the province of Entre Rios, city of Guarapuava – PR, in the 2010/2011 cropping season.

The soil is classified as typical SOUTH BRAZILIAN OXISOL with clay texture, subtropical field phase. Desiccation of soil cover crop (turnip) was carried out 25 days prior to corn sowing with 720 g a.i. ha^{-1} glyphosate.

Plot size was 3.2 x 8.0 m with four corn rows spaced 0.8 m. Two central rows were harvested so that the useful floor area was 1.6 x 8.0 m. Herbicide treatments included three active ingredients: quizalofop-P-tefuryl, which belongs to the chemical group aryloxyphenoxy proprionate, and clethodim and tepraloxydim, both from the chemical group cyclohexanodione applied at 07 and 02 days before corn sowing as described in Table 1. Herbicides were applied with a high precision backpack sprayer equipped with a three-meter bar and six TT 110.02 low drift flat fan nozzles under constant pressure of 1.5 bar and spray volume of 200 liters ha^{-1}.

The experimental design was entirely randomized blocks with four replications in a split-plot scheme where: the factor time interval was the plots and herbicide treatments with their respective rates were the subplots (Table 1).

The sowing of the hybrid corn P30F53HR was performed with a row seeding machine keeping a population of 65,000 plants per hectare. Base fertilization was carried out with 350 kg ha^{-1} of the formula NPK 05-25-25 and cover fertilization with 300 kg ha^{-1} urea applied during the phenological development stage V4.

Weed management at post emergence was performed with manual hoeing to keep the crop free of infestation throughout the cycle. Pest management was carried out according to research recommendations from *FAPA* equally for all treatments.

At 7, 14, 21, and 28 days after corn emergence, visual evaluations of crop injury from herbicide treatments to corn plants were conducted using a percentage scale in which zero represented no symptom of injury on plants and 100 represented plant death.

After physiological maturity of corn seeds, plant height was determined randomly on 10 plants per plot with a wooden ruler from the stem up to the beginning of tassel. Then the number of plants per useful plot and the number of ears per plant were counted. After harvest, which was carried out with row harvest equipment, the thousand-seed weight (TSW), number of grains per ear, and grain yield were determined adjusting moisture to 13%.

Data were subjected to variance analysis, Tukey mean comparison test, and orthogonal contrasts test at 5% probability.

Table 1. Herbicide Treatments applied at two time intervals prior to corn sowing. *FAPA*, 2011.

Treatments	Rate (g a.i. ha^{-1} + % v/v)	Time Interval prior to sowing (days)
1. Check without application	-	-
2. Tepraloxydim + Dash	80 + 0.5%	07
3. Tepraloxydim + Dash	100 + 0.5%	07
4. Clethodim + Lanzar	72 + 0.5%	07
5. Clethodim + Lanzar	96 + 0.5%	07
6. Quizalofop-P-tefuryl + Oppa	96 + 0.5%	07
7. Quizalofop-P-tefuryl + Oppa	120 + 0.5%	07
8. Tepraloxydim + Dash	80 + 0.5%	02
9. Tepraloxydim + Dash	100 + 0.5%	02
10. Clethodim + Lanzar	72 + 0.5%	02
11. Clethodim + Lanzar	96 + 0.5%	02
12. Quizalofop-P-tefuryl + Oppa	96 + 0.5%	02
13. Quizalofop-P-tefuryl + Oppa	120 + 0.5%	02

a.i. = active ingredient; % v/v = % volume/volume

Results and discussion

In general, treatments evaluated did not affect corn in any variable analyzed (Tables 2 and 3). At visual evaluations, no injury symptom was observed in relation to the different herbicide treatments in corn plants regardless of evaluation period.

At both applications carried out at 07 and 02 days before corn sowing, no negative effects of the herbicide treatments was verified for the different variables analyzed for corn.

Herbicides evaluated were not significantly different, neither in relation to the check, regardless of the rate applied or time of application for all variables evaluated (Tables 2 and 3).

Results obtained in this study indicate that the ACCase inhibitor herbicides evaluated, independent of chemical group or rate tested, did not affect plant growth, yield components (Table 2), and grain yield (Table 3) when applied at seven or two days prior to crop sowing. These results indicate the relevance of using ACCase inhibitor herbicides as an alternative to the use of other graminicides. Thus the application of ACCase inhibitor herbicides in association with glyphosate or in sequential with paraquat has proved to be an efficient alternative to control Italian ryegrass biotypes resistant to glyphosate (Vargas et al., 2006; Spader et al., 2008; Spader et al., 2010), although they are still not registered for the use purpose of desiccation at pre-sowing of crops.

Currently there is a limited number of published data about the use of ACCase inhibitor herbicides for desiccation at pre-sowing of cereals which relate the interval between the application of these herbicides and crop sowing (Lingenfelter & Curran, 2007; Fleck et al., 1997). Therefore, more information on the risks of residual activity of these herbicides on crops such as corn is necessary as well as the intervals required so that these products are degraded and do not affect the crop.

Table 2. Mean values for plant height, number of ears per plant, number of grains per ear, and weight of a thousand grains subjected to the application of ACCase inhibitor herbicides at pre-sowing with two time intervals. *FAPA*, 2011.

	Orthogonal Contrasts[1]	**Height (cm)**	**Ear plant^{-1}**	**Grain Ear^{-1}**	**TSW (g)**
1	1 x (2 to 13)	116 x 112^{ns}	1.2 x 1.1^{ns}	449 x 430^{ns}	325 x 315^{ns}
2	1 x (2 to 7)	116 x 110^{ns}	1.2 x 1.1^{ns}	449 x 430^{ns}	325 x 310^{ns}
3	1 x (9 a 13)	116 x 113^{ns}	1.2 x 1.2^{ns}	449 x 429^{ns}	325 x 320^{ns}
4	2 x 3	113 x 108^{ns}	1.2 x 1.0^{ns}	435 x 441^{ns}	319 x 314^{ns}
5	4 x 5	109 x 114^{ns}	1.3 x 1.1^{ns}	448 x 439^{ns}	317 x 308^{ns}
6	6 x 7	108 x 110^{ns}	1.1 x 1.1^{ns}	419 x 400^{ns}	321 x 298^{ns}
7	8 x 9	116 x 111^{ns}	1.0 x 1.0^{ns}	428 x 429^{ns}	328 x 320^{ns}
8	10 x 11	112 x 115^{ns}	1.2 x 1.2^{ns}	436 x 439^{ns}	318 x 318^{ns}
9	12 x 13	114 x 111^{ns}	1.0 x 1.1^{ns}	424 x 419^{ns}	317 x 319^{ns}
10	2 x 8	113 x 116^{ns}	1.2 x 1.0^{ns}	435 x 428^{ns}	319 x 328^{ns}
11	3 x 9	108 x 111^{ns}	1.0 x 1.0^{ns}	441 x 429^{ns}	314 x 320^{ns}
12	4 x 10	109 x 112^{ns}	1.3 x 1.2^{ns}	448 x 426^{ns}	319 x 318^{ns}
13	5 x 11	114 x 115^{ns}	1.1 x 1.2^{ns}	439 x 439^{ns}	308 x 318^{ns}
14	6 x 12	108 x 114^{ns}	1.1 x 1.1^{ns}	419 x 424^{ns}	321 x 317^{ns}
15	7 x 13	110 x 111^{ns}	1.1 x 1.1^{ns}	400 x 419^{ns}	298 x 319^{ns}

[1] Numbers below and to the right correspond to treatment presented in Table 1.
^{ns} No significant contrast at 5% probability.

Table 3. Mean values for corn grain yield subjected to ACCase inhibitor herbicides application at pre-sowing with two time intervals. *FAPA*, 2011.

	Orthogonal Contrasts	Grain Yield (kg ha^{-1})
1	1 x (2 to 13)	11.596 x 11.349^{ns}
2	1 x (2 to 7)	11.596 x 11.249^{ns}
3	1 x (9 to 13)	11.596 x 11.449^{ns}
4	2 x 3	11.115 x 11.104^{ns}
5	4 x 5	11.457 x 11.361^{ns}
6	6 x 7	10.910 x 11.545^{ns}
7	8 x 9	11.157 x 11.391^{ns}
8	10 x 11	11.508 x 11.530^{ns}
9	12 x 13	11.342 x 11.764^{ns}
10	x 8	11.115 x 11.157^{ns}
11	3 x 9	11.104 x 11.391^{ns}
12	4 x 10	11.457 x 11.508^{ns}
13	5 x 11	11.361 x 11.530^{ns}
14	6 x 12	10.910 x 11.342^{ns}
15	7 x 13	11.545 x 11.764^{ns}

[1] Numbers below and to the right correspond to treatment presented in Table 1.
^{Ns} No significant contrast at 5% probability.

The characteristics of residual activity of ACCase inhibitor herbicides are still under study. It is known that such herbicides present solubility in water of 5,520 ppm, pka without information, kow = 15,000 and unknown koc. They do not present mobility in soil and have very short persistence, approximately from two to three days (Vargas & Roman, 2006).

With the appearance and great spread of Italian ryegrass biotypes (*Lolium multiflorum*) resistant to glyphosate in southern Brazil (Roman et al., 2004; Vargas et al., 2006; Spader et al., 2008), studies are needed to not only evaluate the effectiveness of other herbicides to control these species, but also their safety for susceptible crops when applied for ryegrass desiccation prior to crop sowing.

Considering that both herbicides evaluated are efficient to control glyphosate-resistant ryegrass (Vargas et al., 2006; Spader et al., 2008; Spader et al., 2010), their regulation within competent agencies for desiccation use before crop sowing is suggested. Therefore these herbicides might become an important tool to control glyphosate-resistant ryegrass biotypes on no-tillage system contributing to the system sustainability.

Conclusions

Residual activity of the herbicides quizalofop-P-tefuryl, clethodim, and tepraloxydim did not hinder the growth of the hybrid corn P30F53HR when applied at seven or two days before crop sowing.

References

FLECK, N.G.; CUNHA, M.M.; VARGAS, L. Dose reduzida de clethodim no controle de papuã na cultura da soja, em função da época de aplicação. **Planta Daninha**, v.15, n.1, p.18-24, 1997.

HEAP, I. **The International Survey of Herbicide Resistant Weeds**. Disponível em: http://www.weedscience.org. Acesso em: 25 de jan. 2011.

LINGENFELTER, D.D.; CURRAN, W.S. Effect of glyphosate and several ACCase-inhibitor herbicides on Wirestem Muhly (*Muhlenbergia frondosa*) control. **Weed Technology**, v.21, n.3, p.732-738, 2007.

POWLES, S.B.; HOLTUM, J.A.M. **Herbicide resistance in plants: biology and biochemistry**. Boca Raton, 1994.

SPADER, V.; MAKUCH, E.I.; REIS, E.F.; TOLEDO, R. E. B. Manejo de azevém (*Lolium multiflorum*) resistente ao herbicida glyphosate. In: CONGRESSO BRASILEIRO DA CIÊNCIA DAS PLANTAS DANINHAS, 26, 2008, Ouro Preto- MG. **Anais...** Viçosa: SBCPD, 2008.

SPADER, V.; MAKUCH, E. I.; MATERA, J. MACHADO, D. Seletividade de clethodim aplicado anterior a semeadura da cultura do milho. In: CONGRESSO BRASILEIRO DA CIÊNCIA DAS PLANTAS DANINHAS, 27, 2010, Ribeirão Preto - SP. **Anais...** Viçosa: SBCPD, 2010.

VARGAS, L; ROMAN, E.S. Manejo e controle de plantas daninhas na cultura da soja. Passo Fundo: EMBRAPA. Setembro, 2006. (Documentos Online, nº 62).

VARGAS, L. et al. Manejo de azevém resistente ao glyphosate em pomares de maçã com herbicida Select (clethodim). **Revista Brasileira de Herbicidas**, v.5, n.1, 2006.

VIDAL, R.A. **Herbicidas**: mecanismos de ação e resistência de plantas. Porto Alegre: Ribas Vidal, 1997. 165p.

YAMADA, T; CASTRO, P.R.C. Glifosato, herbicida com singular modo de ação: efeitos secundários e implicações fisiológicas e agronômicas. In: Simpósio Sistema Agrícola

Sustentável com Colheita Econômica Máxima Brasil, 2004. **Anais...** São Pedro: POTAFOS, 2004.