CHEMICAL CONTROL OF *Conyza canadensis* (L.), IN MIXTURES OF HERBICIDES WITH GLYPHOSATE IN COFFEE CROP

Carlos Alberto da Silva[1], Gustavo Rabelo Botrel Miranda[2], Alberto Donizete Alves[3], Roseli dos Reis Goulart[4]

(Received: September 28, 2017; accepted: January 15, 2018)

ABSTRACT: The plants invasion of *Conyza* genus has occurred in several regions in Brazil and in the world, due to the selection caused by the continuous use of herbicides with the same active, causing losses in production. This work aims to evaluate the association of herbicides in the control of *C. canadensis***.** The trial was carried out on a farm, in MG, in a Mundo Novo coffee plantation, in a randomized block design (RBD), with 7 treatments and 4 replications, totalizing 28 plots. The treatments were composed by CTU (no application), Glyphosate 1440g i.a ha^{-1}, Glyphosate 1440g i.a ha^{-1} + Ethyl Chlorimuron 25g i.a ha^{-1}, Glyphosate 1440g i.a ha^{-1} + Methyl Metsulfuron 6g i.a ha^{-1}, Glyphosate 1440g i.a ha^{-1} + Flumioxazine 100g i.a ha^{-1}, Glyphosate 1440g i.a ha^{-1} + Ethyl Carfentrazone 32g i.a ha^{-1}, Glyphosate 1440g i.a ha^{-1} + Saflufenacil 56g i.a ha^{-1}. In all treatments, non-ionic Dash adjuvant was used in the proportion of 1% of the application volume. Ten evaluations were carried out using the scores criterion, where 1 means efficiency between 0 and 20%; 2 from 21 to 40%; 3 from 41 to 60%; 4 from 61 to 80%; 5 from 81 and 100%. It is concluded the treatment Glyphosate 1440g i.a ha^{-1} + Saflufenacil 56g i.a ha^{-1} presented superior results from the first evaluation, evolving until the conclusion of this experiment.

Index terms: Horseweed, herbicide, saflufenacil, weed, tank mix.

CONTROLE QUÍMICO DA *Conyza canadensis* (L.), EM MISTURAS DE HERBICIDAS COM GLIFOSATO EM CAFEEIRO

RESUMO: A invasão de plantas do gênero Conyza, tem ocorrido nas mais diversas regiões produtoras de café do Brasil, e no mundo, devido à seleção causada pelo uso contínuo de herbicidas com o mesmo princípio ativo, causando grandes prejuízos na produção. Portanto, este trabalho, tem por objetivo avaliar a associação de herbicidas no controle da *C. canadensis*. O experimento foi conduzido na Fazenda Cava, município de Carmo do Rio Claro, MG, em uma lavoura de café Mundo Novo, no delineamento em blocos casualizados (DBC), com 7 tratamentos e 4 repetições, totalizando 28 parcelas. Os tratamentos foram compostos pela Testemunha, Glifosato 1440g i.a ha^{-1}, Glifosato 1440g i.a ha^{-1} + Clorimuron Etílico 25g i.a ha^{-1}, Glifosato 1440g i.a ha^{-1} + Metsulfuron Metilico 6g i.a ha^{-1}, Glifosato 1440g i.a ha^{-1} + Flumioxazina 100g i.a ha^{-1}, Glifosato 1440g i.a ha^{-1} + Carfentrazona Etílica 32g i.a ha^{-1}, Glifosato 1440g i.a ha^{-1} + Saflufenacil 56g i.a ha^{-1}. Em todos os tratamentos foram utilizados adjuvante Dash® na proporção de 1% da calda. Foram realizadas dez (10) avaliações utilizando-se o critério de notas, onde 1 significa eficiência entre 0 a 20%; 2 eficiência entre 21 a 40%; 3 eficiência entre 41 a 60%; 4 eficiência entre 61 a 80%; 5 eficiência entre 81 a 100%. Conclui-se que o tratamento Glifosato 1440g i.a ha^{-1} + Saflufenacil 56g i.a ha^{-1}, apresentou resultados superiores desde a primeira avaliação até a conclusão deste trabalho.

Termos para indexação: Buva, herbicidas, saflufenacil, plantas daninhas, mistura de tanque.

1 INTRODUCTION

Brazil stands out as the world's largest producer, exporter and consumer of coffee, with a planted area around 2.209 hectares between the Arabica and Conilon species with an estimated production of 49.67 million bags, of which Minas Gerais is the largest producer with an area around 1.180 hectares and an estimated production of around 28.5 million bags (CONAB, 2016).

Among the main problems for the production of coffee stands the weed competition, especially in the period from October to March (grain filling stage) and in plantations in formation when located in the projection of the cup of the coffee tree, requiring an efficient management system of weeds (FIALHO et al., 2010; FIALHO et al., 2011). The presence of these plants can reduce the macronutrient content by up to 50% and the development of young coffee plants by up to 41% (CARVALHO et al., 2013).

Among the most diverse harmful invaders to the coffee crop, stands out the plant known as Horseweed, for its tolerance to the main herbicides available in the market. The genus *Conyza* includes approximately 50 species which are distributed in almost worldwide (KISSMANN; GROTH, 1999).

The damages caused by Horseweed are not only those caused by the competition for light, water, nutrients and space, but for the coffee grower the damages of this species can still cause difficulties in cultural dealings, for example,

[1,2,3,4] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas - Campus Muzambinho - Estrada de Muzambinho, Km 35 - Bairro Morro Preto - Muzambinho - MG - carlosexc@gmail.com,gustavo.miranda@muz.ifsuldeminas.edu.br, alberto.alves@muz.ifsuldeminas.edu.br, roseli.goulart@muz.ifsuldeminas.edu.br

during the sweeping of the grains under the coffee tree cup after the harvest and also, problems with the heating of the cooling system of the tractors caused by the feathers produced by the flowers of this plant.

Therefore it is necessary to control this weed, with mechanical or chemical method. The main control of *Conyza spp.* is the chemical method with herbicides but satisfactory results have not been observed.

The main herbicide used in coffee cultivation, glyphosate, was not successful in the control of *Conyza spp*., because this species shows resistance to this active principle and with a greater global distribution (HEAP, 2014).

According to Yamauti et al. (2010), the control of the Hairy fleabane (*Conyza bonariensis* L.) is not satisfactory, even with sequential applications of glyphosate at the dose of 720 g e.a. ha^{-1}, since it reached only 54.8% of control.

The weed resistance to herbicides is defined as the natural and inheritable ability of certain biotypes within a population to survive and reproduce after exposure to herbicide doses that would be lethal to normal (susceptible) individuals of the same species (CHRISTOFOLETTI et al., 1994).

Due to the rapid selection and dispersion of resistance, the control of this plant became inefficient when using only glyphosate, requiring the adoption of new control strategies, such as the combination with another herbicide (CULPEPPER, 2006; WILSON et al., 2007).

Martins et al. (2012) observed that tank mixtures with Carfentrazone + Glyphosate or 2,4-D + Glyphosate and 2,4-D isolated application presented the best control percentagens of *Commelina benghalensis*. The same authors also evidenced the synergism in the mixture between Carfentrazone + Glyphosato when observed that these products applied alone did not provide satisfactory effects in the control of *C. benghalensis.*

Due to the increasing resistance to glyphhosate, alternatives of tank mixtures for control of this species appear as etyl chlorimuron and metyl metsulfuron, with action mechanism belonging to the chemical group ALS (acetolactate synthase) inhibitors; etyl carfentrazone and flumioxazine, both of the chemical group PROTOX inhibitors, in addition to a new molecule, saflufenacil, with an action mechanism inhibiting the protoporphyrinogen IX oxidase enzyme (PPO or PROTOX). (CARVALHO; LOPEZ-OVEJERO, 2008).

The objective of this work was to evaluate the herbicidal effect of mixing Glyphosate with the different active ingredients Saflufenacil, Ethyl Chlorimuron, Methyl Metsulfuron, Flumioxazine and Ethyl Carfentrazone, applied on Horseweed in coffee plantations.

2 MATERIAL AND METHODS

The experiment was installed on the Cava Farm, in the municipality of Carmo do Rio Claro, MG. The used cultivation to establish the plots was Mundo Novo 379/19, with pruning at 50 cm in height in 2013, and currently with a productivity estimate of 53.33 ha^{-1} bags. The crop spacing is 3.0 m between row and 1.0 m between plants, giving a population of 3,333 plants per hectare. The average altitude is around 843 m, average annual temperature is 20ºC, accumulated annual rainfall 1,564 mm, latitude 20º58'31" S and longitude 46º17'36" W.

The experimental design was a randomized block design (RBD) with seven treatments and four replicates totalizing 28 plots. The treatments consist of mixing the following herbicides: T1-Control Treatment Unit - CTU (just water); T2-Glyphosate (Roundup® 360g L^{-1}) - 1440g a.i. ha^{-1}; T3-Glyphosate (Roundup® 360g L^{-1}) + Ethyl Carfentrazone (Aurora® 400g L^{-1}) - 1440g a.i. ha^{-1} + 32g a.i. ha^{-1}; T4-Glyphosate (Roundup® 360g L^{-1}) + Saflufenacil (Heat® 700g kg^{-1}) - 1440g a.i. ha^{-1} + 56g a.i. ha^{-1}; T5-Glyphosate (Roundup® 360g L^{-1}®) + Flumioxazine (Flumyzin® 500g kg^{-1}) - 1440g a.i. ha^{-1} + 100g a.i. ha^{-1}; T6-Glyphosate (Roundup® 360g L^{-1}) + Methyl Metsulfuron (Zartan® 600g kg^{-1}) 1440g a.i. ha^{-1} + 6g a.i. ha^{-1} e T7-Glyphosate (Roundup® 360g L^{-1}) + Ethyl Chlorimuron (Clorin® 250g kg^{-1}) 1440g a.i. ha^{-1} + 25g a.i. ha^{-1}. In all treatments, 1% non-ionic Dash mineral oil was used. The meteorological conditions during the applications were: minimum temperature of 18ºC and maximum of 31,1ºC, minimum relative humidity of 59%, and winds with velocity between 0,0 and 0,8 km h^{-1} (Source: Cooxupé Weather Station, Carmo do Rio Claro Center).

The meteorological data were provided by the Cooxupé Weather Station in the city of Carmo do Rio Claro, through the Vantage Pro 2 station, with updated data every 15 minutes for 24 hours.

The treatments application were carried out on April 1st, 2016, using a hand-held back sprayer with spear and ADI 11002 jet spray tip calibrated with *Gate* valves (Guarany) with 150 kPa providing an output 250L ha^{-1} of application volume. The application speed was 2.62 km h^{-1}. The plots were 3.5 m by 1.33 m (4,55m²).

At the application time, the coffee plants rows were heavily infested with weeds and with a clear predominance of Horseweed.

The evaluations were performed at 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 days after application of the treatments - DAA. The herbicide efficiency was carried out through a systematic of scores on the plots by three evaluators: score 1: efficiency between 0 to 20%; score 2: efficiency between 21 and 40%; score 3: efficiency between 41 to 60%; score 4: efficiency between 61 and 80% and score 5: efficiency between 81 and 100%.

The collected data were submitted to analysis of variance by the SISVAR 4.3 program (FERREIRA, 2011), and the averages were submitted to the Scott-Knott test at 5% probability.

3 RESULTS AND DISCUSSION

The results obtained after the application of herbicides to control Horseweed (*C. canadensis*) are exhibited in Table 1.

It was verified that the mixture Glyphosate + Saflufenacil, on *C. canadensis*, was classified with score 5 showing efficiency greater than 80% already at 3 DAA. This result remained until 30 DAA, according to the table below, and in this period there was no incidence of regrowth.

This result coincides with the conclusions of Eubank et al. (2013) that affirmed that Saflufenacil associated with Glyphosate with added adjuvant caused an increase in the absorption (6%), and reduction in the translocation (6%), of the herbicide Glyphosate in plants of *C. canadensis*. And the same authors add that although it caused a reduction in the translocation, the presence of Saflufenacil provided an equivalent increase in the absorption of Glyphosate, which may have contributed to the occurrence of synergism.

The systemic distribution can be explained by its weak acid character and also by the metabolic stability in dicotyledonous plants (GROSSMANN et al., 2013).

The mixture of Metsulfuron and Glyphosate at 3 DAA had lower results than glyphosate and equal to the CTU, but in the course of evaluations this herbicide treatment was consistently higher than score 3 up to 30 DAA.

Although the regrowth date was not accurately assessed in this study, it was observed that the treatment of glyphosate + metsulfuron re-emerged after 24 DAA, and the other treatments around 21 DAA. It was not observed regrowth in the glyphosate + saflufenacil treatment.

The association of Glyphosate + Carfentrazone presented satisfactory results reaching at 15 DAA control index above 80%, however, at 30 DAA this index fell to less than 70%, being classified with score 4. For plants at an advanced stage of development, the control levels tend to reduce, as observed by Constantin et al. (2013).

According to the Table 1, it turns out that the association of Glyphosate with Chlorimuron presented satisfactory results in the evaluations from the 15 DAA, receiving a score 4 with an equivalent efficiency at the average of 70% (61-80%), after which it presented regrowth mainly at 30 DAA. Similar result was observed by Fornarolli et al. (2010), where Glyphosate (2.0 L g pc ha^{-1}) + Chlorimuron (80 g pc ha^{-1}) provided 80% control at 90 DAA when applied in 4 to 6-leaf plants. Santos et al. (2010), observed a 75% control at 80 DAA in the treatment where Glyphosate + Chlorimuron (80 g pc ha^{-1}) was applied.

Moreover, observing the results in table 1, it is evidenced that the treatment Glyphosate + Flumioxazine did not stand out in any of the evaluations receiving score 2 varying efficiency between 21 and 40% in the control of *Conyza canadensis.*

The control results of *C. canadensis* by Glyphosate applied in isolation did not present a result superior to 20% receiving score 1 as it is evidenced in Table 1, presenting only intoxication of the apical parts. These results are in agreement with those of Moreira et al. (2007), that in citrus production areas, identified biotypes of the two species of *Conyza* (*C. bonariensis* L. – Hairy fleabane and *C. Canadensis* L. – Horseweed) resistant to Glyphosate.

The unsatisfactory control of Hairy fleabane with the use of Glyphosate led to the suspicion that species of this genus could acquire resistance to this herbicide molecule (VARGAS et al., 2007). This information corroborates with the selectivity observed in the test conducted on the Cava Farm. Another important point perceived in this work are the results obtained from the treatments Glyphosate + Carfentrazone and Glyphosate + Chlorimuron that from 15 DAA to 27 DAA remained control above score 4 (61 to 80%), which leads us to admit that although the plant does not die, this paralyzed plant impairs the appearance of new plants around it by the suppression effect of sowing, competing mainly by light, during a considerable period (27 days).

TABLE 1 - Control efficiency of Conyza canadensis with mixtures of herbicides to glyphosate and evaluations every 3 DAA. - Carmo do Rio Claro, MG, 2015/2016.

Treatment	Days after application DAA									
	3	6	9	12	15	18	21	24	27	30
1. CTU	1,00 e	1,00 d	1,00 d	1,00 e	1,00 d	1,00 f	1,00 d	1,00 c	1,00 e	1,00 e
2. Glif.	1,50 d	1,50 d	2,50 c	1,50 d	2,00 c	1,87 e	1,75 c	2,12 b	2,12 d	1,75 d
3.Glif.+Carf.	4,00 b	3,87 b	3,75 b	3,37 b	4,75 a	4,50 b	4,25 b	4,37 a	4,25 b	3,50 b
4.Glif.+Saf.	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a	5,00 a
5.Glif.+Flum.	2,00 c	2,50 c	3,50 b	2,62 c	3,75 b	2,81 d	1,87 c	2,87 b	2,15 d	2,50 c
6.Glif.+Met.	1,00 e	3,87 b	3,25 b	3,50 b	3,75 b	3,75 c	3,75 b	4,00 a	3,50 c	3,50 b
7.Glif.+Clori.	2,25 c	3,50 b	3,50 b	3,50 b	4,00 b	4,00 c	4,00 b	4,25 a	4,00 b	3,75 b
CV (%)	11,48	15,77	18,49	9,19	7,71	8,64	14,09	17,00	12,24	13,28
F	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**

Averages followed by the same lowercase letter in the column belong to the same group by the Scott - Knott test at 5% significance.

CTU – Control Treatment Unit

It is important to mention that the treatment with glyphosate + saflufenacil herbicides causes selection pressure in favor of genotypes resistant to these molecules. Therefore, the results that are not 100% efficient but still greater than efficiency 80% can be used as herbicide management to try to break this selection pressure while maintaining a satisfactory control for weed control. In this work, it can be observed that Carfentrazone or Chlorimuron associated to Glyphosate can be used in the management of herbicides for Horseweed control because they have a high control, however, without causing selection pressure in the same way as the Glyphosate + Saflufenacil mixture.

For Lopez Ovejero et al., (2008) a possible decrease in the ecological adaptability of the resistant biotype has direct consequences in the competitiveness of the same and, therefore, in its dynamics within the population, directly affecting weed management techniques. Thus, when the selection pressure factor is eliminated (herbicide), the gene frequency of the resistant biotype decreases rapidly in the seed bank due to its lower adaptability, facilitating its management.

4 CONCLUSIONS

Glyphosate + Saflufenacil show to be highly efficient on *C. canadensis*.

Chlorimuron or Carfentrazone associated with Glyphosate obtains scores superior to 4 (61-80% of control) until the 27 DAA.

Glyphosate + Saflufenacil provide high selection pressure to Horseweed.

Chlorimuron or Carfentrazone associated to Glyphosate can be used in Horseweed resistance management.

5 REFERENCES

CARVALHO, L. B.; ALVES, P. L. C. A.; BIANCO, S. Sourgrass densities affecting the initial growth and macronutrient content of coffee plants. **Planta Daninha**, Viçosa, v. 31, n. 1, p. 109-115, Jan/Mar. 2013.

CARVALHO, S. J. P.; LOPEZ–OVEJERO, R. F. Resistência de plantas daninhas aos herbicidas inibidores da protox (Grupo E). In: CHRISTOFOLETTI, P. J (coord). Aspectos de Resistência de Plantas Daninhas a Herbicidas. **Resumos expandidos...** 3. ed. Campinas: Associação Brasileira de Ação a Resistência de Plantas aos Herbicidas (HRAC-BR), 2008. p. 69–77.

CHRISTOFOLETTI, P. J.; FILHO, R. V.; SILVA, C. B. Resistência de Plantas Daninhas aos Herbicidas. **Planta Daninha,** Viçosa, v. 12, n. 1, p. 13–20, jan/jun. 1994.

CONAB–Acompanhamento da safra brasileira. Café, v. 3 – safra 2016, n. 2. **Segundo levantamento**, Brasília, p. 1-104, maio. 2016.

CONSTANTIN, J. et al. 2013. Manejo da buva na entressafra. In.: CONSTANTIN, J. et al. (Eds.). Buva: fundamentos e recomendações para manejo. **Resumos expandidos...** Maringá: Omnipax Editora. p. 41-64.

CULPEPPER, A. S. Glyphosate-induced weed shifts. **Weed Technology,** Champaign, v. 20, n. 2, p. 277-281, Apr/June. 2006.

EUBANK, T. W. et al. Saflufenacil efficacy on horseweed and its interaction with glyphosate. **Weed Biology and Management**, Malden, v. 13, n. 4, p. 135-143, Oct/Dec. 2013.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência & Agrotecnologia**, Lavras, v. 35, n. 6, p. 1039–1042, Nov/Dez. 2011.

FIALHO, C. M. T. et al. Interferência De Plantas Daninhas Sobre O Crescimento Inicial De *Coffea arabica*. **Planta Daninha**, Viçosa, v. 29, n. 1, p. 137-147, jan/mar. 2011.

FIALHO, C. M. T. et al. Competição de plantas daninhas com a cultura do café em duas épocas de infestação. **Planta Daninha**, Viçosa, v. 28, n. especial, p. 969-978, 2010.

GROSSMANN, K. et al. Saflufenacil (KixorTM): biokinetic properties and mechanism of selectivity of a new protoporphyrinogen IX oxidase inhibiting herbicide. **Weed Science**, Champaign, v. 59, n. 3, p. 290-298, 2013.

HEAP, I. Global perspective of herbicide-resistant weeds. **Pest Management Science**, Oxford, v. 70, n. 9, p. 1306- 1315, Sept. 2014.

KISSMANN, K. G.; GROTH, D. **Plantas infestantes e nocivas**. 2. ed. São Bernardo do Campo: Basf, 1999. p. 152-156, 278-284.

LOPEZ-OVEJERO, R. F.; CARVALHO, S. J. P.; CHRISTOFOLETTI, P. J. Recomendações gerais para manejo integrado de plantas daninhas resistentes a herbicidas. In: CHRISTOFOLETTI, P. J (coord). Aspectos de resistência de plantas daninhas a herbicidas. **Anais...** 3. ed. Campinas: associação brasileira de ação a resistência de plantas aos herbicidas (HRAC-BR), 2008. p. 109–119.

MARTINS, D. et al. Manejo químico de espécies de trapoeraba com aplicação isolada e em mistura de diferentes herbicidas. **Revista Caatinga**, Mossoró, v. 25, n. 2, p. 21-28, mar/jun. 2012.

MOREIRA, M. S. et al. Resistência de *Conyza canadenses* e *Conyza bonariensis* ao herbicida ghyfhosate. **Planta Daninha**, Viçosa, v. 25, n. 1, p. 157-164, jan/mar. 2007.

VARGAS, L. et al. (*Conyza bonariensis*) resistente ao Glyphosate na região sul do Brasil. **Planta Daninha**, Viçosa, v. 25, n. 3 p. 573-578, July/Sept. 2007.

WILSON, R. G. et al. Glyphosate-induced weed shifts in glyphosate-resistant corn or a rotation of glyphosate-resistant corn, sugarbeet, and spring wheat. **Weed Technology**, Champaign, v. 21, n. 4, p. 900-909, Oct/Dec. 2007.

YAMAUTI, M. S. et al. Controle químico de biótipos de buva (*Conyza canadensis* e *Conyza bonariensis*), resistentes ao Glyfhosate. **Revista Ciência Agronômica**, v. 41, n. 3, p. 495-500, jul/set. 2010.