https://doi.org/10.18406/2316-1817v14n120221656 e-ISSN 2316-1817

# Herbicide mixtures for post-emergence control of horseweed in coffee interrow

**Breno Ribeiro Bornelli[1], Chayenne de Lira Ferreira[2], Carlos Henrique de Sousa Ferreira[3], Saul Jorge Pinto de Carvalho[4]**

[1] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, *Campus* Machado, Graduado em Agronomia. brenobornelli@hotmail.com.
[2] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, *Campus* Machado, Graduado em Agronomia. chayenneferreira_@hotmail.com.
[3] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, *Campus* Machado, Graduado em Agronomia. carlos.henrique.tec@hotmail.com.
[4] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, *Campus* Machado, Professor Doutor. sjpcarvalho@yahoo.com.br.

Received in: 09/10/2021
Accepted in: 13/05/2022

## Abstract

Glyphosate-resistant biotypes of horseweed (*Conyza* spp.) have been a constant problem for coffee growers all over Brazil. Therefore, this research was developed with the objective of evaluating efficacy of different herbicides, applied isolated or in mixture, for horseweed control in coffee plantation interrows. A field trial was performed with the following treatments (g ha$^{-1}$): glyphosate at 925, glufosinate-ammonium (GA) at 500, saflufenacil at 49, flumioxazin at 50, glyphosate + GA (925 + 500), glyphosate + saflufenacil (925 + 49), glyphosate + flumioxazin (925 + 50), GA + saflufenacil (500 + 49), GA + flumioxazin (500 + 50) and glyphosate + saflufenacil + clethodim (925 + 49 + 108), besides check plots without herbicide application. The treatment with clethodim was included considering a possible concomitant presence of sourgrass (*Digitaria insularis* (L) Fedde) in the areas. At the moment of herbicide application, horseweed was 40 cm tall in pre-flowering. Percent control was evaluated at 7, 14, 21 and 28 days after application (DAA), as well as mass of dry matter at 28 DAA. In general, adequate control of horseweed was obtained with glufosinate-ammonium applications, isolated or in mixture with glyphosate, saflufenacil or flumioxazin. Mixture of glyphosate and saflufenacil has also reached high control of horseweed infestation, without difference to GA treatments. In conclusion, horseweed infestations in coffee interrow may be efficiently controlled with tank mixtures of herbicide.

**Keywords:** *Conyza* spp.; *Coffea arabica*; glufosinate-ammonium; resistance; glyphosate.

## Introduction

Coffee (*Coffea arabica* L.) production in Brazil has reached 61.62 million bags of 60 kg in 2020, which represents an increase of 25% compared to the harvest of 2019 (MERLADETE, 2020). In this scenario, Minas Gerais stands out as the Brazilian largest coffee producing state, with a share of 54% of the national amount. In 2020, despite the delay in the harvest, due to the restrictions imposed by the prevention of coronavirus, Minas Gerais had a record harvest, with 34.6 million bags benefited. The total volume harvested was 36.3% higher and productivity increased by 28.7% compared to the previous year (SEAPA, 2021).

However, higher profitability may be achieved by increasing crop productivity or reducing production costs, or even by optimizing the activities of the production chain, for example, the proper management of weeds (RONCHI *et al.*, 2005). Fialho *et al.* (2011) highlighted the importance of the correct weed management, justified by the damage caused by these species which, due to their rusticity, fast growth and efficient use of environmental resources, end up taking advantage and directly competing with crops.

According to Alcântara, Nóbrega and Ferreira (2009), coffee plants are highly sensitive to weed competition, thus the efficient control of weeds is necessary. During the coffee growth period, weed species may cause elevated damage to coffee plantations, once the absorbing roots of the coffee plants grow superficially in the soil, where most of the weed roots also develop. This period starts with the setting up of the coffee plantation and lasts up to the average age of two years, when light becomes a major limiting factor (CHRISTOFFOLETE, NICOLAI, 2013). Carvalho, Alves and Bianco (2013) observed that weed competition by nutrients is a strong limiting factor to the growth of coffee plants, reducing macronutrients content by up to 50 % and young coffee development by up to 41%. Alcântara and Ferreira (2009) observed yield losses of 20 % in adult coffee plantations due to weed competition.

In the last decades, weed control has been frequently carried out through herbicide applications, as an efficient and economic measure to reduce weed incidence and multiplication (FIALHO *et al*., 2012). However, one of the biggest challenges for weed management is avoiding the selection of herbicide-resistant biotypes, so constant changes in weed management practices are necessary, in order to prevent or delay the identification of herbicide-resistant weeds (CHRISTOFFOLETI, LÓPEZ-OVEJERO, 2003; GONÇALVES NETTO *et al.*, 2021).

In the coffee crop, this challenge is also present, mostly regarding horseweed species (*Conyza* spp.), which cause several problems regarding weed competition. Botanically, these weeds are classified in the genus *Conyza*, family Asteraceae. Among the most important species for Brazilian agriculture, *C. bonariensis* (L.) Cronquist, *C. canadensis* (L.) Cronquist and *C. sumatrensis* (Rets.) Cronquist may be detached. These weeds are characterized as highly resilient plants, which produce a high number of seeds with enhanced potential of dissemination (OSIPE *et al.*, 2010; SANSOM, SABORIDO, DUBOIS, 2013; GAZZIERO *et al.*, 2015).

Horseweed infestation in coffee plantations make coffee trees more sensitive to water deficit, making sweeping difficult and contributing to pest proliferation, such as the coffee borer beetle (CHRISTOFFOLETI, NICOLAI, 2013). In the specific case of coffee growers of the south of Minas Gerais, weed management is not fully satisfactory, as it settled on the high demand for lower cost herbicides and does not rotate active ingredients or mixtures, selecting and contributing to dissemination of herbicide-resistant weeds.

In this sense, glyphosate-resistant species of horseweed have been a constant problem for coffee growers throughout Brazil. Glyphosate continuous use in the coffee crop has frequently selected resistant populations of horseweed, causing high infestations of this weed. According to Braz *et al.* (2017), horseweed species have caused serious damage to agricultural crops, exacerbated by the selection of biotypes resistant to multiple modes of action. In Brazil, biotypes resistant to up to five different mechanisms of action have already been identified (HEAP, 2021).

Considering the importance of coffee growing for the south of Minas Gerais, as well as the relevant problem established by horseweed infestations in the crops, searching for new alternatives for post-emergence control becomes highly important, considering herbicides applied alone or in mixture. Therefore, this research was carried out with the objective of evaluating the efficacy of different herbicides (applied alone or in a mixture) for horseweed control in the interrow of coffee plantations.

## Material and methods

The experiment was carried out in the field, in an adult coffee plantation of the Mundo Novo variety, 3 m in height, located in the municipality of Machado, in the south of Minas Gerais state (21°38’ 27” S, 46° 05’ 48” W), altitude of 950 m. The soil in the area was classified as dystrophic Red-Yellow LATOSOL (EMBRAPA, 2018), whose chemical attributes are described in Table 1.

In this experiment, 11 treatments were adopted, with four replications, summarizing 44 experimental units. Each plot consisted of a coffee plantation interrow (2.5 m) with

7 m in length and homogeneous infestation of horseweed, in the order of 40 plants $m^{-2}$. In each plot, the useful area was defined considering 1 m in width and 5 m in length. Additionally, a 10 m length border was adopted for the beginning and the end of the experimental area.

Experimental treatments (TABLE 2) were installed in a completely randomized block design. In the treatment with glyphosate alone, no adjuvant was added; in all treatments with saflufenacil, the adjuvant Dash® was added at 0.5% v/v; in the other treatments, Assist® at 0.5% v/v was included. At the time of application, horseweed plants were, on average, 0.40 m tall in pre-flowering.

Commercial products adopted were: Roundup Original® (glyphosate), Finale® (GA), Heat® (saflufenacil), Flumyzin 500® (flumioxazin) and Select 240 EC® (clethodim). Treatment 11 (TABLE 2) was included with the aim of simulating weed control in an area with concomitant presence of horseweed and glyphosate-resistant sourgrass, as well as testing the interaction of glyphosate, clethodim and saflufenacil.

For the herbicide application, a $CO_2$-pressurized backpack sprayer was adopted, equipped with a boom with two nozzles (XR 110.02; Teejet®, Wheaton, USA) spaced 0.5 m apart, positioned 0.50 m above the targets, with a relative spray consumption of 200 L $ha^{-1}$.

The application was performed on October 12, 2019 and started at 3:10 pm and ended at 4:20 pm; the average wind speed was 4.3 km $h^{-1}$; relative humidity of 46 %; average temperature of 35.5 °C; open sky, with sun and few clouds.

Percentage control was evaluated at 7, 14, 21 and 28 days after application (DAA), as well as the residual mass of weeds' dry matter at 28 DAA. For control evaluations, the score of zero was assigned in the case of absence of symptoms and 100% for plant death (SBCPD, 1995). For collecting the residual plant material (mass of dry matter), a metal square measuring 0.50 m x 0.50 m was used, which was placed once in a representative location of each plot. All plant material present in the square area was sampled, cut close to the ground, with subsequent drying in an oven at 60 ºC for 72 hours.

For data analysis, F test was applied on the analysis of variance, followed by the Scott-Knott's test (SCOTT, KNOTT, 1974), both with 5% significance.

**Table 1-** Soil analysis[1] of the coffee crop interrows where the experiment was installed. Machado/MG, 2019.

| pH | O.M. | P | K | Ca | Mg | Al | H+Al |
|---|---|---|---|---|---|---|---|
| | dag/kg | mg/dm³ | cmol/dm³ | cmol/dm³ | cmol/dm³ | cmol/dm³ | cmol/dm³ |
| 5,5 | 2,7 | 14,3 | 90 | 2,89 | 1,34 | 0,1 | 3,2 |
| **Ca/Mg** | **Mg/K** | **m** | **S.B.** | **CEC** | **V** | **Ca/CEC** | **Al/CEC** |
| | | % | cmol/dm³ | cmol/dm³ | % | % | % |
| 2,2 | 5,8 | 2 | 4,5 | 7,7 | 58 | 37,73 | 1,31 |

| Mg/CEC | K/CEC | Cu | Fe | Mn | Zn | B |
|---|---|---|---|---|---|---|
| % | % | mg/dm³ | mg/dm³ | mg/dm³ | mg/dm³ | mg/dm³ |
| 17,49 | 3 | 0,2 | 19 | 15 | 3 | 0,22 |

[1]O.M. = organic matter; m % = aluminum saturation; SB = sum of bases; CEC = cation exchange capacity; V % = base saturation.

**Source:** Soil Analysis Laboratory, IFSULDEMINAS *Campus* Machado (2019).

**Table 2.** Treatments and doses applied to the plots infested by horseweed. Machado/MG, 2019.

| Nº | Treatments | Doses (g ha$^{-1}$) |
|---|---|---|
| 1 | Check plots without herbicide application | |
| 2 | Glyphosate | 925 |
| 3 | Glufosinate-ammonium (GA) | 500 |
| 4 | Saflufenacil | 49 |
| 5 | Flumioxazin | 50 |
| 6 | Glyphosate + GA | 925 + 500 |
| 7 | Glyphosate + Saflufenacil | 925 + 49 |
| 8 | Glyphosate + Flumioxazin | 925 + 50 |
| 9 | GA + Saflufenacil | 500 + 49 |
| 10 | GA + Flumioxazin | 500 + 50 |
| 11 | Glyphosate + Saflufenacil + Clethodim | 925 + 49 + 108 |

**Source:** Elaborated by the authors (2019).

## Results and discussion

In the Table 3, results of horseweed percent control are presented for the evaluations performed at 7 and 14 days after application (DAA). In these evaluations, the highest levels of efficacy were reached with glufosinate-ammonium (GA) mixtures and with glyphosate + saflufenacil + clethodim, different from the other treatments. Including clethodim in the last treatment contributed to horseweed control besides its graminicide characteristics. An

**Table 3.** Percent control[1] of horseweed (*Conyza* spp.) when submitted to different herbicide treatments, applied alone or in mixture, evaluated at 7 and 14 days after application (DAA), in the interrows of the coffee crop. Machado/MG, 2019.

| Treatment | | Percent Control | |
|---|---|---|---|
| **Herbicide** | **Dose (g ha$^{-1}$)** | **7 DAA** | **14 DAA** |
| Check plots without herbicide application | | 0.0 G | 0.0 F |
| Glyphosate | 925 | 20.0 F | 16.8 E |
| Glufosinate-ammonium (GA) | 500 | 73.8 B | 86.5 B |
| Saflufenacil | 49 | 43.8 D | 51.8 C |
| Flumioxazin | 50 | 15.0 F | 11.3 E |
| Glyphosate + GA | 925 + 500 | 80.8 A | 89.5 A |
| Glyphosate + Saflufenacil | 925 + 49 | 61.3 C | 78.8 B |
| Glyphosate + Flumioxazin | 925 + 50 | 30.0 E | 32.0 D |
| GA + Saflufenacil | 500 + 49 | 88.0 A | 95.5 A |
| GA + Flumioxazin | 500 + 50 | 89.8 A | 94.0 A |
| Glyphosate + Saflufenacil + Clethodim | 925 + 49 + 108 | 83.0 A | 95.3 A |
| $F_{treat}$ | | 138.116* | 172.293* |
| **CV (%)** | | 10.46 | 9.64 |

[1]Means followed by the same letters in the columns do not differ according to Scott-Knott's test, with 5% significance; *Significant at 1% probability.

**Source:** Elaborated by the authors (2019).

observation that may justify this result is the possible presence of some adjuvant or surfactant on the formulation of clethodim that contributed to glyphosate or saflufenacil absorption and efficacy on horseweed plants. It could also be observed that the treatments with GA alone and the mixture of glyphosate + saflufenacil had higher efficacy values at 14 DAA than at 7 DAA, approaching the best treatments.

In all the evaluations of efficacy, the herbicides glyphosate, saflufenacil and flumioxazin did not reach adequate levels of horseweed control if applied alone. Thus, it became evident that these products applied alone do not control resistant biotypes of this species in post-emergence. To control horseweed, action mechanisms that rapidly degrade plant tissue may be needed, eliminating steams before they emit new shoots and resumes growth; saflufenacil and flumioxazin, even being contact herbicides, allowed a high rate of regrowth and generated chlorosis and necrosis in few parts of the plant, providing low levels of control.

Horseweed plants from the check plots kept full development all over the experiment, with little visual difference for the plots where glyphosate was applied alone. Therefore, in this area, horseweed population could be considered resistant to glyphosate, since even being in vegetative stage and in a small size at the time of application, the highest level of control obtained by this herbicide was of the order of 26.3%, recorded at 28 DAA (TABLE 4).

At 21 DAA, GA applied isolated or in a mixture with glyphosate, saflufenacil and flumioxazin remained among the treatments with the highest levels of horseweed control (TABLE 4). Therefore, it may be considered that isolated application of GA has slower action on horseweed and may have its effects accelerated when mixed with glyphosate, saflufenacil or flumioxazin, obtaining effective results at 7 DAA.

**Table 4.** Percent control[1] of horseweed (*Conyza* spp.) when submitted to different herbicide treatments, applied alone or in mixture, evaluated at 21 and 28 days after application (DAA), in the interrows of the coffee crop. Machado/MG, 2019.

| **Treatment** | | **Percent Control** | |
|---|---|---|---|
| **Herbicide** | **Dose (g ha$^{-1}$)** | **21 DAA** | **28 DAA** |
| Check plots without herbicide application | | 0.0 E | 0.0 E |
| Glyphosate | 925 | 18.8 D | 26.3 C |
| Glufosinate-ammonium (GA) | 500 | 90.5 A | 88.5 A |
| Saflufenacil | 49 | 66.3 B | 58.8 B |
| Flumioxazin | 50 | 17.5 D | 15.0 D |
| Glyphosate + GA | 925 + 500 | 95.3 A | 96.3 A |
| Glyphosate + Saflufenacil | 925 + 49 | 90.0 A | 91.3 A |
| Glyphosate + Flumioxazin | 925 + 50 | 28.8 C | 30.0 C |
| GA + Saflufenacil | 500 + 49 | 97.3 A | 97.8 A |
| GA + Flumioxazin | 500 + 50 | 97.3 A | 96.0 A |
| Glyphosate + Saflufenacil + Clethodim | 925 + 49 + 108 | 97.3 A | 98.0 A |
| **$F_{treat}$** | | 232.108* | 184.256* |
| **CV (%)** | | 8.06 | 8.94 |

[1]Means followed by the same letters in the columns do not differ according to Scott-Knott's test, with 5% significance; *Significant at 1% probability.

**Source:** Elaborated by the authors (2019).

In comparison to glyphosate, the herbicide glufosinate-ammonium also acts on one of the biochemical routes of nitrogen assimilation, but its point of action is the glutamine synthetase, enzyme responsible for the conversion of glutamate into glutamine. The interruption of this process generates accumulation of $NH_4^+$ in cells, which is toxic to plants (DAMIN *et al.*, 2008).

Treatment with glyphosate + saflufenacil was only effective at 21 DAA (TABLE 4). There are disagreements in scientific literature about the interaction of this mixture. Presoto, Andrade and Carvalho (2020) tested this mixture on morning glory (*Ipomoea triloba* L.) and sourgrass (*Digitaria insularis*) and observed additive effects; on the other side, Dalazen *et al*. (2015) tested this mixture in several doses and combinations and concluded that it is a synergistic mixture. It is important to emphasize this divergence because the effects and behavior of herbicides vary greatly due to the weed species, however, no records of antagonism were found for this mixture, which has been widely used in several cultures in Brazil (ASHIGH, HALL, 2010; QUEIROZ *et al.*, 2014).

At 28 DAA, horseweed control levels were similar to 21 DAA, with emphasis on treatments with GA alone or in mixture with glyphosate, saflufenacil or flumioxazin, glyphosate + saflufenacil and glyphosate + saflufenacil + clethodim, which reached the highest levels of control among all treatments (TABLE 4). In the reviewed literature, it was verified that the interaction of saflufenacil and GA is effective and the synergism between them was explained by Takano et al. (2020) who, by studying their mode of action, observed that these two herbicides act on different enzymes, however both result in accumulating large amounts of reactive species of oxygen, eliminating the target plant.

Regarding the dry mass analysis, at 28 DAA, all the treatments that reached the best efficacy rates were the same that promoted the lowest residual dry mass, except for the mixture of glyphosate and saflufenacil (TABLE 5). This

**Table 5.** Residual mass of dry matter[1] (g $m^{-2}$) of horseweed (*Conyza* spp.) when submitted to different herbicide treatments, applied alone or in mixture, evaluated at 28 days after application (DAA), in the interrows of the coffee crop. Machado/MG, 2019.

| Treatment | | Residual Dry Mass[2] |
|---|---|---|
| **Herbicide** | **Dose (g $ha^{-1}$)** | **28 DAA** |
| Check plots without herbicide application | | 280.3 C |
| Glyphosate | 925 | 203.0 C |
| Glufosinate-ammonium (GA) | 500 | 52.9 A |
| Saflufenacil | 49 | 93.1 B |
| Flumioxazin | 50 | 157.9 C |
| Glyphosate + GA | 925 + 500 | 53.2 A |
| Glyphosate + Saflufenacil | 925 + 49 | 105.3 B |
| Glyphosate + Flumioxazin | 925 + 50 | 123.6 B |
| GA + Saflufenacil | 500 + 49 | 49.5 A |
| GA + Flumioxazin | 500 + 50 | 30.5 A |
| Glyphosate + Saflufenacil + Clethodim | 925 + 49 + 108 | 38.4 A |
| **$F_{treat}$** | | 8.351* |
| **CV (%)** | | 26.56 |

[1]Means followed by the same letters in the columns do not differ according to Scott-Knott's test, with 5% significance; [2]Original data presented, but previously transformed by $\sqrt{x+1}$; *Significant at 1% probability.

**Source:** Elaborated by the authors (2019).

mixture had higher mass of dry matter when compared to the mixtures with the best levels of efficacy; this fact may be explained by the small regrowth rate observed on the horseweed plants and by the fact that lower amount of plant tissue was degraded by this mixture, forming small necrotic leaf spots.

In summary, it could be observed treatments with evident synergy for horseweed control, as in the case of saflufenacil and GA. There were also observed additive effects with slower effectiveness, as in the case of the mixture of glyphosate and saflufenacil. Furthermore, GA was an excellent herbicide to control glyphosate-resistant horseweed, alone or in different mixtures.

## Conclusions

Adequate control of horseweed was obtained with glufosinate-ammonium applications, isolated or in mixture with glyphosate, saflufenacil or flumioxazin. Mixture of glyphosate and saflufenacil has also reached high control of horseweed infestation, without difference to GA treatments. In conclusion, horseweed infestations in coffee interrow might be efficiently controlled with tank mixtures of herbicide.

## References


ALCÂNTARA, E. N.; FERREIRA, M. M. Efeito de métodos de controle de plantas daninhas na produção de café durante 30 anos. Simpósio de pesquisa dos cafés do brasil, 6., 2009, Vitória. **Anais...** Brasília, DF: Embrapa Café, 2009. p. 243-276.

ALCÂNTARA, E. N.; NÓBREGA, J. C. A.; FERREIRA, M. M. Métodos de controle de plantas daninhas no cafeeiro afetam os atributos químicos do solo. **Ciência Rural**, v. 39, n. 3, p. 749-757, 2009. Disponível em: https://doi.org/10.1590/S0103-84782009000300018. Acesso em: 03 abr. 2021.

ASHIGH, J. J.; HALL, C. Bases for interactions between saflufenacil and glyphosate in plants. **Journal of Agricultural and Food Chemistry**, v. 58, n. 12, p. 7335- 7343, 2010. Disponível em: https://doi.org/10.1021/jf100595a. Acesso em: 13 maio 2022.

BRAZ, G. B. P.; OLIVEIRA JÚNIOR, R. S.; ZOBIOLE, L. H. S.; RUBIN, R. S.; VOGLEWEDE, C.; CONSTANTIN, J.; TAKANO, H. K. Sumatran fleabane (*Conyza sumatrensis*) control in no-tillage soybean with diclosulam plus halauxifen-methyl. **Weed Tecnology**, v. 31, n. 1, p. 1-9, 2017. Disponível em: https://doi.org/10.1017/wet.2016.28. Acesso em: 10 abr. 2021.

CARVALHO, L. B.; ALVES, P. L. C. A.; BIANCO, S. Sourgrass densities affecting the initial growth and macronutrient content of coffee plants. **Planta Daninha**, v. 31, n. 1, p. 109-115, 2013. Disponível em: https://doi.org/10.1590/S0100-83582013000100012. Acesso em: 18 out. 2021.

CHRISTOFFOLETI, P. J.; LÓPEZ-OVEJERO, R. F. Definições e situação da resistência de plantas daninhas aos herbicidas no Brasil e no mundo. **Aspectos de resistência de plantas daninhas a herbicidas**. Londrina: Associação Brasileira de Ação a resistência de Plantas aos Herbicidas (HRAC-BR), 2003. p. 2-21.

CHRISTOFFOLETI, P. J.; NICOLAI M. Convivência com plantas daninhas não deve limitar cafezal. **Visão Agrícola**, v. 12, n. 5, p. 37-39, 2013. Disponível em: https://www.esalq.usp.br/visaoagricola/sites/default/files/va12-conducao-da-lavoura02.pdf. Acesso em: 27 mar. 2021.

DALAZEN, G.; KRUSE, N. D.; MACHADO, S. L. O.; BALBINOT, A. Sinergismo na combinação de glifosato e saflufenacil para o controle de buva. **Pesquisa Agropecuária Tropical**, v. 45, n. 2, p. 249-256, 2015. Disponível em: http://dx.doi.org/10.1590/1983-40632015v4533708. Acesso em: 20 mar. 2021.

DAMIN, V.; FRANCO, H. C. J.; MORAES, M. F.; FRANCO, A.; TRIVELIN P. C. O. Nitrogen loss in *Brachiaria decumbens* after application of glyphosate or glufosinate-ammonium. **Scientia Agricola**, v. 65, n. 4, p. 402-407, 2008. Disponível em: https://doi.org/10.1590/S0103-90162008000400012. Acesso em: 18 out. 2021.

EMBRAPA. **Sistema brasileiro de classificação de solos**. Brasília, 2018. 355p.

FIALHO, C. M. T.; FRANÇA, A. C.; TIRONI, S. P.; RONCHI, C. P.; SILVA, A. A. Interferência de plantas daninhas sobre o crescimento inicial de *Coffea arabica*. **Planta Daninha**, v. 29, n. 1, p. 137-147, 2011. Disponível em: https://doi.org/10.1590/S0100-83582011000100016. Acesso em: 29 maio 2021.

FIALHO, C. M. T.; SILVA, A. A.; FARIA, A. T.; TORRES, L. G.; ROCHA, P. R. R.; SANTOS, J. B. Teor foliar de nutrientes em plantas daninhas e de café cultivadas em competição. **Planta Daninha**, v. 30, n. 1, p. 65-73, 2012. Disponível em: https://doi.org/10.1590/S0100-83582012000100008. Acesso em: 17 abr. 2021.

GAZZIERO, D. L. P.; LOLLATO, R. P.; BRIGHENTI, A. M.; PITELLI, R. A.; VOLL, E. **Manual de identificação de plantas daninhas da cultura da soja**. 2. ed. Londrina: Embrapa Soja, 2015. 126p.

GONÇALVES NETTO, A.; PRESOTO, J. C.; RESENDE, L. S.; MALARDO, M. R.; ANDRADE, J. F.; NICOLAI, M.; CARVALHO, S. J. P.; RODRIGUES, M. R.; MARÇAL, M. B. T. Effectiveness and selectivity of herbicides applied under pre-emergence conditions in weed management for coffee crops. **Coffee Science,** v. 16, e161963, 2021. Disponível em: https://doi.org/10.25186/.v16i.1963. Acesso em: 13 maio 2022.

HEAP, I. M. **International survey of herbicide-resistant weeds**. Disponível em: www.weedscience.org. Acesso em: 24 mar. 2021.

MERLADETE, A. **Produção dos cafés do Brasil atinge 61,62 milhões de sacas de 60kg em 2020**. Disponível em: https://www.agrolink.com.br/noticias/producao-de-cafe-atinge-61-62-milhoes-de-sacas-de-60kg_440247.html. Acesso em: 27 abr. 2021.

OSIPE, J. B.; FERREIRA, C.; OSIPE, R.; ADEGAS, F. S.; GAZZIERO, D. L. P.; BELANI, R.B. Avaliação do controle químico de buva com o herbicida Kixor associado a outros produtos. In: CONGRESSO BRASILEIRO DA CIÊNCIA DAS PLANTAS DANINHAS, 27., Ribeirão Preto, 2010. **Resumos...** Ribeirão Preto: SBCPD, 2010. p.1864-1867.

PRESOTO, J. C.; ANDRADE, J. F.; CARVALHO, S. J. P. Interação e eficácia de misturas em tanque dos herbicidas saflufenacil e glyphosate. **Revista Brasileira de Herbicidas**, v. 19, n. 4, p. 1-7, 2020. Disponível em: https://doi.org/10.7824/rbh.v19i4.721. Acesso em: 18 out. 2021.

QUEIROZ, J. R. G; SILVA JUNIOR, A. C.; COSTA, A. C. P. R.; MARTINS, D. Eficiência da aplicação da mistura de glyphosate com saflufenacil sobre plantas de *Brachiaria decumbens.* **Revista**

**Brasileira de Herbicidas**, v. 13, n. 1, p. 1-7, 2014. Disponível em: https://doi.org/10.7824/rbh.v13i1.255. Acesso em: 13 maio 2022.

RONCHI, C. P.; SILVA, A. A.; TERRA, A. A.; MIRANDA, G. V.; FERREIRA, F. R. Effect of 2,4-dichlorophenoxyacetic acid as a herbicide on fruit shedding and coffee yield. **Weed Research**, v. 45, n. 1, p. 41-47, 2005. Disponível em: http://dx.doi.org/10.1111/j.1365-3180.2004.00427.x. Acesso em: 10 out. 2021.

SANSOM, M.; SABORIDO, A. A.; DUBOIS, M. Control of *Conyza* spp. with glyphosate – a review of the situation in Europe. **Plant Protection Science**, v. 49, n. 1, p. 44-53, 2013. Disponível em: https://doi.org/10.17221/67/2011-PPS. Acesso em: 25 set. 2021.

SBCPD – SOCIEDADE BRASILEIRA DA CIÊNCIA DAS PLANTAS DANINHAS. **Procedimentos para instalação, avaliação e análise de experimentos com herbicidas**. Londrina: SBCPD, 1995. 42p.

SCOTT, A. J.; KNOTT, M. A. A cluster analysis method for grouping means in the analysis of variance. **Biometrics**, v. 30, n. 3, p. 507-512, 1974. Disponível em: https://doi.org/10.2307/2529204. Acesso em: 27 fev. 2021.

SEAPA. **Seapa divulga o balanço do agronegócio mineiro de 2020**. Disponível em: http://www.agricultura.mg.gov.br/index.php/component/gmg/story/4206-seapa-divulga-o-balanco-do-agronegocio-mineiro-de-2020. Acesso em: 04 abr. 2021.

TAKANO, H. K.; BEFFA, R.; PRESTON, C.; WESTRA, P.; DAYAN, F. E. Glufosinate enhances the activity of protoporphyrinogen oxidase inhibitors. **Weed Science**, v. 68, n. 7, p. 324-332, 2020. Disponível em: https://doi.org/10.1017/wsc.2020.39. Acesso em: 18 out. 2021.