ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.27, n.8, p.585-592, 2023
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v27n8p585-592

Management strategies for *Anredera cordifolia* in coffee culture[1]

Estratégias de manejo para *Anredera cordifolia* na cultura do café

Paulo V. da Silva[2], João P. Z. Coeti[3], Andrea Ferrari[3], Karolainy T. da S. Melo[3], Roque de C. Dias[5], Bruna F. Schedenffeldt[4*], Patricia A. Monquero[4], Pedro A. V. Salmazo[2], Elias S. de Medeiros[2], Carolina C. Bicalho[6] & Munir Mauad[2]

[1] Research developed at Cabo Verde, MG, Brazil
[2] Universidade Federal da Grande Dourados, Dourados, MS, Brazil
[3] Centro Universitário da Fundação de Ensino Octávio Bastos, São João da Boa Vista, SP, Brazil
[4] Universidade Federal de São Carlos, Araras, SP, Brazil
[5] Universidade Federal do Triângulo Mineiro, Iturama, MG, Brazil
[6] Universidade Estadual do Mato Grosso do Sul, Dourados, MS, Brazil

HIGHLIGHTS:

Mechanical control is not efficient for the control of Anredera cordifolia.
The single application of an herbicide, pre- or post-emergence or the combination of the two, is not efficient.
Mechanical control with pre- and post-emergence herbicides is efficient in the control of Anredera cordifolia.

ABSTRACT: Coffee plantations installed at high altitudes and near forested areas have been highly infested with *Anredera cordifolia*. The objective of this work was to evaluate the effectiveness of different pre- and post-emergence herbicide treatments on *A. cordifolia* after mechanical mowing. A field experiment was carried out in a coffee plantation with natural infestation of *A. cordifolia* in a completely randomized design with a split-plot scheme and four replicates, in which the main plot an herbicides application and the subplot was the days after the initial application (DAI). The treatments were as follows: saflufenacil + glyphosate (70 + 960 g a.i. ha^{-1}); chlorimuron + glyphosate (80 + 960 g a.i. ha^{-1}); metsulfuron + glyphosate (6 + 960 g a.i. ha^{-1}); flumioxazin + glyphosate (25 + 960 g a.i. ha^{-1}), and glyphosate (960 g a.i. ha^{-1}); with sequential application of glyphosate (960 g a.i. ha^{-1}); glyphosate + indaziflam (960 + 75 g a.i. ha^{-1}); indaziflam (75 g a.i. ha^{-1}); and a control without herbicide application. Mechanical control, followed by the application of the treatments flumioxazin + glyphosate and metsulfuron + glyphosate in the first application and sequential application of indaziflam, proved to be effective. Control of this weed should be based on the removal of its plant residues from the field to reduce the regrowth and germination of aerial tubers.

Key words: coffee growing, herbicide, indaziflam, mignonette vine

RESUMO: Plantações de café instaladas em altitudes elevadas e próximas a áreas florestais têm sido altamente infestadas por *Anredera cordifolia*. O objetivo deste estudo foi avaliar a eficácia de diferentes tratamentos herbicidas pré e pós-emergência sobre *A. cordifolia* após roçada mecânica. Para tanto, foi conduzido um experimento de campo em uma lavoura de café com infestação natural de *A. cordifolia* em um delineamento inteiramente casualizado com esquema de parcelas subdivididas com quatro repetições, sendo a parcela principal os tratamentos com aplicação de herbicida e a subparcela os dias após a aplicação inicial (DAI). Os tratamentos foram compostos por: saflufenacil + glifosato (70 + 960 g i. a. ha^{-1}); clorimuron + glifosato (80 + 960 g i. a. ha^{-1}); metsulfuron + glifosato (6 + 960 g i. a. ha^{-1}); flumioxazin + glyphosate (25 + 960 g i. a. ha^{-1}) e glifosato (960 g i. a. ha^{-1}); com uma aplicação sequencial de: glifosato (960 g i. a. ha^{-1}); (6) glifosato + indaziflam (960 g i. a. ha^{-1}); e indaziflam (75 g i. a. ha^{-1}), além de uma testemunha sem aplicação de herbicida. O manejo integrado é fundamental para o controle adequado de *A. cordifolia*, devido ao seu desenvolvimento vegetativo agressivo. O controle mecânico, seguido da aplicação dos tratamentos flumioxazin + glyphosate e metsulfuron + glyphosate na primeira aplicação e indaziflam sequencial mostrou-se eficaz. O controle dessa planta daninha deve ser baseado na remoção de seus resíduos vegetais do campo para reduzir a rebrota e a germinação de tubérculos aéreos.

Palavras-chave: cafeicultura, herbicida, indaziflam, bertalha coração

• Ref. 269682 – Received 19 Nov, 2022
* Corresponding author - E-mail: bfschedenffeldt@gmail.com
• Accepted 26 Mar, 2023 • Published 03 Apr, 2023
Editors: Geovani Soares de Lima & Walter Esfrain Pereira

Introduction

The weed *Anredera cordifolia* (Ten.) Steeni is a native species from Brazil and Argentina (Zhang et al., 2020). This species belongs to the Basellaceae family (Alba et al., 2020) and presents a great diversity of popular names. In Brazil, the most common ones are madeira-vine and mignonette vine (Smith et al., 2007; Zhang et al., 2020). In addition, it is known for its aerial tubercles (Purwasih et al., 2018).

This weed typically has ideal development conditions in coffee plantations located in the southern region of Minas Gerais (MG) state and west São Paulo (SP) state, more specifically in the municipality of Caconde, SP. This is because coffee plantations in these regions with high productivity are located in areas of high altitude and fertility (San Gregorio et al., 2021).

However, among the herbicide options used in the management of this species, many, such as picloram, aminopyralid, fluroxypyr, and triclopyr, which are products registered for pasture and not for coffee growing and use synthetic auxins in their mechanism of action (AGROFIT, 2022), cannot be recommended for coffee growing in the Brazilian scenario. In this sense, the targeted application of non-selective herbicides in coffee plantations can result in drift-induced intoxication for the plants, affecting their vegetative development and, consequently, productivity (Silva et al., 2017).

Therefore, given the scarcity of studies in the literature aimed at controlling *A. cordifolia* in coffee crops, the objective of this work was to evaluate the effectiveness of pre- and post-emergence herbicide treatments on the weed *Anredera cordifolia* after mechanical mowing in a coffee crop.

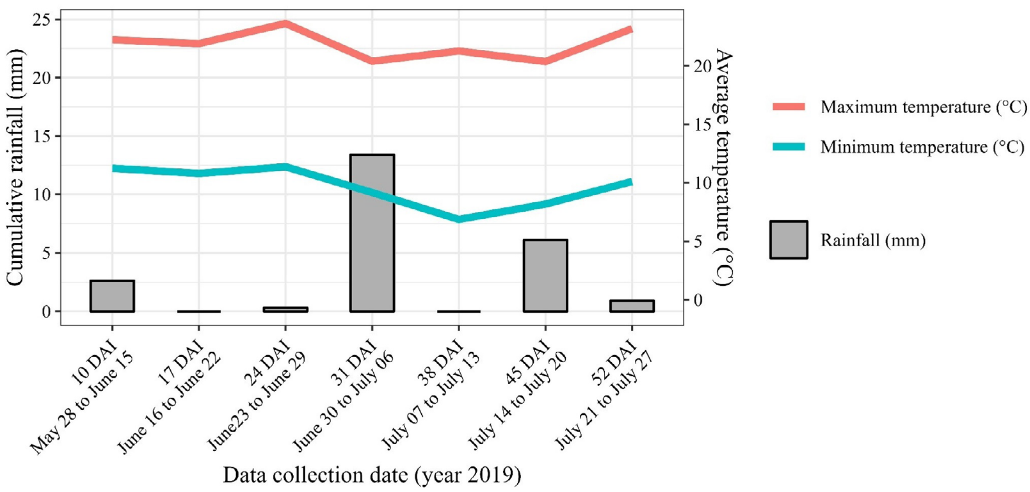
Material and Methods

The experiment was conducted from May 28 to July 27, 2019, at a commercial coffee production farm located in the municipality of Cabo Verde, MG (21° 34' 12.7" S and 46° 30' 13.6" W; altitude of 927 m), which was classified according to the Köppen climate classification as a warm and temperate Cwa-type climate, with an average annual rainfall of 1579 mm that is higher in summer than in winter. The average annual temperature is 20°C.

The climatic conditions of temperature and rainfall in the municipality of Cabo Verde, Minas Gerais, Brazil, are shown in Figure 1. This information refers to TRMM satellite data obtained from the Agrometeorological Monitoring System (AGRITEMPO, 2019). The highest weekly accumulation of rainfall occurred between June 30th and July 6th, 2019, and at the end of this period, the 31 days after the initial application (DAI) sample was collected.

The experiments were carried out in an area cultivated with arabica coffee (*Coffea arabica*) variety 'Novo Mundo' in a 15-year-old crop, conducted in a dryland system. The coffee plantation in question received drastic pruning of the type received on September 10, 2017, so that the lines of the coffee plantation were highly exposed to solar incidence. The experimental area consisted of 216 m^2, totaling 103 coffee plants. Soil chemical analysis was performed according to the methodologies recommended by Teixeira et al. (2017) and are presented in Table 1. Pest and disease control, fertilization, and liming were carried out normally, according to Maia & Furlani (1996).

Prior to the installation of the experiment, a phytosociological weed survey was carried out, aiming to establish the population through a survey using a square inventory methodology. *Anredera cordifolia* plants were the predominant plants in the area, with a density of 56 plants m^{-2}. The experimental design was completely randomized with four replicates, and each experimental unit consisted of two rows of coffee cultivation; each plot was 2 m wide by 3 m long, for a total area of 6 m^2.



DAI - Day after initial application

Figure 1. Accumulated rainfall and maximum and minimum air temperatures in the municipality of Cabo Verde in the state of Minas Gerais, Brazil, during the experiment

Table 1. Soil chemical attributes of the experimental area (0–20 cm)

pH ($CaCl_2$)	Al	H+Al	P (resin)	K	Ca	Mg	SB	CEC	V
4.6	< 1.5	58.0	10.0	5.8	26.0	8.0	39.8	97.8	41

Units – Al, H + Al, K, Ca, Mg, SB, and CEC (mmol$_c$ dm^{-3}); P (resin) (mg dm^{-3}); V, clay, silt, sand (%)

The experimental units received the first control, which consisted of manual mowing. According to the phenological growth stages and BBCH identification keys of weed species, at the time of adoption of the first control method (mowing), *A. cordifolia* plants present in the area had vegetative propagating organs under development (BBCH 49), with constant and new development of young plants and vegetative reproductive organs until they reached their final size (Hess et al., 1997).

After 10 days of mechanical control, which was enough time for the plant to emit regrowth - that is, to issue a new leaf branch - the first herbicide treatment was sequentially applied and divided into two groups. The first group had applications of the following herbicides: (1) Heat, BASF - saflufenacil + Zapp QI 360, Syngenta - glyphosate (70 + 960 g a.i. ha^{-1}); (2) Classic, Corteva - chlorimuron + glyphosate (80 + 960 g a.i. ha^{-1}); (3) Ally, FMC - metsulfuron + glyphosate (6 + 960 g a.i. ha^{-1}); (4) Flumyzin 500 SC, Ihara - flumioxazin + glyphosate (25 + 960 g a.i. ha^{-1}); and (7) glyphosate (960 g a.i. ha^{-1}). Ten days after the post-emergence herbicide application, a sequential application of Alion, Bayer - indaziflam (75 g a.i. ha^{-1}), was applied. The second group received only one application with the following herbicides: (5) glyphosate (960 g a.i. ha^{-1}); (6) glyphosate + indaziflam (960 + 75 g a.i. ha^{-1}); and (8) indaziflam (75 g a.i. ha^{-1}). In addition, a (9) control without herbicide application was utilized for comparison. A split-plot scheme was used, in which the main plot was the herbicide application treatment and the subplot was the DAI visual control evaluations. The arrangement and application of the treatments are shown in Table 2.

The treatments were applied by means of a constant pressure, CO_2 pressurized costal sprayer with fan-type tips XR 110.02, and pressure of 2.0 kgf cm^{-2} with a syrup volume of 150 L ha^{-1}. The conditions at the time of the first herbicide application were ideal: a temperature of 23.5°C, air humidity of 60%, and wind speed of 3.2 km h^{-1}. At the second herbicide application (indaziflam; pre-emergent), the environmental conditions of the application were also ideal: temperature of 23.5°C, humidity of 56%, and wind speed of 1.6 km h^{-1}.

Control of *A. cordifolia* was evaluated at 10, 17, 24, 31, 38, and 52 DAI. The evaluation method was visual, in which scores were attributed in relation to the control. The scale used ranged from 0 (no visible damage) to 100% (total plant death), according to ALAM (1974).

As the control variable of *A. cordifolia* was a proportion, GAMLSS models were used with beta distribution and log link function for the location parameter (Rigby & Stasinopoulos, 2005; Stasinopoulos et al., 2018; Palharani et al., 2023). A Tukey test was used to compare the treatment means. The beta regression model with log link function was used to adjust the control of *A. cordifolia* as a function of DAI. All tests were evaluated at $p \leq 0.05$. Statistical analyses were conducted using R software (R Core Team, 2021).

Results and Discussion

Deviance analysis showed a significant effect of the treatments and the DAI interaction ($F = 2.775$, $p = 0.01$). Figure 2 shows the results of the Tukey test when the treatments in each DAI were compared. At 10 DAI, treatments 1 (mowing; saflufenacil + glyphosate; indaziflam), 2 (mowing; chlorimuron + glyphosate; indaziflam), 3 (mowing; metsulfuron + glyphosate; indaziflam), and 4 (mowing; flumioxazim + glyphosate; indaziflam) did not differ from each other and represented the best treatments, showing control averages greater than 80%.

Treatments 5 (mowing; glyphosate), 6 (mowing; glyphosate + indaziflam), and 7 (mowing; glyphosate; indaziflam) were intermediate, with control averages of 47.5, 26.3, and 41.3%, respectively. The least effective treatment was 8 (mowing; indaziflam) with 6.3% control (Figure 2). All treatments with indaziflam in the second application did not differ from each other at 52 DAI, showing an average control of 47.5 to 80.0%. Treatment 8 (mowing; indaziflam) also showed no significant difference in the percentage of control when compared with treatments 2 (mowing; chlorimuron + glyphosate; indaziflam) and 3 (mowing; metsulfuron + glyphosate; indaziflam) in all evaluation periods (DAI); however, during all evaluations, the results of treatment 8 (mowing; indaziflam) were considered insufficient.

Figure 3 shows the effects of DAI in each treatment.

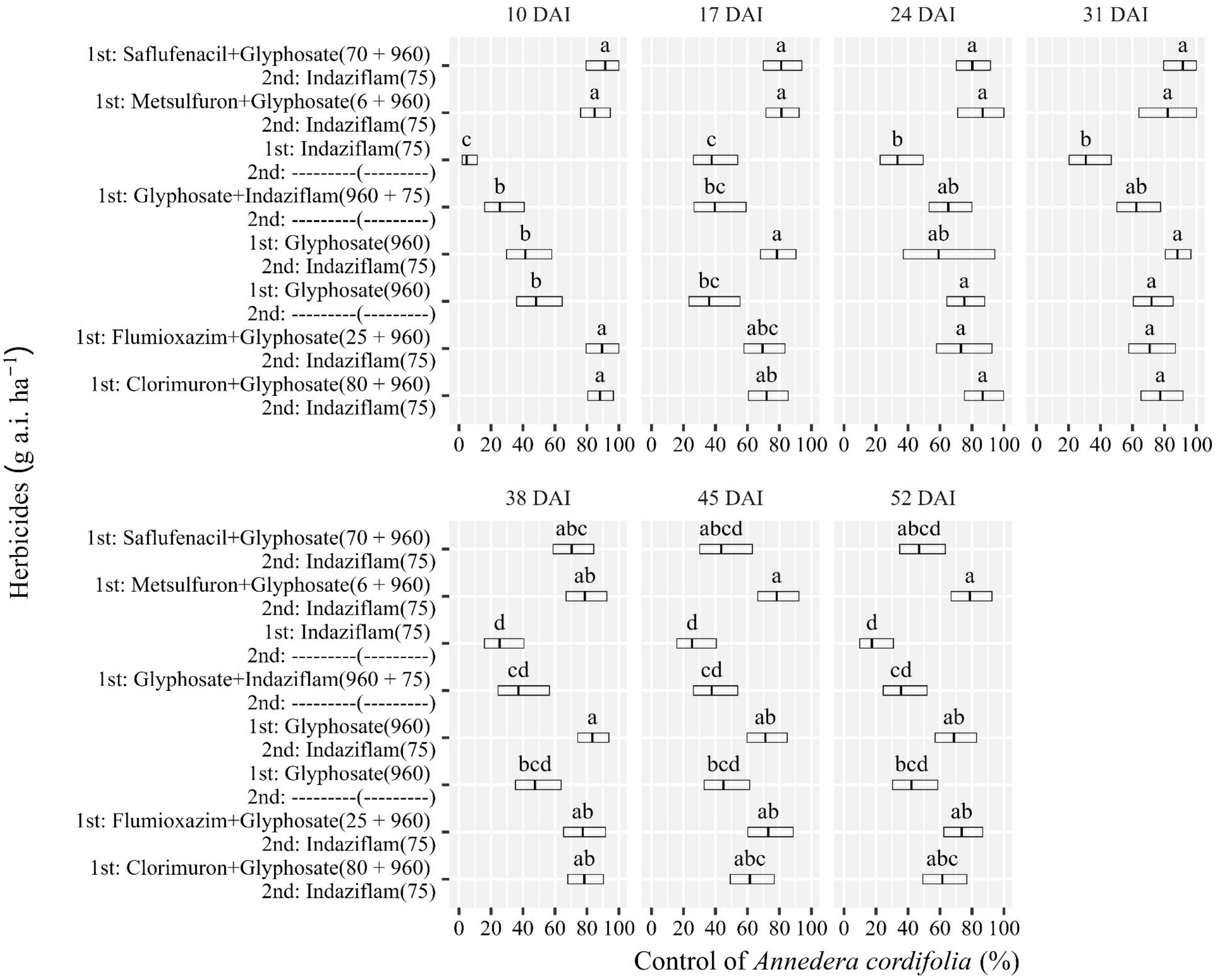
All treatments without two herbicide applications resulted in inadequate control of *A. cordifolia* (glyphosate; glyphosate + indaziflam; indaziflam) during all evaluation periods, with control percentages below 80%. This happened because this weed has intense vegetative growth, and the absence of sequential herbicide applications resulted in rapid regrowth and re-infestation of this weed in the coffee crop.

Glyphosate is a post-emergent and systemic product and has no residual effect on the soil due to its strong adsorption and consequent low mobility (Soares et al., 2021). In this way,

Table 2. Treatments applied to coffee culture aimed at the control of *Anredera cordifolia*

Treatment	First control	First herbicide application*	Second herbicide application (10 DAI)	Dose first application	Dose second application
				(g a.i.ha^{-1})	
1	Mowing	Saflufenacil + Glyphosate[1]	Indaziflam	70 + 960	75
2	Mowing	Clorimuron + Glyphosate[2]	Indaziflam	80 + 960	75
3	Mowing	Metsulfuron + Glyphosate[2]	Indaziflam	6 + 960	75
4	Mowing	Flumioxazim + Glyphosate[3]	Indaziflam	25 + 960	75
5	Mowing	Glyphosate	---------	960	---------
6	Mowing	Glyphosate + Indaziflam	---------	960 + 75	---------
7	Mowing	Glyphosate	Indaziflam	960	75
8	Mowing	Indaziflam	---------	75	---------
9	Control	Control	---------	---------	---------

*Addition of 1% v/v[2] nonionic mineral adjuvant; Addition of 0.05% v/v[3] non-emulsifiable mineral oil; Adding 0.25% non-emulsifiable mineral oil; DAI: days after initial application



Treatments followed by the same letter do not differ significantly ($p \leq 0.05$) by Tukey test
DAI - Days after initial application

Figure 2. Control of *Anredera cordifolia* as a function of applied herbicides on different days after initial application (DAI)

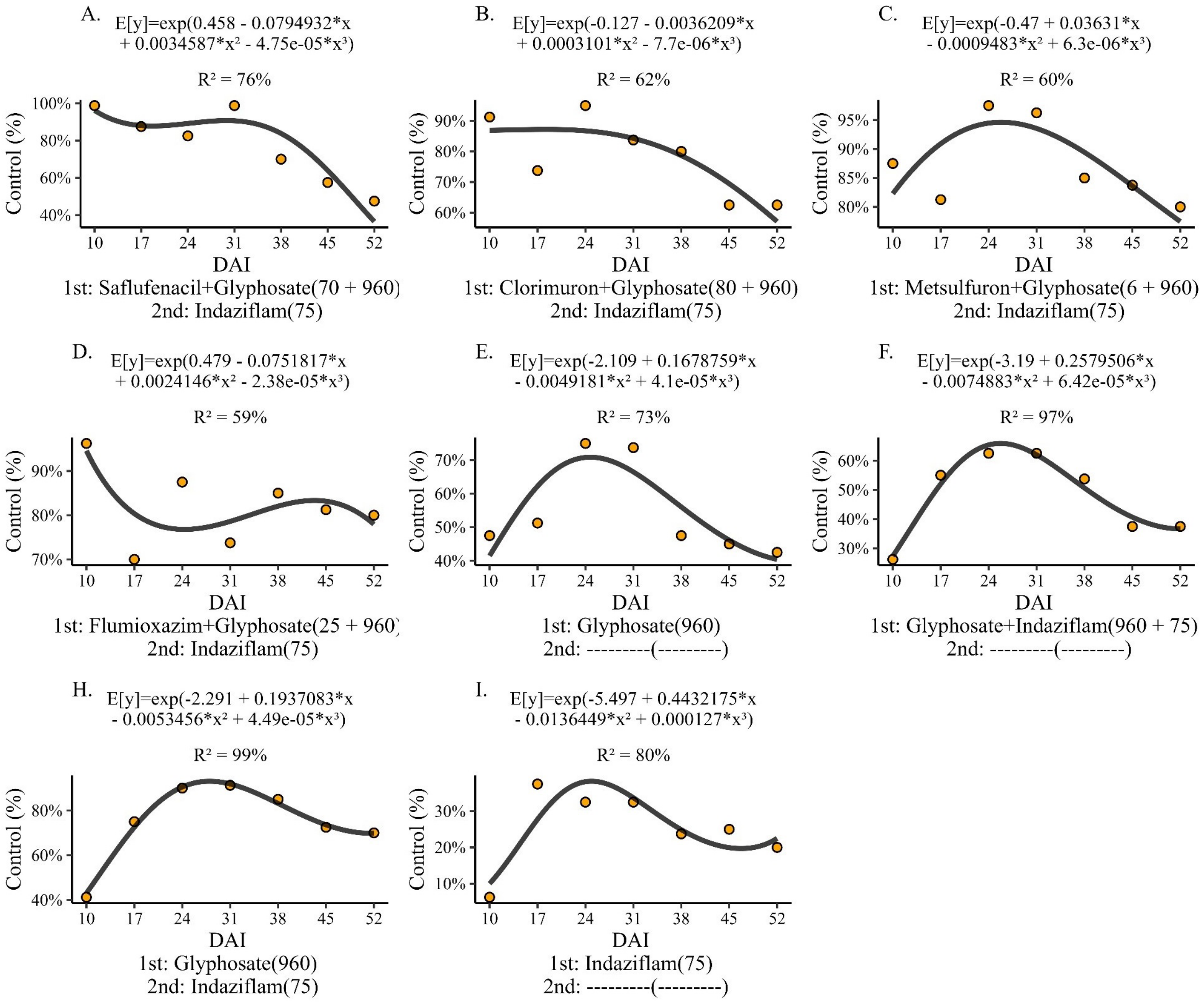
it cannot control new germinative flows or new shoots of *A. cordifolia* vegetative propagation organs. Therefore, glyphosate was probably absorbed by the weed and translocated to the underground tubers; however, they had a high amount of reserve structure due to the (large) size, and the amount of herbicide that came to them was not sufficient to promote the death of these tubers, resulting in regrowth.

Glyphosate does not remain in the soil, and weed plants remain in the field on the soil surface, favoring the germination of a new germinative flow, promoting rapid re-infestation of the area, and resulting in ineffective control during all evaluation periods. The ineffectiveness of *A. cordifolia* control through glyphosate corroborates data obtained by Prior & Armstrong (2001), who conducted a field experiment to control this plant with glyphosate and found that application of this product favored re-infestation by the germination of underground tubers due to the quantitative increase of *A. cordifolia* density in the experimental units. The authors reported that this re-infestation potential may be even greater when glyphosate applications occur at drier times of the year (when this herbicide was applied in this experiment) when translocation activity is not high.

San Gregorio et al. (2021) reported that glyphosate + saflufenacil was the only effective mixture (80%) in controlling *A. cordifolia*, and chlorimuron, flumioxazin, glyphosate, metsulfuron, and saflufenacil were not effective post-emergence, which was associated with a high ability of the species to metabolize these herbicides, contributing to the low efficacy of weed control.

Using the combination of glyphosate and indaziflam and the application of indaziflam, we observed ineffective control of *A. cordifolia*. Therefore, the number of weed plants that remained on the soil surface and the uncontrolled plants in the field may have affected the effectiveness of indaziflam as a pre-emergent control. This behavior occurs because indaziflam is a highly lipophilic herbicide (Kow = 2.88) (Silva et al., 2021). This physicochemical characteristic probably culminated in greater adsorption or interception of indaziflam in *A. cordifolia* and emerged plant residues, thus reducing the amount of product that actually reached the soil to act as a pre-emergence herbicide. This was probably due to the high sorption and unavailability of the product in the soil solution (Mendes et al., 2021), culminating in the inefficiency of indaziflam and residual to control new germinative flows and the regrowth of aerial and underground tubercles of *A. cordifolia*.

This greater retention of indaziflam in straw was confirmed by Clark et al. (2019), who applied this herbicide to straw of three weeds, *Taeniatherum caput-medusae*, *Ventenata dubia*, and *Bromus tectorum*, and observed higher interception (844.3%) for *B. tectorum* and an average of 76% for *V. dubia* and



* Significant at p ≤ 0.05 by t test
DAI - Days after initial application

Figure 3. Control of *Anredera cordifolia* as a function of the days after initial application (DAI) in each of the eight treatments

T. caput-medusae. Herbicide recovery from indaziflam was 54% at 0 d and 33% when rain was applied 1 or 7 days after herbicide application, indicating that the longer that indaziflam remains on straw, the shorter its recovery, reducing the availability of the product in soil solutions for weed control.

This behavior of indaziflam may have hindered its transport from the ground surface to greater depths. Leaching may have been reduced due to the water conditions of this experiment, which did not favor the availability of indaziflam in the soil solution, to the detriment of the dry climate and low amounts of precipitation. González-Delgado & Shukla (2020) confirmed the low mobility of indaziflam at greater soil depths and detected the herbicide at depths from 0 to 12 and 12 to 24 cm at 45 and 90 days after application, and the concentrations of indaziflam in the soil were significantly higher at depths from 0 to 12 cm after 45 days.

Silva et al. (2020) observed that increasing the amount of coffee litter on the soil surface, combined with lower amounts of rainfall (10 and 20 mm), reduced indaziflam leaching, resulting in insufficient incorporation in the first 0.10 m of depth. Therefore, this low mobility of indaziflam may have limited the control of *A. cordifolia* in underground tubers and those positioned deeper in the soil profile. Thus, part of the *A. cordifolia* re-infestation in this experiment may have come from underground tubers.

Conversely, all treatments that, after the mechanical mowing of *A. cordifolia*, received two herbicide applications - that is, a post-emergence herbicide followed by indaziflam sequentially as a pre-emergence herbicide had better control results. In addition, the interval of 20 days after weeding for indaziflam positioning allowed greater degradation of plant residue in the field, resulting in greater exposure of the soil contact surface and favoring indaziflam entry into the soil solution.

This fact was confirmed by Silva et al. (2019), who aimed to control *Commelina benghalensis* (Bengal dayflower) in a coffee crop and observed better control effects when the first post-emergence application was applied with the herbicides saflufenacil and flumioxazin, which are PROTOX (enzyme protoporphyrinogen oxidase) inhibitors, and an indaziflam sequence, obtaining control of 80 and 82.5%, respectively, at 28 DAA (days after application) at the expense of reducing the soil cover.

However, control over 80% was obtained only when the first herbicide application was placed with effective efficacy both for the post-emergence and pre-emergence of weeds, i.a., when the first application consisted of flumioxazin + glyphosate and metsulfuron + glyphosate (AGROFIT, 2022); the latter, although not recommended for pre-emergence application on weeds in a coffee crop, has residual weed control and is even used as a pre-emergence herbicide in other crops (sugar cane and wheat). Conversely, flumioxazin can be used as both a pre- and post-emergence herbicide for the control of weeds in a coffee crop (AGROFIT, 2022).

Treatments with the application of flumioxazin + glyphosate and metsulfuron + glyphosate promoted control greater than 85% in the evaluation at 10 DAI, having a noticeably smaller leaf area at the second herbicide application, which allowed, in quantitative terms, greater arrival of this product to the soil solution, the target of its action. Furthermore, when these residual soil herbicides (flumioxazin and metsulfuron) were applied in the first application, the control of new flows was prolonged, resulting in adequate control until the last evaluation period at 42 DAI. These results indicate an extension or potentiation of the residual effect of indaziflam (pre-emergent).

These results were confirmed by Webb & Harrington (2005), who collected *A. cordifolia* tubers in the field and applied herbicide treatments under laboratory conditions, aiming to analyze the reduction of viability of these tubers. At 154 days after treatment, the authors obtained only 2% germination of the metsulfuron-treated tubers, 62% germination of glyphosate-treated tubers, and 95% germination when no herbicide was used. Regarding control, the authors observed in the field that the application of metsulfuron, glyphosate, and the association of metsulfuron + glyphosate resulted in the control of 3-month-old *A. cordifolia* plants.

In the application of indaziflam sequentially with saflufenacil, control was only effective until 21 DAI. In this treatment, there was rapid control of *A. cordifolia* shoots through the post-emergence application of the herbicide saflufenacil (associated with glyphosate). However, this rapid and expressive control probably did not allow the absorption and translocation of glyphosate (systemic product) (Fadin et al., 2018) to deep underground tubers or aerial tubers. Thus, regrowth was observed in underground and aerial tubers.

Moreover, performing the first application of systemic post-emergence herbicides before the pre-emergence sequential herbicide (in this case, indaziflam) provides longer control of *A. cordifolia* due to the translocation of the product to underground and superficial tubers. This was confirmed in the present experiment when the positioning of a systemic product in the first application (chlorimuron + glyphosate and glyphosate alone) occurred; longer control was obtained than that in the saflufenacil + glyphosate contact product treatment application.

Silva et al. (2018) evaluated the effectiveness of herbicide control in *Conyza canadensis* using glyphosate + saflufenacil (1440 g a.i. ha^{-1} + 56 g a.i. ha^{-1}), a control equivalent to grade 5 (efficiency between 81 and 100%) at 3 days after application of the treatments. *C. canadensis* plants do not have vegetative propagation organs, unlike *A. cordifolia* plants, reinforcing that the rapid control of the aerial part of this weed may have allowed the sprouting or germination of viable or underground tubers due to the less effective translocation of glyphosate.

In all treatments, there was a significant reduction in the control percentage over the course of the evaluation days, with the exceptions being treatments that received a first application of metsulfuron + glyphosate and flumioxazin + glyphosate, which showed no significant difference but a numerical reduction in control.

This behavior can be causally related to the biology of the weed *A. cordifolia*, which presents intense vegetative growth. In addition to these aspects, it presents better development in areas with intense light, similar to the experimental area, which was a coffee plantation that recently underwent the type of pruning that facilitated the constant maintenance of light in the environment and greater exposure to light between the lines of cultivation, producing optimum characteristics for the vegetative development of *A. cordifolia* in a coffee plantation.

Thus, due to the intense vegetative growth (biology) and biological adaptability (ecophysiology) of *A. cordifolia* in coffee plantations and the edaphoclimatic conditions of the productive system, even with the adoption of up to three control strategies, a reduction in control percentages was observed over the evaluation days.

Associated with this fact is also the high yield of tubers, which can be found at densities greater than 1500 tubers per m^2 in the soil in forest environments (Stockard, 1993), in addition to regrowth even after five years (Xifreda et al., 1999). Therefore, the permanence of aerial tubers in the field after mechanical removal may represent a source of field re-infestation, as these propagation organs may remain viable for germination. In addition, *A. cordifolia* aerial tubers can persist in the field for long periods of time, ranging from two to five years (Stockard, 1993), but there are also 15-year reports (Harden et al., 2004).

In the execution of this experiment, we found that the best measure after mechanical control of *A. cordifolia* should be the removal of plant residues from the field plants. This step was even more laborious and essential for the management of the large weed number of aerial tubers that were in contact with soil, allowing an intense and rapid re-infestation of the area. In addition, the removal of waste would allow the arrival of more indaziflam to the soil. This procedure was not performed in the field, and rapid recolonization of the area was observed.

Therefore, *A. cordifolia* presents intense vegetative growth and adaptability to coffee crop production conditions, especially those that have recently been pruned or in early development, which have a higher incidence of light between the lines, allowing more favorable conditions for vegetative development. Thus, the use of isolated control practices and the lack of integration of management methods may result in ineffective control of this weed.

Conclusion

1. Mechanical control, followed by the application of the weed treatment herbicides flumioxazin + glyphosate and

metsulfuron + glyphosate in the first application (as post-emergence) and sequential indaziflam, proved to be effective in the management of *A. cordifolia*.

2. Control of *A. cordifolia* should be based on the removal of its plant residues from the field to reduce the regrowth and germination of aerial tubers.

Literature Cited

AGRITEMPO - Sistema de monitoramento agrometeorológico, 2019. Available on: <http://www.agritempo.gov.br>. Accessed on: Feb. 2023.

AGROFIT - Sistema de Agrotóxicos Fitossanitários. Consulta aberta. 2022. Available on: <http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons> Accessed on: Jul. 2022.

ALAM - Asociation Latinoamericana de Malezas. Recomendaciones sobre unificación de los sistemas de evaluación em ensayos de control de malezas. ALAM, v.1, p.35-38, 1974.

Alba, T. M.; Pelegrin, C. M. G. D.; Sobottka, A. M. Ethnobotany, ecology, pharmacology, and chemistry of *Anredera cordifolia* (Basellaceae): a review. Rodriguésia, v.71, p.1-11, 2020. https://doi.org/10.1590/2175-7860202071060

Clark, S. L.; Silva, P. V. da; Dayan, F. E.; Nissen, S. J.; Sebastian, D. J. The influence of winter annual grass litter on herbicide availability. Weed Science, v.67, p.702-709, 2019. https://doi.org/10.1017/wsc.2019.45

Fadin, D. A.; Tornisielo, V. L.; Barroso, A. A. M.; Ramos, S.; Reis, F. C. dos; Monquero, P. A. Absorption and translocation of glyphosate in *Spermacoce verticillata* and alternative herbicide control. Weed research, v.58, p.389-396, 2018. https://doi.org/10.1111/wre.12329

González-Delgado, A. M.; Shukla, M. K. Mobility, degradation, and uptake of indaziflam under greenhouse conditions. HortScience, v.55, p.1216-1221, 2020. https://doi.org/10.21273/HORTSCI14966-20

Harden, G. J.; Fox, M. D.; Fox, B. J. Monitoring and assessment of restoration of a rainforest remnant at Wingham Brush, NSW. Austral Ecology, v.29, p.489-507, 2004. https://doi.org/10.1111/j.1442-9993.2004.01421.x

Hess, M; Barralis, G.; Bleiholder, H.; Buhrs, L.; Eggers, T.; Hack, H.; Stauss, R. Use of the extended BBCH scale – general for the descriptions of the growth stages of mono- and dicotyledonous weed species. Weed Research, v.37, p.433-441, 1997.

Maia, N. B.; Furlani, A. M. C.; Especiarias, aromáticas e medicinais. Boletim Técnico do Instituto Agronômico de Campinas, Campinas, v.70, p.75-76, 1996.

Mendes, K. F.; Furtado, I. F.; Sousa, R. N. D.; Lima, A. D. C.; Mielke, K. C.; Brochado, M. G. D. S. Cow bonechar decreases indaziflam pre-emergence herbicidal activity in tropical soil. Journal of Environmental Science and Health, Part B, v.56, p.532-539, 2021. https://doi.org/10.1080/03601234.2021.1916302

Palharani, W.; Mauad, M.; Silva, P. V.; Medeiros, E. S.; Schedenffeldt, B. F.; Bicalho Medeiros, C. C. Management of *Digitaria insluaris* in soybean pre-sowing desiccation by ACCase alternative herbicides and its impact on soybean carryover. Journal of Environmental Science and Health, Part B, v.58, p.1-10, 2023. https://doi.org/10.1080/03601234.2023.2172279

Prior, S. L.; Armstrong, T. R. A comparison of the effects of foliar applications of glyphosate and fluroxypyr on Madeira vine, *Anredera cordifolia* (Ten.) van Steenis. Plant Protection Quarterly, v.16, p.33-36, 2001.

Purwasih, R.; Safitri, F.A.; Rahayu, W.E. The potency of Binahong leaves (*Anredera cordifolia* (Ten.) Steenis) to recovery process of wound in the livestock. Advances in Health Sciences Research, v.5, p.211–215, 2018. https://doi.org/10.2991/icoh-17.2018.41

R Core Team. R: A language and environment for statistical computing. Vienna: R CFoundation for Statistical Computing, 2021. Avaiable on: <https://www.R-project.org/>. Accessed on: Jul. 2022.

Rigby, R. A.; Stasinopoulos, D. M. Generalized additive models for location, scale and shape (with discussion). Journal of the Royal Statistical Society: Series C (Applied Statistics), v.54, p.507-554, 2005.

San Gregorio, J. P.; Pioto, N. M.; Forti, V. A.; Rodrigues, J.; Silva, P. V. da; Monquero, P. A. Propagation and control of *Anredera cordifolia* (Ten.) Stennis (madeira vine). Australian Journal of Crop Science, v.15, p.1192-1197, 2021. https://doi.org/10.21475/ajcs.21.15.08.p3320

Silva, C. A.; Miranda, G. R. B.; Alves, A. D.; Goulart, R. dos R. Chemical control of *Conyza canadensis* (L.), in mixtures of herbicides with glyphosate in coffee crop. Coffee Science, v.3, p.252-256, 2018.

Silva, L. G.; Castanheira, D. T.; Voltolini, G. B.; Souza, I. F. D.; Gonçalves, A. H.; Guimarães, R. J. Sintomas de fitotoxicidade e crescimento de mudas de café submetidas aos herbicidas inibidores da PROTOX. Coffee Science, v.12, p.1-7, 2017.

Silva, P. V. da; Barbosa, G. C.; Ferrari, A.; Tronquini, S. M.; Monquero, P. A. Chemical control strategies of *Commelina benghalensis* in coffee crop. Coffee Science, v.14, p.1-9, 2019.

Silva, P. V. da; Dos Santos, M. J.; Tronquini, S. M.; Giraldeli, A. L.; de Carvalho, R. D.; Monquero, P. A.; Inácio, E. M. Indaziflam: Leaching and control of *Urochloa plantaginea* in applications on coffee litter with different rainfall simulations. Coffee Science, v.15, p.1-8, 2020.

Silva, P. V. da; Milagres Viana, H. R.; Monquero, P. A.; Ribeiro, N. M.; Pereira Neto, W.; Inacio, E. M.; Christoffoleti, P. J.; Dias, R. D. C. Influence of sugarcane (*Saccharum officinarum*) straw on weed germination control. Revista de la Facultad de Ciencias Agrarias, v.53, p.220-233, 2021. https://doi.org/10.48162/rev.39.021

Smith, G. V. The biology of Australian weeds: *Anredera cortifolia* (Ten.) Steenis. Plant Protection, v.22, p.2-10, 2007.

Soares, D. O. P.; Pinto, K. G. D.; Gama, L. A. da; Ferreira, C. C.; Bhowmik, P. C.; Albertino, S. M. F. Physical Properties of soil and glyphosate residue as a function of cassava weed management by cover crops in the amazon ecosystem. HortScience, v.56, p.1053-1058, 2021. https://doi.org/10.21273/HORTSCI15895-21

Stasinopoulos, M. D.; Rigby, R. A.; Bastiani, F. D. GAMLSS: A distributional regression approach. Statistical Modelling, v.18, p.248-273, 2018. https://doi.org/10.1177/1471082X18759144

Stockard, J. Rainforest rehabilitation at Wingham Brush. Proceedings of the 7th Biennial Noxious Weeds Conference (New South Wales Agriculture, Orange). 7.ed. New South Wales, 1993. 4p.

Teixeira, P. C.; Donagemma, G. K.; Fontana, A.; Teixeira, W. G. (org.). Manual de métodos de análise de solo. 3.ed. Brasília: Embrapa, 2017. 573p.

Webb, H.; Harrington, K. Control strategies for Madeira vine (*Anredera cordifolia*). New Zealand Plant Protection, v.58, p.169-173. 2005. https://doi.org/10.30843/nzpp.2005.58.4324

Xifreda, C.C.; Argimon, S.; Wulff, A.F. Infraspecific characterization and chromosome numbers in *Anredera cordifolia* (Basellaceae). Thaiszia Journal of Botany, v.9, p.99-108, 1999.

Zhang, X.; Wei, H.; Zhao, Z.; Liu, J.; Zhang, Q.; Zhang, X.; Gu, W. The global potential distribution of invasive plants: *Anredera cordifolia* under climate change and human activity based on random forest models. Sustainability, v.12, p.1-18, 2020. https://doi.org/10.3390/su12041491