



## CHEMICAL CONTROL OF GARDEN SPURGE (*Chamaesyce hirta*) ADULT PLANTS IN THE FIELD

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**ABSTRACT:** *Chamaesyce hirta* is a troublesome weed in producing regions of Brazil; however, little is known about the control of adult plants. We evaluated the control of adult *Chamaesyce hirta* plants in the field. The experiment was installed at COACEN, municipality of Sorriso - MT, in a randomized complete block design, with four replicates. Treatments were arranged in a split plot factor, where plots received the application of 19 herbicides in burndown and subplots received the sequential application of paraquat, glufosinate ammonium, or no herbicide, nine days after the first application. Visual control evaluations were performed at 7, 14, 21 and 28 days after the first application and at 5, 12 and 19 days after the second application. Sequential applications increased the level of control of most treatments. Isolated glyphosate applications, without sequential application did not control *C. hirta*. The addition of saflufenacil to glyphosate + 2,4-D mixture provides effective control with a single application. The mixture of glyphosate + 2,4-D provided better control than glyphosate + chlorimuron-ethyl and was efficient in controlling adult *C. hirta* plants, when used with sequential application of paraquat and ammonium glufosinate.

**KEYWORDS:** *Euphorbia hirta*, Garden spurge, Sequential application, Weed control.

## CONTROLE QUÍMICO DE PLANTAS ADULTAS DE ERVA-DE-SANTA-LUZIA (*Chamaesyce hirta*) EM CAMPO

**RESUMO:** *Chamaesyce hirta* é uma planta daninha importante no Brasil, no entanto pouco se sabe do controle desta infestante adulta. Este trabalho teve como objetivo avaliar o controle de plantas adultas de *Chamaesyce hirta* em campo. O experimento foi instalado na COACEN em Sorriso - MT, em delineamento de blocos casualizados, com quatro repetições. Os tratamentos foram arranjados em parcelas subdivididas, fator parcela: aplicação de 19 herbicidas em manejo de dessecação, fator na subparcela: aplicação sequencial de Paraquat, Glufosinato de Amônio e sem aplicação de herbicida, 9 dias após a primeira aplicação, além da testemunha sem aplicação de herbicida. Avaliações visuais de controle foram realizadas aos 7, 14, 21 e 28 dias após a primeira aplicação e aos 5, 12 e 19 dias após a segunda aplicação. As aplicações sequenciais aumentaram o nível de controle da maioria dos tratamentos, Glyphosate isolado não controlou as plantas de *C. hirta*. A adição do Saflufenacil à mistura Glyphosate + 2,4-D permite o controle em aplicação única. Misturas que contém Glyphosate + 2,4-D são mais eficientes que misturas que contém Glyphosate + Chlorimuron-ethyl e foram eficientes no controle de plantas adultas de *C. hirta* com aplicação sequencial de Paraquat e Glufosinato de Amônio.

**PALAVRAS CHAVE:** *Euphorbia hirta*, Erva-de-santa-luzia, aplicação sequencial, controle de plantas daninhas.

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## INTRODUCTION

*Chamaesyce hirta* (L.) Millsp (garden spurge) is a species widely distributed in Brazil and is capable to produce flowers and fruits throughout the year

(Silva, 2014). The species is present in several Brazilian states, including Acre, Bahia, Goiás, Minas Gerais, Paraná, Rio de Janeiro and São Paulo (Trindade and Lameira, 2014). After surveying soy

and corn producing regions in the states of Goiás and Minas Gerais, Karam et al. (2014) emphasized that among observed weed species, *C. hirta* stands out, and raised a hypothesis that the invader may soon become a major problem in the producing areas of these states, considered difficult to control. In another study, a phytosociological survey was carried out in areas of glyphosate-resistant soy (RR) and conventional soy in southwestern part of the state of Goiás and greater presence of *C. hirta* was observed in areas cultivated with RR soy than in areas with conventional soy cultivation (Santos et al., 2018).

Information on chemical control of *C. hirta* in Brazil is limited, particularly with regard to adult plants. Taking these factors into account, the association of herbicides is an interesting alternative in the management of the garden spurge, since it can prevent the emergence of resistant biotypes, especially when using different mechanisms of action, which may improve the level of control of herbicides applied alone. In addition to this alternative, the use of sequential herbicide applications can be more efficient than the application of herbicides alone since it allows decreasing plant regrowth rates.

The state of Mato Grosso, one of the main soy producers in Brazil, has experienced increases in failures related to the control of *C. hirta* in soy crops. In view of constant complaints and the absence of studies related to the control of this species, we evaluated the control of adult *Chamaesyce hirta* plants in the field in the region of Sorriso, MT.

## MATERIAL AND METHODS

The experiment was installed at Cooperativa Agropecuária e Industrial Celeiro do Norte (COACEN), at Sorriso - MT, from 11/30/2017 to 12/28/2017. The experimental design used was randomized blocks, with four replicates. Treatments were arranged in subdivided plots. In plots, different herbicides were applied in desiccation management (application A) (Table 1). In subplots, sequential application (application B) (Table 2) was performed nine days after the first application, in addition to control without herbicide application. Subplots had dimensions of 4 m in width and 5 m in length, totaling an area of 20 m<sup>2</sup>. In evaluations, 0.5 m on each side and one line on each end of the subplot were not considered.

**Table 1.** Herbicides and rates used in the first sequential desiccation application, aiming to control adult *Chamaesyce hirta* plants in the field.

	Factor (application A)	Dose (g a.i. or a.e. ha <sup>-1</sup> )
1	Glyphosate	1440
2	glyphosate + chlorimuron-ethyl	1440+15
3	glyphosate + chlorimuron-ethyl + flumioxazin	1440+15+50
4	glyphosate + chlorimuron-ethyl + saflufenacil	1440+15+49
5	glyphosate + chlorimuron-ethyl + lactofen	1440+15+180
6	glyphosate + chlorimuron-ethyl + fomesafen	1440+15+250
7	glyphosate + chlorimuron-ethyl + carfentrazone-ethyl	1440+15+28
8	glyphosate + 2,4-D	1440+670
9	glyphosate + 2,4-D + chlorimuron-ethyl	1440+670+15
10	glyphosate + 2,4-D + flumioxazin	1440+670+50
11	glyphosate + 2,4-D + saflufenacil	1440+670+49
12	glyphosate + 2,4-D + lactofen	1440+670+180
13	glyphosate + 2,4-D + fomesafen	1440+670+250
14	glyphosate + 2,4-D + carfentrazone-ethyl	1440+670+28
15	glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin	1440+670+15+50
16	glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil	1440+670+15+49
17	glyphosate + 2,4-D + chlorimuron-ethyl + lactofen	1440+670+15+180
18	glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen	1440+670+15+250
19	glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl	1440+670+15+28
20	Untreated check	-

Assist (0.5% v.v<sup>-1</sup>) was added to all treatments.

**Table 2.** Herbicides used in the second sequential desiccation application, aiming to control adult *Chamaesyce hirta* plants in the field.

	Subplot ator (application B)	Dose (g a.i. ha <sup>-1</sup> )
1	No sequential application	-
2	Paraquat	400
3	Glufosinate-ammonium	500

In all subplots with herbicide application, Assist (0.5% v.v<sup>-1</sup>) was added.

The trade names of herbicides were: glyphosate (RoundUp Original Di®, 370 g L<sup>-1</sup>, SL, Monsanto), chlorimuron-ethyl (Classic®, 250 g kg<sup>-1</sup>, WG, Corteva), flumioxazin (Flumyazin 500®, 500 g kg<sup>-1</sup>, WP, Sumitomo), saflufenacil (Heat®, 700 g kg<sup>-1</sup>, WG, Basf), lactofen (Cobra®, 240 g L<sup>-1</sup>, EC, Bayer) fomesafen (Flex®, 250 g L<sup>-1</sup>, SL, Syngenta), carfentrazone-ethyl (Aurora®, 400 g L<sup>-1</sup>, EC, FMC), 2,4-D (Aminol®, 670 g L<sup>-1</sup>, SL, Adama), paraquat (Gramoxone®, 200 g L<sup>-1</sup>, SL, Syngenta), glufosinate-ammonium (Finale®, 200 g L<sup>-1</sup>, SL, Basf).

The first burnout application (Application “A”) was carried out in plots on 11/30/2017 between 8:30 am and 11:30 am. At the time of application, soil was humid, temperature was 27°C, relative humidity was 65%, and the wind speed was 3.5 km h<sup>-1</sup>. *C. hirta* plants were branched, with inflorescence and seeds, in plants with high infestation.

The sequential burndown application (Application “B”) was carried out on December 9th, 2017, between 9:00 am and 10:30 am, only in one of the subplots. At the time of application, soil was humid, temperature was 26°C, relative humidity was 65%, and the wind speed was 2.5 km h<sup>-1</sup>. *C. hirta* plants had symptoms from the first evaluation.

For the application of treatments, a backpack sprayer of constant pressure based on CO<sub>2</sub> was used, equipped with a bar with four XR 110-0.12 tips spaced 0.50 m from each other (application reach of 2.0 m), under pressure of 30 lb in<sup>-2</sup>. These conditions resulted in application rate of 200 L ha<sup>-1</sup>.

The variables evaluated were: weed control percentage (visual scale, 0-100%, where 0% means no symptoms and 100% total weed death) at 7, 14, 21 and 28 days after application A (DAA (A)) and at 5, 12 and 19 days after application B (DAA (B)).

Data obtained at 7, 14, 21 and 28 DAA (A) were submitted to analysis of variance by the F test and means were compared by the Scott-Knott test at 5% probability. Subsequently, for subdivided plots, data obtained after sequential application were submitted to analysis of variance by the F test and means were compared by the Scott-Knott test at 5% probability.

## RESULTS AND DISCUSSION

Farmers face a significant challenge in controlling adult weeds in the field, and this issue is particularly pronounced with respect to adult *C. hirta* plants due to the lack of available information on effective control methods. The lack of recommendations for effective control strategies combined with the characteristics of the species to produce flowers and fruits throughout the year, the fact that the species germinates in light and dark situations and even in the presence of corn stalk, are factors that favor its dissemination in agricultural areas.

In the evaluation of the control of adult *C. hirta* plants after the first application of herbicides (application A), the results found confirm the difficulty to control its growth, since the highest values obtained were around 50% (Table 3).

**Table 3.** Percentages of control of adult garden spurge (*Chamaesyce hirta*) 7 DAA, after application of treatments in plots under desiccation management without sequential application of herbicides. Sorriso, MT – 2017.

Treatments		Percentage of control of <i>C. hirta</i>
Herbicide	Dose (g a.i. or a.e. ha <sup>-1</sup> )	7 DAA(A)
1 glyphosate	1440	13.75 e
2 glyphosate + chlorimuron-ethyl	1440+15	23.75 d
3 glyphosate + chlorimuron-ethyl + flumioxazin	1440+15+50	36.25 b
4 glyphosate + chlorimuron-ethyl + saflufenacil	1440+15+49	46.25 a
5 glyphosate + chlorimuron-ethyl + lactofen	1440+15+180	32.50 c
6 glyphosate + chlorimuron-ethyl + fomesafen	1440+15+250	20.50 d
7 glyphosate + chlorimuron-ethyl + carfentrazone-ethyl	1440+15+28	26.25 d
8 glyphosate + 2,4-D	1440+670	26.25 d
9 glyphosate + 2,4-D + chlorimuron-ethyl	1440+670+15	29.50 c
10 glyphosate + 2,4-D + flumioxazin	1440+670+50	46.25 a
11 glyphosate + 2,4-D + saflufenacil	1440+670+49	50.00 a
12 glyphosate + 2,4-D + lactofen	1440+670+180	36.75 b
13 glyphosate + 2,4-D + fomesafen	1440+670+250	29.25 c
14 glyphosate + 2,4-D + carfentrazone-ethyl	1440+670+28	31.25 c
15 glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin	1440+670+15+50	40.00 b
16 glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil	1440+670+15+49	47.00 a
17 glyphosate + 2,4-D + chlorimuron-ethyl + lactofen	1440+670+15+180	32.50 c
18 glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen	1440+670+15+250	27.50 d
19 glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl	1440+670+15+28	25.00 d
20 Untreated check		0.00 f
F		34.82*
CV (%)		13.14

Assist (0.5% v.v<sup>-1</sup>) was added to all treatments. \*Significant at 5% probability by the Scott-Knott test. Means followed by the same letter do not differ.

Although the initial assessment at 7 DAA (A) is not conclusive in relation to its control, it is possible to highlight the performance of glyphosate + chlorimuron-ethyl + saflufenacil, glyphosate + 2,4-D + flumioxazin, glyphosate + 2,4-D + saflufenacil and glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil treatments. All evaluated mixtures presented initial control superior to glyphosate alone.

It is noteworthy that, in the group of herbicides with better initial control, three of the four treatments contained saflufenacil and the other flumioxazin. Saflufenacil is a PROTOX inhibiting herbicide, which, applied in mixture with glyphosate, tends to accelerate the process of desiccating the shoots of plants, in addition to providing good residual control. In an experiment, a synergistic effect was observed between herbicides glyphosate and saflufenacil for the control of glyphosate-resistant hairy fleabane rosette stage, at 21 days after the application of herbicides in greenhouse. In addition, the association of glyphosate + saflufenacil (540 g ea ha<sup>-1</sup> + 35 g ia ha<sup>-1</sup>) prevented the regrowth and dispersion of new hairy fleabane seedlings three weeks after application, which did not occur in plants treated with saflufenacil alone (Dalazen et al. 2015).

Flumioxazin, another PROTOX inhibitor, also can accelerate the desiccation rate of glyphosate. In another study, Jaremtchuk et al. (2008) observed that the use of glyphosate + flumioxazin (1080 + 25 and 1080 g and + 40 g ia ha<sup>-1</sup>) accelerated the desiccation of weeds,

allowing sowing three days after application, compared to the minimum period of five days when glyphosate was used alone. It is interesting to note, however, that the best initial control was observed in treatments where glyphosate + 2,4-D + flumioxazin were present, but not in the treatments glyphosate + chlorimuron-ethyl + flumioxazin and glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin, where chlorimuron-ethyl is also present.

Sequential application of herbicides is a practice that allows increasing the level of weed control, especially for perennial weeds or for those resistant or tolerant to certain herbicides. Zobiolo et al. (2018) evaluated different management programs for hairy fleabane (*Conyza spp.*) control and concluded that the mixture of systemic herbicides diclosulam + halauxifen-methyl + glyphosate, combined with the sequential application of contact herbicides, such as ammonium glufosinate, paraquat or saflufenacil, was shown to be an interesting tool to control *Conyza spp.* at different development stages.

In Table 4, isolated glyphosate remained in the group with the worst control results. However, it was observed that most treatments containing glyphosate in the mixture evolved in relation to 7 DAA (A), highlighting treatments glyphosate + 2,4-D + flumioxazin, glyphosate + 2,4-D + saflufenacil, glyphosate + 2,4-D + carfentrazone-ethyl and glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil, which have in common the presence of glyphosate + 2,4-D.

**Table 4.** Percentages of control of mature garden spurge (*Chamaesyce hirta*), after two sequential applications in desiccation management in an evaluation carried out at 14 DAA (A) or 5 DAA (B). Sorriso, MT- 2017.

Herbicides applied on plots (g a.i. or a.e. ha <sup>-1</sup> ) (application A)	Herbicides applied on subplot (application B)		
	Without sequential application	Paraquat (400 g ha <sup>-1</sup> )	Glufosinate-ammonium (500 g ha <sup>-1</sup> )
1 glyphosate (1440)	13.75 Cd	49.50 Bb	64.75 Ad
2 glyphosate + chlorimuron-ethyl (1440+15)	25.00 Cd	54.00 Bb	65.75 Ad
3 glyphosate + chlorimuron-ethyl + flumioxazin (1440+15+50)	42.00 Cc	57.75 Bb	70.25 Ac
4 glyphosate + chlorimuron-ethyl + saflufenacil (1440+15+49)	47.00 Cc	58.75 Bb	78.25 Ab
5 glyphosate + chlorimuron-ethyl + lactofen (1440+15+180)	43.75 Cc	59.00 Bb	72.50 Ac
6 glyphosate + chlorimuron-ethyl + fomesafen (1440+15+250)	15.75 Bd	56.75 Ab	60.00 Ad
7 glyphosate + chlorimuron-ethyl + carfentrazone-ethyl (1440+15+28)	36.50 Bc	60.25 Ab	59.25 Ad
8 glyphosate + 2,4-D (1440+670)	43.25 Bc	74.25 Aa	82.75 Ab
9 glyphosate + 2,4-D + chlorimuron-ethyl (1440+670+15)	64.50 Bb	69.00 Ba	82.00 Ab
10 glyphosate + 2,4-D + flumioxazin (1440+670+50)	75.00 Ba	78.00 Ba	93.50 Aa
11 glyphosate + 2,4-D + saflufenacil (1440+670+49)	79.25 Ba	80.25 Ba	90.75 Aa
12 glyphosate + 2,4-D + lactofen (1440+670+180)	63.75 Bb	76.00 Aa	84.50 Ab
13 glyphosate + 2,4-D + fomesafen (1440+670+250)	60.25 Bb	57.75 Bb	79.50 Ab
14 glyphosate + 2,4-D + carfentrazone-ethyl (1440+670+28)	75.00 Aa	71.00 Aa	82.25 Ab
15 glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin (1440+670+15+50)	68.00 Ab	78.50 Aa	71.75 Ac
16 glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil (1440+670+15+49)	78.25 Aa	80.75 Aa	74.00 Ac
17 glyphosate + 2,4-D + chlorimuron-ethyl + lactofen (1440+670+15+180)	65.25 Bb	79.25 Aa	75.50 Ab
18 glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen (1440+670+15+250)	56.00 Bb	74.75 Aa	82.25 Ab
19 glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl (1440+670+15+28)	62.50 Bb	70.50 Aa	77.75 Ab
20 Untreated check	0.00 Ae	0.00 Ac	0.00 Ae
F		5.03*	
CV (%)		12.47	

Assist (0.5% v.v<sup>-1</sup>) was added to all treatments. The interval between applications A and B was 9 days. \*Means with similar upper-case letters within a row are not significantly different at  $P < 0.05$  according to Scott-Knott's test. Means with similar lower-case letters within a column are not significantly different at  $P < 0.05$  according to Scott-Knott's test.

For glyphosate + 2,4-D mixtures with sequential application, there was a considerable increase in the control level of herbicides glyphosate + 2,4-D + flumioxazin and glyphosate + 2,4-D + saflufenacil, which in the first evaluation after application B demonstrated control level above 90%. These treatments stand out in relation to the others, since they presented high control in a short period after the application, accelerating the control

of *C. hirta* plants, thus being able to be indicated in situations of sowing crops where there is a shorter time gap after desiccation.

Due to the low control levels presented in the initial evaluations of treatment with a single glyphosate application (T1), *C. hirta* plants recovered from the symptoms at 21 DAA (A) and the control results for this treatment were similar to control without herbicide application (Table 5).

**Table 5.** Percentages of control of adult garden spurge (*Chamaesyce hirta*), after two sequential desiccation applications in evaluation carried out at 21 DAA (A) and 12 DAA (B). Sorriso, MT - 2017.

Herbicides applied on plots (g a.i. or a.e. ha <sup>-1</sup> ) (application A)	Herbicides applied on subplot (application B)		
	Without sequential application	Paraquat (400 g ha <sup>-1</sup> )	Glufosinate-ammonium (500 g ha <sup>-1</sup> )
1 glyphosate (1440)	7.50 Cf	61.00 Bc	83.50 Ab
2 glyphosate + chlorimuron-ethyl (1440+15)	35.00 Ce	65.00 Bc	83.50 Ab
3 glyphosate + chlorimuron-ethyl + flumioxazin (1440+15+50)	40.00 Ce	72.75 Bb	84.00 Ab
4 glyphosate + chlorimuron-ethyl + saflufenacil (1440+15+49)	47.50 Cd	74.00 Bb	88.25 Ab
5 glyphosate + chlorimuron-ethyl + lactofen (1440+15+180)	43.75 Cd	69.25 Bb	83.25 Ab
6 glyphosate + chlorimuron-ethyl + fomesafen (1440+15+250)	35.00 Ce	71.50 Bb	83.50 Ab
7 glyphosate + chlorimuron-ethyl + carfentrazone-ethyl (1440+15+28)	46.25 Cd	70.25 Bb	83.25 Ab
8 glyphosate + 2,4-D (1440+670)	52.50 Bd	93.00 Aa	97.25 Aa
9 glyphosate + 2,4-D + chlorimuron-ethyl (1440+670+15)	81.00 Bb	96.75 Aa	99.00 Aa
10 glyphosate + 2,4-D + flumioxazin (1440+670+50)	87.00 Ba	96.00 Aa	99.75 Aa
11 glyphosate + 2,4-D + saflufenacil (1440+670+49)	93.00 Aa	96.00 Aa	98.50 Aa
12 glyphosate + 2,4-D + lactofen (1440+670+180)	67.50 Bc	91.50 Aa	94.75 Aa
13 glyphosate + 2,4-D + fomesafen (1440+670+250)	52.50 Cd	75.75 Bb	98.25 Aa
14 glyphosate + 2,4-D + carfentrazone-ethyl (1440+670+28)	83.50 Bb	86.50 Ba	99.00 Aa
15 glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin (1440+670+15+50)	79.25 Bb	94.50 Aa	92.75 Aa
16 glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil (1440+670+15+49)	92.50 Aa	96.50 Aa	93.50 Aa
17 glyphosate + 2,4-D + chlorimuron-ethyl + lactofen (1440+670+15+180)	75.00 Bc	91.25 Aa	95.00 Aa
18 glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen (1440+670+15+250)	63.25 Bc	95.25 Aa	100.00 Aa
19 glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl (1440+670+15+28)	68.75 Bc	91.75 Aa	95.00 Aa
20 Untreated check	0.00 Af	0.00 Ad	0.00 Ac
F		8.64*	
CV (%)		9.31	

Assist (0.5% v.v<sup>-1</sup>) was added to all treatments. The interval between applications A and B was 9 days. \*Means with similar upper-case letters within a row are not significantly different at  $P < 0.05$  according to Scott-Knott's test. Means with similar lower-case letters within a column are not significantly different at  $P < 0.05$  according to Scott-Knott's test.

Plots that received glyphosate + 2,4-D + saflufenacil, glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin and glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil without application of herbicides in subplots were the only that presented control similar to subplots where plants received a second sequential application. However, for the other treatments, sequential applications contributed to weed control. In these treatments, ammonium glufosinate demonstrated results similar or superior to paraquat. Among the options available on the market, paraquat was the most widely used in terms of cost and benefit. However, this herbicide has been banned in Brazil, and ammonium glufosinate is one of the available alternatives. Regarding the control of *C. hirta*, the results show that

this herbicide is an important option for the second sequential application in weed management systems.

Finally, in the final evaluation (28 DAA (A) and 19 DAA (B)) (Table 6), glyphosate used alone showed control (2.5%) similar to control without herbicide application. In addition, among the 19 herbicides applied to plots that did not receive sequential application, only three demonstrated control level above 85% (glyphosate + 2,4-D + chlorimuron-ethyl, glyphosate + 2,4-D + saflufenacil and glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil). However, in general, sequential applications with contact herbicides were efficient and increased the control of most treatments, and subplots with ammonium glufosinate provided control similar or superior to paraquat.

**Table 6.** Percentages of control of adult garden spurge (*Chamaesyce hirta*), after the two sequential desiccation applications in evaluation carried out at 28 DAA (A) and 19 DAA (B). Sorriso, MT.

Herbicides applied on plots (g a.i. or a.e. ha <sup>-1</sup> ) (application A)	Herbicides applied on subplot (application B)		
	Without sequential application	Paraquat (400 g ha <sup>-1</sup> )	Ammonium glufosinate (500 g ha <sup>-1</sup> )
1 glyphosate (1440)	2.50 Cf	66.25 Bc	80.75 Ab
2 glyphosate + chlorimuron-ethyl (1440+15)	46.25 Ce	68.25 Bc	82.50 Ab
3 glyphosate + chlorimuron-ethyl + flumioxazin (1440+15+50)	40.00 Be	73.25 Ab	80.25 Ab
4 glyphosate + chlorimuron-ethyl + saflufenacil (1440+15+49)	40.00 Be	78.25 Ab	83.00 Ab
5 glyphosate + chlorimuron-ethyl + lactofen (1440+15+180)	43.75 Be	72.00 Ab	79.50 Ab
6 glyphosate + chlorimuron-ethyl + fomesafen (1440+15+250)	47.50 Ce	73.00 Bb	82.00 Ab
7 glyphosate + chlorimuron-ethyl + carfentrazone-ethyl (1440+15+28)	47.50 Be	75.25 Ab	81.25 Ab
8 glyphosate + 2,4-D (1440+670)	75.00 Bc	95.75 Aa	96.75 Aa
9 glyphosate + 2,4-D + flumioxazin (1440+670+50)	86.25 Ba	98.50 Aa	99.50 Aa
10 glyphosate + 2,4-D + saflufenacil (1440+670+49)	83.25 Bb	98.25 Aa	100.00 Aa
11 glyphosate + 2,4-D + lactofen (1440+670+180)	92.00 Aa	97.25 Aa	97.00 Aa
12 glyphosate + 2,4-D + fomesafen (1440+670+250)	69.50 Bd	95.25 Aa	97.50 Aa
13 glyphosate + 2,4-D + carfentrazone-ethyl (1440+670+28)	64.75 Cd	87.00 Ba	98.75 Aa
14 glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin (1440+670+15+50)	79.50 Bb	93.25 Aa	99.50 Aa
15 glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil (1440+670+15+49)	79.50 Bb	98.00 Aa	87.25 Bb
16 glyphosate + 2,4-D + chlorimuron-ethyl + lactofen (1440+670+15+180)	92.25 Ba	99.00 Aa	86.25 Bb
17 glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen (1440+670+15+250)	80.75 Bb	9.00 Aa	97.75 Aa
18 glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl (1440+670+15+28)	68.00 Bd	97.75 Aa	10.00 Aa
19 glyphosate + 2,4-D + flumioxazin (1440+670+50)	74.50 Bc	96.25 Aa	96.75 Aa
20 Untreated check	0.00 Af	0.00 Ad	0.00 Ac
F		12.72*	
CV (%)		7.19	

Assist (0.5% v.v<sup>-1</sup>) was added to all treatments. The interval between applications A and B was 9 days. \*Means with similar upper-case letters within a row are not significantly different at  $P < 0.05$  according to Scott-Knott's test. Means with similar lower-case letters within a column are not significantly different at  $P < 0.05$  according to Scott-Knott's test.

The association of glyphosate + 2,4-D did not provide efficient control of adult *C. hirta* plants in the field (75%). Therefore, it was observed that the sequential application of paraquat and ammonium glufosinate nine days later considerably increases the control of this treatment ( $\geq 98.50\%$ ). As the control level obtained with the association of glyphosate + 2,4-D with sequential application of herbicides was very high, it was assumed that the addition of other herbicides to this mixture does not improve the final control of adult *C. hirta* plants.

Despite the limited information available on controlling adult *Chamaesyce hirta* plants in the field and the fact that sequential applications are typically necessary to control adult weeds, this species was efficiently controlled by glyphosate + 2,4-D + saflufenacil without the need for sequential application. The results were similar to treatments that did involve sequential herbicide applications in subplots. Saflufenacil is an herbicide that has a contact action on dicotyledonous weeds, and when associated with glyphosate in pre-sowing, increases the control level (Queiroz et al., 2014).

Treatments glyphosate + 2,4-D, glyphosate + 2,4-D + chlorimuron-ethyl, glyphosate + 2,4-D + flumioxazin, glyphosate + 2,4-D + saflufenacil,

glyphosate + 2,4-D + lactofen, glyphosate + 2,4-D + carfentrazone, glyphosate + 2,4-D + chlorimuron-ethyl + lactofen (T17), glyphosate + 2,4-D + chlorimuron-ethyl + fomesafen and glyphosate + 2,4-D + chlorimuron-ethyl + carfentrazone-ethyl with sequential application of paraquat or glufosinate-ammonium nine days after the first application are accepted as viable alternatives for *C. hirta* control. Other treatments that demonstrated high control effectiveness were glyphosate + 2,4-D + fomesafen followed by (fb) glufosinate-ammonium; and glyphosate + 2,4-D + chlorimuron-ethyl + flumioxazin and glyphosate + 2,4-D + chlorimuron-ethyl + saflufenacil fb paraquat.

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