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Article

Commelina Species Control with Desiccants Alone and in Mixtures

Controle de Espécies de Commelinas com Dessecantes Isolados e em Misturas

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ABSTRACT - The objective of this study was to evaluate the chemical control of the species *C. benghalensis* and *C. erecta* with desiccants alone and mixtures, as well as the spreading of spray droplets on the leaf surfaces. The experimental design was completely randomized in a 2 x 16 factorial arrangement with four replications, totaling 32 treatments and 128 plots. The first factor is related to the species *C. benghalensis* and *C. erecta* and the second factor corresponds to the treatments carfentrazone-ethyl in doses of 15, 30, 60 g ha^{-1}, which added 0.5% v v^{-1} adhesive spreader; glufosinate ammonium at doses of 100, 200, 400 g ha^{-1}, added 0.5% v v^{-1} mineral oil; glyphosate at 240, 480, 960 g ha^{-1}; carfentrazone-ethyl + glufosinate ammonium in doses of 100, 200, 400 g ha^{-1} being added 0.5% v v^{-1} of mineral oil; carfentrazone-ethyl + glufosinate ammonium in doses of 15+100, 30+200, 60+400 g ha^{-1} being added 0.5% v v^{-1} of mineral oil; and carfentrazone-ethyl + glyphosate at 15+240, 30+480, 60+960 g ha^{-1}, which added 0.5% v v^{-1} of a spreader and sticker agent, besides the controls without applications. There was a difference in control between species for desiccants applied alone. For *C. benghalensis* there was an excellent control (> 85%) for all the treatments. However, for *C. erecta* the best controls involved glufosinate ammonium (200 and 400 g ha^{-1}), carfentrazone-ethyl (30 and 60 g ha^{-1}), glyphosate (960 g ha^{-1}) and all mixtures with an average of 96.6% in the control.

Keywords: weed, droplets surface tension, spreader and sticker agent, chemical control, synergism.

*RESUMO - O objetivo deste trabalho foi avaliar o controle químico das espécies **Commelina benghalensis** e **C. erecta** com dessecantes isolados e em misturas, bem como o espalhamento das gotas de pulverização nas superfícies da folha. O delineamento experimental foi o inteiramente casualizado, no esquema fatorial 2 x 16, com quatro repetições, totalizando 32 tratamentos e 128 parcelas. O primeiro fator refere-se às espécies de **C. benghalensis** e **C. erecta**, e o segundo fator corresponde aos tratamentos: carfentrazone-ethyl nas doses de 15, 30 e 60 g ha^{-1}, sendo adicionado 0,5% v v^{-1} de espalhante adesivo; glufosinate-ammonium nas doses de 100, 200 e 400 g ha^{-1}, adicionado 0,5% v v^{-1} de óleo mineral; glyphosate nas doses de 240, 480 e 960 g ha^{-1}; carfentrazone-ethyl + glufosinate-ammonium nas doses de 100, 200, e 400 g ha^{-1}, sendo adicionado 0,5% v v^{-1} de óleo mineral; carfentrazone-ethyl + glufosinate-ammonium nas doses de 15+100, 30+200 e 60+400 g ha^{-1}, sendo adicionado 0,5% v v^{-1} de óleo mineral; e carfentrazone-ethyl + glyphosate nas doses de 15+240, 30+480 e 60+960 g ha^{-1}, sendo adicionado 0,5% v v^{-1} de espalhante adesivo, além das testemunhas sem aplicações. Houve diferença no controle entre as espécies para os dessecantes aplicados isoladamente. Para **C. benghalensis**, observaram-se controles excelentes (> 85%) em todos os*

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tratamentos avaliados; entretanto, para ***C. erecta****, os melhores controles envolveram glufosinate-ammonium (200 e 400 g ha^{-1}), carfentrazone-ethyl (30 e 60 g ha^{-1}), glyphosate (960 g ha^{-1}) e todas as misturas, com média no controle de 96,6%.*

Palavras-chave: planta daninha, tensão superficial de gotas, espalhante, controle químico, sigernismo.

INTRODUCTION

Commelinas are reported as important due to persistence in agricultural areas because they propagate through seeds and vegetative parts, which makes it difficult to control them, in addition to competing for water, light and nutrients (Souza et al., 2005; Oliveira Jr. and Inoue, 2011; Martins et al., 2012).

In the Brazilian state of Paraná, more frequently four species of the genus *Commelina* (*C. benghalensis*, *C. erecta*, *C. villosa*, *C. diffusa*) occur, the first two being the ones of major importance (Rocha et al., 2007a).

The differentiation between these species can be morphologically made: *C. benghalensis* presents sub-petiolate, ovoid, light-green leaves, aerial flowers, with larger purple and smaller whitish petals, as well as underground flowers. As for *C. erecta*, it presents dark green elliptical and sessile leaves with auricles and only aerial flowers with all petals blue (Kissmann, 1997; Rocha et al., 2007b).

In the direct planting system, these species can be chemically controlled using the carfentrazone-ethyl, glufosinate-ammonium and glyphosate desiccants. The carfentrazone-ethyl desiccant inhibits the protoporphyrinogen oxidase (PPO) enzyme, responsible for one of the stages of chlorophyll synthesis, and has contact action (Christoffoleti et al., 2002). Glufosinate-ammonium is characterized by presenting a mechanism of action that inhibits the glutamine synthetase (GS) enzyme in the path of nitrogen assimilation and contact action (Rodrigues and Almeida, 2012).

Glyphosate is notable for having a systemic action. It belongs to the group of inhibitors of the EPSPs (enolpyruvylshikimate-phosphate-synthase) enzyme, which participates in the path of synthesis of the aromatic amino acids phenylalanine, tyrosine and tryptophan (Amarante Júnior et al., 2002).

Although chemical control is efficient, several studies have reported the tolerance of this genus to glyphosate (Marchi et al., 2013). This fact can be explained by errors related to the identification of the species in the field, since *C. benghalensis* shows greater susceptibility to glyphosate than *C. erecta* (Rocha et al., 2007b).

Another justification is based on the differential absorption of the molecule, which varies among species and may be related to the higher amount of wax in the leaf, cuticle thickness and metabolizing capacity presented by *C. erecta* (Santos et al., 2002; Carvalho et al., 2008; Xu et al., 2011).

Thus, in agricultural areas, commelinas can occur in different proportions, which limits the recommendation of glyphosate as a desiccant due to the existence of some differential tolerance among species. Thus, in order to avoid the escape of tolerant species and the selection of resistant biotypes, a herbicide combination can be used in order to broaden the chemical management action spectrum and to provide some more efficient control of these species (Norsworthy and Grey, 2004).

Werlang and Silva (2002) have used a combination of glyphosate + carfentrazone-ethyl (720 + 15 g ha^{-1}) and verified an excellent control in *C. benghalensis* plants. Rocha et al. (2007a), when evaluating carfentrazone-ethyl + glyphosate (30 + 960 g ha^{-1}), have observed an unsatisfactory control for *C. erecta.*

The differences in control may be due to combinations of the desiccant herbicides which may cause antagonistic, synergistic or additive effects compared to the application of the single products (Takano et al., 2013). Among the verification methods of these effects, the use of the Colby formula (Colby, 1967) is highlighted.

Therefore, this work hypothesis is based on the fact that the chemical control of the species *C. benghalensis* and *C. erecta* may be dependent on the use of the desiccant doses alone and in mixtures, which provide greater sprinkling of the spray droplets on the leaf surfaces.

The objective of this study was to evaluate the chemical control of *C . benghalensis* and *C. erecta* species with single desiccants and in mixtures, as well as the sprinkling of spray droplets on the adaxial and abaxial leaf surfaces.

MATERIAL AND METHODS

The experiment was conducted in two stages. The first one was conducted in a laboratory, when the surface tension and the spreading area of the drops were evaluated. The second stage was conducted in a protected area to evaluate the control efficiency of the species *C. benghalensis* and *C. erecta*.

For the determination of the spreading and control area, a completely randomized design was used, in a 2 x 16 factorial arrangement, with four replications. The first factor referred to species *C. benghalensis* and *C. erecta* and the second one corresponded to treatments: carfentrazone-ethyl in doses of 15, 30 and 60 g ha^{-1}, adding 0.5% v v^{-1} of a spreader and sticker agent (Agral®); glufosinate-ammonium in doses of 100, 200 and 400 g ha^{-1}, with the addition of 0.5% v v^{-1} of mineral oil (Nimbus®); glyphosate in doses of 240, 480 and 960 g ha^{-1}; carfentrazone-ethyl + glufosinate-ammonium in doses of 15 + 100, 30 + 200 and 60 + 400 g ha^{-1}, adding 0.5 v v^{-1} of mineral oil (Nimbus®); and carfentrazone-ethyl + glyphosate in doses of 15 + 240, 30 + 480 and 60+960 g ha^{-1}, adding 0.5% v v^{-1} of a spreader and sticker agent (Agral®), besides controls without application.

C. benghalensis plants were collected in agricultural areas of Brazilian municipality Toledo, PR, and *C. erecta* plants in the Brazilian municipality Cascavel, PR. They were multiplied in pot conditions with 7 dm^{-3}, where three stems were planted, with two buds per pot, on September 26, 2014; 45 days after transplanting (DAT), pruning was carried out to standardize the plants. At 60 days after pruning, the experiments were performed, since the plants were recovered and with a uniform size pattern.

The soil used as a substrate was classified as red Oxisol Eutrudox (clayey texture) (Santos et al., 2013), with the following characteristics: pH = 5.26 ($CaCl_2$); 3.24 $cmol_c$ dm^{-3} of H+ Al; 4.37 $cmol_c$ dm^{-3} of Ca^{+2}; 1.56 $cmol_c$ dm^{-3} of Mg^{2+}; 0.35 $cmol_c$ dm^{-3} of K^+; 4.82 mg dm^{-3} of P; 10.25 dm^{-3} of MO; SB of 6.28 $cmol_c$ dm^{-3}; CTC of 9.52 $cmol_c$ dm^{-3}, and V of 65.97%.

To determine the droplets surface tension, the methodology proposed by Vilela and Antuniassi (2013) was used, and the set of 8 drops of each solution was evaluated corresponding to a repetition. In this way, a completely randomized design with four replications was used, considering only the herbicide treatments.

Spreading was determined on the abaxial and adaxial leaf sides of the leaves of *C. benghalensis* and *C. erecta*. The leaf used in spreading the drops was the second one fully expanded near the apex of the branch, collected in branches that were 25-35 cm in length. Immediately after dropping, with a volume of 12 μL, it was photographed with the help of a Samsung st77 digital camera. For analysis of the image, software Quant vs 1.0.1 was used (Vale et al., 2003). The ambient temperature of the laboratory during determinations was maintained between 21.7 ± 1 °C, with 63% of relative humidity.

To evaluate the control, desiccants were applied in the plants conducted in pots, remaining in the field during the conduction of the experiment. The application was made when the plants were standardized and were 25-35 cm in length of branches in both species.

Spraying of the treatments was carried out with the help of a CO_2-pressurized knapsack sprayer equipped with a boom arranged at a height of 50 cm in relation to the plants, equipped with a boom with four flat jet nozzles (model Magno ADGA 11002) spaced 50 cm apart, with a constant pressure of 2.2 kgf cm^2 and spray mix volume equivalent to 200 L ha^{-1}. The climatic conditions at the time of application were: temperatures from 28 to 30.2 °C, relative humidity of 65% and wind of 4.7 km h^{-1}, between 19 and 20 hours.

Treatments efficiency in controlling the commelinas was evaluated until 35 days after application (DAA) or plant death. The control scores were assigned based on the percentage of phytotoxicity scale proposed by SBCPD (1995), where 0% represents the total absence of injuries and 100% represents the total plant death. In assigning the scores, uniformity of injuries, regrowth capacity and reduction of height and dry matter of the plants aerial part were considered.

To determine the shoot dry matter at 35 DAA, the plants were cut close to the ground, packed in paper bags and dried in a forced circulation oven at 65 °C for 72 hours. After drying, they were weighed on a precision scale. Control data at 35 DAA were submitted to analysis by the model proposed by Colby (1967) to evaluate the synergistic and antagonistic effects among herbicide associations.

All data were submitted to analysis of variance by the F test. In comparing the means, the Scott-Knott test was used at 5% of probability.

RESULTS AND DISCUSSION

According to the results presented in Table 1, it was observed that the droplets surface tensions of all desiccants were reduced in relation to the distilled water tension (72.6 mN m^{-1}), forming nine distinct groups.

The highest reductions in tension were provided by the glufosinate-ammonium and carfentrazone-ethyl + glufosinate-ammonium desiccants group in the three doses used, with a mean of 55.8%, and the lowest was observed in the glyphosate group (240 g ha^{-1}), with an average of 30.9%, in relation to the control.

In the literature, studies related to droplets surface tension between herbicides and adjuvants are limited. Nonetheless, Costa et al. (2014) state that the nonionic spreader and sticker agent

Table 1 - Mean values of herbicide drops surface tension

Treatment	Dose (g ha^{-1})	Surface tension mN m^{-1}
Controls	0	72.60 a
Carfentrazone-ethyl	15	42.97 d
Carfentrazone-ethyl	30	40.98 e
Carfentrazone-ethyl	60	40.88 e
Glufosinate-ammonium	100	32.53 i
Glufosinate-ammonium	200	32.44 i
Glufosinate-ammonium	400	32.16 i
Glyphosate	240	50.19 b
Glyphosate	480	47.90 c
Glyphosate	960	47.97 c
Carfentrazone-ethyl + glufosinate-ammonium	15 + 100	31.87 i
Carfentrazone-ethyl + glufosinate-ammonium	30 + 200	31.84 i
Carfentrazone-ethyl + glufosinate-ammonium	60 + 400	31.74 i
Carfentrazone-ethyl + glyphosate	15 + 240	39.72 f
Carfentrazone-ethyl + glyphosate	30 + 480	37.94 g
Carfentrazone-ethyl + glyphosate	60 + 960	36.84 h
QM		449.139103**
VC (%)		1.19

Means followed by the same lowercase letter in the column do not differ statistically by Scott-Knott test. **Significant at 1% probability.

(0.2% v v^{-1}) added to glyphosate (960 g ha^{-1}) has reduced the surface tension by 64.6% compared to the control.

There was no difference in the droplets spreading area on the leaves adaxial side between the species (Table 2). The dispersion provided by the desiccants in *C. benghalensis* and *C. erecta* was divided into two groups.

The group formed by glyphosate (240, 480 and 960 g ha^{-1}) and by the control presented the worst spreading results in *C. benghalensis*, with mean of 35% lower than the mean of the group consisting of the other desiccants alone and in mixtures. For *C. erecta* the best dispersion was observed in the group consisting of glufosinate-ammonium, carfentrazone-ethyl + glufosinate-ammonium and carfentrazone-ethyl + glyphosate desiccants in all doses tested, with mean of 38.8% higher than that of the control group, carfentrazone-ethyl (15, 30 and 60 g ha^{-1}) and glyphosate (240, 480 and 960 g ha^{-1}).

When analyzing the spreading area of the droplets on the abaxial side, there was a difference between the species (Table 3). The group formed by glufosinate-ammonium alone in the three doses spread 30.9% less in *C. benghalensis* than the same doses evaluated in *C. erecta*.

On the abaxial side of the leaf of *C. benghalensis*, the group consisting of glufosinate-ammonium and glyphosate in all doses, besides the control, spread 27.2% less than the mean of the group formed by the other treatments alone or in mixtures, in the three doses evaluated.

For *C. erecta*, it was observed that the mean in the scattering of the group consisting of glyphosate (240, 480 and 960 ha^{-1}) and control was 22.71% lower than the mean of the group formed by the other treatments.

In relation to the droplet surface tension and the increase of the spreading on the adaxial and abaxial leaf surfaces of the species studied, it can be inferred that the efficiency was dependent on the desiccant used, since glyphosate had the worst results.

Table 2 - Mean values of the adaxial side spreading area on leaves of *C. benghalensis* and *C. erecta*

Treatment	Dose (g ha^{-1})	*C. benghalensis* (cm^2)	*C. erecta* (cm^2)
Controls	0	0.1595 Ab	0.2276 Ab
Carfentrazone-ethyl	15	0.2556 Aa	0.2034 Ab
Carfentrazone-ethyl	30	0.2260 Aa	0.2314 Ab
Carfentrazone-ethyl	60	0.2396 Aa	0.2260 Ab
Glufosinate-ammonium	100	0.2375 Aa	0.2680 Aa
Glufosinate-ammonium	200	0.2761 Aa	0.2748 Aa
Glufosinate-ammonium	400	0.2703 Aa	0.2516 Aa
Glyphosate	240	0.1728 Ab	0.1631 Ab
Glyphosate	480	0.1828 Ab	0.2054 Ab
Glyphosate	960	0.1783 Ab	0.1811 Ab
Carfentrazone-ethyl + glufosinate-ammonium	15 + 100	0.2894 Aa	0.3052 Aa
Carfentrazone-ethyl + glufosinate-ammonium	30 + 200	0.2979 Aa	0.3128 Aa
Carfentrazone-ethyl + glufosinate-ammonium	60 + 400	0.2833 Aa	0.3261 Aa
Carfentrazone-ethyl + glyphosate	15 + 240	0.2797 Aa	0.2702 Aa
Carfentrazone-ethyl + glyphosate	30 + 480	0.2784 Aa	0.2758 Aa
Carfentrazone-ethyl + glyphosate	60 + 960	0.2631 Aa	0.2826 Aa
QM $_{(Species - S)}$		0.001650^{ns}	
QM $_{(Treatments - T)}$		0.015732**	
QM $_{(S \times T)}$		0.001752^{ns}	
VC (%)		17.23	

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ statistically by Scott-Knott test. ** Significant at 1% probability.

Table 3 - Mean values of the abaxial side spreading area on leaves of *C. benghalensis* and *C. erecta*

Treatment	Dose ($g\ ha^{-1}$)	*C. benghalensis* (cm^2)	*C. erecta* (cm^2)
Controls	0	0.1656 Ab	0.2213 Ab
Carfentrazone-ethyl	15	0.2800 Aa	0.2841 Aa
Carfentrazone-ethyl	30	0.2685 Aa	0.2894 Aa
Carfentrazone-ethyl	60	0.2731 Aa	0.2709 Aa
Glufosinate-ammonium	100	0.2023 Bb	0.2823 Aa
Glufosinate-ammonium	200	0.2120 Bb	0.3111 Aa
Glufosinate-ammonium	400	0.2324 Bb	0.2989 Aa
Glyphosate	240	0.1922 Ab	0.2527 Ab
Glyphosate	480	0.2223 Ab	0.2281 Ab
Glyphosate	960	0.2024 Ab	0.2454 Ab
Carfentrazone-ethyl + glufosinate-ammonium	15 + 100	0.2887 Aa	0.2999 Aa
Carfentrazone-ethyl + glufosinate-ammonium	30 + 200	0.3066 Aa	0.3111 Aa
Carfentrazone-ethyl + glufosinate-ammonium	60 + 400	0.2770 Aa	0.3338 Aa
Carfentrazone-ethyl + glyphosate	15 + 240	0.3099 Aa	0.3397 Aa
Carfentrazone-ethyl + glyphosate	30 + 480	0.3079 Aa	0.3104 Aa
Carfentrazone-ethyl + glyphosate	60 + 960	0.2930 Aa	0.3459 Aa
$QM_{(Species – S)}$		0.029509**	
$QM_{(Treatments – T)}$		0.013736**	
$QM_{(S \times T)}$		0.003241**	
VC (%)		17.98	

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ statistically by Scott-Knott test. ** Significant at 1% probability.

As for glyphosate it is not recommended to add a spreader and sticker agent to the spray mix, breaking the droplets tension and leaf spreading are minimized, in addition to the fact that the quantity/quality of epicuticular wax and the density of leaf hairs may interfere with these processes (Hess and Falk, 1990; Santos et al., 2002; Rocha et al., 2007b; Costa et al., 2014).

Although glyphosate has given less droplet scattering on the leaf sides of *C. benghalensis* and *C. erecta*, it was efficient at controlling. However, it was also possible to observe a differential tolerance between the species, especially when the lowest dose of the herbicide was used (Table 4).

For *C. benghalensis*, there was no difference between treatments. Controls were excellent (> 85%) for all doses of desiccants alone and in mixtures. In *C. erecta*, the control was divided into three distinct groups. Glyphosate (240 g ha^{-1}) presented the worst control, with mean of 41.2%. The best controls involved glufosinate-ammonium (200 and 400 g ha^{-1}), carfentrazone-ethyl (30 and 60 g ha^{-1}), glyphosate (960 g ha^{-1}) and all mixtures, with mean in the control of 96.6%.

Different result was verified by Marchi et al. (2013), who, when studying glyphosate (960 g ha^{-1}) (Gliz 480 SL), have found unsatisfactory control (67.7%) at 42 DAA in *C. benghalensis*. The authors also mentioned that only one application does not control this species.

Costa et al. (2011) have observed a similar control for *C. benghalensis* (93.9%) and *C. erecta* (90%) with the use of glyphosate (1,080 g ha^{-1}) (Glifosato Atanor). These authors have stated that this result is related to the slow absorption in *C. benghalensis* and a moderate one in *C. erecta,* besides the plants presenting a distinct morphology, with higher density of trichomes in the adaxial epidermis in *C. benghalensis* and a large starch reserve in the cells of the central cylinder parenchyma in *C. erecta*.

In studies carried out by Rocha et al. (2007a) with carfentrazone-ethyl (30 g ha^{-1}) or in a carfentrazone-ethyl + glyphosate (30 + 960 g ha^{-1}) mixture, control of 100% was observed for *C. benghalensis*.

Likewise, Maciel et al. (2011), using the combination glyphosate + carfentrazone-ethyl (360 + 4 g ha^{-1}) and Martins et al. (2012) with glyphosate + carfentrazone-ethyl (720 + 20 g ha^{-1}), have

Table 4 - Percentage of control and a Colby estimate of *C. benghalensis* and *C. erecta* plant at 35 DAA

Treatment	Dose (g ha^{-1})	*C. benghalensis* (%)	Expectation Colby	*C. erecta* (%)	Expectation Colby
Controls	0	0.0 Ab		0.0 Ad	
Carfentrazone-ethyl	15	100 Aa		81.2 Bb	
Carfentrazone-ethyl	30	100 Aa		88.7 Ba	
Carfentrazone-ethyl	60	100 Aa		96.5 Aa	
Glufosinate-ammonium	100	87.5 Aa		77 Ab	
Glufosinate-ammonium	200	94.5 Aa		98 Aa	
Glufosinate-ammonium	400	100 Aa		99.7 Aa	
Glyphosate	240	94.5 Aa		41.2 Bc	
Glyphosate	480	96.7 Aa		85.7 Ab	
Glyphosate	960	99.7 Aa		96.5 Aa	
Carfentrazone-ethyl + glufosinate-ammonium	15 + 100	92.5 Aa	100 (-)	94 Aa	96.2 (-)
Carfentrazone-ethyl + glufosinate-ammonium	30 + 200	98.2 Aa	100 (-)	99 Aa	99.2 (-)
Carfentrazone-ethyl + glufosinate-ammonium	60 + 400	99.2 Aa	100 (-)	99.5 Aa	100 (-)
Carfentrazone-ethyl + glyphosate	15 + 240	100 Aa	100 (=)	93.7 Aa	90.2 (+)
Carfentrazone-ethyl + glyphosate	30 + 480	100 Aa	100 (=)	96.5 Aa	97.5 (+)
Carfentrazone-ethyl + glyphosate	60 + 960	100 Aa	100 (=)	99.9 Aa	100 (+)
QM $_{(\text{Species – S})}$			1660.320313**		
QM $_{(\text{Treatments – T})}$			4934.632813**		
QM $_{(\text{S x T})}$			373.986979**		
VC (%)			8.79		

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ statistically by Scott-Knott test. ** Significant at 1% probability. (-) Antagonistic, (=) additive and (+) synergistic interactions.

observed a satisfactory control (88%) at 40 DAA and an excellent control (92,7%) at 35 DAA, respectively, which are results that reinforce the control potential when using the herbicide combination in the application.

An antagonistic interaction in both commelina species was observed in combinations carfentrazone-ethyl + glufosinate-ammonium. Despite this, the control efficiency of the species was considered excellent (Table 4). For the combination carfentrazone-ethyl + glyphosate in *C. benghalensis*, there was an additive effect in the three doses tested. However, this combination demonstrated a synergistic effect on the control of *C. erecta*.

Even with the antagonistic interaction observed between carfentrazone-ethyl and glufosinate-ammonium in *C. erecta*, the importance of this combination was emphasized, since the control was excellent (> 92%) and very close to the best results, which have obtained additive or synergistic interactions.

The antagonistic relationship presented by carfentrazone-ethyl + glufosinate-ammonium may have occurred because the two herbicides presented a contact action. As they rapidly destroy the cells, the translocation and redistribution of the herbicide in the plant are limited and both herbicides lose efficiency in reaching their respective sites of action.

In studies carried out by Werlang and Silva (2002) an additive effect of glyphosate + carfentrazone-ethyl was observed in the control of *C. benghalensis*, regardless of the doses evaluated, corroborating the results observed in this study.

Results observed for the plants dry matter corroborated the control efficiency data (Table 5). All treatments were efficient in reducing biomass in both species, but *C. benghalensis* presented the greatest reductions of dry matter in relation to *C. erecta*. The combinations of carfentrazone-ethyl + glufosinate-ammonium (60 + 400 g ha^{-1}) and carfentrazone-ethyl + glyphosate (60 + 960 g ha^{-1}) were the ones that provided the greatest reductions, regardless of the species.

It can be concluded that there was a difference in the control between the species for the desiccants applied alone. For *C. benghalensis*, an excellent control was observed (> 85%) in all

Table 5 - Dry matter mean values of *C. benghalensis* and *C. erecta* plants at 35 DAA

Treatment	Dose ($g\ ha^{-1}$)	*C. benghalensis* (g)	*C. erecta* (g)
Controls	0	8.78 Aa	7.73 Ba
Glufosinate-ammonium	100	1.23 Bc	2.91 Ab
Glufosinate-ammonium	200	0.63 Bd	2.30 Ac
Glufosinate-ammonium	400	0.36 Bd	1.55 Ad
Carfentrazone-ethyl	15	0.56 Bd	1.98 Ad
Carfentrazone-ethyl	30	0.43 Bd	1.72 Ad
Carfentrazone-ethyl	60	0.26 Bd	1.28 Ae
Glyphosate	240	2.32 Bb	3.35 Ab
Glyphosate	480	1.09 Bc	2.57 Ac
Glyphosate	960	0.70 Bd	1.68 Ad
Carfentrazone-ethyl + glufosinate-ammonium	15 + 100	1.08 Bc	2.04 Ad
Carfentrazone-ethyl + glufosinate-ammonium	30 + 200	0.74 Bd	1.40 Ae
Carfentrazone-ethyl + glufosinate-ammonium	60 + 400	0.45 Ad	0.91 Ae
Carfentrazone-ethyl + glyphosate	15 + 240	0.72 Bd	1.91 Ad
Carfentrazone-ethyl + glyphosate	30 + 480	0.73 Bd	1.27 Ae
Carfentrazone-ethyl + glyphosate	60 + 960	0.51 Ad	0.86 Ae
$QM_{(Species – S)}$		26.306178**	
$QM_{(Treatments – T)}$		26.426931**	
$QM_{(S\ x\ T)}$		0.878766**	
VC (%)		20.79	

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ statistically by Scott-Knott test. ** Significant at 1% probability.

treatments evaluated. However, for *C. erecta* the best controls involved glufosinate-ammonium (200 and 400 $g\ ha^{-1}$), carfentrazone-ethyl (30 and 60 $g\ ha^{-1}$), glyphosate (960 $g\ ha^{-1}$) and all the mixtures, with mean of 96.6% in the control. The efficiency of the desiccants alone was more dependent on the dose used than the droplets dispersion on the leaf surfaces of *C. benghalensis* and *C. erecta*.

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