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Article

Herbicide Selectivity to Signal Grass and Congo Grass

Seletividade de Herbicidas ao Capim-braquiária e Capim-ruziziensis

ANÉSIO, A.H.C.[1]*
SANTOS, M.V.[1]
SILVEIRA, R.R.[1]
FERREIRA, E.A.[1]
BRAZ, T.G.S.[2]
TUFFI SANTOS, L.D.[2]
SANTOS, J.B.[1]

*** Corresponding author:**
<arnoncefet@hotmail.com>

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ABSTRACT - This study was conducted in order to evaluate the selectivity of signal grass and congo grass, submitted to post-emergence herbicide application. The experiment was conducted under greenhouse conditions, in Diamantina, Minas Gerais state, and it was arranged in a randomized block design, with five replications. Treatments were set in factor scheme (8 x 2) + 2. Eight herbicides (nicosulfuron; clomazone; glyphosate; fluazifop–p–butyl + fomesafen; lactofen; fomesafen; fluazifop-p-butyl and mesotrione) were applied in doses recommended by the manufacturer on two fodder species: *Brachiaria decumbens* cv. Basilisk (signal grass) and *Brachiaria ruziziensis* (congo grass); in addition, there were two control samples without herbicide application, for a total of 18 treatments. The evaluated herbicides showed less intoxication on signal grass when compared to congo grass. Nicosulfuron and glyphosate promoted higher intoxication on both species when compared to the other herbicides. Glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl, mesotrione and nicosulfuron affected the ratio variable / maximum fluorescence (Fv/Fm) in both species, indicating an effect provided by these herbicides on the electron transport chain. Results demonstrated that signal grass and congo grass have higher susceptibility to glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl, mesotrione and nicosulfuron. congo grass shows higher susceptibility to the studied herbicides when compared to signal grass.

Keywords: *Brachiaria decumbens*, *Brachiaria ruziziensis*, grass control, pasture, weeds forage.

RESUMO - Objetivou-se com este trabalho avaliar a seletividade do capim-braquiária e do capim-ruziziensis, submetidos à aplicação de herbicidas em pós-emergência. O experimento foi realizado em casa de vegetação. O delineamento experimental foi em blocos casualizados com cinco repetições. Os tratamentos foram dispostos em esquema fatorial (8 x 2) + 2, sendo oito herbicidas: nicosulfuron, clomazone, glyphosate, fluazifop-p-butil + fomesafen, lactofen, fomesafen, fluazifop-p-butil e mesotrione, em duas espécies forrageiras, ***Brachiaria decumbens*** *cv. Basilisk (capim-braquiária) e* ***Brachiaria ruziziensis*** *(capim-ruziziensis), mais duas testemunhas, sem aplicação dos herbicidas. Os herbicidas estudados apresentaram menor intoxicação nas plantas de capim-braquiária, quando comparadas às de capim-ruziziensis. O nicosulfuron e glyphosate promoveram maior intoxicação no capim-braquiária e capim-ruziziensis, em comparação aos demais herbicidas. O glyphosate, fluazifop-p-butil + fomesafen, fluazifop-p-butil, mesotrione e nicosulfuron afetaram a relação fluorescência variável/fluorescência máxima (Fv/Fm) em ambas as espécies, indicando efeito na cadeia de transporte de elétrons promovido por esses herbicidas. Os resultados demonstraram que as plantas de capim-braquiária e capim-ruziziensis apresentam maior suscetibilidade ao glyphosate, fluazifop-p-butil + fomesafen, fluazifop-p-butil, mesotrione e nicosulfuron.*

Palavras-chave: *Brachiaria decumbens*, *Brachiaria ruziziensis* controle de gramíneas, pastagem, plantas forrageiras.

[1] Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina-MG, Brasil; [2] Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais, Montes Claros-MG, Brasil.

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INTRODUCTION

In the current Brazilian ruminant production system, pastures constitute the main food source, being the most practical and less expensive way, affordable by all cattle breeders. However, the great amount of degraded pastures has caused damages the production system of grazing ruminants, due to the decrease in productivity and quality of fodder, pest and disease infestation and weed presence (Gimenes et al., 2011).

The interference created by weeds in pastures is one of the factors that most negatively affect animal productivity. The low production of fodder plants submitted to competition occurs due to the fact that weeds are generally more efficient in terms of using nutrients, water and light (Ruas et al., 2002).

The use of herbicides is an important practice to minimize the negative effects caused by weeds in pastures, because of its application speed and need for little labor. However, its effectiveness depends on different variables, among which the weed species that need to be controlled in the pasture (Gimenes et al., 2011).

Weeds present a large diversity of species, and dicots are more common in pastures; however, monocots can infest these areas (Santos et al., 2007).

The study of weed selectivity towards fodder plants is particularly important in the face of the possibility to control morphologically similar plants, helping the establishment of the desired plant. Weed selectivity occurs due to some factors, such as: position of the herbicide in time and space; dose and formulation; differential metabolism between cultures and weeds; anatomical differences between cultures and weeds; resistance in the site of action; use of culture protectors; non-metabolic internal factors of the plant; differences between weeds and cultures in the different phenological stages; application of adsorbent substances; crop; seed size; and genetic engineering (Martins et al., 2007).

The goal of this work was to evaluate the selectivity of signal grass and congo grass, submitted to the application of lactofen, fomesafen, clomazone, mesotrione, fluazifop-p-butyl, fluazifop-p-butyl + fomesafen, nicosulfuron and glyphosate, applied during post-emergence.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse, in the city of Diamantina, Minas Gerais state. The used soil is a dystrophic Red-Yellow Latosol (Embrapa, 2013) and presents clay-sandy texture, with chemical characterization described in Table 1.

The soil was previously sieved, corrected in terms of acidity with Dolomitic limestone and fertilized with 32 kg ha^{-1} N, 112 kg ha^{-1} P_2O_5 and 64 kg ha^{-1} K_2O.

In each planter, two *Brachiaria decumbens* (Syn. *Urochloa decumbens* cv. Basilisk) (signal grass) plants or two *Brachiaria ruziziensis* (Syn. *Urochloa ruziziensis*) (congo grass) plants were cultivated. Each part was constitued by a planter with 1.5 L soil. Fodder species were planted into pots at 1.0 cm depth, being thinned about 20 days after planting.

The experimental design was in randomized blocks, with five replications. Treatments were displayed in (8 x 2) + 2 factor scheme, with eight herbicides: nicosulfuron, clomazone, glyphosate, fluazifop-p-butyl + fomesafen, lactofen, fomesafen, fluazifop-p-butyl and mesotrione. They were applied in the dose recommended by the manufacturer, on two fodder species,

Table 1 - Chemical characteristics of experimental area soil in the 0-20 cm depth layer, Couto de Magalhães de Minas - Minas Gerais state

pH	P	K	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	MO
(H_2O)	(mg dm^{-3})		($cmol_c$ dm^{-3})					(dag kg^{-1})
5.12	1.02	25.30	0.40	0.20	0.76	5.20	0.66	0.70

Brachiaria decumbens (signal grass) and *Brachiaria ruziziensis* (congo grass), plus one control sample for each species, with no herbicide application.

Every 15 days, fertilizations were performed in top-dressing with 1.0 g urea previously diluted in water, per each planter. Other plant species occurring in the planters were manually eliminated.

Herbicides were applied on plants when they were in the 3-formed-tiller stage (30 cm height), simulating in a facility the same conditions that plants have in pasture areas. Herbicide application was performed using a backpack sprayer, equipped with a two XR 11002 ("fan") flat spray nozzle bar, spaced a 0.5 m apart, at bar height 0.5 m, under 210kPa constant pressure. The application was performed inside the greenhouse, in the morning.

The used herbicides were: glyphosate (720 g ha^{-1}), nicosulfuron (60 g ha^{-1}), clomazone (1,080 g ha^{-1}), fluazifop-p-butyl + fomesafen (200 + 250 g ha^{-1}), lactofen (168 g ha^{-1}), fomesafen (250 g ha^{-1}), fluazifop-p-butyl (200 g ha^{-1}) and mesotrione (192 g ha^{-1}). The applied doses correspond to the ones recommended for grasses control by the product manufacturers.

On day 7, 15, 21 and 30 after herbicide application (DAA), plant intoxication was visually evaluated, using a 0 to 100 scale, with 0 as control absence and 100 as total control of the species (EWRC, 1964).

On day 7, 15, 21 and 30 DAA, evaluations were performed on live plants, referring to the photosystem II photochemical efficiency analysis, on signal grass and congo grass leaves, with the use of a fluorometer; the device clamps were placed on the medium third of the youngest fully expanded leaf on the plants. Measurements were performed after 30 minutes of dark adaptation, during the night, with the emission of a 0.3 s saturating light pulse, under 0.6 KHz frequency, when the ratio between variable fluorescence and maximum fluorescence (Fv/Fm) and the electron transport rate (ETR – μmols electrons m^{2} s^{-1}) were evaluated. On day 15, 30 and 60 after cutting (DAC), the aforementioned same evaluations were performed.

On day 30 DAA, both species were cut at soil level. Initially, a plant per pot was quantified, in order to determine the number of total tillers and the number of aerial and basal tillers, as well as dry mass, after drying in a kiln with forced air ventilation at 60 °C. At the same time, the second plant per pot was collected, in order to determine leaf fractions, stem, scenescent matter and leaf/stem relation, with later determination of dry mass, after drying in a kiln with forced air ventilation at 60 °C.

On day 60 after fodder plant collection (DAC), both species were cut at soil level. Initially, a plant per pot was quantified, in order to determine the number of total tillers and the dry mass after kiln drying. At the same time, the second plant per pot was collected, in order to determine leaf fractions, stem, scenescent matter and leaf/stem relation, with later determination of dry mass after kiln drying. After these evaluations, the roots were taken away from planters and washed, determining dry mass after kiln drying.

In order to evaluate herbicides, data were submitted to analysis of variance, and the averages were compared among herbicides by Tukey's test, adopting 5% as the critical level for type I errors. Moreover, comparisons were made between control samples and each applied herbicide, using the Dunnet test, also at 5% critical level for type I errors. Comparisons were made between the studied species and each herbicide, using t test, also at 5% critical level for type I errors. As for intoxication, the analysis of regression was performed, and equation choices were based on the biological response of the phenomenon, in the significance of parameters ($P<0.05$) and in the coefficient of determination.

RESULTS AND DISCUSSION

Intoxication

An increase in the average values of intoxication was observed for the two evaluated species, with the application time, when lactofen was applied; the highest intoxication values were observed for signal grass (59%), compared to congo grass (41%), on day 30 DAA (Figure 1).

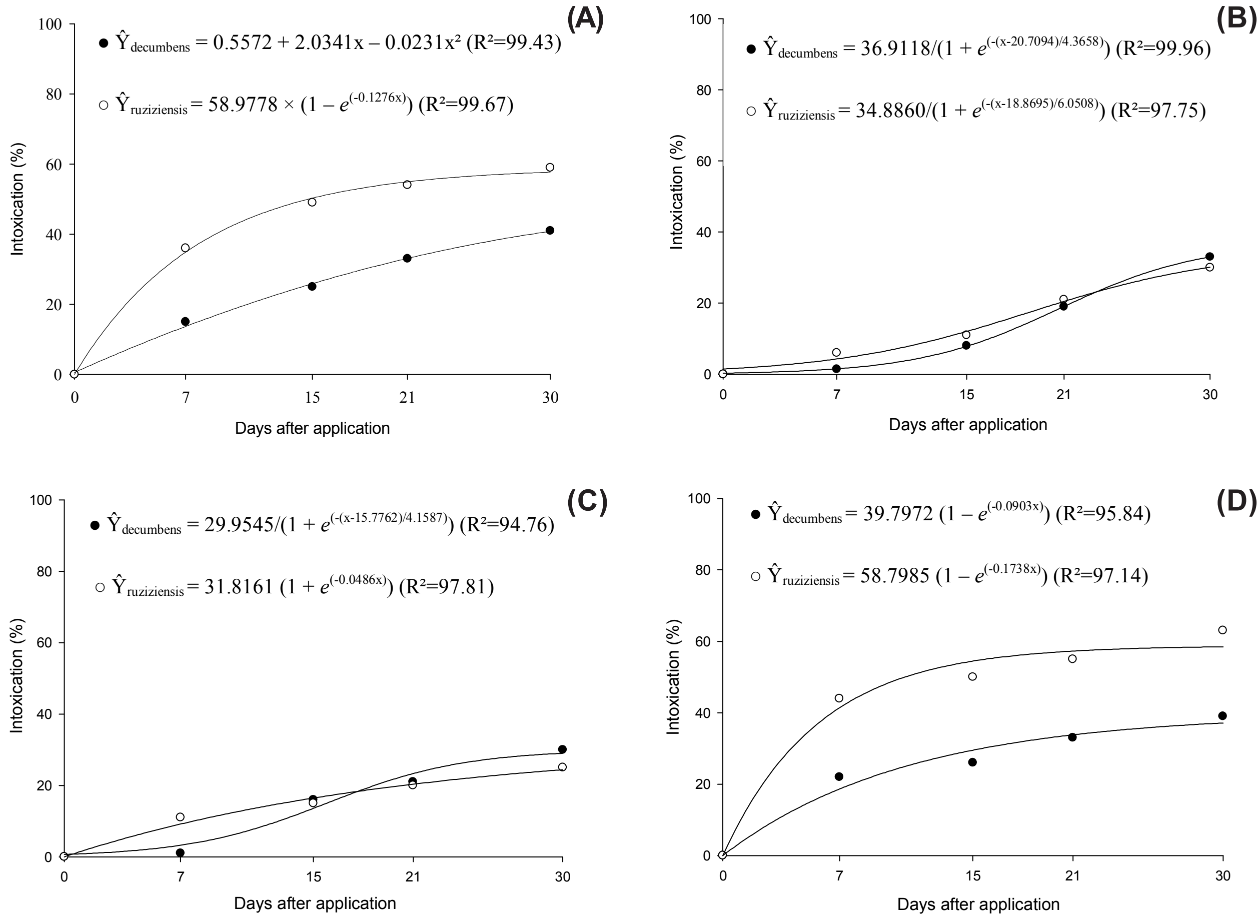

Figure 1 - Intoxication percentage of signal grass (Decumbens ●) and congo grass (Ruziziensis ○) plants, submitted to the application of lactofen (168 g ha^{-1}) (A), fomesafen (250 g ha^{-1}) (B), clomazone (1.080 g ha^{-1}) (C) and mesotrione (192 g ha^{-1}) (D), on day 7, 15, 21 and 30 after application.

Both studied species presented similar intoxication levels when submitted to fomesafen herbicide (Figure 1B). On day 30 DAA, intoxication reached rates of 33 and 30% for signal grass and congo grass, respectively.

Lactofen and fomesafen present broadleaf killer character, but when they are applied on cultures that are considered tolerant, they show low selectivity, displaying moderate injury level (Petter et al., 2011). Both of them act inhibiting the photosynthetic process of weeds, and cause lipid peroxidation in non-target plants, with consequent damage to the plasma membrane (Cataneo et al., 2005); thus, it is possible to explain the fact that both species have presented intoxication symptoms, due to injuries caused by herbicide contact with leaves of the studied species.

As for clomazone intoxication, it is possible to notice that up to approximately day 15 DAA, signal grass presented an intoxication index lower than the congo grass one (Figure 1C); however, after this date, signal grass plants had a higher intoxication index, reaching maximum values on day 30 DAA of 30 and 25% for signal grass and congo grass, respectively.

Carbonari et al. (2010) evaluated weed control in the sugar cane culture with the association of clomazone + hexazinone, and they obtained, on day 23 DAA, signal grass control of 98.7% with a 720 + 180 g ha^{-1} dose.

congo grass plants presented high intoxication percentage (63%) on day 30 DAA, submitted to mesotrione application. Distinctly, signal grass plants presented medium intoxication percentage (39%) on day 30 DAA (Figure 1D).

Similarly to what was observed for mesotrione, congo grass plants presented higher intoxication percentage to fluazifop-p-butyl and fluazifop-p-butyl + fomesafen herbicides, compared to signal grass (Figure 2A and B).

Rezende et al. (2012) evaluated the efficacy of fluazifop-p-butyl + fomesafen application (250 + 200 g ha^{-1}) to control weeds in soybean cultures, and obtained signal grass control of 74.2% and 100% on day 5 and 30 DAA, respectively. However, in this work, signal grass plants presented 46.39% intoxication on day 30 DAA; whereas congo grass plants presented 74.11% intoxication. The low intoxication rate found in this work may be due to higher development (plants in the three-formed-tiller stage) of Brachiaria plants during application.

On day 30 DAA, congo grass and signal grass presented nicosulfuron intoxication levels close to 90 and 78%, respectively (Figure 2C). Martins et al. (2007) evaluated the selectivity of signal grass to herbicides applied during post-emergence when plants had three to four fully expanded leaves and obtained 58.8% intoxication for nicosulfuron in the 50 g ha^{-1} dose, on day 28 DAA; these results were lower than the ones found in this work for the same species, possibly because of the lower dose used by the authors.

Adegas et al. (2011) observed that the application of a nicosulfuron + atrazine mixture (20 + 800 g ha^{-1}) causes low initial intoxication in congo grass plants; however, starting from day 14 DAA, there is a great increase in the injuries caused by the herbicide, reaching levels close to 72%, on

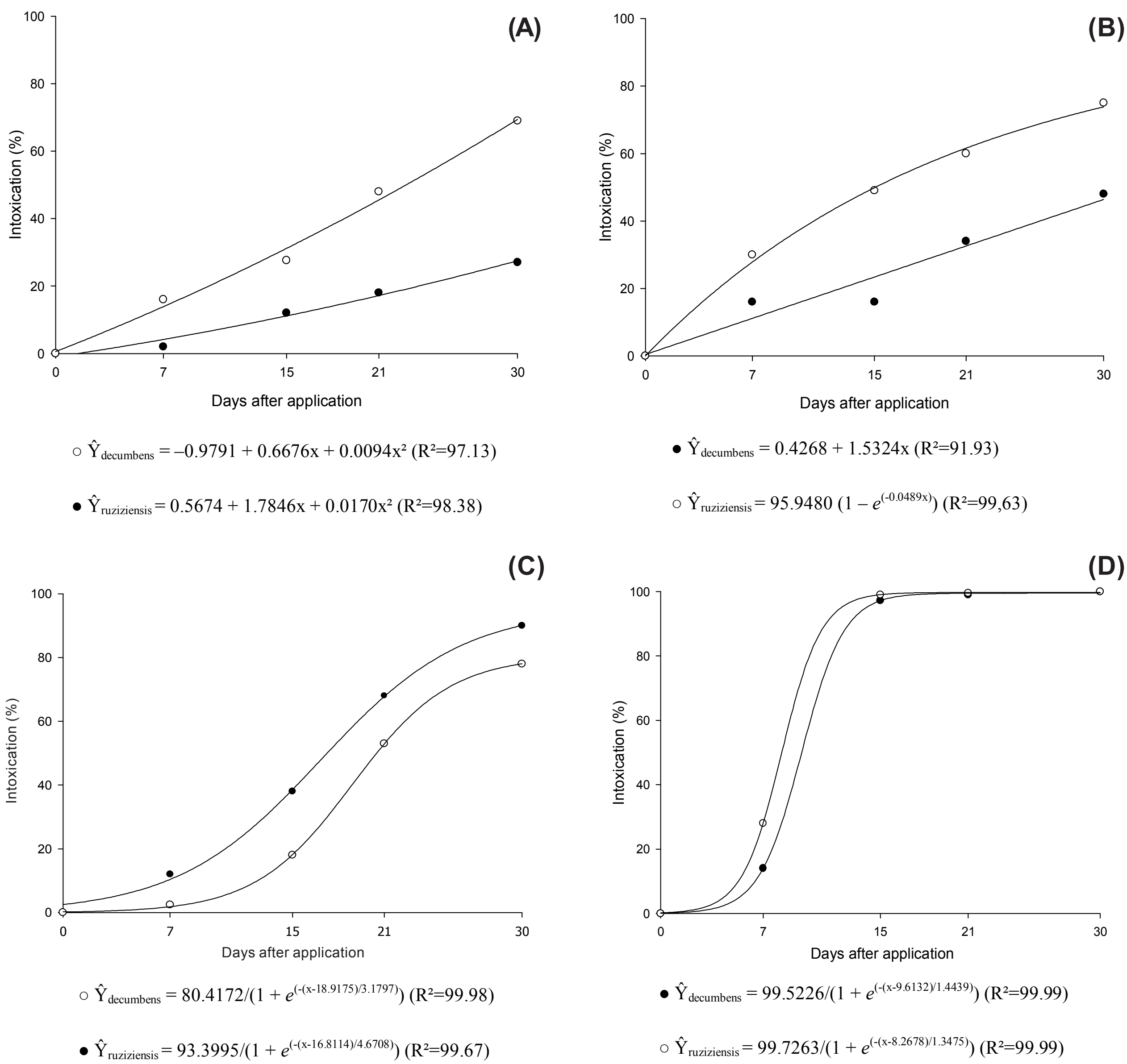

Figure 2 - Intoxication percentage of signal grass (Decumbens ●) and congo grass (Ruziziensis ○) plants, submitted to the application of fluazifop-p-butyl (200 g ha^{-1}) (A), fluazifop-p-butyl + fomesafen (200 + 250 g ha^{-1}) (B), nicosulfuron (60 g ha^{-1}) (C) and glyphosate (720 g ha^{-1}) (D), on day 7, 15, 21 and 30 after application.

day 42 DAA. On sensitive plants, nicosulfuron inhibts growth in a few hours; however, injury symptoms on plants appeared after two weeks from the application (Trezzi e Vidal, 2001). Results presented by these authors are similar to the ones in this work, where initially, both species presented low intoxication on day 7 DAA, but the intoxication level increased after day 15 DAA.

On day 19 DAA, both studied species presented 100% glyphosate intoxication, that is, total control (Figure 2D). Santos et al. (2007) evaluated *Brachiaria brizantha* cv. Marandu control with glyphosate, during pasture formation with Tifton 85 and concluded that the younger the plants, the lower the expense with herbicide to control the species; therefore, younger plants present higher sensitivity. The authors' conclusion may explain the quick control (day 19 DAA) for both studied species.

Phytotechnical data

There was herbicide effects on the number of basal and aerial tillers in congo grass and signal grass (Table 2). Glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron presented differences in congo grass for the number of basal tillers in relation to the control sample. As it is possible to observe in Figures 2A, B, C, and D, these were the herbicides that provided higher toxicity levels in signal grass and congo grass plants.

Among herbicides, lactofen and fomesafen provided higher values for basal and aerial tiller number in congo grass (Table 2). Both lactofen and fomesafen herbicides presented toxic action on dicot weeds (Petter et al., 2011); this supports the found data, since they were the herbicides that less influenced the number of basal and aerial tillers in congo grass.

All herbicides provided differences in the basal tiller number for signal grass in relation to the control sample; glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron were the ones that most influenced the decrease of basal tiller numbers (Table 2). The same results found for basal tillers were observed for the number of aerial tillers. Similarly to congo grass, signal grass plants submitted to glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron did not present aerial tillers (Table 2). These results demonstrate that these herbicides reduced the development of both species.

Similar results to the ones in this work were found by Martins et al. (2007), who verified high susceptibility in plants from the *Brachiaria* genus to the sulfonylurea chemical group (nicosulfuron), in initial applications of 50 g ha^{-1} doses.

The number of basal tillers in treatments where clomazone and lactofen were applied was lower in congo grass, when compared to signal grass (Table 2). Similarly, where there was no

Table 2 - Number and dry mass of signal grass and congo grass basal and aerial tillers, submitted to the application of lactofen, fomesafen, clomazone, mesotrione, fluazifop-p-butyl, fluazifop-p-butyl + fomesafen, nicosulfuron and glyphosate on day 30 after application (DAA)

Herbicide	Basal tillers		Aerial tillers		Basal tiller mass		Aerial tiller mass	
	Congo	Signal	Congo	Signal	Congo	Signal	Congo	Signal
Lactofen	11.2 Ba	20.2 Aa*	11.0 Aa	5.2 Ba*	14.1 Aabc*	12.3 Abc*	12.2 Aa	9.7 Aa
Fomesafen	12.8 Aa	16.6 Ab*	7.6 Aab	4.4 Ba*	14.9 Aab*	13.5 Aab	10.6 Aab	9.4 Aa*
Clomazone	7.0 Bb	17.4 Ab*	7.6 Aab	3.8 Ba*	16.4 Aa	15.3 Aa	11.1 Aab	9.1 Aa*
Mesotrione	7.0 Ab	8.8 Ac*	5.6 Ab	3.2 Aa*	12.0 Abc*	12.6 Ab*	9.9 Ab	9.0 Aa*
Fluazifop-p-butyl	4.6 Ab*	3.8 Ad*	0.0 Aac*	0.0 Ab*	11.4 Ac*	12.0 Abc*	0.0 Ac*	0.0 Ab*
Fluazifop-p-butyl + fomesafen	5.4 Ab*	4.0 Ad*	0.0 Ac*	0.0 Ab*	13.2 Abc*	11.3 Bbc*	0.0 Ac*	0.0 Ab*
Nicosulfuron	5.8 Ab*	4.2 Ad*	0.0 Ac*	0.0 Ab*	14.0 Aabc*	12.2 Abc*	0.0 Ac*	0.0 Ab*
Glyphosate	4.4 Ab*	4.0 Ad*	0.0 Ac*	0.0 Ab*	11.4 Ac*	10.0 Bc*	0.0 Ac*	0.0 Ab*
Control sample	9.4 B	22.8 A	10.6 A	8.2 A	18.9 A	15.6 B	12.4 A	10.7 A
VC (%)	23.81	12.87	25.95	27.77	11.69	9.56	25.95	12.12

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

herbicide application (control sample), the number of basal tillers in congo grass was lower than the one in signal grass.

Signal grass plants showed higher sensitivity to clomazone, lactofen and fomesafen, when compared to their effect on the number of aerial tillers in congo grass (Table 2).

No differences were observed in clomazone effect on the dry mass of basal tillers in congo grass, compared to the control sample (Table 2); however, the other herbicides negatively affected the basal tiller dry mass of the species. Probably, in this work, species evaluation time was not enough for the plant to present negatives effects in its structural form.

Clomazone e fomesafen did not cause reduction of the basal tiller dry mass in signal grass, compared to the control sample (Table 2). Since fomesafen has broadleaf weed killer action, its action on grasses occurs with lower toxicity influence.

There was a reduction of aerial tiller dry mass in signal grass plants, when submitted to lactofen, fomesafen and mesotrione, compared to the control sample (Table 2).

Glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron reflected in production absence of tiller number in both studied species (Table 2). These same herbicides resulted in lower production of total tiller number in both species (Table 3).

Nicosulfuron provided a lower number of total tillers in signal grass, when compared to congo grass, indicating higher negative effects in signal grass for the number of tillers (Table 3). Species from the *Brachiaria* genus present susceptibility to nicosulfuron application during post-emergence in 16 and 32 g ha^{-1} doses, reducing the development rate of fodder plants, as a result of the intoxication caused by the herbicide (Jakelaitis et al., 2006).

The dry mass of total tillers was not altered by clomazone action, compared to the control sample, both for congo grass and signal grass, despite the fact that this herbicide has graminicide action (Table 3). Glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron influenced the reduction of tiller dry mass in both studied species.

Petter et al. (2011) evaluated the selectivity of different herbicides to maize and congo grass cultures and observed a 17.8% dry mass reduction in congo grass on day 28 DAA, when submitted to 192 g ha^{-1} lactofen doses, applied 30 days after planting. The application of lower lactofen doses (168 g ha^{-1}) resulted in a 16.24% dry mass reduction in congo grass on day 30 DAA (Table 4), similar to what was found by the authors.

The dry mass of total tillers was higher in congo grass than in signal grass during treatments with clomazone, fluazifop-p-butyl + fomesafen, lactofen and nicosulfuron; however, where there

Table 3 - Number and dry mass (MS) of signal grass and congo grass total tillers, submitted to the application of lactofen, fomesafen, clomazone, mesotrione, fluazifop-p-butyl, fluazifop-p-butyl + fomesafen, nicosulfuron and glyphosate on day 30 after application (DAA)

Herbicide	Tiller number		Total tiller MS	
	Congo	Signal	Congo	Signal
Lactofen	23.0 Aa	25.8 Aa*	26.3 Aab*	22.0 Ba*
Fomesafen	20.4 Aab	20.2 Ab*	25.5 Aab*	22.9 Aa*
Clomazone	14.6 Abc*	21.8 Ab*	27.5 Aa	24.4 Ba
Mesotrione	14.0 Abc*	12.0 Ac*	21.9 Ab*	21.6 Aa*
Fluazifop-p-butyl	4.6 Ad*	3.8 Ad*	11.4 Bc*	12.0 Ab*
Fluazifop-p-butyl + fomesafen	5.4 Ad*	4.0 Ad*	13.2 Ac*	11.3 Bb*
Nicosulfuron	5.8 Ad*	4.2 Bd*	14.0 Ac*	12.2 Bb*
Glyphosate	4.4 Ad*	4.0 Ad*	11.4 Ac*	10 Ab*
Control sample	20.0 B	31.0 A	31.4 A	26.3 B
VC (%)	23.72	11.94	11.21	8.19

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

Table 4 - Number and total dry mass of signal grass and congo grass tillers submitted to lactofen, fomesafen and clomazone herbicide molecules on day 60 after cutting (DAC)

Herbicide	Tiller number		Total dry mass	
	Congo	Signal	Congo	Signal
Lactofen	20.8 Bb	26.4 Aa*	12.4 Ba	17.2 Aa
Fomesafen	24.8 Ba	28.8 Aa	13.5 Ba	17.9 Aa
Clomazone	22.4 Bab	26.6 Aa*	14.3 Ba	18.9 Aa
Control sample	23.4 B	32 A	13.2 B	19.0 A
VC (%)	9.78	10.73	14.21	10.45

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

was no herbicide application (control sample) the dry mass of congo grass tillers was also higher than the one of signal grass; in this case, it is not possible to conclude that the difference was actually caused by herbicides or by higher congo grass development (Table 3). In the treatment with fluazifop-p-butyl application, it was observed that there was higher total tiller dry mass reduction in congo grass; therefore, there was higher toxicity for this species in relation to signal grass (Table 4).

In treatments with the application of glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl, mesotrione and nicosulfuron, signal grass and congo grass plants did not present re-growth after cutting on day 30 DAA, indicating that these herbicides led to plant death (Table 7). These results demonstrated that signal grass and congo grass plants are not selective to these herbicides, differently from what happened for lactofen, fomesafen and clomazone, which presented re-growth after cutting, on day 30 DAA.

These results do not comply with the ones found by Costa et al. (2013), who evaluated glyphosate efficacy in *B. ruziziensis* management and obtained plant control with glyphosate doses over 720 g ha^{-1}; however, herbicide application was made when plants were in flowering stage. Thus, there was new tiller emission after the fodder plant desiccation. Differently, Santos et al. (2007) evaluated *B. brizantha* with the use of glyphosate in the formation of Tifton 85 pastures and observed the absence of re-growth 60 days after cutting (DAC), even with low herbicide doses (180 g ha^{-1}).

Silva et al. (2004) evaluated the effect of reduced fluazifop-p-butyl doses (18 a 90 g ha^{-1}) in the combination of soy bean and *B. brizantha*, and the results allowed concluding that fluazifop-p-butyl reduces the initial growth of the fodder plant, being able to lead to plant death due to the shadowing imposed by soy bean culture.

Dan et al. (2011) evaluated the initial suppression imposed by mesotrione (192 g ha^{-1}) to *B. brizantha* in the agriculture/cattle integrated system. According to the results, the use of mesotrione, applied on the fodder plant 20 days after cultivation, is an important tool, because there was a decrease in the growth speed of the fodder plant, without limiting the consequent pasture formation.

Nicosulfuron acts on grasses, and this may explain its more intense effect on the studied species, inhibiting re-growth after cutting. Martins et al. (2007) observed a 68% reduction in dry mass for signal grass with the application of nicosulfuron (50 g ha^{-1}), a similar dose to the one used in this work. Based on the results obtained by the authors and by this work, nicosulfuron presents control for both studied species.

Phytotechnical data (after cutting)

On day 60 DAC, clomazone, lactofen and fomesafen did not influence total dry mass in congo grass (Table 4). The number of tillers in congo grass did not differ from the control sample; however, lactofen provided higher reduction of tiller numbers in relation to fomesafen.

In signal grass, there was no herbicide effect on total dry mass, but there was a reduction in the number of tillers due to clomazone and lactofen action on day 60 DAC (Table 4), compared to the control sample.

The number of tillers and total dry mass of congo grass were lower in relation to signal grass in treatments with herbicides and in the control sample; thus, it is not possible to conclude that the difference between the studied species was caused by the herbicides (Table 4) or by the higher growth of signal grass.

Chlorophyll *a* flourescence

As for the variable fluorescence and maximum fluorescence (Fv/Fm) relation of congo grass plants, it was observed that, on day 7 DAA, the herbicides that provided higher relation values were clomazone, fluazifop-p-butyl + fomesafen, lactofen, fomesafen, fluazifop-p-butyl and nicosulfuron (Table 5). It is considered that, when plants have an intact photosynthetic apparatus, they present an Fv/Fm relation from 0.75 to .85 (Bolhàr-Nordenkampf et al., 1989). Thus, it is possible to state that, even if herbicides do not differ from the control sample, they promoted stress in congo grass plants. On day 7 DAA, glyphosate caused higher variable reductions in the same species.

On day 7 DAA, clomazone, lactofen, fomesafen and nicosulfuron did not provide a reduction in the Fv/Fm relation in signal grass, compared to the control sample (Table 5). Except for clomazone, the other herbicides showed Fv/Fm values that were lower than the ideal ones; thus, it is possible to state that these herbicides, even if not different from the control sample, presented some stress level to the plant photosynthetic apparatus.

Both studied species had zero in their Fv/Fm relation starting from day 15 DAA, in the treatment with glyphosate application (Table 5), which led to plant death. Glyphosate presented quick control for both species in the applied dose, as may be observed in Figure 2d.

In congo grass, clomazone, lactofen and fomesafen did not differ from the control sample for Fv/Fm on day 15 DAA (Table 5); however, plants submitted to clomazone were outside the ideal relation range. Among the evaluated herbicides, mesotrione promoted higher Fv/Fm reduction in congo grass plant, with the exception of glyphosate, which led to plant death. The same results obtained with congo grass plants were observed in signal grass plants (Table 5), without any difference between the species.

Table 5 - Variable fluorescence and maximum fluorescence (Fv/Fm) in congo grass and signal grass plants on day 7, 15, 21 and 30 after application (DAA), submitted to lactofen, fomesafen, clomazone, mesotrione, fluazifop-p-butyl, fluazifop-p-butyl + fomesafen, nicosulfuron and glyphosate

Herbicide	7 DAA		15 DAA		21 DAA		30 DAA	
	Congo	Signal	Congo	Signal	Congo	Signal	Congo	Signal
Lactofen	0.73 Aa	0.72 Aab	0.78 Aa	0.76 Aa	0.79 Aa	0.78 Aa	0.75 Aa	0.78 Aa
Fomesafen	0.65 Aa*	0.65 Aabc*	0.77 Aa	0.51 Ac*	0.78 Aa	0.80 Aa	0.78 Aa	0.79 Aa
Clomazone	0.71 Aa	0.75 Aa	0.73 Aa	0.71 Aab	0.75 Aa	0.71 Aab	0.76 Aa	0.75 Aa
Mesotrione	0.45 Ab*	0.52 Ac*	0.46 Ab*	0.27 Ad*	0.41 Ac*	0.44 Ad*	0.51 Ac*	0.46 Ac*
Fluazifop-p-butyl	0.69 Aa	0.57 Abc*	0.68 Aa*	0.63 Abc*	0.59 Ab*	0.54 Acd*	0.56 Abc*	0.48 Ac*
Fluazifop-p-butyl + fomesafen	0.62 Aa*	0.57 Abc*	0.68 Aa*	0.73 Aab	0.71 Aab	0.68 Aabc*	0.67 Aab	0.69 Ab
Nicosulfuron	0.72 Aa	0.66 Aabc*	0.70 Aa*	0.62 Abc*	0.57 Ab*	0.72 Aab	0.61 Ab*	0.65 Ab
Glyphosate	0.28 Ac*	0.13 Ad*	0.00 Ac*	0.00 Ae*	0.00 Ad*	0.00 Ae*	0.00 Ad*	0.00 Ad*
Control sample	0.76 A	0.76 A	0.82 A	0.78 A	0.78 A	0.78 A	0.77 A	0.75 A
VC (%)	9.16	13.35	9.08	10.73	9.85	12.48	11.96	8.99

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

On day 21 and 30 DAA, clomazone, fomesafen, lactofen and fluazifop-p-butyl + fomesafen did not show any difference in relation to the control sample for Fv/Fm in congo grass plants (Table 5). congo grass plants presented recovery from fluazifop-p-butyl + fomesafen on day 21 and 30 DAA; however, relation values were lower than the ideal ones.

On day 21 and 30 DAA, clomazone, fomesafen, lactofen and fluazifop-p-butyl + fomesafen showed differences in relation to the control sample for Fv/Fm in signal grass plants (Table 5). Lactofen and fomesafen herbicides present broadleaf control character; therefore, they do not affect the plant photosynthetic apparatus and, consequently, they present higher Fv/Fm values.

As for electron transport rate (ETR), it was observed that on day 7 DAA, lactofen and nicosulfuron herbicides did not interfere in the ETR of congo grass plants (Table 6). Since ETR parameters determine the electron transport rate in photosystem II (PSII), their use allows detecting the effect of the herbicide action at a lower concentration level, whereas the measurement of the Fv/Fm parameter allows detecting only at a concentration level which is 100 times higher (Abbaspoor et al., 2006).

On day 7 DAA, for signal grass plants, ETR was not influenced by clomazone and nicosulfuron (Table 6). On day 15 DAA, similar results were found in both species (Table 6). Glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl and nicosulfuron promoted ETR reduction in both species, compared to the control sample.

ETR results evaluated on day 21 and 30 DAA on congo grass showed the formation of three groups (Table 6). Plants treated with clomazone, lactofen and fomesafen continued not to suffer herbicide influence, demonstrating tolerance of the studied species. However, plants treated with glyphosate, fluazifop-p-butyl, mesotrione and nicosulfuron showed low ETR values, differing from the control sample. On the other hand, plants treated with fluazifop-p-butyl + fomesafen showed recovery of the ETR value on day 30 DAA, indicating that both species present recovery from the negative effects suffered because of the studied herbicides.

The results found for signal grass were similar to the ones described for the other species, with the exception of nicosulfuron herbicide, since plants presented recovery in the ETR values starting from day 21 DAA (Table 6).

The Fv/Fm relation in signal grass and congo grass plants on days 15, 30 and 60 DAC is presented in Table 7. On day 15 DAC, all treatments reduced the Fv/Fm relation in congo grass plants compared to the control sample, indicating the stress effect on plant photosynthetic apparatus. On day 30 DAC, treatments with the application of fomesafen and clomazone

Table 6 - Electron transport rate (ETR - mmols electrons m^{-2} s^{-1}) in congo grass and signal grass plants on day 7, 15, 21 and 30 after application (DAA), submitted to lactofen, fomesafen, clomazone, mesotrione, fluazifop-p-butyl, fluazifop-p-butyl + fomesafen, nicosulfuron and glyphosate

Herbicide	7 DAA		15 DAA		21 DAA		30 DAA	
	Congo	Signal	Congo	Signal	Congo	Signal	Congo	Signal
Lactofen	21.94 Aa	20.92 Aabc*	19.30 Aab	21.34 Aa	22.12 Ab	18.02 Aab	26.88 Aab	30.50 Aa
Fomesafen	10.10 Ab*	18.12 Abc*	22.08 Aa	20.26 Aab	30.97 Aa	15.94 Abc	27.06 Aab	29.74 Aa
Clomazone	21.78 Aa*	23.50 Aa	21.02 Aa	21.11 Aab	20.30 Ab*	18.02 Aab	27.64 Aa	29.08 Aa
Mesotrione	11.00 Ab*	10.94 Ad*	2.93 Ad*	4.94 Aef*	12.71 Ac*	7.49 Ad*	14.34 Ab*	13.20 Ac*
Fluazifop-p-butyl	20.40 Aa*	17.47 Ac*	15.30 Abc*	9.66 Ade*	19.54 Ab*	9.11 Acd*	17.76 Aab*	17.16 Abc*
Fluazifop-p-butyl + fomesafen	21.82 Aa*	21.26 Aab*	18.05 Aab*	13.62 Acd*	21.64 Ab*	24.94 Aa	20.68 Aab	20.86 Ab
Nicosulfuron	22.48 Aa	23.50 Aa	11.88 Ac*	15.98 Aabc*	17.42 Abc*	16.14 Abc	17.86 Ab*	20.80 Ab
Glyphosate	4.58 Ac*	2.86 Ae*	0.00 Ad*	0.00 Af*	0.00 Ad*	0.00 Ae*	0.00 Ac*	0.00 Ad*
Control sample	26.02 A	24.92 A	23.98 A	22.12 A	26.50 A	21.60 A	25.88 A	25.98 A
VC (%)	13.36	11.47	19.19	18.12	13.73	23.56	25.04	16.29

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

presented Fv/Fm reduction in congo grass, but the species showed relation recovery on day 60 DAC (Table 7).

No reduction was observed in the Fv/Fm relation in signal grass plants on day 15, 30 and 60 DAC (Table 7). These results demonstrated that the species does not present susceptibility to these herbicides after cutting on day 30 DAA. congo grass plants presented higher susceptibility to herbicides on day 15 DAC, since they showed lower values for the relation when compared to the signal grass ones, but with Fv/Fm relation recovery on day 60 DAC.

The treatment with lactofen application reduced congo grass ETR on day 15 DAC, in relation to the control sample (Table 8). However, on day 30 and 60 DAC congo grass presented ETR recovery in the treatment with lactofen application. No difference was observed among the herbicides (Table 8).

Table 7 - Variable fluorescence and maximum fluorescence (Fv/Fm) in congo grass and signal grass plants on day 15, 30 and 60 after cutting (DAC), submitted to lactofen, fomesafen and clomazone

Herbicide	15 DAC		30 DAC		60 DAC	
	Congo	Signal	Congo	Signal	Congo	Signal
Lactofen	0.71 Ba*	0.75 Aa	0.72 Aa	0.75 Aa	0.78 Aa	0.76 Aa
Fomesafen	0.69 Ba*	0.75 Aa	0.73 Aa*	0.74 Aa	0.75 Aa	0.78 Aa
Clomazone	0.70 Ba*	0.74 Aa	0.71 Aa*	0.75 Aa	0.73 Aa	0.78 Aa
Control sample	0.76 A	0.75 A	0.76 A	0.77 A	0.79 A	0.76 A
VC (%)	2.33	1.89	3.98	2.84	8.61	1.53

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

Table 8 - Electron transport rate (ETR- mmols electrons m^{-2} s^{-1}) in congo grass and signal grass plants on day 15, 30 and 60 after cutting (DAC), submitted to lactofen, fomesafen and clomazone

Herbicide	15 DAC		30 DAC		60 DAC	
	Congo	Signal	Congo	Signal	Congo	Signal
Lactofen	17.14 Ba*	21.04 Aa	22.38 Aa	19.64 Aa	24.68 Aa	26.04 Aa
Fomesafen	18.98 Aa	20.28 Aa	19.66 Aa	19.88 Aa	25.52 Aa	28.60 Aa
Clomazone	20.38 Aa	20.34 Aa	21.72 Aa	18.86 Aa	26.28 Aa	25.20 Aa
Control sample	21.58 A	23 A	22.34 A	21.82 A	27.26 A	27.98 A
VC (%)	11.06	7.95	12.07	12.59	7.88	17.50

Averages followed by the same capital letters on the lines (between the species) do not different among themselves by t test at 5% probability. Averages followed by the same lowercase letters in the columns (among herbicides) do not different among themselves by t test at 5% probability. *Significant by Dunnett's test at 5% probability.

Signal grass plants did not present ETR reduction on day 15, 30 and 60 DAC in relation to the control sample (Table 8). As well as for the Fv/Fm relation (Table 7), the species did not present influence from the herbicide action after cutting.

Based on the above considerations, it is possible to conclude that glyphosate, fluazifop-p-butyl + fomesafen, fluazifop-p-butyl, mesotrione and nicosulfuron herbicide did not present selectivity for signal grass and congo grass, since they caused high intoxication and did not allow the recovery of plants from both species after cutting. congo grass plants presented higher susceptibility to the studied herbicides, when compared to signal grass plants.

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