Revista Brasileira de Herbicidas, v.15, n.4, p.313-322, out./dez. 2016 (ISSN 2236-1065)
DOI: http://dx.doi.org/10.7824/rbh.v15i4.490 www.rbherbicidas.com.br

Glyphosate effectiveness in the burndown of signalgrass at two levels of biomass[1]

Eficácia de glyphosate na dessecação de braquiárias em dois níveis de biomassa

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Abstract - The objective of this research was to evaluate the efficacy of glyphosate in desiccating *Urochloa ruziziensis, U. decumbens*, and *U. brizantha* cv. Piatã at two levels of biomass for no-till establishment in Cerrado areas. The experimental design was a randomized complete block design with four replications, in a split-plot system. Plots consisted of two levels of biomass and sub-plots consisted of four doses of Roundup Ultra® - glyphosate at 0.65; 1.30, 1.95 and 2.60 kg ha^{-1} acid equivalent. The application was performed using custom pressurized CO_2 sprayer at the constant pressure of 210 kPa bar equipped with eight nozzles with TT110015, spaced at 0.5 m, and spray solution volume equivalent to 100 liters h^{-1}. The assessments were based on the percentage of control of plant mass, performed on day 10, 15 and 20 after application. It is possible to conclude that *U. ruziziensis* is more sensitive to glyphosate than the other studied species and biomass levels influence doses to be given only for *U. decumbens* and *U. brizantha* cv. Piatã.
Keywords: chemical control; herbicides; vegetation cover; *Urochloa* sp.

Resumo - Objetivou-se com esta pesquisa avaliar a eficácia de glyphosate na dessecação de *Urochloa ruziziensis*, *U. decumbens* e *U. brizantha* cv. Piatã em dois níveis de biomassa para estabelecimento de plantio direto em áreas de Cerrado. O delineamento experimental adotado foi de blocos casualizados, com quatro repetições, em esquema de parcelas subdivididas. As parcelas foram constituídas de dois níveis de biomassa e as subparcelas foram constituídas por quatro dosagens do herbicida glyphosate na marca comercial Roundup Ultra® a 0,65; 1,30, 1,95 e 2,60 kg ha^{-1} de equivalente ácido. A aplicação foi realizada com pulverizador customizado pressurizado a CO_2 com pressão constante de 210 kPa munido de barra com oito bicos com pontas TT110015, espaçados em 0,5 m e consumo de calda equivalente a 100 L ha^{-1}. As avaliações basearam-se na porcentagem de controle da massa vegetal, realizada aos 10, 15 e 20 dias após a aplicação. Conclui-se que a *U. ruziziensis* é mais sensível ao glyphosate que as demais espécies pesquisadas e que os níveis de biomassa influenciam na dose a ser ministrada apenas para a *U. decumbens* e *U. brizantha* cv. Piatã.
Palavras-chaves: controle químico; herbicidas; cobertura vegetal; *Urochloa* sp.

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Introduction

In Brazil, grain producing regions have most of their cultivated areas under Direct Planting (DP) (FEBRAPDP, 2014). In order to comply with one of the premises of the Direct Planting System, ground cover (haystack) must be created and kept on soil in cultivation areas; thus, in the Cerrado biome, due to soil physical-chemical characteristics, high temperatures and proper moisture that help the quick decomposition of plant residues, species of groundcover plants must present hardiness (Kluthcouski, 1998; Ernani et al., 2001; Amado et al., 2002). One of the options for the edaphoclimatic conditions of the Cerrado is the use of plant species from the *Urochloa* genus, which encompasses the innumerous species of signalgrass (Menezes and Leandro, 2004; Timossi et al., 2007; Menezes et al., 2009; Ferreira et al., 2010).

Some *Urochloa* species, as well as producing biomass for direct planting, may provide fodder in integrated systems, such as Crop-Livestock Integration (CLI), suppress weeds, turn nutrients over, fixate carbon into the soil, among other benefits (Menezes and Leandro 2004; Machado and Assis 2010; Pacheco et al., 2013; Lima et al., 2014a; Lima et al., 2014b; Ramos et al., 2014).

The introduction of direct planting in the Cerrado Biome areas brought various changes in the management systems; one of them is the management of the ground cover (burndown) before sowing the culture. In this operation, glyphosate is the main used herbicide.

Groundcover plant species have different levels of sensitivity to glyphosate (Silva et al., 2013), varying in accordance to species, plant development stage and plant mass quantity (Timossi et al., 2006). These authors verified that *U. decumbens* and *U. brizantha* cv. Marandu presented a good control percentage as long as doses of at least 2.16 kg ha^{-1} of glyphosate acid equivalent.

Considering the importance of direct planting and chemical management before sowing, a characteristic that has been little explored by the scientific community is the speed of ground cover control, which is something pursued by farmers that work in regions where two harvests are performed every year with no culture irrigation. Thus, species that are effectively controlled in less time after the application of the herbicide appear to be more adequate, since they provide a higher interval during the rain period to cultivate crops (Silva et al., 2013).

Facing the demand of agriculture and cattle raising, allied to the maximization of resource use with the minimization of negative impacts on the agricultural environment, universities and research institutions in Brazil validated two strategies that, currently, are part of government plans; one of them is the Crop-Livestock Integration (CLI) (BRASIL 2012). Thus, due to the possibility of groundcover plants to also be meant for animal grazing (fodder) during the off-season, it is necessary to know the intrinsic behavior of fodder species, as for their sensitivity to glyphosate in different biomass levels.

Therefore, the objective of this research was to evaluate the effectiveness of glyphosate herbicide doses in the burndown of three *Urochloa* species conducted in the Cerrado biome.

Material and Methods

The research was conducted on experimental field in 2013. The climate of the region, according to the Thornthwaite classification (1948) is B_2 r B’4 a’ type, with well defined dry and rainy seasons. The soil is classified as Distroferric Red Latosol (Santos et al., 2013), with clay texture and slightly wavy relief, located at 680 m altitude. Data for the climate classification of the Jataí municipality, sequential water balance and average temperature, referring to October, November and December 2013 in Jataí, Goiás state (Figure 1) were obtained in the agro meteorological station of the Instituto Nacional de

Meteorologia (National Meteorology Institute - INMET), located at 1000 m from the experimental area.

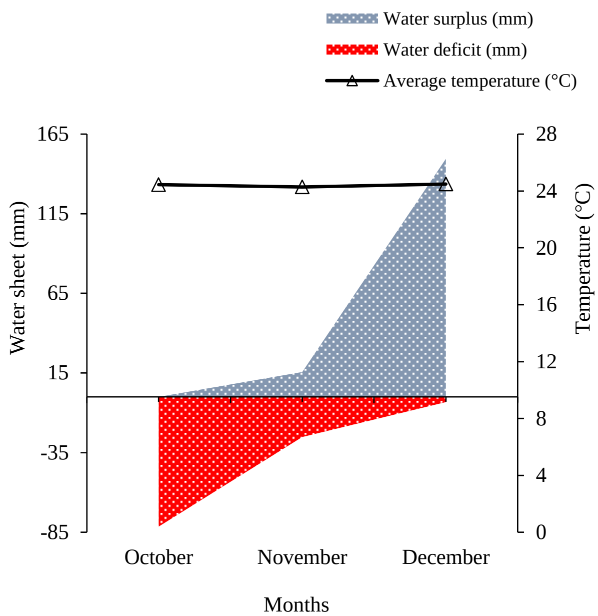

Figure 1. Sequential water balance and average temperature in October, November and December. Jataí (GO), 2013. Source: INMET (2013).

The experimental area was composed of three species from the *Urochloa* genus in vegetative stage and perpetualized about two years after sowing. Three experiments were conducted; the first one with the *U. ruziziensis* species, the second one with the *U. decumbens* species and the third one with *U. brizantha* cv. Piatã.

The adopted design was in randomized blocks, with four replications, in split-plot scheme. Plots were composed of two biomass levels (Natural and Lowered) with 4.0 x 32. m size; sub-plots had 4.0 x 8.0 m size, and were constituted by 0.65, 1.30, 1.95 and 2.60 kg ha^{-1} doses of glyphosate herbicide acid equivalent (a.e.) (Roundup Ultra, 650 g a.e. kg^{-1}, GRDA, Monsanto). It is important to highlight that the product used in this research is registered only for *U. decumbens* and *U. brizantha* cv Piatã species; for these ground covers, 1.3 to 2.275 and 0.975 to 1.625 kg a.e. ha^{-1} doses are recommended, respectively.

In order to obtain the lowest biomass level, ground covers were lowered with motored brush-cutter at approximately 30 cm height, trying to simulate an animal grazing. After this management, the cover was kept in fallow for about 30 days, until the application of the herbicide (11/26/2013) in its respective doses. Thus, for the natural level of biomass, the area with *Urochloa* species kept growing during the period.

By the time of the herbicide application (25/11/2013), the random launch of a metal frame (1.0 x 1.0 m) was adopted in each experimental unit, collecting the aerial parts of plants contained inside the metal frame; they were placed in paper bags, identified and taken to forced air circulation chamber at 65 ±5 ºC and kept under constant weight. Moreover, samples collected at the natural biomass level were processed before being taken to dry; the green aerial part of the plant was separated (leaves and sheaths), in order to obtain dry mass, from the structures of the plant that are in theory proper to absorb the herbicide, as shown in Table 1.

The application of glyphosate was performed with a CO_2 pressurized customized sprayer with 210 kPa constant pressure, equipped with a bar with eight TT110015 nozzles (impact flat spray) spaced 0.5 m apart and with mixture consumption equivalent to 100 L ha^{-1}. The weather conditions in the experiment spot, obtained during herbicide application, were monitored with a portable thermo-hygrometer (Table 2).

On 10, 15 and 20 days after application (DAA), the effectiveness of glyphosate doses over the two biomass levels (natural and lowered) of the three signalgrass species was evaluated, since the sowing of culture(s) in direct planting is recommendable in this time interval (Nunes et al., 2009; Nepomuceno et al., 2012; Giancotti et al., 2015; Nascente et al., 2012). To do so, the visual evaluation of the percentage of ground cover control was adopted, attributing values from 0 to 100, so that zero was given to no control and 100 to total plant control.

Results obtained in the evaluations were submitted to analysis of variance, with the goal of detecting the significance of biomass levels and/or factorial interaction. When pertinent, the Tukey's test at 5% probability was adopted to compare averages.

Table 1. Dry mass (Mg ha^{-1}) of *Urochloa* sp. plants at two biomass levels, natural and lowered, at the time of herbicide application. Jataí (GO), 2013.

Species	Biomass levels (Dry mass Mg ha^{-1})		
	Natural		Lowered
	Total	Green aerial part (photosynthetically active)	
U. ruziziensis	9.6	0.4	1.3
U. decumbens	14.2	2.0	0.9
U. brizantha cv. Piatã.	13.9	1.5	1.2

Table 2. Reported weather conditions at the time of glyphosate herbicide application. Jataí (GO), 2013.

Time		Temperature		Humidity		Wind speed	Cloud coverage
Initial	Final	Initial	Final	Initial	Final		
10:00	11:50	28º C	37.9ºC	57.3%	37.1%	2 - 6 Km h^{-1}	30%

In the two biomass levels or with the occurrence of significant interaction between the studied factors, doses were split within each biomass level by non-linear regression, using the hyperbolic model (Equation 1):

$$y = \frac{a.x}{(b+x)} \quad (1)$$

Where:

y = control percentage; x = herbicide dose (kg of a.e. ha^{-1}); a and b = estimated parameters (regression coefficients) of the model.

The model was selected considering the significance of the regression analysis of variance, the determination coefficient (R^2), the significance of regression coefficients using the "t" test and the knowledge about the evolution of biologic phenomena.

Results and Discussion

In the analysis of variance summary (Table 3) of the researched values, it is possible to observe that 10 days after application (DAA), there was no difference between biomass levels in the three *Urochloa* species. On day 15 and 20 DAA, biomass levels influenced the control over *U.decumbens* and *U. brizantha* cv. Piatã. There is also a significant interaction between the studied factors in *U. brizantha* cv. Piatã during two evaluation periods (15 and 20 DAA).

Biomass levels did not probably interfere in controlling *U. ruziziensis* (Tables 3 and 4), possibly due to the higher sensitivity to the herbicide compared with the other studied species (Silva et al., 2013; Ceccon and Concenço 2014). Despite the fact, that on 15 and 20 DAA, at the natural biomass level, there was less control of *U. decumbens*, values are above 80%, which is considered satisfactory (SBCPD, 2000). It is important to highlight that, in the same evaluation periods (15 and 20 DAS), biomass levels interfere in controlling *U. brizantha* cv. Piatã; however, control was not satisfactory (lower than 80%) in the respective evaluation periods (Tables 3 and 4). However, it is important to point out the occurrence of significant interaction between factors (biomass level and herbicide dose) for such species, that is, the levels of each factor act in association to control it.

Table 3. Summary of the analysis of variance performed with the results obtained from *U. ruziziensis*, *U.decumbens*, *U. brizantha* cv. Piatã on day 10, 15 and 20 days after application (DAA). Jataí (GO), 2013.

Species		Variable	10 DAA	15 DAA	20 DAA
U. ruziziensis	Fc	Biomass levels (N)	7.668^{ns}	3.649^{ns}	0.904^{ns}
		Herbicide dose (H)	5.254*	6.139*	1.233^{ns}
		N x H	0.429^{ns}	1.135^{ns}	0.360^{ns}
		CV % Plot	6.21	1.18	1.87
		CV % Sub-plot	4.10	1.14	1.97
U.decumbens	Fc	Biomass levels (N)	2.460^{ns}	11.772*	13.064*
		Herbicide dose (H)	8.879*	28.060*	65.858*
		N x H	0.096^{ns}	1.495^{ns}	2.420^{ns}
		CV % Plot	21.39	7.23	5.91
		CV % Sub-plot	6.85	5.00	3.60
U. brizantha cv. Piatã.	Fc	Biomass levels (N)	2.008^{ns}	19.330*	20.062*
		Herbicide dose (H)	4.533*	23.723*	33.803*
		N x H	0.148^{ns}	3.631*	3.134*
		CV % Plot	18.67	9.54	10.57
		CV % Sub-plot	17.43	12.04	10.05

* Significant at 5% significance.

Table 4. Control percentage of *U. ruziziensis, U. decumbens, U. brizantha* cv. Piatã on natural and lowered biomass levels provided by doses of glyphosate herbicide on day 10, 15 and 20 days after application (DAA). Jataí (GO), 2013.

Biomass levels	*U. ruziziensis*			*U. decumbens*			*U. brizantha* cv. Piatã.		
	10	15	20	10	15	20	10	15	20
	DAA								
Lowered	94.25	99.6	99.75	66.1	90.2 a	92.5 a	46.9	65.4	73.3
Natural	88.68	98.8	99.1	74.6	82.0 b	85.9 b	42.7	56.0	61.9
LSD	-	-	-	-	7.03	5.9	-	-	-

It is important to highlight that at the natural biomass level, *U. ruziziensis* had a biomass accumulation of 4.6 and 4.3 Mg ha^{-1} less total dry mass than *U. decumbens* and *U. brizantha* cv. Piatã, respectively. Thus, it would be possible to ascribe to this fact the satisfactory control (>80%) of the species right on day 10 DAA (Table 1). Yet, what reinforces the possibility of a higher sensitivity of the species to the herbicide molecule is that it has less dry mass (0.4 Mg ha^{-1}) referring to the green aerial part of the plant (photosynthetically active leaves). Moreover, when lowered and after 30 days, at the time of burndown, *U. ruziziensis* had accumulated more dry mass than the other studied species (Table 1).

In spite of having performed and presented the analysis of variance (Table 3) of data referring to the dose factor and the interaction between the studied factors (biomass level and dose), they will be discussed in the regression study (Table 5 and Figure 2), regardless of the significance of the F test of the analysis of variance. Therefore, it is important to stress that the regression studies on levels of a quantitative factor or its split within another factor, do not depend on the significance of the F test in the analysis of variance, but they do depend on the significance of the F test from the analysis of regression and regression coefficients, among other parameters (Banzatto and Kronka, 2013).

The analysis of regression of the dose factor in each biomass level from the three studied *Uroclhoa* species (Figure 2) was significant at levels of up to 3.3%. Values of control percentage of the three studied *Uroclhoa* species on day 10, 15 and 20 DAA (Table 5) may be satisfactory represented by the hyperbolic model (Equation 1) due to the significance of regression, regression coefficients and to the elevated values of the determination coefficient, according to the analyzed variables.

Table 5. Regression coefficients (a and b) and determination coefficient (R^2 and adjusted R^2) of the hyperbolic model adjusted to values of control percentage of *U. ruziziensis*, *U. decumbens*, *U. brizantha* on day 10, 15 and 20 after application (DAA). Jataí (GO), 2013.

DAA	Biomass Level	*U. ruziziensis*			
		Regression coefficients		Determination coefficient	
		a	*b*	R^2	Adjusted R^2
10	Natural	92.3271*	0,0519***	0.9734	0.9476
	Lowered	100.5933*	0.0857**	0.9904	0.9809
15	Natural	100.9985*	0.0283*	0.9932	0.9864
	Lowered	100.478 *	0.0115**	0.9888	0.9777
20	Natural	100.9766*	0.0234* *	0.9890	0.9780
	Lowered	100.2983*	0.0069 *	0.9940	0.9880
		U. decumbens			
10	Natural	75.1695*	0.1744**	0.9910	0.9820
	Lowered	83.7624*	0.1585**	0.9915	0.9831
15	Natural	96.3027*	0.2279*	0.9944	0.9888
	Lowered	108.8505*	0.2719*	0.9889	0.9779
20	Natural	106.1920*	0.3121*	0.9967	0.9934
	Lowered	106.7423*	0.2005****	0.9751	0.9509
		U. brizantha cv. Piatã.			
10	Natural	53.5950*	0.3392****	0.9797	0.9597
	Lowered	59.8955*	0.3709***	0.9841	0.9684
15	Natural	73.3658*	0.4080*	0.9852	0.9705
	Lowered	111.0299*	1.0060******	0.9852	0.9705
20	Natural	84.2597*	0.4874***	0.9889	0.9780
	Lowered	84.2597*	0.0069 *	0.9834	0.9671

* Significant at 1% significance; ** Significant at 2% significance; *** Significant at 3% significance; **** Significant at 4% significance; ****** Significant at 6% significance.

The effectiveness in controlling *U. ruzizieinsis*, *U. decumbens*, *U. brizantha* cv. Piatã by glyphosate, in different periods, presented variation according to doses. In all evaluation periods, values of control percentage hyperbolically increased with the increase of the glyphosate dose (Figure 2 and Table 5).

On day 10 DAA, the evolution in *U. ruzizieinsis* control (Figure 2) with 0.65, 1.30, 1.95 and 2.60 kg a.e. ha^{-1} doses resulted in 85.8, 88, 90.3 and 90.8% control and 88.8, 94.5, 97 and 96.8% control at natural and lowered biomass levels, respectively. Since it provides control above 80% right on day 10 DAA for both biomass management, *U. ruziziensis* allows crop-sowing starting from this period (10 DAA) without reducing the productivity of grain crops (Nunes et al., 2009; Nascente and Crusciol, 2012; Nepomuceno et al., 2012; Giancotti et al., 2015). It is important to highlight that the reduction in soybean productivity by this species is due to the production of a chemical substance (protodioscin) which provides phytotoxic effects in soybean seedlings (allelopathic effect). Yet, it is possible to presume that its residual effect may last for up to 10 DAA linked to the 80 mm rainfall precipitation (Nepomuceno, 2011).

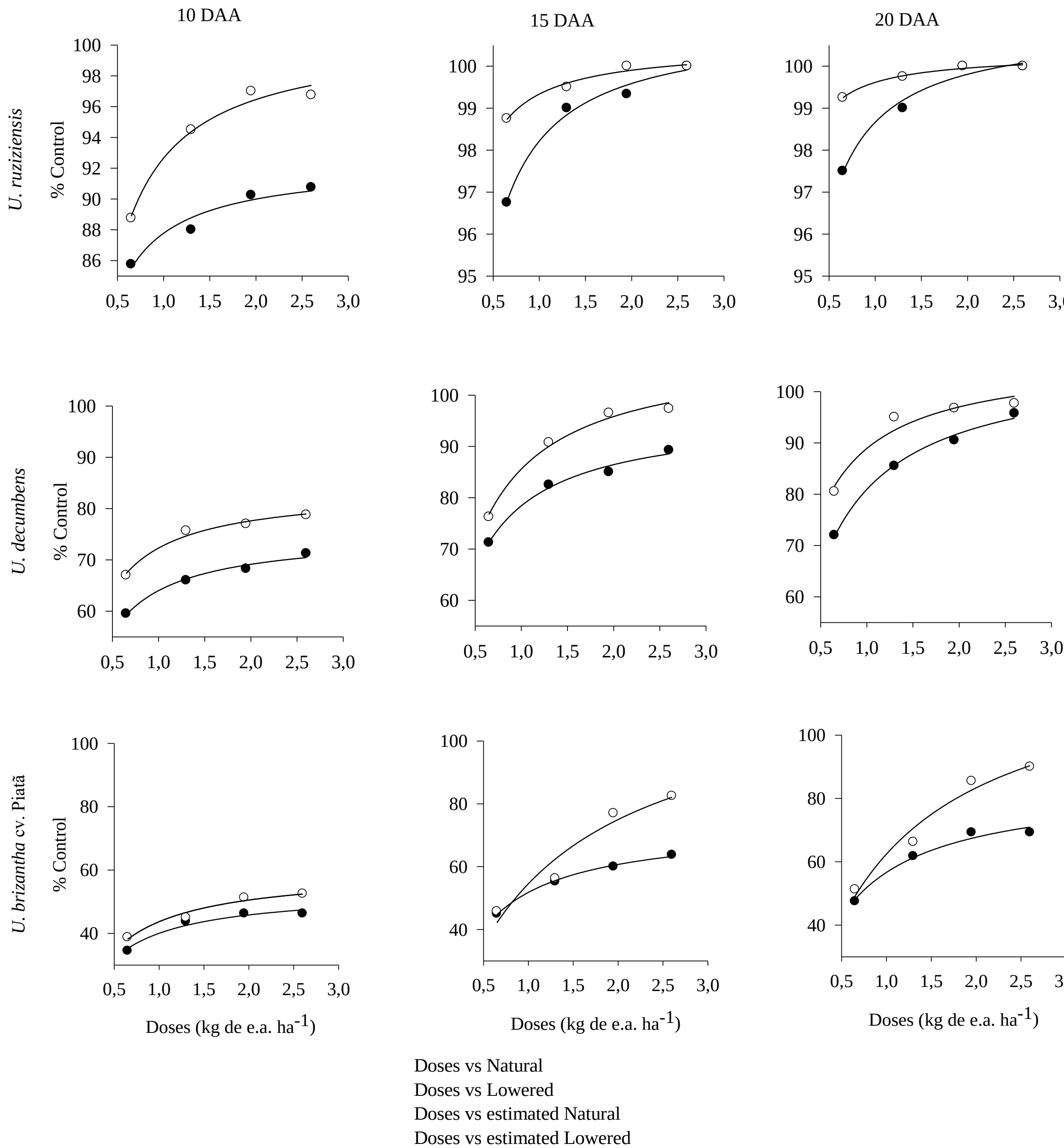

Figure 2. Control percentage of *U. ruziziensis*, *U. decumbens*, *U. brizantha* cv. Piatã provided by 0.65, 1.30, 1.95 and 2.60 kg ha^{-1} doses of acid equivalent (a.e.) of glyphosate herbicide on natural and lowered biomass levels on day 10, 15 and 20 days after application (DAA). Jataí (GO), 2013.

The 0.65 kg ha^{-1} glyphosate dose did not provide *U. decumbens* control above 80% (Figure 2) at natural biomass level in none of the evaluation periods (10, 15 and 20 DAA). At the lowered biomass level with the same dose, a lower than 80% control was observed only on day 20 DAA. Yet, in both biomass managements, on day 10 DAA, no dose provided satisfactory control. On day 15 DAA there was satisfactory control estimated by the regression model (Equation 1 and Table 5), starting from 0.76 and 1.12 kg ha^{-1} glyphosate at the respective lowered and natural biomass levels. The use of *U. decumbens* for direct planting will incur higher expenses with herbicides compared with *U. ruziziensis*. It must be pointed out that, in case of not using integrated systems such as CLI so that animal grazing (fodder) occurs and lowers the biomass level for grazing and/or stamping, some 17.9% more herbicide will be necessary to obtain the same control (<80%) as CLI systems, which provide biomass reduction.

In case grain crop sowing, like soybean, is performed with ground cover control lower than 80%, there may be damages to the sowing operation, such as “bushing” and cutting difficulties, which may cause failures in the final stand of the crop (Greco and Benez, 2003). Therefore, the use of *U. decumbens* in both biomass levels may incur delays to the sowing of grain crops, such as soybean, since on day 10 DAA the control was not satisfactory with all doses (Figure 1). This delay in the implantation of the crop will decrease the due time for the sowing of the second crop in proper regions.

A *U. brizanatha* cv. Piatã (Figure 2) at the natural biomass level was not effectively controlled by the doses (0.65, 1.30, 1.95 and 2.60 kg. ha^{-1} glyphosate) in the evaluated periods (10, 15 and 20 DAA). When lowered, the ground cover was controlled by 80% on day 15 and 20 DAA with doses estimated by the regression model (Equation 1 and Table 5) starting from 2.09 and 1.85 kg ha^{-1} herbicide, respectively.

Nunes et al. (2010) obtained *U. decumbens* and *U. brizanatha* cv. Piatã control of 85.4 and 89.4% in the respective doses of 1.44 and 2.16 kg ha^{-1} glyphosate on day 10 DAA. Nonetheless, in this study, covers remained established for two years in the area, without any management, which may have incremented the biomass increase not only in the aerial part, but also of the root system and so justifying the higher tolerance to herbicide doses. Thus, in case it should be necessary to implant and maintain covers (*U. decumbens* and *U. brizanatha* cv. Piatã) for an equal period to the one of the research in grain cultivation areas, the difficulty in controlling them is clear.

Based on the results obtained in the research, it is possible to deduce that *U. brizantha* is more recommendable for establishment in areas meant for the sole livestock farming, since in integrated production systems such as the Crop-Livestock Integration (CLI), the management of this species is expensive, ending up in higher expenses and impact on the environment. Facing the control easiness of *U. ruziziensis* with lower doses and its ability to suppress weeds by competition, allelopathic effect and physical barrier, it is possible to praise its sustainability in production systems aiming at minimizing the impact on the environment (Nepomuceno, 2011; Silva et al, 2013; Ceccon and Concenço, 2014; Lima et al., 2014a; Lima et al., 2014b).

Conclusions

Urochloa ruziziensis at both biomass levels is more sensitive to glyphosate than *Urochloa decumbens* and *Urochloa brizantha* cv. Piatã.

The biomass level influences the control of *Urochloa decumbens* and *Urochloa brizantha* cv. Piatã.

Urochloa brizantha cv. Piatã at natural biomass level was not effectively controlled in any of the established glyphosate doses.

Acknowledgements

Acknowledgements to the staff of the Laboratório de Plantas Daninhas (LPD), who collaborated to the establishment and performance of the research.

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