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Organosilicone surfactant together with glyphosate in the control of *Brachiaria decumbens*[1]

Surfatante siliconado e glyphosate no controle de ***Brachiaria decumbens***

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Abstract - The research goal was to evaluate the effects of silicone surfactant and simulated rainfall in glyphosate efficiency in controlling *Brachiaria decumbens*. The experiments were carried out at (a unit of the University of São Paulo) Escola Superior de Agricultura Luiz de Queiroz (ESALQ – Luiz de Queiroz College of Agriculture) in greenhouse conditions, in a randomized block design with four replications. In one experiment, a simulated rainfall of 10 mm was carried out, 30 minutes after treatments application, and in the other there was no simulation. The treatments were arranged in a 5x3 factorial arrangement, with the first factor corresponding to the doses of glyphosate (0, 135, 270, 540 and 1080 g ha^{-1} a.e.), and the second one to the doses of silicone surfactant (0, 50 and 100 mL ha^{-1}). The applications were performed at 30 days after sowing. In the presence of a simulated rainfall, the percentage of control was increased and chlorophyll content was reduced in the dose of 135 g ha^{-1} a.e. of glyphosate, together with 100 mL ha^{-1} of silicone surfactant. Increase in lipid peroxidation was also observed with the addition of 100 mL ha^{-1}. In the experiment without a simulated rain, at seven days after treatments application, a higher percentage of control was observed at doses of 540 and 1080 g ha^{-1} a.e. with 100 mL ha^{-1} of silicone surfactant. Therefore, the use of silicone surfactant at a dose of 100 mL ha^{-1} increases the efficiency of glyphosate in the control of *Brachiaria decumbens* in the absence of simulated rain and rain conditions held for half an hour after application.
Keywords: *Brachiaria*; control; herbicide; precipitation

Resumo - O objetivo da pesquisa foi avaliar os efeitos de surfatante siliconado e de chuva simulada sob a eficiência do glyphosate no controle de *Brachiaria decumbens*. Os experimentos foram desenvolvidos na “Escola Superior de Agricultura Luiz de Queiroz” em condições de casa de vegetação, no delineamento de blocos casualizados, com quatro repetições. Em um experimento realizou-se chuva simulada de 10 mm, 30 minutos após a aplicação dos tratamentos, e no outro não ocorreu a simulação. Os tratamentos foram arranjados no esquema fatorial 5x3, com o primeiro fator correspondente as doses de glyphosate (0, 135, 270, 540 e 1080 g ha^{-1} e.a.), e o segundo as doses de surfatante siliconado (0, 50 e 100 mL ha^{-1}). As aplicações foram realizadas aos 30 dias após a semeadura. Na presença de chuva simulada ocorreu o aumento do percentual de controle e redução no teor de clorofila na dose de 135 g ha^{-1} e.a. de glyphosate juntamente com 100 mL ha^{-1}

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de surfatante siliconado. Também foi observado aumento na peroxidação lipídica com adição de 100 mL ha^{-1}. No experimento sem chuva simulada, aos sete dias após a aplicação dos tratamentos foi observado maior percentual de controle nas doses de 540 e 1080 g ha^{-1} e.a. com 100 mL ha^{-1} de surfatante siliconado. Portanto, o uso de surfatante siliconado na dose de 100 mL ha^{-1} aumenta a eficiência de glyphosate no controle de *Brachiaria decumbens* sem a presença de chuva simulada e em condições de chuva ocorrida até meia hora depois da aplicação.
Palavras-chaves: capim-braquiária; controle; herbicida; precipitação

Introduction

Brachiaria decumbens is a plant from South Africa, widely used as forage for animal feed. However, this species is considered an important weed in Brazilian crops (Queiroz et al., 2014).

The most widely used means to control grasses such as *Brachiaria decumbens* has been the use of broad spectrum action herbicides such as glyphosate. However, some formulations of this herbicide can take three to four hours to be absorbed by plants and are subject to control inefficiency in the event of rain in the first hours after application (Franco et al., 2012).

The inherent problems of slow absorption of the herbicide can be minimized with the use of silicone surfactants. These products may be defined as spreaders, acting in reducing the solution static surface tension at 22 mN m^{-1}, facilitating the penetration of systemic pesticides (Franco et al., 2012) and this feature can increase the herbicide absorption rate, increasing the product efficiency in the occurrence of rain shortly after application (Antuniassi et al., 2010). Additionally, some surfactants such as the silicone ones, provide reduction of the droplets surface tension, which enables greater scattering of the herbicide on the leaf, leading to an increased cuticular penetration of the herbicide (Procópio et al., 2002).

The surfactants provide increased leaf surface area covered by the herbicide, reduction in the activity of cuticular waxes, delay in crystallization of the herbicides formulations deposited on the leaf surface, and also increased penetration of these products via stomata (Gaskin e Zabkiewicz, 1992; Stock e Holloway, 1993; Sun et al., 1996; Procópio et al., 2002). Some authors claim that another benefit caused by surfactants to the herbicide spray mix is that this practice can provide a reduction in herbicide doses, as well as improvements in weed control on rainy days (Singh e Mack, 1993).

The use of silicone surfactants has been reported as a measure to mitigate the effect of rain after herbicide applications, besides providing the possibility of reducing the herbicide dose to be applied. However, there are still few studies aimed at evaluating the actual effect of this product on glyphosate effectiveness. Therefore, this study aimed to evaluate silicone surfactant effects and simulated rainfall under glyphosate efficiency in controlling *Brachiaria decumbens*.

Material and Methods

The experiments were conducted in the greenhouse at the Department of Plant Production of the Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba, SP, in the period April-June 2013. The experimental design used was randomized blocks, in a 5x3 factorial arrangement, with five doses of glyphosate and three doses of silicone surfactant, with four replications for each treatment.

The *Brachiaria decumbens* species was used, with sowing being held in 2 L capacity pots containing Plantmax substrate. At 15 days after sowing, plants thinning was carried out, leaving only nine plants per pot. The treatments application was performed 30 days after sowing, when the plants had a tiller with about five fully expanded leaves.

Glyphosate doses were applied in a formulation containing 360 g L^{-1} of acid equivalent, at doses of 0, 135, 270, 540 and 1080 g ha^{-1} a.e., each dose being applied at concentrations of 0, 50 and 100 mL ha^{-1} of silicone surfactant.

The treatments application was done with a knapsack sprayer, pressurized at CO_2, using 8002-type spray nozzles, pressure of 200 kPa and spray mix volume of 200 L ha^{-1}. These same treatments were applied in two different experiments, one without simulated rainfall and the other with simulated rainfall. The simulated rainfall was performed 30 minutes after the treatments application, being applied the equivalent of 10 mm of rainfall. On the day of the application, the average temperature was 20 °C and the day remained cloudy.

The visual percentage of weed control was evaluated at 7 and 21 days after application of treatments by means of a percentage rating scale in which zero represented no control and 100% total control of the plants, as proposed by the Brazilian Society of Weed Science (Sociedade Brasileira da Ciência das Plantas Daninhas, 1995). After seven days, the SPAD (Soil Plant Analysis Development) assessment and quantification of lipid peroxidation in the leaves were also performed, and the latter analysis was performed only in the experiment with simulated rainfall.

To determine the SPAD index, a chlorophyll portable meter (brand Minolta, model SPAD-502) was used, allowing instantaneous readings of relative chlorophyll content in the leaf without destroying it. This evaluation was performed in three plants of each pot, using the middle portion of the fully expanded leaves.

The lipid peroxidation quantification was determined according to the technique by Heath e Packer (1968). 100 mg of the plant material were macerated, subsequently homogenized in 5 mL of solution containing thiobarbituric acid (TBA) at 0.25% and trichloroacetic acid (TCA) at 10% (0.25 g of TBA and 10 g of TCA in 100 mL of water). Then, the contents were transferred to test tubes with screw caps and plastic wrap, and incubated in water bath at 90 °C for 1 hour. After cooling, the homogenate was centrifuged at 8,000 rpm for 15 minutes at room temperature and then the supernatant collected from each sample was subjected to absorbance readings with a UV-visible spectrophotometer at 560 and 600 nm. The results were expressed in nmol of thiobarbituric acid reactive substances (TBARS) per gram of fresh matter.

At the end of the experiment, the plants dry matter was assessed. For this, the plants were removed from the pot and each organ was separately stored in paper bags, and drying the different plant parts was performed using the standard method in an oven with forced air circulation and temperature of 70 °C until reaching constant weight. At the end of drying, the plants were weighed in a 0.01 g precision balance.

The data obtained were submitted to analysis of variance by F-test and the means of the silicone surfactant factor were compared by Tukey's test at 5% significance level and the glyphosate doses means were submitted to regression analysis. The analyses were performed using the statistical program Sisvar.

Results and Discussion

In both experiments, there was a significant interaction between the factors in all the variables analyzed. In the experiment with simulated rain at seven days after application (DAA) no differences were observed in *Brachiaria decumbens* plant control percentage under different doses of silicone surfactant (Table 1). However, at 21 DAA, differences were observed in the control of *Brachiaria decumbens* between the surfactant doses used and the lowest dose of glyphosate (135 g a.e. ha^{-1}).

In the experiment in which there was no presence of simulated rain, the application of silicone surfactant with glyphosate provided significant differences in weed control within the first 7 DAA (Figure 1). These differences became apparent when the use of silicone surfactant took place associated with doses of 540 and 1080 g ha^{-1} a.e. of glyphosate; in these treatments, the dose of 100 mL ha^{-1} of surfactant provided an increase of 75 and 50% in the control of *Brachiaria decumbens*, respectively, when compared to treatments without applying silicone surfactant. However, at 21 DAA, the differences in the control percentage were observed only at low doses of glyphosate (135 and 270 g ha^{-1} a.e.). The dose of 135 g ha^{-1} a.e. associated with 100 mL ha^{-1} of silicone surfactant provided an increase of 137% in the control efficiency of *Brachiaria decumbens*.

Table 1. Percentage of *Brachiaria decumbens* plants control submitted to application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with and without conducting simulated rain of 10 mm. Evaluations performed at 7 and 21 days after application (DAA).

Doses of glyphosate (g ha^{-1} a.e.)	Doses of silicone surfactant (mL ha^{-1})					
	0	50	100	0	50	100
	7 DAA			21 DAA		
	With a simulated rainfall					
0	0 ns	0	0	0 a*	0 a	0 a
135	5	5	3	23 c	38 b	73 a
270	15	15	16	90 a	90 a	95 a
540	15	18	20	95 a	95 a	100 a
1080	16	16	18	100 a	100 a	100 a
CV (%)	28.83			10.57		
LSD (%)	7.20			12.07		
Doses of glyphosate (g ha^{-1} a.e.)	Doses of silicone surfactant (mL ha^{-1})					
	0	50	100	0	50	100
	7 DAA			21 DAA		
	Without a simulated rainfall					
0	0 a	0 a	0 a	0 a	0 a	0 a
135	8 a	11 a	10 a	40 c	75 b	95 a
270	18 a	23 a	22 a	83 b	88 ab	100 a
540	16 b	20 b	28 a	85 a	100 a	100 a
1080	20 b	19 b	30 a	100 a	100 a	100 a
CV (%)	27.02			13.66		
LSD (%)	7.35			16.67		

* Means followed by the same letters in the rows do not differ statistically by the Tukey's test at 5% significance. ^{ns} Non-significant

The effect observed with the addition of silicone surfactant in the lowest glyphosate dose can be the result of this product capacity to reduce the droplet surface tension, facilitating the scattering and providing a larger contact area between the leaf surface and the herbicide, which leads to increased absorption (Stevens et al., 1994; Martins et al., 2010). Furthermore, according to Balneaves et al. (1993), using herbicide underdoses is what allows the effects of different surfactants on herbicides to be better evaluated.

The data obtained in the experiment with simulated rainfall differ from some studies showing the effects of applying silicone surfactant doses in higher doses of glyphosate. Franco et al. (2012) have conducted a simulated rainfall one hour after applying the treatments and found differences in the application doses of up to 200 mL ha^{-1} of silicone surfactant with doses of 720 and 1080 g ha^{-1} a.e. of glyphosate in controlling *Cynodon dactylon*. The application effects of these same doses of silicone surfactant with doses of 360, 480 and 720 g ha^{-1} a.e. of glyphosate were also observed in species *Ipomoea grandifolia; Euphorbia heterophylla; Senna obtusifolia* and *Echinochloa colonum* (Franco et al., 2012).

The glyphosate effect observed only at the lowest dose in the experiment with simulated rainfall may also be related to the lower stage of development of weeds that consequently required smaller doses of herbicide for the control.

At 7 DAA, in the experiment with simulated rain, the doses of 691, 787 and 800 g ha^{-1} a.e. of glyphosate were the ones that provided a higher percentage of *Brachiaria decumbens* control when associated with 50, 100 and 0 mL ha^{-1} of silicone surfactant, respectively (Figure 1A). Without the presence of rain, the best doses of glyphosate became the doses of 668, 793 and 797 g ha^{-1} a.e., when applied in conjunction with 50, 0 and 100 mL ha^{-1} of silicone surfactant, respectively (Figure 1B).

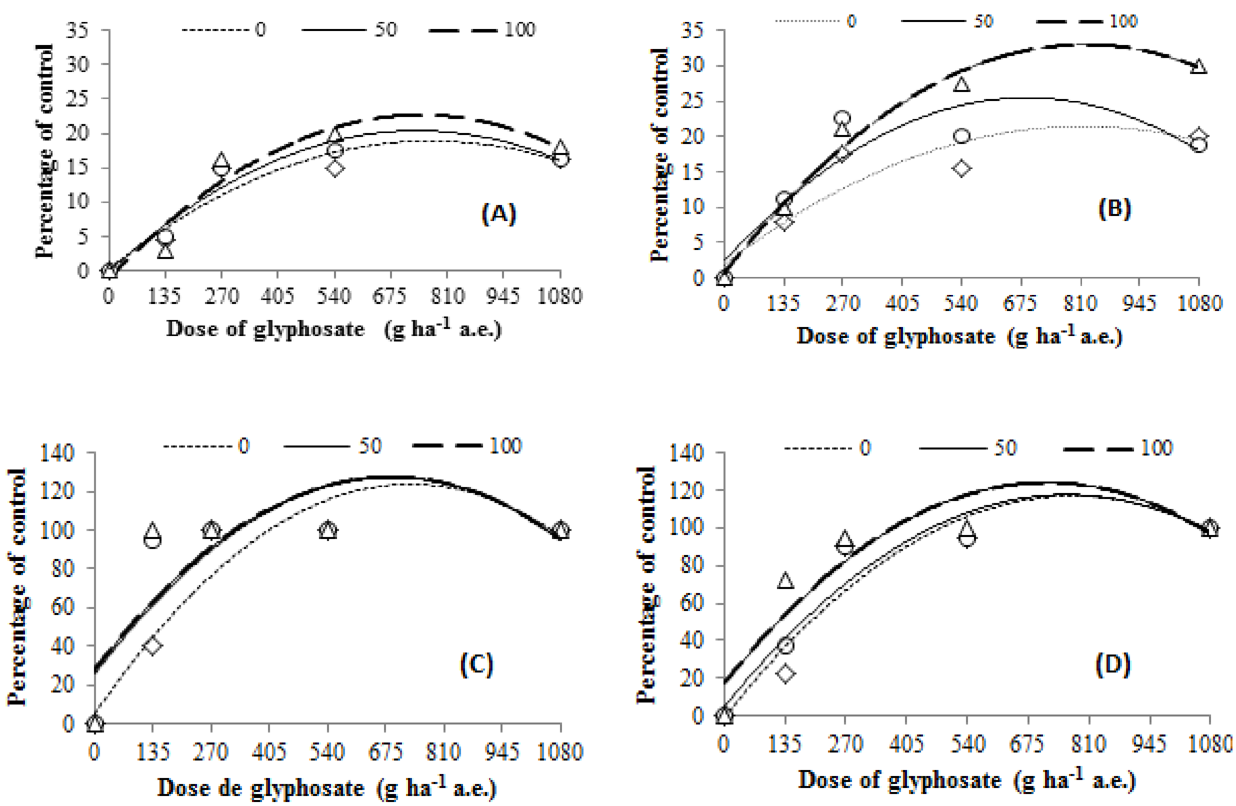

Figure 1. Percentage of *Brachiaria decumbens* plants control submitted to application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1} with simulated rainfall of 10 mm at 7 (A) and 21 (C) DAA and without conducting the simulated rainfall at 7 (B) and 21(D) DAA.

After 21 DAA, in the experiment with simulated rainfall, it was observed that the most effective dose of glyphosate to control *Brachiaria decumbens* without association with silicone was 805 g ha^{-1} a.e. The application of silicone surfactant provided that lower doses of glyphosate started to be more efficient in control, showing values of 733 g ha^{-1} a.e. when applied together with 50 mL ha^{-1} of silicone surfactant and 726 g ha^{-1} a.e. when applied with 100 mL ha^{-1} (Figure 1C).

The plants that were not subjected to simulated rainfall at 21 DAA were more efficiently controlled in the presence of 805 g ha^{-1} a.e. of glyphosate when silicone surfactant was not applied. The application of silicone surfactant provided greater control efficiency for the doses of 733 and 726 g ha^{-1} a.e. when associated with 50 and 100 mL ha^{-1} of silicone surfactant, respectively (Figure 1D). The regression equations and their respective values of the coefficient of determination for the analyzed variables are shown in Table 2.

One of the symptoms of the herbicide effect in weed control is the yellowing of leaves (Farias et al. 2012); this symptom can be elucidated by means of the SPAD value analysis (Table 3). In the experiment with simulated rainfall, in plants on which 135 g ha^{-1} a.e. of glyphosate together with silicone surfactant were applied, a reduction in chlorophyll content, a reduction of 29 to 25% of the SPAD index for doses of 50 and 100 mL ha^{-1} of silicone surfactant, respectively, were observed when compared with the control. In the remaining doses, no significant differences were observed in the SPAD value with the addition of silicone surfactant. When there was the presence of simulated rainfall, significant differences were also observed between the treatments.

Table 2. Regression equations adjusted for the variables evaluated in *Brachiaria decumbens* plants subjected to the application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with and without conducting simulated rain of 10 mm.

Assessment	Dose of silicone (mL ha^{-1})	With a simulated rainfall		Without a simulated rainfall	
		Equation	R^2	Equation	R^2
Percentage of control (7 DAA)	0	$y = -3E{-}05x^2 + 0.048x + 0.3346$	0.89	$y = -3E{-}05x^2 + 0.0476x + 2.0385$	0.84
	50	$y = -4E{-}05x^2 + 0.0553x – 0.0577$	0.95	$y = -5E{-}05x^2 + 0.0668x + 2.4808$	0.83
	100	$y = -4E{-}05x^2 + 0.0636x – 1.1615$	0.92	$y = -5E{-}05x^2 + 0.0797x + 0.7308$	0.98
Percentage of control (21 DAA)	0	$y = -0.0002x^2 + 0.3219x + 5.5385$	0.90	$y = -0.0002x^2 + 0.3035x – 0.6923$	0.90
	50	$y = -0.0002x^2 + 0.2932x + 25.846$	0.70	$y = -0.0002x^2 + 0.2957x + 4.8462$	0.92
	100	$y = -0.0002x^2 + 0.2906x + 27.692$	0.69	$y = -0.0002x^2 + 0.2987x + 17.077$	0.85
SPAD value	0	$y = -0.0117x + 30.351$	0.77	–	–
	50	$y = -0.0053x + 23.21$	0.77	–	–
	100	$y = -0.0044x + 23.652$	0.69	–	–
Lipid peroxidation	0	$y = 0.0233x + 13.36$	0.94	–	–
	50	$y = 0.0227x + 19.366$	0.96	–	–
	100	$y = 0.0267x + 20.992$	0.81	–	–
Dry matter	0	$y = 7E{-}07x^2 – 0.001x + 0.3989$	0.87	$y = 7E{-}07x^2 – 0.001x + 0.3706$	0.76
	50	$y = 9E{-}07x^2 – 0.0013x + 0.4587$	0.84	$y = 9E{-}07x^2 – 0.0014x + 0.4455$	0.81
	100	$y = 5E{-}07x^2 – 0.0008x + 0.2515$	0.72	$y = 5E{-}07x^2 – 0.0007x + 0.2545$	0.72

There was a linear reduction of the SPAD value from the increase of the glyphosate doses applied; this behavior was observed for the three doses of silicone surfactant used (Figure 2A).

The decrease in chlorophyll content of plants, indirectly measured by means of the SPAD index, is a side effect of the glyphosate herbicide (Cole, 1985). This herbicide inhibits the synthesis of δ-Aminolevulinic acid (dALA or δ-ALA), which is a precursor of chlorophyll biosynthesis (Kitchen et al., 1981; Nilsson, 1985; Moldes, 2006; Gomes et al, 2014). The application of glyphosate can also cause loss of nitrogen by the plant (Damin et al, 2008), which directly affects the chlorophyll content, due to the fact that nitrogen is part of its formulation.

The reduction in chlorophyll content by the application of glyphosate has led to increased lipid peroxidation (Table 4). The addition of 100 mL h^{-1} of silicone surfactant has afforded a 72% increase in lipid peroxidation at the dose of 135 g ha^{-1} a.e. and 82% at the dose of 540 g ha^{-1} a.e. of glyphosate, when compared to the control treatment.

Table 3. SPAD value (Soil Plant Analysis Development) of *Brachiaria decumbens* plants subjected to the application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with and without conducting simulated rain of 10 mm. Evaluations at 7 days after application of treatments.

Doses of glyphosate ($g\ ha^{-1}$ a.e.)	Doses of silicone ($mL\ ha^{-1}$)					
	0	50	100	0	50	100
	With a simulated rainfall			Without a simulated rainfall		
0	32.1 a*	24.8 b	25.0 ab	28.3 ns	25.2	26.9
135	31.2 a	22.2 b	23.5 b	25.4	21.8	21.5
270	23.7 a	20.1 a	20.5 a	21.9	23.9	21.6
540	21.6 a	20.2 a	20.7 a	20.6	19.7	21.1
1080	19.5 a	18.1 a	19.6 a	19.1	23.6	20.3
CV (%)	14.59			13.72		
LSD (%)	6.80			5.92		

* Means followed by the same letters in the rows do not differ statistically by the Tukey's test at 5% significance. ns Non-significant

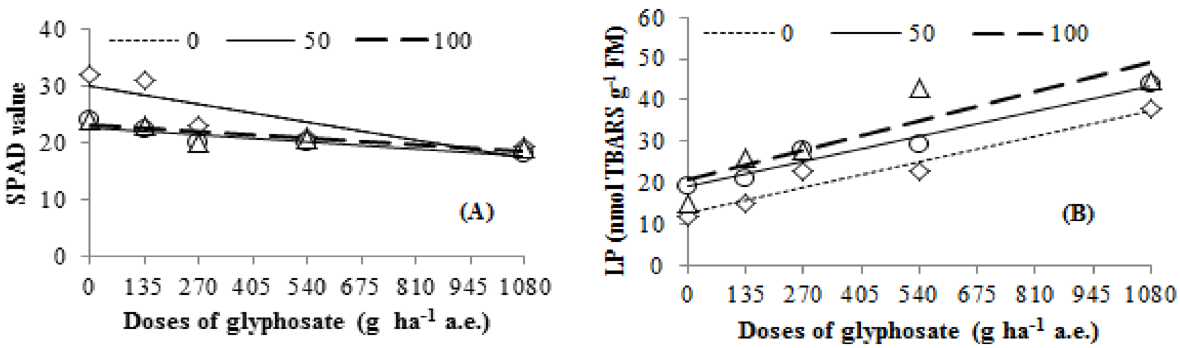

Figure 2. SPAD value and lipid peroxidation (LP) of *Brachiaria decumbens* plants subjected to the application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, on performing simulated rain of 10 mm. Evaluations at seven days after application of treatments.

From the regression models, a linear increase was shown in lipid peroxidation level in *Brachiaria decumbens* plants with an increase of the glyphosate doses, a behavior that was recorded for all the treatments with silicone surfactant used (Figure 2B).

Increased lipid peroxidation may be a result of glyphosate on the oxidative stress in plants. According to Ahsan et al. (2008) and Gomes et al. (2014), glyphosate blocks the shikimic acid synthesis pathway, which provides free radicals increase in the plant and thus causes lipid peroxidation. In addition, lipid peroxidation can be related to the reduction of chlorophyllous pigments, particularly carotenoids, which function as photoprotective structures (Taiz e Zieger, 2013). The photoprotection mechanism involves the suppression of the triplet states of chlorophyll, thus avoiding formation of singlet oxygen ($^1O_2$) (Cardoso, 1997; Taiz e Zieger, 2013). Therefore, the carotenoids reduction leads to increased free radicals in plants, which triggers a series of processes such as, for example, lipid peroxidation. Such damage to the lipid membrane leads to membrane selectivity loss, cell content leakage, and consequently cell death (Blokhina et al., 2003).

Table 4. Lipid peroxidation (LP – nmol TBARS g^{-1} FM) of *Brachiaria decumbens* plants, seven days after the application of glyphosate doses along with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with the completion of simulated rain of 10 mm.

Doses of glyphosate ($g\ ha^{-1}$ a.e.)	Doses of silicone ($mL\ ha^{-1}$) 0	50	100
0	12.2 a	19.2 a	15.2 a
135	15.5 b	21.1 ab	26.7 a
270	23.8 a	28.6 a	28.1 a
540	24.0 b	29.6 b	43.7 a
1080	38.6 a	44.3 a	45.5 a
CV (%)		9.98	
LSD (%)		17.41	

* Means followed by the same letters in the rows do not differ statistically by the Tukey's test at 5% significance

According to Ding et al. (2011), glyphosate can provide a reduction in photosynthetic activity of the plant; thereby, lower production of photoassimilates also occurs. Moreover, the reduction of chlorophyll content, brought about by glyphosate application, can also lead to reduction in photosynthetic activity and therefore lower mass accumulation in the plant (Zobiole et al. 2012). These characteristics were observed in the experiment with simulated rainfall, where plants with lower SPAD value had lower dry matter accumulation (Table 5).

From the plant dry matter data it is observed that at the dose of 135 g ha^{-1} a.e. the application of 100 mL h^{-1} of silicone surfactant provided a decrease of 68% in the plants dry matter relative to the control in the experiment with simulated rain (Table 5).

The accumulation of dry matter in the experiment with simulated rainfall was different between the silicone surfactant doses only at the lowest glyphosate dose studied. In this dose it was possible to notice that the silicone surfactant may have potentiated the herbicide effect because of its features that aid in absorption. Thus, the product may have affected the plant photosynthetic activity, providing a reduction in dry matter.

Table 5. Dry matter of *Brachiaria decumbens* plants, 30 days after the application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with and without conducting simulated rain of 10 mm.

Doses of glyphosate ($g\ ha^{-1}$ a.e.)	Doses of silicone ($mL\ ha^{-1}$)					
	0	50	100	0	50	100
	With a simulated rainfall			Without a simulated rainfall		
0	1.35 a*	1.61 a	0.95 b	1.35 b	1.61 a	0.95 c
135	0.69 a	0.63 ab	0.22 b	0.46 a	0.49 a	0.27 a
270	0.38 a	0.35 a	0.21 a	0.34 a	0.33 a	0.24 a
540	0.35 a	0.29 a	0.15 a	0.32 a	0.22 a	0.20 a
1080	0.29 a	0.27 a	0.15 a	0.23 a	0.22 a	0.19 a
CV (%)		24.24			24.58	
LSD (%)		0.35			0.24	

* Means followed by the same letters in the rows do not differ statistically by the Tukey's test at 5% significance

The regression models showed for experiment with simulated rain that the *Brachiaria decumbens* plants had lower dry matter content in doses of 714, 722 and 800 g ha^{-1} a.e. of glyphosate when associated with doses of 0, 50 and 100 mL ha^{-1} of silicone, respectively (Figure 3A). On the other hand, in the absence of simulated rain, the plants showed a smaller amount of dry matter when subjected to doses of 714, 778 and 700 g ha^{-1} a.e., when applied with 0, 50 and 100 h^{-1} of silicone, respectively (Figure 3B).

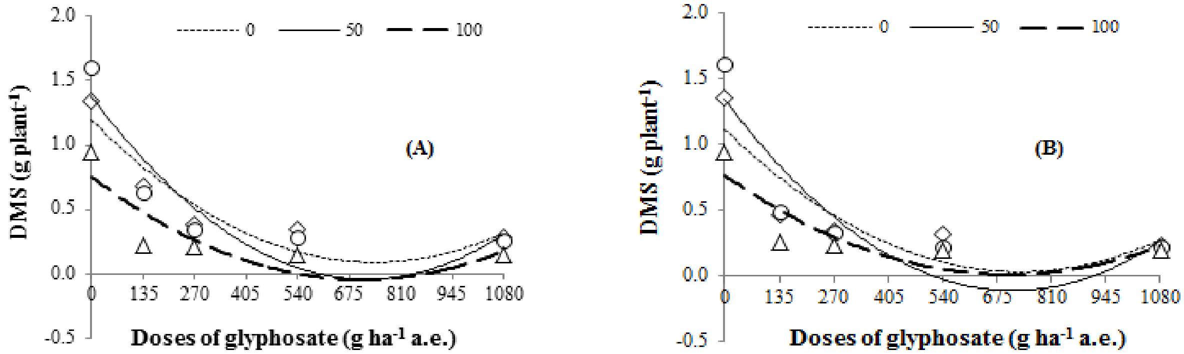

Figure 3. Dry matter of *Brachiaria decumbens* plants subjected to the application of glyphosate doses with silicone surfactant at doses of 0, 50 and 100 mL ha^{-1}, with (A) and without (B) conducting simulated rainfall of 10 mm. Evaluations performed at 30 days after application of treatments.

Conclusions

The use of silicone surfactant at a dose of 100 mL ha^{-1} increases glyphosate efficiency in the control of *Brachiaria decumbens* in wet conditions held until half an hour after application. These effects are best evidenced by the application of lower doses of the herbicide. Without the presence of rain, the addition of silicone surfactant to the herbicide has afforded the faster control of *Brachiaria decumbens*.

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