Action of rain on the efficiency of herbicides applied post-emergence in the control of *Senna obtusifolia*[1]

Ação da chuva na eficiência de herbicidas aplicados em pós-emergência no controle de S*enna obtusifolia*

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ABSTRACT - The objective of this study was to evaluate the effect of rainfall on the effectiveness of herbicides applied post-emergence on plants of *Senna obtusifolia*. The experiment was carried out under green-house conditions and the experimental design was completely randomized design with four replications, with treatments in a 7x8 factorial arrangement (seven herbicides treatments and eight rain intervals). The herbicides used were five formulations of glyphosate (Roundup Original, Roundup WG, Roundup Transorb, Roundup Transorb R and Roundup Ultra) applied at a rate of to 1,080 g a.e. ha^{-1}, glufosinate-ammonium (Finale) at 400 g a.i. ha^{-1} and 2,4-D (DMA 806) at 1,000 g a.e. ha^{-1}. The rain simulation occurred at intervals of 15; 30; 60; 120; 240, 360, and 480 minutes after the herbicides application. A control treatment without herbicide application was added. Visual evaluations of control plants were taken at 7; 14; 21 and 28 days after application and at the end the dry mass of plants was determined. The rain occurrence after 15 minutes of application of glyphosate formulations Roundup Transorb, Roundup Transorb R and Roundup Ultra did not affect the control efficiency on plants of *S. obtusifolia*. For formulations of Roundup Original and Roundup WG and, 2,4-D it was necessary a 30 minutes period without rain for an efficient control of weed.

Key words: Glufosinate-ammonium. Sicklepod. Glyphosate. Weed. 2,4-D.

RESUMO - O objetivo do presente trabalho foi avaliar o efeito da ocorrência de chuvas na eficiência de herbicidas aplicados em pós-emergência no controle de *Senna obtusifolia*. A pesquisa foi desenvolvida em condições de casa-de-vegetação e o delineamento experimental utilizado foi o inteiramente casualizado, com quatro repetições, sendo os tratamentos dispostos em um esquema fatorial 7 x 8 (sete tratamentos químicos e oito intervalos de chuva). Os tratamentos químicos constaram da aplicação de cinco formulações de glyphosate (Roundup Original, Roundup WG, Roundup Transorb, Roundup Transorb R e Roundup Ultra) a 1.080 g e.a. ha^{-1}, amonio-glufosinate (Finale) a 400 g i.a. ha^{-1} e 2,4-D (DMA 806) a 1.000 g e.a. ha^{-1} e, oito intervalos de tempo para simulação da chuva: 15; 30; 60; 120; 240; 360 e 480 minutos após a aplicação dos herbicidas e uma testemunha sem chuva. Foram realizadas avaliações visuais de controle das plantas aos 7; 14; 21 e 28 dias após a aplicação dos herbicidas e ao final determinou-se a massa seca das plantas. A ocorrência de chuvas após 15 minutos da aplicação do herbicida glyphosate nas formulações Roundup Transorb, Roundup Transorb R e Roundup Ultra não afetou a eficiência de controle das plantas de *S. obtusifolia*. Para as formulações Roundup Original e Roundup WG e para o herbicida 2,4-D foi necessário um período de 30 minutos sem chuva para que proporcionassem um controle eficiente da planta daninha. Já, o controle proporcionado pelo herbicida amonio-glufosinate mostrou-se consistente apenas quando da ocorrência de chuva após 8 horas de sua aplicação.

Palavras-chave: Amonio-glufosinate. Fedegoso. Glyphosate. Planta daninha. 2,4-D.

INTRODUCTION

Senna obtusifolia (L), known locally as *fedegoso*, occurs quite commonly in cultivated areas in Brazil and is the cause of problems for major crops. This species, which is probably native to the Americas, is widely dispersed over tropical and subtropical regions of the world, including Brazil, where it is found in all regions (KISSMANN; GROTH, 1999). It is an aggressive, highly-prolific plant, having large seeds and showing low sensitivity to most herbicides used in the cultivation of sugar cane (LORENZI, 2006; RODRIGUES; ALMEIDA, 2005).

Soybean cultivation is another example of where this weed has great economic importance. Bozsa, Oliver and Driver (1989), observed losses of 30% in soybean production due to the interference of 3.3 fedegoso plants per metre close to the sowing furrow. Cruz *et al.* (2009), when quantifying the population-density levels of weed species in rotated crops of soybean, corn and rice in the cerrado region of the Brazilian state of Roraima, verified the presence of 4,333 plants of *S. obtusifolia* per hectare.

For an effective control of this species and a reduction in production costs, the use of herbicides, such as glyphosate, glufosinate-ammonium and 2,4-D, that are not selective and have a systemic action, is a management option, mainly of dessication in a no-tillage system. However, the efficacy of these herbicides is closely related to the extent of the absorption process.

Deuber (1982), cites studies showing that the absorption of herbicides is limited by the amount that passes through the leaf cuticle, and that this is influenced by environmental conditions, by the species of weed and by the characteristics of the herbicides. The immediate consequence of this is less absorption and the consequently lower efficiency of the herbicide (SOUZA *et al.*, 2011).

Rainfall occurring after the post-emergence application of herbicides may compromise weed control. Not only the rainfall, but also the interval between application and the rainfall, the amount and intensity of the rainfall (ANDERSON, ARNOLD, 1984; HAMMERTON, 1967) and the different formulations and concentrations of herbicides can influence the rate of absorption and translocation of the active ingredient, as well as the efficiency of the weed control (MARTINI; PEDRINHO JUNIO; DURIGAN, 2003; MONQUERO; SILVA, 2007; PEDRINHO JUNIOR *et al.*, 2002a).

Some studies have been carried out to demonstrate the effect of rainfall after the application of glyphosate on weed species (JAKELAITIS *et al.*, 2001; PEDRINHO JUNIOR *et al.*, 2002b; ROMAM, 2001). Anderson *et al.* (1993) demonstrated the effect of rain on the efficacy of glufosinate-ammonium applied to barley and foxtail grass.

Reports of the possible effects of rain on the efficacy of the herbicide 2,4-D are scarce in the literature, but there are several works that demonstrate its efficiency in the control of numerous species of weeds (BIJANZADEH; GHADIRI, 2006, CASON; ROOST, 2011; CORREIA; ZEITOUM, 2010; EVERITT; KEELING, 2007; SIEBERT; GRIFFIN; JONES, 2004).The aim of this work therefore, was to evaluate the influence of rainfall at different intervals after the post-emergence application of the herbicides 2,4-D, glyphosate and glufosinate-ammonium in different formulations (Roundup Original, Roundup Transorb, Roundup Transorb R, Roundup Ultra and Roundup WG) in the control of *S. obtusifolia*.

MATERIAL AND METHODS

The study was initiated in January 2009 at the Centre for Advanced Weed Research (NuPAM) of the Department of Plant Production, Agricultural Sector, at the School of Agronomic Sciences/UNESP in Botucatu, São Paulo.

Seeds of *S. obtusifolia* were sown in plastic pots with a capacity of 2.5 litres of soil, and stored in a greenhouse with a controlled temperature of 26 ± 2 °C.

The soil was fertilised with an NPK formulation of 04-14-08 and corrected with dolomitic limestone, following soil analysis and the fertiliser recommendations of Technical Bulletin 100 (RAIJ *et al.*, 1996) for maize cultivation. After emergence of the seedlings, they were thinned out, leaving one plant per pot.

The experimental design was completely randomised, with four replications, and arranged in a 7 x 8 factorial scheme (seven chemical treatments and eight time intervals for rainfall after application), with the tested treatments consisting of glyphosate in five formulations (glyphosate isopropylamine salt - Roundup Original; glyphosate ammonium salt - Roundup Transorb; glyphosate isopropylamine salt - Roundup Transorb R; glyphosate ammonium salt - Roundup Ultra) at 1,080 g ai ha⁻¹, glufosinate-ammonium (Finale) at 400 g ai ha⁻¹ and 2,4-D (DMA 806) at 1,000 g ai ha⁻¹. Eight time intervals were assessed of 15, 30, 60, 120, 240, 360 and 480 minutes to simulate the occurrence of rainfall after spraying the herbicides at 15 mm for 5 minutes, and simulating a possible occurrence of precipitation in the summer.

The herbicides were applied post-emergence, when the plants of *fedegoso* reached a height of from 15 to 20 cm, using a CO_2 pressurized backpack sprayer, equipped with a spray bar having two flat spray tips, type "Teejet" XR 11002VS, spaced 50 cm apart, with a working pressure of 200 kPa for a volume of 200 L ha⁻¹.

Rainfall simulation was carried out after application of the herbicide, at the stipulated times and using a stationary spray.

Visual assessments of weed control were conducted at 7, 14, 21 and 28 days after application (DAA), by means of a percentage grading scale, where 0 (zero) corresponds to no demonstrable damage and 100 (hundred) to the death of the plants, as proposed by SBCPD (1995). The parameters used to establish the grades for visual control were: biomass accumulation; growth inhibition; amount and uniformity of damage; and plant capacity for regrowth.

At the end of the evaluation period, the dry matter of the plants was determined after drying in a forced-air ventilation oven at 65 °C for 72 h and subsequent weighing. The results obtained underwent variance analysis by the F-test and the averages from the treatments were compared by the Tukey test (p < 0.05). The original data were transformed, with equation 1 being used for the percentage of control data and equation 2 for the dry-weight values.

$$y = arc\ sine\ (raiz\ (x/100))\qquad(1)$$

$$y = root\ (x + 1,0)\qquad(2)$$

RESULTS AND DISCUSSION

At the first evaluation, carried out at 7 DAA, it was seen that all the chemical treatments resulted in damage to the plants of *S. obtusifolia*, irrespective of the occurrence of rainfall after application; but only the treatment employing application of glyphosate as the Roundup WG formulation and that with glufosinate-ammonium provided satisfactory control of the weed; over 80% control, with rainfall six and four hours after application respectively (Table 1). Similar results were found by Barnes and Oliver (2003), who observed control percentages above 80% for plants of *S. obtusifolia* submitted to glyphosate application at 7 DAA, but without further rainfall.

It should be noted that the best control seen with the treatments of glyphosate application in the Roundup Transorb R and Roundup Ultra formulations, glufosinate-ammonium and 2,4-D which received rainfall after 4, 6 or 8 hours compared to the treatment without rain, might be due to a redistribution of the product in the shoots. Santos *et al.* (2004) observed that simulated dew on plants of *Urochloa decumbens* after the application of glyphosate (540 g a.e. ha^{-1}) provided greater control averages than when dew did not occur.

It was further found that except for treatments employing applications of Roundup Transorb R and Roundup Ultra, the remaining glyphosate-based treatments were influenced by the different periods of simulated rainfall, presenting better control with increases in the period until rainfall occurred. On the other hand, the treatments with the glufosinate-ammonium and 2,4-D herbicides were not affected by the occurrence of rain after their application.

Table 1 - Percentage of control of *Senna obstusifolia* seven days after the application of different herbicides and formulations, for periods without rain. Botucatu SP, 2009

Chemical treatment	Time until the occurence of rain (minutes)							
	15	30	60	120	240	360	480	No rain
glyphosate[1]	11.0 Bc[8]	20.0 Bbc	21.3 Bbc	11.0 Bc	18.5 Bbc	47.0 ABabc	57.3 ABCab	63.0 ABa
glyphosate[2]	22.5 ABb	26.8 ABb	32.8 ABb	35.0 Bb	50.0 Abab	82.5 Aa	81.3 ABa	83.0 Aa
glyphosate[3]	34.3 ABb	22.8 ABb	36.8 ABb	25.5 Bb	33.3 Bb	37.5 Bab	47.3 BCab	77.8 Aa
glyphosate[4]	24.0 ABb	41.5 ABab	26.5 ABab	35.0 Bab	55.8 Abab	65.8 ABa	54.0 ABCab	36.3 BCab
glyphosate[5]	24.8 ABb	12.8 Bb	47.3 ABab	47.0 ABab	43.5 Bab	46.0 ABab	66.3 ABCa	15.0 Cb
glufosinate-a[6]	58.0 Aa	61.3 Aa	64.0 Aa	78.3 Aa	88.3 Aa	83.0 Aa	91.5 Aa	81.3 Aa
2,4-D[7]	9.5 Ba	12.8 Ba	25.0 ABa	28.5 Ba	28.0 Ba	36.3 Ba	30.0 Ca	28.0 BCa
F Herbicides (H)	23.870**							
F Period (P)	14.289**							
F (H) X (P)	1.946**							
C.V. (%)	30.1							

Averages followed by the same upper-case letter in a column and lower-case letter on a line do not differ statistically by Tukey test at 0.05 probability (p<0.05) [1] Roundup Original (1,080 g a.e. ha^{-1}); [2] Roundup WG (1,080 g a.e. ha^{-1}); [3] Roundup Transorb (1,080 g a.e. ha^{-1}); [4] Roundup Transorb R (1,080 g a.e. ha^{-1}); [5] Roundup Ultra (1,080 g a.e. ha^{-1}); [6] Finale (400 g a.i. ha^{-1}); [7] DMA 806 (1,000 g a.e. ha^{-1}) glufosinate-a = glufosinate-ammonium [8] The values of the statistical analysis as well as the letters shown were obtained from the original data, transformed according to the equation: y = arc sine (root (x / 100)) ** Significant at 1% probability

At 14 DAA of the treatments, it was found that in the absence of rainfall simulation, all the treatments under study presented higher average levels of weed control, above 73%. Whereas, with the simulation of rain 15 minutes after application of the herbicides, only those treatments supplying glyphosate in the Roundup Transorb and Roundup Ultra formulations resulted in satisfactory control of the *fedegoso* plants (Table 2). With rain occurring one hour after application of the herbicides, all the treatments showed percentages of control of the *S. Obtusifolia* plants of above 76 %, with the exception of the treatment involving an application of 2,4-D. Pedrinho Junior *et al.* (2002b) observed a marked difference between formulations of EPSPS inhibitor herbicides in the control of a weed population under simulated rainfall up to four hours after application.

It was found that simulating rainfall at different periods within each chemical treatment more intensely affected the Roundup Original and Roundup WG formulations of glyphosate and the 2,4-D, all of which controlled the plants more efficiently at the longer time intervals of rain simulation. Jakelaitis *et al.* (2001) and Martini, Pedrinho Junior and Durigan (2003) also observed at 14 DAA reductions in the percentages of control provided by the herbicide glyphosate in various formulations (Roundup CS, Roundup WG, Roundup Transorb, Zapp and Zapp Qi) when rain occurred one hour after application of the herbicide, in relation to longer periods between application and rainfall, when applied

to plants of *Digitaria horizontalis* and *U. decumbens* respectively. Siebert, Griffin and Jones (2004) reported that the herbicide 2,4-D provided excellent control of another species of weed, *Ipomoea coccinea*, when applied without the later occurrence of rainfall.

At 21 DAA of the herbicides, it was found that all the formulations based on glyphosate controlled the *Senna obtusifolia* efficiently, but the percentages of control were dependent on the period prior to rainfall and on the formulation of the herbicide. Some formulations of glyphosate (Roundup Original, Roundup Transorb, Roundup Transorb R and Roundup Ultra) maintained their efficiency when rainfall occurred 15 minutes after application of the herbicide (Table 3). However, with the Roundup WG formulation, a period of 30 minutes without rain was necessary for its efficiency not to be reduced. Kirkwood and McKay (1994) found that the effectiveness of glyphosate is dependent on such processes as the retention of the herbicide on the leaf surface, foliar penetration, translocation within the plant to the place of action and inhibition of the target enzyme (EPSPs).

For the herbicide 2,4-D, an increase in its efficiency was seen for periods with no rain of more than 30 minutes after application. However, it should be noted that, regardless of the methods of control in those treatments where rainfall is simulated 2, 4, 6 and 8 hours after application of this herbicide not being statistically different from the treatment with no rainfall, that treatment presented a control which was inferior to the others. This shows that rainfall after a certain period

Table 2 - Percentage of control of *Senna obstusifolia* 14 days after the application of different herbicides and formulations, for periods without rain. Botucatu SP, 2009

Chemical treatment	Time until the occurence of rain (minutes)							
	15	30	60	120	240	360	480	No rain
glyphosate[1]	55.8 ABbc[8]	50.0 Bc	83.8 ABabc	85.0 ABabc	89.5 ABabc	100.0 Aa	97.0 Aa	94.3 Aab
glyphosate[2]	43.5 ABb	75.0 ABab	76.0 ABab	78.8 ABab	80.3 ABab	92.5 ABab	92.3 ABa	99.3 Aa
glyphosate[3]	85.5 Aa	84.0 Aa	97.0 ABa	99.3 Aa	91.8 ABa	94.3 ABa	90.5 ABa	100.0 Aa
glyphosate[4]	59.8 ABb	77.0 ABab	95.0 ABab	81.3 ABab	98.0 Aa	95.3 ABab	98.8 Aa	79.5 Aab
glyphosate[5]	74.8 Aab	61.8 ABb	99.5 Aa	95.0 ABab	87.0 ABab	89.8 ABab	99.5 Aa	84.8 Aab
glufosinate-a[6]	70.3 ABa	76.8 ABa	76.5 ABa	93.8 ABa	84.8 ABa	70.8 ABa	94.0 ABa	99.3 Aa
2,4-D[7]	24.8 Bb	52.5 ABab	61.0 Bab	64.8 Ba	66.3 Ba	58.8 Bab	62.0 Bab	73.0 Aa
F Herbicides (H)	13.514**							
F Period (P)	9.989**							
F (H) X (P)	1.122ns							
C.V. (%)	21.2							

Averages followed by the same upper-case letter in a column and lower-case letter on a line do not differ statistically by Tukey test at 0.05 probability (p<0.05) [1] Roundup Original (1,080 g a.e. ha^{-1}); [2] Roundup WG (1,080 g a.e. ha^{-1}); [3] Roundup Transorb (1,080 g a.e. ha^{-1}); [4] Roundup Transorb R (1,080 g a.e. ha^{-1}); [5] Roundup Ultra (1,080 g a.e. ha^{-1}); [6] Finale (400 g a.i. ha^{-1}); [7] DMA 806 (1,000 g a.e. ha^{-1}) glufosinate-a = glufosinate-ammonium [8] The values of the statistical analysis as well as the letters shown were obtained from the original data, transformed according to the equation: $y = \arcsin(\sqrt{x/100})$ ** Significant at 1% probability

Table 3 - Percentage of control of *Senna obstusifolia* 21 days after the application of different herbicides and formulations, for periods without rain. Botucatu SP, 2009

Chemical treatment	Time until the occurence of rain (minutes)							
	15	30	60	120	240	360	480	No rain
glyphosate[1]	77.5 Aab[8]	77.5 ABab	95.0 ABab	88.8 Aab	89.5 ABab	100.0 Aa	99.8 Aab	100.0 Aa
glyphosate[2]	65.0 Ab	92.5 ABab	81.3 ABab	83.8 Aab	94.0 Aab	99.8 Aa	98.0 Aa	99.5 Aa
glyphosate[3]	95.8 Aa	95.0 Aa	100.0 Aa	100.0 Aa	98.5 Aa	99.5 Aa	95.8 Aa	100.0 Aa
glyphosate[4]	94.8 Aa	87.5 ABa	99.0 ABa	96.0 Aa	99.8 Aa	99.3 Aa	99.8 Aa	94.3 Aa
glyphosate[5]	77.0 Aa	84.5 ABa	99.5 ABa	100.0 Aa	99.5 Aa	96.0 Aa	100.0 Aa	90.0 Aa
glufosinate-a[6]	88.3 Aab	76.8 ABab	83.3 ABab	86.3 Aab	59.8 Bb	53.8 Bb	91.3 Aa	99.8 Aa
2,4-D[7]	26.3 Bb	67.0 Ba	75.7 Ba	89.5 Aa	90.3 ABa	88.8 ABa	87.5 Aa	80.8 Aa
F Herbicidas (H)	15.898**							
F Período (P)	7.316**							
F (H) X (P)	2.025**							
C.V. (%)	15.6							

Averages followed by the same upper-case letter in a column and lower-case letter on a line do not differ statistically by Tukey test at 0.05 probability (p<0.05) [1] Roundup Original (1,080 g a.e. ha^{-1}); [2] Roundup WG (1,080 g a.e. ha^{-1}); [3] Roundup Transorb (1,080 g a.e. ha^{-1}); [4] Roundup Transorb R (1,080 g a.e. ha^{-1}); [5] Roundup Ultra (1,080 g a.e. ha^{-1}); [6] Finale (400 g a.i. ha^{-1}); [7]DMA 806 (1,000 g a.e. ha^{-1}) glufosinate-a = glufosinate-ammonium [8] The values of the statistical analysis as well as the letters shown were obtained from the original data, transformed according to the equation: y = arc sine (root (x / 100)) ** Significant at 1% probability

of post-emergence application of 2,4-D was beneficial to its effectiveness. The rain may have allowed for absorption of the herbicide by the roots, thereby increasing its control.

Unlike the other treatments, the glufosinate-ammonium presented a decrease in control percentages with rainfall at intervals of 4 to 6 hours after application; for the the remaining treatments however, it presented a control considered as good to excellent and which ranged from 76.8% to 99.8% for rainfall 30 minutes after application and for no rainfall respectively. Christoffoleti, Kehdi and Cortez (2001) reported percentages of control very similar to those seen here when applying glufosinate-ammonium to resistant biotypes of *U. Plantaginea*, susceptible to ACCase inhibitor herbicides without no rainfall occurring after application.

In the final visual control evaluation conducted on this species at 28 DAA, it was noted that the glufosinate-ammonium presented theoretically inconsistent responses to the periods of 15 minutes to 6 hours, with those lots that received rain 8 hours after application and those that received no rain having total control of the *fedegoso* plants (Table 4). The observed results corroborate those of Rodrigues and Almeida (2005), who stated that for this herbicide to perform well, it is necessary for rainfall not to occur for at least 6 hours after application.

For the herbicide 2,4-D, with the exception of the treatment of 15 minutes without rain, none of the remaining periods adversely influenced its control, corroborating the results of Caceres *et al*. (2010), who, when studying the effect

of this herbicide on the control of plants of *S. obtusifolia*, also found high control percentages of the weed when using this herbicide at 30 DAA without any further occurrence of rain.

For the glyphosate formulations, it should be noted that despite their all presenting statistically similar controls, Roundup Original and Roundup WG provided control of over 99% of *fedegoso* plants only after 6 hours without rain from application, while the formulations Roundup Transorb and Roundup Transorb R resulted in the same control after 15 minutes, and the formulation Roundup Ultra after 30 minutes from application.

In relation to the dry weight of the *Senna obtusifolia* plants at the end of the visual evaluations, it can be seen that only the treatment giving an application of the herbicide 2,4-D was influenced by the different periods until the occurrence of rain, having higher amounts of dry mass in those plants subjected to longer intervals of time between the application and the occurrence of rain (Table 5).

Although there were no statistical differences for the occurrence of rain in the other chemical treatments, these presented similar effects to 2,4-D, reducing the accumulation of dry mass as the period without rain increased. This fact was also reported by Monquero and Silva (2007) who, when studying the effect of two dosages of glyphosate (720 and 1,440 g ha^{-1}) applied to plants of *I. purpurea* and *Euphorbia heterophylla* submitted to six periods after application for the

occurrence of rainfall, observed that generally the dry matter of the plants under study was reduced with the increase in the time interval between application and the simulated rainfall. It is noteworthy that the plants initially used in the study were uniform and that after the application of the different herbicides and formulations, and independently of the treatment tested, they accumulated little dry mass.

Table 4 - Percentage of control of *Senna obstusifolia* 28 days after the application of different herbicides and formulations, for intervals of time without rain. Botucatu SP, 2009

Chemical treatment	Time until the occurence of rain (minutes)							
	15	30	60	120	240	360	480	No rain
glyphosate[1]	90.3 Aa[8]	97.3 ABa	99.0 Aa	91.5 ABa	93.3 Aa	100.0 Aa	100.0 Aa	100.0 Aa
glyphosate[2]	86.8 Aa	98.8 Aa	99.0 Aa	96.3 ABa	97.5 Aa	100.0 Aa	99.8 Aa	100.0 Aa
glyphosate[3]	99.8 a	99.8 Aa	100.0 Aa	100.0 Aa	100.0 Aa	100.0 Aa	99.8 Aa	100.0 Aa
glyphosate[4]	99.0 Aa	98.5 Aa	100.0 Aa	99.8 Aa	100.0 Aa	100.0 Aa	100.0 Aa	100.0 Aa
glyphosate[5]	95.0 Aa	99.3 Aa	100.0 Aa	100.0 Aa	100.0 Aa	99.3 Aa	100.0 Aa	100.0 Aa
glufosinate-a[6]	98.4 Aa	80.0 Bbc	77.0 Bbc	83.0 Babc	67.5 Bc	50.3 Bd	91.3 Aab	100.0 Aa
2,4-D[7]	49.5 Bb	91.5 ABa	88.8 ABa	99.8 Aa	98.0 Aa	97.5 Aa	98.5 Aa	96.5 Aa
F Herbicidas (H)	23.692**							
F Período (P)	5.510**							
F (H) X (P)	3.422**							
C.V. (%)	10.1							

Averages followed by the same upper-case letter in a column and lower-case letter on a line do not differ statistically by Tukey test at 0.05 probability (p<0.05) [1] Roundup Original (1,080 g a.e. ha^{-1}); [2] Roundup WG (1,080 g a.e. ha^{-1}); [3] Roundup Transorb (1,080 g a.e. ha^{-1}); [4] Roundup Transorb R (1,080 g a.e. ha^{-1}); [5] Roundup Ultra (1,080 g a.e. ha^{-1}); [6] Finale (400 g a.i. ha^{-1}); [7]DMA 806 (1,000 g a.e. ha^{-1}) glufosinate-a = glufosinate-ammonium [8] The values of the statistical analysis as well as the letters shown were obtained from the original data, transformed according to the equation: $y = \arcsin(\sqrt{x/100})$ ** Significant at 1% probability

Table 5 - Dry weight (g) of *Senna obstusifolia* plants 28 days after the application of different herbicides and formulations, for intervals of time without rain. Botucatu SP, 2009

Chemical treatment	Time until the occurence of rain (minutes)							
	15	30	60	120	240	360	480	No rain
glyphosate[1]	0.16 Ba[8]	0.13 Aa	0.09 Aa	0.18 ABCa	0.17 Aa	0.10 Aa	0.06 Aa	0.06 Aa
glyphosate[2]	0.28 Ba	0.10 Aa	0.10 Aa	0.33 ABa	0.09 Aa	0.07 Aa	0.06 Aa	0.07 Aa
glyphosate[3]	0.09 Ba	0.11 Aa	0.06 Aa	0.07 BCa	0.08 Aa	0.08 Aa	0.10 Aa	0.06 Aa
glyphosate[4]	0.11 Ba	0.15 Aa	0.09 Aa	0.07 BCa	0.07 Aa	0.08 Aa	0.09 Aa	0.08 Aa
glyphosate[5]	0.32 Ba	0.14 Aa	0.09 Aa	0.12 ABCa	0.06 Aa	0.14 Aa	0.08 Aa	0.18 Aa
glufosinate-a[6]	0.06 Ba	0.14 Aa	0.07 Aa	0.06 Ca	0.14 Aa	0.27 Aa	0.08 Aa	0.05 Aa
2,4-D[7]	0.89 Aa	0.33 Abc	0.32 Abc	0.37 Ab	0.25 Abc	0.17 Abc	0.10 Abc	0.22 Ac
F Herbicidas (H)	13.058**							
F Período (P)	5.285**							
F (H) X (P)	2.130**							
C.V. (%)	5.4							

Averages followed by the same upper-case letter in a column and lower-case letter on a line do not differ statistically by Tukey test at 0.05 probability (p<0.05) [1] Roundup Original (1,080 g a.e. ha^{-1}); [2] Roundup WG (1,080 g a.e. ha^{-1}); [3] Roundup Transorb (1,080 g a.e. ha^{-1}); [4] Roundup Transorb R (1,080 g a.e. ha^{-1}); [5] Roundup Ultra (1,080 g a.e. ha^{-1}); [6] Finale (400 g a.i. ha^{-1}); [7]DMA 806 (1,000 g a.e. ha^{-1}) glufosinate-a = glufosinate-ammonium [8] The values of the statistical analysis as well as the letters shown were obtained from the original data, transformed according to the equation: $y = \arcsin(\sqrt{x/100})$ ** Significant at 1% probability

CONCLUSIONS

1. The minimum period without rain after application of the herbicide 2,4-D, in order for its efficiency not to be compromised, was 30 minutes;

2. The occurrence of rain 15 minutes after the application of glufosinate-ammonium and glyphosate herbicides in the Roundup Transorb, Roundup Transorb R and Roundup Ultra formulations did not affect the control efficiency of these herbicides and formulations;

3. A period of 30 minutes without rain was necessary for the glyphosate herbicide in the Roundup Original and Roundup WG formulations to provide efficient weed control.

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