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# Use of different doses of glyphosate to control invasive plants: *Bidens pilosa*, *Commelina benghalensis, Digitaria insularis*, *Ipomoea grandiofolia* and *Tridax procumbens*

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**Abstract**

Glyposhate is among the most widely used herbicides in Brazil and worldwide and has a broad spectrum of control, low toxicity, non-selective, and systemic action. In Brazil, it has been increasingly consumed after its release to be used in plants with tolerance to the product; however, excessive use has contributed to select resistant or tolerant weed species. Our goal was to evaluate the efficiency of weed control by using glyphosate in a growth chamber at different doses, periods of applications, and weed species. The experimental design was completely randomized – factorial scheme 7 x 5 – by assessing seven doses of glyphosate: 0; 720; 960; 1200; 1440; 1680, and 1920 g $ha^{-1}$ i.a., in five weeds: black picket, bitter grass, bull herb, viola string, and ragged, with five repetitions. The weeds were sowed in polyethylene pots with three plants per pot. Assessments of dry biomass were conducted after 7, 14, and 21 days of application (DAA) with the treatment of glyphosate in scores from 0 to 100%. We concluded that the herbicide was efficient at controlling the black picket and bitter grass species as 100% of the weed plants 14 DAA died with the doses of 720 g $ha^{-1}$ i.a. Doses of glyphosate required to reach indices of control above 915 were 1680 g $ha^{-1}$ i.a. for ragged, 960 g $ha^{-1}$ i.a. for bull herb, and 1440 g $ha^{-1}$ i.a. for viola string at 21 DAA – since these are considered hard to control. It is recommended to apply 1440 g ha-1 i.a. of glyphosate for an effective control over 80% of all invasive plants assessed at 21 DAA,.

**Keywords:** weed, chemical control, herbicide.
**Abbreviations**: CRD _ Completely randomized design, g ha _ Grams per hectare, DAA _ Days after application, g e. a. _ Grams per active ingredient, ha _ Hectare, *S* _ Species, D _ Doses, *C canadensis _ Conyza canadensis, C. bonariensis _ Conyza bonariensis, C sumatrensis _ Conyza sumatrensis, C benghalensis _ Commelina benghalensis*, *I grandiofolia _ Ipomoea grandiofolia, E heterophylla _ Euphorbia heterophylla, T procumbens _ Tridax procumbents, B. pilosa _ Bidens pilosa*, *D. insularis _ Digitaria insularis, DB _* Dry biomass.

## Introduction

Glyphosate has been used to control weeds for many years in several production systems and is among the most widely used herbicides in Brazil and worldwide; in addition, it has a systemic action, broad-spectrum control, and low toxicity to non-target organisms (Christoffoleti et al., 2008). In Brazil, it has been used for more than 30 years, which has been increasing after the its release to be used in genetically modified tolerant plants – in some areas up to three applications have been made in the same crop cycle (Moreira et al., 2007).

According to Ikeda (2013), such an increase in use is largely related to the flexibility of glyphosate at controlling weeds at different development stages since it is a non-selective herbicide applied in a post-emergence period to control perennial and annual weed species, with broad or narrow leaves; in addition to the fact that the plant necrosis and death occur within just a few days. However, Koger and Reddy (2005) point out to the frequent use of this active principle, due to the excess of applications, as a significant contribution to the selection of resistant and/or tolerant biotypes in weed species.

According to Christoffoleti and Lopez Ovejero (2008) and Kissmann (2013), weeds become resistant to the herbicide when a group of plants is able to survive and reproduce after being exposed to the commonly applied dose, which would normally be lethal to a susceptible population of the same species. According to Monquero et al. (2005), Ferreira et al. (2009) and Dalazen et al. (2015), this occurs for glyphosate with fleabanes (*Conyza canadensis, C. bonariensis* and *C. sumatrensis*), bitter grass (*Digitaria insularis*), milkweed (*Euphorbia heterophylla*), Italian ryegrass (*Lolium multiflorum*), among others.

In turn, Ferreira et al. (2009), Ikeda (2013), Takano et al. (2013) and Marchi et al. (2013) define tolerance as the ability of some species to survive and reproduce after treatment with herbicides, even when suffering from injuries. This has occurred for glyphosate in broadleaf species and in more advanced development stages, which has proved common in ragged (*Commelina benghalensis L.*), bull herb (*Tridax procumbens L.*), hot herb (*Spermacoce latifolia* Aubl.), viola string (*Ipomoea grandiofolia L.*), Brazilian pusley (*Richardia brasiliensis*), fire-extinguisher (*Alternanthera tenella* Colla), Johnson grass (*Sorghum halepense* (L.) Pers.), among others.

Some studies using doses of glyphosate have indicated that the control of some weeds has not been satisfactory. Correia et al. (2008) used high doses of glyphosate (1200 g e.a. $ha^{-1}$) to control ragged (*C. benghalensis*) population using plants with four to six leaves and found low efficiency (42.5%). As for fleabanes (*Conyza sp*.), Yamauti et al. (2010) conducted sequential applications of glyphosate at 720 e.a. $ha^{-1}$ and observed a control ranging only 54.8%. Ramires et al. (2010) applied 960 e.a. $ha^{-1}$ of pure glyphosate in viola string (*I. grandiofolia L.*) for plants with four to six leaves and obtained control of 76.2%.

Procópio et al. (2007) assessed the isolated application of glyphosate at doses of 480, 960, and 1.440 g e.a. $ha^{-1}$, and found efficiency values of 40, 55, and 65% in milkweed (*E. heterophylla*) applied with four to eight leaves; 30, 40, and 55% in ragged (*C. benghalensis*) with two to six leaves; 50, 50, and 55 % in viola string (*I. grandifolia*) with two to six leaves, as well as 30, 55, and 65% in asthma plant (*Chamaesyce hirta*) with two to six leaves, 25 days after the application, respectively.

In general, the growth of weeds resistant to herbicides can be said to result from their incorrect use since the repetition of a single herbicide or mechanism of action induces a quick development of resistant biotypes (Ferreira et al., 2009). For this reason, the intense use of glyphosate in agricultural areas has favored selection pressure, which, combined with the good ecological adaptability of weed species and the use of inadequate doses, has contributed to select tolerant or resistant species. In this context, our study aimed at evaluating the control efficiency of glyphosate in a growth chamber at different doses, periods of application, and weed species.

**Results and discussions**

The analysis of data variance revealed a significant effect for the species (S) and doses (D) as well as an interaction between the assessed parameters (S x D) (Table 1).

***Percentage of control of invasive plants***

The analysis of the control percentage for the plants assessed revealed values significantly higher along the sequence 21>14>7 DAA for all evaluated species (Table 2). However, the minimum 80% control predicted in the legislation was found only at 14 DAA for *B. pilosa* and *D. insularis*, which increased significantly at 21 DAA for all weeds. Still, for *I. grandifolia* and *C. benghalensis* the minimum amount required by law could not be reached.

On day 7 of treatment using DAA with glyphosate, the *D. insularis* and *B. pilosa* species were controlled at levels above 65%, whereas *T. procumbens*, *I. grandifolial*, and *C. benghalensis* below 60%. *C. benghalensis* had the lowest percentage control value (25%). Such differences in control were significant for all species, except for *B. pilosa* (66%) and *D. insularis* (70%), which did not differ.

On day 14, the control indices increased for all species with values considered excellent (86%) for *B. pilosa* and *D. insularis*, good for *T. procumbens* (78%), and regular for *C. benghalensis*, *I. grandifolia* (between 60 and 41%), according to the scale proposed by Alam (1974).

On day 21, control remained constant for *B. pilosa* and *D. insularis* (86%) while increased for the remaining species, reaching 83% for *T. procumbens*, 74% for *I. grandifolia* and 72% for *C. benghalensis*. Thus, the treatment was regarded at least good for all plants assessed, however, only three reached the acceptable level of control established in the current legislation – 80%.

***The stage of invasive plant development***

The plant development stage may alter the effect of glyphosate since both height and leaf number influence the efficiency of the product (Vidal et al., 2014). A similar study by Marchi et al. (2013)evaluated the efficiency of glyphosate at controlling ragged (*Commelina benghalensis* L.) on days 7, 14, 21, and 30 after the application (DAA) found the percentage control advancing slowly and reaching levels above 80% only for the assessment performed on day 21 DAA – dose of 960 g $ha^{-1}$ i.a.

According to Carvalho et al. (2008), under field conditions, control efficiency is affected by the climatic condition at the time of application. Considering that it had rained on the eve of the application, the efficiency could increase, as the sediments or the excessive amount of dust on the leaves had been removed facilitating better absorption of the product applied. However, if it had rained soon after the application, the leaves would have been washed and the control efficiency decreased significantly; although, such conditions are controlled in a greenhouse.

Dry biomass production of *B. pilosa* (0.64 g), *I. grandifolia* (0.67 g) and *C. benghalensis* (0.60 g) were statistically equal ($p < 0.05$) and above the values recorded for *D. insularis* (0.38 g) and *T. procumbens* (0.20 g), which proves that weed control is more effective when the application is conducted at the ideal stage (four to six leaves).

The assessment of glyphosate dose at 720 g $ha^{-1}$ i.a. at the E1 (two to four leaves), E2 (four to six leaves), and E3 (six to 10 leaves) stages for species considered difficult to control (*Commelina benghalensis*, *Richardia brasiliensis*, *Euphorbia heterophylla*, *Spermacoce latifolia*, *Ipomoea grandifolia*, and *Conyza* spp.) by Takano et al. (2013) foud that the control is higher with an application at the early stages of weed development – more effective along the sequence 2 – 4 > 4 – 6 and >10 leaves.

**Table 1.** Analysis of the variances of the treatments (species) and applied doses of glyphosate in the evaluated weeds at 7, 14 and 21 days after application of glyphosate.

| Evaluation | GL | 7 DAA | 14 DAA | 21 DAA | DB |
|---|---|---|---|---|---|
| Species (S) | 4 | 220.28** | 879.68** | 178.60** | 34.34** |
| Doses (D) | 6 | 260.88** | 2148.35** | 3622.54** | 283.77** |
| S x D | 24 | 10.52** | 47.85** | 31.86** | 20.80** |

** Statistic significant difference in the Test F on the 1% threshold.

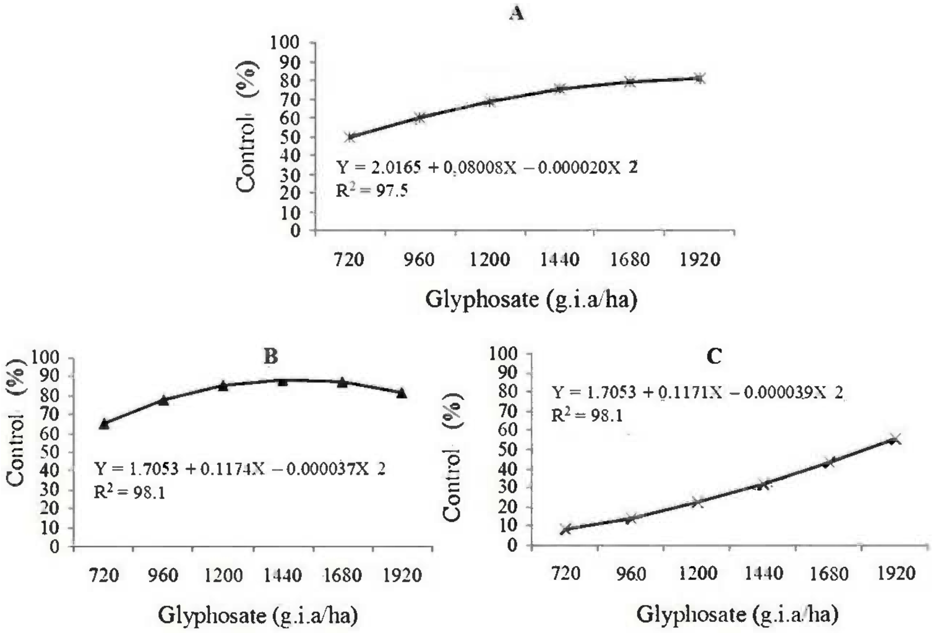


**Fig 1.** Model adjusted for the control (%) of bull herb (*T. procumbens* L.) (A), ragged (*C. benghalensis* L.) (B) and bitter grass (*D. insularis* L. (Fedde)) (C), respectively, at 7 DAA of glyphosate.

**Table 2.** Percentage of control and dry biomass (DB) of Black picket (*Bidens pilosa* L.), Bitter grass (*Digitaria insularis* L. (Fedde)), Bull herb *(Tridax procumbens* L.), viola string (*Ipomoea grandiofolia* L.) and *ragged* (*Commelina benghalensis* L.) at 7, 14 and 21 days after application (DAA) of glyphosate.

| Invasive Plants | 7 DAA | 14 DAA | 21 DAA | DB |
|---|---|---|---|---|
| | .....................%...................... | | | g |
| *B. pilosa* | 66 a* | 86 a* | 86 a* | 0.64 a* |
| *D. insularis* | 70 a | 86 a | 86 a | 0.38 b |
| *T. procumbens* | 59 b | 78 b | 83 b | 0.20 c |
| *I. grandifolia* | 38 c | 59 c | 74 c | 0.67 a |
| *C. benghalensis* | 25 d | 46 d | 72 d | 0.60 a |
| DMS | 5 | 2 | 2 | 0.13 |
| CV (%) | 15 | 5 | 4 | 41 |

* = Means followed by the same letter in the column do not statistically differ from each other in Tukey's test on the 5% threshold. DMS = Significant minimal difference; CV = Coefficient of variation.

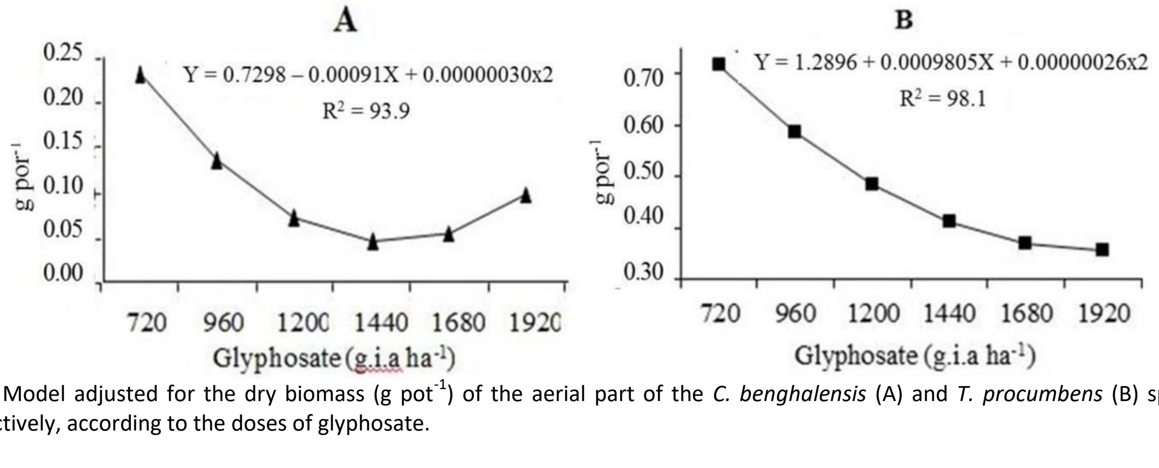


**Fig 2.** Model adjusted for the dry biomass (g pot$^{-1}$) of the aerial part of the *C. benghalensis* (A) and *T. procumbens* (B) species, respectively, according to the doses of glyphosate.

**Table 3.** Development of the interaction species x doses regarding weed control at 7, 14 and 21 days after application of glyphosate[1].

| Invasive Plants | Doses of glyphosate | | | | | |
|---|---|---|---|---|---|---|
| | 720 | 960 | 1200 | 1440 | 1680 | 1920 |
| | ………………g ha$^{-1}$ i.a…………… | | | | | |
| | 7 days | | | | | |
| *B. pilosa* | 73 Aa | 72 Aa | 78 Aa | 78 Aba | 80 Aa | 84 Aa |
| *D. insularis* | 72 Aa | 79 Aab | 78 Aab | 90 Aa | 86 Aab | 85 Aab |
| *T. procumbens* | 57 Bc | 58 Bc | 66 Abc | 74 Bab | 75 Aab | 85 Ab |
| *I. grandifolia* | 21 Cc | 26 Cbc | 37 Bb | 59 Ca | 57 Ba | 63 Ba |
| *C. benghalensis* | 7 Dc | 12 Dc | 27 Bb | 28 Db | 49 Ba | 53 Ba |
| CV (%) | .................................15.0................................. | | | | | |
| | 14 days | | | | | |
| *B. pilosa* | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa |
| *D. insularis* | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa |
| *T. procumbens* | 78 Ba | 83 Bab | 84 Bb | 88 Bb | 93 Bbc | 97 Ac |
| *I. grandifolia* | 59 Ca | 64 Cab | 68 Bb | 73 Cb | 89 Bc | 93 Ab |
| *C. benghalensis* | 27 Da | 42 Db | 54 Bc | 62 Dd | 69 Ce | 72 Be |
| CV (%) | .................................5.0................................. | | | | | |
| | 21 days | | | | | |
| *B. pilosa* | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa |
| *D. insularis* | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa | 100 Aa |
| *T. procumbens* | 88 Ba | 95 Ab | 97 Abc | 100 Ac | 100 Ac | 100 Ac |
| *I. grandifolia* | 81 Ca | 84 Ca | 84 Ba | 93 Bb | 99 Ac | 98 Bc |
| *C. benghalensis* | 54 Da | 74 Db | 78 Cb | 85 Cc | 98 Ad | 92 Be |
| CV (%) | .................................4.0................................. | | | | | |

[1]Means followed by the same lowercase letter in the row and upper case in the column do not statistically differ from each other in Tukey's test ($p < 0.05$). CV = Coefficient of variation.

**Table 4.** Dry biomass from of black picket (*Bidens pilosa* L.), bitter grass (*Digitaria insularis* L. (Fedde)), bull herb *(Tridax procumbens* L.), viola string (*Ipomoea grandiofolia* L.) and ragged (*Commelina benghalensis* L.) at different doses of glyphosate.

| Doses | Dry biomass | | | | |
|---|---|---|---|---|---|
| | *B. pilosa* | *D. insularis* | *T.procumbens* | *I. grandifolia* | *C. benghalensi* |
| g ha$^{-1}$ i.a. | ...............................g................................. | | | | |
| 0 | 3.432 a[1] | 2.260 a[1] | 0.756 a[1] | 2.592 a[1] | 1.286 a[1] |
| 720 | 0.202 b | 0.038 b | 0.164 b | 0.400 b | 0.694 b |
| 960 | 0.214 b | 0.054 b | 0.098 b | 0.390 b | 0.628 bc |
| 1200 | 0.142 b | 0.078 b | 0.122 b | 0.440 b | 0.534 bc |
| 1440 | 0.122 b | 0.033 b | 0.072 b | 0.210 b | 0.348 bc |
| 1680 | 0.160 b | 0.100 b | 0.142 b | 0.312 b | 0.330 bc |
| 1920 | 0.198 b | 0.126 b | 0.020 b | 0.378 b | 0.398 bc |
| CV (%) | ...............................41.0............................... | | | | |

[1]Means followed by the same lowercase letter in the column do not differ statistically from each other in Tukey's test ($p < 0.05$). CV = Coefficient of variation.

***The interactions between weed control and glyphosate doses***

The analysis of the interaction between species and doses revealed that on day 7 DAA of glyphosate, control rates were very low in *C. benghalensis*, ranging from 7% at the lowest dose (720 g ha$^{-1}$ i.a.) to 53% at the highest dose (1920 g ha$^{-1}$ i.a.) (Table 3) – reaching the regular standard. For all doses assessed, control rates for *I. grandifolia* and *C. benghalensis* ranged from poor to regular, for *B. pilosa* and *D. insularis* from good to very good, whereas *T. procumbens* ranged from regular to good, the second classification proposed by Alam (1974).

On day 14 DAA, the total control was achieved for *B. pilosa* and *D. insularis* at all assessed doses, while it significantly increased for *T. procumbens* and *I. grandifolia* and reached the excellent level at the two largest doses (1680 and 1920 g ha$^{-1}$ i.a.); for *C. benghalensis*, though, the control ranged from poor to good.

Monquero et al. (2005) and Procópio et al. (2007) obtained similar results for the ragged (*C. benghalensis*) – increased control levels. Carvalho et al. (2008) emphasized that no treatment with glyphosate was effective at controlling this weed, having reached the highest level on day 14 DAA – 50% with at 1440 g ha$^{-1}$ i.a. In turn, Timossi et al. (2006) found that the application of glyphosate 1440 g ha$^{-1}$ i.a. was effective for the management of the plants assessed (Bitter grass, Grass burr, fire-extinguisher), except for ragged, which was tolerant to glyphosate at doses up to 2880 g ha$^{-1}$ i.a.

On day 21, at the lowest dose assessed (720 g ha$^{-1}$ i.a.), the control ranged from 54 to 100%, whereas at the highest dose (1920 g ha$^{-1}$ i.a.) it ranged from 92 to 100% for all weeds assessed. This indicates that at doses above 960 g ha$^{-1}$ i.a., control can be considered good (81 – 70%), according to the scale proposed by Alam (1974).

Similar results were achieved by Rodrigues and Almeida (2011) by assessing the application of different glyphosate concentrations in a single application or along sequential applications at doses of 480; 720; 960; 1200, and 1440 g $ha^{-1}$ i.a. on day 31 after emergence (DAE). The authors applied 720 g $ha^{-1}$ i.a. on day 22 DAE, 480 g $ha^{-1}$ i.a. on day 42 DAE, 960 g $ha^{-1}$ i.a. on day 22 DAE, and 720 g $ha^{-1}$ i.a. on day 42 DAE. All doses were efficient at controlling *T. procumbens* and *I. grandifolia* in the area. The authors also found that it was only 21 days after glyphosate application and at the highest dose that control values above 91% were obtained for the *C. benghalensis* species. The doses required in our study to achieve control rates of 98 and 92% consisted of 1680 and 1920 g $ha^{-1}$ i.a., respectively.

Santos et al. (2001) obtained a control of 94% when studying *C. benghalensis* inside polyethylene boxes in an unprotected area by applying glyphosate at the flowering stage, initially at 720 g $ha^{-1}$ i.a. 25 days after application (DAA), with 100% at 63 DAA with 720, 1440, 2160, 2880, and 3600 g $ha^{-1}$ i.a. The species *B. pilosa* and *D. insularis* reached values equal to 100% on day 14 DAA at 720 g $ha^{-1}$ i.a., whereas *T. procumbens* reached 100% control at 1440 G $ha^{-1}$ i.a. on day 21 DAA.

Ramires et al. (2011) studied the control of *Ipomoea grandifolia* by using pure glyphosate or associated with latifolicides in the RR® soybean crop and found higher efficacy in relation to the application of pure glyphosate at 480 g $ha^{-1}$ i.a. upon the use of this herbicide with protox-inhibiting herbicides. The authors also mentioned that mixtures containing glyphosate at 960 g $ha^{-1}$ i.a. and other post-emergent herbicides (cloransulam-methyl, chlorimuron-ethyl, imazethapyr, lactofen, fomesafen, flumiclorac-pentyl, and bentazon) provided improved control efficiency, regardless the leaf stage of the weeds – "two to three" or "four to six.

***Control of biomass production of the invasive plant provided by the herbicide***

In the evaluation of the dry biomass (DB) of the evaluated weeds, the effectiveness of the herbicide glyphosate was verified in the control of the species. The application of glyphosate at 720 g $ha^{-1}$ i.a. was sufficient to provide the amount of DB significantly ($p < 0.05$) lower in all the plants if compared with the control. This effect is greater as the herbicide doses increased; however, there were no differences, except for *C. benghalensis*, between doses of 720 and 1920 g $ha^{-1}$ i.a. (Table 4).

The regression analysis reveals that the quadratic ($R^2$ = 0.98) model had the best adjustment to *T. procumbens* species seven days after the herbicide application; it showed that the higher herbicide dose the better the control of the species up to a maximum value of about 80% for the dose of 1920 g $ha^{-1}$ i.a. and 50% for 720 g $ha^{-1}$ i.a. (Figure 1).

For *C. benghalensis*, the quadratic mathematical model equation ($R^2$ = 0.96) has a concave shape indicating better control of this species as the doses of glyphosate increases; however, the control percentage values are lower when than *T. Procumbens*, which indicates more difficulties to control this species at the doses tested. For *D. insularis*, the highest control percentage occurred at 1440 g $ha^{-1}$ i.a., above 80%, a dose at which control begins to decline perhaps indicating a lower absorption or efficiency of the herbicide for this species and causing regrowth.

The regression analysis showed that the quadratic ($R^2$ = 0.98) mathematical model had the best adjustment revealing effective control with considerable reductions of dry biomass of *C. benghalensis* plants and higher glyphosate doses (Figure 2), since *C. benghalensis* DB decreased from 0.71 to 0.41 g/pot as the glyphosate dose doubled from 720 to 1440 g $ha^{-1}$ i.a., enabling a reduction of 57% in dry biomass. At the doses of 1680 and 1920 g $ha^{-1}$ i.a. such a decrease becomes lower and the curve less steep as the biomass is reduced from 0.36 to 0.35 g/pot, respectively.

Marchi et al. (2013) assessed the *Commelina benghalensis* species present in high infestations in RR® soybean crops and found that the control of this species can be obtained with only one glyphosate application at 960 g $ha^{-1}$ i.a. when associated with the post-emergent herbicides cloransulam-methyl, chlorimuron-ethyl, imazethapyr or lactofen, without significant loss in productivity.

Significant quadratic regression was found in *T. procumbens*, in which doses of 720; 960; 1200, and 1440 g $ha^{-1}$ i.a. provided the species with lower DB production. With the application of a higher dose – from 1680 to 1920 g $ha^{-1}$ i.a. – the DB production of the species increased from 0.056 to 0.099 g/pot, respectively, for the dose of 1440 g $ha^{-1}$ i.a. (Figure 2). Foloni et al. (2005) observed that the control of *T. procumbens* on days 20 and 51 DAA was susceptible to glyphosate at 480, 720, 960, 1200, and 1440 g $ha^{-1}$ i.a. on day 31 after emergence (DAE). However, the authors found that on days 20 and 51 DAA, the application of glyphosate at 1440 g $ha^{-1}$ i.a. provided a statistically superior control in relation to the values obtained with applications of 480 and 720 g $ha^{-1}$ i.a.

**Materials and methods**

***Location of the experimental area***

The study was conducted in an experimental area located in the municipality of Piracicaba – SP, Brazil, under the geographical coordinates of 22° 42' 9'' south latitude and 47° 38'30'' west longitude and an altitude of approximately 540 m, inside polyethylene pots arranged in a growth chamber and regulated at 28°C, with relative humidity of 80% and 14 hours of light.

***The weather***

The region climate is tropical humid type Cwa according to Köppen classification with dry and mild winter, mean annual temperature of 23.9°C – maximum of 30.3°C and minimum of 19.1°C – mean annual precipitation of 1,273.3 mm, with July as the driest month and January as the rainiest (Inmet, 2017). Figures contain data collected at the meteorological station located close to the experimental area.

***Experimental design***

The experimental design was completely randomized in a factorial scheme 7 x 5 and assessed seven glyphosate doses: 0 (control), 720, 960; 1200, 1440, 1680, 1920 g.i.a. $ha^{-1}$; applied in five invasive plants: 1 – Black picket (*Bidens pilosa* L.); 2 – Ragged (*Commelina benghalensis* L.); 3 – Bitter grass

(*Digitaria insularis* L. (Fedde)); 4 – Viola string (*Ipomoea grandiofolia* L.), and 5 – Bull herb (*Tridax procumbens* L.) with five repetitions. The seeds of invasive plants were obtained from a company which produces seeds of weeds.

These weeds were initially sowed in a polyethylene box and upon presenting a definitive pair of leaves, transplanted to 9.5 cm diameter pots containing PlantaMax® substrate at a density of three plants per pot. Glyphosate applications – commercial product Roundup Ready® by Monsanto do Brasil – at 480 g $L^{-1}$ of i.a. were carried out 25 days after the emergence of invasive plants when presenting development stage of two to six perennial leaves. These applications were performed using a laboratory sprayer (spray chamber) at a pressure of 279.3 Kpa, with the tip 110.02, which applies a volume of 300 L $ha^{-1}$ of the liquid at a temperature of $25^oC$ and a relative humidity between 60 and 70%.

***Assessments***

The assessment of control were conducted on days 7, 14, and 21 after treatment (DAA) with glyphosate application and attributed scores from 0 to 100% considering the following control classification: Excellent = 100 to 91%; Very good = 91 to 80%; Good = 81 to 70%; Sufficient = 71 to 60%; Regular = 60 to 41%; None or poor = 40 to 0%, according to the scale of the Latin American Weed Association (Alam, 1974).

The remaining weeds (live or dead) were cut close to the neck region with scissors on day 21 DAA, placed in paper bags identified for drying process through a forced-air circulation chamber at $65^oC$ for 72 hours to determine the dry biomass of the species.

***Statistical analysis***

Data were subjected to an analysis of variance by using the statistical software SANEST. For the significant qualitative analysis (weed species) in the F Test, we compared the mean values through Tukey's test at a 5% limit. We performed the qualitative analysis of glyphosate doses with a regression by choosing the model which presented the highest significance on Sigmaplot Software version 2010.

**Conclusion**

Glyphosate controlled the species *B. pilosa* and *D. insularis* considering that 100% of them died 14 days after its application (DAA) at 720 g $ha^{-1}$ i.a. The glyphosate dose required to achieve control indices above 91% was 1680 g $ha^{-1}$ i.a. for *C. grandifolia*, 960 g $ha^{-1}$ i.a. for *T. procumbens*, and 1440 g $ha^{-1}$ i.a. for *I. grandifolia* on day 21 DAA, therefore considered difficult to control. It is recommended to apply 1440 g ha-1 i.a. of glyphosate for effective control over 80% for all the invasive plants assessed on day 21 DAA.

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