

Ambrosia sp.: dose-response to glyphosate

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Abstract: Farmers have reported difficulty in controlling *Ambrosia* sp., observing uncontrolled plants in soybean fields even after post-emergence glyphosate application. The aim of this study was to evaluate the response of *Ambrosia* sp. to different rates of the herbicide glyphosate. The experiment was conducted in duplicate in a greenhouse at the Federal University of Santa Catarina, Curitiba campus, between September and December 2022, using a completely randomized design with four replications. The treatments consisted of the application of nine increasing rates of the herbicide glyphosate (0; 93.75; 187.5; 375; 750; 1500; 3000; 6000; 12000 g ae ha⁻¹) when the *Ambrosia* sp. plants had between 4 to 8 true leaves. The following parameters were evaluated: height; percentage of control; and final above-ground dry matter mass. The results indicated growth inhibition, resulting in reduced height for rates starting from 1500 g ae ha⁻¹ in *Ambrosia* sp. The evaluation of final above-ground dry matter mass showed a reduction between 73 and 95%, depending on the dose applied. Even the high rates used were not able to achieve excellent control (>90%) of the species.

Resumo: Agricultores têm relatado dificuldade no controle de *Ambrosia* sp., observando plantas não controladas em lavouras de soja mesmo após a aplicação de glifosato em pós-emergência. O objetivo deste estudo foi avaliar a resposta de *Ambrosia* sp. a diferentes doses do herbicida glifosato. O experimento foi conduzido em duplicata em casa de vegetação na Universidade Federal de Santa Catarina, campus Curitiba, entre setembro e dezembro de 2022, em delineamento inteiramente casualizado com quatro repetições. Os tratamentos consistiram na aplicação de nove doses crescentes do herbicida glifosato (0; 93,75; 187,5; 375; 750; 1500; 3000; 6000; 12000 g e.a. ha⁻¹) quando as plantas de *Ambrosia* sp. apresentavam entre 4 a 8 folhas verdadeiras. Os seguintes parâmetros foram avaliados: estatura; porcentagem de controle; e massa da matéria seca da parte aérea final. Os resultados indicaram inibição do crescimento, resultando em redução da estatura para doses a partir de 1500 g e.a. ha⁻¹. A avaliação da massa da matéria seca da parte aérea final mostrou uma redução entre 73 e 95%, dependendo da dose aplicada. Mesmo as doses elevadas utilizadas não foram capazes de atingir controle excelente (>90%) da espécie.

Keywords: glyphosate, increasing dose, weed, common ragweed.

Palavras-chave: glyphosate, increment de dose, planta daninha, cravovana.

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The species *Ambrosia* sp. (common ragweed), belonging to the Asteraceae family, is an annual, herbaceous plant with an erect stature, measuring between 40-80 cm in height, but can reach up to 150 cm (Lorenzi, 2014; Iamónico, 2016; Rockenbach and Rizzardi, 2024). Native to North and Central America, its spread to other countries mainly occurred through seeds and grains of crops of agricultural importance contaminated (Iamónico, 2016).

In Brazil, there is a risk of increased incidence of this invasive plant, especially in the Midwest, Southeast, and South regions (Formigheiri et al., 2018). *A. artemisiifolia* can cause economic damage to crops such as soybeans and corn, as its cycle coincides with the growing season of these grains (Grangeot et al., 2006). In soybean fields, the presence of 1 plant per 1.5 m² of this species can lead to production losses of up to 30% (Dinelli et al., 2013), while in corn, 1 plant per m² can reduce yield by 200 to 300 kg (Makra et al., 2015).

Another issue is the presence of allelopathic compounds in its composition, which, when released through plant decomposition, can inhibit the germination, emergence, and growth of crops of agricultural interest (Formigheiri et al., 2018, Iamónico 2016).

The use of the herbicide glyphosate achieves over 95% control of the species when applied to seedlings and over 85% control when applied to mature plants (Lorenzi, 2014). However, the recurrent application of glyphosate in pre-planting desiccation and post-emergence in crops has led to an increase in the number of weed species resistant to this herbicide (Borsato and Penckoowski, 2019). Although resistance has been confirmed in other countries, there are no records of glyphosate-resistant *A. artemisiifolia* biotypes in Brazil (Heap, 2025).

Brazilian farmers have reported difficulty in controlling *Ambrosia* sp., observing uncontrolled plants in soybean fields even after post-emergence glyphosate application (Rockenbach and Rizzardi, 2024). Therefore, studies on the dose-response evaluation of *Ambrosia* sp. to glyphosate are important to determine the effective rate for its control, aiming to guide management strategies for this invasive species in agricultural systems. Moreover, these studies can provide indications of possible resistance cases, for instance, when the rate required to control the species is much higher than the recommended rate on the label.

For this study, *Ambrosia* sp. seeds were collected in April 2022 from the field in Irineópolis, in the Northern Plateau region of Santa Catarina, Brazil. These seeds were from four plants that survived the application of glyphosate herbicide in a soybean field, and the seeds from these four plants were mixed together. After collection, in September 2022, the seeds were sent to the laboratory at the Federal University of Santa Catarina, Curitibanos campus, where they were subjected to dormancy breaking by low-temperature stratification method, remaining in a BOD chamber for 49 days at 4°C (Willemsen, 1975).

For germination, the seeds were subjected to optimal conditions to express their maximum germination potential, which for *Ambrosia* sp. is a temperature of 25°C and a photoperiod of 12 hours (Dinelli et al., 2013). The seeds were placed on two layers (two sheets) of germination paper and covered with another layer (one sheet); the paper was moistened with distilled water at a ratio of 3.0 mL per gram of dry paper. After the cotyledon leaves emerged, the seedlings were selected and transplanted into 8 cm tall pots with a volume of 0.240 liters, filled with substrate, for the experiment.

The experiment was conducted in a greenhouse at the Federal University of Santa Catarina, Curitibanos campus, located at the geographical coordinates 27°17'05" S and 50°32'05" W. The pots were irrigated as needed, and the temperature in the greenhouse was maintained at around 25°C. When the *Ambrosia* sp. plants had 2 true leaves, they were transplanted into pots with a volume of 0.573 liters to

provide more space for root development.

To obtain greater reliability of the results, the experiment was carried out in duplicate. A completely randomized experimental design was used with nine treatments and four replications. The treatments consisted of the application of increasing rates of glyphosate herbicide, as follows: 0; 93.75; 187.5; 375; 750; 1500; 3000; 6000; 12000 g ae ha⁻¹. These rates correspond to, respectively, 0, 1/8, 1/4, 1/2, 1, 2, 4, 8, and 16 times the recommended rate of the herbicide.

To define the reference rate of the herbicide (recommended rate = 1), the registered rate for soybean crops was considered, which is 750 g of acid equivalent (ae) per hectare. This equates to 1.5 L ha⁻¹ of the commercial product Zapp QI 620 (500 g L⁻¹ of glyphosate acid equivalent), formulated and manufactured by Syngenta, and registered with MAPA for several agricultural crops, including soybeans (Agrofit, 2022).

The application of glyphosate herbicide was carried out outside the greenhouse on September 30, 2022, at 11:00 AM, when the plants had between 4 and 8 true leaves (BBCH-scale 14-18) (Figure 1). A precision CO₂-pressurized backpack sprayer was used, equipped with a boom containing three XR 110.015 flat-fan nozzles, spaced 0.5 m apart, under a pressure of 196.1 kPa, at a walking speed of 3.6 km h⁻¹, providing an application rate of 150 L ha⁻¹. At the time of application, the temperature was 19.5°C, with winds at 0.2 km h⁻¹, and relative humidity around 61.3%, measured by a digital thermo-hygrometer.



Figure 1. *Ambrosia* sp. stage at the time of glyphosate application, in Curitibanos, SC, 2022.

The variables evaluated were: height, control percentage, and above-ground dry matter mass of *Ambrosia* sp. plants. Data on height were collected at 7, 14, 21, and 28 days after application (DAA). Control percentage was assessed based on the expression of injuries caused by the herbicide (such as chlorosis, necrosis, and reduced size/growth), rated from 0 (no control) to 100 (plant death) (Sbcpd, 1995, Kuva et al., 2016). Glyphosate efficacy was evaluated at 7, 14, 21, 28, and 42 DAA. At 42 DAA, surviving plants and controls were harvested for their above-ground parts, which were then dried in a forced air circulation oven at 55°C for 3 days to determine the above-ground dry matter mass, and subsequently weighed on a precision scale.

For all evaluated variables, data transformation was performed using the formula $\sqrt{(x + 2)}$. Subsequently, the data were subjected to analysis of variance (ANOVA) using the Sisvar program and regression analysis, as the factor was quantitative (rates). All tests were conducted with a

significance level of 5%.

The ANOVA results showed significant effects of the tested rates for all variables and evaluation periods. Since the factor was quantitative, regression analysis was adjusted, considering the biological effect of the variable concerning the increasing rates of glyphosate, the significance of the model parameters ($p < 0.05$), and the R-squared value (R^2). Notably, the R^2 value was above 0.90 for all variables and evaluation periods, providing confidence in the models' representation of the data.

There was little variation in plant height among the glyphosate rates at 7 DAA, as the plants were still small, including the control. In the subsequent evaluations at 14, 21, and especially 28 DAA, it was observed that rates higher than 2700 g ae. ha⁻¹ resulted in an 80% reduction in plant height compared to the untreated control (Figure 2). These results indicate that glyphosate application inhibited the growth of *Ambrosia* sp.

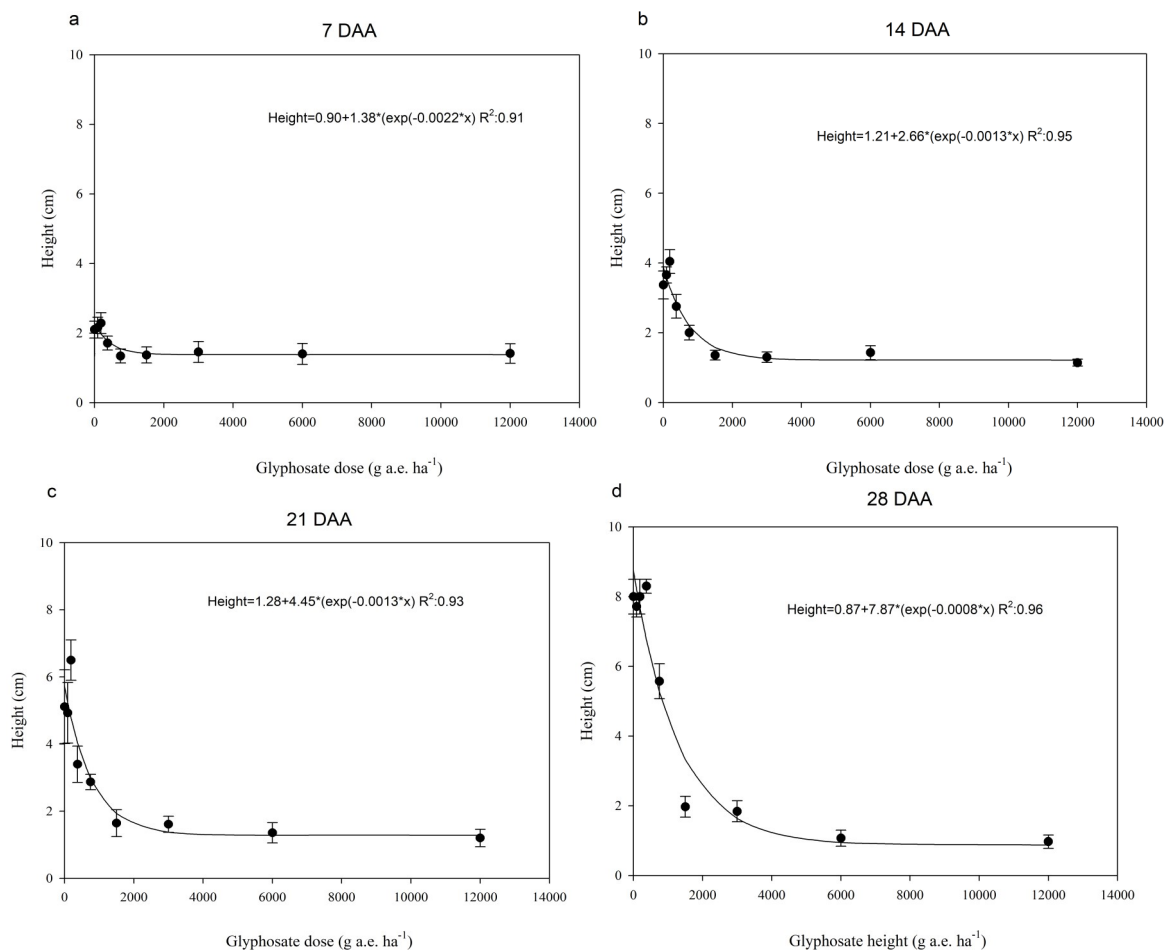


Figure 2. Height of *Ambrosia* sp. in 7 (a), 14 (b), 21 (c) and 28 (d) days after glyphosate application (DAA, in Curitiba, SC, 2022).

Regarding the control of *Ambrosia* sp. plants (Figure 3), all glyphosate rates provided low control in the initial evaluations (7 and 14 DAA). Only rates above 4800 g ae ha⁻¹ at 14 DAA showed control greater than 50%, however, the highest rate studied did not exceed 61.5% control, proving to be ineffective (Sbcpd, 1995). The low control in these

evaluations is due to glyphosate being a systemic herbicide that takes several days after application to visually manifest its effects on the plants (Roman et al., 2005). The highest control, observed at 28 DAA, was achieved with rates starting from 2800 g ae ha⁻¹, stabilizing control at 74%.

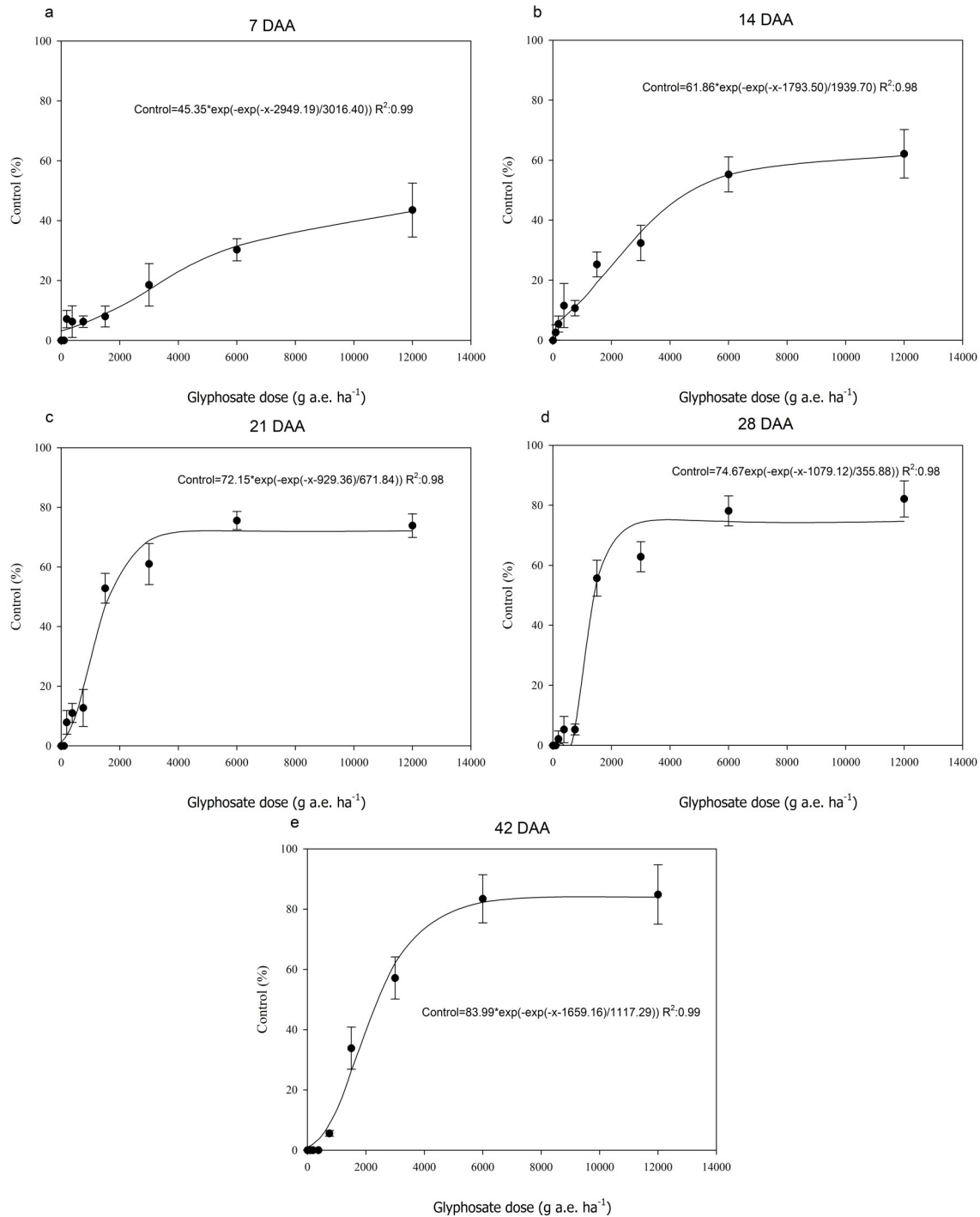


Figure 3. Percentage of control of *Ambrosia* sp. in 7 (a), 14 (b), 21 (c), 28 (d) and 42 (e) days after glyphosate application (DAA), in Curitibanos, SC, 2022.

It is important to note that for control to be considered "acceptable," it must be greater than or equal to 80% (Sbcpd, 1995). Thus, the control responses at 28 DAA with the use of rates 8 and 16 times higher than the recommended rate (6000 and 12000 g ae ha⁻¹) were insufficient. According to Bohren (2006), failures in controlling *A. artemisiifolia* stimulate the emission of shoots from the base of the stem, making management even more difficult.

In the final evaluation at 42 DAA, glyphosate rates below 5100 g ae ha⁻¹ resulted in insufficient control of

Ambrosia sp., while rates above 5100 g ae ha⁻¹ achieved a maximum of 84% control. However, it is important to note that this rate exceeds the maximum recommended on the label, indicating its impracticality due to economic and environmental costs.

Wang et al. (2022) conducted a study in China evaluating different herbicides for controlling *A. artemisiifolia*. Glyphosate, applied at the beginning of the reproductive period at a rate of 900 g ae ha⁻¹, achieved only 58% control of the plants but significantly reduced seed production by 97%. Studies have shown the necessity of

using glyphosate rates higher than those recommended on the label for controlling other species. Silva and Silva (2017) observed in a study conducted in the states of Minas Gerais and Goiás that to achieve more than 80% control of *Conyza spp.*, rates ranging from 4320 to 25000 g ae ha⁻¹ were required, varying among biotypes, while the recommended label rate was 1080 g ae ha⁻¹.

Regarding the dry matter mass analysis of the above-ground parts of *Ambrosia* sp., there was a reduction in dry matter mass compared to the control for all studied rates, with the greatest reduction occurring at rates above 1500 g ae ha⁻¹ (Figure 4). Doubling the glyphosate rate (1500 g ae ha⁻¹) resulted in approximately a 73% reduction in

dry matter mass accumulation. Applying glyphosate at rates starting from 2650 g ae ha⁻¹ led to a reduction in above-ground dry matter production of *Ambrosia* sp. by more than 80% compared to the control (zero rate). Studies on *C. bonariensis*, a species in the same botanical family as *Ambrosia* sp., showed that increasing the glyphosate rate to 1155.9 g ha⁻¹ resulted in a 50% reduction in dry matter mass (Dalazen et al., 2015).

Figure 5 illustrates the control results for *Ambrosia* sp. at rates of 0, 750, and 12,000 g ae ha⁻¹. It can be observed that not even a rate 16 times the recommended dose was sufficient to achieve total control of the species.

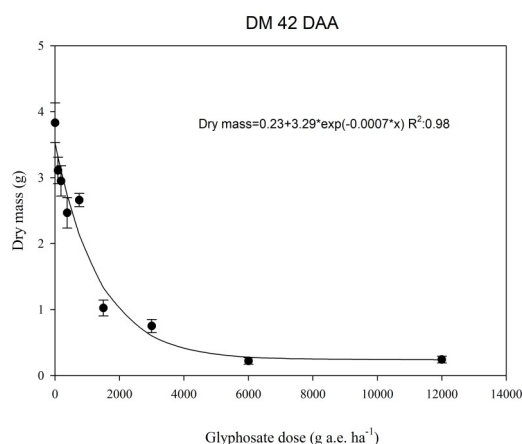


Figure 4. Dry matter mass of *Ambrosia* sp. in 42 days after glyphosate application (DAA), in Curitiba, SC, 2022.

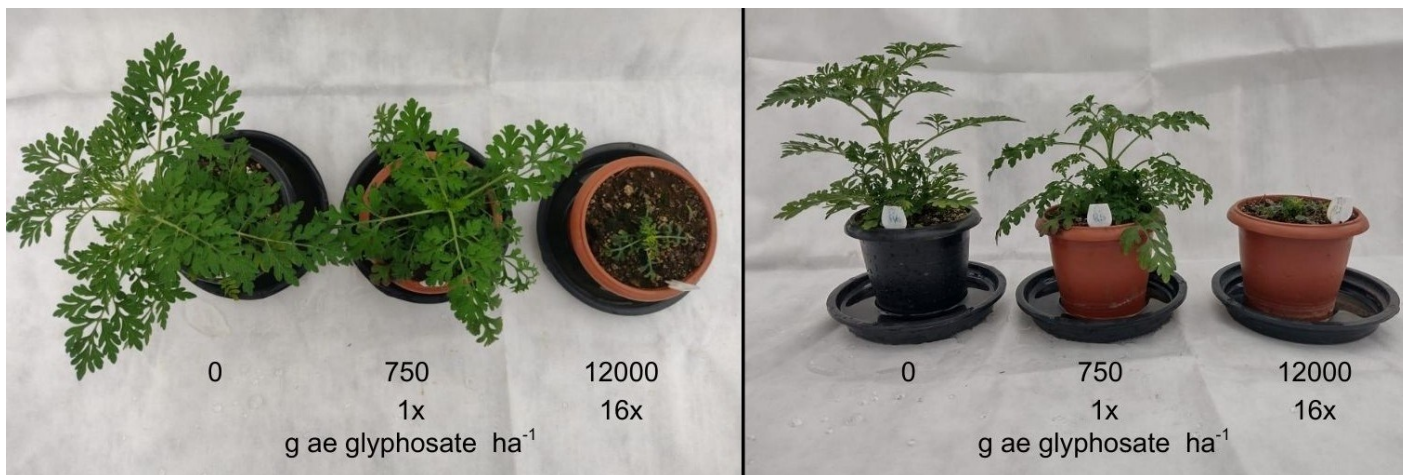


Figure 5. *Ambrosia* sp. at 42 DAA of glyphosate at rates of 0, 750 (1x), and 12,000 (16x) g ae ha⁻¹.

As observed in the present study, although the herbicide rates did not cause plant death, they were sufficient to affect assimilate production, reducing aerial growth and, consequently, the accumulation of dry matter. The results obtained in this study suggest a potential resistance of *Ambrosia* sp. to glyphosate, as rates much higher than recommended were necessary to achieve 80% control. Therefore, it is essential to conduct further studies to confirm this resistance in Brazil, following all necessary steps for formal validation. Since this species has 21 confirmed reports of resistance to glyphosate in the United States and Canada (Heap, 2025). Identifying and confirming glyphosate resistance will allow the adoption of more effective and

sustainable management strategies to address this issue.

In conclusion, the control of *Ambrosia* sp. was not excellent (>90%) or total even with the application of 16 times the recommended rate of glyphosate (12000 g ae ha⁻¹). The results highlight a possible resistance of this species to glyphosate.

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