

RESEARCH PAPER

Conyza sumatrensis: A new weed species resistant to glyphosate in the Americas

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Recent reports of weed-control failures after the use of glyphosate led to suspicion about the selection of resistant biotypes of *Conyza* at locations in west and north Paraná, Brazil. Plants were collected, identified as *Conyza sumatrensis* and subsequently evaluated for possible resistance to glyphosate in four stages of weed development. The experiments were carried out in a greenhouse by combining biotypes, stages of development and a range of glyphosate doses. All the suspected biotypes were collected from locations in Cascavel, Toledo, Assis Chateaubriand, Tupãssi and Campo Mourão with a history of glyphosate use in burndown and in glyphosate-resistant soybean for at least the four previous years and were compared to a susceptible biotype (São Jorge do Ivaí) with no previous history of herbicide use. The doses of glyphosate ranged from 0 to 5760 g ae ha⁻¹. The biotypes were considered as resistant if two combined criteria were present (resistance factor > 1 and the rate required to achieve 80% control is >720 g ha⁻¹). The results provided evidence that there is a marked difference in the level of control of older plants and also confirmed the presence of some resistant biotypes. For applications at the first stage of development, two biotypes that were resistant to glyphosate were identified (Cascavel-1 and Tupãssi-6). For applications in the second stage of development, beyond the biotypes that were found in the first stage, three other biotypes were considered as resistant: Toledo-5, Assis Chateaubriand-7 and Floresta-10. However, for applications at the third and fourth stages, all the biotypes were considered as resistant.

Keywords: dose–response curve, EPSPS inhibitors, herbicide, Sumatran fleabane, tall fleabane.

The Asteraceae family comprises 23 000 species of plants that are organized into 1600–1700 genera and are distributed worldwide, except in Antarctica (Funk *et al.* 2005). Among the *Conyza* genre, there are nearly 50 species that are distributed almost throughout the world (Kissmann & Groth 1999). Species that have been associated more often with cases of resistance to herbicides in

South America are *Conyza bonariensis* and *Conyza canadensis*. These two species also are known as *Conyza crispa* (Pourr.) Rupr. and *Erigeron canadensis*, respectively.

However, the species that are known as the most widespread worldwide are *Conyza sumatrensis* and *C. canadensis* (Thebaud & Abbott 1995). This is probably related to particular reproductive characteristics that are associated with the invasive potential of these species, such as high seed production, rapid germination and a high dispersal ability of the seeds (achenes) (Hao *et al.* 2009). However, *C. sumatrensis* has not been mentioned among those resistance cases and, so far, very limited information regarding its relevance as a weed has been reported in the Americas.

Conyza sumatrensis, or *Conyza albida* Willd. ex Spreng., is considered to be a native species of South America, but it has spread throughout the tropical and

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subtropical areas in all continents (Thebaud & Abbott 1995; Pruski & Sancho 2006). *Conyza canadensis* is found mainly in colder areas, such as those with altitudes that are >1000 m, while *C. bonariensis* usually is limited to warmer areas in lower altitudes (≤ 400 –500 m), a habitat similar to that of *C. sumatrensis*, which also grows in sunny, warm environments (Vladimirov 2009). These three species have evolved cases of resistance to different herbicides. Evidence suggests that the selection of resistant biotypes in a population is related closely to the selection of preexisting resistant biotypes that, due to the selection pressure that is exerted by the repeated use of a single herbicide or a single mode of action, find the conditions to multiply and disperse in a particular area (Betts *et al.* 1992).

Biotypes with resistance to four different mechanisms of action (inhibitors of PSI and II, acetolactate synthase [ALS] and 5-enol-pyruvyl-shikimate-3-phosphate synthase [EPSPS]; Heap 2012) have been reported in *C. bonariensis*. In Brazil, biotypes of *C. bonariensis* that are resistant to glyphosate also have been reported (Heap 2012). Previous studies in Brazil have demonstrated that, for those areas with high infestations of glyphosate-resistant *Conyza*, the use of cover crops such as oats (*Avena sativa*), followed by fall management with glyphosate + 2,4-D (1080 + 1005 kg ha⁻¹), can provide very good levels of weed control prior to soybean sowing (Oliveira Neto *et al.* 2010).

For *C. canadensis*, the first report of resistance was found in Japan in 1980 for the herbicide, paraquat. After that, another 45 resistance cases of *C. canadensis* to a number of herbicides were reported (Heap 2012), such as to glyphosate (Song *et al.* 2011), ALS inhibitors (Zheng *et al.* 2011) and paraquat (Dulai *et al.* 1998). In Brazil, biotypes of *C. canadensis* that are resistant to glyphosate also have been reported (Heap 2012). So far, only five reports of resistance to herbicides have been described for *C. sumatrensis*. Four of them were related to resistance to paraquat: in Japan (Hanioka 1989) and in Sri Lanka and Taiwan (Heap 2012). Only one case referred to glyphosate, which was in Spain (González-Torralva *et al.* 2012).

Weed resistance to herbicides is a topic of growing concern among farmers and weed scientists, as well as all those who are involved in recommending and prescribing herbicides. Therefore, events of poor weed control with traditional chemical alternatives should be investigated in order to determine if these events are related to weed resistance or to other eventual misuses in application technology.

In 2010–2011, the ineffective control of Sumatran fleabane with glyphosate was observed in several soybean fields in west and north Paraná, Brazil. The

fields had been in continuous Round-up-ready soybean/conventional corn rotation for the last 7–8 years. Glyphosate was applied at least three times during 2011 and had been used for the previous 4 years. Glyphosate causes injury symptoms on Sumatran fleabane, but the plants can recover. The objective of this research was to determine if the Sumatran fleabane biotypes from selected fields in west and north Paraná had developed resistance to glyphosate.

MATERIAL AND METHODS

Seed collection and botanical identification

Sumatran fleabane plants were collected from different farms that were located in west and north Paraná, Brazil (Fig. 1). Seventeen plants were collected from each site on February 17 2010. Each plant was identified, individually placed in a paper bag and dried (45°C for 24 h) to facilitate the removal of the seeds. Each collection site was georeferenced with a global positioning system. The collected seeds were germinated in a greenhouse (May 2010) and the plants were irrigated daily until full flowering (January 2011), when they were harvested to compose an exsiccata. The exsiccata was sent to the Institute of Biology – Herbarium Uberlandense at Federal University of Uberlândia, where they were cataloged and identified as *C. sumatrensis* (Retz.) E. Walker. The samples that were collected for identification are available at the Herbarium of the State University of Maringá (HUEM 2011), under the records HUEM 21290, HUEM 21291, HUEM 21292, HUEM 21293 and HUEM 21294.

Greenhouse trials: Assessing the resistance to glyphosate

After species identification, the plants were analyzed for the possible resistance of *C. sumatrensis* to glyphosate that was applied at different stages of development. For this, four steps were conducted in a greenhouse from January to October 2011. Each step corresponded to the evaluation of a particular developmental stage.

A second collection of full mature seeds of *C. sumatrensis* was carried out on January 31 2011 in the previous georeferenced points in order to supply the greenhouse studies on glyphosate resistance. Also, the seeds from a susceptible biotype were collected from Meu Cantinho Farm, São Jorge do Ivaí, in a neighborhood with no previous use of glyphosate for at least 8 years and where weed control was based on mechanical or manual methods. The plant and seed sampling collection procedures were as above.



Fig. 1. Locations of the seed collection of *Conyza sumatrensis* in Paraná, Brazil. All the seeds were collected in January 2011.

The *C. sumatrensis* seeds were sown on the soil surface (≤ 0.5 cm) in 3 dm³ pots in May 2011. The roots and straw were eliminated by sieving (4 mm). The texture of the soil samples that were used to fill the pots was classified as Clay (34% sand, 6% silt and 50% clay).

Tests that were related to resistance to glyphosate were carried out on plants of four distinct stages of development; that is, plants with five-to-six true leaves (1.5 ± 0.2 cm high), eight-to-nine leaves (5 ± 0.5 cm high), 12–15 leaves (8–10 cm high) and 20–23 leaves (12–15 cm high).

One week after sowing, most of the seeds had germinated already and the pots were thinned to two emerged plants per pot. The experimental units were kept under greenhouse conditions and were irrigated daily. In order to obtain dose–response curves of *C. sumatrensis* (percentage control and shoot biomass) to glyphosate, doses corresponding to $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4 and 8 times the recommended dose (720 g ae ha⁻¹) for burndown applications in *C. bonariensis* (Moreira *et al.* 2007) were used and a check without a herbicide application also was used. Therefore, the doses of glyphosate that were applied were: 0, 90, 180, 360, 720, 1440, 2880 and 5760 g ae ha⁻¹. As there is no labeled dose of glyphosate to control *C. sumatrensis* in Brazil so far, it was decided to use the doses that are recommended for *C. bonariensis* control. Among the three main *Conyza* species (*C. sumatrensis*, *C. bonariensis* and *C. canadensis*), *C. sumatrensis* is considered to be the most sensitive to glyphosate (GR₅₀ values of 2.9, 15.7 and 34.9 g ai ha⁻¹, respectively; (González-Torralva *et al.* 2010).

All the applications of glyphosate were carried out with a CO₂-pressurized backpack sprayer (Unknown, Maringá, Brazil) that was equipped with flat-fan nozzles that were calibrated to deliver 200 L ha⁻¹ at 241 kPa and 3.6 km h⁻¹. The applications always were carried out by considering a distance of 0.5 m between the tips and the target plants. All the suspected glyphosate-resistant and -susceptible biotypes of *C. sumatrensis* were treated with herbicide when the plants were at the four distinct stages of development that were mentioned earlier.

The experimental design was a randomized complete block that was arranged in a triple factorial arrangement ($7 \times 8 \times 4$), constituted by the glyphosate doses, biotypes and stages of development, respectively. The treatments were replicated four times.

Data analysis

The visible injury ratings were determined 28 days after the herbicide applications and were based on a scale ranging from 0% (no control) to 100% (dead plants). Ratings that were $\geq 80\%$ were considered as acceptable,

whereas ratings that were $\geq 90\%$ were considered as satisfactory. At 28 days after application, the remaining *C. sumatrensis* plants were harvested, placed in paper bags and dried (65°C for 72 h) and weighed (g per pot). The shoot dry mass was corrected to percentage values by comparing the values that were obtained in the treatments to those that were found for the control shoot dry mass (dose: 0 g ae ha⁻¹), considered as 100%.

The data from the greenhouse experiments, which used a series of glyphosate rates, were subjected to non-linear regression in addition to an ANOVA. The level of *C. sumatrensis* control and the shoot dry weight, expressed as a percentage of the untreated control, were regressed against the glyphosate rate. The weed-control rates were adjusted to the non-linear logistic dose–response curve (Streibig 1988):

$$y = \frac{a}{1 + \left[\frac{x}{b} \right]^c}, \quad (1)$$

where y = percentage control (visible injury rating or dry weight biomass), x (independent variable) = herbicide dose (g ae ha⁻¹) and a , b and c = the estimated parameters of the equation, as follows: a = mathematical asymptote, b = the dose that provides 50% of weed control (asymptote) and c = is the slope of the curve.

From the log-logistic equations, dose–response curves were elaborated. Based on the adjusted models, the doses (g ae ha⁻¹) of glyphosate that provided 50%, 80% and 90% of weed control (GR₅₀, GR₈₀ and GR₉₀) were calculated. In order to carry out that calculation, the log-logistic model was inverted, leaving it as a function of y , according to Carvalho *et al.* (2005):

$$x = b \times \sqrt[c]{\frac{a}{y} - 1}. \quad (2)$$

Based on the GR₅₀ values, the resistance factor (RF = GR₅₀ resistant/GR₅₀ susceptible) was calculated for each *C. sumatrensis* biotype. The data were analyzed with SigmaPlot (2006) for the regression analysis. The estimates of the herbicide dose that caused a 50% growth reduction (GR₅₀) were determined by using the fitted regression equations. In order to confirm resistance, the GR₅₀ values for *C. sumatrensis* biotypes 1–7 were compared with those of the susceptible standard. If the 95% confidence intervals of the predicted GR₅₀ values overlapped with that of the susceptible standard, it was concluded that the biotype was not resistant. A second criterion, based on the labeled dose of glyphosate (720 g ae ha⁻¹), also was adopted. Therefore, in order to

determine if a certain biotype is resistant, it should present as $RF > 1$ and the rate required to achieve 80% control is $>720 \text{ g ae ha}^{-1}$.

RESULTS AND DISCUSSION

A significant ($P < 0.05$) interaction was found among the biotypes, doses and stages of development. For applications at the first stage of development (five-to-six leaves, $1.5 \pm 0.2 \text{ cm}$), excellent control for most of the biotypes of *C. sumatrensis* was achieved with doses of glyphosate below the recommended dose (720 g ae ha^{-1}). The I_{90} ($242.8 \text{ g ae ha}^{-1}$) of the susceptible biotype was equivalent to 33.72% of the recommended rate. Although high levels of *Conyza* control were found within the dose range in this work,

two biotypes were considered as resistant ($RF > 1$ and $GR_{80} > 720 \text{ g ha}^{-1}$): Cascavel-1 and Tupãssi-6 (Table 1). Although such values were <10 , a second criterion ($GR_{80} > 720 \text{ g ae ha}^{-1}$) also was achieved for these biotypes. It is likely that these biotypes will have some impact in the field as the recommended doses probably will not provide control.

In general, for the applications that were carried out at the second stage of *Conyza* development (eight-to-nine leaves, $5 \pm 0.5 \text{ cm}$), lower levels of weed control were found in relation to the younger plants. At this stage, five biotypes were determined as resistant to glyphosate (Table 2). As well as those biotypes that were found to be resistant at the first stage of development (Table 1), Toledo-5, Assis Chateaubriand-7 and Floresta-10 also were resistant.

Table 1. Adjusted parameter estimates (a, b, c) and coefficient of determination (R^2) of the log-logistical model, as well as the doses that provided 50, 80 and 90% control (GR_{50} , GR_{80} , GR_{90}) and the resistance factors that were obtained after the glyphosate applications on the plants of *Conyza sumatrensis* with five-to-six leaves

Biotype	a	b	c	R^2	<u>GR₅₀</u>	<u>GR₈₀</u>	<u>GR₉₀</u>	RF†
					g ae ha ⁻¹			
Susceptible	93.55	267.13	−1.31	0.99	102.02	176.35	242.80	1.00
Cascavel-1	114.42	207.72	−0.67	0.98	142.46	728.65	1446.95	1.40
Toledo-5	101.83	62.10	−0.93	0.99	59.76	250.75	549.76	0.59
Tupãssi-6	93.55	267.13	−1.31	0.99	296.92	1039.99	3172.61	2.91
Assis Chateaubriand-7	100.12	72.17	−2.30	0.99	72.09	131.53	186.67	0.71
Campo Mourão-8	102.15	63.96	−1.16	0.99	61.68	193.54	359.54	0.60
Floresta-10	108.12	156.70	−0.77	0.99	128.88	609.04	1255.68	1.26

† Resistance factor (RF) was calculated by dividing the GR_{50} dose of the suspected resistant biotypes by the GR_{50} of the standard susceptible biotype.

Table 2. Adjusted parameter estimates (a, b, c) and coefficient of determination (R^2) of the log-logistical model, as well as the doses that provided 50, 80 and 90% control (GR_{50} , GR_{80} , GR_{90}) and the resistance factors that were obtained after the glyphosate applications on the plants of *Conyza sumatrensis* with eight-to-nine leaves

Biotype	a	b	c	R^2	GR_{50}	GR_{80}	GR_{90}	RF†
g ae ha ⁻¹								
Susceptible	101.49	207.37	-1.31	0.99	202.78	563.68	992.64	1.00
Cascavel-1	97.84	275.28	-0.74	0.98	292.28	2 102.22	7 512.50	1.44
Toledo-5	100.22	554.19	-1.02	0.99	551.85	2 140.91	4 699.77	2.72
Tupãssi-6	83.76	551.98	-0.99	0.99	820.74	12 110.66	—	4.05
Assis Chateaubriand-7	107.63	366.69	-1.11	0.99	322.58	957.41	1 597.43	1.59
Campo Mourão-8	183.37	3540.99	-0.27	0.99	90.79	1 359.86	3 086.81	0.45
Floresta-10	106.42	456.96	-0.29	0.99	300.73	21 209.53	165 651.46	1.48

† Resistance factor (RF) was calculated by dividing the GR_{50} dose of the suspected resistant biotypes by the GR_{50} of the standard susceptible biotype.

For the third (12–15 leaves, 8–10 cm) and fourth (20–23 leaves, 12–15 cm) stages of development, all the biotypes (except the susceptible one) were classified as resistant, taking into consideration the RF and GR₈₀ (Tables 3,4). For applications at the third stage, the range of glyphosate doses in this study did not provide satisfactory ($\geq 90\%$) levels of control of Toledo-5 and Tupãssi-6 and therefore the GR₉₀ values were not calculated.

Such an effect also could be observed for the applications to the oldest plants (20–23 leaves). For the biotype that was considered to be susceptible, the recommended dose of glyphosate was sufficient to provide acceptable control ($\geq 80\%$) of *C. sumatrensis* in all the stages of weed development that were evaluated here. According to the equation parameters that were found for the plants with 20–23 leaves, the dose of

635.27 g ae ha⁻¹ would be enough to attain 80% of the control, which is considerably lower than the recommended dose (720 g ae ha⁻¹).

Differences in the response of *C. sumatrensis* to glyphosate that were observed among the stages of development suggest that plant growth significantly decreases weed control, so that chemical management probably will attain the best results when the applications are made on young plants. Thus, a summary of the RFs in the present work is found in Table 5. The shoot dry mass RF values confirm the same trend that was found for the percentage control RF values; that is, increased RF values with higher stages of development of *C. sumatrensis*.

The results of this study corroborate the studies by Gonzalez-Torralva *et al.* (2010). The authors analyzed the effect of herbicide applications on plants with

Table 3. Adjusted parameter estimates (a, b, c) and coefficient of determination (R^2) of the log-logistical model, as well as the doses that provided 50, 80 and 90% control (GR₅₀, GR₈₀, GR₉₀) and the resistance factors that were obtained after the glyphosate applications on the plants of *Conyza sumatrensis* with 12–15 leaves

Biotype	a	b	c	R^2	g ae ha ⁻¹			RF†
					GR ₅₀	GR ₈₀	GR ₉₀	
Susceptible	103.10	234.13	-1.17	0.99	222.37	679.45	1 222.71	1.00
Cascavel-1	103.28	532.72	-0.66	0.98	483.90	3443.56	9 613.77	2.11
Toledo-5	89.15	593.47	-1.08	0.99	743.54	4378.67	–	3.25
Tupãssi-6	75.63	490.24	-1.04	0.99	933.25	–	–	4.08
Assis Chateaubriand-7	94.49	412.68	-1.37	0.99	449.54	1442.21	3 709.04	1.96
Campo Mourão-8	234.82	15 800.16	-0.41	0.99	644.33	3139.98	4 932.74	2.81
Floresta-10	91.01	388.83	-0.76	0.99	504.34	5251.32	140 686.53	2.20

† Resistance factor (RF) was calculated by dividing the GR₅₀ dose of the suspected resistant biotypes by the GR₅₀ of the standard susceptible biotype.

Table 4. Adjusted parameter estimates (a, b, c) and coefficient of determination (R^2) of the log-logistical model, as well as the doses that provided 50, 80 and 90% control (GR₅₀, GR₈₀, GR₉₀) and the resistance factors that were obtained after the glyphosate applications on the plants of *Conyza sumatrensis* with 20–23 leaves

Biotype	a	b	c	R^2	g ae ha ⁻¹			RF†
					GR ₅₀	GR ₈₀	GR ₉₀	
Susceptible	96.13	215.22	-1.48	0.99	227.28	635.27	1323.15	1.00
Cascavel-1	70.05	387.18	-0.74	0.96	1341.54	–	–	5.90
Toledo-5	104.99	2438.31	-0.79	0.99	2160.56	10 683.94	–	9.50
Tupãssi-6	67.99	567.56	-1.49	0.99	1129.76	–	–	4.97
Assis Chateaubriand-7	71.79	317.1	-1.17	0.99	642.705	–	–	2.83
Campo Mourão-8	71.26	427.71	-0.72	0.96	1391.56	–	–	6.12
Floresta-10	75.55	501.94	-0.81	0.99	1153.13	–	–	5.07

† Resistance factor (RF) was calculated by dividing the GR₅₀ dose of the suspected resistant biotypes by the GR₅₀ of the standard susceptible biotype.

Table 5. Evolution of the resistance factors for the relative shoot dry mass (SM) (%) and visual control (%) in four stages of *Conyza sumatrensis* development

Biotype	Stage of development							
	5–6 leaves		8–9 leaves		12–15 leaves		20–23 leaves	
	SM	Control	SM	Control	SM	Control	SM	Control
Susceptible	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cascavel-1	4.00	1.40	1.41	1.44	2.33	2.11	9.17	5.90
Toledo-5	0.91	0.59	2.53	2.72	3.27	3.25	8.80	9.50
Tupãssi-6	3.96	2.91	4.06	4.05	2.35	4.08	6.40	4.97
Assis Chateaubriand-7	0.42	0.71	1.86	1.59	2.40	1.96	2.51	2.83
Campo Mourão-8	0.91	0.60	0.41	0.45	2.72	2.81	6.57	6.12
Floresta-10	1.73	1.26	1.52	1.48	2.27	2.20	6.38	5.07

different growth stages (rosette, bolting and flowering) for the species, *C. bonariensis* and *C. Canadensis*. Less susceptibility to the herbicide was found in older plants. Therefore, the dynamics of weed resistance to herbicides depends on factors that are related to the genetics of resistant genes (frequency in population and dominance), to plant reproduction biology (self-pollination, capacity of seed production and mechanisms of pollen dispersion) and to the herbicide (site of action, chemical structure, level of activity for a specific species and residual activity) (Powles & Yu 2010).

The mechanisms of weed resistance to glyphosate can be divided into two main groups: those involving changes to the herbicide's target site and those that are not related to the target site (Powles & Preston 2006; Powles & Yu 2010). Mutations at the target site and gene amplification are two examples of mechanisms of resistance that are related to the site of action. Limited absorption and/or translocation and glyphosate sequestration in vacuoles are examples of mechanisms that do not involve the target location of the herbicide's action (Powles & Yu 2010). In this study, the younger plants tended to be controlled by applying glyphosate even at doses below the recommended dose. Apparently, under these conditions, herbicide translocation is favored because of the plasmodesmata, direct plasma channels between neighboring cells that allow the exchange of informational, functional and structural molecules and xenobiotics between cells belonging to the same domain, as compared to the less efficient movement across membranes (Concenço *et al.* 2007).

These factors might pose a reasonable explanation as to why higher levels of control were found in the younger plants. Still, in the present study, three biotypes that were resistant to glyphosate were found when the herbicide was applied to plants early in the first stage of development (five-to-six leaves).

It has been suggested that, in these cases, resistance could be related to a change in the herbicide's site of action, such as the change at the EPSPS site that was proposed by Powles and Preston (2006). Another hypothesis that could explain the resistance of younger plants is EPSPS gene amplification and reduced sensitivity to the herbicide. Mueller *et al.* (2003) measured the level of shikimic acid that was produced by both resistant and susceptible *C. canadensis* plants and suggested that, in addition to the overexpression of the EPSPS gene in the resistant plants, it could be that the isomers of EPSPS had a lower affinity for the glyphosate molecule, which could confer the characteristic of resistance to the plants.

With the development of plants, the size exclusion limit of a plasmodesmata decreases, which might explain why the plants became less susceptible to glyphosate as they developed. This herbicide is one of the few known examples of herbicide translocation in which the importance of plasmodesmata is considered. The formation of secondary plant cell walls, among other factors, also might have limited the translocation of the herbicide in the older plants, as they are thicker and less permeable.

One of the reasons that has been given to explain the resistance of *C. sumatrensis* biotypes to glyphosate is the reduced translocation of glyphosate in plants. Resistant populations of *C. bonariensis* and *C. canadensis* have been demonstrated to have lower rates of translocation of glyphosate from the treated areas into other parts of the plant, which does not happen in susceptible plants (Feng *et al.* 2004; Ferreira *et al.* 2008). As glyphosate is a fast and efficiently translocated molecule, any reduction in the transport of the herbicide into areas of the plant might produce a large effect, as regards to plant mortality.

Dinelli *et al.* (2006) investigated the possible mechanisms that are involved in the resistance of *C. canadensis*

to glyphosate and observed a greater level of herbicide translocation toward the leaves in the resistant biotypes, unlike in the susceptible biotype, where the highest concentration of the herbicide was translocated to the roots. The work that was carried out by Feng *et al.* (2004) completed the theory of the differential translocation of glyphosate in *Conyza* plants. The authors suggested that resistance probably is related to the modification of the cellular distribution of glyphosate, which prevents the herbicide loading into the phloem and the influx into the plastids, thereby resulting in a reduced overall translocation of the herbicide within the plant.

Four different hypotheses have been proposed (Shaner 2009) to explain the mechanism of reduced translocation: (i) a change in the transporter that carries the glyphosate into the cell; (ii) the increased action of a transporter that carries the glyphosate into the vacuole; (iii) increased active efflux pumps of glyphosate; (iv) the increased action of a transporter that carries glyphosate out of the chloroplast; (v) reduced movement of the herbicide through the transpiration flow; and (vi) the inability of the herbicide to reenter the phloem.

Studies are still needed to promote a deeper understanding of the mechanisms of resistance in *C. sumatrensis*. The identification of resistance mechanisms could lead to the development of management strategies for weed resistance, based on physiological, biochemical and genetic parameters.

In this study, the existence of populations of *C. sumatrensis* was confirmed, as well as the resistance of some of these biotypes to glyphosate. Furthermore, it was observed that the application of glyphosate in young plants provided better control levels than in older plants. These results suggest the need for more studies that are aimed at identifying the Sumatran fleabane species that are present in the Americas. This is the first report of *C. sumatrensis* that is resistant to glyphosate in Brazil, as well as in the Americas.

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