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Article

Weeds in Second Corn Crops in the Period of Transgenic Soybean Implantation in the Middle Paranapanema Region

Plantas Daninhas em Lavouras de Milho Safrinha no Período de Implantação da Soja Transgênica no Médio Paranapanema

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ABSTRACT - The Middle Paranapanema region concentrates a large part of the second corn production in São Paulo State. Weed surveys in commercial areas are important for monitoring and directing their management. In 2006, 2007, and 2008, weed surveys were carried out on 27, 25, and 24 corn crops, respectively, in ten counties of this region. At the grain filling stage, crops were zigzag sampled with 20 points of 1 m^2 per area. In addition, information on weed management, soil cover, and history of the summer crop were collected. The phytosociological parameters frequency, density, abundance, and importance value index were determined. The results evidenced *Cenchrus echinathus* as the most important species in 2006 and 2007, in addition to high importance values in 2008, which reflected the need to improve its management. *Bidens pilosa*, *Digitaria horizontalis*, and *Euphorbia heterophylla* were important species for the crop. Although under a low frequency, outbreaks of *Leonurus sibiricus* and *Gnaphalium spicatum* were observed in the areas, increasing their importance in 2007 and 2008. Atrazine was the most used herbicide over the agricultural years, with a low use of other products. Soil cover presented a high variation, but a high number of fields presented a low soil cover. Despite the increase of transgenic soybean in this region, no consistent evidence of changes in weed community resulted from this transition.

Keywords: *Zea mays* L., phytosociological survey, weeds.

RESUMO - A região do Médio Paranapanema concentra grande parte da produção de milho safrinha do Estado de São Paulo. Levantamentos de plantas daninhas em áreas comerciais são importantes para monitorar a sua evolução e manejo. Assim, levantamentos de plantas daninhas foram realizados em lavouras de milho safrinha em dez municípios dessa região, em 2006, 2007 e 2008, sendo avaliadas 27, 25 e 24 lavouras de milho, respectivamente. No estádio de enchimento de grãos, as lavouras foram percorridas em ziguezague, sendo amostrados 20 pontos de 1 m^2 por lavoura. Adicionalmente, foram coletadas informações sobre manejo de plantas daninhas, cobertura do solo e histórico da cultura de verão. Calcularam-se os parâmetros fitossociológicos frequência, densidade, abundância e índice de valor de importância. Os resultados evidenciam ***Cenchrus echinathus*** *como a espécie mais importante nas safrinhas 2006 e 2007 e com altos valores em 2008, o que sugere a necessidade de aperfeiçoar o seu manejo.* ***Bidens pilosa, Digitaria horizontalis*** *e* ***Euphorbia heterophylla*** *foram espécies infestantes importantes na cultura. Infestações abundantes de* ***Leunurus sibiricus*** *e* ***Gnaphalium spicatum*** *foram constatadas, o que elevou a importância dessas espécies em 2007 e 2008, porém foram plantas com baixa frequência na área. O herbicida atrazine foi o mais*

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utilizado nos anos agrícolas avaliados, sendo verificado baixo uso de outros produtos. A cobertura do solo apresentou grande variação, todavia houve elevado número de propriedades com baixa cobertura. Houve introdução e grande avanço da soja transgênica na região durante o período avaliado, porém não se evidenciou mudança consistente na comunidade infestante do milho safrinha no decorrer do estudo.

Palavras-chave: *Zea mays* L., avaliação fitossociológica, plantas daninhas.

INTRODUCTION

The regions of Assis, Ourinhos, and Itapeva, in the Paranapanema river basin, are the largest producers of the second corn crop in São Paulo State, with 63.7% of the total produced (Martins et al., 2017), almost always in a succession to soybean. The Assis region is located in the Middle Paranapanema Valley, where the second corn crop has reached an area of at least 120,000 hectares per year since 1994 (Furlaneto and Nardon, 2007).

In weed community surveys conducted in 1995 in the Middle Paranapanema region by Duarte and Deuber (1999), shortly after the introduction of the second corn crop in the region, and by Duarte et al. (2007), from 1997 to 1999, part of the second corn crop showed a high weed infestation.

In this region, the production environment of the second corn crop, especially at lower temperatures, has not reduced weed emergence since some of them are specific, such as radish (*Raphanus sativus*), and others seem to have adapted to autumn/winter, such as southern sandbur (*Cenchrus echinatus*) and hairy beggarticks (*Bidens pilosa*), although with a less vigorous development, which allows reducing herbicide doses in relation to summer crops (Duarte et al., 2007).

Each species responds differently to environmental pressures and practices such as crop rotation and soil and herbicide management may have a major impact on weed community (Dieleman et al., 2000; Smith and Gross, 2006). Weed population assessments in agroecosystems are important to determine how a community is changed over time in response to selective pressures arising from agronomic practices (Nkoa et al., 2015). Surveys have been conducted in commercial areas to characterize the most problematic weed species and herbicides used (William et al., 2006; Givens et al., 2009; Grey et al., 2014). These monitoring are a valuable tool for documenting the dynamics of herbicide use, as well as the perceptions that guide decisions regarding the selection of these products (Givens et al., 2009).

In the Middle Paranapanema region, soil management systems evolved from the introduction of the second corn crop for the no-tillage system in almost all farms. However, a continuous succession of soybean and second corn crop predominates without interruption (monoculture), in addition to the use of herbicides with the same active ingredient for more than 15 years. Duarte (2004) reported that the continuous use of only the post-emergence active ingredient atrazine in these areas has selected some species.

Another relevant aspect that may interfere with weed community of the second corn crop is the Roundup Ready technology that has been used in soybean in the Middle Paranapanema region from the 2005/2006 season and after four years in the second corn crop. In the 2006/2007 season, more than half of the soybean sown in this region was transgenic. The continuous use of glyphosate in soybean may result in an impact on the weed community of the second corn crop in succession. In this sense, according to Lopez-Ovejero et al. (2016a), it is important an appropriate regional weed monitoring program for accompanying the resistance dispersion.

Programmed repetitions of phytosociological studies may indicate variation trends of the importance of one or more populations, which may be associated with the adopted agricultural practices (Oliveira and Freitas, 2008). Thus, detailed surveys of the weed community during the beginning of adoption of the Roundup Ready technology in the short term together with future studies in the medium and long term may provide an understanding of the impact of this technology on the second corn crop cultivation.

This study aimed to carry out a phytosociological survey of the weed community in areas cultivated with the second corn crop in southwestern São Paulo State during three agricultural years at the beginning of adoption of the Roundup Ready technology in soybean.

MATERIAL AND METHODS

The survey was carried out in Assis, Campos Novos Paulista, Cândido Mota, Cruzália, Florínea, Ibirarema, Maracaí, Palmital, Pedrinhas Paulista, and Platina within a radius of approximately 50 km between the latitudes of 22°36' and 22°54', longitudes of 50°00' and 50°47', and altitudes of 318 and 546 m. According to Köppen classification, the climate of the Middle Paranapanema region is classified as Cwa, a mesothermic climate with a dry winter in transition to Cfa, a mesothermic and humid climate without drought (Brunini and Prela, 2007).

Weed survey was conducted in 27, 25, and 24 common production fields in 2006, 2007, and 2008, respectively, with the following distribution and number of production fields in the three agricultural years: Assis (1-1-1), Campos Novos Paulista (2-2-2), Cândido Mota (5-5-5), Cruzália (6-6-6), Florínea (3-3-3), Ibirarema (1-0-0), Maracaí (2-2-2), Palmital (1-0-0), Pedrinhas Paulista (4-4-3), and Platina (2-2-2).

The method was adapted from the square inventory or census of plant population (Braun-Blanquet, 1950), which is based on the use of a 1.0 x 1.0 m square, randomly placed in the crop production field, using a rectangle of 0.5 x 1.0 m twice at each sampling point since most of the corn interrow spacing was 0.80 m.

The survey was carried out from the grain filling stage to the physiological maturity of corn, around 90-120 days after sowing, in July 2006, 2007, and 2008.

The areas were zigzagged and the square inventory was randomly placed 40 times on each farm (two 0.5 m^2 squares per sampling point and 20 points sampled). Therefore, sampling consisted of 20 m^2 randomly distributed in the entire extension of each production field. The plants contained in the square were identified, being counted the number of individuals per species.

The phytosociological parameters frequency, density, abundance, and from them the relative frequency, relative density, relative abundance, and importance value index were calculated from the number of individuals registered per species. The formulas proposed by Mueller-Dombois and Ellenberg (1974) were used to obtain these parameters.

In addition, the information about the weed control method and the predecessor summer crop were collected at each production field. Soil cover was estimated by the visual method, in which percentages from 0 to 100%, at a 25% scale, were assigned at the same points the weed sampling was carried out in each production field by using the sampling square.

RESULTS AND DISCUSSION

Soybean was the main summer crop that preceded the second corn crop (Table 1). In the period covered by the survey, a great advance in transgenic soybean was observed in the region in 2006/2007 and 2007/2008 seasons when compared to 2005/2006. Corn presented a low percentage of production fields as a summer crop, which is positive in terms of weed management since in this case, different crops in the first and second crop facilitate the use of different active ingredients of herbicides.

The herbicide atrazine (isolated or combined with other active ingredients) was the most used in the production fields, but with an increased use of nicosulfuron in the last year, accounting for 95.8 and 25.0% of the production fields in 2008, respectively (Table 1).

Some farmers have reported phytotoxicity problems of some corn hybrids to nicosulfuron, which can be attributed to their differential tolerance to nicosulfuron, in addition to the application stage, which may result in a reduced productivity (Spader and Vidal, 2001).

Atrazine was the most used herbicide in 1997, 1998, and 1999, according to surveys carried out during this period, in addition to the mechanical weed control and a high percentage of

Table 1 - Summer crop and chemical weed management in the Middle Paranapanema region in 2006, 2007, and 2008

	2006	2007	2008
Summer crop	(% of production fields assessed)		
Conventional soybean	70.4	20.0	29.2
Transgenic soybean	14.8	52.0	50.0
Corn	14.8	28.0	20.8
Chemical weed management	(% of production fields assessed)		
Atrazine	77.8	84.0	95.8
2,4-D	7.4	-	8.3
Mesotrione	-	12.0	4.2
Nicosulfuron	7.4	8.0	25.0
Without control	22.2	8.0	4.2

production fields without any control (Duarte et al., 2007). Atrazine controls dicotyledonous weeds and some annual grasses, being applied in pre- and post-emergence of weeds. However, this herbicide is applied only in post-emergence in the second corn crop. In addition, atrazine has a half-life in the field of 60 days and its persistence increases under conditions of cold and dry soils (Rodrigues and Almeida, 2011).

At the time of this survey, the adoption of no-tillage system modified the management previously adopted with the mechanical control. Despite the normally low investment in weed control in the second corn crop (Adegas et al., 2011), a reduction of production fields without any weed control was observed in the region, being about 22.2% in 2006 and 4.2 % in 2008.

Soil cover varied over the years but it may be considered as low in most areas (Figure 1). In 2006, 29.6% of the production fields presented a range of 50-75% of soil cover, but in the following two years, this value was close to 8%. Between 60 and 80% of production fields presented less than 50% of soil cover. In this case, the predecessor crop (which in most cases was soybean) presented a low C/N ratio and, therefore, a fast decomposition, not forming a sufficient soil cover for the second corn crop. Didon et al. (2014) observed that weeds responded differently to the type of soil cover and climatic conditions. With transgenic crops, soil cover is an important strategy for weed management in the region, being a complement to chemical control.

Tables 2, 3, and 4 show the results of the phytosociological parameters relative frequency, relative abundance, and relative density of weed species found in the surveys carried out in 2006, 2007, and 2008, respectively.

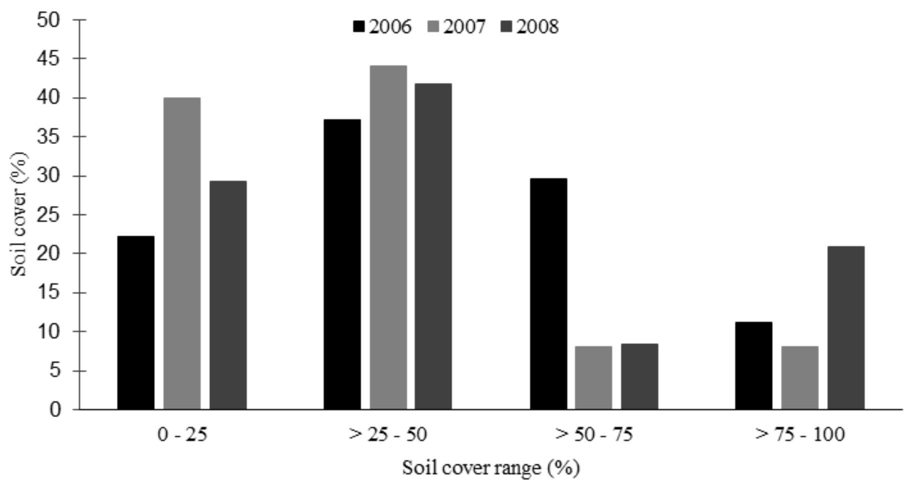

Figure 1 - Soil cover (%) in second corn crop production fields cultivated under the no-tillage system in the Medium Paranapanema region in 2006, 2007, and 2008.

Table 2 - Phytosociological indices of relative frequency (Frr), relative abundance (Abr), relative density (Der), and importance value index (IVI) of weeds in 27 second corn crop production fields in the Middle Paranapanema region in 2006

	Frr	Abr	Der	IVI
Cenchrus echinatus	18.0064	10.6984	39.8816	68.5864
Bidens pilosa	16.2915	5.5879	18.8465	40.7259
Euphorbia heterophylla	14.6838	2.7695	8.4192	25.8725
Raphanus sativus	9.2176	4.0611	7.7497	21.0284
Commelina benghalensis	7.0740	2.9535	4.3254	14.3529
Digitaria horizontalis	7.1811	2.6150	3.8877	13.6839
Sorghum halepense	3.3226	4.0798	2.8064	10.2088
Leonurus sibiricus	0.6431	8.3156	1.1071	10.0658
Sida sp.	4.5016	2.5417	2.3687	9.4120
Chamaesyce sp.	1.2862	6.2851	1.6735	9.2448
Emilia sonchifolia	2.2508	4.4203	2.0597	8.7308
Glycine max	3.7513	2.0886	1.6220	7.4620
Echinochloa crus-galli	1.1790	4.0084	0.9784	6.1657
Amaranthus sp.	2.2508	2.4864	1.1586	5.8958
Cyperus rotundus	0.3215	4.2545	0.2832	4.8593
Porophyllum ruderale	0.1072	4.6413	0.1030	4.8514
Acanthospermum hispidum	1.5005	1.9891	0.6179	4.1076
Brachiaria plantaginea	1.9293	1.5471	0.6179	4.0943
Chloris sp.	0.1072	3.4810	0.0772	3.6654
Tridax procumbens	0.1072	3.4810	0.0772	3.6654
Phyllanthus tenellus	0.4287	2.3206	0.2060	2.9553
Leucas martinicensis	1.0718	1.5084	0.3347	2.9149
Eleusine indica	1.0718	1.3924	0.3090	2.7732
Croton glandulosus	0.1072	2.3206	0.0515	2.4793
Sidastrum micranthum	0.2144	1.7405	0.0772	2.0321
Parthenium hysterophorus	0.4287	1.4504	0.1287	2.0079
Ipomoea sp.	0.3215	1.1603	0.0772	1.5591
Avena strigosa	0.2144	1.1603	0.0515	1.4262
Senna obtusifolia	0.1072	1.1603	0.0257	1.2932
Lepidium virginicum	0.1072	1.1603	0.0257	1.2932
Digitaria insularis	0.1072	1.1603	0.0257	1.2932
Solanum sisymbriifolium	0.1072	1.1603	0.0257	1.2932

Species of the following families were registered (2006-2007-2008): Amaranthaceae (1-1-1), Asteraceae (6-5-8), Brassicaceae (2-3-3), Commelinaceae (1-1-1), Convolvulaceae (1-1-1), Cyperaceae (1-0-1), Euphorbiaceae (4-4-3), Fabaceae (2-2-2), Lamiaceae (2-2-2), Malvaceae (2-1-1), Oxalidaceae (0-1-0), Poaceae (9-10-9), Portulacaceae (0-1-0), Rubiaceae (0-0-1), and Solanaceae (1-1-1). The total number of species corresponding to 2006, 2007, and 2008 were 32, 33, and 34, respectively. Therefore, a little change was observed in species diversity over the years.

The five species with the highest importance value index in 2006 were *Cenchrus echinatus* (IVI = 68.6), *Bidens pilosa* (IVI = 40.7), *Euphorbia heterophylla* (IVI = 25,9), *Raphanus sativus* (IVI = 21.0), and *Commelina benghalensis* (IVI = 14.3). In 2007, *C. echinatus* was the main weed species (IVI = 43,1), followed by *Leonurus sibiricus* (IVI = 33.3), *E. heterophylla* (IVI = 26.8), *Digitaria horizontalis* (IVI = 24.2), and *B. pilosa* (IVI = 20.0).

In 2007, *L. sibiricus*, commonly called honeyweed, presented an importance value three times higher in comparison to 2006. Despite the low frequency of this species in the region, its high importance value was attributed to its high abundance in the production fields where it was registered (Table 3). According to Lorenzi (2008), *L. sibiricus* generally forms dense pure population infestations.

Table 3 - Phytosociological indices of relative frequency (Frr), relative abundance (Abr), relative density (Der), and importance value index (IVI) of weeds in 25 second corn crop production fields in the Middle Paranapanema region in 2007

	Frr	Abr	Der	IVI
Cenchrus echinatus	17.7551	3.7249	21.6301	43.1101
Leonurus sibiricus	1.8367	19.6560	11.8077	33.3005
Euphorbia heterophylla	11.9388	3.0347	11.8495	26.8230
Digitaria horizontalis	10.4082	3.1249	10.6374	24.1705
Bidens pilosa	9.4898	2.5654	7.9624	20.0176
Amaranthus sp.	5.3061	3.9499	6.8548	16.1108
Raphanus sativus	5.1020	2.7177	4.5350	12.3548
Gnaphalium spicatum	0.8163	8.6886	2.3197	11.8247
Commelina benghalensis	5.5102	2.0642	3.7200	11.2943
Glycine max	6.1224	1.4925	2.9885	10.6034
Sorghum halepense	4.4898	2.3341	3.4274	10.2512
Oxalis latifolia	0.3061	8.7669	0.8777	9.9508
Sida sp.	4.0816	1.2368	1.6510	6.9694
Avena strigosa	0.1020	7.5145	0.2508	7.8673
Coronopus didymus	0.8163	4.3052	1.1494	6.2709
Leucas martinicensis	1.5306	2.4631	1.2330	5.2267
Digitaria insularis	1.3265	2.5048	1.0867	4.9181
Chamaesyce sp.	1.3265	2.2158	0.9613	4.5037
Zea mays	2.5510	1.0019	0.8359	4.3889
Chloris sp.	1.4286	1.9681	0.9195	4.3162
Eleusine indica	1.9388	1.3183	0.8359	4.0931
Lepidium virginicum	0.6122	2.4005	0.4807	3.4934
Sonchus oleraceus	0.6122	2.2961	0.4598	3.3681
Phyllanthus tenellus	0.7143	1.6103	0.3762	2.7007
Echinochloa crus-galli	0.8163	1.4872	0.3971	2.7006
Emilia sonchifolia	0.8163	1.0176	0.2717	2.1056
Brachiaria plantaginea	1.1224	0.6262	0.2299	1.9785
Ipomoea sp.	0.4082	0.7828	0.1045	1.2954
Portulaca oleracea	0.2041	0.6262	0.0418	0.8721
Ricinus communis	0.2041	0.6262	0.0418	0.8721
Acanthospermum hispidum	0.1020	0.6262	0.0209	0.7491
Solanum americanum	0.1020	0.6262	0.0209	0.7491
Senna obtusifolia	0.1020	0.6262	0.0209	0.7491

The importance of *C. echinatus* was lower in 2007 when compared to 2006 due to its lower density and abundance, but its absolute frequency remained practically the same over the three years (data not shown). In addition, even at a low density, many production fields showed infestation with *C. echinatus* at an advanced development stage and with a high seed production. This species can be considered as having a low level of control over the years, showing the need of improving its management.

Dan et al. (2011) pointed out that *C. echinatus* is a frequent weed in areas of corn, sorghum, and millet in Brazil. Although atrazine is one of the most used herbicides in these crops, applications at later stages were inefficient in controlling this species, which may explain its importance in the surveys.

The species *B. pilosa* had a high frequency in the area. Density, abundance, and frequency were lower in 2007 when compared to the other years. According to Carmona and Villas Boas (2001), agricultural practices that favor the concentration of seeds of *B. pilosa* on the soil surface, such as the no-tillage system adopted in this region, may cause higher germination flows in the short term, requiring a greater attention in the management, but end up being advantageous in the medium and long terms since it accelerates the reduction of seed bank in the soil.

Table 4 - Phytosociological indices of relative frequency (Frr), relative abundance (Abr), relative density (Der), and importance value index (IVI) of weeds in 24 second corn crop production fields in the Middle Paranapanema region in 2008

	Frr	Abr	Der	IVI
Gnaphalium spicatum	17.5065	30.2482	57.1130	104.8677
Digitaria horizontalis	12.0155	14.1436	18.3290	44.4881
Cenchrus echinatus	10.8527	8.6271	10.0981	29.5780
Bidens pilosa	13.3075	3.9844	5.7187	23.0107
Euphorbia heterophylla	5.7494	3.7198	2.3066	11.7758
Raphanus sativus	5.8140	2.4015	1.5059	9.7213
Commelina benghalensis	4.5866	1.6331	0.8079	7.0275
Avena strigosa	1.6796	3.0708	0.5563	5.3067
Sida sp.	3.6822	0.9903	0.3933	5.0658
Richardia brasiliensis	0.3876	4.2718	0.0496	4.7090
Sorghum halepense	1.7442	2.3921	0.4500	4.5862
Leucas martinicensis	1.6150	2.5224	0.4394	4.5767
Glycine max	3.3592	0.6944	0.2516	4.3051
Amaranthus sp.	2.2610	1.1624	0.2835	3.7068
Leonurus sibiricus	0.7752	2.3308	0.1949	3.3009
Acanthospermum hispidum	2.1964	1.0171	0.2409	3.4544
Eleusine indica	1.6150	1.2409	0.2161	3.0720
Phyllanthus tenellus	1.2920	1.2459	0.1736	2.7115
Zea mays	1.6150	0.8950	0.1559	2.6659
Coronopus didymus	0.9690	1.3561	0.1417	2.4668
Sonchus oleraceus	1.5504	0.6357	0.1063	2.2924
Echinochloa crus-galli	0.7106	1.2020	0.0921	2.0047
Emilia sonchifolia	0.9690	0.5764	0.0602	1.6056
Nicandra physaloides	0.7752	0.7204	0.0602	1.5559
Tridax procumbens	0.2584	1.1442	0.0319	1.4345
Brachiaria plantaginea	0.3876	0.9323	0.0390	1.3589
Desmodium tortuosum	0.2584	1.0171	0.0283	1.3038
Chamaesyce hirta	0.3876	0.8476	0.0354	1.2706
Cyperus sp.	0.1938	1.0171	0.0213	1.2322
Ipomoea sp.	0.4522	0.6538	0.0319	1.1379
Parthenium hysterophorus	0.0646	1.0171	0.0071	1.0888
Digitaria insularis	0.2584	0.7628	0.0213	1.0425
Lepidium virginicum	0.3230	0.5085	0.0177	0.8493
Porophyllum ruderale	0.3230	0.5085	0.0177	0.8493

Another important aspect of the survey is regarding the verification of volunteer soybean and corn plants in the assessed areas. These plants are the result of harvest losses in summer crops. However, in comparison with the survey carried out in 1995, in which *Glycine max* was among the most important weed species (Duarte and Deuber, 1999), a positive advance was observed in relation to harvest losses since this species was the 12th, 10th, and 13th in the period from 2006 to 2008, respectively.

Volunteer plants are even more important in production fields where corn and soybean are resistant to glyphosate, being necessary other herbicides for their control. López-Ovejero et al. (2016b) reported that loose grains or lost ears could remain on the soil surface when harvesting the second corn crop tolerant to glyphosate, with a viability of germination and emergence over the dry season (winter period). These grains lead to the establishment of voluntary plants, which causes a significant negative interference in soybean productivity in succession. Thus, these volunteer plants may have increased their importance with the subsequent introduction of the RR second corn crop in the region.

The species *Gnaphalium spicatum* stood out in 2008 with a high IVI (104.9), being found under a high density and frequency in the production fields. This species occurred only from 2007 (IVI = 11.8). A high potential of dissemination was observed for this species, but with a low potential of competition since during the assessment these plants were at an initial development stage, which would limit their competition with corn. This is an annual or biannual plant, 15 to 30 cm high, propagated by seeds, with a clear preference for shaded areas with high contents of organic matter, and vegetative phase in the winter (Lorenzi, 2008). According to Prela-Pantano et al. (2009), the region presents a higher probability of occurrence of minimum temperature between 0 and 5 ^{o}C in July, which may have favored its establishment.

The second most important species in 2008 was *D. horizontalis* (IVI = 44.5). Jakelaitis et al. (2003) reported that the post-emergence mixture of nicosulfuron and atrazine did not provide adequate control of *D. horizontalis*. Considering that these active ingredients were used in the assessed areas, especially atrazine, this may have contributed to the high importance values found for this species in the region. The species *C. echinatus* (IVI = 29.6), *B. pilosa* (IVI = 23.01), and *E. heterophylla* (IVI = 11.8) also stood out.

Although with lower IVI values in 2008, *E. heterophylla* had a prominent position in the surveys. This species has an extraordinary capacity of multiplication, fast growth, and formation of dense stands due to its high seed production and viability under the Brazilian conditions. Its cycle between the emergence and fruiting is short so that two to four generations may occur within a year (Kissmann and Groth, 1999). This species is among the important weeds for soybean cultivation, especially in transgenic production fields, where it has been selected due to its tolerance to glyphosate (Vidal et al., 2007). Thus, *E. heterophylla* must be monitored in the later surveys since the transgenic soybean presented a significant increase of cultivated area in this region.

Regarding the climatic factor in the period from 2006 to 2008, the first year of survey was the worst in terms of productivity of the second corn crop in the region, with frequent soil water deficiencies (data not shown). The best rainfall distribution was observed in 2008 when compared to 2007. However, no precipitation was observed in July, during the surveys. These pluviometric changes may favor the outbreaks of some weeds, in addition to increasing or reducing the competitive potential of the crop with certain plants, which may explain the variations in the species positions in terms of IVI over the assessments. In the samplings carried out in 2006, the driest year, *G. spicatum* was not registered in the survey but became important with the increasing amount and frequency of rainfall from March to June.

In comparison with the assessments of the previous years, *C. echinatus*, at the beginning of the establishment of the second corn crop in 1995 (Duarte and Deuber, 1999), was sixth in frequency (*E. heterophylla* = *G. max* = *C. benghalensis* > *B. pilosa* = *R. sativus* > *C. echinatus*). However, this species became the main weed in the period from 1997 to 1999 (*C. echinatus* > *B. pilosa* > *E. heterophylla* > *R. sativus* > *D. horizontalis* > *C. benghalensis*) (Duarte et al., 2007), being the main species in the assessments carried out from 2006 to 2008. In addition, a reduction in importance of *R. sativus* and an increase in the importance of *D. horizontalis* were observed over the years. This information shows that the grasses were favored from the introduction of the second corn crop, which is a result of the selection pressure exerted by herbicides and management. *E. heterophylla* and *B. pilosa* continued to be important species over the years.

The survey evidenced the initial point of use of the Roundup Ready technology in the region, with no evident changes in the weed community attributed to an increase in production fields with transgenic soybean. These data are an important subsidy for assessments of the impact of transgenic use in the region in the period that follows this survey. During the survey period and soon after, weed resistance to herbicides was intensified in Brazil. According to the Brazilian Herbicide Resistance Action Committee (HRAC-BR, 2017), the following species presented a record of resistance in relation to EPSPs (enolpyruvylshikimate phosphate synthase) inhibitors, to which glyphosate belongs: *Lolium perenne* ssp. *multiflorum* (2003), *Conyza canadensis* (2005), *Digitaria insularis* (2008), *Conyza sumatrensis* (2010), *Chloris elata* (2014), *Amaranthus palmeri* (2015), and *Eleusine indica* (2016).

With the results of this survey, we can conclude that *C. echinatus* is the most important weed species for the second corn crop in the region. *E. heterophylla*, *B. pilosa*, and *D. horizontalis* were frequent species over the assessments. Plants such as *L. sibiricus* and *G. spicatum* stood out, but in general, they presented a low frequency in the area. The most commonly used herbicide was atrazine, with a reduced use of other herbicides. Soil cover showed a high variation, but production fields with a low soil cover predominate. A high advance of transgenic soybean was observed in the region, but no evidence of a consistent change in weed community of the second corn crop was observed over the assessment period that could be attributed to glyphosate use.

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