Acta Scientiarum
http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v40i1.33049
CROP PRODUCTION

Phytosociology of weed in the southwestern Goiás region

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ABSTRACT. Roundup Ready® technology adoption and the cultivation of a second crop have changed chemical control methods and weed management in the southwest region of Goiás State, Brazil. Considering these changes, this study aimed to perform a phytosociological survey in areas with glyphosate resistant soybeans and conventional soybeans as the main harvest and sorghum, maize, millet or fallow in succession as the second harvest. A multivariate matrix of the floristic composition was constructed, and the indicator values of the individual number and dry biomass of species were measured. Based on the number of individuals, the species *Chamaesyce hirta*, *Bidens subalternans*, and *Cissampelos ovolifolia* were typical of areas cultivated with glyphosate-resistant soybean, while *Euphorbia heterophyla* presented indicator values of areas with conventional soybean cultivation. During the second harvest period, significant indicator values were observed for *Crotalaria spectabilis* in maize areas, *Cenchrus echinatus* in sorghum, and *Commelina benghalensis*, *Sida glaziovii*, *Ipomoea grandifolia*, *Sida rhombifolia*, and *Ipomoea cordifolia* in areas with millet. The species *Conyza bonariensis* was typical in the period before the herbicide application at post-emergence in harvest. Volunteer soybean presented as typical for the period before the herbicide application at post-emergence in the second harvest. Weeds that were difficult to control or were tolerant and resistant to the herbicide applications were recorded in the areas studied.

Keywords: soybean, second crop, crop succession, resistance, herbicide.

Fitossociologia de plantas daninhas na região sudoeste de Goiás

RESUMO. A adoção da tecnologia Roundup Ready® e o cultivo de segunda safra alteraram os métodos de controle químico e o manejo das plantas daninhas na região sudoeste do Estado de Goiás, Brasil. Tendo em vista estas alterações, este estudo teve o objetivo de realizar um levantamento fitossociológico em áreas de soja resistente ao glyphosate e soja convencional na safra principal e sorgo, milho, milheto ou pousio em sucessão na segunda safra. Foi constituída uma matriz multivariada da composição florística e calculado o valor indicador do número de indivíduos e biomassa seca das espécies. Com base no número de indivíduos as espécies *Chamaesyce hirta*, *Bidens subalternans* e *Cissampelos ovolifolia* foram típicas de áreas de cultivo com soja resistente ao glyphosate, enquanto que *Euphorbia heterophyla* apresentou valor indicador para áreas de cultivo de soja convencional. Na safrinha, os valores indicadores significativos foram observados para: *Crotalaria spectabilis,* nas áreas de milho; *Cenchrus echinatus* no sorgo; e *Commelina benghalensis*, *Sida glaziovii*, *Ipomoea grandifolia*, *Sida rhombifolia* e *Ipomoea cordifolia*, nas áreas com milheto. A espécie *Conyza bonariensis* foi típica do período que antecede a aplicação de herbicidas em pós-emergência na safra. A soja voluntária apresentou-se como típica para o período que antecede a aplicação de herbicidas em pós-emergência na safrinha. Foram registradas plantas daninhas de difícil controle, tolerantes e resistentes às aplicações de herbicidas nas áreas estudadas.

Palavras-chave: soja, safrinha, sucessão de culturas, resistência, herbicida.

Introduction

Soybean varieties genetically modified for resistance to glyphosate have been available for Brazilian agriculture since 2005. These cultivars have been developed to increase productivity and resistance to various factors, such as use of herbicides, diseases and lodging. However, the use of these cultivars has changed chemical control methods and the management of spontaneous plant communities in different farming systems (Balbinot Jr. & Veiga, 2014).

With the use of Roundup Ready® technology, chemical control mechanisms have a unique action mechanism from glyphosate, which directly influences the establishment of weed plants. This herbicide has a wide action spectrum with favourable environmental characteristics and is effective at weed control. However, in less than a decade, this technology's efficiency has been endangered by the occurrence of weed species that are tolerant and/or resistant to applications of this herbicide (Webster & Sosnoskie, 2010).

Changes in production systems regarding crop and management practices may influence weed species diversity (Clements, Weise, & Swanton, 1994). In American agriculture, the conversion of conventional tillage systems to no-till systems and the intensive use of glyphosate in transgenic cropping has significantly influenced the composition and populations of weeds (Swanton, Clements, & Derksen, 1993; Shaner, 2000).

According to Culpepper, et al. (2006), some strategies are necessary for mitigating the changes in the weed community resulting from the cultivation expansion of materials resistant to glyphosate, such as associating the herbicides with an action method other than glyphosate; rotating cultivars that are resistant to glyphosate with conventional cultivars; and rotating glyphosate with other herbicides with different action mechanisms.

In addition to its use post-emergence in crops with induced resistance, glyphosate is widely used in desiccation operations in pre-planting. Herbicides used in management before crop sowing for the formation of dry biomass on the soil surface are important tools in no-tillage systems, especially desiccants considered to have no residual effects, such as glyphosate and paraquat (Carvalho & Velini, 2001). However, studies have found that in no-tillage systems, some invasive species, such as *Spermacoce latifolia, Synedrellopsis grisebachii, Commelina benghalensis*, and *Tridax procumbens*, have been selected because of successive glyphosate applications in Cerrado agricultural areas (Procópio, Menezes, Betta, & Betta, 2007). Other weed species were also reported as tolerant to this herbicide: *Ambrosia artemisiifolia* (Kapusta, et al., 1994), *Sesbastiania exaltata, Ipomoea* spp. (Jordan & Christoffoleti 1997; Lich, Renner, & Penner, 1997), and *Apocynum cannabinum*, *Asclepsias syriaca* (Wyrill & Burnside, 1976). Until 2016, thirty-six species of weeds resistant to glyphosate in the world had been reported. In Brazil, there are six confirmed resistant biotypes: *Chloris elata*, *Conyza canadensis, Conyza bonariensis, Conyza sumatrensis, Digitaria insularis*, and *Lolium multiflorum* (Heap, 2016).

In the south-western Goiás State region, no-tillage systems with cultivation of two annual harvests are predominant. Soybean is cultivated at the beginning of the rainy season, with maize, sorghum and millet in succession in the second season (off-season), which provides dry biomass production on the soil surface after harvest. Soybean cultivation and crops in the second harvest influence weed establishment, because implementation of diversified cropping systems reduces selection pressure favouring populations of specific weeds and subsequently decreasing the probability of changes in weed flora (Liebman & Dyck, 1993).

Considering the changes in cropping systems in relation to chemical control methods and management from the adoption of soybean cultivars genetically modified for resistance to glyphosate, this study had the objective of performing a phytosociological survey in areas of glyphosate resistant soybean and conventional soybean as main harvest and sorghum, maize, millet and fallow as second crops in the south-western Goiás State region.

Material and methods

The studies were conducted in Goiás Southwest region, in agricultural areas of Rio Verde, Santa Helena de Goiás, Montividiu, and Santo Antonio da Barra municipalities, in the crop year of 2012/2013, from June 2012 to July 2013.

Regarding the Köppen and Gêiser classification, sites present AW climate (tropical climate without precipitation in winter), with average temperatures from 23.0 to 24.3°C and average annual rainfall from 1,510 to 1,663 mm, with the highest concentration in summer. Winters are dry with mild temperatures and no rain from May to September. Soil of the region is Red Latosol distroferric and Red dystrophic (Santos et al., 2011).

Phytosociological surveys were conducted in seven production systems (treatments) with five repetitions at different properties, which had at least three consecutive years of implementation, totalling thirty-five agricultural areas (Table 1). These properties use predominantly the soybean cultivar modified for resistance to glyphosate with Roundup Ready technology (RR soybean) and conventional soybean as the main crop, with successions of maize, sorghum and millet or fallow in the second crop.

The field survey was conducted in three evaluation periods: before desiccation for soybean crop deployment; prior to the first herbicide application at post-emergence in soybean crops at 20 days after sowing; and prior to herbicide application at post-emergence 20 days after second crop deployment, or in a fallow area. Weeds were inventoried from the random release of a hollow frame (0.5 x 0.5 m) in sample areas and phytosociological analysis was based on Braun-Blanquet (1979) methodology.

Table 1. Survey areas for weeds in Goiás Southwest region, where: RR soybean (genetically modified soybean) and CV Soybean (conventional soybean).

	Treatment		Location	Municipality
No.	Soybean/Summer	Late harvest	Coordinates (UTM)	
Treat. 1	RR Soybean	Maize	22 k 482613.93/8100304.26	Montividiu
Treat. 1	RR Soybean	Maize	22 k 540809.09/8008785.91	Rio Verde
Treat. 1	RR Soybean	Maize	22 k 524462.03/8019154.20	Rio Verde
Treat. 1	RR Soybean	Maize	22 k 560434.78/8044516.10	Santa Helena
Treat. 1	RR Soybean	Maize	22 k 528012.52/8021719.00	Rio Verde
Treat. 2	RR Soybean	Millet	22 k 503225.37/8077848.74	Rio Verde
Treat. 2	RR Soybean	Millet	22 k 505769.78/8079871.48	Montividiu
Treat. 2	RR Soybean	Millet	22 k 506350.89/8079876.84	Montividiu
Treat. 2	RR Soybean	Millet	22 k 524439.59/8016860.74	Rio Verde
Treat. 2	RR Soybean	Millet	22 k 482278.90/8083495.89	Montividiu
Treat. 3	RR Soybean	Sorghum	22 k 532499.20/8030623.97	Santa Helena
Treat. 3	RR Soybean	Sorghum	22 k 525340.12/8020605.52	Rio Verde
Treat. 3	RR Soybean	Sorghum	22 k 480231.77/8099772.54	Montividiu
Treat. 3	RR Soybean	Sorghum	22 k 503766.73/8078668.74	Montividiu
Treat. 3	RR Soybean	Sorghum	22 k 560464.02/8042437.67	Santa Helena
Treat. 4	RR Soybean	Fallow	22 k 502135.51/8079836.23	Rio Verde
Treat. 4	RR Soybean	Fallow	22 k 503231.39/8080329.71	Rio Verde
Treat. 4	RR Soybean	Fallow	22 k 481486.73/8099463.40	Montividiu
Treat. 4	RR Soybean	Fallow	22 k 480977.40/8099669.14	Montividiu
Treat. 4	RR Soybean	Fallow	22 k 506231.98/8044023.95	Rio Verde
Treat. 5	CV Soybean	Maize	22 k 500502.47/8079165.26	Montividiu
Treat. 5	CV Soybean	Maize	22 k 500701.46/8079859.67	Montividiu
Treat. 5	CV Soybean	Maize	22 k 526129.0/8018108.76	Rio Verde
Treat. 5	CV Soybean	Maize	22 k 525957.64/8018272.84	Rio Verde
Treat. 5	CV Soybean	Maize	22 k 518887.66/8019237.99	Rio Verde
Treat. 6	CV Soybean	Millet	22 k 525933.31/8018614.52	Rio Verde
Treat. 6	CV Soybean	Millet	22 k 526285.71/8018965.53	Rio Verde
Treat. 6	CV Soybean	Millet	22 k 540987.37/8057939.34	St. Ant. da Barra
Treat. 6	CV Soybean	Millet	22 k 541670.84/8058093.42	St. Ant. da Barra
Treat. 6	CV Soybean	Millet	22 k 541911.35/8057517.36	St. Ant. da Barra
Treat. 7	CV Soybean	Sorghum	22 k 525763.47/8018402.43	Rio Verde
Treat. 7	CV Soybean	Sorghum	22 k 540645.54/8073577.33	St. Ant. da Barra
Treat. 7	CV Soybean	Sorghum	22 k 540331.35/8073928.66	St. Ant. da Barra
Treat. 7	CV Soybean	Sorghum	22 k 507115.76/8044911.38	Rio Verde
Treat. 7	CV Soybean	Sorghum	22 k 506929.16/8044116.21	Rio Verde

RR soybeans (glyphosate-tolerant soybeans with Roundup Ready technology) and CV soybeans (conventional soybeans).

Considering the three seasons of field surveys in each agricultural area of 20 hectares with five repetitions, twenty sampling units were standardized (5 m^2 $season^{-1}$ or 15 m^2 in total), totalling 100 units per treatment (25 m^2 $season^{-1}$ or 75 m^2 in total) and 700 sampling units in each survey stage (175 m^2 $season^{-1}$ or 525 m^2 in total) in 2,100 sampled frame-inventories.

Weeds present in frames were cut close to the soil and transferred to the laboratory for identification and individual number accounting for each species. After botanical identification, they were placed in paper bags to determine shoot dry mass by drying in forced ventilation at 65°C for 72h and weighing on a precision scale.

Field data were processed from PC-ORD Software (McCune & Mefford, 2011). A multivariate matrix for each response variable descriptor of weed floristic composition in the areas studied was formed. Relative structural descriptors (frequency, abundance and indicator value) for shoot dry mass and individual number of species were calculated.

Indicator species analysis was used (Dufrene & Legendre, 1997) to statistically evaluate the occurrence of weed species typical of a certain condition (treatment). This analysis calculates an indicator value, derived from the product between frequency and relative abundance, which is tested regarding statistical significance by Monte Carlo test ($p < 0.05$). As the results of this type of analysis are comparative, the RR soybean + fallow treatment was excluded due to lack of a conventional soybean + fallow treatment for occurrence categorizing. Only indicator values of species are presented in tables.

Results and discussion

Individual numbers and shoot dry biomass were used in an analysis of species occurrence (Table 2). In total, 79 species of weeds were inventoried. The variation in the number of individuals and shoot dry biomass among the evaluation periods was observed and showed predominantly higher values in the period before management desiccation for soybean sowing.

The species *Ageratum conyzoides*, *Brosimum gaudichaudii*, *Digitaria ciliares*, *Hyptis lophanta*, and *Neea theifera* had occurrences of less than 5% and were automatically deleted by the software.

In the comparative data of the number of individuals between soybeans genetically modified for resistance to glyphosate and conventional soybeans, the *C. hirta* species presented a significant indicator value (VI: 49, p: 0.01) as a typical occurrence in areas cultivated with RR soybean (Table 3).

Table 2. Number of individual distribution (NI) and shoot dry biomass (DB) of weed species in the Southwest Goiás Region.

Family	Species	Common name	NI	DB (g)
Poaceae	*Cenchrus echinatus* L.	sandbur, southern	680	1,589.75
Asteraceae	*Conyza bonariensis* (L.) Cronq.	fleabane, hairy	44	398.78
Amaranthaceae	*Alternanthera tenella* Colla	Joyweeds	244	367.41
Malvaceae	*Sida glaziovii* K. Schum	Malva	134	366.72
Asteraceae	*Praxelis pauciflora* (Kunth) R. M. King e H. Rob.	Anil	60	198.82
Commelinacea	*Commelina benghalensis* L.	dayflower, Benghal	261	193.92
Malvaceae	*Malvastrum coromandelianum* (L.) Garcke	False mallow, broom weed	39	152.24
Asteraceae	*Conyza canadensis* (L.) Cronq.	horseweed	48	151.66
Euphorbiaceae	*Chamaesyce hirta* (L.) Mill	spurge, garden	276	146.7
Poaceae	*Eleusine indica* (L.) Gaertn.	goosegrass	112	143.46
Poaceae	*Panicum maximum* Jacq.	see *Urochloa maxima*	13	138.99
Malvaceae	*Sida rhombifolia* L.	sida, arrowleaf	48	136.92
Asteraceae	*Bidens subalternans* DC.	Picão-preto	176	111.68
Asteraceae	*Tridax procumbens* L.	buttons, coat	56	103.21
Poaceae	*Digitaria insularis* (L.) Mez ex Ekman	sourgrass	44	94.55
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	foxtail, knotroot	22	91.71
Smilacaceae	*Smilax polyantha* Griseb.	smilaxes	9	86.61
Fabaceae	*Glycine max* (L.) Merr.	soybean	284	85.89
Cyperaceae	*Cyperus difformis* L.	sedge, smallflower umbrella	85	79.21
Poaceae	*Pennisetum setosum* (Sw). Rich.	Fountain grass	45	74.39
Polygonaceae	*Rumex obtusifolius* L.	dock, broadleaf	2	22.46
Smilacaceae	*Smilax campestris* Griseb.	catbriers, greenbriers, pricklyivys, and smilaxes	3	21.65
Poaceae	*Digitaria ciliaris* (Retz.) Koel.	crabgrass, southern	5	19.51
Solanaceae	*Solanum americanum* P. Mill.	nightshade, American black	5	19.42
Asteraceae	*Acanthospermum hispidum* DC.	starbur, bristly	2	18.65
Boraginaceae	*Heliotropium indicum* L.	heliotrope, Indian	1	16.51
Euphorbiaceae	*Cnidoscolus urens* (L.) Arthur	bull nettle', 'spurge, nettle', or 'mala mujer' (evil woman).	1	15.13
Myrtaceae	*Eugenia* sp.	Cagaita	3	15.03
Lamiaceae	*Leonotis nepetifolia* (L.) R. Br.	Lionsear	12	15.00
Mennispermaceae	*Cissampelos* sp.1	Orelha-de-onça	9	14.73
Malvaceae	*Sida cordifolia* L.	sida, heartleaf	5	12.45
Asteraceae	*Synedrellopsis grisebachii* Hieron & Kuntze	Straggler daisy	3	12.41
Asteraceae	*Bidens pilosa* L.	beggarticks, hairy	6	11.04
Poaceae	*Pennisetum americanum* (L.) Leeke	Millet	16	10.44
Polygonaceae	*Rumex acetosella* L.	sorrel, red	6	9.38
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Birch, bois de fer, bois de Ste. Lucie, bois petite, feuille, guava Berry	2	7.90
Crhysobalanaceae	*Couepia grandiflora* Benth.	Oiti	1	7.63
Lamiaceae	*Heteropterys* sp.	-----	3	7.29
Malvaceae	*Sida urens* L.	Tropical fanpetals, balaizortie	3	7.19
Rubiaceae	*Spermacoce latifolia* Aubl.	Buttonweed	7	7.19
Fabaceae	*Senna obtusifolia* (L.) H. S. Irwin & Barneby	Sicklepod	33	73.24
Mennispermaceae	*Cissampelos* sp.2	Orelha-de-onça	10	60.95
Poaceae	*Rhynchelytrum repens* (Willd.) C. E. Hubbard	see *Melinis repens*	15	49.93
Asteraceae	*Emilia fosbergii* Nichols.	Cupid's-shaving-brush	6	47.97
Asteraceae	*Gnaphalium coarctatum* Willd	Cudweed	22	43.29
Convolvulaceae	*Ipomoea grandifolia* L.	Morning glory, sweet, potato, bindweed,moonflower	65	42.00
Fabaceae	*Crotalaria spectabilis* Roth	crotalaria, showy	15	40.78
Smilacaceae	*Smilax brasiliensis* Spreng.	Catbriers, greenbriers, prickly-ivys, or, smilaxes	5	39.41
Poaceae	*Sorghum halepense* (L.) Pers.	johnsongrass	1	38.00
Rubiaceae	*Richardia brasiliensis* (Moq.) Gomez	pusley, Brazil	14	37.15
Euphorbiaceae	*Euphorbia heterophylla* L.	poinsettia, wild	100	35.82
Poaceae	*Urochloa* sp.	signalgrass, Dominican	11	35.19
Lamiaceae	*Mimosa hirsutissima* Mart.	Malicia	5	35.11
Amaranthaceae	*Amaranthus viridus* L.	amaranth, slender	13	33.79
Convolvulaceae	*Ipomoea cordifolia* L. (triloba)	Heart-leaved morning glory	46	33.49
Fabaceae	*Andira vermifuga* Mart. Ex Benth.	Angelim-do-cerrado	4	30.74
Mennispermaceae	*Cissampelos ovolifolia* DC.	Orelha-de-onça	8	28.41
Asteraceae	*Vernonia ferruginea* Less.	ironweed	2	28.20
Poaceae	*Digitaria insularis* (L.) Mez ex Ekman	sourgrass	21	26.81
Poaceae	*Zea mays* L.	corn, volunteer	16	24.07
Simaroubaceae	*Simaba* sp.	-----	1	6.72
Fabaceae	*Crotalaria incana* L.	Woolly rattlepod	1	6.68
Fabaceae	*Indigofera hirsuta* Harvey	indigo, hairy	6	5.61
Rubiaceae	*Spermacoce verticilata* L.	Shrubby false buttonweed	3	4.79
Smilacaceae	*Smilax ovolifolia* Roxb.	Common name, include catbriers, greenbriers, pricklyivys, and smilaxes	1	4.69
Moraceae	*Brosimum gaudichaudii* Trécul.	mama-cadela	1	4.03
Nyctaginaceae	*Neea theifera Oerst.*	nia, neea, or saltwood.	2	3.83
Malvaceae	*Sida spinosa* L.	Prickly fanpetals	1	1.75

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Family	Species	Common name	NI	DB (g)
Asteraceae	*Ageratum conyzoides* L.	ageratum, tropic	1	1.40
Malvaceae	*Pavonia rosa-campestris* A. St. Hill	Rosa-vermelha	3	1.24
Asteraceae	*Cresta sphaerocephala* DC	João-bobo	1	1.20
Lamiaceae	*Hyptis lophanta* Mart. Ex Benth	Bushmint	1	1.16
Cyperaceae	*Cyperus odoratus* L.	Flatsedge	1	1.05
Euphorbiaceae	*Phyllanthus tenellus* Roxb.	Phyllanthus, long-stalked	2	0.93
Anacardiaceae	*Lithraea molleoides* (Vell.) Engl.	Aroeira-brava	1	0.90
Connaraceae	*Connarus suberosus* L.	Pau-de-brinco	1	0.85
Vochysiaceae	*Qualea parviflora* Mart.	Pau-terra	1	0.45
Caesalpiniaceae	*Bauhinia* sp.	Orchid tree	1	0.31
Malvaceae	*Gossypum hirsutum* L.	Upland cotton or Mexican, cotton	3	0.19
	Total		3,219	5,815.74

Table 3. Indicator values (VI) of weeds, divided into two groups: Group 1 (areas with soybean crops resistant to glyphosate and Group 2 (areas with conventional soybean crops) in the Southwest region of Goiás. Calculations based on number of individuals (VI/NI) and dry biomass of species (VI/DB).

Species	Soybean type									
	VI/NI			MC		VI/DB			MC	
	GD	1	2	DP	P*	GD	1	2	DP	P*
Acanthospermum hispidum	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Alternanthera tenella	1	21	11	3.83	0.37	1	17	14	4.21	0.84
Amaranthus viridis	1	4	2	2.15	0.88	2	1	4	2.28	0.88
Andira vermifuga	2	1	1	1.48	1.00	2	0	2	1.17	1.00
Bauhinia sp.	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Bidens pilosa	1	4	0	1.30	0.49	1	4	0	1.33	0.49
Bidens subalternans	1	35	10	4.47	0.06	1	38	8	5.20	0.04
Cenchrus echinatus	2	34	44	3.78	0.46	2	32	46	6.16	0.51
Chamaesyce hirta	1	49	16	4.35	0.01	1	51	14	4.84	0.01
Cissampelos sp.1	2	2	4	2.07	0.94	2	2	4	2.15	0.68
Cissampelos sp.2	2	1	3	1.97	0.73	2	0	4	2.04	0.62
Cissampelus ovolifolia	1	11	0	2.24	0.05	1	11	0	2.25	0.06
Cnidoscolus urens	2	0	2	0.03	1.00	2	0	2	0.03	1.00
Commelina benghalensis	1	31	31	4.09	0.95	2	27	35	5.54	0.69
Connarus suberosus	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Conyza bonariensis	2	4	6	3.09	0.84	2	2	8	3.37	0.77
Conyza canadensis	1	5	4	2.75	0.87	2	2	6	3.10	0.85
Couepia grandifolia	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Cresta sphaerocephala	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Crotalaria incana	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Crotalaria spectabilis	1	9	0	2.09	0.12	1	9	0	2.12	0.12
Cyperus odoratus	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Cyperus difformis	2	7	20	3.40	0.19	2	7	20	3.54	0.18
Digitaria horizontalis	1	6	3	2.64	0.65	1	5	4	2.63	0.83
Digitaria insularis	1	4	3	2.30	1.00	1	3	3	2.26	1.00
Eleusine indica	1	32	12	4.49	0.12	1	34	10	4.43	0.06
Emilia fosbergii	2	0	4	1.48	0.50	2	0	4	1.20	0.49
Eugenias sp.	2	1	3	1.57	1.00	2	1	2	1.77	1.00
Euphorbia heterophyla	2	5	27	3.84	0.06	2	11	20	4.88	0.50
Glycine max	1	18	13	3.56	0.62	1	23	7	3.83	0.18
Gnaphalium coarctatum	2	1	6	2.34	0.45	2	0	8	2.72	0.34
Gossypum hirsutum	1	4	0	1.56	0.50	1	4	0	1.21	0.48
Heliotropium indicum	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Heteropteris sp.	1	4	0	1.48	0.48	1	4	0	1.34	0.50
Indigofera hirsuta	1	7	0	1.65	0.23	1	7	0	1.75	0.25
Ipomoea cordifolia	2	8	9	3.14	0.95	2	4	13	3.94	0.43
Ipomoea grandifolia	1	21	5	3.90	0.14	1	19	6	4.40	0.30
Leonotis nepetifolia	1	7	2	2.48	0.51	1	8	0	2.88	0.30
Lithraea molleoides	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Malvastrum coromamdelianum	1	10	7	3.04	0.69	1	12	5	3.40	0.51
Mimosa hirsutissima	1	3	1	1.62	1.00	2	1	2	1.87	1.00
Myrcia guianensis	1	4	0	1.67	0.49	1	4	0	1.18	0.49
Panicum maximum	1	9	1	2.76	0.49	1	11	0	2.85	0.13
Pavonia rosa-campestris	1	4	0	1.48	0.49	1	4	0	1.32	0.49
Pennisetum americanum	1	4	1	2.04	0.62	1	3	1	2.08	0.88
Pennisetum setosum	1	10	2	3.28	0.46	1	8	5	3.44	0.71
Phyllanthus tenellus	1	1	1	1.67	1.00	2	1	1	1.56	1.00
Praxelis pauciflora	1	6	5	3.17	0.96	2	5	6	3.41	0.93
Qualea parviflora	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Rhynchelytrum repens	1	9	0	1.95	0.11	1	9	0	2.00	0.12
Richardia brasiliensis	2	2	4	2.24	0.70	2	2	5	2.35	0.67
Rumex acetoselha	2	0	4	1.67	0.50	2	0	4	1.39	0.48

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Species	Soybean type									
	VI/NI			MC		VI/DB			MC	
	GD	1	2	DP	P*	GD	1	2	DP	P*
Rumex obtusifolius	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Senna obtusifolia	2	3	18	3.45	0.13	2	3	18	3.71	0.13
Setaria parviflora	1	6	4	2.67	0.80	1	8	2	3.01	0.52
Sida cordifolia	1	2	0	1.33	1.00	1	2	0	1.14	1.00
Sida glaziovii	2	14	14	3.90	0.99	2	11	17	4.00	0.62
Sida rhombifolia	1	13	5	3.35	0.34	1	11	6	3.45	0.55
Sida spinosa	2	0	2	0.03	1.00	2	0	2	0.03	1.00
Sida urens	1	4	0	1.67	0.50	1	4	0	1.29	0.49
Simaba sp.	1	4	0	1.67	0.49	1	4	0	1.23	0.51
Smilax brasiliensis	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Smilax campestris	1	9	0	1.93	0.11	1	9	0	2.04	0.12
Smilax ovolifolia	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Smilax polyantha	2	0	7	1.75	0.25	2	0	7	1.80	0.24
Solanum americanum	2	0	2	0.03	1.00	2	0	2	0.03	1.00
Sorghum halepense	2	0	2	0.03	1.00	2	0	2	0.03	1.00
Spermacoce latifolia	2	0	5	1.94	0.49	2	1	4	1.95	0.62
Spermacoce verticilata	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Synedrellopsis grisebachii	1	2	0	0.03	1.00	1	2	0	0.03	1.00
Tridax procumbens	1	14	4	3.35	0.34	1	11	6	3.48	0.62
Urochloa decumbens	1	6	1	2.14	0.35	1	6	1	2.22	0.37
Vernonia ferruginea	1	4	0	1.67	0.49	1	4	0	1.51	0.49
Zea mays	2	1	3	1.68	0.76	1	2	0	1.64	1.00

GD: group of dominance of specie - DP: standard deviation - P*: probability - MC: Monte Carlo test.

Bidens subalternans (VI: 35) and *Cissampelos ovolifolia* (VI: 11) are indicative of RR soybean areas, and *Euphorbia heterophyla* (VI: 5) is indicative of conventional soybean areas. Those species showed marginally significant indicator values ($p < 0.10$). However, it is worth noting that these very low indicator values were observed for *C. ovolifolia* and *E. heterophyla* (Table 3). The marginal significance of *C. ovolifolia* was because, although all recorded subjects of this species have been observed in RR soybean, these were found in only 11% of plots under this type of soybean. *E. heterophyla*, accounted for 80% of counted subjects that were observed under conventional soybean, however being in only 27% of evaluated plots under this type of soybean this relative frequency contributed to the low indicator value.

Regarding the weed dry biomass for the two types of soybeans, only *C. hirta* (VI: 51, p: 0.01) and *B. subalternans* (VI: 38, p: 0.04) had indicator value for areas cultivated with RR soybean (Table 3). From the total shoot dry mass obtained from *C. hirta*, 74% was found in areas of RR soybean and 26% in areas of conventional soybean. *B. subalternans* data show that 71% of shoot dry mass was found in areas of RR soybean and 29% where conventional soybean was cultivated. Regarding the relative frequency of *B. subalternans*, its presence was observed in 53% of samples from areas of RR soybean but only 29% of samples from conventional soybean areas.

Eleusine indica (VI: 34) and *C. ovolifolia* (VI: 11) species showed marginally significant indicator values ($p < 0.10$), being more typical in areas under RR soybean (Table 3). However, it is worth noting the very low indicator values observed for *C. ovolifolia,* as already reported when the data were analysed regarding number of individuals. For *E. indica,* 67% of recorded shoot dry mass was observed in RR soybean, often in 51% of evaluated samples. By using shoot dry mass for this type of analysis, no species showed as typical from environments cultivated with conventional soybeans.

In the comparative analysis for the number of individuals in relation to the second crop, it is noticed that only *C. spectabilis* had a significant indicator value (VI: 13, p: 0.03) for areas with maize as second harvest (Table 4). This result is mainly due to the relative abundance data on this species, because 100% of individuals were detected in areas cultivated with maize in the off - season. This variable was strong enough to promote significance because this species was observed in only 13% of the samples in maize areas. In general, traditional cultures deficient in soil plant cover such as maize result in increased presence of weeds (Concenço, Ceccon, Correia, Leite, & Alves, 2013). Even though maize can produce significant amounts of dry mass, the coverage provided by this culture may be deficient because the biomass is significantly concentrated in stems with few leaves covering the soil to prevent germination and seedling growth (Andrade, 1995). In addition, high temperatures and humidity increase decomposition rates in the Cerrado region.

Based on Monte Carlo testing, it was significant, as typical for millet areas, for the following species *C. benghalensis* (VI: 40, p: 0.01), *S. glaziovii* (VI: 30, p: 0.01), *I. grandifolia* (VI: 24, p: 0.04), *S. rhombifolia* (VI: 23, p: 0.01), *I. cordifolia* (VI: 20, p: 0.02), and *C. bonariensis* (VI: 17, p: 0.04) (Table 4). This demonstrates the increased population of broadleaf weeds in millet fields due to the reduced use of herbicides in the study areas. However, millet, despite its high growth rate, is less efficient at invasive suppression due to its erect sub-shrubby development, reducing the coating capacity of the soil surface. Another factor that decreases millet's efficiency is its slow initial growth favouring weed competition (Alvarenga, Cabezas, Cruz, & Santana, 2001).

Table 4. Indicator values (VI) of weeds divided into three groups: Group 1 (off season with maize), Group 2 (off season with millet) and Group 3 (off season with sorghum), in Southwest Goiás. Calculations based on number of individuals (VI/NI) and dry biomass of species (VI/DB).

Species	Off season type											
	VI/NI				MC		VI/DB				MC	
	GD	1	2	3	DP	P*	GD	1	2	3	DP	P*
Acanthospermum hispidum	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Alternanthera tenella	2	9	21	4	3.93	0.15	2	9	21	4	4.41	0.18
Amaranthus viridis	1	8	0	1	2.71	0.17	1	9	0	1	3.06	0.35
Andira vermifuga	1	7	0	0	2.08	0.33	1	7	0	0	1.65	0.33
Bauhinia sp.	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Bidens pilosa	1	3	1	0	1.82	1.00	1	3	1	0	1.88	1.00
Bidens subalternans	3	12	7	22	4.72	0.36	3	18	6	18	5.29	0.77
Cenchrus echinatus	3	28	13	41	3.56	0.02	3	19	12	51	6.18	0.02
Chamaesyce hirta	1	25	15	21	4.28	0.63	1	23	16	22	4.77	0.89
Cissampelos sp.1	1	11	0	1	2.64	0.07	1	10	0	1	2.76	0.10
Cissampelos sp.2	3	1	0	3	2.50	0.92	3	1	0	4	2.80	0.55
Cissampelus ovolifolia	1	4	0	2	2.78	0.82	1	2	1	2	2.77	0.95
Cnidoscolus urens	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Commelina benghalensis	2	21	40	8	3.96	0.01	2	13	48	9	5.69	0.01
Connarus suberosus	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Conyza bonariensis	2	0	17	0	3.77	0.04	2	0	20	0	4.25	0.04
Conyza canadensis	2	5	7	0	3.23	0.54	2	3	10	0	3.71	0.30
Couepia grandifolia	3	0	0	3	0.05	1.00	3	0	0	3	0.05	1.00
Cresta sphaerocephala	3	0	0	3	0.05	1.00	3	0	0	3	0.05	1.00
Crotalaria incana	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Crotalaria spectabilis	1	13	0	0	2.65	0.03	1	13	0	0	2.84	0.03
Cyperus odoratus	3	0	0	3	0.05	1.00	3	0	0	3	0.05	1.00
Cyperus difformis	3	7	8	9	3.67	0.99	1	10	7	7	3.79	0.86
Digitaria horizontalis	2	0	8	3	3.30	0.43	2	1	6	2	3.20	0.63
Digitaria insularis	1	4	2	2	2.80	0.86	1	3	1	2	2.86	0.87
Eleusine indica	1	27	1	21	4.60	0.11	3	23	2	23	4.62	0.26
Emilia fosbergii	2	0	7	0	2.09	0.33	2	0	7	0	1.70	0.34
Eugenias sp.	1	4	0	1	2.42	0.78	1	3	0	2	2.43	0.77
Euphorbia heterophyla	3	15	1	21	4.00	0.13	3	9	1	26	5.31	0.08
Glycine max	3	9	8	13	3.74	0.81	3	10	9	11	4.12	0.95
Gnaphalium coarctatum	2	2	4	0	2.98	0.80	2	1	6	0	3.33	0.47
Gossypum hirsutum	1	2	0	1	2.17	1.00	3	0	0	3	1.70	1.00
Heliotropium indicum	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Heteropteris sp.	2	0	2	1	2.11	1.00	2	0	3	1	1.87	1.00
Indigofera hirsuta	1	10	0	0	2.31	0.10	1	10	0	0	2.40	0.11
Ipomoea cordifolia	2	7	20	0	3.52	0.02	2	3	27	0	4.72	0.01
Ipomoea grandifolia	2	4	24	2	4.28	0.04	2	6	16	3	5.02	0.33
Leonotis nepetifolia	2	1	4	3	3.03	0.90	2	0	9	0	3.59	0.26
Lithraea molleoides	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Malvastrum coromamdelianum	3	6	3	7	3.40	0.90	2	4	6	6	3.82	0.98
Mimosa hirsutissima	2	1	5	0	2.36	0.34	2	0	7	0	2.52	0.32
Myrcia guianensis	2	0	2	2	2.35	1.00	3	0	0	3	1.65	1.00
Panicum maximum	1	13	1	0	3.42	0.15	1	12	0	1	3.52	0.10
Pavonia rosa-campestris	1	2	0	1	2.08	1.00	3	1	0	3	1.86	1.00
Pennisetum americanum	3	0	0	6	2.75	0.40	3	1	0	5	2.73	0.69
Pennisetum setosum	3	4	1	8	4.05	0.65	3	3	2	7	4.05	0.78
Phyllanthus tenellus	1	2	2	0	2.34	1.00	2	1	2	0	2.19	1.00
Praxelis pauciflora	1	5	5	2	3.72	0.94	1	6	4	1	4.06	0.83
Qualea parviflora	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Rhynchelytrum repens	3	0	0	5	2.66	0.40	3	0	1	4	2.66	0.71
Richardia brasiliensis	2	3	7	0	2.83	0.29	2	4	6	0	2.88	0.46
Rumex acetoselha	1	2	0	2	2.33	1.00	3	1	0	3	1.95	1.00
Rumex obtusifolius	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Senna obtusifolia	2	8	14	1	3.86	0.27	2	6	13	2	4.06	0.36
Setaria parviflora	2	4	7	1	3.12	0.60	2	1	10	1	3.74	0.29
Sida cordifolia	2	1	3	0	1.85	1.00	2	0	3	0	1.61	1.00
Sida glaziovii	2	5	30	2	4.18	0.01	2	2	37	2	4.25	0.00
Sida rhombifolia	2	3	23	0	3.64	0.01	2	5	21	0	3.71	0.02
Sida spinosa	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Sida urens	2	0	2	2	2.36	1.00	2	0	3	1	1.81	1.00
Simaba sp.	3	0	0	7	2.35	0.33	3	0	0	7	1.74	0.33
Smilax brasiliensis	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Smilax campestris	1	4	1	1	2.42	0.77	1	3	1	1	2.58	0.64

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Species	Off season type											
	VI/NI				MC		VI/DB				MC	
	GD	1	2	3	DP	P*	GD	1	2	3	DP	P*
Smilax ovolifolia	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Smilax polyantha	1	10	0	0	2.41	0.11	1	10	0	0	2.49	0.10
Solanum americanum	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Sorghum halepense	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Spermacoce latifolia	1	8	0	1	2.45	0.24	1	6	0	1	2.52	0.32
Spermacoce verticilata	3	0	0	3	0.05	1.00	3	0	0	3	0.05	1.00
Synedrellopsis grisebachii	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Tridax procumbens	2	3	14	2	3.88	0.21	2	3	11	3	3.77	0.38
Urochloa decumbens	1	6	2	0	2.71	0.38	1	4	4	0	2.86	0.67
Vernonia ferruginea	2	0	7	0	2.33	0.32	2	0	7	0	2.13	0.33
Zea mays	1	10	0	0	2.32	0.09	1	10	0	0	2.25	0.10

GD: group of dominance of specie - DP: standard deviation - P*: probability - MC: Monte Carlo test.

The predominant and typical species of sorghum areas was *C. echinatus* (VI: 41, p: 0.02). The lack of graminicides and selectivity for sorghum may be associated with this result. Regarding reduced weed populations in the three analysed crops, maize and millet showed greater diversity and number of individuals. The presence of sorghum straw on the soil surface plays an important role in weed control due to physical and allelopathic effects (Theisen, Vidal, & Fleck, 2000; Alvarenga et al., 2001; Favero, Jucksch, Alvarenga, & Costa, 2001), allowing reduction or even cessation of herbicide use. However, the smallest species diversity in sorghum areas may be associated with higher selection pressure with few dominant species in the analysed areas.

Concerning dry biomass, also in relation to the type of cultivation in off-season, only *C. spectabilis* had a significant indicator value for maize areas based on dry weight of shoots, with the same indicator value and significance level (VI: 13, p: 0.03) (Table 4). In maize crops, at Sete Lagoas – Minas Gerais State, Oliveira, Alvarenga, Oliveira, and Cruz (2001) reported the occurrence of *D. horizontalis, C. echinatus, Urochloa plantaginea, Setaria. geniculata, Ipomoea* sp., *Euphorbia* spp., *R. brasiliensis*, *B. Pilosa*, and *A. conyzoides* species. These data were similar to this study except for *U. plantaginea, S. Geniculata*, and *A. conyzoides*, which did not occur in the areas of second-crop maize in this survey.

For millet areas, the typical species were *C. benghalensis* (VI: 48, p: 00.1), *S. glaziovii* (VI: 37, p: 0.01), *I. cordifolia* (VI: 27, p: 0.01), *S. rhombifolia* (VI: 21, p: 0.02), and *C. bonariensis* (VI: 20, p: 0.04) (Table 4). According to Pasqualetto, Costa, Silva, and Sediyama (2001), when using millet as a second crop culture there is a prevalence of dicotyledonous weeds in crops in sequence. This may be associated with non-use of herbicides in millet, or even with late applications, in which some species are not controlled.

In sorghum areas *C. echinatus* had the highest indicator value, being the only species with validation by Monte Carlo test as typical of this environment (VI: 51, p: 0.02). The results confirmed that *C. echinatus* is the most difficult weed to control in sorghum crops due to the low control efficiency of atrazine for this species, one of the few herbicides available for use on this crop. *C. echinatus,* besides being an important weed both in summer and in "off - season" crops, is one of the more difficult plants to control in sorghum and millet crops (Duarte, Silva, & Deuber, 2007; Abit, et al., 2009). Moreover, it is also a problem in the Cerrado region due to its restrictions or even the absence of herbicides recorded with selective graminicide action for these crops (Dan et al., 2011a).

Regarding the number of individuals and seasons of the survey, a greater number of individuals was verified in the first evaluation, a period that preceded pre-planting desiccation (Table 5).

Typical species for the period prior to desiccation for soybean planting or early spring were: *A. tenella* (VI: 27, p: 0.02), *A. viridis* (VI: 17, p: 0.01), *C. echinatus* (VI: 42, p: 0.01), *C. hirta* (VI: 45, p: 0.01), *Cissampelos* sp.1 (VI: 17, p: 0.01), *Cissampelos* sp.2 (VI: 13, p: 0.03), *C. canadensis* (VI: 30, p: 0.01), *G. coarctatum* (VI: 20, p: 0.01), *M. coromandelianum* (VI: 50, p: 0.01), *P. maximum* (VI: 17, p: 0.04), *P. pauciflora* (VI: 37, p: 0.01), *R. repens* (VI: 13, p: 0.03), *S. obtusifolia* (VI: 24, p: 0.01), *S. parviflora* (VI: 30, p: 0.01), *S. glaziovii* (VI: 53, p: 0.01), *S. rhombifolia* (VI: 30, p: 0.01), and *T. procumbens* (VI: 36, p: 0.01). The occurrence of these species may be associated with the capacity for survival and multiplication in the fallow period that extends from the second crop harvest until desiccation of main crop.

Table 5. Indicator values (VI) of weeds, divided into three groups: Group 1 (survey in September/October), Group 2 (survey in November) and Group 3 (survey in March). Calculations based on numbers of individuals (VI/NI) and dry biomass of species (VI/DB).

Species	Evaluation time											
	VI/NI				MC		VI/DB				M	
	GD	1	2	3	DP	P*	GD	1	2	3	DP	P*
Acanthospermum hispidum	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Alternanthera tenella	1	27	7	3	4.06	0.02	1	30	7	1	4.51	0.02
Amaranthus viridis	1	17	0	0	2.70	0.01	1	17	0	0	3.09	0.01
Andira vermifuga	1	7	0	0	2.08	0.32	1	7	0	0	1.65	0.33
Bauhinia sp.	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Bidens pilosa	1	7	0	0	1.83	0.33	1	7	0	0	1.88	0.33
Bidens subalternans	1	16	14	10	4.63	0.87	1	18	14	7	5.35	0.76
Cenchrus echinatus	1	42	10	32	3.54	0.01	1	77	5	5	6.08	0.00
Chamaesyce hirta	1	45	7	17	4.19	0.00	1	45	6	19	4.87	0.01
Cissampelos sp.1	1	17	0	0	2.65	0.01	1	17	0	0	2.76	0.01
Cissampelos sp.2	1	13	0	0	2.46	0.03	1	13	0	0	2.81	0.04
Cissampelus ovolifolia	1	8	0	0	2.86	0.40	1	9	0	0	2.85	0.11
Cnidoscolus urens	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Commelina benghalensis	2	9	33	24	4.01	0.10	2	16	28	15	5.61	0.61
Connarus suberosus	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Conyza bonariensis	2	0	17	2	3.74	0.05	2	0	20	0	4.26	0.02
Conyza canadensis	1	30	0	0	3.31	0.00	1	30	0	0	3.69	0.00
Couepia grandifolia	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Cresta sphaerocephala	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Crotalaria incana	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Crotalaria spectabilis	1	3	2	0	2.67	0.93	2	2	2	0	2.84	1.00
Cyperus odoratus	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Cyperus difformis	1	14	10	2	3.75	0.39	2	11	13	2	3.86	0.56
Digitaria horizontalis	3	2	0	14	3.22	0.06	3	5	0	8	3.10	0.35
Digitaria insularis	3	0	4	6	2.88	0.43	3	0	3	7	2.77	0.27
Eleusine indica	3	14	9	17	4.59	0.76	1	28	4	13	4.58	0.08
Emilia fosbergii	1	7	0	0	2.09	0.33	1	7	0	0	1.68	0.32
Eugenias sp.	1	10	0	0	2.36	0.10	1	10	0	0	2.39	0.10
Euphorbia heterophyla	1	23	6	5	3.99	0.06	1	38	3	1	5.22	0.00
Glycine max	3	0	0	90	3.71	0.00	3	0	0	90	3.97	0.00
Gnaphalium coarctatum	1	20	0	0	2.96	0.00	1	20	0	0	3.31	0.00
Gossypum hirsutum	1	7	0	0	2.19	0.33	1	7	0	0	1.70	0.32
Heliotropium indicum	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Heteropteris sp.	1	7	0	0	2.09	0.33	1	7	0	0	1.88	0.33
Indigofera hirsuta	2	1	4	0	2.34	0.54	2	2	3	0	2.39	0.76
Ipomoea cordifolia	3	4	0	26	3.47	0.00	3	9	0	11	4.62	0.55
Ipomoea grandifolia	2	8	21	1	4.19	0.07	1	17	15	0	4.98	0.33
Leonotis nepetifolia	1	7	5	0	3.08	0.49	1	13	1	0	3.61	0.12
Lithraea molleoides	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Malvastrum coromamdelianum	1	50	0	0	3.44	0.00	1	50	0	0	3.84	0.00
Mimosa hirsutissima	1	10	0	0	2.38	0.11	1	10	0	0	2.53	0.11
Myrcia guianensis	1	7	0	0	2.36	0.33	1	7	0	0	1.66	0.32
Panicum maximum	1	17	1	0	3.43	0.04	1	19	0	0	3.41	0.01
Pavonia rosa-campestris	1	7	0	0	2.09	0.33	1	7	0	0	1.86	0.33
Pennisetum americanum	2	1	6	0	2.75	0.39	2	2	5	0	2.82	0.71
Pennisetum setosum	2	5	13	0	3.88	0.24	2	9	9	0	4.16	0.51
Phyllanthus tenellus	1	7	0	0	2.35	0.33	1	7	0	0	2.22	0.34
Praxelis pauciflora	1	37	0	0	3.69	0.00	1	37	0	0	4.10	0.00
Qualea parviflora	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Rhynchelytrum repens	1	13	0	0	2.70	0.04	1	13	0	0	2.71	0.03
Richardia brasiliensis	1	4	1	2	2.90	0.80	1	5	1	1	2.88	0.64
Rumex acetoselha	1	2	0	2	2.34	1.00	3	1	0	3	1.95	1.00
Rumex obtusifolius	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Senna obtusifolia	1	24	1	2	3.73	0.01	1	25	2	0	4.22	0.01
Setaria parviflora	1	30	0	0	3.12	0.00	1	30	0	0	3.74	0.00
Sida cordifolia	1	7	0	0	1.87	0.32	1	7	0	0	1.59	0.32
Sida glaziovii	1	53	4	0	4.08	0.00	1	42	8	0	4.33	0.00
Sida rhombifolia	1	30	2	0	3.70	0.00	1	24	5	0	3.74	0.01
Sida spinosa	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Sida urens	1	7	0	0	2.36	0.33	1	7	0	0	1.80	0.32
Simaba sp.	1	7	0	0	2.33	0.32	1	7	0	0	1.73	0.33
Smilax brasiliensis	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Smilax campestris	1	8	1	0	2.49	0.26	1	9	0	0	2.63	0.11
Smilax ovolifolia	2	0	3	0	0.05	1.00	2	0	3	0	0.05	1.00
Smilax polyantha	1	10	0	0	2.36	0.10	1	10	0	0	2.47	0.10
Solanum americanum	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Sorghum halepense	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Spermacoce latifolia	3	1	0	6	2.50	0.33	3	1	0	7	2.56	0.18
Spermacoce verticilata	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Synedrellopsis grisebachii	1	3	0	0	0.05	1.00	1	3	0	0	0.05	1.00
Tridax procumbens	1	36	0	0	3.83	0.00	1	32	1	0	3.80	0.00
Urochloa decumbens	1	8	0	0	2.64	0.17	1	7	1	0	2.71	0.26
Vernonia ferruginea	1	2	2	0	2.34	1.00	1	2	1	0	2.12	1.00
Zea mays	2	0	10	0	2.35	0.10	2	0	10	0	2.23	0.10

GD: group of dominance of specie - DP: standard deviation - P*: probability - MC: Monte Carlo test.

In the second seasons of the survey, in the period that precedes the spraying of herbicides on soybean crops at post-emergence, *C. bonariensis* was the only species with indicator validated by Monte Carlo test (VI: 17, p: 0.05). Due to the use of glyphosate in desiccation and multiplication of *C. bonariensis* biotypes with herbicide resistance, this species has been highlighted in soybean areas cultivated with varieties resistant to this herbicide, which may be associated with its occurrence in the areas of the study. This reflects the need for changes in management and control practices to reduce the occurrence of this species (Vargas et al., 2013).

Glycine max (VI: 90, p: 0.01) and *I. cordifolia* (VI: 26, p: 0.01) were typically occurring species in the period from the beginning of the second harvest. Problems with infestation of volunteer soybean plants in off-season crops have been intensifying in recent years, resulting in concerns related to the empty sanitary period. Often the need to perform harvesting in a short time, due to the installation of off - season crops, even in the rainy season with the occurrence of crop losses, has helped to aggravate this problem, thus enabling soybean to be invasive in second harvest crops. Atrazine has been the most suitable agent for the control of volunteer soybean plants (Dan et al., 2011b), whereas most of the agricultural areas are cultivated with modified soybeans for resistance to glyphosate. The species *I. cordifolia* has been characterized as tolerant to several herbicides, including glyphosate, which enables this species to multiply and increase its population in the off - season.

Regarding the comparative description of dry biomass in relation to the seasons of the survey, in the first evaluation (before desiccation for soybean seeding) the species *A. tenella* (VI: 30, p: 0.02), *A. viridis* (VI: 17, p: 0.01), *C. echinatus* (VI: 77, p: 0.01), *C. hirta* (VI: 45, p: 0.01), *Cissampelos* sp.1 (VI: 17, p: 0.01), *Cissampelos* sp.2 (VI: 13, p: 0.02), *C. canadensis* (VI: 30, p: 0.01), *E. heterophyla* (VI: 38, p: 0.01), *G. coarctatum* (VI: 20, p: 0.01), *M. coromandelianum* (VI: 50, p: 0.01), *P. maximum* (VI: 19, p: 0.01), *P. pauciflora* (VI: 37, p: 0.01), *R. repens* (VI: 13, p: 0.03), *S. obtusifolia* (VI: 25, p: 0.01), *S. parviflora* (VI: 30, p: 0.01), *S. glaziovii* (VI: 42, p: 0.01), *S. rhombifolia* (VI: 24, p: 0.01), and *T. procumbens* (VI: 32, p: 0.01) were the typical plants occurring at that season (Table 5).

In the second evaluation (before application of herbicides at post-emergence), the indicator value was lower compared to the first epoch, and it could have been influenced by lower developmental stage of weeds, thus less dry biomass formation by weeds. However, this hypothesis seems to have had no great influence, because the analysis using shoot dry weight showed the same result as the analysis performed by plant counting. Among the species with predominance in group two, only *C. bonariensis* presented significance to be identified as typical of this time of occurrence (VI: 20, p: 0.02).

Voluntary soybeans were again characterized as typical weeds in the off-season period in analyses performed based on shoot dry weight (VI: 90, p: 0.01) (Table 5). It is clear that the number of species found considerably decreased over the evaluation periods, with stabilization occurring and permanence of some species between the second and third time. This can be explained due to the differences in chemical control performance and soil coverage by soybean. Before the first assessment or any chemical weed control was carried out, at this period areas are discovered without agriculture presence for a longer time. Furthermore, decomposition rates of dry biomass for the Cerrado region are high, showing poor surface soil coverage under no-tillage systems in this region.

Conclusion

The *Alternanthera tenella*, *Chamaesyce hirta*, *Cenchrus echinatus*, *Conyza bonariensis*, *Glycine max*, *Commelina benghalensis*, *Sida glaziovii*, and *Praxelis pauciflora* species were the most abundant in number of individuals and dry biomass of shoots regardless of the type of soybean, off - season crop type or assessment time. *Chamaesyce hirta* and *Bidens subalternans* are typically from genetically modified soybeans. *Cenchrus echinatus* showed indicator values in sorghum growing areas off season based on the number of individuals and the shoot dry mass. Regarding the other crops, *Crotalaria spectabilis* is typical for maize, and *Commelina benghalensis*, *Sida glaziovii*, *Ipomoea grandifolia*, *Sida rhombifolia*, *Ipomoea cordifolia*, and *Conyza bonariensis* are typical for millet. The desiccation period prior to soybean sowing had the greatest number of species. The species *Commelina benghalensis* and *Cenchrus echinatus* are widely distributed in Southwest Goiás State and were recorded in all production systems during the three evaluation periods.

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Received on August 9, 2016.
Accepted on December 5, 2016.