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Article

Weed Incidence after Soybean Harvest in No-Till and Conventional Tillage Croprotation Systems in Roraima's Cerrado

Ocorrência de Plantas Infestantes após Colheita da Soja em Sistemas Rotacionado em Plantios Direto e Convencional no Cerrado de Roraima

ALBUQUERQUE, J.A.A.[1]*
SANTOS, T.S.[1]
CASTRO, T.S.[1]
MELO, V.F.[1]
ROCHA, P.R.R.[1]

ABSTRACT - The goal of this study was to evaluate the occurrence of weeds after soybean harvest in rotational systems of no-till and conventional tillage in the savannah of Roraima, Brazil. Two simultaneous experiments were conducted in adjacent areas, the first one with no-till soil management system and the second one with the conventional system, with crop rotations for five agricultural years: pearl-millet (2007/2008), soybean (2008/2009), maize (2009/2010), cowpea with maize (2010/2011), soybean (2011/2012) and maize (2012/2013). The used experimental design was the randomized block one with 28 plots, sized 3 x 15 m (45 m^2) distributed in 4 blocks. In May 2010, the combined sowing of cowpea and maize was performed, and later, during the same month of 2011 soybean was sown. Thirty days after harvesting, weeds were collected. The botanical classification of species was performed by classes, families, scientific and popular names, as well as comparisons with specialized bibliographies. The evaluated phyto-sociological parameters were: relative frequency (FRR), relative density (DRR), dominance (Do), importance value index (IVI), Sorensen's similarity index (SI), numbers of individuals (ha^{-1}) and dry mass (%). Among the 37 species found in both planting systems, 60% belonged to the Liliopsida class; Fabaceae and Malvaceae stood out. However, Poaceae, belonging to the Magnoliopsida class, had the highest number of species in both systems. Most weed species were common in both systems.

Keywords: *Glycine max*, phytosociology, weeds, savannah, morphological characteristics.

RESUMO - Objetivou-se com este trabalho avaliar a ocorrência de plantas infestantes após colheita da soja, em sistemas rotacionado de plantio direto e convencional no cerrado de Roraima. Foram implantados dois experimentos simultâneos em áreas adjacentes, sendo o primeiro com sistema de manejo do solo em plantio direto e o segundo em sistema convencional, com as rotações de culturas por cinco anos agrícolas: milheto (2007/2008), soja (2008/2009), milho (2009/2010), feijão-caupi com milho (2010/2011), soja (2011/2012) e milho (2012/2013). Foi utilizado o delineamento experimental em blocos casualizados com 28 parcelas experimentais, sendo cada parcela de 3 x 15 m (45 m^2), distribuídas em quatro blocos. Em maio de 2010 foi feita a semeadura consorciada feijão-caupi com milho e, posteriormente, no mesmo mês de 2011, foi semeada a cultura da soja; 30 dias após a colheita, foram realizadas as coletas das plantas infestantes. A classificação botânica das espécies foi realizada por classes, famílias, nomes científicos e populares, além de comparações com bibliografias especializadas. Os parâmetros fitossociológicos avaliados foram: frequência relativa, densidade relativa,

*** Corresponding author:**
<anchietaufrr@gmail.com>

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dominância, índice de valor de importância e índice de similaridade de Sorensen, sendo calculados os números de indivíduos (ha^{-1}) e massa seca (%). Das 37 espécies encontradas em ambos os sistemas de plantio, 60% pertencem à classe Liliopsida, onde se destacaram as famílias Fabaceae e Malvaceae. Entretanto, a Poaceae, pertencente à classe Magnoliopsida, apresentou o maior número de espécies em ambos os sistemas. A grande maioria das espécies de plantas infestantes foi comum em ambos os sistemas.

Palavras-chaves: *Glycine max*, fitossociologia, plantas invasoras, savana, características morfológicas.

INTRODUCTION

Soybean is the main agricultural culture in Brazil, which is the second biggest world soybean producer. Its production was 85.4 million tons in the 2014/2015 harvest, a 12% growth in relation to the previous one (82 million tons) (Conab, 2016). Its grain is rich in proteins, and the plant may be used as green manure, fodder, silage and pasture. Soybean is used mainly for the extraction of vegetal oil and bran.

While still taking the first steps towards its growth in the Brazilian agricultural production, the state of Roraima is leading to the productive development of its main exportation product: soybean. During the 2014/2015 harvest, the planted area was 16 thousand hectares, whereas during the 2015/2016 one, producers sowed 25 thousand hectares, with a 40% increase and a harvest of over one million bags (Correia, 2015).

Roraima's cerrados include 4 million hectares and are located in the Center-Northeastern part of the state, which is a part of the main area of the savanna in Northern Amazon, reaching the extreme North of Brazil, Guyana, Venezuela and Colombia. The relief is mainly plain to slightly undular; the predominant soils are Argisol and Latosol (Melo et al., 2010).

The no-till system is considered to the most important for the sustainability of Brazilian agro-ecosystems (Crusciol et al., 2010; Franchini et al., 2012; Nascente et al., 2013). Currently, it is estimated that this system in used in 75% of the area occupied by annual grain cultivations in Brazil (Embrapa, 2015). This technology is based on the implantation of cultures with no previous soil preparation, over the culture remains of the previous cultivation.

Culture rotation allows changing the composition of weeds, allowing the population reduction of some species. In Roraima, the soybean production system in no-till has been widespread for a few years. This culture represents an alternative for the agricultural use of cerrado areas, since it presents good adaptation to the local edaphoclimatic conditions, has good economic value, allows the rotation of cultures and is provided with production technologies (Embrapa, 2009).

The practice of conventional tillage management systems creates a proper environment for the appearance of resistant infesting species and changes in its flora. The sustainability of a production system (no-till and conventional tillage) is not only based on environmental conservation and preservation aspects, but also in economic and commercial ones (Epamig, 2010). According to Soares et al. (2011), any change in the soil management system (conventional, no-till, minimum cultivation, cultures used in culture rotation) generally causes great impact in the diversity and quantity of weed population.

The competition with weeds is one of the factors that most affect the development and productivity of soybean cultures, since they hinder harvesting and are a shelter for pests and diseases and harmful allelopathic actions, causing a decrease of up to 80% in the culture productivity (Constantin et al., 2009; Correia and Durigan, 2010). The identification of weeds in planting areas allows verifying the qualitative and quantitative differences of the found species (Santos et al., 2016).

In each harvesting period, some species stand out because of various factors, among which: species characteristics, climate, seed bank, culture development, control period and adopted planting system (Albuquerque et al., 2013, 2014).

The state of Roraima is a distant area from great soybean, rice and maize production centers, and therefore it struggles with high costs and lack of materials (especially herbicides, insecticides and manure) and with the slow technology diffusion. However, it is extremely important that weed surveys are conducted over cultivations, in order to have greater representativeness of the invading species (Cruz et al., 2009).

The progress of phyto-sociological studies has been happening slowly and not at the same time as different research groups of the country. Generally speaking, one of the main reasons of this difference is due to the low number of researchers acting in this area, in different regions of Brazil (Giehl and Budke, 2011), especially in Roraima. In the agronomic point of view, knowing species diversity is essential to understand the dynamics of weeds and agricultural crops. In spite of this importance, few works were published about surveying weeds in this state (Cruz et al., 2009; Albuquerque et al., 2013, 2014; Oliveira et al., 2015).

The goal of this work was to evaluate the occurrence of weeds after the harvest of soybean in rotational systems of no-till and conventional tillage in Roraima's cerrado.

MATERIAL AND METHODS

Two experiments (no-till and conventional tillage) were implanted during the agricultural years 2007/2008, 2008/2009, 2009/2010, 2011/2012 and 2013/2014 in the experimental area of Agricultural Science Center (Centro de Ciências Agrárias) from the Universidade Federal de Roraima, in Boa Vista, Roraima state (latitude 2º52'15,49" N, longitude 60º42'39,89" W and altitude 85 m). The soil type is characterized as Dystrophic Yellow Latosol, which is representative of Roraima's cerrado (savannah) (Benedetti et al., 2011) (Table 1).

Table 1 - Chemical characterization of Dystrophic Yellow Latosol at 0-10 cm and 10-30 cm depths under native vegetation, with no agricultural use, in cerrado's areas in Roraima, before planting, 2016

Depth	pH	C	P	$Ca^{2+}+Mg^{2+}$	K^+	Al^{3+}	H+Al	SB	CTC	m	V	Dens.	Sand	Silt	Clay
(cm)		(g kg^{-1})	(mg kg^{-1})	(cmol$_c$ dm^{-3})						(%)		(kg m^{-3})	(g kg^{-1})		
0-10	4.6	9.3	0.5	0.1	0.1	0.8	2.4	0.2	2.6	82.4	6.3	1,438	624	74	302
10-30	4.8	8.4	0.2	0.1	0.0	0.7	2.1	0.1	2.2	86.7	5.1	1,356	618	60	322

C= organic carbon; m = saturation by Al; V = saturation by bases; Dens. = soil density.

The experiments were installed in adjacent areas (no-till and conventional tillage systems), simultaneously, in areas with crop rotation: pearl millet; soybean; maize; cowpea with maize; soybean and maize (Table 2).

The experimental design (both experiments) in randomized blocks was used, with 28 experimental units, sized 3 x 15 m (45 m^2), distributed in four blocks.

In the first stage of the experiments (2007/2008), plant material (native plants) was left as soil covering in the no-till plantation system. In the management of vegetation with desiccation, the active ingredient glyphosate was used (commercial product Roundup Original in doses of 2.5 and 200 L ha^{-1} mixture volume), by using a manual back sprayer, applied before the implantation of the initial culture (pearl millet). After completing its cycle, straw was left on the floor, in order to be used in the planting of the following cultures.

In May 2010, the mixed planting of cowpea and maize was performed and, subsequently, in May 2011, soybean was implanted; after 30 days from its harvest, weeds were collected.

As for weed samples (harvest), an iron square was used, welded at the edges, sized 0.50 x 0.50 m, randomly launched 32 times in the soybean culture part, during both experiments. The collected species were cut close to the soil level (with the help of pruning shears and a machete), separated, identified and quantified through the sum of two samples per experimental unit.

Table 2 - Description of periods and cultures used in crop rotation in both experiments, in Roraima's cerrado areas, 2016

Period	Culture
2007/2008	Pearl millet
2008/2009	Soybean
2009/2010	Maize
2010/2011	Cowpea + maize
2011/2012	Soybean
2012/2013	Maize

Initially, the botanical classification of the species was performed, by class, family, scientific name and common name, through the comparison with specialized biographies. The botanical nomenclature was based on APG II, according to Souza and Lorenzi (2008). The descriptive analysis of the following phyto-sociological parameters was performed: relative frequency (Frr) = species frequency x 100/total frequency of all species; Relative density (Drr) = species density x 100/ total density of all species; dominance (Do) = species dry mass x 100/total dry mass of all species; and importance value index (IVI) = Fr + Dr + Do (Brandão et al., 1998). In order to obtain dry mass, species were placed in Kraft-type paper; subsequently, all papers with already organized plants were taken to a forced air circulation oven at 59 ^{o}C, in order to obtain dry mass with a precision scale.

In order to analyze the Similarity Index (SI) of weeds in no-till areas (area A), conventional tillage areas (area B) and with common species in both areas (area C), the following formula was used: SI (%) = (2C/A+B) x 100 (Müeller-Dombois and Ellenberg, 1974). The number of individuals (ha^{-1}) and dry mass (%) were estimated and the propagation type, life cycle and growth habits of weeds were described, according to works conducted by Albuquerque et al. (2013, 2014) and Oliveira et al. (2015).

RESULTS AND DISCUSSION

In both experiments (no-till and conventional tillage), 37 weed species were found; among them, 60.16% belong to the Monocotyledon class, where the Fabaceae and Malvaceae families stood out, with 26.08% each one (Table 3). Other studies conducted in Roraima's cerrado have confirmed the species number predominance of the Fabaceae family (Cruz et al., 2009; Flores and Rodrigues, 2010; Albuquerque et al., 2013, 2014).

In spite of the fact that most species belong to the Monocotyledon botanical family, the Magnoliopsida class presented a higher number of species, and Poaceae (Gramineae) stood out in relation to the number of species, with a percentage of 32.43% (Table 3). In works conducted by Albuquerque et al. (2013), while evaluating the incidence of weeds in the maize culture after soybean in Roraima's cerrado, nine families were identified; the highest occurrence belonged to Poaceae, Fabaceae, Malvaceae and Cyperaceae, supporting the results from this research. According to López-Ovejero et al. (2016), when the culture before soybean is maize, generally the presence of volunteer maize plants reduces soybean production; however, in the experiment there were practically no volunteer plants from the previous culture (maize).

Poaceae are frequently found in weed surveys around Northern South America's cerrados, whereas Cyperaceae are more frequent in the state of Roraima than in other cerrados in Central Brazil (Miranda and Absy, 1997).

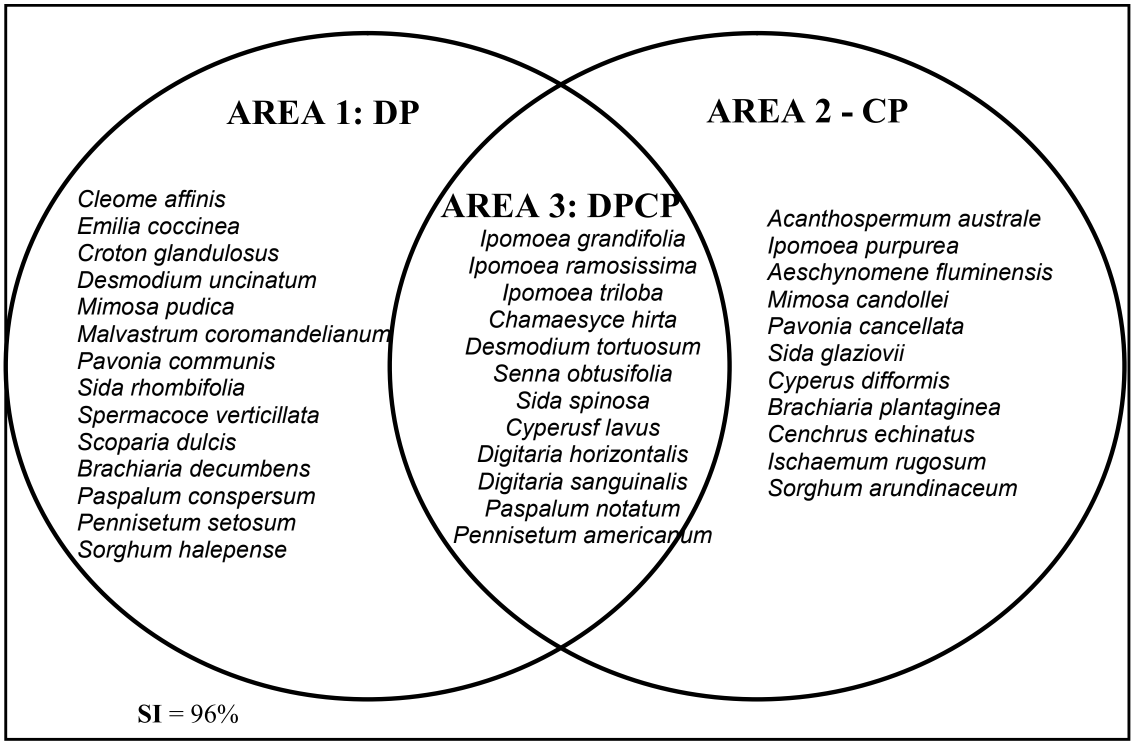
As for the two managing systems, 37 weeds species were found: 11 species in the conventional tillage, 14 in the no-till and 12 species were common in both managements. According to Pacheco et al. (2016), the quantity and diversity of the seed bank in the soil may change the results about soil management and used production systems. The calculated similarity index (SI) was 96% (Figure 1). It is expressed in percentage, being maximum (100%) when all species are common to the two areas and minimum (0%) when there is no common species (Sorensen, 1972). According to Felfili e Venturoli (2000), this index may be considered elevated when it is higher than 50%.

Firstly, the variables from the conventional tillage system were discussed. In Table 4, it is possible to observe that the species *Digitaria sanguinalis* (hairy crabgrass) and *Ischaemum rugosum* (wrinkle grass) presented higher values as for number of individuals (3,270 and 1,770 ha^{-1}, respectively), dry mass (145.12 and 328.18%, respectively) and as for the phyto-sociological parameters in the conventional tillage system. *Digitaria sanguinalis* presents high germination power; it is a very aggressive plant. Its seeds are covered in hair and are easily transported by the wind (Souza and Lorenzi, 2008). This species sexually propagates in a controlled way during the young stage; it presents good control. However, in the adult stage, when it presents rhizomes, the chemical control with glyphosate herbicide become ineffective. *Ischaemum rugosum* appeared only in the conventional tillage system, since it is a recently-introduced weed, but considered common in various regions.

Table 3 - Botanical class, family, scientific and common names of 37 collected weed species after soybean harvest in rotational conventional tillage and no-till system, performed in Roraima's cerrado, 2016

Class	Family	Scientific name	Common name
Monocotyledon	Capparaceae	*Celoma affinis* DC	African cabbage, spiderwisp
	Compositae (Asteraceae)	*Acanthos permumaustrale* (Loefl.) Kuntze	Paraguayan starburr, Ihi kukae hipa, Paraguay bur, Paraquay starbur, Pipili
		Emilia coccinea (Sims) G. Don	Tasselflower, Scarlet tassleflower
	Convolvulaceae	*Ipomoea grandifolia* (Dammer) O'Donell	Morning glory, water convolvulus, bindweed, moonflower
		Ipomoea purpúrea (L.) Roth	Morning glory, water convolvulus or kangkung, sweet potato, bindweed, moonflower
		Ipomoea ramosissima (Poir.) Choisy	Morning glory, water convolvulus or kangkung, sweet potato, bindweed, moonflower
		Ipomoea triloba L.	Morning glory, water convolvulus or kangkung, sweet potato, bindweed, moonflower
	Euphorbiaceae	*Chamaesyce hirta* (L.) Milisp	Pill-bearing spurge, asthma plant, hairy spurge, garden spurge, pillpod sandman.
		Croton glandulosus L.	Vente conmigo, tooth-leaved croton, tropic croton and sand croton.
	Fabaceae	*Aeschynomene fluminensis* Vell.	Jointvetch
		Desmodium tortuosum (Sw.) DC.	Tick-trefoil, tick clover, hitch hikers, beggar lice
		Desmodium uncinatum (Jacq.) DC.	Tick-trefoil, tick clover, hitch hikers, beggar lice
		Mimosa candolei L.	Giant sensitive plant .
		Mimosa pudica L.	Sensitive plant, sleepy plant, Dormilones, shy plant
		Senna obtusifolia (L.) H. S. Irwin & Barneby	Chinese senna, American sicklepod, sicklepod.
	Malvaceae	*Malvastrum coromandelianum* (L.) Garcke	Threelobe false mallow
		Pavonia cancellata (L.) Cav.	Swampmallows
		Pavonia communis A. St.-Hil.	Gingerbush
		Sida glaziovii K. Schum.	Brazilian sida
		Sida rhombifolia L.	Arrowleaf sida, rhombus-leaved sida, Paddy's lucerne, jelly leaf
		Sida spinosa L.	Pricky fanpetals .
	Rubiaceae	*Spermacoce verticillata* (L.) G. Mey.	Shrubby false buttonweed
	Scrophulariaceae	*Scoparia dulcis* L.	Licorice weed, goatweed, scoparia-weed, sweet-broom
Magnoliopsida	Cyperaceae	*Cyperus flavus* (Vahl) Nees.	Denton's flatsedge
		Cyperus difformis L.	Variable flatsedge, smallflower umbrella-sedge
	Poaceae (Gramineae)	*Brachiaria decumbens* (Stapf) R. D. Webster	Surinam grass, signal grass, Kenya sheep grass, sheep grass
		Brachiaria plantaginea (Link) R. D. Webster	Alexandergrass, Plantain signalgrass .
		Cenchru sechinatus L.	Southern sandbur, burgrass, spiny burrgrass
		Digitaria horizontalis Willd.	Jamaican crabgrass
		Digitaria sanguinalis (L.) Scop.	Hairy crabgrass, hairy finger-grass, large crabgrass, crab finger grass, purple crabgrass
		Ischaemum rugosum SALISB.	Wrinkle duck-beak, saramattagrass, wrinkle grass
		Paspalum conspersum Schrad.	Talquezal
		Paspalum notatum Flugge	Bahia grass
		Pennisetum americanum (L.) Leeke	Pearl millet
		Pennisetum setosum (Sw.) Rich.	Mission grass
		Sorghum halepense (L.) Pers.	Johnson grass
		Sorghum arundinaceum (Willd.) Stapf.	Common wild sorghum

In the conventional tillage, within the main five species in the Poaceae family, *Digitaria sanguinalis*, *Ischaemum rugosum* and *Paspalum notatum*, with RVI's of 23.36%, 23.31% and 7.73%, respectively (Table 4).



1 NT - No-Till, 2 CT - Conventional Tillage, 3 NTCT - Both.

Figure 1 - Venne's diagram and Sorensen's similarity index (SI), illustrating 37 collected weed species after soybean harvesting in rotational conventional tillage and no-till systems, performed in Roraima's cerrado, 2016

Digitaria sanguinalis, *Ischaemum rugosum* and *Paspalum notatum* presented higher importance in the area, corresponding to 54.4% of the total relative importance value index. *Digitaria sanguinalis* stood out for its high relative density (Dr = 40.9%), that is, for the high number of individuals in the samples. *Ischaemum rugosum* stood out for its elevated dominance (Do = 33.35%), that is, for the elevated dry mass of its individuals in the samples, indicating large-sized individuals. *Paspalum notatum* is the third most important species in rotational conventional tillage areas, followed by *Desmodium tortuosum* and *Sida spinosa*, with 5.72% and 5.65% RVI's. Another 11 species had RVI's between 1 and 5%, and moreover, seven species presented lower than 1% RVI (Table 4).

In the conventional tillage area, a total of 23 species was found, and in the no-till area they were 27, practically the same species number in both managements. However, none of them presented a higher than 20% RVI. *Chamaesyce hirta* was the most important species in the area, presenting a 15.3% RVI, followed by *Paspalum notatum*, with 12.49%, and *Ipomoeara mosissima*, with 10.75%. Four species had an RVI between 5 and 10%, ten had an RVI between 1 and 5% and nine had a lower than 1% RVI in this soil management system (Table 4).

Of the five main species in conventional tillage RVI, four were also found in no-till areas, with the exception of *Ischaemum rugosum*, which was not found in any sample from no-till areas. *Digitaria sanguinalis* and *Desmodium tortuosum* had their importance reduced by 23.36% and 5.72% respectively in the conventional tillage to 7.75% and 0.92% in the no-till planting, whereas the importance of *Paspalum notatum* increased by 7.73% in the conventional tillage to 12.49% in the no-till system. Gomes and Christoffoleti (2008) stated that since the seed quantity in the soil bank seed of no-till soil is high, seeds that germinate and become competitive can be considered very low. Straw left over the soil by the no-till system generally becomes a barrier, inhibiting the germination of some weed species, by physical, biological and chemical processes (Müller et al., 2012).

The importance of *Sida spinosa* remained the same in both planting systems (5.65% for CT and 5.53% for NT) (Table 4).

Table 4 - Scientific names, number of individuals (NI ha^{-1}), dry mass (DM%), relative frequency (Frr), relative density (Drr), dominance (Do), importance value index (IVI) and relative importance value index (RVI) of 37 weeds after soybean harvesting in rotational no-till and conventional tillage systems, performed in Roraima's cerrado, 2016

Conventional tillage							
Scientific names	NI	DM	Frr	Drr	Do	IVI	RVI
Digitaria sanguinalis	3270	145.12	14.45	40.90	14.75	70.09	23.36
Ischaemum rugosum	1770	328.18	14.45	22.14	33.35	69.93	23.31
Paspalum notatum	910	34.81	8.29	11.38	3.54	23.20	7.73
Desmodium tortuosum	130	58.13	9.63	1.62	5.91	17.16	5.72
Sida spinosa	60	89.27	7.13	0.75	9.07	16.95	5.65
Cyperusf lavus	330	40.83	4.82	4.12	4.15	13.09	4.36
Senna obtusifolia	100	83.25	2.31	1.25	8.46	12.02	4.01
Chamaesyce hirta	270	25.26	4.82	3.37	2.57	10.76	3.59
Brachiaria plantaginea	230	27.6	4.82	2.87	2.80	10.49	3.50
Sorghum arundinaceum	40	48.59	4.82	0.50	4.94	10.25	3.42
Ipomoea ramosissima	210	14.53	5.97	2.62	1.48	10.07	3.36
Cenchrus echinatus	240	23.81	1.16	3.00	2.42	6.58	2.19
Digitaria horizontalis	140	9.13	2.31	1.75	0.93	4.99	1.66
Mimosa candollei	60	16.56	2.31	0.75	1.68	4.75	1.58
Pennisetum americanum	40	12.3	2.31	0.50	1.25	4.06	1.35
Ipomoea grandifolia	50	4.84	2.31	0.62	0.49	3.42	1.14
Acanthospermum australe	60	7.77	1.16	0.75	0.79	2.70	0.90
Aeschynomene fluminensis	10	7.94	1.16	0.12	0.81	2.08	0.69
Cyperus difformis	30	1.08	1.16	0.37	0.11	1.64	0.55
Ipomoea triloba	10	2.59	1.16	0.12	0.26	1.54	0.51
Ipomoea purpurea	20	0.7	1.16	0.25	0.07	1.48	0.49
Sida glaziovii	10	1.41	1.16	0.12	0.14	1.42	0.47
Pavonia cancellata	10	0.49	1.16	0.12	0.05	1.33	0.44
Total	8000	984.19	100.00	100.00	100.00	300.00	100.00
No-till							
Chamaesyce hirta	2100	132.7	13.99	21.64	10.28	45.91	15.30
Paspalum notatum	1790	107.52	10.71	18.44	8.33	37.48	12.49
Ipomoea ramosissima	1030	98.59	13.99	10.61	7.64	32.24	10.75
Cyperusf lavus	1210	33.92	13.99	12.46	2.63	29.08	9.69
Digitaria sanguinalis	1170	62.15	6.39	12.05	4.81	23.26	7.75
Spermacoce verticillata	180	140.86	5.35	1.85	10.91	18.12	6.04
Sida spinosa	280	38.72	10.71	2.89	3.00	16.59	5.53
Senna obtusifolia	120	138.26	1.04	1.24	10.71	12.98	4.33
Digitaria horizontalis	800	10.99	3.11	8.24	0.85	12.20	4.07
Sorghum halepense	50	117.74	1.04	0.51	9.12	10.67	3.56
Malvastrum coromandelianum	110	94.34	1.04	1.13	7.31	9.47	3.16
Ipomoea triloba	20	98.59	1.04	0.21	7.64	8.88	2.96
Pennisetum setosum	110	74.75	1.04	1.13	5.79	7.96	2.65
Scoparia dulcis	10	49.15	1.04	0.10	3.81	4.94	1.65
Desmodium uncinatum	270	13.42	1.04	2.78	1.04	4.85	1.62
Brachiaria decumbens	120	30.96	1.04	1.24	2.40	4.67	1.56
Mimosa pudica	30	9.9	2.07	0.31	0.77	3.14	1.05
Desmodium tortuosum	50	2.22	2.07	0.51	0.17	2.76	0.92
Paspalum conspersum	80	11.28	1.04	0.82	0.87	2.73	0.91
Ipomoea grandifolia	100	8.5	1.04	1.03	0.66	2.73	0.91
Emilia coccinea	20	5.38	2.07	0.21	0.42	2.70	0.90
Pennisetum americanum	10	7.42	1.04	0.10	0.57	1.71	0.57
Cleome affinis	10	2.13	1.04	0.10	0.16	1.30	0.43
Sida rhombifolia	20	0.65	1.04	0.21	0.05	1.29	0.43
Croton glandulosus	10	0.51	1.04	0.10	0.04	1.17	0.39
Pavonia communis	10	0.28	1.04	0.10	0.02	1.16	0.39
Total	9710	1290.93	100	100	100	300	100

Chamaesyce hirta and *Ipomoeara mosissima* were also present in both soil management systems, but they gained importance in the no-till system, going from relative importance value indices of 3.59% and 3.36% to 15.30% and 10.75% RVI's, respectively (Table 4).

Spermacoce verticillata, *Sorghum halepense* and *Malvastrum coromandelianum* were not present in conventional tillage areas, but they had an importance of 6.04%, 3.56% and 3.16%, respectively, in no-till areas (Table 4). In the no-till system, weed seed germination may be caused by changes in the soil temperature; there are species whose germination is stimulated by the increase in soil temperature, occasioned by the straw on the surface (Gomes and Christoffoleti, 2008).

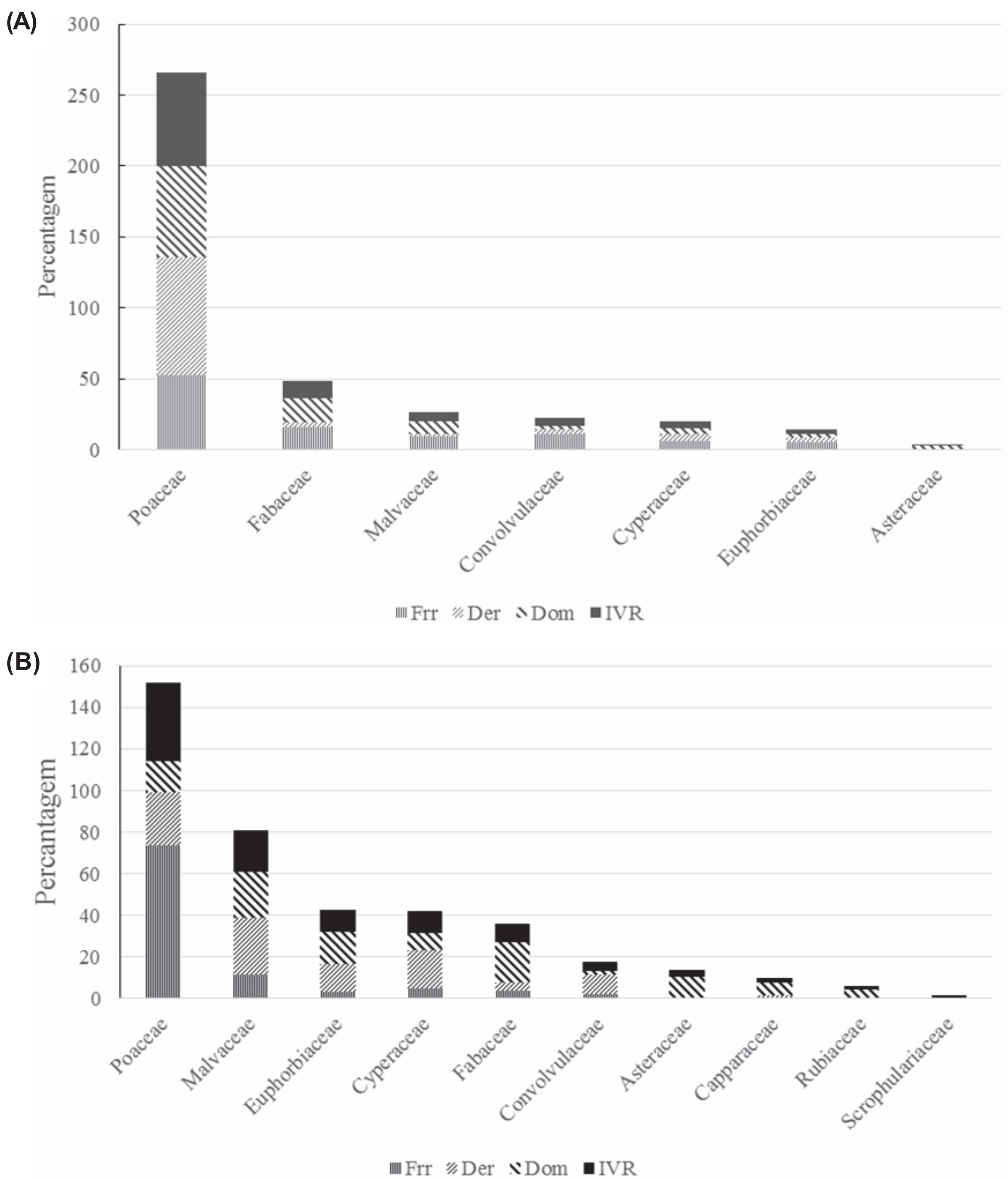


Figure 2 - Relative frequency (Fr), relative density (Dr), dominance (Do), and relative importance value index (RVI) of weed families found after soybean harvesting in rotational (A) conventional tillage system, and (B) no-till system, performed in Roraima's cerrado, 2016.

Ischaemum rugosum stood out for its elevated dominance (Do = 33.35%), that is, for the elevated dry mass of its individuals in the samples, indicating large-sized individuals. *Paspalum notatum* is the third most important species in rotational conventional tillage areas, followed by *Desmodium tortuosum* and *Sida spinosa*, with 5.72% and 5.65% RVI's. Another 11 species had RVI's between 1 and 5%, and moreover, seven species presented lower than 1% RVI (Table 4). In works conducted by Albuquerque et al. (2016) with cultures of soybean, maize and rice in conventional tillage and no-till, results demonstrated that there was significant interaction between soil management systems and production systems in the population and dry mass of weeds during all evaluation periods (17, 47, 111 and 177 days after desiccation).

In relation to the botanical families of the species found in the areas, it is possible to notice higher family variability in the no-till specifically (10) in comparison with the conventional

Table 5 - Scientific names, conventional (CTS) and no-till (NTS) tillage systems, propagation method (PM), life cycle (LC) and growth habit (GH) of 37 collected weed species after soybean harvest in rotational conventional and no-till system, performed in Roraima's cerrado, 2016

Scientific names	System	PM	LC	GH
Acanthospermum australe	CTS	Seeds	Annual	Herbaceous, prostrated
Aeschynomene fluminesis	CTS	Seeds	Perennial	Sub-shrubby
Brachiaria decumbens	NTS	Seeds and through rhizomes	Perennial	Herbaceous, erect
Brachiaria plantaginea	CTS	Seeds	Annual	Herbaceous, erect or occasionally ascendent
Cenchrus echinatus	CTS	Seeds	Annual	Herbaceous, erect
Chamaesyce hirta	BOTH	Seeds	Annual	Prostrated and sub-ascendent
Cleome affinis.	NTS	Seeds	Annual	Very branched erect, herbaceous
Croton glandulosus	NTS	Seeds	Annual	Erect, very branched, more or less woody at the basis
Cyperus difformis	CTS	Seeds	Perennial	Herbaceous, erect
Cyperusf lavus	BOTH	Seeds and through rhizomes	Perennial	Herbaceous
Desmodium tortuosum	BOTH	Seeds	Annual	Herbaceous
Desmodium uncinatum	NTS	Seeds	Perennial	Erect or ascendant, herbaceous, not very branched
Digitaria horizontalis	BOTH	Seeds and rooting on inferior nodes	Annual	Herbaceous
Digitaria sanguinalis	BOTH	Seeds	Annual	Herbaceous
Emilia coccinea	NTS	Seeds	Annual	Herbaceous, erect, glabrous or hairy
Ipomoea grandifolia	BOTH	Seeds	Annual	Climbing, voluble, herbaceous
Ipomoea purpúrea	CTS	Seeds	Annual	Climbing, herbaceous
Ipomoea ramosissima	BOTH	Seeds	Annual	Herbaceous
Ipomoea triloba	BOTH	Seeds	Annual	Herbaceous
Ischaemum rugosum	CTS	Seeds	Annual	Herbaceous, erect
Malvastrum coromandelianum	NTS	Seeds	Annual or Perennial	Herbaceous or sub-shrubby, erect
Mimosa candolei	CTS	Seeds	Perennial	Sub-shrubby
Mimosa pudica	NTS	Seeds	Perennial	Herbaceous or little woody, prostrated.
Paspalum conspersum	NTS	Seeds and by small rhizomes	Perennial	Herbaceous, Caespitose and erect
Paspalum notatum	BOTH	Seeds and through rhizomes	Perennial	Herbaceous, prostrated-ascendant
Pavonia cancellata	CTS	Seeds	Annual	Herbaceous, prostrated
Pavonia communis	NTS	Seeds	Perennial	Herbaceous/Sub-shrubby
Pennisetum americanum	BOTH	Seeds	Annual	Herbaceous, erect
Pennisetum setosum	NTS	Seeds or through rhizomes	Perennial	Herbaceous, erect
Scopa riadulcis	NTS	Seeds	Annual	Herbaceous, erect, branched
Senna obtusifolia	BOTH	Seeds	Annual	Sub-shrubby, woody and erect
Sida glaziovii	CTS	Seeds	Perennial	Herbaceous or sub-shrubby
Sida rhombifolia	NTS	Seeds	Annual or Perennial	Sub-shrubby, erect
Sida spinosa	BOTH	Seeds	Perennial	Herbaceous or sub-shrubby, erect
Sorghum halepense	NTS	Seeds and by rhizomes	Perennial	Erect, caespitose
Sorgum arundinaceum	CTS	Seeds	Annual or Perennial	Herbaceous, caespitose and erect
Spermacoce verticillata	NTS	Seeds	Perennial	Herbaceous, erect, branched

tillage (7) (Figure 2A, B). The main found botanical family, not only in species number (12), but also in accumulated importance value index, was Poaceae with 66.5% in the conventional tillage (Figure 2A) and 38% in no-till (Figure 2B). It is also possible to consider the Fabaceae, Malvaceae and Euphorbiaceae families as important. According to Jakelaitis et al. (2003), the presence of straw on the soil surface before planting may also modify the conditions for seed germination and the emergence of seedlings, due to the physical effect of covering and the release of allelopathic substances.

Morning glory (Convolvulaceae) and coco-grass (Cyperaceae) were problematic mainly in the no-till, where the effect of straw partially contained the infestation from Poaceae (Figure 2B).

In Table 5, it is possible to observe that, among weeds found in both planting systems, the seed propagation method (76%) and the life cycle of approximately 50% among annual and perennial prevailed; the predominant growth habit was the herbaceous one (75%), typical of cerrado vegetation. Other works conducted with other cultures support this result, such as the ones by Albuquerque et al. (2013, 2014) and Oliveira et al. (2015). In order for the agricultural science professional to have the conditions to recommend the proper type of management in an agricultural property, they have to have basic knowledge about various factors, such as propagation methods, life cycle and growth habits, as well as being able to identify weed species, especially at a young stage.

Among the species found in both planting systems, 60% belong to the Monocotyledon class, where the Fabaceae and Malvaceae families stand out; however, it was the Poaceae belonging to the Magnoliopsida class the one representing the highest number of species in both systems. As for the phyto-sociological parameters, in the conventional tillage system, *Digitaria sanguinalis* and *Ischaemum rugosum* stood out, and in the no-till system, *Chamaesyce hirta* e *Paspalum notatum* stood out. By the similarity index, it was possible to deduce the similar weed species existing between both management systems, demonstrating high homogeneity.

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