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PHYTOSOCIOLOGICAL SURVEY OF WEED PLANTS IN SOYBEAN CULTURE IN THE GURGUÉIA VALLEY

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ABSTRACT - Phytosociology is a set of ecological assessment methods that aim to provide a view of plant species distributions within a plant assemblage. The objective of the current study was to identify and quantify the plants designated as weeds in a glyphosate-resistant soybean crop, using a phytosociological survey of a conventional planting system on the Fazenda Agrosantos (09°27'4124.4" S and 45º01'00.4" O), Vale do Gurguéia, Monte Alegre municipality Piauí state, Brazil. The site lies at a mean altitude of 652 m. Field collections were made 15 days after initial soya planting. For sampling, a 0.40 x 0.40 m quadrat was used, thrown randomly twenty times within the experimental area. Weeds were identified and quantified using the sum of the samples obtained from the quadrat samples. Plants that lay within the quadrat were identified, counted and collected for identification, which was carried out by comparison with specialist bibliographies and weed identification manuals. Evaluated variables were: frequency, density, abundance, relative frequency, relative density, relative abundance and species importance value index. In the soybean cultivation area, 60% of the sampled species were Eudicotyledons, and a total of 8 botanical families and 10 weed species were identified. The species *Cenchrus echinatus*, *Ipomoea asarifolia* (Desr.) Roem. & Schult, *Amaranthus retroflexus* L. and *Zea mays* L showed the highest values for the analyzed variables, and should therefore be of special attention to soybean producers in the region of Vale da Gurguéia, Piauí, Brazil.
Keywords: *Glycine max* L., phytosociology, importance value index.

LEVANTAMENTO FITOSSOCIOLÓGICO DE PLANTAS DANINHAS NA CULTURA DA SOJA NO VALE DO GURGUÉIA

RESUMO - A fitossociologia é um conjunto de métodos de avaliações ecológicas que objetivam proporcionar uma visão abrangente da distribuição das espécies de plantas de uma comunidade vegetal. Objetivou-se com este trabalho identificar e quantificar as plantas daninhas da cultura da soja resistente ao glifosato, por meio de levantamento fitossociológico sob sistema de plantio convencional na região do Vale do Gurguéia. O levantamento fitossociológico de plantas daninhas foi realizado na Fazenda Agrosantos, no município de Monte Alegre (PI), sob as coordenadas 09°27'4124.4" S e 45º01'00.4" O e altitude de 652m. As coletas foram realizadas 15 dias após o plantio da Soja. Para amostragem, utilizou-se quadrado de ferro, 0,40 x 0,40 m, lançado aleatoriamente vinte vezes na área experimental. As plantas daninhas foram identificadas e quantificadas por meio do somatório das amostras obtidas pelo lançamento do quadrado. As plantas abrangidas pelo quadrado de amostragem foram identificadas, contadas e recolhidas, para identificação, que foi realizada por comparação com bibliografias especializadas e manuais de identificação de plantas daninhas. As variáveis avaliadas compreenderam: frequência, densidade, abundância, frequência relativa, densidade relativa, abundância relativa e índice de valor de importância das espécies. Na área de cultivo de soja foram verificadas que 60% das espécies amostradas eram Eudicotiledôneas. Foram identificadas 8 famílias botânicas e 10 espécies de plantas daninhas. As espécies *Cenchrus echinatus*, *Ipomoea asarifolia (Desr.) Roem. & Schult*, *Amaranthus retroflexus* L. e *Zea mays* L apresentaram os maiores valores para as variáveis analisadas, portanto devem ser motivo de atenção especial para os produtores de soja na região do Vale da Gurguéia.
Palavras-chave: *Glycine max* L., fitossociologia, índice de valor de importância.

INTRODUCTION

Soya (*Glycine max* L.) is one of the most important crops in world agriculture, due to its high productive capacity, chemical composition and nutritional value. It can be used for both human and animal feed, and so has high socioeconomic importance (MENEZES et al., 2019). Brazil is the second largest soybean producer in the world, with a 2018/2019 harvest of 114.843 million tons, produced from an estimated area of 35.822 million hectares (CONAB, 2019).

Among the soya production practices, weed management is of great importance, since the interference of these plants can result in loss of harvest productivity, as well as lower product quality and/or increased production costs, thus lowering market competitivity of the final product (VITORINO et al., 2017). Decision making on the

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appropriate weed management strategies in soybean crops depends on the identification and density of the weed species presente, and on how they can negatively interfere in a given crop (ANDRADE JUNIOR et al., 2018).

Phytosociology is a set of ecological assessment methods that aim to provide a comprehensive view of the distribution of plant species, including within a planted crop (CONCENÇO et al., 2013). It is also important because it allows evaluation of species assemblage composition within an area through analysis of frequency and relative frequency, density and relative density, abundance and relative abundance and importance value index. This forms an essential tool in the analysis of the plant assemblage present in a given cultivation area (GOMES et al., 2010).

The basis for the formulation of an efficient control mechanism is a firm understanding of the biology of the harmful flora present in cultivated areas. The establishment of an infesting plant assemblage in a given region depends on a variety of factors, such as soil type, crop-specific management practices adopted, and seed bank composition, among other aspects. Consequently, the dynamics of these species can vary greatly depending on the floristic composition of the assemblage, which in turn, is influenced by the type and intensity of the management practices adopted in the planting area. These can lead to changes in the population size and the distribution of species within the assemblage (ALBUQUERQUE et al., 2013). Therefore, it is essential to know which weed species are in the area, in order to determine the most effective control strategy and to mitigate the losses caused by the presence of these weeds in cultivation systems (CHAUHAN, 2012).

In recent years, the states of Maranhão, Tocantins, Piauí and Bahia, a region known as MATOPIBA, have contained more than 11% of the soybean cultivated area and production within Brazil (CONAB, 2019). However, this is still low compared to states such as Mato Grosso, Paraná and Rio Grande do Sul. The identification of weed species in the area is crucial for producers, because the losses that these plants cause via direct competition for resources with the crop or resulting from the release of allelopathic substances, are directly related to weed species, population density and stage of development (MARTINS et al., 2019; PEREIRA et al., 2011).

The Cerrados do Piauí have edaphoclimatic conditions favorable to the cultivation of annual crops and, for this reason, they have become an important agricultural frontier in the country (PACHECO et al., 2013). The Piauiese cerrado is the fourth most largest in Brazil, and the largest in the northeastern sector of the country, with some 11.9 million hectares, corresponding to 46% of the total area of the state. This represents 5.9% of the Brazilian cerrado and 36.9% of the area of cerrado within the northeast region as a whole (AGUIAR and MONTEIRO, 2005). In recent years there has been a noticeable increase in large-scale agriculture in the region, with a predominance of soybean cultivation. Since the State of Piauí is one of the last agricultural frontiers in Brazil, studies of soja crop weed infestation are in thier infancy. However, they are essential for this rapidly expanding crop, making appropriate surveys a matter of urgency.

Accordingly, the objective of the current study was to identify and quantify the main weeds present in the initial development and in the cultivation of glyphosate-resistant soybean in the Vale do Gurguéia region of Piauí, using a phytosociological survey of a conventional planting system.

MATERIALS AND METHODS

The soya weed phytosociological survey was carried out at Fazenda Agrosantos, Monte Alegre municipality, Piauí state, Brazil (09°27’4124.4” S, 45º01’00.4” E: altitude, 652 m). The management system for the area was conventional planting, with soil preparation including NPK fertilization (16:16:16), and incorporating with a leveling harrow seven days before the soya sowing, the latter carried out with a vacuum planter at a depth of 4 cm with 15 seeds per linear meter, using variety M-8349 IPRO. The area has a history of soya cultivation under conventional planting.

Weeds were collected early in the 2017/2018 season, 25 days after soybean planting. To provide a quantified phytosociological study of the weed assemblage, a 0.4 x 0.4 m iron quadrat was used, with sampling involving 20 random throws within the study area (quadrat inventory method), using a zigzag walk for access.

Plants within the quadrat were noted, counted and collected for identification, which was carried out by comparison with specialized literatubre and weed identification manuals.

For weeds analysis, botanical classes, families, species, propagation forms and life cycle were determined, and the following phytosociological parameters calculated: frequency (F); density (D); abundance (A); relative frequency (RF), relative density (RD), relative abundance (RA) and importance value index (IVI), according to the methodology proposed by Mueller-Dombois and Ellenberg (1974), and described in Table 1.

Frequency was transformed into classes, following Raunkiaer (1934) (Table 2). The density (number of individuals per area) was determined for each species (Table 3), with scores assigned using the scale from Cain and Castro (1959). Abundance was assessed using an adaptation of the scale used by Carvalho and Pitelli (1992) (Table 4).

TABLE 1 - Description of the evaluated variables, formulas and evaluation method for the phytosociological study.

Characteristics	Methods
Frequency (F)	$\frac{\text{Nº of quadrats in which a species was encountered}}{\text{Nº of quadrats, total}}$
Density (D)	$\frac{\text{Nº of individuals of a species, total}}{\text{Total area sampled}}$
Abundance (A)	$\frac{\text{Nº of individuals per species, total}}{\text{Nº of quadrats where a species was encountered, total}}$
Relative Frequency (RF)	$\frac{\text{Species frequency x 100}}{\text{Total frequency of all species}}$
Relative Density (RD)	$\frac{\text{Species density x 100}}{\text{Total species density}}$
Relative Abundance (RA)	$\frac{\text{Nº of species abundances x 100}}{\text{Total abundance of all species}}$
Importance Value Index (IVI)	(RF + RD + RA)

TABLE 2 - Frequency Classes (Rounkiaer, 1934).

	Classes				
	A	B	C	D	E
Frequencies	0.01 - 0.20	0.21 - 0.40	0.41 - 0.60	0.61 - 0.80	0.81 - 1.0

[1/] Frequencies with values less than 0.01 are not included in the table above as these constitute species considered rare or not highly representative.

TABLE 3 - Density categories (plants. m^{-2}) according to the Cain and Castro (1959) classification.

	Categories				
	1	2	3	4	5
Densities[1]	1 - 4	5 - 14	15 - 29	30 - 99	≥100

[1/] Cain and Castro (1959) does not include a class for density values below 1 plant m^2, and there were no such records in the current study.

TABLE 4 - Abundance classification adaptated from Carvalho and Pitelli (1992).

Classes	Abundance
U - A species found only once in the study area	<1%
R - Species rarely found and/or potentially unnoticed within the sample	1.1 - 10%
Sol - Species occasionally found within the sample	10.1 - 20%
Sp - Species in relative abundance, but not impacting crops	20.1 - 30%
Cop - Species widely distributed and, in some cases, impacting the culture	>30%

RESULTS AND DISCUSSION

A total of 10 weed species were identified, belonging to 8 families. Of these, 60% belonged to the eudicotyledonous class (Table 5). According to Pitelli (1987), plants of the same class have similar needs and, for this reason, soybean culture favors the presence and permanence of other eudicotyledons. Vitorino et al. (2017) found similar results in phytosociological studies of soybean crop weeds growing under different spacings, with a predominance of eudicotyledons among identified weed species.

In an organic okra cultivation system, Santos et al. (2017) also found a predominance of eudicotyledons among the weeds identified from the area. In a phytosociological study of corn, Ferreira et al. (2019) also found eudicotyledons dominated the associated weed assemblage. The diversity of different species found in the current work may be due to the use of conventional tillage, which can homogenize the distribution of weed seeds present in the soil (GOULART et al., 2020).

The most common botanical family was Poaceae, with three species, while all other families were represented by only one species (Table 5). Menezes et al. (2019) also found that Poaceae predominanced among the identified weed species growing with soybean cropped under different management forms in the Cerrado of Roraima. According to Lorenzi (2008), this prevelance of Poaceae within weed assemblage may be due to their high production of diaspores, which facilitate their dissemination and the occupation of planting areas, even those in adverse environmental conditions. Most of the species present in the study area had sexual reproduction and have an annual life cycle (about 90%), with the exception of *Commelina benghalensis* which, in addition to sexual reproduction, also spreads asexually by rhizomal fragmentation and has a perennial life cycle. Albuquerque et al. (2012) notes that a knowledge of the diversity of weeds present in the cultivation area is important from an agronomic point of view, as it allows an understooding of the dynamics of these species in relation to the crop plants themselves.

The ideal management of weeds in a cultivation area begins with the correct identification of their botanical species, with emphasis on those that are most important due to the history of the area, taking into account their relative frequencies, densities and abundances in the area under cultivation (BUNHOLA and SEGATO, 2017).

TABLE 5 - Weeds by species, family, common name (CN), Botanical class (Clas.), Propagation method (MP) and Life cycle (LC).

No.	Species	Family	CN (Brazil)	Clas.	MP	LC
1	*Amaranthus retroflexus* L.	Amaranthaceae	Caruru Gigante	E	S	A
2	*Commelina benghalensis* L.	Commelinaceae	Trapoeraba	M	S/R	P
3	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	Convolvulaceae	Corda de viola	E	S	A
4	*Euphorbia hirta* L.	Euphorbiaceae	Erva de Santa Luzia	E	S	A
5	*Glicyne max* L.	Fabaceae	Soja	E	S	A
6	*Eleusine indica* L.	Poaceae	Capim-pé-de-galinha	M	S	A
7	*Cenchrus echinatus* L.	Poaceae	Capim-Carrapicho	M	S	A
8	*Zea maiz* L.	Poaceae	Milho	M	S	A
9	*Portulaca oleracea* L.	Portulacaceae	Beldroega	E	S	A
10	*Borreria verticillata* (L.) G. Mey.	Rubiaceae	Vassourinha de Botão	E	S	A

Clas.: E = eudicotyledon, M = monocotyledon, MP: S = seeds, R = rhizomes, CV: A = annual, P = perrenial.

Cenchrus echinatus was the common species in the area, with an approximate density of 163 plants per square meter, and hence receiving a score of 5 (Table 6) in the Cain and Castro (1959) classification. This species occcurred with a class C frequency, that is with moderate to high distribution in the area. This can be explained by the high dispersion capacity of the seeds, that has a structural adaptation, in the form of bristles, that allow it to adhere easily to surfaces (LORENZI, 2008). Consequently, its abundance classification is Cop, that is a species widely distributed and, in some cases, suppressing the crop.

TABLE 6 - Frequency (F), relative frequency (FR), frequency class, density (D), relative density (RD) and density class, abundance (A), relative abundance (RA) and weed abundance class in an area of soybean cultivation under conventional cultivation.

Species Number	Frequency			Density			Abundance		
	F	RF	Class	D	RD	Class	A	RA	Classes
1	0.15	6	A	16.25	6.2	3	17.33	13.35	Sol
2	0.3	12	B	4.06	1.55	1	2.16	1.66	R
3	0.3	12	B	43.43	16.58	4	23.16	17.84	Sp
4	0.1	4	A	0.93	0.35	---	1.5	1.15	R
5	0.1	4	A	7.81	2.98	2	12.5	9.62	Sol
6	0.15	6	A	8.43	3.22	2	9	6.93	R
7	0.55	22	C	163.12	62.29	5	47.45	36.55	Cop
8	0.4	16	B	36.56	4.41	4	14.62	9.5	Sol
9	0.25	10	B	4.66	1.55	1	2.6	2	R
10	0.2	8	A	2.18	0.83	1	1.75	1.34	R

R = Species rarely found and/or potentially unnoticed within the sample, Sol = Species occasionally found within the sample, Sp = Species in relative abundance, but not impacting crops, Cop = Species widely distributed and, in some cases, impacting crops.

For the frequency classification, the species *Commelina benghalensis* L., *Ipomoea asarifolia* (Desr.) Roem. & Schult., *Zea maiz* L. and *Portulaca oleracea* L. were classified as B, according to the Raunkiaer (1934) classification. In terms of density, both *Ipomoea asarifolia* (Desr.) Roem. & Schult. and *Zea maiz* L. showed high values, being level 4, on the scale proposed by Cain and Castro (1959). The species with the highest abundance values were *Cenchrus echinatus* (Cop) and *Ipomoea asarifolia* (Desr.) Roem & Schult (Sp). The results of frequency, density and abundance can indicate a wide distribution of the plants in the overall study area.

When the frequency classification is intermediate and the density and abundance are high, such as *Ipomoea asarifolia* (Desr.) Roem. & Schult. this may indicate that these plants are found in areas of denser and more shaded sites, and so will not dominate the entire study area. The control of abundant species in the area should preferably be carried out prior to soy germination, as this is the best time to ensure they do not compete with the crop plants. Less common species can be controlled by more specific management practices, thus avoiding the accumulation of biomass and competitive interferance with the crops (CONCENÇO et al., 2013).

Volunteer corn (*Zea mays* L.) proved to be a potentially important weed, both because it is an RR® crop and due to the recoded phytosociological aspects. As a weed this species had the second highest frequency (B) and the 3rd highest density (code 4), and a Sol level of abundance classification. The glyphosate tolerance characteristic of RR® hybrid corn allows this single herbicide to be used selectively on crops such as soya but, on the other hand, the same resistance makes this method of control inviable when high densities of RR® maize appear as a weed (MACIEL et al., 2013).

The way to evaluate all this information and test the true importance of an individual weed species in a given agricultural ecosystem is via the Importance Value Index (IVI). However, to ascertain the most effective method of handling weeds with high importance values, it is also necessary to know aspects of their biology, such as means of propagation, life cycle and growth habit (FERREIRA et al., 2019).

The species *C. echinatus* L. showed the highest importance value index (IVI) and, as a result, it would be the likely target species for any weed control case study for in the area. The high IVI can be explained by the well-developed seed-bank, the result of an extensive pre-existing population of this weed species present in the area, as a result of presence in previous crops. This species has a high competitive capacity and dispersion potential and can cause direct and indirect damage to crops. In addition, it is difficult to control in the cerrados, due to the low availability of appropriate registered herbicides (DAN et al., 2011). Both *I. asarifolia* (Desr.) Roem. & Schult., *Amaranthus retroflexus* L. and *Zea mays* L. had intermediate IVI values (Figure 1).

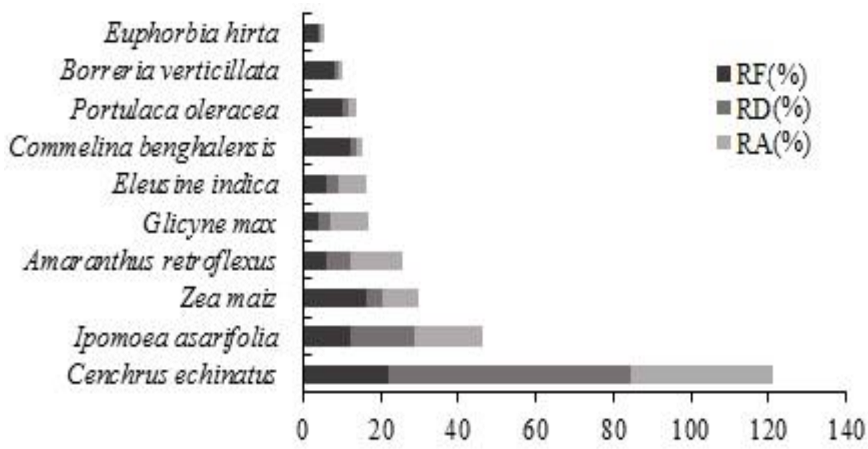

FIGURE 1 - Composition of the importance value index (IVI), with relative frequency (RF%), relative density (RD%), Relative abundance (RA%) of weeds in a soybean cultivation area, Piauí, Brazil.

Individual species characteristics, edaphoclimatic conditions, seed bank composition and crop cultivation characteristics are the most factors most likely to alter the phytosociological composition of a weed assemblage (MENEZES et al., 2019). With this, the importance of understanding the general and population biology of the weeds in the region of the Gurguéia Valley, Piauí, is clear, as is the need to improve the planning of weed management in the region.

CONCLUSIONS

In the soybean cultivation area, that 60% of the sampled weed species were Eudicotyledons.

Eight botanical families and 10 weed species were identified.

The species *Cenchrus echinatus, Ipomoea asarifolia* (Desr.) Roem. and Schult., *Amaranthus retroflexus* L. and *Zea mays* L. had the highest values for the analyzed variables, and should thus be the focus of special attention from soybean producers in the Vale da Gurguéia region of Piauí, Brazil.

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